ADDENDUM TO NON-MAJOR COMPREHENSIVE PLAN APPROVAL APPLICATION

Transmittal No. X266786: BACT Analysis for EMD Alternative

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Weymouth Compressor Station

Atlantic Bridge Project

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1. EXECUTIVE SUMMARY

In October 2015, Algonquin Gas Transmission, LLC (Algonquin) submitted an application to the Massachusetts Department of Environmental Protection (MassDEP) for a Non-Major Comprehensive Plan Approval (NMCPA) to authorize construction and operation of the Weymouth Compressor Station (the Facility). MassDEP issued a final NMCPA for the Facility in January 2019. On June 3, 2020, the United States Court of Appeals for the First Circuit issued its decision in *Town of Weymouth v. Mass. Dep't Envtl. Prot.*, 961 F.3d 34 (1st Cir. 2020). In that decision, the court affirmed all aspects of MassDEP's decision making except one.

Specifically, the Court found that MassDEP *"did not follow its own established procedures for assessing whether an electric motor was the Best Available Control Technology (BACT)." Id.* at 38. As a result, the Court vacated the NMCPA issued for the Weymouth Compressor Station and remanded the matter to MassDEP for it to fill in what the Court perceived as evidentiary gaps in the administrative record and to determine whether an electric motor is BACT for the natural gas-fired turbine proposed for the Weymouth Compressor Station.[1]

On June 12, 2020, MassDEP Commissioner Suuberg remanded the matter to the Presiding Officer and on June 24, 2020, MassDEP Commissioner Suuberg established a schedule for the further administrative proceedings anticipated by the Court.

Pursuant to Commissioner Suuberg's orders and the First Circuit's Decision, Algonquin submits the following addendum to the NMCPA application for the Atlantic Bridge Project - Weymouth Compressor Station (Transmittal No. X266786) assessing whether electric motor drive (EMD) is BACT for the SoLoNO$_X$™ natural gas-fired Solar Taurus 60-7802 combustion turbine[2] (SoLoNO$_X$ Taurus 60) component of the Facility.

MassDEP regulations provide two alternative options for defining BACT for minor sources such as the Facility:

1. BACT can be defined as "Top Case" in lieu of an emissions unit-specific top-down analysis. Under 310 CMR 7.02(8)(a)(2)(a), the Top Case is the "*level of control from the most recent plan approval or other action issued by the Department;*" and/or
2. Applicants can identify BACT for their specific application using a top-down BACT analysis, consistent with MassDEP guidance (and EPA guidance by reference).

This Addendum demonstrates that Top Case BACT is a SoLoNO$_X$ turbine with an oxidation catalyst limiting NO$_X$ to 9 ppmvd @ 15% O_2 during normal operation.[3] As described below, MassDEP's own regulations, its BACT guidance, and its Top Case BACT guidelines apply Top Case BACT to the specific emission source and specific fuel proposed by a permit applicant. Accordingly, it would be inconsistent with these authorities to

[1] Algonquin has filed a petition for panel rehearing with the Court, seeking rehearing and remand without vacating Algonquin's permit. *See* Algonquin Gas Transmission, LLC's Petition for Panel Rehearing, *Town of Weymouth v. Mass. Dep't of Envtl. Prot.*, Nos. 19-1794, 19-1797, & 19-1803 (Consolidated) (1st Cir. July 1, 2020).

[2] SoLoNO$_X$ is a trademark of Solar Turbines which indicates this manufacturer's lean premix or dry low NO$_X$ design for the turbine's combustion chamber and fuel injectors.

[3] *See* Agawam Plan Approval (#WE-17-021). *See also* Hopkinton Plan Approval (#CE-17-032). The Agawam Plan Approval and Hopkinton Plan approval are defined and discussed below.

require an EMD – and thus the substitution of one fuel or energy source for another – to satisfy BACT requirements in this case.

Alternatively, and as additional grounds for excluding EMD as BACT, the Addendum also demonstrates that a top-down BACT analysis for the Facility shows that an EMD is not BACT because:

- Substituting an EMD for a natural gas-fired engine to drive a compressor at the Facility would improperly substitute or "redefine the source." EMD is therefore properly excluded in Step 1 from further consideration; and/or, independently and alternatively,
- The detailed economic and environmental evaluation under Step 4 provided in this Addendum demonstrates that EMD is not BACT for the Facility.

For these reasons, and discussed in more detail below, MassDEP was correct in excluding EMD as BACT in the NMCPA, and it should again select as BACT a SoLoNO$_X$ turbine with a limit of 9 ppmvd NO$_X$ @ 15% O$_2$ during normal operating conditions with an oxidation catalyst.

A signed, updated MassDEP BACT form is included with this Addendum in Appendix E.

2. OVERVIEW OF MASSACHUSETTS REGULATIONS AND GUIDANCE

Massachusetts requires a comprehensive plan approval (CPA) for certain minor sources like the Facility. *See* 310 CMR 7.02(5)(a)(1) (requiring certain minor NSR sources to obtain a comprehensive plan approval). CPAs for minor sources require an evaluation of BACT. *See id.* 7.02(8)(a)(2) (BACT is required of all CPA approvals).

The Regulations define BACT as follows:

> *BEST AVAILABLE CONTROL TECHNOLOGY means an emission limitation based on the maximum degree of reduction of any regulated air contaminant emitted from or which results from any* ***regulated facility*** *which the Department, on a case-by-case basis taking into account energy, environmental, and economic impacts and other costs, determines is achievable for* ***such facility*** *through* ***application of production processes and available methods, systems and techniques for control*** *of each such contaminant. The best available control technology determination shall not allow emissions in excess of any emissions standard established under the New Source Performance Standards, National Emissions Standards for Hazardous Air Pollutants or under any other applicable section of 310 CMR 7.00, and may include a design feature, equipment specification, work practice, operating standard or combination thereof.*

310 CMR 7.00 (emphases added).

"Facility" means "*any installation or establishment and associated equipment, located on the same, adjacent or contiguous property, capable of emissions; and for the purpose of 310 CMR 7.15, it means any structure, installation, building, equipment, or ship.*" 310 CMR 7.00.[4]

The Regulations specify two means of identifying BACT for the Facility. An applicant may submit to MassDEP a "top-down BACT analysis" for its specific application or emission unit: "***Applicants shall identify BACT for their specific application*** *using a top-down BACT analysis. Refer to Department guidance for conducting a top-down BACT analysis.*" *Id.* 7.02(8)(a)(2) (emphasis added). Alternatively, *"[i]n lieu of* ***an emission unit-specific top-down BACT analysis****, an applicant may propose an emission control limitation by using*" one or more listed approaches, including: "*[p]ropos[ing] a level of control from the most recent plan approval or other action issued by the Department (Top Case BACT).*" 310 CMR 7.02(8)(a)(2)(a) (emphasis added). In keeping with this regulatory framework, Algonquin first undertook a Top Case BACT analysis to determine whether a recent plan approval or action by the Department provides an applicable emission control limitation for Top Case BACT. In addition, Algonquin also undertook a top-down BACT analysis to identify BACT for Algonquin's specific air plan approval application.

Starting with its Top Case BACT Analysis presented in Section 3.1, and as specified at 310 CMR 7.02(8)(a)(2)(a), Algonquin identifies the emission levels achieved by lean premix or dry low NO_X combustion technology with an oxidation catalyst as the "*level of control from the most recent plan approval*

[4] The regulations further define "Facility Component" as "*any part of a facility, including, but not limited to, any equipment, pipe, duct, boiler, tank, turbine, furnace, structural or non-structural member at the facility.*" 300 CMR 7.00.

or other action issued by the Department" for a natural gas-fired stationary combustion turbine and therefore the appropriate Top Case BACT.

In Section 3.2, Algonquin demonstrates that MassDEP's regulations and Top Case BACT Guidelines confirm that an EMD alternative is properly excluded from the BACT analysis before a top-down analysis is required.

Alternatively, and as an additional ground for excluding EMD as BACT, Algonquin has detailed its top-down BACT analysis in Section 4, which demonstrates that EMD is not BACT for two independent reasons: (1) in Step 1 of the top-down BACT analysis, EMD would improperly substitute or redefine the source under Massachusetts regulations and guidance; and (2) under Step 4 of the top-down BACT analysis, EMD is not a cost-effective control and would have other significant energy and environmental impacts.

EMD is not BACT under any approach.

3. TOP CASE BACT ASSESSMENT FOR PROJECT

3.1 Dry Low NO_X Technology with Oxidation Catalyst is Top Case BACT for Algonquin's Facility

MassDEP's air regulations state that, "*[i]n lieu of an emission unit-specific top-down BACT analysis, an applicant may propose an emission control limitation by using*" one or more listed approaches, including: "*[p]ropos[ing] a level of control from the most recent plan approval or other action issued by the Department (Top Case BACT).*" 310 CMR 7.02(8)(a)(2)(a). Pursuant to 310 CMR 7.02(8)(a)(2)(a), MassDEP's recently issued Plan Approval for the Agawam Compressor Station establishes the emission levels achieved by lean premix or dry low NO_X combustion technology with an oxidation catalyst as the "*level of control from the most recent plan approval or other action issued by the Department*" for a natural gas-fired stationary combustion turbine and, therefore, the Top Case BACT.

3.1.1 January 24, 2020, Agawam Plan Approval

The most recent MassDEP Plan Approval for a simple cycle natural gas-fired stationary combustion turbine is NMCPA Approval # WE-17-021 issued to Tennessee Gas Pipeline Company, LLC for its Agawam Compressor Station authorizing the installation of a Solar Taurus 70-10802S, or equivalent, natural gas-fired lean-burn premix simple cycle combustion turbine (Agawam Plan Approval, attached as Appendix A). NO_X BACT for this turbine was determined to be the use of SoLoNO$_X$ combustion technology to achieve emissions of no greater than 9 ppmvd @ 15% O_2 during normal operating conditions. Carbon monoxide (CO) and volatile organic compounds (VOC) BACT for this turbine was determined to be the use of an oxidation catalyst to achieve emissions of no greater than 1.25 ppmvd CO @ 15% O_2 and 5 ppmvd VOC (as propane) @ 15% O_2 during normal operating conditions. *See* App. A at 13.[5] Neither the applicant nor MassDEP identified EMD as a possible control technology for Top Case or top-down BACT purposes. Pursuant to 310 CMR 7.02(8)(a)(2)(a), the Agawam Plan Approval establishes that lean premix or dry low NO_X combustion technology with an oxidation catalyst—the "level of control" from the most recent plan approval issued by the Department—is Top Case BACT for Algonquin's Facility.[6]

3.1.2 February 26, 2019, Hopkinton Plan Approval

In February 2019, MassDEP approved another NMCPA Application for a natural gas-fired stationary combustion turbine in Hopkinton (Hopkinton Plan Approval, attached as Appendix B). NO_X BACT for this turbine was determined to be the use of SoLoNO$_X$ combustion technology to achieve emissions of no greater than 9 ppmvd @ 15% O_2 during normal operating conditions. *See* App. B at 4. Neither the applicant nor MassDEP identified EMD as a possible control technology for Top Case or top-down BACT purposes. Pursuant to 310 CMR 7.02(8)(a)(2)(a), the Hopkinton Plan Approval further supports the conclusion that lean premix or dry low NO_X combustion technology is Top Case NO_X BACT for Algonquin's Facility.

[5] The NMCPA for the Facility limits VOC to 2.4 ppmvd VOC (as propane) @ 15% O_2 during normal operating conditions.

[6] EMD was identified as an alternative to a natural gas-fired stationary combustion turbine in an Expanded Environmental Notification Form submitted for the Agawam project under the Massachusetts Environmental Policy Act (MEPA), and it was ruled out much like it was ruled out by Algonquin in its Resource Report 10 (RR10), submitted to the FERC in connection with the Atlantic Bridge Project (Docket No. CP16-9-000), and evaluated in the Enviromental Assessment that was issued by the FERC staff on May 2, 2016. Consistent with the the Regulations and MassDEP guidance, neither the applicant nor MassDEP considered EMD as part of the BACT Analysis for the Agawam project.

Based on the Agawam and Hopkinton plan approvals, Algonquin respectfully requests that MassDEP determine that Top Case BACT for the Facility is the use of SoLoNO$_X$ combustion technology to achieve NO$_X$ emissions of no greater than 9 ppmvd @ 15% O_2 during normal operating conditions and the use of oxidation catalyst to achieve emissions of no greater than 1.25 ppmvd CO @ 15% O_2 and 5 ppmvd VOC (as propane) @ 15% O_2 during normal operating conditions.[7]

3.2 MassDEP's Exclusion of EMD from the BACT Analysis in the Agawam and Hopkinton Approvals is Consistent with Its Regulations and Guidance

3.2.1 MassDEP's Regulations Do Not Support Consideration of EMD as BACT for a Natural Gas Combustion Turbine

MassDEP's definition of BACT does not support consideration of EMD as BACT for a natural gas combustion turbine because an EMD is inconsistent with the "facility," "application," or "emission unit" as proposed by Algonquin.

EMD is not an element of Algonquin's Facility. The Section 7.00 definition of BACT allows MassDEP to evaluate the "*application of production processes and available methods, systems and techniques for control*" only for "such facility." The phrase "such facility" refers to the "regulated facility" that has been proposed by the applicant and that is the subject of the CPA proceeding. An EMD is not an element of the regulated facility proposed by Algonquin. *See* 310 CMR 7.00.

EMD is not Algonquin's proposed application. MassDEP's regulations further clarify that BACT is specific to the "application" (i.e., the facility that Algonquin proposes to put to use) as proposed by the applicant: "*Applicants shall identify BACT for their specific application using a top-down BACT analysis. Refer to Department guidance for conducting a top-down BACT analysis.*" *Id.* 7.02(8)(a)(2) (emphasis added).

EMD is not Algonquin's proposed emission unit. MassDEP's regulations further clarify that BACT is specific to the "emission unit" as proposed by the applicant: "*In lieu of an* ***emission unit-specific*** *top-down BACT analysis, an applicant may propose an emission control limitation by using [a Top Case approach].*" *Id.* (emphasis added). This means that the BACT evaluation is conducted on the specific emission unit proposed by an applicant, not a different kind of emissions unit, or indeed, an alternative that produces no emissions at all.

MassDEP's evaluation of production processes and available systems and techniques for control is limited to the specific facility, application, and emission unit that is the object of an application for a plan approval—in this case a stationary combustion turbine fired by the natural gas flowing through the Facility. Therefore, Massachusetts regulations do not support consideration of EMD in the BACT analysis because an EMD is a different facility, application, or emission unit from the combustion turbine proposed.

[7] This BACT Addendum post-dates the Agawam and Hopkinton plan approvals and so properly applies them now to determine Top Case BACT.

3.2.2 MassDEP's Top Case Guidelines Are Evidence that the Regulations Do Not Support EMD as BACT

MassDEP's "Top Case Best Available Control Technology (BACT) Guidelines" (the Top Case Guidelines) confirm that analysis of an EMD as an alternative to a natural gas-fired stationary combustion turbine is inconsistent with the Regulations. The Top Case Guidelines "*present Top Case BACT guidelines for Non-major air contaminants emitting sources*" including natural gas-fired stationary combustion turbines.[8] The Top Case Guidelines provide that:

> *Use of the applicable Top Case BACT emissions limitations contained herein may preclude the need for applicants to prepare and submit a "top-down BACT analysis" for MassDEP's review, and will streamline the Air Quality permitting process for both the applicants and MassDEP . . .*

Top Case Guidelines at 1.

The Agawam and Hopkinton plan approvals—not the Top Case Guidelines[9]—identify Top Case BACT for Algonquin's Facility. *See* 310 CMR 7.02(8)(a)(2)(a). However, the Top Case Guidelines also provide unambiguous examples of how MassDEP interprets its regulations to require the evaluation of BACT only for the facilities, applications, or emission units proposed by a permit applicant. As set out in the following table, the Top Case Guidelines specify Top Case BACT for combustion sources by identifying different combustion sources (e.g., simple cycle combustion turbines and combined cycle combustion turbines), further distinguishing those sources by the fuel combusted, and then identifying the BACT to control emissions from those fuel-specific sources.

[8] S*ee* MASS. DEP'T ENVTL. PROT., TOP CASE GUIDELINES AT COVER PAGE (June 2011), *available at* https://www.mass.gov/doc/top-case-bact-guidelines/download, attached as Exhibit 1. The Top Case Guidelines for certain combustion sources have been confirmed by MassDEP as recently as March 2020. *See, e.g.*, 310 CMR 7.26(43) (specifying emission rates for turbines with a rated power output of less than or equal to 10 MW that are identical to the corresponding emission rates in the Top Case Guidelines).

[9] The Top Case Guideline for a natural gas-fired stationary combustion turbine (1 MW to 10 MW combustion turbines powered by natural gas) identifies SCR and an oxidation catalyst as possible required technology to meet MassDEP's Industry Performance Standards at 310 CMR 7.26(43). A review of the latest BACT determinations in EPA's RACT/BACT/LAER Clearinghouse (RBLC) database, as well as other state agencies' BACT databases, reveals that MassDEP's Industry Performance Standards have not been achieved by simple cycle turbines used as natural gas-fired compressor drivers. This is due to the load-following operation of compressor drive turbines which result in variable turbine loads on an ongoing basis in response to the real-time demand for natural gas. And, with respect to SCR, the First Circuit has already affirmed MassDEP's determination that it is not cost effective for the Facility.

Table 3-1. MassDEP Top Case BACT for Combustion Turbines[10]

COMBUSTION TURBINES (June 2011)					
Source Type	**Fuel**	**Air Contaminant**	**Emission Limitations**	**BACT Determination**	**Control Technology**
Combustion Turbine 1MW to 10MW	Natural Gas	NO_X	0.14 lbs/MW-hr	310 CMR 7.26(43) IRP Regulation	► SCR ► Oxidation Catalyst (possible required technology)
		NH_3	2.0 ppmvd @ 15% O_2		
		CO	0.09 lbs/MW-hr		
		CO_2	1900 lbs/MW-hr		

No Top Case BACT specified in the Top Case Guidelines for any combustion source identifies a change in fuel (e.g., from distillate oil to natural gas[11]), a substitution of one category of combustion source for another (e.g., from a simple cycle turbine to a reciprocating engine), or a substitution of one energy source for another (e.g., renewable for thermal generation). Nor do the Top Case BACT Guidelines specify EMD as a potential control technology for any combustion turbine or any other combustion source. Because application of Top Case BACT emissions limitations contained in the Top Case Guidelines may "*preclude the need for applicants to prepare and submit a 'Top-down BACT analysis*" and the Top Case Guidelines do not identify an alternative fuel or power source as a possible control technology for any combustion source, the Top Case Guidelines demonstrate that EMD is properly excluded from Top Case BACT before any top-down analysis.

The Top Case approach above supports a renewed determination that BACT is based on the use of SoLoNO$_X$ and oxidation catalyst.

Alternatively, and as an additional ground to exclude EMD as BACT, Algonquin demonstrates below in Section 4 that a top-down analysis also confirms that a SoLoNO$_X$ turbine equipped with an oxidation catalyst is BACT in this case.

[10] Applicable portion of table reproduced from "MassDEP Top Case BACT Guidelines – Combustion Sources," June 2011, p. 15, https://www.mass.gov/files/documents/2016/08/vc/bactcmb.pdf.

[11] This is the case even though the Top Case BACT NO_X emission rate for combustion turbines firing distillate oil is 0.34 lbs/MWh, which is more than twice the emission rate of 0.14 lbs/MWh for combustion turbines firing natural gas.

4. SUPPLEMENTAL TURBINE TOP-DOWN BACT ANALYSIS

The top-down BACT analysis specified at 310 CMR 7.02(8)(a)(2) requires that all available control technologies be ranked in descending order of control effectiveness. The most stringent or "top" control option is the default BACT emission limit unless the applicant demonstrates, and MassDEP agrees, that energy, environmental, and/or economic impacts justify the conclusion that the most stringent control option is not achievable in that case. Upon elimination of the most stringent control option, the next most stringent alternative is evaluated in the same manner. This process continues until a BACT is selected.

The five steps in a top-down BACT evaluation can be summarized as follows:

- Step 1. Identify all possible control technologies
- Step 2. Eliminate technically infeasible options
- Step 3. Rank the technically feasible control technologies based upon emission reduction potential
- Step 4. Evaluate ranked controls based on energy, environmental, and/or economic considerations
- Step 5. Select BACT

4.1 Step 1: EMD as Possible Control Technology

Algonquin first evaluates whether EMD is a possible control technology to be included in step one of a top-down BACT analysis for the Facility. The answer is no for two alternative reasons having to do with the source that is the object of the NMCPA application. The first reason, described in more detail in Section 4.1.1 below, is that MassDEP's Regulations explicitly limit the range of control technologies to be evaluated to those that could be applied to the source proposed by the applicant for Plan Approval. The second reason, described in more detail in Section 4.1.2 below, is that MassDEP's BACT Guidance incorporates the Environmental Protection Agency's (EPA) redefining the source doctrine. Thus, as additional grounds for finding that EMD is excluded as BACT, MassDEP's regulations do not support consideration of a source that is a substitute for the proposed source. In addition, EPA guidance that is incorporated into MassDEP's Guidance by reference also does not support consideration of technologies that redefine the source.

4.1.1 MassDEP's Regulations and Guidance Do Not Support Consideration of a Control Technology that is a Substitute for the Proposed Source

The same analysis presented in Section 3.2, applies in this first step of the top-down analysis. MassDEP's Regulations and guidance are unambiguous that the evaluation of production processes and available systems and techniques for control are limited to the specific facility, application, and emission unit that is the object of an application for Plan Approval. Alternatives—even those that might be inherently less polluting—are not a proper part of a BACT analysis if they would substitute a different source type for the source proposed by the applicant. MassDEP's Top Case Guidelines, discussed in Section 3.2.2 above, list categories of combustion sources, further distinguish those sources by the fuel combusted, and then identify Top Case BACT for the fuel-specific source types, without suggesting a change in fuel, a substitution of one category of combustion source for another, or a substitution of one energy source for another. Neither the Agawam Approval nor the Hopkinton Approval, discussed in Section 3.1 above, required the applicant to consider an EMD as part of their BACT analysis. Therefore, EMD must be excluded from Step 1 because it is not an appropriate control technology that should be evaluated in connection with the Facility proposed by Algonquin—a stationary combustion turbine fired by the natural gas flowing through the Facility.

4.1.2 By Incorporating EPA Guidance, MassDEP Guidance Does Not Support Consideration of Control Technology that Redefines the Source

Even if MassDEP's Regulations and guidance were ambiguous regarding whether they support consideration of a control technology that would be a substitution for the proposed source, any such ambiguity would be resolved by the MassDEP BACT Guidance's incorporation of EPA guidance that excludes from consideration a technology that redefines the source. The MassDEP BACT Guidance states:

> *MassDEP needs to balance the many impacts of a project while reviewing its proposed emission limits. You must use a top-down procedure to determine BACT. * * * This procedure is . . . further described in the . . . October 1990 draft EPA New Source Review Workshop Manual.*

MassDEP BACT Guidance at 3. In turn, the EPA's New Source Review Workshop Manual[12] explicitly states: "*Historically, EPA has not considered the BACT requirement as a means to redefine the design of the source when considering available control alternatives.*" NSR Workshop Manual at B.13.

EPA's Two-Part Test for Determining Whether a Control Alternative Redefines the Source. The United States Court of Appeals for the Ninth Circuit has summarized the EPA's two-part test for determining when the evaluation of an alternative production process as a control technology veers into an illegitimate redefinition of the source proposed by the permit applicant.

> *First, "the permit applicant initiates the process and . . . defines the proposed facility's end, object, aim or purpose—that is the facility's basic design." The purpose must be "objectively discernable." Additionally, the applicant's proposed definition "must be for reasons independent of air permitting" and cannot be motivated by cost savings or avoidance of risks.*
>
> *Second, EPA takes a "hard look" at the proposed definition to determine which design elements are inherent to the applicant's purpose and which elements can be changed to reduce pollutant emissions without disrupting the applicant's basic business purpose.*

Helping Hands Tools v. Envtl. Prot. Agency, 848 F.3d 1185, 1194 (9th Cir. 2016) (citations omitted).[13] Though MassDEP's Regulations and guidance do not support an evaluation of alternative production processes of the sort conducted by the EPA under its rules, EPA's redefining the source doctrine further demonstrates that consideration of EMD would be improper here.

Over time, EPA has applied the redefining the source doctrine in numerous contested permit proceedings, two of which have been upheld by United States Courts of Appeals.[14] Two categories of these cases are most relevant to Algonquin's BACT analysis of the Facility: (1) cases evaluating facilities co-located with

[12] See Envtl. Prot. Agency, New Source Review Workshop Manual (Draft) (1990) (hereinafter, NSR Workshop Manual).

[13] *Accord Sierra Club v. Envtl. Prot. Agency*, 499 F.3d 653, 655 (7th Cir. 2007) (allowing the permitting authority to exclude "redesign" of the proposed source from the control technology review). *See also Friends of Buckingham v. State Air Pollution Control Bd.*, 947 F.3d 68, 73 (4th Cir. 2020) (describing the EPA's development of the two-part redefining the source principle to resolve an ambiguity in the Act as it applies to major NSR permitting).

[14] *In re Sierra Pacific Indus.*, PSD App. 13-01, 2013 WL 3791510 (Envtl. App. Bd., July 18, 2013), *aff'd sub nom Helping Hands Tools v. Envtl. Prot. Agency*, 848 F.3d 1185; *In re Prairie State Generating Co.*, PSD App. No. 05-05, 2006 WL 2847225 (Envtl. App. Bd., Aug. 24, 2006), *aff'd sub nom Sierra Club v. Envtl. Prot. Agency*, 499 F.3d 654.

sources of fuel, energy, or raw materials; and (2) cases evaluating switching a fuel or source of energy from that proposed by the applicant.

Co-location of sources of fuel, energy, or raw materials. In the *Helping Hands Tools* case, the permit applicant proposed to combust on-site waste wood biomass to generate energy. Project opponents argued that using solar energy or combusting natural gas would result in lower emissions and should have been considered as BACT. The Ninth Circuit concluded as follows: "*When a fuel source is co-located with a facility, EPA need not consider in the BACT analysis fuel sources that are not readily available, because it would re-define the source.*" *Helping Hands Tools*, 848 F.3d at 1195. In the *Sierra Club* case, the permit applicant proposed to build a coal-fired power plant that was located at the mouth of a coal mine. Project opponents argued that the applicant should be required under BACT to transport cleaner coal from elsewhere to lower emissions. The Seventh Circuit affirmed the EPA's conclusion that "*consideration of low-sulfur coal, because it necessarily involves a fuel source other than the co-located mine, would require [the applicant] to redefine the fundamental purpose or basic design of its proposed Facility. * * * [R]eceiving coal from a distant mine would require [the applicant] to reconfigure the plant as one that is not co-located with a mine, and this reconfiguration would constitute a redesign.*" *Sierra Club*, 499 F.3d at 657. In the *Russell City Energy Center* case,[15] the permit applicant proposed to construct a gas-fired combined cycle power plant that used recycled municipal wastewater for cooling. Project opponents argued that the permitting authority should have evaluated under BACT dry cooling that would not require water and that would have reduced emissions of particulate matter. The EPA's Environmental Appeals Board (EAB) affirmed the permitting authority's conclusion that:

> *[T]his facility was specifically designed from the very beginning to make use of recycled water from the City of Hayward wastewater treatment plant. * * * [T]he Board concludes that [the permitting authority] did not abuse its discretion in determining that dry cooling would "redefine the source" and therefore need not be included in the BACT analysis.*

Russell City Energy Center at *54.

Switching a fuel or energy source. The NSR Workshop Manual does not require an evaluation under BACT of a process that uses different raw materials or fuels from those proposed by the applicant. "*Lower-polluting processes should be considered based on demonstrations made on the basis of manufacturing identical or similar products from identical or similar raw materials or fuels.*" NSR Workshop Manual at B.10. This general approach has been used in many EAB cases to disallow the substitution of one source of fuel for another, and more recently, one source of energy for another. *See, e.g.*, *In re City of Palmdale*, PSD App. No. 11-07, 2012 WL 4320533 (Envtl. App. Bd., Sep. 17, 2012) (holding that substitution of solar energy for thermal energy at a proposed power plant would redefine the source). *See generally*, *In re Prairie State Generating Co.*, PSD App. No. 05-05, 2006 WL 2847225 (Envtl. App. Bd., Aug. 24, 2006); *In re SEI Birchwood, Inc.*, PSD App. No. 93-11, 1994 WL 36876 (Envtl. App. Bd., Jan. 27, 1994); *In re Old Dominion Power Coop.*, PSD App. No. 91-39, 1992 WL 92372 (Envtl. App. Bd., Jan. 29, 1992); *In re Pennsauken Cty.*, PSD App. No. 88-8, 1988 WL 249035 (Envtl. App. Bd., Nov. 10, 1988) (all rejecting the substitution of a fuel for the one proposed by the applicant).

MassDEP has concluded in at least one major CPA that a BACT analysis need not include a technology that would redefine the source. In its draft PSD permit for NRG's Canal Generating Station Unit 3, MassDEP stated:

[15] *In re Russell City Energy Center*, PSD App. No. 10-01, 2010 WL 5573720 (Envtl. App. Bd., Nov. 18, 2010).

> *According to the Application, the Project is designed to compete in the capacity and energy markets as a generator with particular value related to its quick-start capability and relatively high efficiency. As such, the Project is capable of providing up to 350 MW of electricity in 10 minutes. The Applicant demonstrated that combined-cycle turbine technology is not capable of achieving this level of quick start. Therefore, MassDEP determined that the BACT analysis need not include an analysis of combined-cycle technologies that would redefine the source.*

Mass. Dept. Envtl. Prot., PSD Permit Fact Sheet Canal Unit Three 14 (Jan. 5, 2017).

4.1.3 Application of "Redefines the Source" Guidance to EMD at Weymouth

Consideration of an EMD here would improperly redefine the source under the EPA's redefining the source doctrine as discussed below.

The Facility's basic design or purpose. As stated in the FERC proceedings for this project,

> *The purpose of the Atlantic Bridge Project is to economically provide the pipeline capacity necessary for the transportation of significant and diverse natural gas supplies from a receipt point at Mahwah, New Jersey to the Project shippers' delivery points primarily in Massachusetts, Maine and at the United States ("U.S.") – Canadian border. The Project would provide additional capacity on the Algonquin system and facilitate south-to-north flow on the Maritimes system in order to provide additional gas supply to New England and the Maritime provinces of Canada.*

RR10, Section 10.2.

As the Presiding Officer found in the related Chapter 91 Waterways proceeding:

> *To achieve the AB's purpose of moving natural gas from south to north through the HubLine, natural gas in the pipeline needs to be able to flow from the Applicant's I-9 pipeline into the HubLine. The Applicant has customers north of the HubLine with which it has agreements to deliver natural gas supplies at certain delivery points and at certain pressures. The Applicant sized and designed the AB project's facilities to meet the firm capacity requirements of the precedent agreements.*

In the Matter of Algonquin Gas Transmission LLC, OADR Docket Nos. 2017-011, 012, Waterways Application No. W16-4600, Recommended Interlocutory Decision on Issues 1, 7, and 8 (Nov. 21, 2018) at 13, attached hereto as Ex. 2.

The existing facilities cannot transport natural gas from the I-9 into the HubLine because they cannot overcome the pressure difference between those pipeline segments without additional compression at the southern end of the HubLine. *In the Matter of Algonquin Gas Transmission LLC*, OADR Docket Nos. 2017-011, 012, Waterways Application No. W16-4600, Recommended Interlocutory Decision on Issues 1, 7, and 8 (Nov. 21, 2018) at 15. Thus, the Facility's end, object, aim or purpose is to provide additional compression necessary to transport gas south to north from the I-9 into the HubLine. *See id.* at 23.

Elements of design that are inherent to the Facility's basic design or purpose. Under the second part of the two-part test, MassDEP reviews the stated purpose of the project and discerns whether the Project's basic design elements are inherent to this stated purpose and which design elements could be changed to reduce emissions without disrupting the applicant's basic business purpose. As described below, the selection of a SoLoNO$_X$ turbine over EMD as a compressor driver is inherent to the basic design and cannot be changed without disrupting Algonquin's stated business purpose for the Project.

The Facility, as a component of the Atlantic Bridge Project, is needed to provide the additional compression required to move gas into the higher-pressure Maritimes pipeline due to its location between the lower pressure Algonquin system and the higher pressure system. Natural gas pipeline facilities are co-located with the Facility and provide a readily available fuel for the compressor driver and other ancillary equipment at the site. Therefore, the Facility is designed to combust a portion of the natural gas that it is compressing to achieve the basic purpose of increasing gas pressure in the pipeline at that location. In contrast, the electrical transmission facilities that would be necessary to power an EMD are neither available at the site nor co-located with the Facility and would require the development of substantial infrastructure to bring it to the Facility. As discussed above, the selection of a natural gas-fired turbine instead of an EMD as the compressor driver for the Facility was made based on consideration of several key factors including the availability and distance of the necessary electrical infrastructure. As a result of this selection, the fact that the Facility can be powered by natural gas at wholesale costs has made the use of natural gas for the compressor driver integral to the project as the Atlantic Bridge customer contracts have been executed based on this design and corresponding fuel costs.

An electric-driven compressor unit was assessed as a Facility design alternative in the Environmental Assessment issued by FERC for the Atlantic Bridge Project.[16] The additional major infrastructure identified for the Weymouth Station to power EMD, based on information collected for this BACT Addendum, includes the following:

- Upgrades to Existing Edgar Substation;
- High Voltage Transmission Line Installation;
- Right of Way Land Purchase Costs (High Voltage Transmission Line);
- Weymouth Site Substation Installation; and
- Medium Voltage Line Install at Weymouth Station.

The total cost of the additional infrastructure listed above is $15.8 million. These additional elements of infrastructure would require substantial engineering and redesign of the Facility and are therefore inappropriate, given that the natural gas fuel source for the proposed SoLoNO$_X$ Taurus 60 turbine is already co-located at the Facility site.

The replacement of the natural gas-fired SoLoNO$_X$ Taurus 60 with an EMD would also impermissibly switch the fuel or power source at the site from co-located natural gas to electricity provided by the grid. As this replacement would require a complete project redesign, it does not meet the intent of the NSR Manual guidance that consideration of a lower-polluting process be confined to equipment "*manufacturing identical or similar products from identical or similar raw materials or fuels.*" NSR Workshop Manual at B.10. Furthermore, it would disrupt the basic business process of the facility as it was conceived from the start. The fuel type for the Facility is integral to the contract structure for Atlantic Bridge customers.

[16] "Atlantic Bridge Project Environmental Assessment," Office of Energy Projects, FERC, Docket No CP16-9-000, May 2016.

Moreover, as the Presiding Officer recognized in the related Chapter 91 proceedings: "*Once put into operation, the compressor station will play an integral role in enabling the flow of natural gas from the lower pressure pipeline segments to the south into the HubLine, thereby serving the purpose of the Atlantic Bridge project of delivering natural gas to contracted-for delivery points to the north.*" *In the Matter of Algonquin Gas Transmission LLC*, OADR Docket Nos. 2017-011, 012, Waterways Application No. W16-4600, Recommended Interlocutory Decision on Issues 1, 7, and 8 (Nov. 21, 2018) at 15. The Facility would be unable to meet its basic business purpose with an EMD when power from the grid is unavailable. That is, during electric power outages, Algonquin would not be able to transport gas from the lower pressure Algonquin system into the higher pressure system. In contrast, the basic design for the Facility specified a natural gas-fired compressor unit equipped with an emergency generator that is fueled by the same gas that the turbine is compressing, to provide the limited electric power necessary to run the compressor station in the event of an electrical outage, enabling Algonquin to deliver natural gas to contracted-for delivery points on the higher pressure system to the north.

Providing a reliable source of natural gas to New England is an overarching business purpose for the Atlantic Bridge Project as stated in the FERC Resource Report 1 filing:

> *The Atlantic Bridge Project, a proposed expansion of the Algonquin and Maritimes systems, will connect abundant North American natural gas supplies with markets in the Northeast United States and the Maritime provinces of Canada. Algonquin and Maritimes are strategically positioned to answer the region's need for more domestic, clean-burning natural gas. The additional supply will enhance the reliability of energy throughout the New England region, moderate future natural gas and electricity price volatility, and generate savings for homeowners, businesses and manufacturers.*

The fact that a control technology may be consistent with the basic design and purpose of one facility does not necessarily make it so for other facilities. *See, e.g.*, *In re La Paloma Energy Center*, PSD App. No. 13-10, 2014 WL 1066556 at *19 (Envtl. App. Bd., Mar. 14, 2014) (noting case-specific aspects that would cause solar power at a combined cycle facility to redefine the source even though at least one other combined cycle facility did include hybrid solar power for other purposes). That EMD may be used at other compressor stations is not relevant given the particular operating requirements of the Weymouth Compressor Station and the need for compression that enables the flow of natural gas to the north.

Specifically, in the basic design phase of a compressor station, key considerations in evaluating the power source (i.e., electric power-driven compression vs. natural gas-powered drivers) include:[17]

- The availability and proximity of a suitable electric power supply or substation; and
- The electricity rates from the local distribution company.

As indicated in the original Atlantic Bridge Project filings with FERC, these and other factors were taken into consideration in determining the basic design for the Facility. In consideration of the general factors above, the following was concluded with respect to possible power sources that could meet the Facility's basic business purpose.

[17] "Interstate Natural Gas Pipeline Efficiency," Interstate Natural Gas Association of America, Washington, DC, October 2010, p1-1.

- There is insufficient electricity supply at the Facility site to power an EMD and the site has no existing electric substation. Algonquin determined that the additional construction, environmental and other impacts to install the necessary electricity infrastructure made the EMD option infeasible. On the other hand, natural gas is co-located at the Facility site.
- The Facility will provide critical compression needs and a step-up in pipeline pressure for reliable delivery to the Maritimes system. If Algonquin were to install an EMD, then natural gas delivery to the Maritimes system would cease during a power outage, preventing the delivery of natural gas from south of the compressor station to points north.
- In considering an EMD option initially, Algonquin concluded that the installation of the required infrastructure would significantly impact the project schedule and thereby not meet the delivery needs of the Project Shippers. Also, the electricity rates are significantly higher than wholesale rates for natural gas that is already available at the Facility site, and therefore are not compatible with the existing Atlantic Bridge Project contract requirements.

Accordingly, the basic compressor station design specified installation of a natural gas-fired turbine-driven compressor unit from the start. The initial project filings for the Atlantic Bridge Project stated the following in regard to the use of a natural gas turbine compressor driver at the Facility:

> *Algonquin proposes to install one Solar Taurus [70] gas-fired compressor unit providing the necessary horsepower to meet the pressure requirements for the required deliveries into the Maritimes system. To ensure system reliability, the gas turbine will be equipped with an emergency generator that is fueled by the same gas that the turbine is compressing, and sufficiently sized to run the compressor station in the event of an electrical outage.*[18]

For all of these reasons, Algonquin respectfully requests that MassDEP conclude that it would disrupt the Applicant's basic business purpose to require an EMD here. EMD must therefore be excluded under Step 1 because it would redefine the source.

In addition, Algonquin offers a top-down analysis in Sections 4.2 below4.4 below, which provides another basis for MassDEP to conclude that a SoLoNO$_X$ turbine equipped with an oxidation catalyst is BACT in this case. Algonquin respectfully requests that MassDEP make additional findings confirming that an EMD is not BACT under the remaining steps of a top-down BACT approach.

4.2 Step 2: Elimination of Technically Infeasible Options

After the identification of potential control options, the second step in the BACT analysis is the elimination of technically infeasible options. A control option is eliminated from consideration if there are process-specific conditions that would prohibit the implementation of the control or if the highest control efficiency of the option would result in an emission level that is higher than any applicable regulatory limits.

According to the NSR Workshop Manual,

> *A demonstration of technical infeasibility is based on a technical assessment considering physical, chemical and engineering principles and/or empirical data* ***showing that the technology would***

[18] "Resource Report 10, Atlantic Bridge Project, Pre-Filing Draft," March 2015, Spectra Energy Partners, FERC Docket No. PF15-12-000, p. 10-20. For the avoidance of doubt, the emergency generator discussed here was intended to provide modest station backup power, not power to drive the compressor.

***not work on the emissions unit under review**, or that unresolvable technical difficulties would preclude the successful deployment of the technique.*[19]

There is inadequate electricity supply at the Facility to support an EMD. Overcoming the absence of power would require significant infrastructure outside of the Facility. Nonetheless, to further demonstrate that EMD is not BACT, we discuss the subsequent steps of the top-down analysis of EMD below.

4.3 Step 3: Ranking of Technically Feasible Options

In Step 3, the remaining technically feasible control technologies are ranked in order from most effective to least effective. Consistent with the First Circuit's decision this addendum is only providing additional information relative to the SoLoNO$_X$ Taurus 60 natural gas-fired turbine and an EMD. Accounting only for air emissions within the Facility fence line, EMD would be ranked as most effective, with zero air emissions in the vicinity of the Facility from the EMD. However, an EMD would cause substantial upstream air emissions. The environmental impacts due to upstream electricity generation are further discussed in Step 4 of the analysis.

4.4 Step 4: Evaluation of Economic, Environmental and Energy Impacts of EMD Alternative

The fourth of the five steps in the top-down BACT assessment procedure is to evaluate the most effective control and document the results. The environmental, energy, and economic impacts associated with the EMD alternative as compared to the SoLoNO$_X$ Taurus 60 natural gas-fired turbine are presented below.

Before Step 4 economic impacts can be estimated, system design parameters must be specified. It is important to ensure that the parameters used, such as upper bound operating data, are consistent when comparing the cost effectiveness and environmental impacts of control options. Therefore, for the purposes of this BACT analysis, Algonquin has estimated the economic and environmental impacts of the EMD alternative based on the previously permitted upper bound operating conditions and design parameters for the SoLoNO$_X$ Taurus 60 turbine, as suggested by the NSR Workshop Manual.[20]

The permitted operating conditions provide a consistent comparison between the EMD and Taurus 60 turbine and provide the worst-case baseline emissions from the gas-fired turbine. The following specific operating parameters were utilized in the development of the specifications for an EMD that would represent an "equivalent" replacement to the SoLoNO$_X$ Taurus 60 turbine:

- **Hours of Operation**

The SoLoNO$_X$ Taurus 60 turbine is permitted to operate 8,760 hr/yr. These same hours of operation are applied to the operation of an EMD. Any adjustments to the hours of operation assumed for the EMD would necessarily need to be similarly applied to the hours of operation (and resulting emissions) of the SoLoNOX Taurus 60 turbine.

- Fuel Consumption

The SoLoNO$_X$ Taurus 60 turbine is permitted to combust no more than 592.23 million standard cubic feet ("MMscf") of natural gas per year. However, since there are inherent differences in how natural gas-fired turbines and EMDs drive compressors, the maximum fuel for a natural gas-fired turbine is not directly

[19] NSR Workshop Manual, p. B20.

[20] NSR Workshop Manual, October 1990, pg. B.39.

comparable to the input electricity needed for the EMD. Therefore, while an upper bound heat input to the natural gas turbine is used to calculate the potential emissions from the turbine, an output based operational specification is a more appropriate upper bound operating condition to define an equivalent EMD.

- **Horsepower (HP) Rating**

Since the compressor driver is sized to meet the HP requirements for the compressor, this is the basis for deriving the electricity demand for an EMD of equivalent size. At the average annual ambient conditions at the Facility, the SoLoNO$_X$ Taurus 60 turbine is capable of delivering an annual average of 7,758 HP to the compressor.[21] Therefore, to determine the electricity demand for an equivalent EMD, Algonquin started with the 7,758 HP compressor provided by the SoLoNO$_X$ Taurus 60 and, using the known efficiencies of the system, calculated the electricity consumption required for an EMD to provide this same annual average HP output.

Table 4-1 provides the derivation of the upper bound operating parameters used to evaluate the energy, environmental, and economic impacts of an "equivalent" EMD replacement of the proposed Taurus 60 turbine.

Table 4-1. Derivation of EMD Electricity Requirements[22]

Parameter	Value
Maximum Annual Average HP Requirement (Mechanical Output to Compressor)	7,758 HP
Gear Box Efficiency (Motor Shaft Output to Compressor Shaft Input)	94.4%
Motor Output Required to Deliver 7,758 HP to Compressor	8,220 HP
HP/MW Conversion	1,341 HP/MW
Required EMD Maximum Annual Average MW (Electrical Output)	6.13 MW
Motor Efficiency of 9,000 HP EMD @ 91.3% Load (i.e., 8,219 HP)	97.13%
EMD Maximum Annual Average MW Requirement (Electrical Input) @ 91.3% Load	6.31 MW
EMD Maximum Annual Operating Hours	8,760 hr/yr
EMD Maximum Annual MW-hr (Electrical Input)	55,278 MWh/yr

4.4.1 Energy Impacts

The most obvious energy impact from the use of EMD instead of natural gas-fired turbines is the reliance on external electric generating capacity. The electricity generated at a power plant travels through a series of high-voltage transmission lines and substations that step-down the high voltage power to lower voltage. There are inherent losses that occur as electricity generated by power plants travels to customers. These losses mainly occur from energy dissipated in the conductors, transformers, and other equipment used for transmission, transformation, and distribution of power. Based on 2018 eGRID data[23], 4.88% of the electricity that is generated in the Eastern region is lost. This means that approximately 2,700 MWh/yr will be lost from the use of EMD as calculated in Table 4-2 below.

[21] Average ambient temperatures at the Facility are defined in "Updated Non-Major Comprehensive Plan Approval permit Application – Transmittal Number X266786 (Revised May 2018)," p. 3-2.

[22] "Technical Proposal Submitted to Spectra Energy for the Atlantic Bridge – Weymouth Project," Solar Turbines, Inquiry No. H015-0023, June 6, 2020. (See Appendix D)

[23] Released January 2020 and revised in March 2020. Next planned eGRID data release is scheduled for the first quarter 2022.

Table 4-2. Calculated Electricity Distribution Losses

Parameter	Value
EMD Maximum Annual MW-hr (Electrical Input)	55,278 MWh/yr
Gross Grid Efficiency Loss	4.88%
Maximum Annual Electricity Generated to Power EMD	57,976 MWh/yr
Energy Losses from EMD Use	2,698 MWh/yr

4.4.2 Environmental Impacts

The use of EMD at the Facility is not a zero-emissions option. The EMD would not cause combustion emissions within the fence at the Facility (direct emissions from the compressor driver only), but other environmental impacts would be increased, including:

- An increase in indirect air emissions (from the upstream generation of electricity);
- An increase in the amount of land disturbed; and
- The creation of new permanent visual and noise impacts.

Increase in Indirect Air Emissions

Because the EMD would be solely reliant on the electric grid for power, an EMD would result in an increase in emissions from power plants. While the Facility is in close proximity to the Fore River Generating station, electricity customers in New England are served by an integrated power grid. Therefore, the specific source of generation of the electricity that would power an EMD at the Facility cannot be narrowed to a single generating unit. Power to the grid is dependent on a variety of sources throughout the region and a balance between their availability and grid demand. To estimate indirect emissions resulting from replacement of the Project's natural gas-fired SoLoNO$_X$ Taurus 60 turbine with an EMD, the most recent output-based emission rates from EPA's Emissions & Generation Resource Integrated Database (eGRID) for the NPCC New England eGRID Subregion (NEWE) in Table 4-3 were used. This emission factor basis was selected since it best represents the geographical location of the Project.

Table 4-3. eGRID Emission Rates – NPCC New England Subregion[24, 25]

Pollutant	Emission Rate (lbs/MWh)
NO$_X$	0.387
SO$_2$	0.136

The eGRID emission factors in Table 4-3 were multiplied by the annual electricity requirement for an EMD derived in Table 4-2 to estimate indirect emissions from the operation of EMD. Table 4-4 presents a comparison of the SoLoNO$_X$ Taurus 60 turbine potential emissions to the emissions generated offsite for powering an equivalent EMD.

[24] Output based emission factors referenced from eGRID2018 Subregion Output Emission Rates for the Total NPCC New England (NEWE) Subregion, https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

[25] According to data provided in "2018 ISO New England Electric Generator Air Emissions Report," May 2020, the 2018 annual average generator emission rate in the state of Massachusetts for NO$_X$ (0.48 lb/MWh) was significantly higher than the regional average reflected in the eGRID data, while the SO$_2$ emission rate (0.12 lb/MWh) was slightly lower than the regional average. (see report at https://www.iso-ne.com/static-assets/documents/2020/05/2018_air_emissions_report.pdf)

Table 4-4. Emissions Comparison (tpy)

Compressor Option	NO_X (TPY)	SO_2 (TPY)
Natural Gas-Fired Solar Taurus 60 Turbine	10.03	4.23
EMD	11.23	3.94

As illustrated, the environmental impact on the region of air emissions caused by powering an EMD is similar to that of the SoLoNO$_X$ Taurus 60 turbine. While numeric eGRID emissions rates for carbon monoxide (CO), volatile organic compounds (VOC), and particulate matter are not readily-available for comparison, it can reasonably be assumed that they would also be comparable to or higher than the SoLoNO$_X$ Taurus 60 turbine, particularly considering the planned installation of an oxidation catalyst (with control efficiencies of 95% and 50% for CO and VOC, respectively).

While the annual emissions comparison is important, the disparity in the hourly emission rates between the SoLoNO$_X$ Taurus 60 turbine and the grid emissions related to EMD operation is also an important consideration when it comes to the basic intent of a state's minor source permitting program, which is to maintain the National Ambient Air Quality Standards (NAAQS). During times of higher electricity demand, such as extreme cold in the winter months and extreme heat in the summer months, the electric grid operator must rely on higher polluting sources (i.e., non-baseload units) to meet the demand on the grid. A comparison of NO_X emission rates during these high impact time periods shown in Table 4-5 clearly demonstrates the SoLoNO$_X$ Taurus 60 turbine's environmental benefit over EMD with respect to potential impacts on ozone NAAQS attainment during these periods. The maximum NO_X emission rate of the SoLoNO$_X$ Taurus 60 turbine is nearly 25% lower than the non-baseload emission rate for the electric grid. In this broader context, the Facility is even more of a benefit to the state and the region, in that its purpose is to increase gas supply to the region, including expected benefits to electric generating sources, to enhance New England's power system reliability. Also, the Facility is designed to combust a portion of the gas it is transferring. The result is a net benefit to air quality during these high impact time periods when compared to the EMD alternative.

Table 4-5. NO_X Emission Rate Comparison (lbs/MW-hr)

Pollutant	Solar Taurus 60-7802 Emission Rate (lbs/MWh)[a]	Average Annual Emission Rate (lbs/MWh)[b]	Non-Baseload Emission Rate (lbs/MWh)[b]
NO_X	0.385	0.387	0.501

[a] The rate shown for the SoLoNO$_X$ Taurus 60 turbine is based on heat rate at HHV and annual average temperature of 46.65°F. However, during ozone season, when impact on ozone NAAQS attainment is most critical, this rate would be slightly lower.
[b] Output based emission factors referenced from eGRID2018 Subregion Output Emission Rates for the Total NPCC New England (NEWE) Subregion (https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid)

In addition, another environmental impact from increased power plant generation includes ammonia slip emissions from the use of SCR at fossil fuel-fired power plants.

Increased Land Disturbance Impacts

The Facility site is currently not equipped with the necessary infrastructure to supply sufficient electricity for EMD units. In the Environmental Assessment issued by FERC for the Atlantic Bridge Project, an EMD

compressor driver alternative was addressed.[26] The additional infrastructure identified for the Facility would disturb an additional 3+ acres of land due to the construction and installation of the following:

- 0.5 mile of buried high voltage transmission line;
- Construction of a new substation at the Facility; and
- Upgrade of existing electrical substation.

Although the transmission line and substation would be installed in a manner to minimize impacts, such impacts (e.g. land use, right of way clearing, etc.) must be considered. In order to reach the Facility, the high voltage transmission line would be installed underground for approximately a half mile, going under a road and bridge.

The potential substation installation area at the Facility is a relatively narrow strip of land located northwest of the existing Massachusetts Water Resources Authority (MWRA) paved access road. This proposed area is currently part of the Facility's temporary construction workspace and is being used for contractor parking. Upon the completion of compressor station construction, this area will be restored and revegetated. Construction of a new electric substation in this area, however, would result in permanent impacts with the construction of a new aboveground facility. This is not the case with the currently designed Facility.

New Visual Impacts

The installation of EMD for the Project would result in additional visual impacts due to the physical presence of a new onsite substation. The new substation would be visible to residents across the Weymouth Fore River and King's Cove.

4.4.3 Economic Feasibility Analysis

Economic analyses were performed to compare total costs (capital and operating) for EMD as an alternative to the SoLoNO$_X$ Taurus 60 turbine. Capital costs include the initial cost of the components intrinsic to the complete control system. Annual operating costs include the financial requirements to operate the control system on an annual basis and include overhead, maintenance, outages, raw materials, and utilities.

In a traditional economic feasibility analysis (i.e., where an add-on control technology is being added to the proposed emission unit rather than replacing it) the costs associated with a proposed control technology are added on top of the cost of the emissions unit. However, in this case, the "control system" is the use of an EMD in lieu of a natural gas-fired turbine. As such, the cost of the proposed "control technology" is the difference in cost between the Facility with a natural gas-driven compressor (and no EMD) and the Facility with an EMD (and no natural gas-driven compressor).

In outlining the process for estimating the costs of BACT, the NSR Workshop Manual indicates that the first step is to specify the control system battery limits and indicates that for options defined as an inherently lower-emitting process, the battery limits may be the entire process or project.[27] Additional guidance related to battery limits is provided in the EPA's OAQPS Cost Control Manual:[28]

[26] "Atlantic Bridge Project Environmental Assessment," Office of Energy Projects, FERC, Docket No CP16-9-000, May 2016.

[27] NSR Workshop Manual, p. B.33.

[28] EPA Air Pollution Control Cost Manual, Section 1, Chapter 2:Cost Estimation: Concepts and Methodology, US EPA OAQPS, November 2017, https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf.

A battery limit is the geographic boundary defining the coverage of a specific project [3]. Usually this encompasses all equipment of interest (in this case, the pollution control equipment), […] This estimate would mainly apply to control systems installed in existing plants, though it could also apply to those systems installed in new plants when no special facilities for supporting the control system (i.e., off-site facilities) would be required. Off-site facilities include units to produce steam, electricity, and treated water; laboratory buildings; and railroad spurs, roads, and other transportation infrastructure items. […] it may be necessary—especially in the case of control systems installed in new or "grass roots" plants—for extra capacity to be built into the site generating plant to service the system. For example, installation of a venturi scrubber, which often requires large amounts of electricity, would require including costs associated with off-site facilities.

The battery limits for this analysis include the prime mover (i.e., EMD or natural gas-fired SoLoNO$_X$ Taurus 60 turbine) and compressor package as well as any additional infrastructure required for the operation of the prime mover. In the case of EMD, like the venturi scrubber described in the OAQPS Cost Control Manual excerpt above, there will be significant costs associated with off-site facilities that must be included within the battery limits. Therefore, the following costs are considered for each unit type in the economic feasibility analysis:

Figure 4-1. Summary of Cost Items

EMD	SoLoNO$_X$ Taurus 60 Turbine
► Capital Costs EMD Compressor Set* Upgrades to Existing Edgar Substation High Voltage Transmission Line Installation Right of Way Land Purchase Costs (High Voltage Transmission Line) Weymouth Site Substation Installation and Civil Work Medium Voltage Line Install at Weymouth Station ► Operating Costs Cost of Maintenance of EMD* Utilities – Electricity	► Capital Costs Additional Cost of a 9 ppm SoLoNO$_X$ Taurus Turbine Compressor Set (Including air intake and exhaust equipment) Fuel Gas System Equipment Fuel Gas System Installation Turbine Air Intake Installation and Foundations Turbine Exhaust Installations and Foundations ► Operating Costs Additional Cost of Maintenance of the Gas-fired Turbine over EMD Utilities – Natural Gas

* Cost of EMD Compressor Set and Cost of Maintenance of EMD are shown as zero in Table 4-6 and Appendix C because based on data from OEM showing differential cost rather than total costs.

As discussed at the beginning of Section 4.4, care was taken to ensure that the costs for each option were analyzed on a comparable or "equivalent" basis. For example, as illustrated in Table 4-2, the maximum annual quantity of electricity required at the Facility to power the EMD option is derived from the maximum annual mechanical output specified for the SoLoNO$_X$ Taurus 60 turbine in the NMCPA application, which is the basis for calculating the maximum annual quantity of natural gas consumed for the SoLoNO$_X$ Taurus 60 turbine option. Further, the costs of electricity vs. natural gas are based on data from the same time period

(i.e., CY2019).[29] These and other cost considerations are discussed in the following section. Detailed cost analyses are included in Appendix C.

4.4.3.1 Total Capital Investment

The Total Capital Investment (TCI) is the sum of the total direct costs (TDC) and total indirect costs. Direct costs are defined as the capital investment required to purchase the equipment. Examples of direct costs include purchased equipment costs (PEC) and installation costs. Indirect costs include engineering costs, contractor fees, project contingencies and costs for administration and supervision, taxes and interest. For this analysis, the indirect costs are included in the quotes received for the scope listed in Figure 4-1.

The capital costs for the EMD and SoLoNO$_X$ Taurus 60 turbine compressor sets are provided as the difference in capital costs for a turbine driver over an EMD driver based on information provided by Solar Turbines. One of the most significant costs associated with the use of EMD is related to the additional infrastructure required to provide the site with sufficient electricity capacity to power the EMD. Specifically, at the Facility, these installation costs include:

- Upgrades to Existing Edgar Substation;
- High Voltage Transmission Line Installation;
- Right of Way Land Purchase Costs (High Voltage Transmission Line);
- Weymouth Site Substation Installation; and
- Medium Voltage Line Install at Weymouth Station.

It should be noted that supervisory labor is not included in the cost estimate, but is an additional cost related to this installation. Each one of these items is in addition to the purchase of the EMD itself. To accurately estimate the costs of each of these items, Algonquin has obtained vendor estimates. The total capital investment associated with an EMD compressor driver vs. a SoLoNO$_X$ Taurus 60 turbine compressor driver is shown in Table 4-6.

[29] According to EPA Air Pollution Control Cost Manual, Chapter 2 – SCR (June 2019), when estimating direct annual operating costs, the current price of these commodities should be used and industrial plants should use prices from their latest utility bills.

Table 4-6. Capital Cost Comparison of EMD Driver vs. SoLoNO$_X$ Taurus 60 Turbine Driver[30]

Items	EMD-Driver	SoLoNO$_X$ Taurus 60 Turbine-Driver
Baseline Station (without Compressor Driver/Infrastructure)	**$98,062,212**	**$98,062,212**
Capital Costs:		
Driver Compressor Set (Cost Differential)	--	$2,358,087
Upgrades to Existing Edgar Substation	$1,300,000	--
High Voltage Transmission Line Install	$8,500,000	--
Right-of-Way Land Purchase Costs	$619,460	--
Weymouth Site Substation Installation and Civil Work	$4,718,000	
Medium Voltage Line Install	$693,764	
Fuel Gas System Equipment and Installation	--	$408,579
Turbine Air Intake System Installation		$306,406
Turbine Exhaust System Installation		$516,075
Total Capital Investment	**$113,893,436**	**$101,651,359**
Difference in Total Capital Investment – EMD vs. SoLoNO$_X$ Turbine Options	**$12,242,077**	

As shown in the table above, a detailed cost analysis yields an estimate of the net additional cost for EMD of $12.2 million. The additional cost of $12.2 million represents the capital cost of the proposed "control technology" in this BACT analysis.

4.4.3.2 Total Annual Cost

The Total Annual Costs are defined as the expenses associated with the annual operation of the different compressor driver options and are the sum of direct annual costs and indirect annual costs.

4.4.3.2.1 Direct Annual Costs (Operating Costs)

Direct annual costs include operating and maintenance costs as well as utilities cost.

Natural gas costs associated with the SoLoNO$_X$ Taurus 60 turbine are based on the permitted annual fuel usage of the SoLoNO$_X$ Taurus 60 turbine at average annual temperature and maximum horsepower and a unit price for the fuel calculated based on the Algonquin city-gate price and the calculation set forth in Algonquin's FERC Gas Tariff, Sixth Revised Vol. 1, General Terms and Conditions (the "Tariff"), Section 25.

The natural gas necessary to fuel the Weymouth Compressor Station's turbine will come directly from Algonquin's pipeline. Algonquin receives this gas from its customers who provide their share of fuel gas by tendering Algonquin in-kind fuel, which is referred to as the fuel reimbursement quantity. Algonquin does not own the gas it transports on its system. Accordingly, when it uses gas for combustion, it incurs the cost associated with that gas. Algonquin's contracts with its Atlantic Bridge Project customers contemplate that

[30] See Appendix C for detailed cost analysis with references for each line item.

an estimated percentage of natural gas will be collected from those customers by Algonquin for fuel, including for Algonquin's compression units along its natural gas pipeline system. To determine the actual volume of gas used in relation to the amount to which it is entitled, Algonquin determines the monthly difference between: (i) the actual fuel reimbursement quantity of natural gas that Algonquin receives from its customers under their respective contracts: and (ii) the actual quantity of Company Use Gas for the month. *See* Tariff, Sections 29 and 32. "Company Use Gas" includes the amount of gas used by Algonquin for fuel, including compressor fuel. The under- or over-realization of in-kind compensation gas is recorded each Month in the volumetric fuel imbalance account. *See* Tariff, Section 32.5, Volumetric Fuel Imbalance Account. Stated simply, Algonquin determines the actual amount of gas it used for fuel, and compares this volume against the fuel reimbursement quantity it receives under its contracts. The difference between the actual amount of natural gas used for fuel and the estimated volumes of fuel, as set forth in Algonquin's contracts, is then recorded in the volumetric fuel imbalance account.

Although Algonquin does not monetize the amount in the volumetric fuel imbalance account, when Algonquin needs to convert imbalance volumes of gas into a dollar value, it does so based on the Algonquin city-gate price and the calculation set forth in Section 25.10 of the Tariff. *See*, e.g., Tariff, Section 25 Imbalance Resolution Procedures. Algonquin's Fuel Reimbursement Quantity Filing, submitted annually to FERC, includes the price, measured in dollars per dekatherm (DTH) paid or received for imbalance volumes in accordance with Section 25 of the Tariff (the "Unit Costs"). The average Unit Costs for 2019 were $ 3.04/MMBtu.[31] This average price is representative of the costs that Algonquin incurred for gas combusted throughout 2019.[32]

This price is significantly lower than the standard industrial user rate of natural gas because there are no distribution costs included. Furthermore, this cost is integral to defining the Facility. When negotiating contracts with clients, Algonquin applies a certain amount of gas to be used as fuel for compression. At the end of each month, the amount of gas used is reconciled against the contracted amount. For this analysis, Algonquin applied the average Unit Costs for 2019 to the total volume of fuel authorized in the air permit, 592.23 MMscf/year, resulting in a total annual utility cost of $1,834,373/year for the SoLoNO$_X$ Taurus 60 turbine.

To estimate the cost of electricity for the EMD, Algonquin multiplied the maximum annual electricity requirements by the average industrial rate in Massachusetts for 2019 based on EIA data ($0.1437/kW-hr). As previously described and illustrated in Table 4-1, the maximum annual electricity usage for the EMD option was derived directly from the basis for maximum annual natural gas usage by the SoLoNO$_X$ Taurus 60 turbine, to ensure that costs are compared on a comparable basis. This results in a total annual utility cost of $7,943,500/year for an EMD.

Maintenance costs are also included in the direct annual cost for each of the units. Solar Turbines provided an estimate of the additional annual maintenance costs for a gas turbine driver which are over and above the annual maintenance costs for an EMD driver of $207,403/year. This represents the cost differential between the higher cost complete maintenance contract for the SoLoNO$_X$ Taurus 60 turbine, which includes manufacturer recommended maintenance inspections, tuning and periodic overhauls, and the complete maintenance contract for the EMD's more limited maintenance requirements. In addition to this, the SoLoNO$_X$ Taurus 60 turbine would be subject to initial and ongoing compliance stack testing. An estimate for the turbine stack testing to be performed at the Weymouth Compressor Station to demonstrate initial

[31] 1 dekatherm (DTH) = 1 MMBtu

[32] The natural gas used to fuel the SoLoNO$_X$ Taurus 60 turbine will come directly from Algonquin's pipeline.

compliance of $27,500 is provided in Appendix D. Ongoing annual compliance testing costs are assumed to be equivalent to this quote, even though the full battery of initial testing is not required each year. Also, the costs associated with periodic CO catalyst change out is estimated at $93,000 per change out based on the vendor quote provided in Appendix D. This cost is annualized over an assumed catalyst life span of three years (i.e., three years at 10.137% interest), conservatively based on the 5-16 year range provided in Table 2.4 of the Incinerators and Oxidizers (November 2017) chapter in the OAQPS Cost Manual, though Enbridge's experience at other compressor stations suggests that the catalyst should last approximately 7 years before showing signs of performance degradation.

A comparison of the direct annual costs associated with an EMD compressor driver vs. a SoLoNO$_X$ Taurus 60 Turbine compressor driver is shown in Table 4-7.

Table 4-7. Direct Annual Costs Comparison of EMD Driver vs. SoLoNO$_X$ Taurus 60 Turbine Driver[33]

Items	EMD-Driver	SoLoNO$_X$ Taurus Turbine-Driver
Maintenance (Cost Differential)	--	$207,403/year
Annual Stack Testing		$27,500
Oxidation Catalyst Replacement ($93,000 every 3 years)		$37,487
Utilities – Natural Gas	--	$1,834,373/year
Utilities – Electricity	$7,943,500/year	
Total Direct Annual Operating Costs	**$7,943,500/year**	**$2,106,763/year**
Difference in Total Direct Annual Operating Costs – EMD vs. SoLoNO$_X$ Turbine Options	**$5,836,737/year**	

The additional cost of $5,836,737/year represents the direct annual cost of the proposed "control technology" in this BACT analysis.

4.4.3.2.2 Indirect Annual Costs

Indirect annual costs are independent of the level of production (i.e., they are "fixed" costs) and include such categories as administrative charges, property taxes, insurance, administrative charges including permitting costs and capital cost amortized into capital recovery. Indirect annual costs of property taxes, insurance and the administration costs associated with the operation of each option do not vary significantly between the options, so these costs were not included in the economic evaluation.

Indirect annual costs also include annualized capital costs. To annualize capital costs, an interest rate and project life must be estimated to determine the Capital Recovery Factor (CRF), which is used to convert the total capital cost estimate into equivalent annualized costs. When the CRF is multiplied by the capital investment, the product is the uniform end-of-year payment necessary to repay the investment in a defined amount of years. The CRF can be calculated based upon the following equation:

$$CRF = [i * (1+i)^n] / [(1+i)^n - 1]$$

Where: i = interest rate; and

[33] See Appendix C for detailed cost analysis with references for each line item.

n = number of years of the investment.

A 10.137% nominal interest rate has been selected for this evaluation as it represents Algonquin's current after-tax real rate of return, as calculated using Algonquin's 2019 FERC Financial Report Form No.2. This aligns with the basis for interest rates as recommended in the OAQPS Cost Control Manual.[34] The investment life, n, has been conservatively assumed equal to a fifty-year payback period. Typically, in a control device analysis, a payback period on the order of 20 years is assumed. The capital recovery factor is applied to the total additional cost of EMD as determined in Table 4-6 above and results in an estimated annual capital recovery of $1,250,993/year on the total additional capital investment for EMD of $12,242,077.

4.4.3.2.3 Total Annual Cost of EMD Driver

Total annual costs are then calculated by summing together the direct annual cost of replacing the proposed SoLoNO$_X$ Taurus 60 turbine with an EMD (derived in Table 4-7) and the annual capital recovery on the total capital investment (derived in Table 4-6) to determine a single annualized cost estimate as shown in Table 4-8 below.

Table 4-8. Additional Annual Cost of EMD Driver

Item	Annual Cost ($/year)
Annual Recovery on Additional Capital Investment for EMD	$1,250,993
Annual Additional Operating Costs for EMD	$5,836,737
Annual Cost of Control	**$7,087,730**

4.4.3.3 Cost Effectiveness Determination

4.4.3.3.1 Baseline Emissions

In addition to cost, the economic feasibility of a control option depends on the amount of pollutant removed. This component of the equation is directly related to baseline emissions selection. The NSR Workshop Manual incorporated by reference in the MassDEP BACT Guidance notes that the selection of the proper "baseline emissions rate" for use in evaluating the average cost effectiveness of control technologies is an estimate of the realistic upper-bound case scenario for a specific project. The NSR Workshop Manual is clear that the baseline emissions rate is not derived based on an absolute worst-case operation but should consider inherent physical or operational constraints on the specific source.

Specifically, the EPA states that the baseline emissions rate "*represents a realistic scenario of upper boundary uncontrolled emissions for the source.*" NSR Workshop Manual at B.37. EPA then provides two caveats to using "uncontrolled emissions" as the baseline emission rate. The first caveat allows a permitting authority to assume that the baseline emissions rate is equal to the emissions from an inherently lower polluting process when evaluating the cost effectiveness of an add-on control. *See id.* The second caveat is broader and allows the baseline emissions rate to be calculated based on realistic considerations. In particular:

> *Estimating realistic upper-bound case scenario[s] does not mean that the source operates in an absolute worst-case manner all the time. For example, in developing a*

[34] *EPA Air Pollution Control Cost Manual, Chapter 2,* Nov. 2017, pg 15.

> *realistic upper boundary case, baseline emissions calculations can also consider inherent physical or operational constraints on the source. Such constraints should accurately reflect the true upper boundary of the source's ability to operate and the applicant should submit documentation to verify these constraints. . . . If the assumptions have a deciding role in the BACT determination, the reviewing agency should include enforceable conditions in the permit to assure that the upper bound assumptions are not exceeded.*

NSR Workshop Manual at B.37–B.38.

On appeal, the First Circuit concluded that when evaluating the cost-effectiveness of a post-process emissions control, the baseline emissions rate may take into account the inherently lower polluting SoLoNO$_X$ process. *See Weymouth*, 961 F.3d at 48, *quoting* NSR Workshop Manual at B.37. This is consistent with the first caveat from the NSR Workshop Manual because SoLoNO$_X$ is not an add-on control device.

But the First Circuit also suggested that when evaluating the cost-effectiveness of an alternative process emission control (like EMD), the baseline emission rate may not take into account the inherently lower polluting aspects of SoLoNO$_X$. *See id.* at 45, n.8. The court's suggestion is, however, inconsistent with the NSR Workshop Manual's approach to determining realistic upper boundary emissions for two reasons.

First, as set forth in the NSR Workshop Manual quote above, the baseline emission rate is calculated for "the source." Here, "the source" proposed for the project is a lean, premix combustion turbine (i.e., the SoLoNO$_X$ turbine). "The source" is not an outdated technology diffusion flame combustion turbine. Baseline emissions must be calculated using "the source" under review, not a hypothetical source not proposed for installation.

Second, also as set forth in the quote above, upper boundary emissions for baseline emission rate purposes may be limited as long as the reviewing agency includes enforceable conditions in the permit. Algonquin has proposed and MassDEP has approved just the kinds of enforceable permit conditions that the NSR Workshop Manual says limit the facility's upper boundary emissions. Specifically, MassDEP has approved the installation of a Solar Taurus 60 gas turbine at the Facility using SoLoNO$_X$ technology. SoLoNO$_X$ is a type of combustion chamber design that is integral to the design of the entire turbine. In other words, the approved SoLoNO$_X$ Taurus 60 turbine—the only emission unit authorized to be installed—has an inherent physical constraint that limits the facility's upper boundary emissions. In addition, Algonquin has proposed, and MassDEP previously included, enforceable conditions in the NMCPA that limit emissions of NO$_X$ during normal operations to 9 parts per million. Taken together, these enforceable permit conditions limit the realistic worst-case emissions from the Facility and constitute the baseline emissions rate for the Facility.[35]

In summary, MassDEP does not require the use of "unrealistic" assumptions when calculating the baseline emissions rate. In this case, it would be unrealistic to assume that Algonquin would install a turbine type and design inconsistent with the project scope, or an outdated combustor design for this application that is no longer offered for sale in the United States, or that any installed turbine would be operated in excess of permit limits.

In this case, the administrative record and Algonquin's permit show realistic baseline emissions rates for the proposed SoLoNO$_X$ Taurus 60 as presented in the following table.

[35] Indeed, MassDEP would almost certainly *not* authorize the construction of an outdated natural gas turbine at a compressor station that had uncontrolled emissions significantly higher than the SoLoNO$_X$ Taurus 60 turbine. The Agawam and Hopkinton plan approvals, *see* App. A and B, respectively, require the installation of modern gas turbines.

Table 4-9. Baseline Emissions

Pollutant	PTE (tpy)
NO_X	10.03
CO	17.28
VOC	2.64
$PM_{10/2.5}$	1.99
SO_2	4.23

The annual emissions shown above are based on the maximum operation of normal operations at 100% load, 62 hours per year of startup, 59 hours per year of shutdown, and 12 hours per year of cold temperatures (less than 0°F but greater than -20°F).[36] A detailed description of the emissions calculation methodology was included in the original NMCPA application.

According to 310 CMR 7.02(1)(d), the requirements for plan approval under 310 CMR 7.02 are applicable to greenhouse gases only if construction of a facility or emission units results in potential emissions of equal to or greater than 75,000 tpy CO_2e. The potential emissions for the Facility are estimated to be 52,090 tpy CO_2e. Therefore, BACT for CO_2e is not addressed in this addendum.

4.4.3.3.2 Average Cost Effectiveness

Average cost effectiveness is calculated as the total annualized cost of the control divided by the annual emissions reductions, or the difference between the baseline emission rate and the controlled emission rate. The following formula is used to calculate average cost effectiveness:

$$Average\ Cost\ Effectiveness\ \left(\frac{\$}{ton}\right) = \frac{Control\ Option\ Annualized\ Cost}{Baseline\ Emission\ Rate - Control\ Option\ Emission\ Rate}$$

Since the emissions difference is defined as the difference from the baseline emission rate, it follows that control option annualized cost should also be the difference between the baseline option cost and the control option cost. In this case, the equation can be more clearly written as follows:

$$Average\ Cost\ Effectiveness\ \left(\frac{\$}{ton}\right) = \frac{EMD\ \text{Facility}\ Cost - \ 9\ ppm\ Solar\ Taurus\ 60\ \text{Facility}\ Cost}{9\ ppm\ Solar\ Taurus\ 60\ Emission\ Rate - EMD\ Emission\ Rate}$$

In this case, the EMD Emission Rate is zero for all pollutants.

[36] A project-specific review of historical meteorological conditions informed the annual representation of emissions, and thus further justifies the approach as a "realistic upper bound".

Table 4-10. Average Cost Effectiveness by Pollutant

Pollutant	Cost per Ton of Pollutant Removed ($)
NO_X	$706,653
CO	$410,170
VOC	$2,684,746
$PM_{10/2.5}$	$3,561,673
SO_2	$1,675,586

As shown in Table 4-10, the cost effectiveness of EMD at the Facility is far beyond what MassDEP considers economically feasible (defined in MassDEP's BACT Guidance as between $11,000 and $13,000 for NO_X and VOC and $4,000 to $6,000 for SO_2, CO, and $PM_{10/2.5}$).

In a 1997 letter, EPA Region 4 suggested that for a control device that effects reductions in multiple pollutants, the total amount of pollution reduced should be included in the cost effectiveness analyses.[37] Table 4-11 shows that the multipollutant cost effectiveness of EMD at the Facility is also well above what MassDEP considers economically feasible.

Table 4-11. Multipollutant Cost Effectiveness

Pollutant	Additional Annual Cost for EMD	Pollutants Removed (tpy)	Cost per Ton of Pollutant Removed ($)
Total	$7,087,730	36.17	$195,956

These results establish that EMD is cost prohibitive.

4.4.3.3.3 Alternative Baseline Emissions

As an alternative, Algonquin evaluated other emissions information for lean premix technology to determine a higher-emitting upper bound for this type of turbine design. For this alternative baseline analysis, Algonquin references the lean premix emission rates in the EPA's AP-42: Compilation of Air Emissions Factors, Chapter 3.1, Stationary Gas Turbines which were published in 2000. Specifically, for NO_X, the lean premix emission rate is 9.9×10^{-2} lbs/MMBTU, which is approximately 25 ppm NO_X for the proposed unit.[38]

While the NSPS KKKK NO_X emission limit for this turbine is 25 ppm, the AP-42 emission rate (published in 2000) is independent from and predates the NSPS limit (71 FR 38497, July 6, 2006). A review of the NSPS KKKK docket suggests that this limit was set to the level achievable by modern lean premix gas combustion turbines. As such, the proposed alternative baseline emissions are not limited by the NSPS, but rather, the NSPS was established at the rate that was achieved by uncontrolled lean premix turbines at its time of promulgation.

[37] Envtl. Prot. Agency, Calculation of Cost Effectiveness of Emission Control Systems (Mar. 24, 1997).

[38] AP-42, Section 3.1: Stationary Gas Turbines, Table 3.1-1.

To ensure conservatism, Algonquin has applied cost effectiveness calculations assuming that Solar's recent advancements of SoLoNO$_X$ are not taken into account, and the generic and "uncontrolled" capability of lean premix units is applied at approximately 25 ppm NO$_X$.

This is also consistent with a technical deficiency letter issued by the MassDEP on July 24, 2018 related to the permitting of a Mars 100 natural gas-fired turbine for the Hopkinton LNG Plant, in which the Department asked for the following,

> *Explanation of whether the proposed SoLoNO$_X$ combustors for the proposed BACT emissions of nitrogen oxides is an add-on optional feature or an integral part of the turbine. If it is an add-on optional feature, then you will need to recalculate the cost-effectiveness of selective catalytic reduction (SCR) for nitrogen oxides (NO$_X$), based on a starting point of 25 parts per million (ppm) of NO$_X$ being reduced to the level of control achievable by a combination of SoLoNO$_X$ burners and SCR.*

This confirms MassDEP already had an understanding that 25 ppm is an "uncontrolled" emissions level generally achieved by lean premix turbines available on the market today as indicated by the AP-42 factor.

Algonquin conservatively calculates the alternative baseline emissions in the following manner. Emissions from normal steady-state operation were calculated using AP-42, Chapter 3.1 NO$_X$ and CO emission rates (in lbs/MMBTU) for a lean premix turbine along with the maximum annual permitted fuel use for the SoLoNO$_X$ Taurus 60 turbine (592.23 MMscf/yr). In addition, baseline emissions were based on AP-42, Chapter 3.1 emission rates for VOC, PM and SO_2. These values represent continuous operation at steady state for the turbine.

However, since AP-42 emission factors only consider steady-state operation, Algonquin has accounted for startup and shutdown (SU/SD) and low temperature (less than 0 °F but greater than -20°F) operation for the alternative baseline turbine by adding the same SU/SD and low temperature emissions permitted for the SoLoNO$_X$ Taurus 60 turbine. This is an appropriate assumption for the baseline turbine since the SoLoNO$_X$ Taurus 60 turbine's emission characteristics during SU/SD and low temperature operation will be similar to the SU/SD and low temperature emissions from the lean premix unit represented in AP-42. It should be noted that the calculation for shutdowns in this alternative baseline do not assume the same control efficiency for CO as the SoLoNO$_X$ Taurus 60. This is because the SoLoNO$_X$ Taurus 60 turbine would be equipped with an oxidation catalyst that is presumed to be effective during shutdowns based on the expected temperature of exhaust during shutdown. The alternative baseline proposed here assumes no oxidation catalyst.

This is a conservative calculation of the annual emissions because it represents a total of 8,760 hr/yr of normal operation and then adds the SU/SD and low temperature emissions to this total (in reality, each hour of start-up, shut-down, and low temperature operation will replace an hour of steady state operation and its emissions). Based on this approach, the approximate "*realistic scenario of upper boundary uncontrolled emissions for the source*" has been determined.

The alternative baseline annual emission rates for a natural gas turbine are shown in the table below.

Table 4-12. Alternative Baseline Emissions

Pollutant	PTE (tpy)
NO_X	30.32
CO	37.42
VOC	2.79
$PM_{10/2.5}$	2.01
SO_2	4.26

As indicated above, the annual alternative baseline emissions shown above are based on 8,760 hours operation at 100% load, plus 62 hours per year of startup, 59 hours per year of shutdown, and 12 hours per year of cold temperatures (less than 0 °F but greater than -20°F) at the same rates used for the SoLoNO$_X$ turbine. Detailed emission calculations are provided in Appendix C.

4.4.3.3.4 Cost Effectiveness Results for Alternative Baseline

As shown in the following tables, the cost effectiveness of EMD using the alternative baseline is still beyond what MassDEP considers economically feasible. The cost of the alternative baseline turbine used to calculate the $/ton values shown in Tables 4-13 and 4-14 is assumed to be the same as that developed for the SoLoNO$_X$ Taurus 60 turbine, which is a conservative assumption.

Table 4-13. Average Cost Effectiveness by Pollutant – Alterative Baseline Basis

Pollutant	Cost per Ton of Pollutant Removed ($)
NO_X	$233,758
CO	$189,396
VOC	$2,536,424
$PM_{10/2.5}$	$3,531,071
SO_2	$1,663,519

Table 4-14. Multipollutant Cost Effectiveness - Alternative Baseline

Pollutant	Additional Annual Cost for EMD	Pollutants Removed (tpy)	Cost per Ton of Pollutant Removed ($)
Total	$7,087,730	76.81	$92,281

4.4.3.3.5 Cost Effectiveness Sensitivity Analysis

To illustrate the extent to which EMD is not economically feasible at the Facility, Algonquin considered a sensitivity analysis to determine the baseline emissions that would be required to reach the maximum cost effectiveness thresholds of $13,000 per ton ($NO_X$ and VOC) and $6,000 per ton (CO, SO_2, and $PM_{10/2.5}$).

The following figures show the cost effectiveness trend along with the proposed baseline emissions cost effectiveness and alternative baseline emissions cost effectiveness. As can be seen, the total emissions reduction (i.e., the baseline emissions level when considering EMD as BACT) would have to exceed 545 tpy to reach the minimum cost effectiveness threshold of $13,000 per ton and 1,181 tpy to reach the minimum economic effectiveness threshold of $6,000 per ton.

This demonstrates that even when considering the co-benefits from other pollutant reductions, the use of EMD at the Facility is not economically feasible. There is no reasonable basis for concluding that the appropriate baseline emissions level for calculating average cost effectiveness here would exceed 545 tpy. Furthermore, even if the appropriate baseline for calculating average cost effectiveness exceeded 545 tpy, that would indicate that an additional incremental-cost-effectiveness analysis, rather than an average-cost-effectiveness analysis, would be useful here to assess the cost-effectiveness of EMD. MassDEP's BACT guidance provides that "*[i]ncremental control cost differences can be used*" when "*comparing two control techniques or technologies with very similar levels of reduction for the same air contaminant*." If the applicable NO_X baseline exceeded 545 tpy, the over 98% level of reduction achieved by SoLoNO$_X$ (i.e., reduction to 10.03 tpy of NO_X) would be "very similar" to EMD's 100% level of reduction. Under those circumstances, an incremental cost analysis would be appropriate, and the results of that incremental analysis would be the same as the cost-effectiveness analysis presented in Section 4.4.3.3.2. *See* NSR Workshop Manual at B.41 (formula for calculating incremental cost effectiveness); *cf. In re Genesee Power Station Ltd. P'ship*, 1993 WL 484880 at *10 & nn. 13, 15 (Envtl. App. Bd. 1993) (analyzing "*incremental cost*," and concluding that it would not "*be reasonably cost effective to require the permittee to spend an additional $5 million to reduce particulate emissions by 23 tons per year*").

Based on the information provided under Step 4 of the BACT analysis, Algonquin respectfully requests that MassDEP determine that EMD is not BACT for the Facility's SoLoNO$_X$ Taurus 60 turbine.

Figure 4-2. Average Cost Analysis Sensitivity

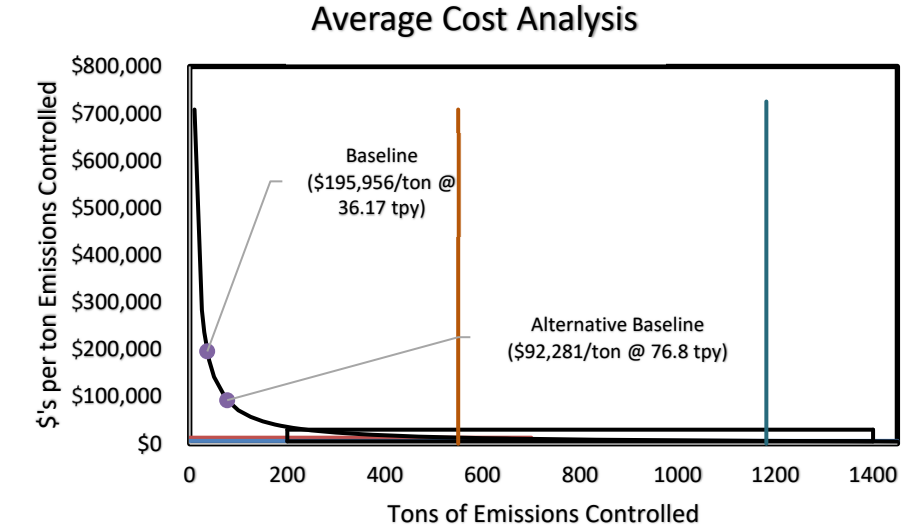
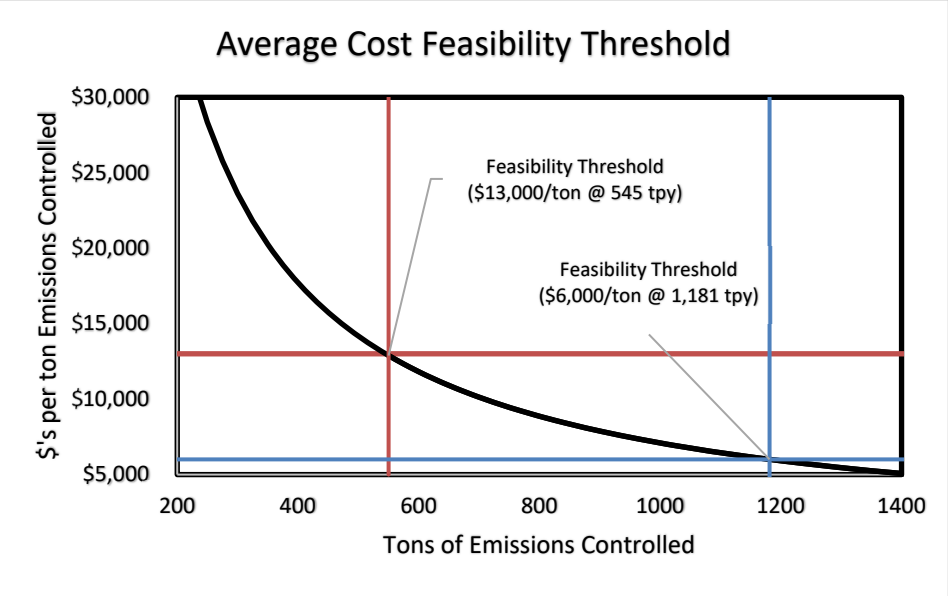


Figure 4-3. Up-Close Average Cost Feasibility Threshold Sensitivity



APPENDIX A. AGAWAM PLAN APPROVAL

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Western Regional Office • 436 Dwight Street, Springfield MA 01103 • 413-784-1100

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

January 24, 2020

Mr. Thomas W. Burgett
Tennessee Gas Pipeline Company, LLC
8 Anngina Drive
Enfield, CT 06082

RE: **Agawam**
ePlace Authorization #: AQ02F-0000049
Application #:17-AQ02/03F-000007-APP
Approval #: WE-17-021
Class: OP
FMF No.: 133246
AIR QUALITY PLAN APPROVAL

Dear Mr. Burgett:

The Massachusetts Department of Environmental Protection ("MassDEP"), Bureau of Air and Waste, has reviewed your Non-major Comprehensive Plan Application ("Application") listed above. This Application concerns the proposed construction and operation of a new natural gas-fired combustion turbine at your existing compressor station located at 1615 Suffield Street in Agawam, Massachusetts ("Facility"). The Application bears the seal and signature of John Woodhull, Massachusetts Registered Professional Engineer Number 39884. The MassDEP Form BWP AQ Sound form bears the seal and signature of Cole Pavlina, Temporary Massachusetts Registered Professional Engineer Number 506.

This Application was submitted in accordance with 310 CMR 7.02 Plan Approval and Emission Limitations as contained in 310 CMR 7.00 "Air Pollution Control" regulations adopted by MassDEP pursuant to the authority granted by Massachusetts General Laws, Chapter 111, Section 142 A-O, Chapter 21C, Section 4 and 6, and Chapter 21E, Section 6. MassDEP's review of your Application has been limited to air pollution control regulation compliance and does not relieve you of the obligation to comply with any other regulatory requirements.

A Notice of Public Comment of the proposed Non-major Comprehensive Plan Approval was voluntarily published by MassDEP on the MassDEP's website on December 20, 2019. As such, the 30-day public comment period ended on January 20, 2020. During the public comment period, no comments were received.

MassDEP has determined that the Application is administratively and technically complete and that the Application is in conformance with the Air Pollution Control regulations and current air

pollution control engineering practice, and hereby grants this **Plan Approval** for said Application, as submitted, subject to the conditions listed below.

Please review the entire Plan Approval, as it stipulates the conditions with which the Facility owner/operator ("Permittee") must comply in order for the Facility to be operated in compliance with this Plan Approval.

1. DESCRIPTION OF FACILITY AND APPLICATION

A. FACILITY DESCRIPTION

Tennessee Gas Pipeline Co., LLC (TGP) owns and operates an existing Compressor Station (CS) 261 located at 1615 Suffield Street in Agawam, Massachusetts. CS 261 is a natural gas transmission facility serving pipeline natural gas markets in the Northeast Region. The Facility is tasked with ensuring the proper operating pressure and transmission of natural gas along the pipeline route. The Facility is staffed for a single eight-hour daytime shift but it operates 24 hours per day. Operation of the Facility is continuously, remotely monitored and controlled 24 hours per day from a control facility in Texas.

The Facility does not produce any goods but has contracts with natural gas production companies (producers) specifying that the TGP pipeline will be available 8,760 hours per year to transfer natural gas to local distribution systems (LDCs) and electrical utilities for power generation. The LDCs then provide gas to residential, commercial, and industrial infrastructure. The schedule of operation and the amount of natural gas compression at any time is based on demand.

The natural gas that is in TGP's pipeline has already been treated and/or processed to remove impurities prior to its custody transfer into the TGP pipeline system. The Facility also uses the natural gas that is currently transported on TGP's pipeline as fuel in the Facility's combustion units. This same natural gas is transferred through TGP's pipeline system and ultimately consumed by public and private infrastructure, including homes, businesses, government offices, and schools, among other end-users.

B. HISTORY

The Facility was originally constructed in 1960. The Facility is currently equipped with four natural gas-fired combustion turbines. Each turbine drives a compressor. All of the combustion turbines at the Facility operate in a simple cycle (no heat recovery) configuration compressing the natural gas and then discharging it to the transmission pipeline at the required operating pressure. The turbines have the ability to operate simultaneously, independent of each other or not at all depending on the natural gas demand. The existing turbines consist of:

Emission Unit #1 – a 54.8 million Btu per hour Solar Centaur H turbine, constructed 1991
Emission Unit #2 – a 16.46 million Btu per hour Solar T-1001 turbine, constructed 1965
Emission Unit #3 – a 51.4 million Btu per hour Solar Centaur T-4500 turbine replaced an identical Solar Centaur T-4500 turbine on January 6, 1996

Emission Unit #4 - a 59.84 million Btu per hour Solar Centaur 50 turbine, constructed 2000

Other air contaminant sources at the Facility include Emission Unit #5- a 2.2 million Btu per hour, 201 brake-horsepower, natural gas-fired Waukesha C10263 emergency stationary reciprocating internal combustion engine (RICE), Emission Unit #6 - a 0.5 million Btu per hour #2 fuel oil-fired Waukesha 135DKU emergency stationary RICE and other exempt activities as defined in 310 CMR 7.00: Appendix C.

C. PROJECT DESCRIPTION

The proposed plan approval is for the construction and operation of a new Solar Taurus 70-10802S, or equivalent, natural gas-fired lean-burn pre-mix simple cycle combustion turbine with a maximum heat input rate of 94.5 million Btu per hour at 0 degrees Fahrenheit (°F) and a maximum output of 11,997 horsepower at 0°F , an associated centrifugal compressor and additional ancillary piping components which increase the potential for fugitive leaks of natural gas at the Facility. For purposes of this project, all heat input rates utilized by this approval are representative of the higher heating value. The proposed combustion turbine and associated centrifugal compressor will be used for pipeline natural gas compression.

As part of the project, the two oldest turbines, which are Emission Unit #1 and Emission Unit #2, and an emergency RICE, which is Emission Unit #5, will be removed from the Facility. The new combustion turbine will be constructed in the place of the existing Emission Unit #1 and will be housed within an existing enclosed building. Emission Unit #5 will be replaced with a new 755 brake-horsepower, natural gas-fired, 4-stroke, lean burn Caterpillar emergency stationary RICE.

The proposed combustion turbine, also called a gas turbine, is an internal combustion engine that operates with rotary motion. The gas turbine consists of three major components which are the compressor, combustor and the power turbine. The combustion process of the turbine begins by drawing ambient air into the compressor section where it is compressed to the appropriate pressure and then directed to the combustor section where the fuel, which is natural gas from the pipeline, is introduced, ignited and burned. Since this turbine has a lean-burn (meaning a lower fuel-to-air ratio), pre-mix combustor, also known as SoLoNOx combustion technology, the fuel and air are thoroughly mixed in an initial stage resulting in a uniform, lean, unburned air/fuel mixture which is delivered to a secondary stage where the combustion reaction takes place. The combustion process results in a hot gas mixture of air and combustion products which expand in the power turbine section. The expansion of the hot gas mixture creates the force that drives the turbine and rotates the engine shaft which is coupled to a centrifugal compressor. When pipeline pressure lowers due to downstream customer use or ambient temperature variation, the Facility can direct gas from the pipeline into the centrifugal compressor. The combustion turbine driven centrifugal compressor draws in the low pressure natural gas, raises the pressure of the natural gas and discharges the higher pressure natural gas into the pipeline.

The worst case potential to emit from the combustion turbine was determined by comparing two operating scenarios. The first scenario determined the emissions from the combustion turbine operating 8,760 hours per year at an annual average ambient temperature of 48 °F with an annual average heat input rate of 91.02 million Btu per hour. The second scenario, also called the composite scenario, conservatively determined the emissions from the combustion turbine during normal operations for 8,510 hours per year at an annual average ambient temperature of 48 °F with an annual average heat input rate of 91.02 million Btu per hour, 200 hours per year of operation at ambient temperatures less than 0°F and greater than or equal to -10°F (based on review of historical meteorological data from Bradley International Airport from 1940s to present including a safety factor of two times) with a maximum heat input rate of 95.76 million Btu per hour (@ -10°F) and a maximum of 50 hours per year of startup and shutdown with 150 startup/shutdown cycles (1 cycle = 20 minutes of startup/shutdown) per year. The composite scenario was the worst case operating scenario for annual emissions as shown in 'Table 2-1 Solar Taurus 70 Potential Annual Emissions Summary' of the Emissions Calculations section of the application. The worst case composite scenario for annual emissions from the combustion turbine is also shown in Table 1 below.

In order to make the composite scenario potential to emit enforceable, the Facility has proposed an annual fuel usage restriction of 776.241 million standard cubic feet per 12 consecutive month period for the combustion turbine. This annual fuel usage restriction corresponds to the combined fuel usage from 8,510 hours per year of normal operation at an annual average heat input rate of 91.02 million Btu per hour, 200 hours per year of operation at ambient temperatures below 0° F and greater than or equal to -10°F and 150 startup and shutdown cycles per year.

The new piping components or fugitive emission components, such as valves, connectors, flanges, etc., that are associated with this project will have the potential for fugitive natural gas leaks. The Facility estimated volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions from the fugitive gas leaks using an operating schedule of 8760 hours per year, an estimated count of the new piping components, the weight percent of the desired emission from the natural gas analysis and the emission factors (in units of pounds/hour/source) from Table 2-4 for Oil and Gas Production Operations found in the United States Environmental Protection Agency (USEPA) document # EPA-453/R-95-017 entitled "*Protocol for Equipment Leak Emission Estimates*." The resultant emissions are contained in Table 1 below.

The project will also vent natural gas to atmosphere as part of normal operations necessary to relieve pressure in the system. Natural gas will be vented to atmosphere from the following processes/equipment:

- Compressor case venting- Compressor case venting will occur to relieve pressure on the compressor dry gas seal while the turbine is not operating, except in the event of 14-day pressurized holds.

- Compressor dry gas seals- The dry gas seals are the equipment on the centrifugal shaft of the compressor which limit the high pressure natural gas from escaping the compressor. Natural gas is used as a seal gas so there will be some emission of natural gas through the primary and secondary dry gas seals which will be vented through the primary and secondary vents on the compressor. The dry gas seal leakage flow rate is a function of the compressor suction pressure. Therefore, as the pressure increases, the leakage flow rate will also increase.

- Valve operator venting -Valve operators are gas-actuated valves which release natural gas when the turbine is turned on or off during startup and shutdown.

- Purging- Purging of gas occurs when the turbine is opened to the atmosphere for maintenance checks or activities. Prior to placing the turbine back in operation, some natural gas will be vented to atmosphere as air is purged from the system.

Based on gas chromatography results, the VOC content of the natural gas transported by TGP is expected to be less than 1% by weight. The natural gas representative gas analysis provided with the application shows the VOC and HAP content of natural gas to be 0.5138% by weight and 0.0075% by weight, respectively. The resultant emissions from venting are included in the project emissions summarized in Table 1 below.

Table 1
Project Potential Annual Emissions (Tons Per Year)

Pollutant	Solar Taurus 70 Combustion Turbine	Piping Component Fugitives	Vented Emissions	Emergency Engine	Project Annual Emissions
NOx	14.14	-	-	0.5	14.64
CO	3.99	-	-	1.00	4.99
VOC	2.14	0.04	0.99	0.25	3.41
PM[1]	2.63	-	-	0.008	2.64
PM_{10}[2]	2.63	-	-	0.008	2.64
$PM_{2.5}$[3]	2.63	-	-	0.008	2.64
SO_2	5.59	-	-	0.011	5.60
Total HAPs	0.21	0.001	0.014	0.059	0.28

[1] PM consists of all filterable and condensable PM including PM_{10} and $PM_{2.5}$.
[2] PM_{10} consists of filterable and condensable PM with an aerodynamic diameter equal to or less than 10 microns.
[3] $PM_{2.5}$ consists of filterable and condensable PM with an aerodynamic diameter equal to or less than 2.5 microns.
NOx = Nitrogen oxides
CO = carbon monoxide
VOC = volatile organic compound
PM = total particulate matter
SO_2 = sulfur dioxide
HAP = hazardous air pollutant

As discussed above, the combustion turbine will be equipped with SoLoNOx combustion technology which ensures a uniform air/fuel mixture to minimize the emissions of NOx, CO, VOCs and HAPs. The SoLoNOx combustion technology will be capable of operating at ambient temperatures greater than or equal to 0 ° F and at operating loads of 50% or greater. Since the startup and shutdown of the combustion turbine occur at operating loads less than 50%, the SoLoNOx will not be active during startup and shutdown. In addition, the combustion turbine will be equipped with an add-on control device, or post-combustion technology, which is an Advanced Catalyst Systems, Model: ADVOCAT, or equivalent, oxidation catalyst for the control of CO, VOCs and HAPs. The oxidation catalyst will be capable of controlling CO, VOC and HAP emissions at all ambient temperatures and during operating loads of 50% or greater. During shutdown, but not startup, the oxidation catalyst will still be active as the catalyst block will remain heated since it is exposed to hot exhaust gases. It is the Facility's operating policy and Solar's recommendation to not run the combustion turbine at less than 50% load except during a very short time during startup and shutdown, as it would be potentially damaging to the turbine to operate otherwise.

The exhaust gases from the combustion turbine will be vented through a 60 inch diameter stack, the top of which is at least 30.5 feet above the roof and at least 62.5 feet above the ground. The stack gas exhaust flow rate will be between 119,228 and 132,850 cubic feet per minute.

D. Project Alternatives

The Facility investigated three possible alternatives to the proposed natural gas-fired combustion turbine, also referred to by TGP as the "HP Replacement Project", to provide both additional natural gas transportation capacity and improved reliability to the Projects' shippers. The three possible alternatives were: a pipeline looping option; rewheeling the existing compressor units; and an electric drive option for the compressor turbine. The following options were discussed in Section 3.3.3 of the Draft Environmental Impact Report (DEIR) – 261 Upgrade Projects, dated December 14, 2018, and have been included below, in their entirety, as part of the review for this plan approval application.

Pipeline Looping Option

In lieu of the HP Replacement Project, an extension of the proposed Looping Project was considered as an option to add additional natural gas transportation capacity to TGP's system. TGP determined that to avoid the need for the HP Replacement Project, it would need to extend the proposed 2.1 miles of 12-inch-diameter loop by an additional 2.1 miles and add 5.0 miles of 36-inch mainline loop. The 5.0 miles of 36-inch mainline loop and the additional 2.1 miles of Line 261B pipeline loop required for the Looping Only option would have significant environmental and landowner impacts compared to the proposed HP Replacement Project, which is sited entirely within TGP's existing CS 261 Facility. These impacts would include 2.8 miles of new pipeline loop within the Sandisfield State Forest and Otis State Forest. Furthermore, the addition of a longer pipeline loop and mainline loop would not solve the reliability issue related

to the existing older compressor engines or achieve the emissions and noise reductions associated with the HP Replacement Project. For these reasons, the Looping Only option was not deemed to be a viable alternative to the HP Replacement Project and was not further considered.

Rewheel Compressors

Rewheeling is a process that can be used on compressor units to accommodate different process conditions (e.g., increase the flow or pressure) within certain design and performance limits. However, the age of the existing Saturn and Centaur (EU #1 and EU #2) compressor units at CS 261 limits the engineering options to meet the design conditions needed to provide the additional natural gas capacity requested by the Projects' shippers. Further, the reliability issues related to the use of these existing older compressor engines would remain. Rewheeling the older units would also not result in the emissions and noise reductions anticipated with replacement by the new unit. For these reasons, rewheeling the existing compressors was not deemed to be a viable alternative to the HP Replacement Project and was not further considered.

Electric Driver Option

TGP evaluated the use of electric motor-driven compression as opposed to the proposed natural gas turbine driven compressor unit. After this evaluation, TGP determined that it would replace two existing natural gas turbine driven compressor units with one natural gas turbine compressor unit at CS 261 for the reasons provided below:

- Although electric driven compression would eliminate certain stationary source emissions at CS 261, these emissions would simply be transferred to electric generation facilities in the area, the majority of which utilize natural gas. An even worse emissions scenario occurs if an electric motor driven compressor consumed electricity from the marginal electric supplier using coal, oil, refuse, or wood fired generation. In New England, these sources accounted for 8.4 percent of the generation fuel in 2017 and 11.3 percent through the first four months of 2018 (ISO-NE 2018a).

- While reliability of the local electric transmission lines is good, electric supply is still vulnerable and not as reliable as using natural gas for fuel. The supply of electricity for electric motor driven compression is subject to power line outages (such as during storm events including ice) or black or brown-outs due to power plant outages or general lack of generating capacity. Continued retirement of nuclear, coal, and oil-fired capacity in New England is expected to further constrain electricity supply (i.e., closure of Vermont Yankee, Brayton Point, and Pilgrim) (U.S. NRC 2017; Finucane 2017; Abel and Ellement 2016). Peak natural gas usage (and thereby also compression use) and peak electricity usage occur simultaneously for this region during cold winter weather, further increasing the chances of loss of electric power exactly when the compression is most needed.

- Mechanical problems with an electric motor drive can be much more complex and result in extended downtime while the motor is repaired or replaced.

- Electric driven compression would necessitate the construction of a new building, electric substation, and ancillary equipment within TGP's existing CS 261 site. Given the existing facilities on the site, the only location where these facilities could be located would be in the southwest portion of the site, which has a large wetland system associated with Worthington Brook. This work would require a substantial amount of wetland fill, likely requiring substantial approvals pursuant to the Wetlands Protection Act. In contrast, TGP's proposed HP Replacement Project will not require construction beyond the existing developed portion of the site, and only minimal (0.03 acres), temporary wetland disturbance during construction. Siting electric driven compression and associated facilities on an adjacent site (e.g., the Hickory Street Pipeyard property) would require extensive permanent tree clearing within forested wetlands and uplands to route the necessary power lines to the site.

- Significantly higher capital cost to customers would be incurred from installing an electric drive compressor unit ($43.6 million ["MM"]) as compared to the proposed natural gas driven Taurus turbine ($22.9 MM). Fuel costs for electric driven compression are significantly higher compared to natural gas. Over 20 years, TGP estimates the additional fuel cost would amount to approximately $84 MM in additional costs for Massachusetts consumers.

For these reasons, electric driven compression was not deemed to be a viable alternative to the HP Replacement Project and was not further considered.

The above findings in the DEIR were accepted on April 5, 2019 by the former Secretary for the Executive Office of Energy and Environmental Affairs, Matthew A. Beaton. Subsequently, the current Secretary for the Executive Office of Energy and Environmental Affairs, Kathleen A. Theoharides, accepted the results of the Final Environmental Impact Report (FEIR) in her certificate dated August 2, 2019. MassDEP also agrees with the findings of TGP's project alternatives analysis for the proposed natural gas-fired combustion turbine. In addition, the accepted FEIR included Section 61 findings pursuant to the Global Warming Solutions Act of 2008. The Section 61 findings are discussed in further detail in Section 6. and Appendix A herein.

E. REGULATORY REQUIREMENTS

The applicable air pollution control regulatory requirements include demonstration by TGP of compliance with:

- **MassDEP Plan Approval Requirements – 310 CMR 7.02**
- **Other State Regulatory Requirements – 310 CMR 7.00**
- **The Emission Offsets and Nonattainment Review - 310 CMR 7.00: Appendix A**
- **Operating Permit and Compliance Program -310 CMR 7.00: Appendix C**
- **National Ambient Air Quality Standards (NAAQS)**
- **New Source Performance Standards (NSPS)**

Other federal air pollution control regulations that are not triggered by the Facility are: the Prevention of Significant Deterioration (PSD), 40 CFR Section 52.21; the National Emission Standards for Hazardous Air Pollutants (NESHAP) and the requirements of Compliance Assurance Monitoring (CAM). The Facility is below the emission thresholds for PSD since the Facility does not emit greater than 250 tons per year of any regulated New Source Review (NSR) pollutant in an area designated as attainment under sections 107(d)(1)(A)(ii) or (iii) of the Act. The existing Facility is also not a major source of HAPs since it has the potential to emit less than 10 tons of any individual HAP and less than 25 tons for any combination of HAPs. Therefore the proposed combustion turbine is not subject to 40 CFR Part 63 Subpart YYYY since the Facility is not a major source of HAPs. The requirements of CAM codified in 40 CFR §§ 64.1 through 64.10 apply to control devices at a Title V facility used to comply with emissions limitations for sources which have pre-control emissions greater than the applicable major source threshold. The proposed combustion turbine, which will be equipped with an oxidation catalyst control device, will not be subject to CAM because the pre-control emissions for carbon monoxide, volatile organic compounds, total hazardous air pollutants and individual HAPs do not exceed the applicable major source thresholds of 100 tons per year, 50 tons per year, 25 tons per year and 10 tons per year, respectively.

The applicable regulatory programs are discussed below in the context of the proposed Facility.

MassDEP Plan Approval Regulations – 310 CMR 7.02

Since the proposed project plans to construct and operate a fuel utilization emission unit (combustion turbine) with a maximum energy input capacity of 40 MMBtu/hr or greater utilizing natural gas or propane, the Facility is required to file an application for a comprehensive plan approval pursuant to 310 CMR 7.02(5). The emissions from the new piping components and venting processes are also subject to the plan approval requirements of 310 CMR 7.02 as they are associated with the combustion turbine project. The review of a Facility's comprehensive plan approval application is regulated pursuant to 310 CMR 7.02(1)(b) and 310 CMR 7.02(5) and is limited to regulating emissions from stationary sources.

Stationary sources which are subject to the plan approval requirements of 310 CMR 7.02 must demonstrate that they will attain and maintain the best available control technology (BACT) emission rates for all regulated air pollutants emitted pursuant to the requirements of 310 CMR 7.02(8)(a)2. Pursuant to 310 CMR 7.00, BACT means an emission limitation based on the maximum degree of reduction of any regulated air contaminant emitted from any regulated facility which MassDEP, on a case-by-case basis taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility. BACT may also include a design feature, equipment specification, work practice, operating standard or combination thereof.

In addition, the stationary sources subject to 310 CMR 7.02 must demonstrate that the resulting emissions will not exceed an applicable emission limitation specified in 310 CMR 7.00 or result

in a violation of any provision of 310 CMR 7.00 and will not cause or contribute to a violation of applicable Massachusetts and National Ambient Air Quality Standards (NAAQS).

The carbon dioxide equivalent (CO_2e) emissions from the project (combustion turbine, fugitive pipeline and venting emissions and emergency engine) have been estimated by TGP to be 51,484 tons per year. Since the potential to emit for greenhouse gases is ≤ 75,000 tons per year of CO_2e, the plan approval requirements of 310 CMR 7.02 do not apply to greenhouse gas emissions pursuant to 310 CMR 7.02(1)(d).

The construction and operation of the new 755 brake-horsepower, natural gas-fired, 4-stroke, lean burn Caterpillar emergency stationary RICE is not subject to the plan approval requirements of 310 CMR 7.02 since it will be certified pursuant to the MassDEP Environmental Results Program for Emergency Engines and Turbines at 310 CMR 7.26(42). However, the emergency engine is part of the project and is included for purposes of demonstrating compliance with the NAAQS.

Other State Regulatory Requirements – 310 CMR 7.00

In addition to being subject to the BACT requirements of 310 CMR 7.02(8)(a)2., the combustion turbine project is subject to the visible emission requirements of 310 CMR 7.06, the dust, odor, construction and demolition requirements of 310 CMR 7.09 and the noise reduction requirements of 310 CMR 7.10.

MassDEP promulgated regulations governing noise from new and existing equipment under 310 CMR 7.10 and Policy 90-001. According to the MassDEP Policy 90-001, new equipment is not permitted to increase ambient sound pressure levels by more than ten (10) decibels above the lowest measured community sound pressure level at both the property boundaries and the nearest inhabited structures. In addition, new equipment is not permitted to emit tonal noise. Tonal noise occurs when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by three (3) decibels or more.

Emission Offsets and Nonattainment Review - 310 CMR 7.00: Appendix A

The Facility is an existing major stationary source of NOx pursuant to the Emission Offsets and Nonattainment Review regulations of 310 CMR 7.00: Appendix A because the Facility has the potential to emit more than 50 tons per year of NOx and is located in an Ozone Transport Region even though the area is currently designated as attainment/unclassifiable for ozone in 40 CFR §81.322. Therefore, the Facility must calculate the net emissions increase for NOx from the physical change to determine the applicability of 310 CMR 7.00: Appendix A.

The Facility has demonstrated that the air contaminant emissions from the construction and operation of the project will not have a significant net emission increase for NOx and is therefore not a major modification as defined in 310 CMR 7.00: Appendix A. As a result, the project will not be subject to 310 CMR 7.00: Appendix A.

Operating Permit and Compliance Program (Title V) – 310 CMR 7.00: Appendix C

The existing Facility is considered to be a "major source", as defined in 310 CMR 7.00: Appendix C, since it has the potential to emit greater than 50 tons per year of nitrogen oxides NOx. Therefore the Facility is subject to the Operating Permit and Compliance Program pursuant to 310 CMR 7.00: Appendix C(2). The Facility currently has a Title V Operating Permit WE-18-017, issued August 12, 2019. The Facility will be required to submit a minor modification application to their Title V Operating Permit to incorporate the requirements from Plan Approval #WE-18-017 prior to commencing operation of the combustion turbine.

Because the Facility is required to report air emissions data to the Department pursuant to 310 CMR 7.00: Appendix C (The Air Operating Permit Program) and had stationary emission sources that emitted greenhouse gases during the previous calendar year, the Facility is subject to the greenhouse reporting requirements pursuant to 310 CMR 7.71(3)(a)1. Therefore, the Facility is required to report, certify, and verify direct emissions of greenhouse gases pursuant to 310 CMR 7.71(5), (6) and (7).

National Ambient Air Quality Standards (NAAQS)

The USEPA promulgated NAAQS for criteria pollutants, for the protection of public health and welfare (40 CFR Part 50). The MassDEP has adopted many of these same standards in Regulation 310 CMR 6.00. The criteria pollutants are particulate matter with an aerodynamic diameter of less than or equal to 10 microns (PM_{10}), fine particulate matter with a mean diameter of less than or equal to 2.5 microns ($PM_{2.5}$), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and lead (Pb). The applicable NAAQS can be found in the table titled "Summary of Criteria Pollutant Refined Modeling Analysis" contained in the ambient air quality impact analysis discussion section of this plan approval.

Agawam is located in a region currently classified as either in attainment/unclassifiable area for all criteria pollutants. However, the proposed project area is treated as moderate ozone nonattainment because Massachusetts is part of the Northeast ozone transport region.

To identify those new sources with the potential to violate or contribute to a violation of an ambient air quality standard, the USEPA has adopted significant impact levels (SILs) for PM_{10}, NO_2, SO_2, and CO. If the predicted impacts of a new source are found to be below the SILs, using USEPA-approved computer dispersion screening models, no further modeling analysis is required to assess compliance with the ambient air quality standards. If the modeled impacts are found to exceed the SILs, a more detailed dispersion modeling analysis is required to assess compliance with ambient air quality standards. This more detailed analysis must consider the impacts associated not only with the new source, but also with existing sources in the region.

A detailed discussion of the project's ambient air quality impact analysis is contained in Section G. herein.

New Source Performance Standards (NSPS)

The proposed combustion turbine will be subject to the federal requirements of 40 CFR Part 60 Subpart KKKK - Standards of Performance for Stationary Combustion Turbines because it is rated at a heat input at peak load equal to or greater than 10 MMBtu/hour, based on the higher heating value (HHV) of the fuel, and will have commenced construction after February 18, 2005. Subpart KKKK contains applicable emission limitations of 0.06 pounds per million Btu of heat input for SO_2 and 25 parts per million (ppm) @ 15% O_2 for NOx. A separate NOx limit of 150 ppm @ 15% O_2 is applicable to operating at less than 75% of peak load and when ambient temperatures are below 0ºF. TGP will demonstrate compliance with the NO_x emission limitation through stack testing as required by 40 CFR 60.4400 which must occur at ambient temperatures above 0° F. Compliance with the below 0° F NOx limit will be based on the guarantee from Solar Turbines which limits the NOx emissions to no greater than 42 ppm @ 15% O_2 at temperatures less than 0°F but greater than -20°F. Subpart KKKK allows for biennial testing of NOx emissions if the NOx emission result from the performance test is less than or equal to 75 percent of the 25 ppm NOx emission limit (18.75 ppm). TGP is proposing a NOx emission limit not to exceed 9 ppmdv @ 15% O2 at ambient temperatures greater than or equal to 0°F which would qualify for biennial testing. However, TGP has stated that they will conduct more frequent annual NOx stack tests.

TGP has elected to be exempt from monitoring the total sulfur content of natural gas by complying with either 40 CFR 60.4365(a) or (b). 40 CFR 60.4365(a) and (b) allows for compliance with the SO_2 limitation of 0.060 pounds per million Btu of heat input to be demonstrated by using: a current, valid purchase contract, tariff sheet or transportation contract for the sulfur fuel quality characteristics, or representative fuel sampling data which show that the sulfur content of the fuel does not exceed 26 ng SO_2/J (0.060 lb SO_2/MMBtu) heat input for continental areas. At a minimum, the amount of fuel sampling data specified in section 2.3.1.4 or 2.3.2.4 of appendix D to 40 CFR Part 75 is required.

The proposed gas turbine will not be subject to the federal requirements of 40 CFR Part 60 Subpart GG - Standards of Performance for Stationary Gas Turbines because turbines subject to Subpart KKKK are exempt from complying with the requirements of Subpart GG pursuant to 40 CFR § 60.4305(b).

The federal requirements of 40 CFR Part 60 Subpart OOOOa - Standards of Performance for Crude Oil and Natural Gas Facilities for which Construction, Modification or Reconstruction Commenced After September 18, 2015, will apply to the collection of fugitive emissions components at the compressor station, as defined in 60.5430a, due to the modification of the compressor station described in 40 CFR 60.5365a(j)(2). As defined in 60.5430a, fugitive emissions components are not devices that vent as part of normal operation. For purposes of Subpart OOOOa fugitive emissions are defined as: Any visible emission from a fugitive emissions component observed using optical gas imaging or an instrument reading of 500 ppm or greater using Method 21. In accordance with 60.5397a, the Facility will be required to monitor all fugitive emission components by developing a fugitive emissions monitoring plan that covers

the collection of fugitive emissions components at the compressor station, conduct an initial monitoring survey within 60 days of the modification and conduct ongoing surveys in accordance with 60.5397a(g)(2), (3), (4) and (5), repair or replace all sources of fugitive emissions, keep records for each monitoring survey as specified in 60.5420a(c)(15) and submit annual reports in accordance with 60.5420a(b)(1), (7) and (11). The Facility currently plans to use optical gas imaging as the technique for determining fugitive emissions.

F. Best Available Control Technology (BACT) Analysis

The Solar Taurus 70-10802S, or equivalent, natural gas-fired lean-burn pre-mix simple cycle combustion turbine, associated centrifugal compressor and additional ancillary piping components will emit the following regulated air pollutants: NOx, CO, VOCs, SO_2, PM, PM_{10}, $PM_{2.5}$ and HAPs. Each of these pollutants has been evaluated in the following paragraphs for compliance with the applicable requirements of BACT pursuant to 310 CMR 7.02(8)(a)2.

Combustion Turbine NOx BACT

NOx is created during the fuel combustion process of the combustion turbine. NOx consists of a combination of nitric oxide and nitrogen dioxide. The formation of NOx from fuel combustion results primarily from two forms which are thermal NOx and fuel-derived NOx. Thermal NOx is generated from the oxidation of nitrogen in the inlet air in the high-temperature, post-flame region of the turbine's combustion zone. Fuel-derived NOx is formed by the oxidation of fuel-bound nitrogen. Therefore, NOx control technologies can be grouped into two categories: combustion controls and post-combustion controls. The combustion controls minimize the formation of NOx by altering the conditions under which the combustion reaction occurs and post combustion controls, also called add-on control devices, chemically convert the NOx generated in the combustion reaction into nitrogen (N2) and water.

The available combustion controls that were evaluated in this BACT analysis consist of:

- Water/Steam Injection – This technology injects water/steam into the combustion zone in order to reduce the heat produced by the combustion reaction which in turn lowers the combustion temperature and then minimizes the formation of thermal NOx. The amount of NO_x mitigation is dependent upon the amount of water/steam injected. A disadvantage is that this technology requires 0.8 to 1.0 pounds of water per pound of fuel fired. In addition, the use of water/steam has the potential to smother the combustion reaction.

- Dry Low NOx Combustors, known as Solar's SoLoNOx - This technology injects excess air to obtain a uniform, lean, unburned air-fuel mixture. The lean air-fuel mixture lowers the combustion temperature and then minimizes the formation of thermal NOx.

The available post-combustion controls that were evaluated in this BACT analysis consist of:

- Selective Catalytic Reduction (SCR) – A SCR is placed downstream of the combustion turbine and injects ammonia or urea into the exhaust stream so it can be thoroughly mixed prior to passing over a catalyst. The catalyst is used to convert the NOx to N2 and water at lower exhaust gas temperatures (~400°F - ~800°F) as compared to a SNCR.

- Selective Non-Catalytic Reduction (SNCR) – A SNCR is similar to SCR in that it also injects ammonia or urea into the exhaust stream to react with NOx. However, the SNCR does not use a catalyst because it is designed to convert NOx at higher exhaust gas temperatures (~1600°F- ~2000°F) than compared to a SCR.

- Catalytic Absorption – (historically known as SCONOx but renamed EMx) – This control device uses a catalyst to absorb NOx emissions which are converted and desorbed during the cyclic regeneration process as N2 and water. No ammonia is needed for the catalyst reaction. The operating temperature range for this technology is 300°F to 700°F.

Of the five potentially available control technologies, all are technically feasible except for SNCR and catalytic absorption. SNCR is not technically feasible because the exhaust temperature of the combustion turbine will be less than 1000°F which is lower than the SNCR's minimum operating temperature of 1600°F. In addition, SNCR has not been installed on any similar sized simple cycle combustion turbines used at natural gas compressor stations. Catalytic absorption is not technically feasible because the exhaust temperature of the combustion turbine is greater than 800°F which is higher than the catalyst's maximum operating temperature of 700°F.

The remaining three technically feasible control technologies have been ranked in order of the lowest NOx outlet concentration which are SCR, SoLoNox and water/steam injection. Since SCR achieves the lowest NOx outlet concentration, it would be considered BACT for control of NOx emissions. However, an economic cost analysis was conducted. The cost analysis resulted in a $ per ton of NOx removed that was not cost-effective for the purposes of BACT.

Since SCR is not economically feasible, the next best technology is SoLoNOx. Based on the Solar Turbines emission data, the use of SoLoNOx is warranted to achieve a NOx emission concentration of 9.0 parts per million dry volume basis (ppmvd) at 15% O2 at ambient temperatures greater than or equal to 0° F during operating loads between 50% and 100%. The NOx emission rate has been verified by reviewing EPA's RACT/BACT/LAER Clearinghouse (RBLC) and other similar sized simple cycle combustion turbines used at natural gas compressor stations which have been recently approved. Therefore, BACT for the Solar Taurus 70 combustion turbine is the use of SoLoNOx combustion technology and a NOx emission limit of no greater than 9 ppmdv @ 15% O2 at ambient temperatures greater than or equal to 0° F during operating loads between 50% and 100%. This emission limit is more stringent than the applicable NOx emission limit contained in 40 CFR Part 60 Subpart KKKK.

TGP has calculated the contribution of NOx emissions to be 12.51 tons in any 12 consecutive month period outside of cold temperature operations. The annual emission rate was based on the worst case composite operating scenario (discussed in Section C. herein) which included a NOx emission concentration of 9.0 ppmvd at 15% O2, 8,510 hours per year of normal operations at an annual average ambient temperature of 48 degrees F with an annual average heat input rate of 91.02 million Btu per hour.

NOx Cold Temperature Operation

Since the SoLoNOx system does not operate at ambient temperatures below 0°F, TGP has proposed alternative NOx limits during these conditions based on information from Solar Turbines. At ambient temperatures below 0°F, Solar's turbine models are controlled with a Pilot Active Control Logic to increase pilot fuel which improves flame stability but leads to higher emissions. Without the increase in pilot fuel at temperatures below 0°F the turbine may exhibit combustor rumble, as operation may be near the lean stability limit. Therefore, Solar Turbines has provided a warranted NOx emission limit of 42 ppmvd at 15% O2 for ambient temperatures between 0°F and -20°F during operating loads between 50% and 100%. This emission rate has been proposed as BACT and is more stringent than the applicable NOx emission limit of 150 ppm at 15% O2 for ambient temperatures below 0°F contained in 40 CFR Part 60 Subpart KKKK.

TGP has calculated the contribution of NOx emissions to be 1.48 tons in any 12 consecutive month period for ambient temperatures between 0°F and -10°F during operating loads between 50% and 100%. The annual emission rate was based on the worst case composite operating scenario (discussed in Section C. herein) which included a maximum NOx emission of 42 ppmvd at 15% O2 and 200 hours per year of operation at ambient temperatures below 0° F and greater than or equal to -10° F (based on meteorological data from Bradley International Airport from 1940s to present including a safety factor of two times).

NOx Startup/Shutdown

During startup and shutdown of the combustion turbine, the SoLoNOx control technology will not be active since the combustion turbine's operating load is below 50%. Since NOx emissions are uncontrolled and the combustion flame is in transition during startup and shutdown, Solar Turbines has provided NOx emission estimates in pounds of NOx per startup and shutdown.

TGP has calculated the contribution of NOx emissions during startup and shutdown to be 0.15 tons in any 12 consecutive month period. The annual emission rate was calculated using the Solar Turbines startup/shutdown emission estimates, a 20 minute startup and shutdown cycle consisting of 10 minutes for each startup (from first combustion of fuel to when SoLoNOx is active) and 10 minutes for each shutdown (from when SoLoNOx is inactive to flame out), 50 hours per year of startup/shutdowns and 150 startup/shutdown cycles per year. The length and number of startup/shutdown cycles were based on the worst case composite operating scenario for annual emissions from the combustion turbine which was previously discussed in Section C herein.

Solar Turbines has expressed in their Product Information Letter (PIL) that emission estimates provided for startup and shutdown are not warranted, have been based on limited testing and analysis and have not measured an actual startup/shutdown event. The PIL goes on to mention that it may prove to be very challenging to accurately measure emissions, using steady state source test methods, during a non-steady state such as startup/shutdown. Based on this information, it is difficult to establish meaningful and enforceable individual limits on startup and shutdown events since a compliance demonstration with any such emission limit would prove futile. It is also not practically enforceable to establish limitations on the number of startup and shutdown events since most of these events are based on market conditions that are outside the Facility's ability to control. While market conditions may be outside of TGP's ability to control, work practice standards requiring minimization of operation under these conditions, such as minimizing the duration of startups and shutdowns in accordance with the manufacturer's recommendations, can be utilized. TGP has also proposed to monitor and record the number of startup and shutdowns which will include the date, time and duration of each individual startup and shutdown event.

NOx Annual Emissions - Worst Case Composite Operating Scenario
In summary, the combustion turbine's annual NOx emissions from startup/shutdown, normal operation and operation at ambient temperatures below 0°F have been determined to be 0.15 tons, 12.51 tons and 1.48 tons, respectively. Based on this worst case composite operating scenario, the combustion turbine's total combined BACT NOx emission limit is 14.14 tons in any 12 consecutive month period.

Combustion Turbine CO BACT
CO emissions are created from the incomplete oxidation of carbon during the fuel combustion process of the combustion turbine. Similar to NOx controls, the control of CO emissions can be grouped into two categories: combustion controls and post-combustion controls. The combustion controls minimize incomplete combustion and post-combustion controls, also called add-on control devices, oxidize the CO generated in the combustion reaction into CO_2.

The combustion controls consist of the use of good combustion practices/techniques which include the proper ratio of combustion air and fuel to minimize incomplete combustion without the formation of excessive quantities of other pollutants. While the use of SoLoNOx combustion technology is primarily for the reduction in NOx emissions, it does provide some reduction in CO emissions since the lean air-fuel mixture results in more of the fuel being completely oxidized. Solar Turbines has guaranteed an uncontrolled 25 ppmvd @ 15% O_2 emission rate for CO while the SoLoNOx combustion technology is operating at ambient temperatures greater than or equal to 0° F during operating loads between 50% and 100%.

The available post-combustion controls that were evaluated in this BACT analysis consist of:

- Oxidation Catalyst –The exhaust gases from the combustion process pass over the control device's precious metal catalyst bed where the excess oxygen oxidizes the CO to CO2. The oxidation process takes place spontaneously, without the requirement for introducing reactants.

- SCONOx/EMx – This control device uses a precious metal catalyst that oxidizes the CO while it also absorbs NOx.

Of the three potentially available control technologies, only SCONOx is not technically feasible. As discussed in the NOx BACT section, SCONOx is not technically feasible because the exhaust temperature of the combustion turbine is greater than 800°F which is higher than the catalyst's maximum operating temperature of 700°F.

TGP has proposed to use both of the technically feasible control technologies which are good combustion practices and an oxidation catalyst. For the oxidation catalyst control device, TGP has proposed to use a Advanced Catalyst Systems, ADVOCAT, or equivalent, oxidation catalyst. The oxidation catalyst has one layer of catalyst made of platinum supported by alumina oxide on ferroalloy steel with an operating temperature range between 550°F and 1250°F. The oxidation catalyst is capable of achieving a CO destruction efficiency of 95% which will result in a CO outlet concentration of 1.25 ppmdv @ 15% O2 based on the Solar Turbine's guaranteed CO inlet concentration of 25 ppmvd @ 15% O2. The CO emission rate has been verified by reviewing the USEPA's RBLC and other similar sized simple cycle combustion turbines used at natural gas compressor stations which have been recently approved. Therefore, BACT for the Solar Taurus 70 combustion turbine is the use of good combustion practices, an oxidation catalyst and a CO emission limit of no greater than 1.25 ppmdv @ 15% O2 at ambient temperatures greater than or equal to 0° F during operating loads between 50% and 100%.

TGP has calculated the contribution of CO emissions to be 1.06 tons in any 12 consecutive month period from normal operations. The annual emission rate was based on the worst case composite operating scenario (discussed in Section C. herein) which included a CO emission concentration of 1.25 ppmvd at 15% O2, 8,510 hours per year of normal operations at an annual average ambient temperature of 48°F with an annual average heat input rate of 91.02 million Btu per hour.

CO Cold Temperature Operation

Since the SoLoNOx system does not operate at ambient temperatures below 0°F, TGP has proposed alternative CO limits during these conditions based on information from Solar Turbines. As previously discussed in the NOx BACT discussion, Solar Turbine's models are controlled with a Pilot Active Control Logic to increase pilot fuel which improves flame stability but leads to higher emissions at ambient temperatures below 0°F. However, the oxidation catalyst is capable of operating at ambient temperatures below 0°F because it is enclosed in the exhaust ductwork and exposed to the hot turbine exhaust gases. Therefore, TGP has proposed a controlled CO emission limit of 5 ppmvd at 15% O2 for ambient temperatures between 0°F and -

20°F during operating loads between 50% and 100%. This CO emission rate has been proposed as BACT and is based on a warrantied uncontrolled CO inlet concentration of 100 ppmvd at 15% O2, as provided by Solar Turbines, and a minimum 95% destruction efficiency from the oxidation catalyst.

TGP has calculated the contribution of CO emissions to be 0.11 tons in any 12 consecutive month period from cold temperature operations. This annual emission rate was based on the worst case composite operating scenario (discussed in Section C. herein) which included a maximum CO emission of 5 ppmvd at 15% O2 and 200 hours per year of operation at ambient temperatures below 0°F and greater than or equal to -10°F (based on meteorological data from Bradley International Airport from 1940s to present including a safety factor of two times).

CO Startup/Shutdown

During startup of the combustion turbine, the SoLoNOx and oxidation catalyst control technologies are not active since the combustion turbine's operating load is below 50% and the exhaust temperature is below the oxidation catalyst's minimum operating temperature. However, the oxidation catalyst will be active during shutdown since it is expected to remain within the required operating temperatures. In addition, the combustion turbine is equipped with an Enhanced Emissions Control which was developed by Solar Turbines to improve the startup and shutdown transitions to and from SoLoNOx. The Enhanced Emission Control provides a smoother control of the temperature and pilot fuel flow during the transitions to and from SoLoNOx operation which results in lower CO and VOC emissions during startup and shutdown. Solar Turbines has provided CO emission estimates in pounds of CO per startup and shutdown which include the use of the Enhanced Emission Control.

TGP has calculated the contribution of CO emissions during startup and shutdown to be 2.82 tons in any 12 consecutive month period. This annual emission rate was calculated using the Solar Turbines emission estimates in conjunction with a 95% destruction efficiency from the oxidation catalyst during shutdown only, a 20 minute startup/shutdown cycle consisting of 10 minutes for each startup (from first combustion of fuel to when SoLoNOx is active) and 10 minutes for each shutdown (from when SoLoNOx is inactive to flame out), 50 hours per year of startup/shutdowns and 150 startup/shutdown cycles per year. The length and number of startup/shutdown cycles were based on the worst case composite operating scenario for annual emissions from the combustion turbine which was previously discussed in Section C herein.

In addition, TGP has proposed supporting monitoring, recordkeeping and work practice requirements for startup/shutdown events as discussed in the NOx startup/shutdown section.

CO Annual Emissions - Worst Case Composite Operating Scenario

In summary, the combustion turbine's annual CO emissions from startup/shutdown, normal operation and operation at ambient temperatures below 0°F have been determined to be 2.82 tons, 1.06 tons and 0.11 tons, respectively. Based on the worst case composite operating

scenario, the combustion turbine's total combined BACT CO emission limit is 3.99 tons in any 12 consecutive month period.

Combustion Turbine VOC and HAPs BACT

VOC emissions, which are photochemically reactive in the vapor phase, are a combination of different organic compounds, including some that are classified as HAPs. HAPs are a group of 187 pollutants as designated by the Clean Air Act. The organic HAPs emitted by the proposed combustion turbine are all considered to be VOCs. Because these HAPs are VOCs, the same methods can be used to mitigate their emissions.

VOCs and HAPs are products of incomplete combustion which can be further controlled by oxidation to create CO_2 and H_2O. In this case, VOCs and HAPs are controlled in the same way as CO so the available combustion and post-combustion controls are the same as those reviewed for CO.

The combustion controls consist of the use of good combustion practices/techniques which include the proper ratio of combustion air and fuel to minimize incomplete combustion without the formation of excessive quantities of other pollutants. Solar Turbines has provided an uncontrolled 5 ppmvd @ 15% O_2 emission rate for VOCs while the SoLoNOx combustion technology is operating at ambient temperatures greater than or equal to 0° F during operating loads between 50% and 100%.

The available post-combustion controls that were evaluated in this BACT analysis consist of:

- Oxidation Catalyst –The exhaust gases from the combustion process pass over the control device's precious metal catalyst bed where the excess oxygen oxidizes the VOC/HAPs to CO_2 and water vapor. The oxidation process takes place spontaneously, without the requirement for introducing reactants.

- SCONOx/EMx – This control device uses a precious metal catalyst that oxidizes the VOC/HAPs while it also absorbs NOx.

Of the three potentially available control technologies, only SCONOx is not technically feasible as previously discussed in the CO BACT section.

TGP has proposed to use both of the technically feasible control technologies which are good combustion practices and an oxidation catalyst. The oxidation catalyst is capable of achieving a VOC and HAP destruction efficiency of 50% based on vendor guarantees.

Based on this guaranteed VOC destruction efficiency and Solar Turbine's uncontrolled VOC concentration of 5 ppmvd @ 15% O2, BACT for VOCs is an outlet concentration of 2.5 ppmvd @ 15% O2, measured as propane at ambient temperatures greater than or equal to 0° F during operating loads between 50% and 100% using good combustion practices and an oxidation

catalyst. The VOC emission rate has been verified by reviewing EPA's RBLC and other similar sized simple cycle combustion turbines used at natural gas compressor stations which have been recently approved.

BACT for HAP emissions has been calculated to be 0.00051 pounds per million Btu of heat input based on the use of good combustion practices, an oxidation catalyst guaranteed destruction efficiency of 50% and emission factors from EPA AP-42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1, Chapter 3.1 Stationary Gas Turbines, April 2000. The HAP limit applies at all ambient temperatures and during operating loads between 50% and 100%.

TGP has calculated that the contribution of VOC emissions from the combustion turbine are 1.213 tons in any 12 consecutive month period and 0.199 tons of total HAPs in any 12 consecutive month period from normal operations. These emissions were based on the worst case composite operating scenario (discussed in Section C. herein) which included a controlled VOC emission concentration of 2.5 ppmvd at 15% O2, a HAP emission rate of 0.00051 pounds per million Btu of heat input, 8,510 hours per year of normal operations at an annual average ambient temperature of 48 °F with an annual average heat input rate of 91.02 million Btu per hour.

VOC/HAP Cold Temperature Operation

Since the SoLoNOx system does not operate at ambient temperatures below 0°F, TGP has proposed alternative VOC limits during these conditions based on information from Solar Turbines. As previously discussed in the NOx and CO BACT discussion, Solar Turbine's models are controlled with a Pilot Active Control Logic to increase pilot fuel which improves flame stability but leads to higher emissions at ambient temperatures below 0°F. However, the oxidation catalyst is capable of operating at ambient temperatures below 0°F because it is enclosed in the exhaust ductwork and exposed to the hot turbine exhaust gases.

Uncontrolled VOC emissions were calculated using Solar Turbine's cold weather unburned hydrocarbon concentration of 50 ppmvd at 15% O2 and an estimation that 20% of unburned hydrocarbons are VOCs (the ratio provided by Solar Turbines for normal operation). This resulted in an uncontrolled VOC concentration of 10 ppmvd at 15% O2. Based on this uncontrolled VOC concentration and a guaranteed minimum 50% destruction efficiency from the oxidation catalyst, BACT for VOCs at ambient temperatures between 0°F and -10°F during operating loads between 50% and 100% is 0.61 pounds per hour, which is equivalent to an outlet concentration of 5 ppmvd at 15% O2, measured as methane, (as shown in the supporting calculations), at a maximum heat input rate of 95.76 million Btu per hour (@-10°F).

An alternative HAP limit for ambient temperatures below 0ºF is not being requested as the emission rates of 0.00051 pounds per million Btu of heat input are inclusive of all ambient temperatures and the oxidation catalyst is expected to operate at a 50% destruction efficiency at ambient temperatures below 0°F.

TGP has calculated the contribution of VOC and total HAP emissions to be 0.06 tons in any 12 consecutive month period and 0.005 tons in any 12 consecutive month period, respectively, for ambient temperatures between 0°F and -10°F during operating loads between 50% and 100%. These emission rates were based on the worst case composite operating scenario (discussed in Section C. herein) that included a maximum VOC emission of 5 ppmvd at 15% O2, measured as methane, a maximum HAP emission rate of 0.00051 pounds per million Btu of heat input and 200 hours per year of operation at ambient temperatures below 0° F and greater than or equal to -10° F (based on meteorological data from Bradley International Airport from 1940s to present including a safety factor of two times).

VOC/HAP Startup/Shutdown

During startup of the combustion turbine, the SoLoNOx and oxidation catalyst control technologies are not active since the combustion turbine's operating load is below 50% and the exhaust temperature is below the oxidation catalyst's minimum operating temperature. However, the oxidation catalyst will be active during shutdown since it is expected to remain within the required operating temperatures. In addition, the combustion turbine is equipped with an Enhanced Emissions Control which was developed by Solar Turbines to improve the startup and shutdown transitions to and from SoLoNOx. The Enhanced Emission Control provides a smoother control of the temperature and pilot fuel flow during the transitions to and from SoLoNOx operation which results in lower VOC emissions during startup and shutdown. Solar Turbines has provided startup/shutdown emission estimates in pounds of VOC per startup and shutdown which include the use of the Enhanced Emission Control and a destruction efficiency of 50% during shutdown only. For HAPs, TGP calculated the emissions in pounds of HAP per startup and shutdown based on a maximum HAP emission rate of 0.05 pounds per hour and a destruction efficiency of 50% during shutdown only.

TGP has calculated the contribution of VOC and total HAP emissions during startup/shutdown to be 0.863 tons in any 12 consecutive month period and 0.00182 tons in any 12 consecutive month period, respectively. The annual emission rates were calculated using the Solar Turbines and TGP emission estimates for VOCs and HAPs in conjunction with a 20 minute startup/shutdown cycle consisting of 10 minutes for each startup (from first combustion of fuel to when SoLoNOx is active) and 10 minutes for each shutdown (from when SoLoNOx is inactive to flame out), 50 hours per year of startup/shutdowns and 150 startup/shutdown cycles per year. The length and number of startup/shutdown cycles were based on the worst case composite operating scenario for annual emissions from the combustion turbine which was previously discussed in Section C herein.

In addition, TGP has proposed supporting monitoring, recordkeeping and work practice requirements for startup/shutdown events as discussed in the NOx startup/shutdown section.

VOC/HAP Annual Emissions – Worst Case Composite Operating Scenario

In summary, the combustion turbine's annual VOC and total HAP emissions from startup/shutdown, normal operation and operation at ambient temperatures below 0°F have been determined to be: 0.863 tons of VOCs and 0.00182 tons of total HAPs during startup/shutdown, 1.213 tons of VOCs and 0.199 tons of total HAPs at ambient temperatures greater than or equal to 0° F during operating loads between 50% and 100%, and 0.06 tons per year of VOCs and 0.005 tons per year of total HAPs for ambient temperatures between 0°F and -20°F during operating loads between 50% and 100%. Based on the worst case composite operating scenario, the combustion turbine's total combined BACT emission limit is 2.14 tons of VOCs in any 12 consecutive month period and 0.206 tons of total HAPs in any 12 consecutive month period.

Combustion Turbine SO_2 BACT

Emissions of SO_2 from the combustion of natural gas result from the oxidation of sulfur compounds present in the fuel. Natural gas inherently contains very low amounts of sulfur relative to other fossil fuels. The proposed combustion turbine would only be fired on natural gas.

The BACT analysis indicated that no add-on control devices for SO_2 emissions have been installed on combustion turbines at natural gas compressor stations. The only control technique available is the use of low-sulfur containing fuels.

The federal Natural Gas Act (NGA) and the Federal Energy Regulatory Commission's (FERC) regulations on open-access transportation require TGP to provide transportation service in accordance with it's FERC Gas Tariff. The standard contained in Article II, Section 5(g) of the Facility's FERC NGA Gas Tariff, effective January 1, 2012, states that gas delivered to the Transporter (TGP) "shall not contain more than ten (10) grains of total sulfur (including mercaptans). However, Transporter shall not refuse to accept delivery of gas that contains five (5) grains or less of total sulfur (including mercaptans), which standard shall be referred to as Transporter's total sulfur Safe Harbor". While the FERC Safe Harbor provision mandates TGP to accept natural gas containing up to 5 grains of total sulfur, the acceptance of natural gas containing greater than 5 grains but no more than 10 grains of total sulfur is at TGP's discretion. Therefore, TGP has proposed that BACT for SO_2 is the use of a low-sulfur containing fuel, natural gas, containing a sulfur content of no greater than 5 grains of total sulfur (including mercaptans) per 100 standard cubic foot of natural gas (equivalent to 0.014 pounds per million Btu of heat input). The sulfur content limit applies at all ambient temperatures and during all operating loads. In addition, the sulfur content limitation is more stringent that the applicable SO_2 emission limitation specified in 40 CFR Part 60, Subpart KKKK which is 0.06 pounds of SO_2 per million Btu of heat input.

SO_2 Annual Emissions - Worst Case Composite Operating Scenario

The combustion turbine's annual SO_2 emissions from the use of natural gas containing a maximum of 5 grains of total sulfur (including mercaptans) per 100 standard cubic foot of natural gas during startup/shutdown, normal operation and operation at ambient temperatures below 0°F and greater than or equal to -10°F have been determined to be 0.033 tons, 5.42 tons

and 0.134 tons, respectively. Based on the worst case composite operating scenario, the combustion turbine's total combined BACT SO_2 emission limit is 5.59 tons in any 12 consecutive month period

Combustion Turbine PM, PM_{10} and $PM_{2.5}$ BACT

The PM emissions from the combustion of natural gas in the combustion turbine result from noncombustible trace constituents in the fuel. Much of the PM emitted from natural gas combustion, which consists of small airborne solid or liquid particles, is derived from sulfur contained in the fuel. PM, also called total PM, consists of all filterable and condensable PM, including the two subcategories of PM which are PM_{10} and $PM_{2.5}$. The PM_{10} and $PM_{2.5}$ take into account the diameter of the particles with the 10 and 2.5 indicating the maximum diameter of the particle, in microns. Because $PM_{2.5}$ also has a diameter less than 10 microns, all $PM_{2.5}$ is also PM_{10}. PM emissions from the combustion of natural gas combustion are generally considered to be all less than 1.0 microns in aerodynamic diameter with the majority of the PM being the condensable type. Condensable PM emissions initially exist as a gas in the stack but later condense in the cooler ambient air to form a liquid or solid. The condensable portion of PM can be measured by USEPA Method 202. The portion of PM that is not condensable is referred to as filterable. The filterable portion of PM exists in the stack in either the solid or liquid state and can be measured on an USEPA Method 5 filter. According to the USEPA, PM emissions are negligible from the combustion of natural gas. In addition, the combustion of natural gas generates fewer PM emissions as compared to other fuels like coal, oil and wood.

In reviewing control technologies for PM, PM_{10} and $PM_{2.5}$, TGP indicated that the combustion controls for a simple cycle turbine consist of the use of good combustion practices/techniques which include the proper ratio of combustion air and fuel to minimize incomplete combustion without the formation of excessive quantities of other pollutants. The use of a low-sulfur containing fuel, such as natural gas, also minimizes PM emissions. For post-combustion controls, TGP indicated that no such controls have been identified as having been applied to combustion turbines at natural gas compressor stations which coincides with the USEPA's RBLC.

Based on the above information, BACT for PM, PM_{10} and $PM_{2.5}$ is the use of good combustion practices and the use of natural gas containing a sulfur content of no greater than 5 grains per 100 standard cubic foot of natural gas. In addition, the PM, PM_{10} and PM2.5 emissions have each been limited to no more than 0.0066 pounds per million Btu of heat input, which applies at all ambient temperatures and during all operating loads, based on emission factors from EPA AP-42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1, Chapter 3.1 Stationary Gas Turbines, April 2000. The PM, PM_{10} and $PM_{2.5}$ emission limit is equivalent to the most stringent PM limits contained in the USEPA's RBLC for similar sized simple cycle combustion turbines at natural gas compressor stations.

PM, PM_{10} and $PM_{2.5}$ Annual Emissions - Worst Case Composite Operating Scenario

In summary, the combustion turbine's annual PM, PM_{10} and $PM_{2.5}$ emissions from startup/shutdown, normal operation and operation at ambient temperatures below 0°F and greater

than or equal to -10°F have been determined to be 0.016 tons, 2.56 tons and 0.063 tons, respectively. Based on the worst case composite operating scenario, the combustion turbine's total combined BACT emission limit is 2.64 tons of PM in any 12 consecutive month period, 2.64 tons of PM_{10} in any 12 consecutive month period and 2.64 tons of $PM_{2.5}$ in any 12 consecutive month period.

Venting Process/Equipment Fugitive VOC and HAP BACT

Natural gas is vented to atmosphere as part of normal operations necessary to relieve pressure in the system due to the startup and shutdown of the combustion turbine and associated centrifugal compressor. As previously discussed in the Facility description, the processes/equipment which emit fugitive VOC and HAP emissions are associated with compressor case venting, compressor gas seal system venting, valve operator venting and purging.

The control technologies available to all gas venting processes/equipment consist of recompression of the vented gas into the pipeline and flaring the vented gas. More specifically, emissions from compressor case venting can be minimized by maintaining the operating pressure of the compressor casing after a shutdown for a maximum 14-day pressurized hold. The 14-day time period is based on information from Solar Turbines which indicates that a hold time longer than 14 days with prolonged pressures may be detrimental to the compressor case seal life and may result in premature failure. At the expiration of 14 days, if the compressor has not been called back into service, the compressor case will be vented to the atmosphere.

Emissions from compressor gas seal system venting can be minimized by using wet or dry seals on the centrifugal shaft of the compressor. Dry seals are considered a superior technology compared to wet seals. Wet seals use a high-pressure oil as a barrier against escaping gas. Dry seals do not use any circulating seal oil but use high-pressure natural gas to seal the compressor and operate mechanically under the opposing force created by hydrodynamic grooves and static pressure. According to the USEPA, dry seals, as compared to wet seals, emit less natural gas, have lower power requirements, improve compressor and pipeline operating efficiency and performance, enhance compressor reliability and require significantly less maintenance.

Of the four potentially available control technologies listed above, only recompression of the vented gas was determined to not be technically feasible due to its low volume, short duration, and infrequent nature.

Of the three technically feasible control technologies, only the flare was considered not a viable alternative since it would cause adverse environmental impacts resulting in additional emissions of NOx, CO, particulates and SO_2.

Therefore, TGP has proposed that BACT for fugitive VOC and HAP emissions from venting are minimizing the compressor case venting emissions by maintaining the operating pressure of the compressor casing after a shutdown for a minimum 14-day pressurized hold as well as the use of dry seals on the centrifugal shaft of the compressor. As part of good operating practices, the

turbine computer control system will be used to initiate and release the 14-day pressurized hold and the dry gas seal system will be equipped with instrumentation to continuously monitor the differential pressure to determine when seal maintenance is necessary.

Based on TGP's calculations, the combustion turbine's BACT fugitive emission limit from all of the venting process/equipment is 0.99 tons of VOCs in any 12 consecutive month period and 0.014 tons of total HAPs in any 12 consecutive month period.

Piping Components Fugitive VOC and HAP BACT

Piping components at the Facility currently consist of connectors, valves, flanges and other associated components which are in high pressure natural gas transmission service. These components are subject to wear and have the potential to emit natural gas which results in fugitive emissions, such as VOCs and HAPs. As part of this project, additional piping components are necessary for the construction and operation of the proposed combustion turbine and emergency generator. Since additional piping components are being proposed with an increased potential to emit fugitive natural gas, a BACT analysis is required.

For purposes of satisfying BACT for the project's piping components, TGP has proposed to minimize fugitive emissions/leaks by complying with the applicable requirements of 40 CFR Part 60 Subpart OOOOa. Subpart OOOOa requires the monitoring of all of the facility's fugitive emission components, as defined in 40 CFR Section 60.5430a, using a fugitive emissions monitoring plan in accordance with 40 CFR Section 60.5397a(b), also commonly referred to as a leak detection and repair (LDAR) program. The fugitive emissions monitoring plan is used to identify piping components at the compressor station which may have fugitive emissions so that they can be repaired within a certain timeframe. The fugitive emission monitoring plan is subject to the applicable requirements of 40 CFR Part 60 Subpart OOOOa.

In addition, MassDEP will require TGP to conduct monthly audible, visible, olfactory (AVO) inspections during daylight hours while the Facility is operating to detect for the presence of visible fugitive air contaminants; the presence of audible fugitive air contaminants; and the presence of malodors. The monthly AVO inspections will supplement the quarterly monitoring required by Subpart OOOOa. Monthly AVO inspections have been accepted as BACT, in addition to a fugitive emissions monitoring plan, in other recent/similar plan approvals for the monitoring of fugitive emissions from piping components.

Therefore, MassDEP has determined that BACT for the fugitive VOC and HAP emissions from facility-wide piping components consists of complying with the applicable requirements of 40 CFR Part 60, Subpart OOOOa and conducting monthly supplemental AVO inspections. Due to the limited significance of emissions from this source, provided leaks are identified and repaired in a timely manner, it is not necessary to establish a numerical emission limitation.

G. Ambient Air Quality Impact Analysis

This section documents the results from an air quality computer dispersion modeling analysis performed using the USEPA approved AERMOD model (version 18081) to demonstrate that the predicted ambient air quality impacts associated with the operation of the Facility's future configuration and proposed project will comply with the NAAQS for CO, NO_2, PM_{10}, $PM_{2.5}$ and SO_2.

The modeling impact assessment first modeled the impacts from the project, consisting of the proposed Solar Taurus 70-10802S natural gas-fired lean-burn pre-mix simple cycle combustion and new 755 brake-horsepower, natural gas-fired, 4-stroke, lean burn Caterpillar emergency stationary RICE, against the SILs. The SIL modeling included runs with the proposed combustion turbine operating at 50% and 100% load conditions. Then a facility-wide model was conducted of the Facility's future configuration (proposed project plus EU #3 and EU #4) for comparison with the NAAQS. The NAAQS modeling of the facility-wide future configuration also included operation of the proposed combustion turbine at both the 50% and 100% load conditions plus an extra run for 1-hour NO_2 representing operation at the below 0°F ambient air condition.

The air quality computer dispersion modeling analysis was reviewed by MassDEP.

Modeled Conditions and Stack Parameters

All emission units included in the modeling analysis use natural gas only. The existing #2 fuel-oil fired diesel emergency engine (EU #6) was not included in the modeling. As mentioned above, the SIL and NAAQS phases of the modeling accounted for the 50% and 100% operating load cases for the proposed combustion turbine.

Because emission rates and flue gas characteristics for a given turbine load vary as a function of ambient air temperature and fuel use, a range of ambient air operating temperatures (0, 48, 70, and 90°F) were considered for natural gas fuel use at 100% and 50% operating loads. To be conservative, the short-term modeling analysis was conducted using the lowest stack exhaust temperature and exit velocity coupled with the maximum emission rate of the proposed combustion turbine over all ambient air temperature cases for each operating load. Annual modeling was based on the stack exhaust parameters for the 100% load case at an ambient air temperature of 48°F as this case was deemed to be most representative of annual average conditions.

Because NOx emissions from combustion turbines increase significantly at extremely low ambient air temperatures, the MassDEP also requested modeling of a low ambient air temperature condition (below 0°F) for 1-hour NO_2 only.

The existing combustion turbines were modeled using the corresponding maximum allowable emissions, including the higher maximum allowable NOx emissions for the low ambient air

temperature condition (below 0°F). The annual NOx emissions were adjusted higher to account for the higher short-term emissions under low ambient air temperature conditions.

Type of Model
The refined air quality analysis was performed with USEPA's AERMOD model (version 18081), using USEPA's recommended regulatory default options and rural dispersion coefficients. Land use around the proposed site indicated that a rural dispersion environment was appropriate for the modeling analysis. For the modeling conversion of NO_x to NO_2, the Tier 2 Ambient Ratio Method (ARM2) with default inputs was utilized. BPIPPRM version 04274 was used to perform GEP stack height analysis and calculate building-specific downwash parameters for adjacent buildings and the stacks. It was verified that the input files included the building-specific parameters.

Meteorological Data
Meteorological inputs consisted of five years (January 2013-December 2017) of sequential surface observations from the NWS station at Bradley International Airport in Windsor Locks, CT and corresponding upper air observations from Albany, NY. The meteorological data-set was obtained from CTDEEP and was appropriate to use in this modeling analysis. The dataset was derived using the 1-minute ASOS wind data to reduce the frequency of calm conditions and the ADJ_U* option was correctly employed.

Background Air Quality Monitors
Appropriate background concentrations from MassDEP's Springfield-Liberty Street monitoring site for the 2015-2017 period were utilized in the analysis. The Springfield monitor is the closest monitoring station to the project located approximately 5.5 miles north/northeast of the Facility.

Receptor Network
A nested Cartesian receptor grid was centered on the Facility with spacing of 20-meters beyond the fence line out to 300 meters, 50-meters out to 500 meters, 100-meters out to 3 km, 500-meters out to 5 km, 1000-meters out to 10 km, and 2000-meters out to 20 km. Facility property line receptors spaced at 20-meter increments were also used. This resulted in a total of 5573 receptors being used in the modeling analysis. Actual terrain elevations for each receptor were obtained from the USGS National Elevation Dataset (NED) and processed using the AERMAP preprocessor.

USEPA SILs
The maximum predicted impacts for the project are below the USEPA SILs for all pollutants and averaging periods. Impacts below USEPA SILs are considered by themselves to be an acceptable demonstration of attainment with applicable NAAQS. The results are shown in Table 3-1 of the Facility's Dispersion Modeling Report dated November 2018, and in the table below.

Maximum Modeled Concentrations for Significance Determination – Project Only

Pollutant	Averaging Period	Maximum Modeled Concentration 100% load ($\mu g/m^3$)	Maximum Modeled Concentration 50% load ($\mu g/m^3$)	Overall Maximum Concentration ($\mu g/m^3$)	SIL ($\mu g/m^3$)	Percent of SIL[(1)]
NO_2	1-hour	2.88	2.98	2.98	7.5	40%
	Annual	0.18	-	0.18	1	18%
CO	1-Hour	189.57	189.58	189.58	2000	9%
	8-hour	19.51	19.51	19.51	500	4%
PM_{10}	24-hour	0.12	0.11	0.12	5	2%
$PM_{2.5}$	24-hour	0.10	0.09	0.10	1.2	9%
	Annual	0.01	-	0.01	0.3	3%
SO_2	1-hour	0.76	0.65	0.76	7.9	10%
	3-hour	0.67	0.61	0.67	25	3%

[(1)] Approximate, rounded values.

Air Dispersion Modeling Results

Even though the maximum predicted impacts for the project are below the EPA SILs for all pollutants, a facility-wide NAAQS modeling analysis was conducted at MassDEP's request for the future configuration of the Facility with the proposed project. The predicted total impact concentrations represent the maximum model-predicted worst-case impact (based on condition and/or year) from the future configuration of the Facility plus background. The results of this modeling analysis are shown in Table 3-2 of the Facility's Dispersion Modeling Report dated November 2018, and in the table below.

Summary of Criteria Pollutant Refined Modeling Analysis - Future Configuration of the Facility

Pollutant	Averaging Period	Modeled Design Concentration ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Modeled Total Impact Concentration (with background) ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	Percent of NAAQS(3)
NO_2	1-hour(1)	8.23	83.35	91.58	188	49%
	1-hour(2)	25.62	83.35	108.97	188	58%
	Annual	0.56	22.84	23.40	100	23%
CO	1-hour	187.44	2528.74	2716.18	40000	7%
	8-hour	19.12	2298.85	2317.97	10000	23%
PM_{10}	24-hour	0.98	27.67	28.65	150	19%
$PM_{2.5}$	24-hour	0.48	17.40	17.88	35	51%
	Annual	0.06	6.92	6.98	12	58%
SO_2	1-hour	0.76	11.70	12.46	196.5	6%
	3-hour	0.88	12.07	12.95	1300	1%

(1) Based on normal temperature ranges for turbines.
(2) Based on below 0° F emissions for turbines.
(3) Approximate, rounded values.

Conclusion
The reviewed modeling demonstrates that the air contaminant emissions from the future configuration of the Facility with the proposed project will neither cause nor contribute to a condition of air pollution with respect to its criteria pollutant emissions as indicated by the modeling analysis described herein.

H. Sound Impacts and Mitigation
A sound analysis, which was included with the Application, evaluated the sound from the operation of the new Solar Taurus 70-10802S, or equivalent, simple cycle combustion turbine and associated centrifugal compressor. In addition, TGP has proposed to mitigate the sound using the following sound suppression and sound transmission prevention features which include:

- Turbine Exhaust Silencer
- Turbine Inlet Silencer
- Turbine Inlet Pulse Updraft Filter
- Upgraded Lube Oil Cooler

- Compressor Building - Existing STC-29 Wall and Roof System
- Equipment Door – Existing STC-21 Insulated Roll-up Door
- Building Ventilation – Existing Silencers and Hoods

To determine the overall change in sound pressure levels from the Facility due to the removal of Emission Unit #1 (54.8 million Btu per hour Solar Centaur H turbine, constructed 1991) and Emission Unit #2 (16.46 million Btu per hour Solar T-1001 turbine, constructed 1965) as well as the addition of the Solar Taurus 70 combustion turbine (94.5 million Btu per hour) and centrifugal compressor, TGP took sound pressure level measurements at the North and West property line while the existing Facility was operating. These sound pressure level measurements were compared, at the same locations, to the predicted sound pressure levels of the Facility, post-project, using typical operating scenarios (determined from a statistical evaluation of the existing stations operating conditions) during the daytime (7AM-10PM) and the quietest early morning hours of 1 AM until 4AM. The comparison of the existing and post-project Facility sound pressure levels resulted in decreased sound pressure levels during both the daytime and early morning hours as provided in Table 8-2 of the Pre-Construction Noise Study dated September 5, 2018, and prepared by SLR International Corporation. The decreased sound pressure levels are a result of the post project Facility being able to satisfy the pipeline capacity using fewer and more modern units. Therefore, TGP has demonstrated that the sound pressure level contributions from the post-project Facility are expected to be quieter than the current operations.

MassDEP also evaluated whether operation of the post-project Facility would cause a “pure tone” condition, defined as any octave band center frequency sound pressure level exceeding the two adjacent center frequency sound pressure levels by 3 decibels or more. The sound analysis showed that there were no predicted pure tones from the post-project Facility.

Historically, there have not been any sound complaints concerning the existing Facility based on MassDEP records. If the post-project Facility will be quieter than the existing Facility, as demonstrated by the sound analysis, than it is not anticipated to have any sound issues.

Based on the proposed sound mitigation measures and the expected decrease in sound pressure levels from the post-project Facility, MassDEP’s review has determined that the sound impacts attributable to the Facility will be mitigated to the maximum extent practical and will comply with 310 CMR 7.10.

2. EMISSION UNIT IDENTIFICATION

Each Emission Unit ("EU") identified in Table 1 is subject to and regulated by this Plan Approval:

Table 1

EU	Description	Design Capacity	Pollution Control Device
7	Solar Taurus 70-10802S, or equivalent as determined by MassDEP, natural gas-fired lean-burn pre-mix simple cycle combustion turbine	• maximum heat input rate of 94.5 million Btu per hour @ 0 °F • maximum output of 11,997 horsepower @ 0°F	Oxidation Catalyst
7a	Venting Processes- including compressor case venting, compressor gas seal system venting, valve operator venting and purging associated with operation of EU 7.	NA	None
14	Facility-wide Piping Components (valves, flanges, etc.) in natural gas service	NA	None

Table 1 Key:

EU = Emission Unit

F = Fahrenheit

° = degrees

3. APPLICABLE REQUIREMENTS

A. OPERATIONAL, PRODUCTION and EMISSION LIMITS

The Permittee is subject to, and shall not exceed the Operational, Production, and Emission Limits as contained in Table 2a/2b:

Table 2a

EU	Operational / Production Limit	Air Contaminant	Emission Limit
7	1. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., EU 7 shall use no more than 776.241 million standard cubic feet of natural gas per consecutive 12-month period.	NOx	42 ppmvd at 15% O_2 (1) 9.0 ppmvd at 15% O_2(2) 14.14 TPY(3)
		CO	5.0 ppmvd at 15% O_2 (1) 1.25 ppmvd at 15% O_2(2) 3.99 TPY(3)
	2. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., only natural gas shall be used as fuel for EU 7.		
	3. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., EU 7 shall not operate more than 200 hours per consecutive 12-month period during ambient temperatures less than 0°F but greater than -10°F.	VOC	5.0 ppmvd at 15% O_2(1), measured as methane 2.5 ppmvd at 15% O_2(2), measured as propane 2.14 TPY(3)
	4. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., EU 7 shall not operate at less than 50% load except during startup and shutdown.	PM	0.0066 lb/MMBtu(3) 2.64 TPY(3)
		PM_{10}	0.0066 lb/MMBtu(3) 2.64 TPY(3)
	5. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2. the total sulfur content, including mercaptans, of the natural gas shall not exceed 5 grains per 100 standard cubic foot of natural gas.	$PM_{2.5}$	0.0066 lb/MMBtu(3) 2.64 TPY(3)
		SO_2	5.59 TPY(3)
	6. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2. each startup of EU 7 shall be no longer than 10 minutes from first combustion of fuel to when SoLoNOx is active.	HAPs (total)	0.00051 lb/MMBtu(1,2) 0.206 TPY(3)

Table 2b			
EU	**Operational / Production Limit**	**Air Contaminant**	**Emission Limit**
7	7. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2. each shutdown of EU 7 shall be no longer than 10 minutes from when SoLoNOx is inactive to flame out.	Opacity	Less than 5%, except 5% to less than 10% for up to 2 minutes during any one hour
7a	8. To determine the compliance status with the annual VOC and HAP emissions limit, VOC and HAP emissions from EU 7a shall be based on a consecutive 12-month total of monthly emissions using Equation 1 herein.	VOC	0.99 TPY
		HAPs (total)	0.014 TPY

Equation 1:

$$m_{pollutant\ per\ consecutive\ 12-month\ period} = \sum_{month=1}^{\substack{consecutive \\ 12-month\ period}} \frac{Q_{gas\ per\ month}\rho_{Gas\ monthly\ average}wt\%_{Pollutant\ monthly\ average}}{2000\ pounds}$$

m = mass of pollutant in units of tons as summed from the previous 12 months of monthly pollutant emissions
wt%= weight percent of pollutant in natural gas on a monthly average basis
Q = quantity of natural gas used per month in units of standard cubic feet
ρ = density of natural gas in units of pounds per standard cubic feet on a monthly average basis

Table 2a/2b Key:

EU = Emission Unit
F = Fahrenheit
° = degrees
CO = Carbon Monoxide
HAP (total) = Total Hazardous Air Pollutants
lb/MMBtu = pounds per million Btu of heat input
NO_x = Nitrogen Oxides
PM = Total Particulate Matter
PM_{10} = Particulate Matter less than or equal to 10 microns in diameter
$PM_{2.5}$ = Particulate Matter less than or equal to 2.5 microns in diameter
ppmvd = parts per million by volume, dry basis
SO_2 = Sulfur Dioxide
SoLoNOx = Solar Turbine's dry low NOx technology
TPY = tons per consecutive 12-month period
VOC = Volatile Organic Compounds

Table 2a/2b Notes:

1.These emission limits apply during ambient temperatures less than 0°F but greater than -10°F at operating loads equal to or greater than 50%.
2. These emission limits apply during ambient temperatures equal to or greater than 0°F at operating loads equal to or greater than 50%.
3. These emission limits apply at all ambient temperatures and at all operating loads.
4. Compliance with the emission limits is based on the applicable EPA reference test method.

B. COMPLIANCE DEMONSTRATION

The Permittee is subject to, and shall comply with, the monitoring, testing, record keeping, and reporting requirements as contained in Tables 3a/3b/3c/3d, 4a/4b/4c, and 5a/5b/5c:

Table 3a	
EU	**Monitoring and Testing Requirements**
7	1. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., EU 7 shall be equipped with instrumentation which shall monitor the manufacturer's recommended operational parameters and continuously indicate whether EU 7 is operating in or out of low-NOx mode, i.e. SoLoNOx mode.
	2. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., the Advanced Catalyst Systems, ADVOCAT, or equivalent, oxidation catalyst associated with EU 7 shall be equipped with instrumentation which shall continuously monitor the catalyst bed inlet temperature as well as the pressure differential across the catalyst bed during operation of EU 7.
	3. EU 7 shall be equipped with instrumentation which shall monitor the number of startups, shutdowns and the duration of each event.
	4. EU 7 shall be equipped with instrumentation which shall monitor the operating load.
	5. EU 7 shall be equipped with instrumentation which shall accurately measure the quantity of natural gas combusted in EU 7.
	6. Pursuant to 40 CFR 60.4365(a) and (b), the Permittee shall utilize one of the following sources of information for purposes of determining the compliance status for the applicable fuel sulfur requirement of the fuel: a. The fuel quality characteristics in a current, valid purchase contract, tariff sheet or transportation contract for natural gas that shall specify the maximum total sulfur content of the natural gas used at the Facility. b. Representative fuel sampling data which show that the sulfur content of the fuel does not exceed 5 grains per 100 standard cubic feet of natural gas. At a minimum, the amount of fuel sampling data specified in section 2.3.1.4 or 2.3.2.4 of appendix D to 40 CFR Part 75 is required.
	7. The Permittee shall continuously monitor the ambient temperature during operation of EU 7.
	8. Within 60 days of achieving maximum production rate, but no later than 180 days after initial startup, the Permittee shall conduct initial USEPA reference method testing for EU 7. The testing shall be conducted on a date mutually agreed upon with MassDEP. Testing shall be conducted to determine the emission rates of NOx, CO, VOC, PM, PM_{10} and $PM_{2.5}$ while EU 7 is operating at plus or minus 25 percent of 100 percent of peak load. The Permittee may perform testing at the highest achievable load point, if at least 75 percent of peak load cannot be achieved in practice.

Table 3b

EU	Monitoring and Testing Requirements
7	9. After the performance of the initial USEPA reference method testing, the Permittee shall conduct subsequent USEPA reference method testing on an annual basis for NOx and CO and on a biennial basis for VOC and $PM_{2.5}$. The testing shall be conducted while EU 7 is operating at plus or minus 25 percent of 100 percent of peak load. The Permittee may perform testing at the highest achievable load point, if at least 75 percent of peak load cannot be achieved in practice. "Annual basis" for purposes of this condition is defined to be no more than 12 months from the date of the previous NOx and CO test. "Biennial basis" for purpose of this condition is defined to be no more than 24 months from the date of the previous NOx, CO, VOC and $PM_{2.5}$ test.
	10. If and when MassDEP requires it, the Permittee shall conduct emission testing in accordance with USEPA Reference Test Methods and 310 CMR 7.13.
7a	11. EU 7a shall be equipped with instrumentation capable of monitoring the duration of each pressurized hold for the compressor casing after each shutdown.
	12. EU 7a shall be equipped with instrumentation which shall continuously monitor the differential pressure of the dry seal system (or other indicators as approved by MassDEP) to verify the dry seal system incorporated into the design of the centrifugal compressor associated with EU 7 has not deteriorated past its useful life due to normal wear and tear, contamination, etc.
	13. The dry seal system for EU 7a shall be equipped with an audible alarm which shall sound if abnormal seal operation is detected.
7 7a	14. The Permittee shall monitor all operations to ensure sufficient information is available to comply with 310 CMR 7.12 Source Registration.
14	15. The Permittee shall monitor all fugitive emission components using optical gas imaging or other monitoring method as approved by MassDEP.
	16. Pursuant to 40 CFR 60.5397a(a), the Permittee shall monitor all fugitive emission components, as defined in 40 CFR 60.5430a, in accordance with paragraphs (b) through (g) of 40 CFR 60.5397a.
	17. Pursuant to 40 CFR 60.5397a(b), the Permittee shall develop an emission monitoring plan that covers the collection of fugitive emission components at compressor stations within each company defined area in accordance with paragraphs (c) and (d) of 40 CFR 60.5397a.
	18. Pursuant to 40 CFR 60.5397a(c), the Permittee's fugitive emissions monitoring plan shall include the elements specified in paragraphs 40 CFR 60.5397a(c)(1) through (8), at a minimum, and as listed below: a. Frequency for conducting surveys. Surveys must be conducted at least as frequently as required by 40 CFR 60.5397a(f) and (g). b. Technique for determining fugitive emissions (*i.e.,* Method 21 at 40 CFR part 60, appendix A-7, or optical gas imaging). c. Manufacturer and model number of fugitive emissions detection equipment to be used. d. Procedures and timeframes for identifying and repairing fugitive emissions components from which fugitive emissions are detected, including timeframes for fugitive emission components that are unsafe to repair. Your repair schedule must meet the requirements of 40 CFR 60.5397a(h) at a minimum. e. Procedures and timeframes for verifying fugitive emission component repairs. f. Records that will be kept and the length of time records will be kept. g. If you are using optical gas imaging, your plan must also include the elements specified in 40 CFR 60.5397a (c)(7)(i) through (vii). h. If you are using Method 21 of appendix A-7 of this 40 CFR Part 60, your plan must also include the elements specified in paragraphs 40 CFR60.5397a(c)(8)(i) and (ii). For the purposes of complying with the fugitive emissions monitoring program using Method 21 a fugitive emission is defined as an instrument reading of 500 ppm or greater.

Table 3c

EU	Monitoring and Testing Requirements
14	19. Pursuant to 40 CFR 60.5397a(d), the Permittee's fugitive emissions monitoring plan shall include the elements specified in paragraphs 40 CFR 60.5397a(d)(1) through (4), at a minimum, as applicable and as listed below: a. Sitemap. b. A defined observation path that ensures that all fugitive emissions components are within sight of the path. The observation path must account for interferences. c. If you are using Method 21, your plan must also include a list of fugitive emissions components to be monitored and method for determining location of fugitive emissions components to be monitored in the field (*e.g.* tagging, identification on a process and instrumentation diagram, etc.). d. Your plan must also include the written plan developed for all of the fugitive emission components designated as difficult-to-monitor in accordance with 40 CFR 60.5397a(g)(3)(i) of this section, and the written plan for fugitive emission components designated as unsafe-to-monitor in accordance with 40 CFR 60.5397a (g)(3)(ii).
	20. Pursuant to 40 CFR 60.5397a(e), each monitoring survey shall observe each fugitive emissions component, as defined in 40 CFR 60.5430a, for fugitive emissions.
	21. Pursuant to 40 CFR 60.5397a(f)(2), the Permittee shall conduct an initial monitoring survey within 60 days of the startup of EU 7.
	22. Pursuant to 40 CFR 60.5397a(g), a monitoring survey of each collection of fugitive emissions components at a compressor station shall be performed at the frequencies specified in 40 CFR 60.5397a(g)(2), as listed below and with the exceptions noted in 40 CFR 60.53.97a(g)(3) and (4). a. A monitoring survey of the collection of fugitive emissions components at a compressor station within a company-defined area must be conducted at least quarterly after the initial survey. Consecutive quarterly monitoring surveys must be conducted at least 60 days apart.
	23. Pursuant to 40 CFR 60.5397a(g)(5), the requirements of 40 CFR 60.5397a(g)(2) are waived for any collection of fugitive emissions components at a compressor station located within an area that has an average calendar month temperature below 0° Fahrenheit for two of three consecutive calendar months of a quarterly monitoring period. The calendar month temperature average for each month within the quarterly monitoring period must be determined using historical monthly average temperatures over the previous three years as reported by a National Oceanic and Atmospheric Administration source or other source approved by MassDEP and the USEPA. The requirements of 40 CFR 60.5397a (g)(2) of this section shall not be waived for two consecutive quarterly monitoring periods.
	24. Pursuant to 40 CFR 60.5397a(h)(3)(i) and (ii), each repaired or replaced fugitive emissions component must be resurveyed as soon as practicable, but no later than 30 days after being repaired, to ensure that there are no fugitive emissions. a. For repairs that cannot be made during the monitoring survey when the fugitive emissions are initially found, the operator may resurvey the repaired fugitive emissions components using either Method 21 or optical gas imaging within 30 days of finding such fugitive emissions. b. For each repair that cannot be made during the monitoring survey when the fugitive emissions are initially found, a digital photograph must be taken of that component or the component must be tagged for identification purposes. The digital photograph must include the date that the photograph was taken, must clearly identify the component by location within the site (*e.g.*, the latitude and longitude of the component or by other descriptive landmarks visible in the picture).

Table 3d	
EU	**Monitoring and Testing Requirements**
14	25. Pursuant to 40 CFR 60.5397a(h)(3)(iv), operators that use optical gas imaging to resurvey the repaired fugitive emissions components, are subject to the resurvey provisions specified in 40 CFR 60.5397a(h)(3)(iv)(A) and (B) and as listed below: a. A fugitive emissions component is repaired when the optical gas imaging instrument shows no indication of visible emissions. b. Operators must use the optical gas imaging monitoring requirements specified in 40 CFR 60.5397a(c)(7).
	26. Beginning on the startup date of EU 7, the Permittee shall conduct monthly walk-around inspections during daylight hours and while the Facility is operating to detect for: a. the presence of visible fugitive emissions. b. the presence of audible fugitive emissions. c. the presence of olfactible fugitive emissions.

Table 3a/3b/3c/3d Key:

AVO = audible, visible, olfactory
CFR = Code of Federal Regulations
CO = Carbon Monoxide
EU = Emission Unit
NOx= Nitrogen oxides
PM = Total Particulate Matter
PM_{10} = Particulate Matter less than or equal to 10 microns in diameter
$PM_{2.5}$ = Particulate Matter less than or equal to 2.5 microns in diameter
USEPA = The United States Environmental Protection Agency
VOC= Volatile Organic Compounds

Table 4a	
EU	**Recordkeeping Requirements**
7	1. The Permittee shall maintain comprehensive and accurate records of: a. the date, time and duration, in units of minutes, of each startup and shutdown event. b. the number of startup and shutdown events each month and in each 12 consecutive month period.
	2. EU 7 shall be equipped with instrumentation which shall continuously record the catalyst bed inlet temperature, the pressure differential across the catalyst bed, the SoLoNOx status and the operating load during operation of EU 7.
	3. The Permittee shall maintain comprehensive and accurate records during the operation of EU 7 of: a. the actual ambient temperature of each hour. b. the date and time during which the ambient temperature is less than 0° Fahrenheit. c. the number of hours each month and in each 12 consecutive month period during which the ambient temperature is less than 0° Fahrenheit. d. the date, duration of time and reason for any operating loads less than 50% which do not occur during startup or shutdown. e. the date, duration of time and reason for each period during which the SoLoNOx is not operational.
7a	4. EU 7a shall be equipped with instrumentation which shall continuously record the differential pressure of the dry seal system (or other indicators as approved by MassDEP).
	5. The Permittee shall maintain comprehensive and accurate records of all alarms associated with the dry seal system which shall include: a. the date and time of each alarm. b. the differential pressure during each alarm. c. the reason for the alarm. d. the corrective action taken.
	6. The Permittee shall maintain comprehensive and accurate records of each occurrence of gas venting which shall include: a. the date and time of venting. b. quantity of gas vented. c. reason for venting. d. the dates, start time, end time and duration of each pressurized hold associated with compressor case venting.
	7. The Permittee shall maintain comprehensive and accurate records of: a. the amount of natural gas vented to atmosphere each month. b. the weight percent of VOCs in natural gas on a monthly average basis, with supporting calculations and/or documentation. c. the weight percent of total HAPs in natural gas on a monthly average basis, with supporting calculations and/or documentation. d. the density of natural gas in units of pounds per standard cubic feet on a monthly average basis, with supporting calculations and/or documentation.

Table 4b

EU	Recordkeeping Requirements
14	8. Pursuant to 40 CFR 60.5397a(a), the Permittee shall keep records in accordance with paragraph (i) of 40 CFR 60.5397a.
	9. Pursuant to 40 CFR 60.5397a(i), records for each monitoring survey shall be maintained as specified in 40 CFR 60.5420a(c)(15).
	10. Pursuant to 40 CFR 60.5420a(c), the Permittee shall maintain the records identified as specified in 40 CFR 60.7(f) and in 40 CFR 60.5420a(c)(15). All records required by this subpart must be maintained either onsite or at the nearest local field office for at least 5 years. Any records required to be maintained by this subpart that are submitted electronically via the USEPA's CDX may be maintained in electronic format.
	11. Pursuant to 40 CFR 60.5420a(c)(15), for each collection of fugitive emissions components at a compressor station, the Permittee shall maintain the records identified in 40 CFR 60.5420a (c)(15)(i) through (iii) and as listed below: a. The fugitive emissions monitoring plan as required in §60.5397a(b), (c), and (d). b. The records of each monitoring survey as specified in 40 CFR 60.5420a(c)(15)(ii)(A) through (I) and as listed below. i. Date of the survey. ii. Beginning and end time of the survey. iii. Name of operator(s) performing survey. You must note the training and experience of the operator. iv. Monitoring instrument used. v. When optical gas imaging is used to perform the survey, one or more digital photographs or videos, captured from the optical gas imaging instrument used for conduct of monitoring, of each required monitoring survey being performed. The digital photograph must include the date the photograph was taken and the latitude and longitude of the collection of fugitive emissions components at a compressor station imbedded within or stored with the digital file. As an alternative to imbedded latitude and longitude within the digital file, the digital photograph or video may consist of an image of the monitoring survey being performed with a separately operating GPS device within the same digital picture or video, provided the latitude and longitude output of the GPS unit can be clearly read in the digital image. vi. Ambient temperature, sky conditions, and maximum wind speed at the time of the survey. vii. Any deviations from the monitoring plan or a statement that there were no deviations from the monitoring plan. viii. Documentation of each fugitive emission, including the information specified in 40 CFR 60.5420a(c)(15)(ii)(I)(1) through (12). c. For the collection of fugitive emissions components at a compressor station, if a monitoring survey is waived under §60.5397a(g)(5), you must maintain records of the average calendar month temperature, including the source of the information, for each calendar month of the quarterly monitoring period for which the monitoring survey was waived.

Table 4c

EU	Recordkeeping Requirements
14	12. The Permittee shall maintain a log of the results of each monthly AVO inspection which shall include, but is not limited to: a. the date of the inspection performance. b. the beginning and end time of the inspection performance. c. a list of each detected visible, audible or olfactible fugitive emission; if any of these are not detected, a statement shall be made that specifies which of the emissions were not detected. d. the physical location and/or source of each detected visible, audible or olfactible fugitive emission. e. the name of the company representative performing the inspection. f. the corrective actions taken for any detected visible, audible or olfactible fugitive emissions.
7 7a 14	13. The Permittee shall maintain adequate records on-site to demonstrate compliance status with all operational, production, and emission limits contained in Table 2a/2b above. Records shall also include the actual emissions of air contaminant(s) emitted for each calendar month and for each consecutive twelve-month period (current month plus prior eleven months). These records shall be compiled no later than the 15th day following each month. An electronic version of a MassDEP approved record keeping form, in Microsoft Excel format, may be downloaded at https://www.mass.gov/guides/massdep-facility-wide-emission-restrictions-caps-reporting#-record-keeping-&-reporting-.
	14. The Permittee shall maintain records of monitoring and testing as required by Table 3a/3b/3c/3d.
	15. The Permittee shall maintain a copy of this Plan Approval, underlying Application and the most up-to-date SOMP for the EU(s) and PCD(s) approved herein on-site.
	16. The Permittee shall maintain a record of routine maintenance activities performed on the approved EU(s), PCD(s) and monitoring equipment. The records shall include, at a minimum, the type or a description of the maintenance performed and the date and time the work was completed.
	17. The Permittee shall maintain a record of all malfunctions affecting air contaminant emission rates on the approved EU(s), PCD(s) and monitoring equipment. At a minimum, the records shall include: date and time the malfunction occurred; description of the malfunction; corrective actions taken; the date and time corrective actions were initiated and completed; and the date and time emission rates and monitoring equipment returned to compliant operation.
	18. The Permittee shall maintain records required by this Plan Approval on-site for a minimum of five (5) years.
	19. The Permittee shall make records required by this Plan Approval available to MassDEP and USEPA personnel upon request.
7 7a	20. The Permittee shall maintain records to ensure sufficient information is available to comply with 310 CMR 7.12 Source Registration.

Table 4a/4b/4c Key:

AVO = audible, visible, olfactory
CFR = Code of Federal Regulations
EU = Emission Unit
HAPs = Hazardous Air Pollutants
SOMP = Standard Operating and Maintenance Procedure
PCD = Pollution Control Device
VOCs = Volatile Organic Compounds
USEPA = United States Environmental Protection Agency

Table 5a	
EU	**Reporting Requirements**
7	1. Pursuant to 40 CFR 60.7(a)(1), the Permittee shall notify the Western Regional Office of MassDEP and the USEPA, in writing, the actual date that construction of EU 7 commenced. This notice shall be postmarked no later than 30 days after such date.
	2. The Permittee shall notify the Western Regional Office of MassDEP and the USEPA, in writing, the actual date of initial startup of EU 7. This notice shall be provided to MassDEP within 5 days of initial startup and to the USEPA in accordance with 40 CFR 60.7(a)(3).
	3. At least 30 days prior to emission testing, the Permittee shall submit to the Western Regional Office of MassDEP for written approval a stack emission pretest protocol.
	4. The Permittee shall provide the Western Regional office of MassDEP and the USEPA at least 30 days prior notice of any performance test to afford the MassDEP and the USEPA the opportunity to have an observer present. If after 30 days notice for an initially scheduled performance test, there is a delay (due to operational problems, etc.) in conducting the scheduled performance test, the owner or operator of an affected facility shall notify the MassDEP and the USEPA as soon as possible of any delay in the original test date, either by providing at least 7 days prior notice of the rescheduled date of the performance test, or by arranging a rescheduled date with the MassDEP and the USEPA by mutual agreement. The USEPA shall only be notified for testing that is required pursuant to 40 CFR Part 60 Subpart KKKK.
	5. Within 60 days after emission testing, the Permittee shall submit to the Western Regional Office of MassDEP a final stack emission test results report. A final stack emission test results report shall also be submitted to the USEPA in accordance with 40 CFR 60.4375(b).
14	6. Pursuant to 40 CFR 60.5397a(a), the Permittee shall report in accordance with paragraph (j) of 40 CFR 60.5397a.
	7. Pursuant to 40 CFR 60.5397a(j), annual reports shall be submitted for each collection of fugitive emissions components at each collection of fugitive emissions components at a compressor station that include the information specified in 40 CFR 60.5420a(b)(7). Multiple collection of fugitive emissions components at a compressor station may be included in a single annual report.

Table 5b

EU	Reporting Requirements
14	8. Pursuant to 40 CFR 60.5420a(b), the Permittee shall submit annual reports containing the information specified in 40 CFR 60.5420a(b)(1) and (7) and as listed below. The Permittee shall submit annual reports following the procedures specified in 40 CFR 60.5420a(b)(11). The initial annual report is due no later than 90 days after the end of the initial compliance period as determined according to 40 CFR 60.5410a. Subsequent annual reports are due no later than same date each year as the initial annual report. If you own or operate more than one affected facility, you may submit one report for multiple affected facilities provided the report contains all of the information required as specified in 40 CFR 60.5420a(b)(1) through (8), except as provided in 40 CFR 60.5420a(b)(13). Annual reports may coincide with title V reports as long as all the required elements of the annual report are included. You may arrange with the USEPA and MassDEP a common schedule on which reports required by this part may be submitted as long as the schedule does not extend the reporting period. a. The general information specified in 40 CFR 60.5420a (b)(1)(i) through (iv) for all reports as listed below: i. The company name, site name associated with the affected facility, US Well ID or US Well ID associated with the affected facility, if applicable, and address of the affected facility. If an address is not available for the site, include a description of the site location and provide the latitude and longitude coordinates of the site in decimal degrees to an accuracy and precision of five (5) decimals of a degree using the North American Datum of 1983. ii. An identification of each affected facility being included in the annual report. iii. Beginning and ending dates of the reporting period. iv. A certification by a certifying official of truth, accuracy, and completeness. This certification shall state that, based on information and belief formed after reasonable inquiry, the statements and information in the document are true, accurate, and complete. b. For the collection of fugitive emissions components at each compressor station within the company-defined area, the records of each monitoring survey including the information specified in 40 CFR 60.5420a(b)(7)(i) through (xii) and as listed below. For the collection of fugitive emissions components at a compressor station, if a monitoring survey is waived under 40 CFR 60.5397a(g)(5), you must include in your annual report the fact that a monitoring survey was waived and the calendar months that make up the quarterly monitoring period for which the monitoring survey was waived. i. Date of the survey. ii. Beginning and end time of the survey. iii. Name of operator(s) performing survey. If the survey is performed by optical gas imaging, you must note the training and experience of the operator. iv. Ambient temperature, sky conditions, and maximum wind speed at the time of the survey. v. Monitoring instrument used. vi. Any deviations from the monitoring plan or a statement that there were no deviations from the monitoring plan. vii. Number and type of components for which fugitive emissions were detected. viii. Number and type of fugitive emissions components that were not repaired as required in §60.5397a(h). ix. Number and type of difficult-to-monitor and unsafe-to-monitor fugitive emission components monitored. x. The date of successful repair of the fugitive emissions component. xi. Number and type of fugitive emission components placed on delay of repair and explanation for each delay of repair. xii. Type of instrument used to resurvey a repaired fugitive emissions component that could not be repaired during the initial fugitive emissions finding.

Table 5c	
EU	**Reporting Requirements**
14	9. Pursuant to 40 CFR 60.5420a(b)(11), the Permittee shall submit reports, concerning 40 CFR Part 60, Subpart OOOOa, to the USEPA via the CEDRI. (CEDRI can be accessed through the USEPA's CDX (*https://cdx.epa.gov/)*.) You must use the appropriate electronic report in CEDRI for this subpart or an alternate electronic file format consistent with the extensible markup language (XML) schema listed on the CEDRI Web site (*https://www.epa.gov/electronic-reporting-air-emissions/compliance-and-emissions-data-reporting-interface-cedri#list)* If the reporting form specific to this subpart is not available in CEDRI at the time that the report is due, you must submit the report to the Administrator at the appropriate address listed in §60.4. Once the form has been available in CEDRI for at least 90 calendar days, you must begin submitting all subsequent reports via CEDRI. The reports must be submitted by the deadlines specified in this subpart, regardless of the method in which the reports are submitted.
	10. All reports submitted to EPA concerning 40 CFR Part 60, Subpart OOOOa shall also be submitted in hard copy to the Western Regional Office of MassDEP.
7 7a 14	11. The Permittee shall submit to MassDEP all information required by this Plan Approval over the signature of a "Responsible Official" as defined in 310 CMR 7.00 and shall include the Certification statement as provided in 310 CMR 7.01(2)(c).
	12. The Permittee shall notify the Western Regional Office of MassDEP, BAW Air Quality Chief by telephone: 413-755-2115, email: marc.simpson@mass.gov or fax : 413-784-1149, as soon as possible, but no later than three (3) business day after discovery of an exceedance(s) of Table 2a/2b requirements. A written report shall be submitted Air Quality Chief at MassDEP within ten (10) business days thereafter and shall include: identification of exceedance(s), duration of exceedance(s), reason for the exceedance(s), corrective actions taken, and action plan to prevent future exceedance(s).
7 7a	13. The Permittee shall report annually to MassDEP, in accordance with 310 CMR 7.12, all information as required by the Source Registration/Emission Statement Form.
Facility-wide	14. The Permittee shall notify the Western Regional Office of MassDEP, in writing, the date on which EU 1, EU 2 and EU 5 have been removed from the Facility or rendered inoperable. This notice shall be provided to MassDEP within (5) days of each emission unit being removed or rendered inoperable.

Table 5a/5b/5c Key:

BAW = Bureau of Air and Waste
EU = Emission Unit
CEDRI = Compliance and Emissions Data Reporting Interface
CDX = Central Data Exchange
CFR = Code of Federal Regulations
USEPA = The United States Environmental Protection Agency

4. SPECIAL TERMS AND CONDITIONS

A. The Permittee is subject to, and shall comply with, the Special Terms and Conditions as contained in Table 6a/6b below:

Table 6a

EU	Special Terms and Conditions
7	1. EU 7 is subject to Subpart KKKK of the federal Standards of Performance for New Stationary Sources, 40 CFR Part 60.4300 through 60.4420 and shall comply with all applicable requirements.
	2. EU 7 shall consist of the equipment specified in Table 1 herein.
	3. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., EU 7 shall be equipped with an Advanced Catalyst Systems, ADVOCAT, or equivalent, oxidation catalyst.
	4. The oxidation catalyst associated with EU 7 shall have a minimum operating temperature of 550°F at the inlet of the catalyst bed during any time that EU 7 is operating, except during startup.
	5. The following definitions apply to the operation of EU 7: "Startup" means the ten minute period from first combustion of fuel to when SoLoNOx is active. "Shutdown" means the ten minute period from when SoLoNOx is inactive to flame out.
7a	6. EU 7a consists of the venting processes associated with the operation of EU 7 as specified in Table 1 herein.
	7. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., the centrifugal compressor associated with EU 7 shall incorporate dry seals.
	8. Pursuant to the best available control technology provision of 310 CMR 7.02(8)(a)2., after a shutdown of EU 7, the Permittee shall maintain the operating pressure of the compressor casing through the next startup of EU 7 or for a minimum 14-day pressurized hold, whichever occurs first.
	9. The centrifugal compressor, along with the dry seals, associated with EU 7 shall be maintained in accordance with the manufacturer's recommended practices.
14	10. EU 14 consists of the equipment specified in Table 1 herein.
	11. EU 14 is subject to Subpart OOOOa of the federal Standards of Performance for New Stationary Sources, 40 CFR Part 60.5360a through 60.5499a and shall comply with all applicable requirements.
	12. Pursuant to 40 CFR 60.5397a(a), the Permittee shall repair all sources of fugitive emission in accordance with paragraph (h) of 40 CFR 60.5397a. For purposes of 40 CFR Part 60 Subpart OOOOa, fugitive emissions are defined as: Any visible emission from a fugitive emissions component observed using optical gas imaging or an instrument reading of 500 ppm or greater using Method 21.

Table 6b	
EU	**Special Terms and Conditions**
14	13. Pursuant to 40 CFR 60.5397a(h), each identified source of fugitive emissions shall be repaired or replaced in accordance with 40 CFR 60.5397a(h)(1) and 40 CFR 60.5397a(h)(2) and as listed below: a. Each identified source of fugitive emissions shall be repaired or replaced as soon as practicable, but no later than 30 calendar days after detection of the fugitive emissions. b. If the repair or replacement is technically infeasible, would require, a compressor station shutdown, or would be unsafe to repair during operation of the unit, the repair or replacement must be completed during the next scheduled compressor station shutdown, or within 2 years, whichever is earlier.
7 7a 14	14. The Permittee may make the approved changes herein, upon the submittal and receipt by MassDEP of a BWP AQ 10 Operating Permit Minor Modification application pursuant to 310 CMR 7.00 Appendix C (8)(d)3.
Facility-wide	15. Existing EU 1, EU 2 and EU 5 shall be removed from the Facility, or rendered inoperable, prior to the operation of EU 7.

Table 6a/6b Key:

CFR = Code of Federal Regulations
EU = Emission Unit

B. The Permittee shall install and use an exhaust stack, as required in Table 7, on each of the Emission Units that is consistent with good air pollution control engineering practice and that discharges so as to not cause or contribute to a condition of air pollution. Each exhaust stack shall be configured to discharge the gases vertically and shall not be equipped with any part or device that restricts the vertical exhaust flow of the emitted gases, including, but not limited to, rain protection devices known as "shanty caps" and "egg beaters."

C. The Permittee shall install and utilize exhaust stacks with the following parameters, as contained in Table 7, for the Emission Units that are regulated by this Plan Approval:

Table 7				
EU	**Stack Height Above Ground (feet)**	**Stack Inside Exit Dimensions (inches)**	**Stack Gas Exit Velocity Range (CFM)**	**Stack Gas Exit Temperature Range (°F)**
7	62.5	60	119,228 – 132,850	~854

Table 7 Key:

EU = Emission Unit
cfm = cubic feet per minute
°F = Degree Fahrenheit

5. GENERAL CONDITIONS

The Permittee is subject to, and shall comply with, the following general conditions:

A. Pursuant to 310 CMR 7.01, 7.02, 7.09 and 7.10, should any nuisance condition(s), including but not limited to smoke, dust, odor or noise, occur as the result of the operation of the Facility, then the Permittee shall immediately take appropriate steps including shutdown, if necessary, to abate said nuisance condition(s).

B. If asbestos remediation/removal will occur as a result of the approved construction, reconstruction, or alteration of this Facility, the Permittee shall ensure that all removal/remediation of asbestos shall be done in accordance with 310 CMR 7.15 in its entirety and 310 CMR 4.00.

C. If construction or demolition of an industrial, commercial or institutional building will occur as a result of the approved construction, reconstruction, or alteration of this Facility, the Permittee shall ensure that said construction or demolition shall be done in accordance with 310 CMR 7.09(2) and 310 CMR 4.00.

D. Pursuant to 310 CMR 7.01(2)(b) and 7.02(7)(b), the Permittee shall allow MassDEP and / or USEPA personnel access to the Facility, buildings, and all pertinent records for the purpose of making inspections and surveys, collecting samples, obtaining data, and reviewing records.

E. This Plan Approval does not negate the responsibility of the Permittee to comply with any other applicable Federal, State, or local laws or regulations now or in the future.

F. The Application is incorporated into this Plan Approval by reference. Should there be any differences between the Application and this Plan Approval, the Plan Approval shall govern.

G. Pursuant to 310 CMR 7.02(3)(k), MassDEP may revoke this Plan Approval if the construction work is not commenced within two years from the date of issuance of this Plan Approval, or if the construction work is suspended for one year or more.

H. This Plan Approval may be suspended, modified, or revoked by MassDEP if MassDEP determines that any condition or part of this Plan Approval is being violated.

I. This Plan Approval may be modified or amended when in the opinion of MassDEP such is necessary or appropriate to clarify the Plan Approval conditions or after consideration of a written request by the Permittee to amend the Plan Approval conditions.

J. Pursuant to 310 CMR 7.01(3) and 7.02(3)(f), the Permittee shall comply with all conditions contained in this Plan Approval. Should there be any differences between provisions contained in the General Conditions and provisions contained elsewhere in the Plan Approval, the latter shall govern.

6. MASSACHUSETTS ENVIRONMENTAL POLICY ACT

The project was determined to be subject to the requirements of the Massachusetts Environmental Policy Act (MEPA) Massachusetts General Laws (M.G.L.) Chapter 30, Section 61-62H. On August 2, 2019, the Secretary of Energy and Environmental Affairs (EEA) issued a Certificate for TGP's Final Environmental Impact Report (FEIR)- EEA No. 15879 concerning the construction of a 2.1-mile long pipeline loop in Agawam; replacement of two combustion turbines with a single, larger combustion turbine at TGP's Compressor Station 261 (CS 261) in Agawam; and construction of a new meter station in Longmeadow. It also identified appurtenant structures and access roads and removal of a portion of an inactive pipeline. The certificate stated that the FEIR- EEA No. 15879 adequately and properly complies with MEPA and its implementing regulations. As part of the FEIR, the proponent included Section 61 findings pursuant to the Global Warming Solutions Act of 2008. The proponent has committed to implementing the Section 61 Findings, provided in Appendix A herein, to avoid, minimize and mitigate damage to the environment.

7. APPEAL OF DECISION

This Decision is an action of MassDEP. If you are aggrieved by this action, you may request an adjudicatory hearing. A request for a hearing must be made in writing and postmarked within twenty-one (21) days of the date of issuance of this Decision.

Under 310 CMR 1.01(6)(b), the request must state clearly and concisely the facts, which are the grounds for the request, and the relief sought. Additionally, the request must state why the Decision is not consistent with applicable laws and regulations.

The hearing request along with a valid check payable to the Commonwealth of Massachusetts in the amount of one hundred dollars ($100.00) and a completed Adjudicatory Hearing Fee Transmittal Form, http://www.mass.gov/eea/docs/dep/service/adr/adjherfm.doc must be mailed to:

Commonwealth of Massachusetts
Department of Environmental Protection
P.O. Box 4062
Boston, MA 02211

This request will be dismissed if the filing fee is not paid, unless the appellant is exempt or granted a waiver as described below. The filing fee is not required if the appellant is a city or town (or municipal agency), county, or district of the Commonwealth of Massachusetts, or a municipal housing authority.

MassDEP may waive the adjudicatory hearing filing fee for a person who shows that paying the fee will create an undue financial hardship. A person seeking a waiver must file, together with the hearing request as provided above, an affidavit setting forth the facts believed to support the claim of undue financial hardship.

Should you have any questions concerning this Plan Approval, please contact Cortney Danneker by telephone at 413-755-2234, or in writing at the letterhead address.

This final document copy is being provided to you electronically by the Department of Environmental Protection. A signed copy of this document is on file at the DEP office listed on the letterhead.

Marc Simpson
Air Quality Permit Chief
Bureau of Air and Waste

ecc:
MassDEP/WERO – Peter Czapienski
MassDEP/Boston - Yi Tian
Fariba Mehdizadeh – Tennessee Gas Pipeline Co., LLC

Appendix A

FINDING PURSUANT TO M.G.L. CHAPTER 30, SECTION 61

Project Name: Tennessee Gas Pipeline 261 Upgrade Projects
Project Location: Agawam and Longmeadow
Project Proponent: Tennessee Gas Pipeline Company LLC
EEA Number: 15879

The FEIR provided draft Section 61 Findings for use by State Agencies. The Proponent has committed to implementing the measures listed below to avoid, minimize and mitigate damage to the environment. The Proponent must provide a greenhouse gas self-certification to the MEPA office that is signed by an appropriate professional (e.g., engineer, architect, transportation planner, general contractor) and indicates that all of the required mitigation measures, or their equivalent to achieve emissions reductions identified in the FEIR, have been completed for each building. The certification must be supported by plans that clearly illustrate the greenhouse gas mitigation measure have been incorporated into the project.

Greenhouse Gas Emissions

- Use of hot-taps to minimize the amount of vented gas when pipelines are connected;
- Cathodic protection of pipes to minimize leaks caused by pipeline corrosion;
- Use of gas odorizer to allow for quicker leak detection;
- Conduct periodic flyovers of the pipeline to inspect the condition of the ROW;
- Maintain readily available leak repair equipment to minimize releases of gas;
- Reduce pressure prior to venting pipelines;
- Incorporate design features in the new turbine to minimize the release of natural gas, including a dry seal system;
- Use of an electric start for the new turbine;
- Inspection and maintenance of the compressor units to minimize leaks; and,
- Use of construction vehicles meeting Tier 3 and 4 emission standards.

Climate Change Adaptation and Resiliency

- Design pipeline crossings of water bodies to minimize impacts from high velocity flows;
- Design facilities in accordance with federal safety standards to protect pipelines, buildings and other structures from storm and fire related damage;
- Use of a backup generator to maintain power at the compressor station and meter station in the event of a loss of power;
- Remote monitoring of gas pressures, flows and deliveries; and,

- Respond to natural disasters and emergencies in accordance with the Proponent's Emergency Response Manual.

Air Quality

- Use of SoLoNox combustion control system in the compressor turbine to minimize NOx formation;
- Use of sensors in low temperature conditions to adjust fuel mixture to the compressor turbine;
- Implementation of good combustion practices in the compressor turbine, such as maintaining the proper ratio of air and fuel;
- Use of an oxidation catalyst in the compressor turbine;
- Use of low sulfur natural gas fuel for the compressor turbine;
- Minimize release of gas during venting and use of dry seals;
- Use of low-VOC natural gas; and,
- Limit idling by construction vehicles, comply with MassDEP's Diesel Retrofit Program during construction and require contractors to use ultra-low sulfur diesel in off-road engines.

Noise

- Use of custom exhaust silencer with the new compressor turbine to reduce operational sound levels compared to existing conditions;
- Use at least one in-duct silencer for the air intake system;
- Place most equipment at the meter station within buildings;
- Install building ventilation systems in the meter station buildings to minimize noise;
- Use of landscaping to minimize noise;
- Use sound curtains if necessary during HDD;
- Conduct construction activities during daylight hours; and,
- Equip construction equipment with mufflers.

APPENDIX B. HOPKINTON PLAN APPROVAL

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Central Regional Office • 8 New Bond Street, Worcester MA 01606 • 508-792-7650

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Matthew A. Beaton
Secretary

Martin Suuberg
Commissioner

February 26, 2019

Mr. Miguel Rodriguez
Hopkinton LNG Corp.
157 Cordaville Road
Southborough, MA 01772

RE: Hopkinton
ePlace Authorization No.: AQ02F-0000017
Application No.: 17-AQ02/AQ03F-000006
Approval No.: CE-17-032
Class: OP
FMF No.: 130904
AIR QUALITY PLAN APPROVAL

Dear Mr. Rodriguez:

The Massachusetts Department of Environmental Protection ("MassDEP"), Bureau of Air and Waste, has reviewed your Non-major Comprehensive Plan Application ("Application") listed above. This Application concerns the proposed construction and operation of a replacement LNG Liquefaction system (turbine compressor and ancillary equipment) at your liquefied natural gas ("LNG") storage facility located at 52 Wilson Street in Hopkinton, Massachusetts ("Facility"). The Application bears the seal and signature of Kristen Santoro, Massachusetts Registered Professional Engineer Number 47121.

This Application was submitted in accordance with 310 CMR 7.02 Plan Approval and Emission Limitations as contained in 310 CMR 7.00 "Air Pollution Control" regulations adopted by MassDEP pursuant to the authority granted by Massachusetts General Laws, Chapter 111, Section 142 A-O, Chapter 21C, Section 4 and 6, and Chapter 21E, Section 6. MassDEP's review of your Application has been limited to air pollution control regulation compliance and does not relieve you of the obligation to comply with any other regulatory requirements.

MassDEP has determined that the Application is administratively and technically complete and that the Application is in conformance with the Air Pollution Control regulations and current air pollution control engineering practice, and hereby grants this **Plan Approval** for said Application, as submitted, subject to the conditions listed below.

Please review the entire Plan Approval, as it stipulates the conditions with which the Facility owner/operator ("Permittee") must comply in order for the Facility to be operated in compliance with this Plan Approval.

This information is available in alternate format. Contact Michelle Waters-Ekanem, Director of Diversity/Civil Rights at 617-292-5751.
TTY# MassRelay Service 1-800-439-2370
MassDEP Website: www.mass.gov/dep

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1. DESCRIPTION OF FACILITY AND APPLICATION

A. HISTORY AND DESCRIPTION OF OPERATIONS

The Permittee operates a liquefied natural gas ("LNG") vaporization and natural gas ("NG") liquefaction facility ("the Facility"). During high demand months (winter) the Facility operates in vaporization mode, and during low demand months the Facility liquefies NG for storage.

The Facility was constructed around 1967 and has not been significantly modified since then. To date MassDEP has not issued any Air Quality Plan Approvals for the whole Facility, since its construction predates the promulgation of the Air Pollution Control Regulations. The Facility is a major source for nitrogen oxides ("NO_x") and volatile organic compounds ("VOC"). The Permittee holds an Operating Permit ("OP") for the Facility, most recently issued as Renewal Operating Permit Transmittal Number ("Tr") X236053 on August 17, 2012.

The Facility is the largest natural gas supply system peak-shaving plant facility in New England, with a gas storage capacity of 3 billion cubic feet (36.5 million gallons). The Facility provides a backup supply of independent natural gas for Eversource's customers, as well as helps to maintain seasonal natural gas price stability to consumers. In the recent past, the Facility has needed to operate more often due to pipeline constraints limiting natural gas into the region. Eversource's natural gas distribution system serves 300,000 customers in 36 towns across Massachusetts.

Peak-shaving LNG facilities, including Hopkinton LNG, typically operate 20 to 30 days a year, or in some years not at all. The typical concept of "peak-shaving" is that natural gas is maintained in a liquefied state during the spring, summer and fall seasons, and is stored for peak-demand use during the winter months. When the Facility is vaporizing at full capacity, the gas in storage would be vaporized and injected into the pipeline in approximately 12 days.

The Facility helps provide system resiliency and control of the price of natural gas for consumers in Massachusetts during periods of high demand, typically during very cold winter periods. During these times, LNG that is stored on-site is vaporized back to natural gas and used to supplement supply in the Eversource distribution system.

On May 18, 2016, MassDEP issued Plan Approval Tr X268846 to the Permittee for replacing the burners on the four existing LNG vaporizers that are used to vaporize the LNG in storage prior to injecting it into the natural gas distribution system during the winter months. On January 16, 2018, MassDEP issued Plan Approval Tr X268846-A1 to amend the vaporizer plan approval by clarifying the name of the Permittee ("Hopkinton LNG Corp.").

The Facility has historically used four existing, natural gas fired reciprocating internal combustion engine ("RICE") powered compressors to compress the coolant used in the natural gas liquefaction process. A fifth RICE has been used as a boil-off gas ("BOG") compressor.

B. PROJECT DESCRIPTION

The Permittee proposes to replace its existing nominal 17 Million Standard Cubic Feet per Day ("MMscfd") natural gas pretreatment and liquefaction systems with construction of a slightly larger, state-of-the-art nominal 21 MMscfd pretreatment and liquefaction system on the opposite side of Wilson Street, directly to the south of the existing LNG storage tanks, including new supporting auxiliary systems, cooling systems, control systems and electrical distribution. The centerpiece of this project will be a Solar Mars 100 gas turbine compressor to replace the existing RICE compressors. The Project will include certain air pollution control equipment, including a small thermal oxidizer and a state-of-the-art elevated emergency flare designed for a smokeless destruction of released methane.

The Solar Mars 100 turbine will be natural-gas fired and rated at126.6 million British Thermal Units per hour ("MMBtu/hr") at full load, ISO conditions, and will be designated as Emission Unit ("EU") 20. As stated in the Application, various constituents of pipeline natural gas that could interfere with methane liquefaction will be combusted by the Solar Mars 100 turbine.

The Project also includes four new BOG compressors, all of which will be the same model positive displacement compressor. The two primary BOG compressors will have electric drive motors. The two backup BOG compressors will be powered by natural-gas fired engines rated at 14.6 MMBtu/hr each and will be designated as EU 26 and 27.

There will be a new emergency flare stack rated at 825.7 MMBtu/hr. It will burn natural gas that must be released from the process during liquefaction startup and shutdown each season (several hours per year), and during process upsets (expected to be only a few hours per year). The flare will be designated as EU 24.

In addition, the Project will include the following four smaller ancillary natural gas fired equipment systems:

- Hot Oil Heater rated at 12.6 MMBtu/hr (EU 21)
- Nominal 300 kilowatt ("kW") emergency generator rated at 1.02 MMBtu/hour
- Regenerative Gas Heater rated at 4.4 MMBtu/hr (EU 22)
- Thermal Oxidizer rated at 5.5 MMBtu/hr (control device for the amine stripper offgas) (EU 23)

All of the above mentioned new fuel burning equipment will burn only natural gas. The fuel burning equipment will emit products of combustion including nitrogen oxides ("NOx"), carbon monoxide ("CO"), particulate matter ("PM"), and sulfur dioxide ("SO_2").

The proposed emergency generator and the two natural gas-fired Boil-off Gas Compressor engines are subject to the 310 CMR 7.26 Environmental Results Program ("ERP") and will be

certified to meet applicable ERP emission limits. The regenerative gas heater is below the threshold established in 310 CMR 7.02 for plan approvals. Therefore these units are not subject to this Plan Approval; however, the potential emissions from each of these units are included in the Project total emissions for purposes of determining whether the project is subject to review under other regulations.

Following installation of the new liquefaction system, the existing liquefaction system will remain onsite as backup to the new system. The old and new liquefaction systems will not operate simultaneously. The Permittee will decommission the old system following successful commissioning and a two-year reliability demonstration of the new liquefaction system equipment.

C. Applicable Regulatory Requirements

1. State Requirements

Best Available Control Technology ("BACT")

The Application presented a Top-Down BACT analysis for NOx, CO and VOC from the new turbine. The use of SoLoNOx combustors will achieve 9 parts per million ("ppm") NOx, 15 ppm CO, and 5 ppm VOC at 15 percent Oxygen ("@15% O_2"). MassDEP has determined that these emission rates represent BACT for these air contaminants.

The RICE engines serving the two backup BOG compressors will meet the Environmental Results Program ("ERP") limits for NOx and CO, which represent BACT for these units.

Air Dispersion Modeling

This section summarizes the results from an ambient air quality dispersion modeling analysis for the Project to demonstrate that the predicted air quality impacts will comply with the National Ambient Air Quality Standards ("NAAQS") and Massachusetts Ambient Air Toxic Guidelines 24-hour Threshold Effects Exposure Limit ("TEL") and the annual Allowable Ambient Limit ("AAL") for formaldehyde.

a) Air Modeling Methodology

The air quality modeling analysis was performed with the latest version (18081) of the United States Environmental Protection Agency ("USEPA") AERMOD dispersion modeling program.

The Permittee modeled the emissions from the emission units of the proposed new Project emitting at their maximum allowable operation rates. Only sources with a heat rate greater than 10 MMBtu/hr were considered, as recommended by MassDEP. In addition, emissions from the Facility's existing four LNG vaporizers were included in the modeling. For comparison with

annual limits, the vaporizer emissions were combined with the Project emissions. For comparison with short-term limits, the vaporizer emissions and Project emissions were not required to be combined, because the vaporizers and the Project equipment will not operate simultaneously. The Facility's existing compressor engines were not included, as they will not operate simultaneously with the new Project equipment. For all short-term averages, the maximum allowable hourly emissions were modeled over 8,760 hours of operation; the annual averages were scaled by the appropriate annual hours of operation. In addition, five (5) years of surface meteorological data (2012 through 2016), were provided by MassDEP, and utilized to run the model.

The resulting data set from the modeling program was added to real time background data collected at MassDEP air monitoring stations in Ware, MA and Worcester, MA from 2015 through 2017 to predict total potential air quality concentrations, including emissions from the Facility.

b) Air Modeling Results

The following table presents the modeling results, the background data collected in Ware and Worcester, the total predicted emissions, and the NAAQS for each pollutant (except formaldehyde). There is no NAAQS for formaldehyde but the TEL/AAL are provided.

The Table A results show that the modeled emissions for criteria pollutants were found to be below NAAQS, and those for formaldehyde were below TEL/AAL limits.

Table A - Air Modeling Results

Pollutant	Averaging Period	Modeling Results	Background Emissions	Total Predicted Emissions (modeling plus background)	NAAQS or TEL/AAL
		($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)
NO_2	1-hour	As a feature of the AERMOD model, the 1-Hour NO_2 Design Value of 169.6 was calculated by AERMOD for every hour based on the seasonal background concentrations in Table 3-9.		169.6	188
	Annual	4.0	5.3	9.3	100
SO_2	1-hour	4.1	8.7	12.8	196
CO	1-hour	1098.1	2061	3159	40,000
	8-hour	616.4	1260	1876	10,000
$PM_{2.5}$	24-hour	3.1	13.3	16.4	35
	Annual	0.4	4.2	4.6	12
PM_{10} [1]	24-hour	5.2	21	26.2	150
Formaldehyde	24-hour	0.10	N/A	N/A	2.0
	Annual	0.02	N/A	N/A	0.08

Table Key:

AAL = Allowable Ambient Limit
CO = carbon monoxide
NAAQS = National Ambient Air Quality Standard
NO_2 = nitrogen dioxide
PM_{10} = particulate matter less than or equal to 10 microns in diameter
$PM_{2.5}$ = particulate matter less than or equal to 2.5 microns in diameter
SO_2 = sulfur dioxide
TEL = Threshold Effects Limit
$\mu g/m^3$ = microgram per cubic meter
N/A = Not available

Table Notes:

Note 1: Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, EPA revoked the annual PM10 standard in 2006 (effective December 17, 2006).

Sound Monitoring and Modeling Study

Operation of the new liquefaction system will cause sound emissions that may cause noise. The application described the following proposed sound-emitting equipment and associated sound suppression and sound transmission prevention features:

- Specification of "low noise" options for rotating equipment, including motors, pumps, and various fin fan coolers
- Layout modifications to improve noise dissipation and/or shielding
- Specification of combustion turbine Manufacturer's acoustical enclosure as a primary noise barrier, all to be constructed inside an acoustical building (B01)
- Combustion turbine stack and inlet silencers
- Location of all four boil-off gas compressors inside an acoustical building (B02)
- Specification of "hospital grade silencers" on reciprocating internal combustion engines (RICE)
- Upgraded acoustical building insulation treatment for the compressor and turbine buildings

The Permittee conducted background sound level monitoring and established ambient sound levels at locations of interest based on these measurements and MassDEP guidance. The Permittee then calculated or modeled predicted sound impacts from measured ambient sound levels and project sound emissions. Table B summarizes the predicted sound levels at the following locations.

Receptor ID	Receptor Type and Distance to Project Center Line
PL-1	Northern Property Line (1,400 ft. N)
PL-3	Western Property Line (410 ft. W)
PL-4	Southern Property Line (705 ft. S)
R-1	Residence at Intersection of Wilson and Kruger St (2,000 ft. N)

Receptor ID	Receptor Type and Distance to Project Center Line
R-2	Residence - off Cedar Rd (5,500 ft. NW)
R-3	Residence - 38 Wilson St (1,780 ft. S)
R-4	Residence - 70 Cedar St (1,420 ft. SW)
R-5	Baypath Humane Society (1,580 ft. NW)
R-6	Legacy Farms North (3,100 ft. NE)
R-7	Women's Homeless Shelter (1,340 ft. SE)

Table B Predicted Sound Levels

Sound Modeling Locations	Lowest Background Sound Level (L_{90}, dBA)	Predicted Maximum Sound Level from Facility (dBA)	Total Predicted sound Level (dBA)	Predicted Sound Level Change (dBA)
PL-1	41.3	38.1	43	+ 1.7
PL-3	33.2	41.9	42.4	+ 9.1
PL-4	33.2	40.2	41.0	+ 7.8
R-1	39.6	34.8	40.8	+ 1.2
R-2	39.3	24.6	39.4	0.1
R-3	39.6	32.9	40.4	0.8
R-4	39.6	32.9	40.4	0.8
R-5	39.6	34.3	40.7	1.1
R-6	39.6	34.2	40.7	1.1
R-7	39.6	38.3	42.0	2.4

Based on review of the engineering design of the Facility including sound mitigation measures and predicted Facility sound level impacts, MassDEP has determined that the design of the project incorporates sound suppression and sound transmission prevention elements that constitute necessary equipment, service and maintenance, and necessary precautions to prevent unnecessary sound emissions, as required by 310 CMR 7.10.

After the approved project commences operation, the Permittee shall conduct a sound survey (Table 3, Condition 18). The sound survey shall be performed in accordance with a protocol reviewed and approved by MassDEP in accordance with Table 5, Condition 9.

2. Federal Requirements

The Permittee shall comply with Federal New Source Performance Standards ("NSPS") 40 CFR 60 Subpart KKKK for the turbine. The Permittee will comply with these standards by complying with the Table 2 emission limits in this Plan Approval.

The Permittee shall comply with National Emission Standards for Hazardous Air Pollutants ("NESHAP") for RICE, 40 CFR Part 63, Subpart ZZZZ, by complying with 40 CFR 63 Subpart JJJJ for the BOG compressor engines. The Permittee shall comply with these standards by complying with the Table 2 emission limits in this Plan Approval.

2. EMISSION UNIT IDENTIFICATION

Each Emission Unit identified in Table 1 is subject to and regulated by this Plan Approval:

Table 1

EU	Description	Design Capacity (MMBtu/hr)	Pollution Control Device
20	Solar Mars 100 CombustionTurbine	126.6	SoLoNox combustors
21	Hot Oil Heater	12.6	None
23	Amine System Vent	N/A	Thermal Oxidizer rated at 5.5 MMBtu/hr
24	Emergency Flare	825.7	None
26	Boil-Off Gas Compressor Engine	14.6	CO and NOx catalyst
27	Boil-Off Gas Compressor Engine	14.6	CO and NOx catalyst

Table 1 Key:

EU = Emission Unit
CO = carbon monoxide
MMBtu/hr = Million British thermal units per hour
NOx= nitrogen oxides

3. APPLICABLE REQUIREMENTS

A. OPERATIONAL, PRODUCTION and EMISSION LIMITS

The Permittee is subject to, and shall not exceed the Operational, Production, and Emission Limits as contained in Table 2:

Table 2

EU	Operational / Production Limit	Air Contaminant	Emission Limit
20	1. 451,000,000 cubic feet natural gas per year, which is equivalent to 5,000 hours per year at full load, ISO Conditions (59 °F, 60% relative humidity and 29.92 inches mercury atmospheric pressure)	NOx	9 ppm, 0.04 lb/MMBtu, 5.06 lb/hr, 9.21 tpy
		CO	15 ppm, 0.041 lb/MMBtu, 5.14 lb/hr, 9.74 tpy
		VOC	5 ppm, 0.002 lb/MMBtu, 0.27 lb/hr, 0.53 tpy
		HAP (single) (formaldehyde)	0.0007 lb/MMBtu, 0.03 lb/hr, 0.07 tpy
		HAP (total)	0.06 lb/hr, 0.149 tpy
		SO_2	0.002 lb/MMBtu, 0.25 lb/hr, 0.47 tpy
		$PM/PM_{10}/PM_{2.5}$ [1]	0.007 lb/MMBtu, 0.84 lb/hr, 1.53 TPY
		Opacity	No visible emissions
21	2. 5,000 hours per year	NOx	0.018 lb/MMBtu, 0.23 lb/hr, 0.57 TPY
		CO	0.07 lb/MMBtu, 0.93 lb/hr, 2.33 TPY
		VOC	0.0054 lb/MMBtu, 0.07 lb/hr, 0.17 TPY
		HAP (single) (formaldehyde)	0.0018 lb/MMBtu, 0.028 lb/hr, 0.056 TPY
		HAP (total)	0.029 lb/hr, 0.058 TPY
		SO_2	0.002 lb/MMBtu, 0.03 lb/hr, 0.06 TPY
		$PM/PM_{10}/PM_{2.5}$ [1]	0.008 lb/MMBtu, 0.09 lb/hr, 0.24 TPY
		Opacity	No visible emissions

Table 2			
EU	**Operational / Production Limit**	**Air Contaminant**	**Emission Limit**
23	3. 5,000 hours per year	NOx	125 ppm, 0.83 lb/hr, 2.09 TPY
		VOC	0.03 lb/hr, 0.08 TPY
			99 % overall control efficiency or ≤ 10 ppm VOC or HAP exhaust concentration, whichever is least stringent
24	4. 300 hours per year	NOx	0.068 lb/MMBtu, 56.15 lb/hr, 8.4 TPY
		CO	0.31 lb/MMBtu, 256 lb/hr, 38.4 TPY
		VOC	0.06 lb/MMBtu, 49.5 lb/hr, 7.4 TPY
		SO_2	0.02 lb/MMBtu, 1.65 lb/hr, 0.25 TPY
		$PM/PM_{10}/PM_{2.5}$ [1]	0.0075 lb/MMBtu, 6.15 lb/hr, 0.92 TPY
		Opacity	No visible emissions
26 and 27	5. 5,000 hours per year, each engine	NOx	0.15 lb/MWh, 1.0 g/BHP-hr [2]
		CO	1 lb/MWh, 2.0 g/BHP-hr
		VOC [3]	0.7 g/BHP-hr
		Opacity	No visible emissions
Project-wide [4]	6. None	CO_2eq	60,238 TPY

Table 2 Key:

EU = Emission Unit
NO_x = Nitrogen Oxides
CO = Carbon Monoxide
SO_2 = Sulfur Dioxide
PM = Total Particulate Matter
PM_{10} = Particulate Matter less than or equal to 10 microns in diameter
$PM_{2.5}$ = Particulate Matter less than or equal to 2.5 microns in diameter
VOC = Volatile Organic Compounds
HAP (single) = maximum single Hazardous Air Pollutant
HAP (total) = total Hazardous Air Pollutants.
lb/MMBtu = pounds per million British thermal units
lb/MWh = pounds per megawatt-hour
TPY = tons per consecutive12-month period
lb/hr = pounds per hour
% = percent
g/BHP-hr = grams per brake horsepower-hour
CO_2eq = Carbon Dioxide equivalent
ppm = parts per million by volume at 15% O_2
≤ = Less than or equal to
O_2 = Oxygen

Table 2 Notes

1. $PM/PM_{10}/PM_{2.5}$ refers to collectively designating all particulate matter as being in the size range defined by $PM_{2.5}$.
2. The g/BHP-hr emission limits are the applicable limits from 40 CFR Subpart JJJJ.
3. Volatile Organic Compounds (VOC) not including formaldehyde.
4. Includes EU20, 21, 23, 24, 26 and 27, the regenerative gas heater, the emergency generator, and estimated emissions from fugitive leaks.

B. COMPLIANCE DEMONSTRATION

The Permittee is subject to, and shall comply with, the monitoring, testing, record keeping, and reporting requirements as contained in Tables 3, 4, and 5:

Table 3

EU	Monitoring and Testing Requirements
20	1. The Permittee shall conduct compliance testing on the combustion turbine while it is operating at or near design capacity, to demonstrate compliance with the emission limitations specified in Table 2 above. The Permittee shall conduct the compliance testing in accordance with 40 CFR 60.8. The Permittee shall complete all compliance testing within 60 days after achieving the maximum production rate at which the turbine will be operated, but not later than 180 days after first fire of the turbine.
	2. Following the initial compliance test, the Permittee shall demonstrate continuous compliance for NO_X by one of the following methods: a) The Permittee shall conduct subsequent NO_X performance tests on an annual basis (no more than 14 calendar months following the previous performance test); or b) the Permittee shall develop a parameter monitoring plan following the requirements of 40 CFR 60.4340(2)(ii) and shall continuously monitor the appropriate parameters to determine whether the unit is operating in low-NO_X mode.
	3. If the Permittee chooses to use a parameter monitoring plan to demonstrate continuous compliance for NO_x, then the Permittee shall do the following: a) At least 30 days prior to the initial compliance test required in Condition 1 above, the Permittee shall notify MassDEP in writing of its intention to develop a parameter monitoring plan for continuous compliance monitoring for NO_x and shall submit to MassDEP a draft parameter monitoring plan for approval. The draft parameter monitoring plan shall follow the requirements of 40 CFR 60.4355(a), which reads in part:

Table 3	
EU	**Monitoring and Testing Requirements**
20	"The steam or water to fuel ratio or other parameters that are continuously monitored as described in §§60.4335 and 60.4340 must be monitored during the performance test required under §60.8, to establish acceptable values and ranges. The Permittee may supplement the performance test data with engineering analyses, design specifications, manufacturer's recommendations and other relevant information to define the acceptable parametric ranges more precisely. The Permittee must develop and keep on-site a parameter monitoring plan which explains the procedures used to document proper operation of the NO_X emission controls." b) Upon MassDEP approval of the draft parameter monitoring plan, the Permittee shall continuously monitor and record the appropriate parameters during each run of the initial compliance test, to establish acceptable operating ranges, for purposes of the parameter monitoring plan for the turbine, as specified in §60.4355. c) Within 60 days after the initial compliance test, the Permittee shall submit to MassDEP its proposed final parameter monitoring plan for review and approval. d) Upon MassDEP approval of the final parameter monitoring plan, the Permittee shall follow the plan. e) The Permittee may change the parameter monitoring plan by requesting a change from MassDEP in writing and getting approval from MassDEP for the change.
	4. Following the initial compliance test, the Permittee shall test the turbine every five years to demonstrate compliance with the NO_x and CO emission limitations specified in Table 2 above.
	5. The Permittee shall install, operate and maintain a fuel metering device and recorder that continuously measures and records natural gas consumption in the turbine to ensure compliance with the natural gas limit of 451,000,000 cubic feet per year.
23	6. The Permittee shall continuously monitor the combustion chamber temperature of the thermal oxidizer to ensure 99% destruction efficiency.
23	7. The Permittee shall conduct emission testing on the thermal oxidizer exhaust within 180 days of first fire to demonstrate compliance with the Table 2 VOC and NO_x emission limits.
24	8. The Permittee shall monitor the operating time of the flare with a run-time meter to ensure compliance with the operating hours limit of 300 hours per year.
26 and 27	9. The Permittee shall conduct initial performance testing to demonstrate compliance with the NOx, CO and VOC limits listed in Table 2. The Permittee shall conduct the compliance testing in accordance with 40 CFR 60.8. The Permittee shall complete all compliance testing within 60 days after achieving the maximum production rate at which the BOG engines will be operated, but not later than 180 days after first fire of the engines.

Table 3	
EU	**Monitoring and Testing Requirements**
26 and 27	10. After the initial performance test described in Table 3, Item 9 above, the Permittee shall conduct subsequent performance testing every 8,760 hours of operation or 3 years, whichever comes first, to demonstrate compliance with the NOx, CO, and VOC limits in Table 2.
26 and 27	11. The Permittee shall: a) conduct each performance test within 10 percent of 100 percent peak (or the highest achievable) load and according to the requirements in §60.8 and under the specific conditions that are specified by Table 2 of 40 CFR Part 60 Subpart JJJJ; b) shall not conduct performance tests during periods of startup, shutdown, or malfunction, as specified in 40 CFR §60.8(c); and c) shall conduct three separate test runs for each performance test required in 40 CFR §60.4244, as specified in §60.8(f). Each test run must be conducted within 10 percent of 100 percent peak (or the highest achievable) load and last at least 1 hour; and d) The test report shall comply with the requirements of 40 CFR 60.4245(d).
20, 23, 26 and 27	12. The Permittee shall install appropriately placed sample ports in all exhaust stacks for these EUs which can accommodate the emission testing requirements contained in 40 CFR Part 60 Appendix A.
20, 23, 26 and 27	13. At least 30 days prior to emission testing, the Permittee shall submit to MassDEP for written approval a stack emission pretest protocol.
20, 23, 26 and 27	14. Within 60 days after emission testing, the Permittee shall submit to MassDEP a final stack emission test results report.
21, 23, 26 and 27	15. The Permittee shall monitor the operating time of each unit to ensure compliance with the operating hours limit of 5,000 hours per year.
Facility-wide	16. The Permittee shall monitor all operations to ensure sufficient information is available to comply with 310 CMR 7.12 Source Registration and 310 CMR 7.71 Greenhouse Gas Reporting.
Facility-wide	17. If and when MassDEP requires it, the Permittee shall conduct emission testing in accordance with USEPA Reference Test Methods and Regulation 310 CMR 7.13.
Facility-wide	18. The Permittee shall conduct a sound survey during daytime and nighttime operations in accordance with MassDEP guidelines, to demonstrate that the Facility noise mitigation measures are effective and in conformance with 310 CMR 7.10. The survey shall be conducted within 60 days of the commencement of continuous operation of the Project. The Permittee shall work in full cooperation with MassDEP if the sound survey results deviate from the predicted sound levels from the Liquefier Replacement Project specified in this Plan Approval. The reason for the deviation shall be investigated and changes shall be implemented to remediate any excess sound being generated. MassDEP shall be notified in advance of any physical changes at the facility to reduce sound, and of the times any sound measurements will be made to determine the effect of the changes made.

Table 3 Key:

EU = Emission Unit
CO = Carbon Monoxide
% = Percent
NO_x = Nitrogen Oxides
VOC = Volatile Organic Compounds

Table 4

EU	Record Keeping Requirements
20	1. The Permittee shall record the pipeline fuel gas quality characteristics in a current, valid purchase contract or tariff sheet for the fuel, specifying that the total sulfur content for natural gas is 20 grains of sulfur or less per 100 standard cubic feet and has potential sulfur emissions of less than 26 ng SO_2/J (0.060 lb SO_2/MMBtu) heat input.
	2. The Permittee shall keep records of the parameters that document proper operation of the low-NO_X combustion control system and that are monitored pursuant to Table 3, Condition 2.b. The Permittee shall keep records of excess emissions and monitor downtime as defined in Table 5, Condition 1.
	3. The Permittee shall keep records of each startup and shutdown event, the duration of each event, and associated emissions.
	4. The Permittee shall keep records of the quantity of natural gas combusted in the turbine on a no less than monthly basis, and shall calculate the monthly and twelve-month rolling total emissions from the turbine.
23	5. The Permittee shall keep records of the combustion chamber temperature of the thermal oxidizer.
24	6. The Permittee shall keep records of the operating time of the flare and the explanation as to why the flare was operating.
26 and 27	7. The Permittee shall keep records of the following information: a) All notifications submitted to comply with this 40 CFR Subpart JJJJ and this Plan Approval and all documentation supporting any notification. b) A maintenance plan. c) Records of maintenance conducted on the engines. d) Documentation that the engines meet the emission standards of Table 1 to Subpart JJJJ of 40 CFR Part 60.
20, 21, 23, 26 and 27	8. The Permittee shall keep records of the operating time of each emission unit.

Table 4	
EU	**Record Keeping Requirements**
Facility-wide	9. The Permittee shall maintain adequate records on-site to demonstrate compliance status with all operational, production, and emission limits contained in Table 2 above. Records shall also include the actual emissions of air contaminant(s) emitted for each calendar month and for each consecutive twelve-month period (current month plus prior eleven months). These records shall be compiled no later than the 15th day following each month. An electronic version of the MassDEP approved record keeping form, in Microsoft Excel format, can be downloaded at http://www.mass.gov/eea/agencies/massdep/air/approvals/limited-emissions-record-keeping-and-reporting.html#WorkbookforReportingOn-SiteRecordKeeping.
	10. The Permittee shall maintain records of monitoring and testing as required by Table 3.
	11. The Permittee shall maintain a copy of this Plan Approval, underlying Application and the most up-to-date SOMP for the EU(s) and PCD approved herein on-site.
	12. The Permittee shall maintain a record of routine maintenance activities performed on the approved EU(s), PCD and monitoring equipment. The records shall include, at a minimum, the type or a description of the maintenance performed and the date and time the work was completed.
	13. The Permittee shall maintain a record of all malfunctions affecting air contaminant emission rates on the approved EUs and PCDs and monitoring equipment. At a minimum, the records shall include: date and time the malfunction occurred; description of the malfunction; corrective actions taken; the date and time corrective actions were initiated and completed; and the date and time emission rates and monitoring equipment returned to compliant operation.
	14. The Permittee shall maintain records to ensure sufficient information is available to comply with 310 CMR 7.12 Source Registration and 310 CMR 7.71 Greenhouse Gas Reporting.
	15. The Permittee shall maintain records required by this Plan Approval on-site for a minimum of five (5) years.
	16. The Permittee shall make records required by this Plan Approval available to MassDEP and USEPA personnel upon request.

Table 4 Key:

EU = Emission Unit

PCD = Pollution Control Device

SOMP = Standard Operating and Maintenance Procedure

USEPA = United States Environmental Protection Agency

ng/J = nanograms per Joule

lb/MMBtu = pounds per million British Thermal Units

NO_x = Nitrogen oxides

SO_2 = Sulfur dioxide

Table 5	
EU	**Reporting Requirements**
20	1. The Permittee shall notify MassDEP in writing of the dates of first fire and achievement of maximum production rate of the turbine within 10 days of each of =those dates occurring.
20	2. The Permittee shall submit the following reports to MassDEP for the turbine depending on which method they elect to monitor NO_x emissions: a) If the Permittee elects to continuously monitor parameters or emissions pursuant to Table 3 Condition 2.b, submit reports of excess emissions and monitor downtime, in accordance with §60.7(c). Excess emissions must be reported for all periods of unit operation, including start-up, shutdown, and malfunction. Periods of excess emissions and monitor downtime that must be reported are defined as follows: i) An excess emission is a 4-hour rolling unit operating hour average in which any monitored parameter does not achieve the target value or is outside the acceptable range defined in the parameter monitoring plan for the unit. ii) A period of monitor downtime is a unit operating hour in which any required parametric data are either not recorded or are invalid; or b) If the Permittee performs annual performance tests pursuant to Table 3 Condition 2.a, submit a written report of the results of each performance test before the close of business on the 60th day following the completion of the performance test.
23	3. The Permittee shall notify MassDEP in writing of the date of first fire of the thermal oxidizer within 10 days of that date occurring.
26 and 27	4. The Permittee shall notify MassDEP in writing of the dates of first fire and achievement of maximum production rate of the engines within 10 days of each of those dates occurring.
26 and 27	5. As specified in 40 CFR 60.4245, the Permittee shall submit an initial notification as required in 40 CFR 60.7(a)(1). The notification shall include the following information: a) Name and address of the owner or operator; b) The address of the affected source; c) Engine information including make, model, engine family, serial number, model year, maximum engine power, and engine displacement; d) Emission control equipment; and e) Fuel used.
26 and 27	6. The Permittee shall send MassDEP a compliance certification in accordance with 310 CMR 7.26(43)(e) no later than 30 days *prior* to commencement of operation of the BOG engines.
Facility-wide	7. The Permittee shall submit to MassDEP all information required by this Plan Approval over the signature of a "Responsible Official" as defined in 310 CMR 7.00 and shall include the Certification statement as provided in 310 CMR 7.01(2)(c).

Table 5	
EU	**Reporting Requirements**
Facility-wide	8. The Permittee shall notify the Central Regional Office of MassDEP, BAW Permit Chief by telephone: 508-767-2845, email: roseanna.stanley@mass.gov and CERO.Air@mass.gov , or fax : 508-792-7621, as soon as possible, but no later than three (3) business day after discovery of an exceedance(s) of Table 2 requirements. A written report shall be submitted to the Permit Chief at MassDEP within ten (10) business days thereafter and shall include: identification of exceedance(s), duration of exceedance(s), reason for the exceedance(s), corrective actions taken, and action plan to prevent future exceedance(s).
	9. The Permittee shall report annually to MassDEP, in accordance with 310 CMR 7.12, all information as required by the Source Registration/Emission Statement Form.
	10. The Permittee shall report annually to MassDEP, in accordance with 310 CMR 7.71, all required greenhouse gas emissions.
	11. The Permittee shall submit a sound survey protocol for the required initial compliance test to MassDEP's Central Regional Office for review and approval at least 30 days prior to the scheduled commencement of said survey.
	12. The Permittee shall submit the sound survey results to MassDEP's Central Regional Office, in writing, attention BAW Permit Chief, within 45 days of completion of the sound survey

Table 5 Key:

EU = Emission Unit

NO_x = Nitrogen Oxides

4. SPECIAL TERMS AND CONDITIONS

A. The Permittee is subject to, and shall comply with, the Special Terms and Conditions as contained in Table 6 below:

Table 6	
EU	**Special Terms and Conditions**
20	1. The Permittee shall operate and maintain the stationary combustion turbine, air pollution control equipment, and monitoring equipment in a manner consistent with good air pollution control practices for minimizing emissions at all times including during startup, shutdown, and malfunction, as specified in 40 CFR 60.4333.

Table 6	
EU	**Special Terms and Conditions**
23	2. The Permittee shall maintain in the thermal oxidizer a minimum 1500 ºF combustion chamber temperature whenever the amine stripper process is in use. The Permittee shall have the option of raising or lowering the temperature during compliance testing for the purpose of determining the temperatures that achieve the required emission control, and may operate at whatever temperature achieves the required emission control following MassDEP's acceptance of the compliance test report.
23	3. The Permittee shall install an interlock system to alarm any failure or malfunction of the Thermal Oxidizer, and automatically divert its inlet gas stream to the emergency flare as a temporary safety measure. If the Thermal Oxidizer cannot be returned to service within 24 hours, the Permittee shall cease liquefaction of natural gas until the Thermal Oxidizer is once again fully functional and can be returned to service.
24	4. The Permittee shall operate and maintain the flare in accordance with the manufacturer's recommendations and in a manner consistent with good air pollution control practice for minimizing emissions.
24	5. The Permittee shall operate the flare only during operational upsets, or during startup and shutdown operations. The operation of the pilot flames or the venting of nitrogen gas or instrument air to the flare stack for safe, elevated discharge is not included as part of Flare operation.
	6. The Permittee shall equip the flare exhaust stack with a bird perch inhibitory device.
26 and 27	7. The Permittee shall, to the extent practicable, maintain and operate the engines in a manner consistent with good air pollution control practice for minimizing emissions, as specified in 40 CFR 60.4243(b)(2)(i).
Facility-wide	8. The Permittee shall use the following noise mitigation measures in constructing the Project: a) Specification of "low noise" options for rotating equipment, including motors, pumps, and various fin fan coolers b) Layout modifications to improve noise dissipation and/or shielding c) Specification of combustion turbine Manufacturer's acoustical enclosure as a primary noise barrier, all to be constructed inside an acoustical building (B01) d) Combustion turbine stack and inlet silencers e) Location of all four boil-off gas compressors inside an acoustical building (B02) f) Specification of "hospital grade silencers" on reciprocating internal combustion engines (RICE) g) Upgraded acoustical building insulation treatment for the compressor and turbine buildings
	9. Compliance with the conditions of this Plan Approval does not relieve the Permittee from the obligation to comply with 310 CMR 7.01 and 310 CMR 7.10 when operating the approved equipment or any other activities at the Facility.

Table 6	
EU	**Special Terms and Conditions**
Facility-wide	10. The Permittee shall not operate the new liquefaction equipment approved herein at the same time as the existing liquefaction equipment (the five reciprocating engine compressors designated at EU #1 through #5 in the Operating Permit Tr X236053), except for a very limited duration during initial commissioning of the boil-off gas compressors.
	11. The Permittee shall dismantle the existing liquefaction equipment after the new liquefaction equipment has been commissioned and reliability tested for two calendar years of operation.
	12. The Permittee shall update the existing Operating Permit Renewal application (Tr X273080) within 90 days of the issue date of this Plan Approval.
	13. Any prior Plan Approvals issued under 310 CMR 7.02 shall remain in effect unless specifically changed or superseded by this Plan Approval. The Facility shall not exceed the emission limits and shall comply with approved conditions specified in the prior Plan Approval(s) unless specifically altered by this Plan Approval.

Table 6 Key:

EU = Emission Unit

^{o}F = Degrees Fahrenheit

B. The Permittee shall install and use an exhaust stack, as required in Table 7, on each of the Emission Units that is consistent with good air pollution control engineering practice and that discharges so as to not cause or contribute to a condition of air pollution. Each exhaust stack shall be configured to discharge the gases vertically and shall not be equipped with any part or device that restricts the vertical exhaust flow of the emitted gases, including, but not limited to, rain protection devices known as "shanty caps" and "egg beaters."

C. The Permittee shall install and utilize exhaust stacks with the following parameters, as contained in Table 7, for the Emission Units that are regulated by this Plan Approval:

Table 7				
EU	**Stack Height Above Ground (feet)**	**Stack Inside Exit Dimensions (feet)**	**Stack Gas Exit Velocity Range (feet per second)**	**Stack Gas Exit Temperature Range (°F)**
20	77	7.2	65	880 °F
21	25	2.5	7.4	563 °F

Table 7				
EU	**Stack Height Above Ground (feet)**	**Stack Inside Exit Dimensions (feet)**	**Stack Gas Exit Velocity Range (feet per second)**	**Stack Gas Exit Temperature Range (°F)**
23	32	3	12.6 to 36.8	1600 °F
24	81	10.8	65.6	1831 °F
26	45	1.3	89	1156 °F
27	45	1.3	89	1156 °F

Table 7 Key:

EU = Emission Unit

°F = Degree Fahrenheit

5. GENERAL CONDITIONS

The Permittee is subject to, and shall comply with, the following general conditions:

A. Pursuant to 310 CMR 7.01, 7.02, 7.09 and 7.10, should any nuisance condition(s), including but not limited to smoke, dust, odor or noise, occur as the result of the operation of the Facility, then the Permittee shall immediately take appropriate steps including shutdown, if necessary, to abate said nuisance condition(s).

B. If asbestos remediation/removal will occur as a result of the approved construction, reconstruction, or alteration of this Facility, the Permittee shall ensure that all removal/remediation of asbestos shall be done in accordance with 310 CMR 7.15 in its entirety and 310 CMR 4.00.

C. If construction or demolition of an industrial, commercial or institutional building will occur as a result of the approved construction, reconstruction, or alteration of this Facility, the Permittee shall ensure that said construction or demolition shall be done in accordance with 310 CMR 7.09(2) and 310 CMR 4.00.

D. Pursuant to 310 CMR 7.01(2)(b) and 7.02(7)(b), the Permittee shall allow MassDEP and / or USEPA personnel access to the Facility, buildings, and all pertinent records for the purpose of making inspections and surveys, collecting samples, obtaining data, and reviewing records.

E. This Plan Approval does not negate the responsibility of the Permittee to comply with any other applicable Federal, State, or local laws or regulations now or in the future.

F. The Application is incorporated into this Plan Approval by reference. Should there be any differences between the Application and this Plan Approval, the Plan Approval shall govern.

G. Pursuant to 310 CMR 7.02(3)(k), MassDEP may revoke this Plan Approval if the construction work is not commenced within two years from the date of issuance of this Plan Approval, or if the construction work is suspended for one year or more.

H. This Plan Approval may be suspended, modified, or revoked by MassDEP if MassDEP determines that any condition or part of this Plan Approval is being violated.

I. This Plan Approval may be modified or amended when in the opinion of MassDEP such is necessary or appropriate to clarify the Plan Approval conditions or after consideration of a written request by the Permittee to amend the Plan Approval conditions.

J. Pursuant to 310 CMR 7.01(3) and 7.02(3)(f), the Permittee shall comply with all conditions contained in this Plan Approval. Should there be any differences between provisions contained in the General Conditions and provisions contained elsewhere in the Plan Approval, the latter shall govern.

6. MASSACHUSETTS ENVIRONMENTAL POLICY ACT

MassDEP has determined that the filing of an Environmental Notification Form (ENF) with the Secretary of Energy & Environmental Affairs, for air quality control purposes, was not required prior to this action by MassDEP. Notwithstanding this determination, the Massachusetts Environmental Policy Act (MEPA) and 301 CMR 11.00, Section 11.04, provide certain "Fail-Safe Provisions," which allow the Secretary to require the filing of an ENF and/or an Environmental Impact Report (EIR) at a later time.

7. APPEAL PROCESS

This Decision is an action of MassDEP. If you are aggrieved by this action, you may request an adjudicatory hearing. A request for a hearing must be made in writing and postmarked within twenty-one (21) days of the date of issuance of this Decision.

Under 310 CMR 1.01(6)(b), the request must state clearly and concisely the facts, which are the grounds for the request, and the relief sought. Additionally, the request must state why the Decision is not consistent with applicable laws and regulations.

The hearing request along with a valid check payable to the Commonwealth of Massachusetts in the amount of one hundred dollars ($100.00) and a completed Adjudicatory Hearing Fee Transmittal Form, http://www.mass.gov/eea/docs/dep/service/adr/adjherfm.doc must be mailed to:

Commonwealth of Massachusetts
Department of Environmental Protection
P.O. Box 4062
Boston, MA 02211

This request will be dismissed if the filing fee is not paid, unless the appellant is exempt or granted a waiver as described below. The filing fee is not required if the appellant is a city or town (or municipal agency), county, or district of the Commonwealth of Massachusetts, or a municipal housing authority.

MassDEP may waive the adjudicatory hearing filing fee for a person who shows that paying the fee will create an undue financial hardship. A person seeking a waiver must file, together with the hearing request as provided above, an affidavit setting forth the facts believed to support the claim of undue financial hardship.

Should you have any questions concerning this Plan Approval, please contact Paul Dwiggins by telephone at 508-767-2760, or in writing at the letterhead address.

This final document copy is being provided to you electronically by the Department of Environmental Protection. A signed copy of this document is on file at the DEP office listed on the letterhead.

Roseanna E. Stanley
Permit Chief
Bureau of Air and Waste

ecc: Hopkinton Board of Health
Hopkinton Fire Department
MassDEP/Boston - Yi Tian
MassDEP/Boston –Marilyn Levenson
ERM

APPENDIX C. DETAILED BACT COST ANALYSIS

Appendix C, Table 1. Supporting Data for Cost Analysis

Parameter	Turbine	Units	Reference/Notes
Taurus 60 Average Annual hp Rating (Output)	7,758	hp	hp Rating @ Average Annual Ambient Conditions
Maximum Electric Input	6,310	kW	97.13% motor efficiency of 9,000 HP EMD @ 91.3% Load (i.e., 8,219 HP)
Maximum Electric Output	6,129	kW	Equivalent to Taurus 60 HP rating w/ gearbox & motor efficiency losses
Maximum Heat Input (NG Case)	68.96	MMBtu/hr	Annual Average Heat Input
Maximum Fuel Use (NG Case)	592.23	MMscf/yr	1020 Btu/scf
Maximum Fuel Use (NG Case)	604,075	MMBtu/yr	
9 ppm SoLoNO$_X$ NO$_X$ Emissions	10.0	tpy	Annual Emissions for all modes of operation for 9 ppm SoLoNO$_X$ turbine
9 ppm SoLoNO$_X$ CO Emissions	17.3	tpy	Annual Emissions for all modes of operation for 9 ppm SoLoNO$_X$ turbine
9 ppm SoLoNO$_X$ VOC Emissions	2.64	tpy	Annual Emissions for all modes of operation for 9 ppm SoLoNO$_X$ turbine
9 ppm SoLoNO$_X$ PM Emissions	1.99	tpy	Annual Emissions for all modes of operation for 9 ppm SoLoNO$_X$ turbine
9 ppm SoLoNO$_X$ SO$_2$ Emissions	4.23	tpy	Annual Emissions for all modes of operation for 9 ppm SoLoNO$_X$ turbine
Natural Gas Cost	3.04	$/MMBtu	Average 2019 Algonquin Fuel Reimbursement Quantity (FRQ) Filing price
Electricity Cost	0.1437	$/kW-hr	2019 EIA reported average for MA industrial
Equipment Life (Prime Mover)	50	years	n = Life of Prime Mover
Equipment Life (Oxidation Catalyst)	3	years	n = Life of Oxidation Catalyst
Interest Rate	10.137%		i = Algonquin after tax rate of return (Algonquin 2019 FERC Form 2)
CRF (Prime Mover)	0.1022		CRF = $[i * (1+i)^n] / [(1+i)^n - 1]$
CRF (Oxidation Catalyst)	0.4031		

Appendix C, Table 2. Cost Comparison of EMD SoLoNOx Taurus 60 Turbine

Capital Cost: Parameter	EMD	9 ppm SoLoNOx Turbine	Notes
Baseline Station (without Compressor Driver/Infrastructure)	$ 98,062,212	$ 98,062,212	
Compressor Set (Cost Differential)	$ -	$ 2,358,087	Exhibit 1 - Cost differential between 9 ppm SoLoNOx turbine and EMD
Upgrades to Edgar Substation	$ 1,300,000	$ -	Exhibit 2 - June 17, 2020 Dashiell Letter to L. Smith
High Voltage Transmission Line Install	$ 8,500,000	$ -	Exhibit 2 - June 17, 2020 Dashiell Letter to L. Smith
Right of Way Land Purchase Costs	$ 619,460	$ -	Nancy Kist Written Testimony
Electrical Substation at Weymouth - Installation	$ 3,950,000	$ -	Exhibit 2 - June 17, 2020 Dashiell Letter to L. Smith
Electrical Substation at Weymouth - Civil Work	$ 768,000	$ -	Exhibit 3 - (JL Allen) Weymouth EMD Compressor Installation
Medium Voltage Line Install	$ 693,764	$ -	Exhibit 3 - (JL Allen) Weymouth EMD Compressor Installation
Fuel Gas System - Equipment	*$ -*	*$ 209,756*	Exhibit 6 - Fuel Gas Equipment Cost Summary
Fuel Gas System - Installation	*$ -*	*$ 198,823*	Exhibit 7 - (JL Allen No. 2) Weymouth Fuel Gas System Intake Exhaust Proposal
Turbine Air Intake System Installation	*$ -*	*$ 306,406*	Exhibit 7 - (JL Allen No. 2) Weymouth Fuel Gas System Intake Exhaust Proposal
Turbine Exhaust System Installation	*$ -*	*$ 516,075*	Exhibit 7 - (JL Allen No. 2) Weymouth Fuel Gas System Intake Exhaust Proposal
Total Capital Investment	**$ 113,893,436**	**$ 101,651,359**	
Difference in Total Capital Investment for EMD vs. Turbine	**$ 12,242,077**		
Capital Recovery Factor (Prime Mover)	0.1022		
Capital Recovery on Total Capital Investment	$ 1,250,993		
Annualized Capital Investment for EMD over Turbine	***$ 1,250,993***		

Operating Cost	EMD	9 ppm SoLoNOx Turbine	Notes
Operating Costs			
Maintenance (Cost Differential)	$ -	$ 207,403	Cost differential between annual maintenance for a 9 ppm SoLoNOx turbine and EMD
Utilities - Natural Gas	$ -	$ 1,834,373	Annual natural gas consumption multiplied by 2019 average fuel cost
Stack Testing	$ -	$ 27,500	Canomara LLC Stack Testing Quote (2020 0617)
Oxidation Catalyst		$ 37,487	Cost is the total replacement cost of $93,000 multiplied by the CRF (3 years and 10.137% interest) Solar Turbines, Inc. Quote (2020 0803)
Utilities - Electricity	$ 7,943,500	$ -	Annual electric input multiplied by 2019 average electricity cost for industrial sources in MA
Total Operating Costs	*$ 7,943,500*	*$ 2,106,763*	
Additional Annual Operating Cost of EMD over Turbine Driven	***$ 5,836,737***	*$ -*	
Total Annual Cost	**$ 7,087,730**		
Additional Annual Cost over 9 ppm SoLoNOx Turbine	*$ 7,087,730*		
NO_X Removed (tpy)	10.03		100% removal assumed
CO Removed (tpy)	17.28		100% removal assumed
VOC Removed (tpy)	2.64		100% removal assumed
PM Removed (tpy)	1.99		100% removal assumed
SO_2 Removed (tpy)	4.23		100% removal assumed
Cost per ton of NO_X Removed	**$ 706,653**		
Cost per ton of CO Removed	**$ 410,170**		
Cost per ton of VOC Removed	**$ 2,684,746**		
Cost per ton of PM Removed	**$ 3,561,673**		
Cost per ton of SO_2 Removed	**$ 1,675,586**		

Appendix C, Table 1. Supporting Data for Cost Analysis - Alternative Baseline Analysis

Parameter	Turbine	Units	Reference/Notes
Taurus 60 Average Annual hp Rating (Output)	7,758	hp	hp Rating @ Average Annual Ambient Conditions
Maximum Electric Input	6,310	kW	97.13% motor efficiency of 9,000 HP EMD @ 91.3% Load (i.e., 8,219 HP)
Maximum Electric Output	6,129	kW	Equivalent to Taurus 60 HP rating w/ gearbox & motor efficiency losses
Maximum Heat Input (NG Case)	68.96	MMBtu/hr	Annual Average Heat Input
Maximum Fuel Use (NG Case)	592.23	MMscf/yr	1020 Btu/scf
Maximum Fuel Use (NG Case)	604,075	MMBtu/yr	
Alternative Baseline NO_X Emission Factor	9.9E-02	lb/MMBtu	AP-42 Chapter 3.1 for NG turbine (Lean-Premix)
Alternative Baseline CO Emission Factor	1.5E-02	lb/MMBtu	AP-42 Chapter 3.1 for NG turbine (Lean-Premix)
Alternative Baseline VOC Emission Factor	2.1E-03	lb/MMBtu	AP-42 Chapter 3.1 for NG turbine
Alternative Baseline PM Emission Factor	6.6E-03	lb/MMBtu	AP-42 Chapter 3.1 for NG turbine
Alternative Baseline SO_2 Emission Factor	1.4E-02	lb/MMBtu	AP-42 Chapter 3.1 for NG turbine
Alternative Baseline NO_X Emissions	30.3	tpy	Annual Emisisons for all modes of operation
Alternative Baseline CO Emissions	37.4	tpy	Annual Emisisons for all modes of operation
Alternative Baseline VOC Emissions	2.79	tpy	Annual Emisisons for all modes of operation
Alternative Baseline PM Emissions	2.01	tpy	Annual Emisisons for all modes of operation
Alternative Baseline SO_2 Emissions	4.26	tpy	Annual Emisisons for all modes of operation
Natural Gas Cost	3.04	$/MMBtu	Average 2019 Algonquin Fuel Reimbursement Quantity (FRQ) Filing price
Electricity Cost	0.1437	$/kW-hr	2019 EIA reported average for MA industrial
Equipment Life (Prime Mover)	50	years	n = Life of Prime Mover
Equipment Life (Oxidation Catalyst)	3	years	n = Life of Oxidation Catalyst
Interest Rate	10.137%		i = Algonquin after tax rate of return (Algonquin 2019 FERC Form 2)
CRF (Prime Mover)	0.1022		$CRF = [i * (1+i)^n] / [(1+i)^n - 1]$
CRF (Oxidation Catalyst)	0.4031		

Appendix C, Table 4. Cost Comparison of EMD to Alternative Baseline Turbine

Capital Cost: Parameter		EMD		Alt. Baseline Turbine	Notes
Baseline Station (without Compressor Driver/Infrastructure)	$	98,062,212	$	98,062,212	
Compressor Set (Cost Differential)	$	-	$	2,358,087	Exhibit 1 - Cost differential between 9 ppm SoLoNOx turbine and EMD
Upgrades to Edgar Substation	$	1,300,000	$	-	Exhibit 2 - June 17, 2020 Dashiell Letter to L. Smith
High Voltage Transmission Line Install	$	8,500,000	$	-	Exhibit 2 - June 17, 2020 Dashiell Letter to L. Smith
Right of Way Land Purchase Costs	$	619,460	$	-	Nancy Kist Written Testimony
Electrical Substation at Weymouth - Installation	$	3,950,000	$	-	Exhibit 2 - June 17, 2020 Dashiell Letter to L. Smith
Electrical Substation at Weymouth - Civil Work	$	768,000	$	-	Exhibit 3 - (JL Allen) Weymouth EMD Compressor Installation
Medium Voltage Line Install	$	693,764	$	-	Exhibit 3 - (JL Allen) Weymouth EMD Compressor Installation
Fuel Gas System - Equipment	*$*	-	*$*	*209,756*	Exhibit 6 - Fuel Gas Equipment Cost Summary
Fuel Gas System - Installation	*$*	-	*$*	*198,823*	Exhibit 7 - (JL Allen No. 2) Weymouth Fuel Gas System Intake Exhaust Proposal
Turbine Air Intake System Installation	*$*	-	*$*	*306,406*	Exhibit 7 - (JL Allen No. 2) Weymouth Fuel Gas System Intake Exhaust Proposal
Turbine Exhaust System Installation	*$*	-	*$*	*516,075*	Exhibit 7 - (JL Allen No. 2) Weymouth Fuel Gas System Intake Exhaust Proposal
Total Capital Investment	**$**	**113,893,436**	**$**	**101,651,359**	
Difference in Total Capital Investment for EMD vs. Turbine	**$**	**12,242,077**	**$**	**-**	
Capital Recovery Factor (Turbine)		0.1022			
Capital Recovery on Total Capital Investment	$	1,250,993	$	-	
Annualized Capital Investment for EMD over Turbine Driver	***$***	***1,250,993***	***$***	***-***	

Operating Cost		EMD		Alt. Baseline Turbine	Notes
Operating Costs					
Maintenance (Cost Differential)	$	-	$	207,403	Cost differential between annual maintenance for a 9 ppm SoLoNOx turbine and EMD
Utilities - Natural Gas	$	-	$	1,834,373	Annual natural gas consumption multiplied by 2019 average fuel cost
Stack Testing	$	-	$	27,500	Canomara LLC Stack Testing Quote (2020 0617) - Attachment 3 of response to 8/3/2020 comments
Oxidation Catalyst			$	37,487	Cost is the total replacement cost of $93,000 multiplied by the CRF (3 years and 10.137% interest) Solar Turbines, Inc. Quote (2020 0803)
Utilities - Electricity	$	7,943,500	$	-	Annual electric input multiplied by 2019 average electricity cost for industrial sources in MA
Total Operating Costs	*$*	*7,943,500*	*$*	*2,106,763*	
Additional Annual Operating Cost of EMD over Turbine Driver	***$***	***5,836,737***	*$*	-	
Total Annual Cost	**$**	**7,087,730**			
Additional Annual Cost over Alternative Baseline Turbine	*$*	*7,087,730*			
NO_X Removed (tpy)		30.32			100% removal assumed
CO Removed (tpy)		37.42			100% removal assumed
VOC Removed (tpy)		2.79			100% removal assumed
PM Removed (tpy)		2.01			100% removal assumed
SO_2 Removed (tpy)		4.26			100% removal assumed
Cost per ton of NO_X Removed	**$**	**233,758**			
Cost per ton of CO Removed	**$**	**189,396**			
Cost per ton of VOC Removed	**$**	**2,536,424**			
Cost per ton of PM Removed	**$**	**3,531,071**			
Cost per ton of SO_2 Removed	**$**	**1,663,519**			

APPENDIX D. COST DOCUMENTATION

- Solar Technical Proposal for Electric Motor Drive Compressor Set – June 6, 2020 (Revised 8/5/2020)
- Exhibit 1 – Cost Differential Between 9 ppm SoLoNO$_x$ Turbine and EMD
- Exhibit 2 – June 17, 2020 Dashiell Letter to L. Smith
- Exhibit 3 – (JL Allen) Weymouth EMD Compressor Installation
- Exhibit 6 – Fuel Gas Equipment Cost Summary
- Exhibit 6A – Waterbath Heater Cost (Enbridge PO No. 3100026341)
- Exhibit 6B – Regulators Cost (Enbridge PO No. 3100038392)
- Exhibit 6C – Dry Filter Cost (Enbridge PO No. 3100038392)
- Exhibit 6D – Filter Separator Cost (Enbridge PO No. 3100028313)
- Exhibit 6E – Orifice Meter (Enbridge PO No. 3100036557)
- Exhibit 7 (JL Allen No. 2) Weymouth Fuel Gas System Intake Exhaust Proposal
- June 17, 2020 Stack Testing Cost from Canomara, LLC
- August 3, 2020 CO Catalyst Replacement Cost from Solar Turbines, Inc.

Solar Turbines
A Caterpillar Company

Solar Turbines Incorporated
9330 Sky Park Court
San Diego, CA 92123-5398

Tel: (858) 694-1616
Fax: (858) 694-6267

Technical Proposal

Submitted to:

Spectra Energy

for the:

Atlantic Bridge - Weymouth Project

Electric Motor Drive Compressor Set (Qty:1)

June 6, 2020 : Rev 0

Solar Inquiry No: HO15-0023

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TABLE OF CONTENTS

1 INTRODUCTION

2 SCOPE

2.1 GENERAL DESCRIPTION

This proposal describes product features and provides turbomachinery specifications for the Electric Motor Drive (EMD) compressor set. Presented are descriptions of the basic configuration and installation requirements available at the time of publication.

The Spartan EMD is completely integrated, fully operational and equipped with the accessories and auxiliary systems required for operation. Designed specifically for industrial service, Spartan EMD compressor sets are compact, lightweight units requiring minimal floor space for installation. Proven packaging designs greatly reduce installation costs, time, materials, and labor.

2.2 ELECTRIC MOTOR DRIVE PACKAGE

Driver Skid Description

The electric motor drive is installed on a steel base frame referred to as the driver skid. This skid is a structural steel assembly with beam sections and cross members welded together to form a rigid foundation.

Drip pans are included to collect any potential liquid leakage. Skid connection points for lube oil, seal gas, and instrumentation air are located at the edge of the package. Electrical connections are made in on-skid junction boxes. Machined mounting surfaces on the base frame facilitate component alignment. All skid labels will be written in English.

Major Components and Systems

Major components and systems of the Electric Motor Drive skid include:

- Electric motor
- Voith hydraulic gearbox
- Lubricating oil system
- Turbotronic 5 control system
- Onskid electrical wiring
- Skid with drip pans
- Piping and manifolds

Skid Electrical System Certification and Type

The onskid electrical system will be furnished to meet the following certification requirements:

- National Electrical Code (NEC)

NEC Class I, Group D, Division 2 Electrical System

Onskid electrical equipment is in accordance with NFPA 70 (NEC) requirements for electrical equipment installed in Class I, Group D, Division 2 hazardous locations. When supplied, the off-skid control console, variable frequency drives, and battery charger are nonexplosionproof and must be installed in a nonhazardous location.

Three-Phase and Single-Phase Electrical Rating

The skid will be rated for 60 Hz applications. All three-phase and single-phase motors and electrical components will have a 460 VAC, 3 Phase / 120 VAC, 1 Phase voltage rating. Unless specifically referenced in this proposal, motor starters and contactors are not provided in Solar's scope of supply.

Stainless Steel Instrument Tags

Stainless steel tags with Solar's device identification are provided for onskid instruments and hydromechanical components.

WARNING: This product can expose you to chemicals including lead and lead compounds which are known to the State of California to cause cancer, birth defects, and other reproductive harm. For more information go to www.P65Warnings.ca.gov

2.3 ELECTRIC MOTOR DRIVE

The Electric Motor Driven compressor set is a completely integrated, fully operational package equipped with all accessories and auxiliary systems necessary for normal operation when connected to suitable facilities. Designed specifically for industrial services, the compressor set is a compact, lightweight unit requiring minimal floor space for installation. Proven packaging features greatly reduce installation costs, time, materials, and labor.

Electrical connections on the package are made using metal clad for hazardous locations (MC-HL) cables.

2.4 DRIVEN EQUIPMENT

C33 Compressor Driven Skid

The C33 compressor driven skid includes the centrifugal compressor mounted on a structural steel matching base that, when bolted to the driver skid, forms a continuous base plate on which all the required subsystems are installed. This skid is commonly referred to as the driven skid.

The driven skid is complete and includes all the necessary accessories, auxiliary and control systems for functional operation. Solar's compressor sets with a single Solar compressor can produce pressure ratios of over 3:1 while multiple, tandem-mounted compressors can produce pressure ratios approaching 30:1.

Solar Gas Compressors

Solar gas compressors are designed to achieve a minimum of three years of continuous full-load duty between inspections, and major components are designed for 20 years of continuous operation. Many features commonly used in Solar's compressor designs conform to American Petroleum Institute (API) 617.

Standard features include:

- Vertically split barrel-type construction
- Tilt-pad journal bearings
- Self-aligning tilt-pad thrust bearings
- Rigid modular rotor construction
- Rotor trim balancing
- Overcompensating balance piston
- Radial vibration measurement
- Thrust bearing temperature sensors

NOTE: Solar has developed three spare packages for gas compressor support to increase system availability and reduce the risk of extended outages. For details please see Solar's PIL 212 available upon request.

Impellers

Compressor impellers are designed to conservative stress levels. All impellers are suitable for sour gas applications. Each impeller, after machining, is proof tested to 115% of its maximum mechanical speed.

Rotor Assembly

The rotor assembly consists of stub shafts, impellers, a centerbolt and, if required, rotor spacers to maintain a constant bearing span. These components are individually balanced and are rabbet-fit to each other for concentric alignment. Torque is transmitted through dowel pins. The entire assembly is clamped together with the centerbolt. The rotor assembly is easy to disassemble. The benefits from this type of construction are two-fold. Impellers that can be used in a "restaged" rotor are easily salvaged and downtime is minimized. Reusing old impellers, instead of purchasing new ones to match new operating conditions, enhances the economic feasibility of restaging to maintain optimum compressor performance and the lowest possible operating costs.

Casings

The pressure-containing outer casing of a gas compressor is an assembly of three major components: the suction and discharge end caps, which contain the bearing and seal assemblies, and the centerbody, which holds the rotor and stator assemblies. This is considered a vertically split "barrel" design. The end caps contain all the service ports for oil and gas supply and discharge.

Compressor Flange Orientation, C33

The compressor flanges shall be oriented with the suction flange on the right hand side of the compressor body and the discharge flange on the left hand side as viewed from the driven skid facing forward towards the driver skid. This is the standard configuration for this compressor body.

Lube Oil System

The electric motor, gearbox, and C33 compressor have a common lube oil system.

Compressor Dry Seal System

The dry seal system consists of the seal gas and separation gas systems. The seal system maintains a barrier between the process gas and the compressor bearings. The separation gas system maintains a barrier between the compressor bearing lube oil and the dry gas seals.

Seal Gas System

The seal gas system consists of a primary and secondary gas face seal to prevent the escape of process gas from each shaft end. The primary dry seal takes the full pressure drop. It is used to provide the main sealing function. The secondary or backup seal acts as an emergency barrier between the process gas and the atmosphere and operates at a zero pressure differential.

The system can use clean and dry process gas or an independent clean and dry gas source as seal gas. A customer-furnished separation gas source of air or nitrogen is required to isolate lube oil from the seal gas. The separation gas must be available at all times during lube oil pump operation. Typical seal gas supply flow is 1.34 to 3.35 nm3/min (50 to 125 scfm) at 689 kPag (100 psig) above maximum suction pressure, depending on the compressor model and suction pressure. See PIL 140 for specific demands for each compressor model. The seal gas flow rates are metered by maintaining a constant pressure drop across a flow-limiting orifice in each seal gas supply line to each compressor seal capsule. Differential pressure switches provide low flow alarm and shutdown functions.

The seal gas supply flow is higher than the primary seal leakage. The majority of the seal gas flow travels past the compressor shaft labyrinth seals and into the compressor case. This ensures the dry seal cavity is flushed with clean dry gas and that the dry seal operates in a clean environment. The seal gas may be supplied from the compressor discharge, preferably downstream of the gas cooler, provided the process gas is clean and dry.

The onskid duplex seal gas coalescing filters are designed for typical clean transmission pipeline conditions. If larger particle or liquid loads are expected, a larger off-skid filtration system with a high pressure external seal gas supply is recommended. When the seal gas is supplied from the compressor discharge but the compressor is not operating with a pressure ratio (start-up, shutdown, or pressurized

hold), there is no flow of seal gas through the filters. During these times, the gas leakage across the dry seals is raw process gas from the compressor case.

This is normally not a problem on clean transmission pipeline applications; however, it may be an issue on new pipelines during initial operation, or on pipelines handling wet and/or dirty gas. Under these conditions, an external high-pressure seal gas supply is recommended. Leakage past the primary dry seals is measured by monitoring the pressure drop across an orifice run. High leakage flow alarms and shutdowns are provided by a pressure transmitter. Primary and secondary seal vent lines must be vented by the customer to a safe location.

Dry Gas Seal System Pressure Rating

The seal gas system will be designed to a maximum pressure of 1500 psig at 200°F.

Compressor Discharge Seal Gas Source for Dry Seal System

The seal gas is supplied from the "discharge" of the compressor. This feature provides a package service connection so that the seal gas can be sourced after the process gas discharge cooler. If the compressor discharge temperature is below 93°C (200°F), then the seal gas supply line can be run onskid and the service connection for seal gas supply can be eliminated.

Also included is a driven skid service connection for buffer air for the outboard air seals. The nominal flow rate is 0.134 nm3/min (5 scfm) per compressor and this air supply must be maintained during all phases of compressor pressurization, dry seal vent pressurization and/or lube pump operation.

When the seal gas is supplied from the compressor discharge but the compressor is not operating with a pressure ratio (start-up, shutdown, or pressurized hold), there is no flow of seal gas through the filters. During these times, the gas leakage across the dry seals is raw process gas from the compressor case. This is normally not a problem on clean transmission pipeline applications; however, it may be an issue on new pipelines during initial operation, or on pipelines handling wet and/or dirty gas. Under these conditions, an external high-pressure seal gas supply is recommended.

Electric Seal Gas Boost System

When the seal gas is supplied from the compressor discharge, but the compressor is not operating at a positive pressure ratio (i.e., at start-up, shutdown, or pressurized hold), there is no flow of seal gas through the filters. During this type of operation, the gas leakage across the dry seals is raw process gas from inside the compressor case. This is normally not a problem on clean transmission pipeline applications; however, it may be a problem on new pipelines (until the new line cleans up) or on pipelines handling wet and/or dirty gas. Solar offers a seal gas booster for these applications to prevent unfiltered gas from contaminating the dry gas seals.

A Seal Gas Booster System supplies a source of seal gas pressure during startup, shutdown and pressurized hold. The seal gas booster system is bypassed during normal operation. The booster is an electric motor driven compressor that provides an increase in seal gas pressure that results in the desired flow across the compressor labyrinth seals. The electric motor is driven by a variable frequency drive that modulates the motor speed in order to supply seal gas at the required pressure and flow.

Scope of Supply:

- Boost compressor and motor assembly
- Filters with differential switch
- Transmitters
- RTDs
- Shutoff valves
- Check valve

- Variable frequency drive
- Piping and mounting hardware

Duplex Separation Air Filter

Duplex buffer air supply filters will be provided including isolation valves for filter change out.

Separation Gas System

A circumferential buffer air or nitrogen circumferential-segmented split-ring type seal provides a barrier between the compressor bearing lube oil and the dry gas seals. It is the most outboard component of the complete seal assembly. Air flows between the seal rings and the compressor stub shaft. Separation gas flowing past the outboard seal mixes with lubricating oil and drains to the lube oil reservoir. Air flowing past the inboard seal is vented through the secondary seal gas/buffer air vent.

The separation gas source may be clean dry shop air, instrument air, or nitrogen and must be supplied by the customer. The system includes a hand valve for maintenance, a coalescing filter, a differential pressure regulator, and pressure switches and gauges to monitor the separation gas differential pressure. The system forms a positive separation between the lube oil and the dry seal. Flame arrestors are supplied for the primary and secondary vents. Leakage seal gas and separation gas must be piped away by the customer to selected safe areas.

Hydrostatic Testing

Hydrostatic pressure testing of all compressor casings and end caps is done per API 617 for 30 minutes at 1.5 times the maximum casing design pressure, regardless of application. Parts are thoroughly cleaned prior to testing to ensure all leaks are visible. Test water is treated with a rust inhibitor and the components are thoroughly cleaned and dried after the completion of the test to prevent corrosion. After the compressor completes assembly and testing, it is painted per Solar's paint specification ES 9-58.

Coupling and Guard

Standard configuration for the compressor drive train is Motor, Gearbox and suction end driven Compressor.

Voith to supply gearbox, couplings and coupling guards in compliance with API671.

Included in scope is the cover adapter ring for the driven end of the compressor. Adapter drawings will be provided to Voith and coupling guard will be designed to interface with the adapter. Adapters are manufactured from non-sparking aluminum.

2.5 LUBRICATION SYSTEM

General Description

The lubrication system circulates oil under pressure to the driver and driven equipment. Lube oil is supplied from the lube oil tank located in the driver skid.

The lubrication system incorporates the following components:

- Lube oil (customer furnished)
- AC Motor-driven pre/post lube oil pump
- DC Motor-driven backup lube oil pump
- 120 VDC Step starter (ordinary duty)
- Duplex lube oil filter system with replaceable elements
- Oil level, pressure, and temperature indications
- Pressure and temperature regulators
- Strainers

Synthesized Hydrocarbon (SHC) Lube Oil, Viscosity Grade C46 (S215)

Solar's Specification ES 9-224 defines the type of lube oil acceptable for use in Solar's gas compressors, gears, and driver equipment during normal operating service. For each type of oil, the specification further defines the appropriate viscosity and other physical and chemical requirements. The acceptable conventional oil types are synthesized hydrocarbon (SHC), Class I and petroleum oils, Class II. These oils are further categorized into viscosity grades ISO VG 32 (C32) and ISO VG 46 (C46). The lube oil system operating temperature range, cooler bypass valve calibration, and temperature protection set points are dependent upon the oil viscosity. The oil system control components and set points for this proposal are based on the use of synthesized hydrocarbon oil, viscosity grade C32 for the rotating machinery oil temperature and viscosity requirements and specified ambient temperature range. If a different type of oil or viscosity grade is preferred by the purchaser, this needs to be communicated to Solar for consideration.

Lube Oil Filter

A duplex lube oil filter system is supplied with a filter transfer valve and filter differential pressure indication with alarm. The transfer valve allows a filter transfer to be performed while the motor is running. The lube oil filter system is contained completely within the driver skid. The lube oil filter drain connection is located on the side of the package.

Lube Oil Vent Coalescer

An offskid lube oil vent coalescer is provided to remove oil vapor from the lube oil tank vent airflow. The coalescer drains trapped oil vapor back to the lube oil tank and allows the remaining vent airflow to exhaust to the atmosphere. A tank overpressure alarm and shutdown are also included. Unless specifically referenced in this proposal, the lube oil vent coalescer is loose shipped for offskid installation by others.

Lube Oil Vent Flame Arrestor

The lube oil vent flame arrestor prevents an ignition source from entering the lube oil tank. Unless specifically referenced in this proposal, the flame arrestor is loose shipped for offskid installation by others.

2.6 CONTROLS SYSTEM

General Description

The Turbotronic 5 control system provides for automatic starting, acceleration to operating speed, sequencing control, driver and driven equipment monitoring during operation, and normal and malfunction shutdown.

During operation, the control system, by means of automatic warning and shutdown devices, protects the driver and driven equipment from possible damage resulting from hazards such as high driver temperature or vibration, low lubricating oil pressure and excessive oil temperature. The system input power is 120 Vdc, with internal power conversion providing the 24 Vdc required by the control circuits.

The control processor (controller) performs proportional control, start-up, operation and shutdown sequencing and protection functions, as well as detection and annunciation of abnormal operating conditions. Control for these functions comes from signals the controller receives from solid-state devices, control switches, speed, pressure and temperature transmitters, relays, solenoids, and vibration sensors. These components provide the controller with the data necessary to control and maintain desired process conditions, while maintaining driver speed and temperature at safe levels.

In the event of an abnormal condition or malfunction, the control system indicates the nature of the malfunction. When an alarm or shutdown is displayed, a sequence of appropriate operations begins in response to the detected condition. In the event of a control system failure, the backup relay system initiates a shutdown while operating the lubricating oil system and other subsystems, as required, to avoid driver and driven equipment damage during shutdown.

The Turbotronic 5 control system controls and monitors the electric motor driven package including the driver and driven equipment. The system architecture is based on a Rockwell Automation/Allen-Bradley hardware and software platform and includes fully integrated driven equipment and vibration subsystems.

An independent backup shutdown system provides additional protection. This shuts the package down in a safe and orderly manner in the event of malfunction of the primary control system.

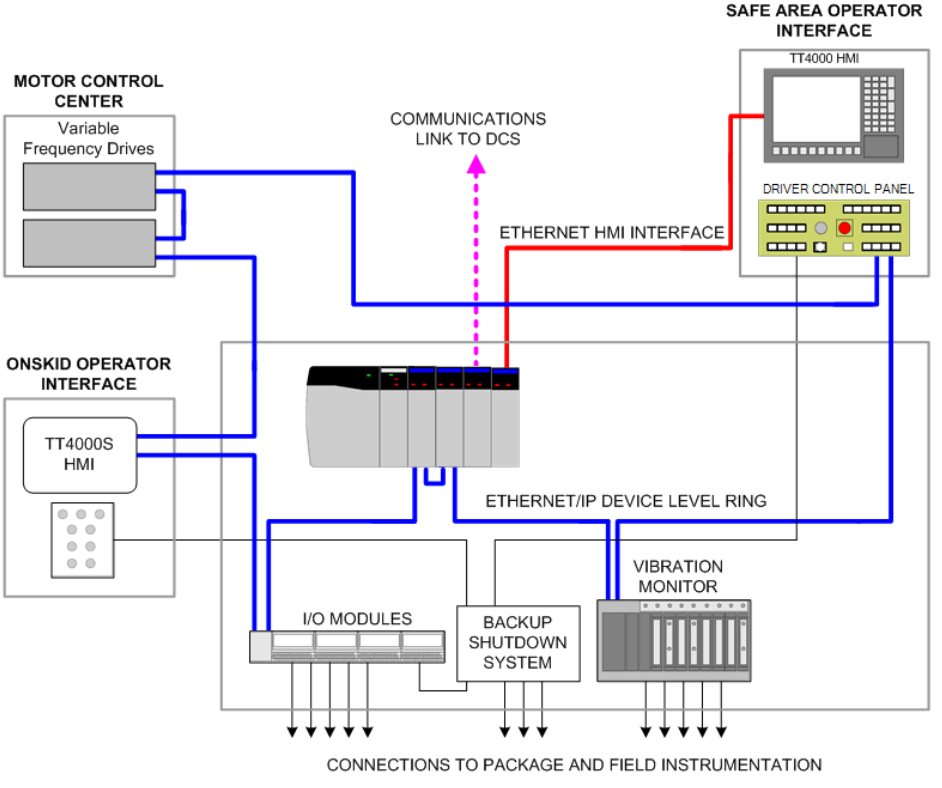
System Architecture

Key system components include:

- ControlLogix controller (Allen-Bradley)
- RSLogix 5000 programming software (Rockwell Automation)
- 1794 Flex I/O input/output modules (Allen-Bradley)
- Vibration monitoring system
- Ethernet/IP Device Level Ring
- TT4000S onskid local operator interface (Solar Turbines)
- Independent backup shutdown system (Solar Turbines)

The Ethernet/IP Device Level Ring network provides primary communications between components. Hardwire backup is provided for critical circuits. All other components are rated NEC Class 1, Division 2 for hazardous area duty and are located on the package skid for the onskid controls configuration or in an auxiliary console for the offskid configuration.

Note: Programming terminals used for commissioning and servicing the control system are not suitable for use in a hazardous atmosphere. Provisions must be made through work processes and procedures, or through the installation design, to ensure these devices can be used to access the control system safely.



Typical Turbotronic 5 System Architecture

Component Descriptions

Controller

The ControlLogix controller, running RSLogix 5000 software, provides primary control. Project-specific programs are created in a Windows-based system and uploaded to the controller. The RSLogix 5000 software supports ladder and function block programming and complies with the International Electrical Code (IEC) 61131-3 standard for programmable controllers.

Ethernet/IP Device Level Ring

Ethernet/IP DLR is the communications backbone of the control system. It provides fast, repeatable, and deterministic communications between the ControlLogix processor, Flex I/O modules, TT4000 system, Variable Frequency Drive (VFD) low voltage (0 - 1000 V) motor drives, and the vibration monitoring system.

ControlNet 1.5

ControlNet 1.5 is the communications used from the Control Logix processor to the medium voltage (1000 – 100,000 V) Variable Frequency Drive (VFD) motor drives we use as a prime mover on our EMD packages. It provides fast, repeatable, and deterministic communications. ControlNet is suitable for up to 3,280 feet (1000 m), further distances require custom features for fiber optic repeaters.

InSight Connect

InSight Connect, Solar's secure connectivity solution for delivering InSight Platform™, is embedded within the standard product configuration. An ethernet bridge module is installed in the controller chassis to establish a link to InSight Connect™. InSight Connect allows for read-only acquisition of data for remote support and technology based services, and does not allow any form of command or control of the machinery. Connectivity options and scope will be defined in collaboration with the customer during project execution phase. Reference Product Information Letter 268 for details.

Device Level Ring (DLR) Interconnect Media, Fiber Optic

The Device Level Ring (DLR) interconnect will be designed using fiber optic adapters to support fiber optic Ethernet cables (Interconnect is supplied by customer). The fiber optic DLR interconnect media will support distances up to 2 kilometers. The Solar provided copper to fiber optic converters will use duplex "SC" type connectors, and is a 100 MB multi-mode fiber optic interface.

Input/Output Modules

Flex I/O modules provide an interface between the package instrumentation and the processor. Specific modules handle discrete inputs, analog inputs, temperature inputs, speed inputs, discrete outputs and analog outputs.

Rockwell Dynamix 1444 Vibration System

The Dynamix 1444 data acquisition modules are configurable to accept non-contact eddy current (proximity) probes, velocity transducers, a standard integrated electronics piezoelectric (IEPE) accelerometer, dynamic pressure or simple voltage signals. Each Dynamix module can monitor up to 4 vibration sensors and a separate tachometer module can read up to two shaft rotational speed signals.

The tachometer enables vibration data captured by the Dynamix module to be referenced to Shaft Rotational Speed.

The following features are available with an offskid TT4000 display: Overall Vibration Amplitude, Gap Voltage, 8 configurable bands (each displaying the Maximum Amplitude within the Band or the Frequency of the Maximum Amplitude within the Band), Spectrum Plot, Time-Waveform Plot, Orbit Plot, 1x Polar Plot, Shaft Centerline Plot, Bode Plot, Waterfall Plot (Spectrum over Time), Cascade Plot (Spectrum over Speed Change) and Historical Logging.

The following features are available with an onskid TT4000S display: Overall Vibration Amplitude, Gap Voltage, 8 configurable bands (each displaying the Maximum Amplitude within the Band or the Frequency of the Maximum Amplitude within the Band) and Historical Logging.

Motor Vibration and Temperature Control

Motor stator temperature monitoring, 2 RTD’s per phase, and journal bearing temperature monitoring, 1 per bearing, is provided. 2X and 2Y proximity probes, 4 channels. Tempreature and vibration indications are displayed on the package video display unit.

Motor Ventilation Control

Solar will provide a discrete output to command the blower motor “on” prior to start. Solar will monitor a discrete input for the blower motor as a status bit for start/run permissive. Blower motor start contactor provided by others.

Backup Shutdown System

The backup shutdown system shuts the package down in a safe and orderly manner without damage to the equipment in the event of a failure in the primary system. The control processor is monitored by both an internal watchdog circuit and by an external watchdog device. If either circuit detects a processor failure, the backup system takes control. It depressurizes the compressor, and activates the DC backup lube oil pump until the rotor reaches 0 rpm speed. Operation can only be restored manually from the control panel after all faults have been cleared. The emergency stop push-button switches are wired to both the primary and backup systems.

System Monitoring and Control Functions

The control system provides sequencing control during startup, steady state operation, and shutdown. Protective functions are provided during all stages of operation.

Starting and Loading

The **Start** command initiates the sequence. Prior to rotation, the lube oil pump undergoes a test cycle to ensure that the bearing housings are properly lubricated.

Steady-State Control

During steady-state operation, the control system keeps the equipment within specified operating conditions.

Speed sensors continuously monitor the EMD speed and the control system makes adjustments to meet operating requirements to keep the speed within specified limits.

Stopping

The EMD may be shutdown either manually or automatically.

The **Normal Stop** command initiates a cooldown stop. The gas compressor is depressurized (if applicable) and the motor runs at idle speed for a preset time to allow the motor drive and driven equipment to cool, ten a signal is sent to stop the motor. The **Emergency Stop** command results in the immediate depressurization of the gas compressor and stops the motor drive without a cooldown period.

In the event of a hazardous condition or equipment malfunction, the control system will shut the package down automatically. These shutdowns are divided into four categories:

- Cooldown stop nonlockout (CN)
- Cooldown stop lockout (CL)
- Fast stop nonlockout (FN)
- Fast stop lockout (FL)

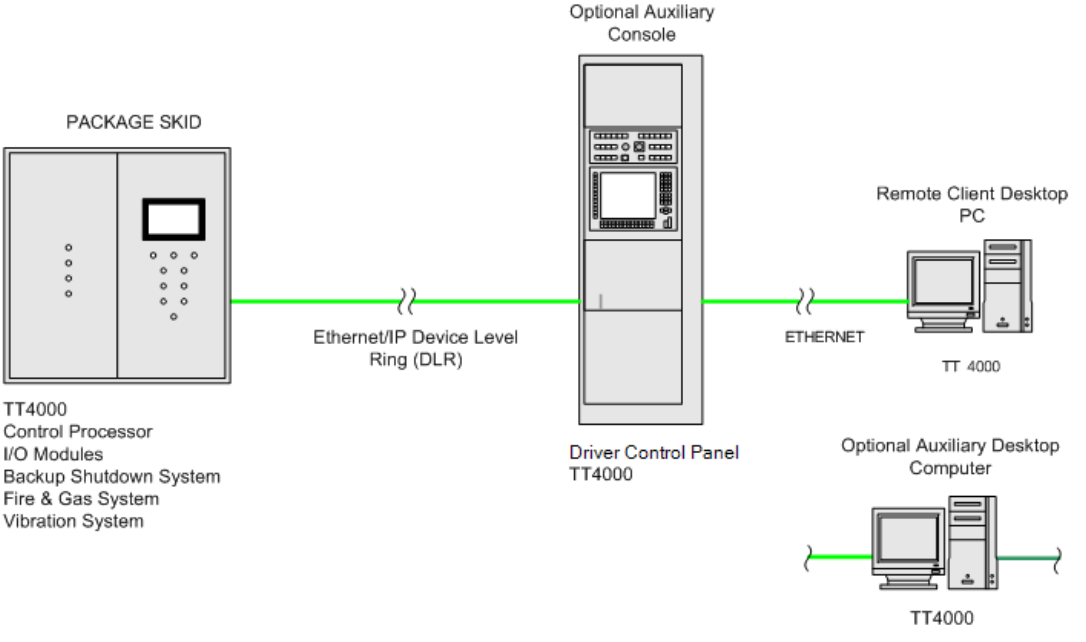
Cooldown and fast stops correspond to the manual normal and emergency stops respectively. Lockout stops inhibit operation of the control system and prevent restarting until the malfunction is reset. Lockout stops result from serious malfunctions that require corrective action before the system can be restarted. Nonlockout stops result from an operational disruption or abnormal condition and can be reset when conditions return to normal.

In the event of a shutdown lubrication of the bearings will shut off after the motor has come to a complete stop and the rundown timer has timed out.

ONSKID CONTROL SYSTEM

The control system components are mounted in one or more panels located on the driver skid. The panels contain the key elements of the system including the Control Processor, the I/O Modules, the Vibration Monitoring System and the onskid display unit. The operator interface includes lighted switches for Start / Starting, Normal Stop / Stopping and Backup System Active / Reset and switches for Speed Increase / Decrease, Off / Local / Aux, Horn Silence, Acknowledge, Reset and Emergency Stop. The onskid display unit provides the following key features:

- Operation Summary – Overview of key operation parameters
- Temperature Summary – Display of all monitored temperatures
- Vibration Summary – Display of all vibration readings
- Alarm Summary – Display of all malfunctions with date and time stamping
- Event Log – Display of date and time stamped sequence of events with sorting and filtering functions
- Historical Data – Stores data surrounding specified events. Data can be played back using the Strip Chart feature.
- Strip Chart – Display of real time data for selected analog signals in strip chart format. Configurable with legend, cursor and zoom features
- Program Constants – Password protected display and modification of controls constant values
- Unit Valve Mimic – Status indication and manual operation of unit valves



Typical Onskid Control System

Auxiliary Desktop PC for Offskid Control Interface

In addition to the onskid display unit located on the driver skid, an Auxiliary Desktop PC with full TT4000 Display and Monitoring System capabilities is provided for use at a secondary location determined by the user.

Video Display Unit

The TT4000 Display and Monitoring System provides all of the information available at the onskid Display as a minimum and includes additional control displays not available onskid, typically including the following standard displays and features:

- Operation Summary – Overview of key operation parameters
- Temperature Summary – Display of all monitored temperatures
- Vibration Summary – Display of all vibration readings
- Alarm Summary – Display of all malfunctions with date and time stamping
- Event Log – Display of date and time stamped sequence of events with sorting and filtering functions
- Historical Data – Stores data surrounding specified events. Data can be played back using the Strip Chart feature.
- Strip Chart – Display of real time data for selected analog signals in strip chart format. Configurable with legend, cursor and zoom features
- Program Constants – Password protected display and modification of controls constant values
- Unit Valve Mimic – Status indication and manual operation of unit valves

Screen displays can be selected independent of the onskid display unit and include the ability to start, normal stop, acknowledge, reset and control package speed and / or load set point. The auxiliary PC operates over an Ethernet/IP Device Level Ring serial link connected to the onskid control processor.

Data Storage and Display

Data can be viewed in a strip chart format in real time, trended, analyzed online, or exported for off-line viewing. All logs are self-describing repositories, containing site information, tag information, and the historical data itself. The data can be viewed online using the Historical Trend Display. The Historical Trend Display allows selection of up to 10 variables for viewing in a digital strip chart format. The objective of historical data monitoring is to provide information of a type and in a format that allows informed decisions to be made in the areas of operation, maintenance, and optimization of the turbomachinery and associated equipment. The information is collected for on-line viewing and analysis or may be exported for storage and off-line analysis. The Discrete Event Log records changes in status for all defined discrete inputs, including operator commands, alarms and shutdown annunciations, and key sequencing and status signals. Up to 5000 events are stored and can be viewed and sorted by heading.

Analog Data are collected and saved to disk. The standard data files are:

Hourly Log - data are read at hourly intervals for 2 years. Each year’s data are stored in a separate file. Data are recorded whether or not the equipment is operating.

Minute Log - data are read and stored at one-minute intervals for the previous 62 days, one file for each day.

10 Second Log - data are read at 10-second intervals for the previous 31 days, one file for each day.

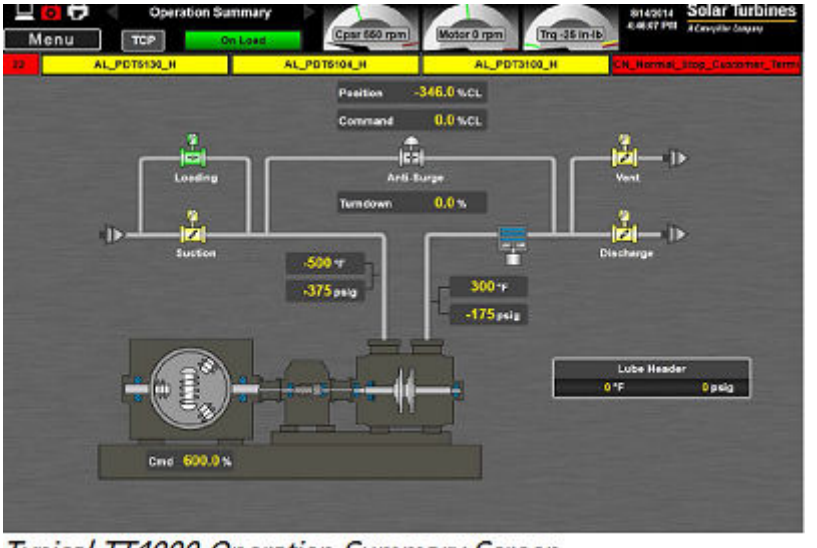
Trigger Log - data are read at one-second intervals for 6 minutes before a “trigger” event that is defined in the software. The standard trigger is a shutdown. Six minutes before the trigger of data are written to a file. Up to 50 trigger logs files can be stored.

TT4000 Display Screens

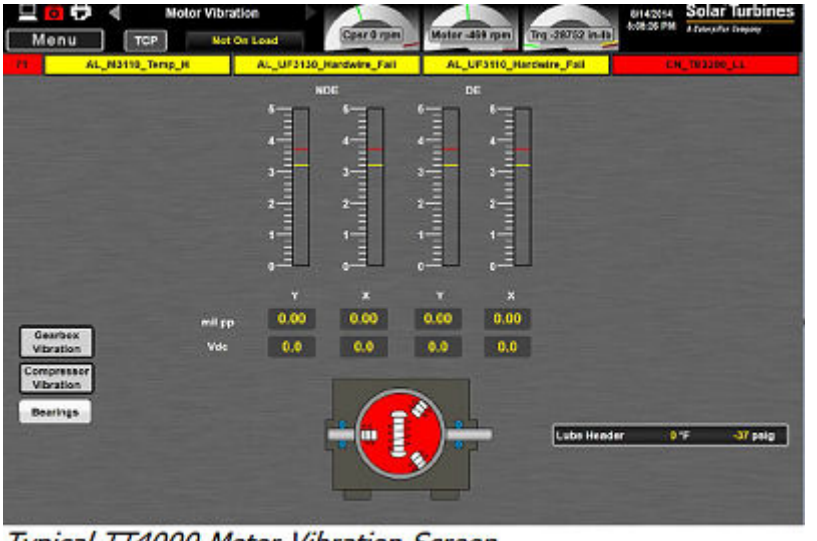
A status bar at the top of every screen displays up to four alarm conditions. Standard display screens include:

- Driver Summary
- Driver Details Screen

- Driver Temperature Summary Screen
- Lube Oil System
- Lube Oil System Details Screen
- Driver Vibration
- Driven Equipment Vibration
- Alarm Summary
- Discrete Event Log
- Strip Chart Display (real time data)
- Historical Data Display (strip chart format)



Typical TT4000 Operation Summary Screen



Typical TT4000 Motor Vibration Screen

Ethernet Network Supervisory Interface

An Ethernet interface module is installed in the control processor rack and connects to the processor through the rack backplane. The user may connect to the module with a standard 10BaseT Ethernet cable. Ethernet is suitable for applications up to 100 m (330 ft) without a hub. Data are transmitted using the Control and Information Protocol (CIP). Analog and discrete data are stored in one-dimensional arrays in the control processor, which may be read by the user. In addition, the user may send supervisory control signals to the processor. Data available include all input analogs, a number of computed values, status indications, and all active alarms and shutdowns. Typical data include:

- Drive train equipment status
- Compressor speed
- Winding temperature
- Lube oil header pressure
- Lube oil temperature
- Ambient temperature
- All alarms and shutdowns
- All panel light status

Supervisory control signals include:

- Start
- Stop
- Acknowledge / Reset
- Remote Speed / Load Set Point

The user is responsible for providing the hardware and software interfaces to the system.

Control Screen Engineering Units in English

Temperature values are displayed in °F and pressure values are displayed in psig.

Control Screen Language in English

Operator interface screen displays are in the English language.

Voith Drive Instrumentation and Monitoring System

Voith Drive Vibration Monitoring System, 1X and 1Y Proximity Probe per Bearing, 8 Channels

The Voith Drive vibration monitoring system provides vibration protection through preset warning indication and shutdown initiation in the event of unacceptable vibration levels. The vibration monitoring system includes additional channels of vibration to monitor two proximity probes at each radial bearing for a total of 8 channels. Vibration level, alarm, and shutdown indications are displayed on the control system video display unit.

Voith Drive Speed Measuring Probes, 2 Channels

Speed sensing probes are provided on the output shaft and connecting sleeve. The speed signal is displayed on the control system video display unit.

Voith Drive Temperature Monitoring, 18 Channels

The Voith Drive temperature monitoring system provides 18 channels of temperature indication and protection. Equipment is protected through pre-set warning indication and shut down initiation in the event of unacceptable bearing temperature. The system monitors thermocouples or RTD’s depending upon the

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type of signal provided by the manufacturer. The temperature level and shutdown indications are displayed on the control system video display unit.

See Voith description of scope for further detail.

ADDITIONAL FEATURES:

Ship Ahead Controls Box

Solar will provide a ship ahead controls box to be loose shipped prior to the package shipment.Customer need date to be specified by Tollgate 1 meeting to ensure Controls Manufacturing build slot is allocated to support accordingly.

2.7 DRIVEN EQUIPMENT CONTROL

Single-Unit Process Control, Suction Pressure

The unit control system includes programming to regulate the EMD speed to maintain a preset suction pressure. Control logic for local and remote, single-unit, set-point adjustment is included. Control is provided using a suction pressure transmitter that is within the anti-surge recycle loop and installed on the package skid. This transmitter is also used for anti-surge control. A purchaser-supplied pressure sensing line for this transmitter must be connected at a distance of at least 5 ±1 pipe diameters upstream of compressor suction and downstream of suction inlet screen or other flow resistances, with provisions to ensure no liquids get trapped in the lines.

If the train suction pressure (upstream of the recycle loop) is to be controlled, the suction pressure 4-20mA signal that is used as process variable (PV) by the control system is be provided from a separate transmitter furnished by purchaser.

The purchaser must provide Solar with the normal operating pressure range and transmitter calibration range to facilitate the control system design.

Single-Unit Process Control, Discharge Pressure

The unit control system includes programming to regulate the EMD speed to maintain a preset discharge pressure. Control logic for local and remote, single-unit, set-point adjustment is included. Control is provided using a discharge pressure transmitter that is within the anti-surge recycle loop and installed on the package skid. This transmitter is also used for anti-surge control. A purchaser-supplied pressure sensing line for this transmitter must be connected at a distance of at least 5 ±1 pipe diameters downstream of compressor discharge and upstream of discharge scrubber, coolers or other flow resistances, with provisions to ensure no liquids get trapped in the lines.

If the train discharge pressure (downstream of the recycle loop) is to be controlled, the suction pressure 4-20mA signal that is used as process variable (PV) by the control system is provided from a separate transmitter furnished by purchaser.

The purchaser must provide Solar with the normal operating pressure range and transmitter calibration range to facilitate the control system design.

Gas Compressor Surge Detection System

The integral surge detection system detects gas compressor discharge pressure pulsations and will alarm, and if necessary initiate a shutdown if pulsations exceed a preset value within a predetermined time period.

Anti-Surge Control

Surge at a given gas compressor speed is caused by excessive head across the gas compressor (isentropic head) for a given suction flow rate. Therefore, surge in the gas compressor may be controlled by decreasing the head across the gas compressor and/or by increasing the flow rate of the gas to the suction side of the gas compressor. The anti-surge control system prevents surge by modulating a surge control (bypass) valve to lower head and increase suction flow. A typical system consists of pressure and temperature transmitters on the gas compressor suction and discharge lines, a flow differential pressure transmitter across the suction flowmeter, an algorithm in the control system, and a surge control valve with corresponding accessories to keep the gas compressor from going into surge. Also included is control for fast stop valve to protect the compressor in the event of a sudden shutdown. For a detailed description of the valve sizing process, refer to Solar's PIL (Product Information Letter) 216, "Anti-surge Control Valve Selection and Fast Stop Analysis."

The following components and information are required from the purchaser in order to facilitate the surge control system design and onsite operation:

- Expected gas compressor operating conditions range for suction pressure (P1), suction temperature (T1), discharge pressure (P2), flow and gas specific gravity
- Flow meter specification sheet
- Purchaser piping and instrumentation diagram including suction and recycle pipe size and schedule
- Anti-surge control (recycle) valve and specification sheet, unless included in Solar's scope
- Suction gas temperature signal (100-ohm platinum resistance temperature device (RTD) preferred)

Typical Solar supplied system scope includes the following:

- Engineering to determine the optimum control algorithms
- Control software programmed and tested for the selected gas compressor staging
- Engineering to specify the anti-surge control valve and accessories, including valve performance evaluation over the gas compressor performance map at varying valve positions
- Engineering to specify the flow meter type and size
- Automatic override of manual control mode
- Evaluation of user piping and instrumentation diagram
- Documentation, including all surge control calculations and program constants
- Gas compressor flow versus differential pressure control with suction pressure and temperature compensation
- Speed set point decoupling
- Surge detection with step valve opening
- On-screen, real-time graphic displays
- On-screen, real-time control parameter setting
- All surge control parameters are available for remote monitoring via serial link
- Suction flow differential pressure transmitter (shipped separately for installation by purchaser or installed on compressor skid if impeller eye is used)
- Suction and discharge pressure transmitters (shipped separately for installation by purchaser)
- Discharge gas temperature RTD (installed on the compressor discharge flange)

Compressor Performance Map Display

This feature provides for the display of a real-time compressor nominal head-versus-cfm performance map and shows the position of the actual operating point. The primary pressure sensing elements are included; however, the flow sensing elements and transmitter are provided by the purchaser. The accuracy of the map is commensurate with the accuracy of the sensing instrumentation. Compressor maps are limited to one gas composition. Side streams, changing gas composition or other factors that can change compressor performance characteristics must be reviewed to confirm compatibility with the software program.

Spring Return Process Valve Operating Logic

Control system logic is programmed to provide a signal to operate the compressor suction, discharge, and loading valves. Upon removal of the signal, the valves return to the normal position.

Compressor Vibration and Temperature Monitoring

X and Y proximity probes are mounted in the compressor driver and driven-end bearings. These probes are monitored continuously by the control system. Alarm and shutdown levels are set to protect the compressor from excessive vibration levels. Axial probes are also provided for position monitoring.

Resistance temperature devices (RTDs) are mounted in the compressor bearing drains and thrust bearing. Alarm and shutdown levels are set to protect the compressor bearings from excessive temperature levels.

2.8 QUALITY ASSURANCE AND TESTING

STANDARD TESTING PER SOLAR'S SPECIFICATIONS

Factory testing is in accordance with Solar's test specifications and as generally outlined below. The purchaser or purchaser's designated representative is provided access to Solar's Production Test facilities to observe factory production tests scheduled in accordance with production and testing schedules. Unavailability of the purchaser or purchaser's representative will not be cause for delay in the performance of the production tests.

Test Facilities

The test facility provides a comprehensive test program using simulators to perform static testing of package systems to verify control, system operation, and component calibration.

Static Test

Solar uses simulation equipment to perform static testing of the controls and package systems to verify electrical and fluid system continuity and calibration.

Gas Compressor Acceptance Test

The gas compressor is tested in accordance with Solar's specifications and as generally outlined below. Prior to assembly of the internal components, all compressor casings receive a hydrostatic pressure test, limited to 30 minutes, per API 617.

Testing is conducted on dedicated test stands using a facility driver. The suction and discharge nozzles are connected to an open loop configuration using atmospheric air. The test evaluates mechanical and aerodynamic performance in accordance with test procedures and acceptance criteria as outlined in applicable test specifications.

The mechanical testing is performed first. The gas and oil seals are tested statically with nitrogen. After preliminary checks and static seal testing, the unit is operated at break-in, then maximum continuous speed. Key mechanical parameters such seal airflow, oil flow and vibration levels are measured and evaluated against established limits.

Aerodynamic performance testing is conducted on completion of the mechanical tests. The primary objective of the test is to confirm the accuracy of the individual stage characteristics used for predicting compressor aerodynamic performance at the air-equivalent design speed by comparing the overall head/ flow speed line from choke to surge and the surge line position against prediction when operating at a speed equivalent to the site design speed. Surge points are determined at various speed points to validate the surge flow estimate for the entire operating speed range. Extensive instrumentation, together with the facility data acquisition and reduction system, validates mechanical and aerodynamic performance.

Electric Motor Drive Package Acceptance Test

Factory testing of the contract motor and VFD are performed in accordance with the manufacturer’s test specifications at the manufacturer’s facility. Installation of the electric motor on the package skid occurs upon arrival at the customer’s site. The following operations listed are checks and adjustments that are performed on the compressor and its corresponding driver and driven skids at Solar’s test facility:

- Pre-Test Operations to review safety instructions and document all shortages
- Electrical System Certification Operations
- Electrical Systems Preparation and Static Operations
  - Vibration System and Gap Voltage Check

- Gas Compressor Vibration System Check
- Package Electrical and Sensing Device Verification
- Control System Power Hookup
- Backup Control System Verification (Static)
- Shop and Field Impact Check
- Lube Oil and Bearing Temperature Alarm and Shutdown Tests
- VFD Verification (AC)
- Lube Oil Pumps Sequence Test

- Lube Oil System Flush and Mechanical System Preparation
- Dry Seal System Operations Pressure Tests, Leak Checks, and Flow Transmitter Verification

Acceptance Test Data

Acceptance test data are reviewed and approved by Test Engineering and the Project Manager and furnished approximately four weeks after completion of acceptance testing. The report provides test results and compares the results to Solar's acceptance test specification requirements by means of calculations, graphs, strip charts and descriptions.

Quality Assurance

All testing operations are conducted under the direct control of Solar's Quality Assurance Activity. This Activity ensures compliance with the test procedures specified.

In addition to final in-plant testing of the finished compressor set, Quality Control engineers maintain surveillance over the manufacture of all purchased parts and subassemblies and are responsible for functional testing of incoming components. The same rigid standards applied to parts manufactured by Solar are applied to all parts that Solar receives from suppliers.

Source Inspection

Solar's suppliers receive quality inspections on a periodic basis in accordance with a standard purchasing contract. However, in order to comply with purchaser's specification, Solar will conduct a final product inspection of the contract equipment at the supplier facility for this project. The purchaser or purchaser's representative is welcome to participate in the source inspection at purchaser's cost. Solar will conduct a final product inspection at the supplier facility for the following contract-specific items:

- Source Inspection of Lube Oil Cooler

Observe on Non-interference Basis

The purchaser or purchaser's designated representative is provided access to Solar's Fabrication and Production Test facilities to observe factory production tests and other normal shop inspections and tests such as rotor balancing, casing and piping hydrostatic testing, and final inspections in accordance with production and testing schedules.

Observation of UCBOP (Unit Control Balance of Plant) software testing is done only as part of the Static Testing of controls software. Observation of package control software is done only as part of the Package Acceptance Test. Please note that the production test facilities are a constrained resource. Accordingly, the unavailability of the purchaser or purchaser's representative shall not be cause for delay/deferment of the scheduled production test(s).

Weld Radiography of Pressure [15 psig or greater] Piping for Lube Oil System, 20% of Welds

Radiographic inspection procedure is performed per ASME V, in accordance with acceptance standard per ASME B31.3. 20 % inspection of circumferential butt welds of the lube oil system pressure piping means one of every five welds will be radiographed with at least one weld per pipe assembly.

Weld Radiography of Piping and Manifolds for Seal System, 100% of Welds

Radiographic inspection is performed in accordance with ASME Section V. 100% of the seal system piping and manifold circumferential butt welds are inspected by radiographic examination in accordance with ANSI / ASME B31.3.

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2.9 PRESERVATION, INSTALLATION AND DOCUMENTATION

General Description

This section describes preservation, general installation requirements, and project documentation.

Preservation

Long term or short term preservation can be provided for the motor and package. The type of preservation required dependents upon the following:

- Type of transportation (sea, air, or truck)
- Climatic conditions during transport and storage
- Storage period
- Storage facilities
- Static and dynamic loads imposed during shipment

Refer to Solar's Product Information Letter 097, "Package Preservation and Preparation for Shipment," for additional guidelines.

Short-Term Preservation

This proposal is providing for short-term preservation. The following conditions allow for short-term package preservation:

- Equipment will be stored in an improved storage area for less than 6 months before installation
- Transportation is not by ship
- Transportation does not include transshipment (package will not go from truck to barge to truck, etc., e.g., rigorous loads will not be encountered during shipment)
- Package will not be exposed to severe weather conditions during transport

Site Requirements

Solar's compressor sets require minimal site preparation. The package is supplied with self-contained systems for control and bearing lubrication, minimum piping and wiring connections are required for installation. All service connections are conveniently located on the outer edge of the skid.

Mechanical Installation Requirements

TPIM-1010

Solar's document TPIM-1010 "Package Installation Guidelines - Compressor Sets and Mechanical Drives" outlines the responsibilities of the Customer and Solar regarding installation of the package. It provides guidelines for the installation of the standard package design and the interface with the driven equipment.

Mounting

Correct mounting of the package is vital to successful package installation and requires adequate preparation by the user. The site pad thickness is governed by soil condition and the weight of the package. Mounting pad locations and loads will differ with each package and will be clearly shown on the installation drawings. The equipment layout should provide adequate floor space for major components with sufficient room around the package for routine maintenance access.

Alignment Tooling, Quantity 1

Special tooling is provided for aligning the entire equipment train, including electric motor, primary gearbox, and gas compressor.

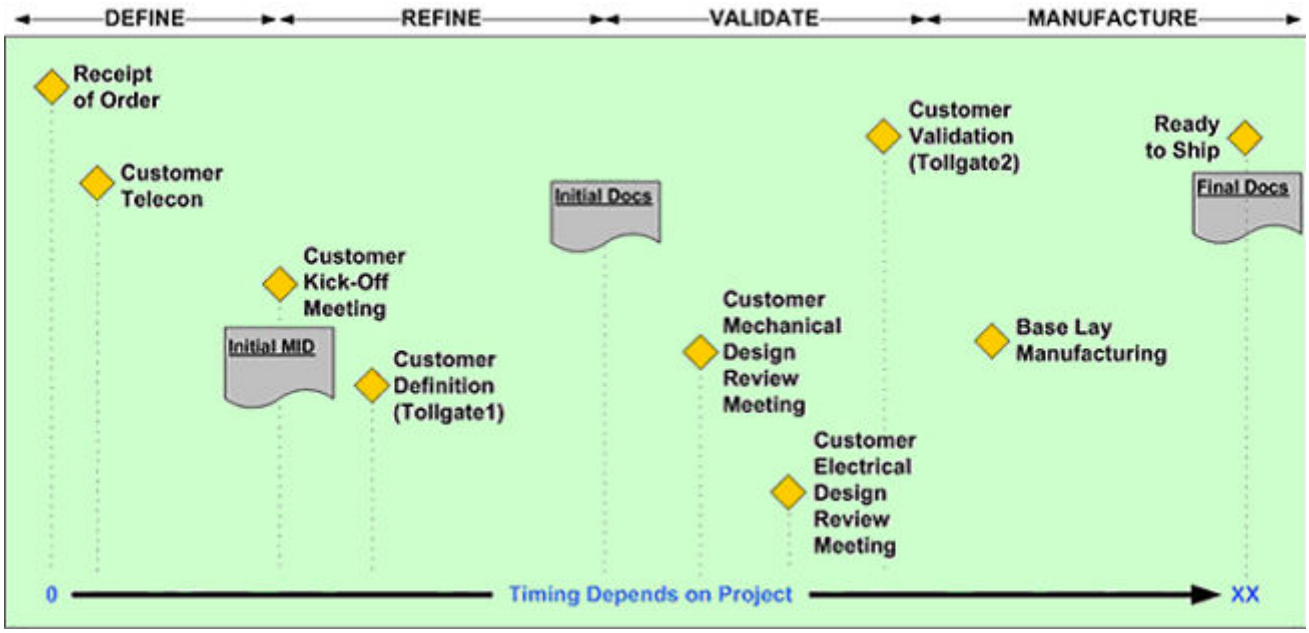
The tooling will include:

- Dial indicator kit
- Alignment tool
  - Motor output to primary gearbox input shaft
  - Primary gearbox output shaft to compressor
- Custom storage container

Order Fulfillment

Objective

Solar's objective is to fulfill orders efficiently and provide a comprehensive set of accurate project documents in a timely manner. The order fulfillment timeline shown in the figure below illustrates the major events through which a typical project will pass. Some events shown are internal to Solar, however, all events are important in ensuring a successful project outcome.



Major Project Events

The following is a description of each event shown in the figure above, and the roles that are expected of both Solar and our Customer:

• **Receipt of Order** is the official starting point of the project and is when Solar assigns a team of technical experts to engineer and execute the project. The team is led by the Project Manager and Project Engineer. They are the respective key commercial and technical contacts for the Customer.

• A **Customer Teleconference** is normally conducted within one week After Receipt of Order (ARO) and is held between the Solar Team and the Customer to review the project requirements. This meeting includes a review of the project timeline, key deliverables, and data required from both Solar and the Customer. In addition, Solar and the Customer will mutually agree on the timing and location of the Customer Kickoff meeting. The Document List, (Table 1), will be reviewed and document submittal dates agreed upon. The document schedules within Table 1 are dependent on receipt of timely definition from the Customer.

• The **Customer Kickoff Meeting (CKOM)** may be scheduled as early as four weeks after receipt of order. Ideally, by this time, the appropriate technical and commercial customer representatives have been assigned (e.g. Engineering & Procurement Contractor EPC, if applicable). Solar strongly recommends that the Customer Kickoff meeting be held in San Diego, California so the resources of the entire Solar project team can be utilized. The objective of this meeting is to resolve and finalize any open items related to the Package Definition scope of supply. Package Definition covers everything directly associated with the physical package.

During this meeting a review of the initial Mechanical Interface Drawing (MID) will be conducted. This document contains package dimensions, external connection points, and other package details. Major supplier OEM equipment, complex air inlet and exhaust systems, and custom features will not be available until subsequent revision of the drawing.

• **Customer Definition (Tollgate 1)** is a major event that can only be passed after project definition is complete and confirmed. Customer Definition should be provided within 1 week after the CKOM to maintain the document commitment dates as shown in Table 1. Once complete definition is received from the customer, the Solar project team incorporates the scope details, supplier OEM equipment definition (as applicable) and customer definition into the documents and issues the next submittal of customer documents for review. Delays in receiving Tollgate 1 project definition will cause delays in issuance of customer documents. Changes to project scope and definition after Tollgate 1 could impact project cost and schedule.

• **Mechanical and Electrical Design Review Meetings** are typically held two weeks after Solar issues the Tollgate 1 document submittal packet to our customer. The exact timing depends on the readiness of Solar, our customer, and on the overall project schedule. The purpose of these meetings is to confirm that all customer requirements, including unit balance of plant items, have been captured accurately and are acceptable to all parties. Timely completion of these review meetings is critical to ensuring that the manufacturing phase remains on schedule.

• **Customer Validation (Tollgate 2)** occurs after the Design Review meetings and is based on the mutual agreement that the project definition is complete and validated. If definition items are still open at this point, passing Tollgate 2 may be delayed. Delays at this point in the project may have an impact on both delivery and cost. Once Tollgate 2 has been passed, the design will be considered validated and firm.

Any subsequent scope changes after Tollgate 2 will potentially have a major impact on cost and delivery, and require a Change Order.

Project Documentation

Electronic Document Control

Solar utilizes an Electronic Document Control system based on a collaborative workspace technology. This collaborative workspace allows a single location for project documentation. Document transfers between Solar, Customers, Major Suppliers, and Contractors occurs instantly through this workspace area on the web. Documents are routed and tracked on a real time basis using email tasking and

notifications. This process provides immediate access and complete visibility of all project documentation from the Kickoff all the way through to commissioning of the project. Users are provided with a user name, password, and instructions on how to use the system. The Electronic Document Control operates on standard Internet protocols and meets the highest Internet security standards.

Format

Documents are submitted electronically through Solar's collaborative workspace. Documents are submitted in English, and in the Adobe PDF format. While Solar's documentation package provided in Table 1 is considered comprehensive, Solar recognizes that some customers have additional requirements. These additional requirements, can be quoted at additional cost and to an agreed upon delivery schedule.

Customer Tollgate Definition Requirements

In order for the customer to receive timely documents as stated in Table 1, certain definition will be required on a timely basis. The details of what type of definition are required and when, are dependent on the type of project and the overall project schedule. During the course of the project Solar's Project Manager and Project Engineer will communicate the definition requirements to the customer to insure that the project remains on schedule. Delays in receipt of customer definition for a given project Tollgate will cause delays in the issuance of documents and may also cause delays in overall project schedule.

Critical Documents

The following documents, when provided, are considered critical and require timely review and input in order to avoid delays on the project:

- Mechanical Interface Drawing requires timely review and re-issuance by the Customer.
- Unit Control Balance of Plant Drawing requires timely submittal of Customer P&IDs in order to finalize this drawing.
- Anti-Surge Design requires timely submittal of Customer P&IDs and piping volumes in order to finalize this drawing.
- OEM Supplier Documents are required by Solar in order to maintain the schedule shown in Table 1. Complete definition on the OEM driven equipment, electric motor, gearbox and shaft end details, including an accurate CAD/dxf model of the OEM equipment offered, is required.

Final Documents (As-Shipped)

The final documents are issued as stated in Table 1. These final documents capture the design or configuration of the project as it leaves Solar's factory, and are commonly referred to as the As-Shipped documents. Solar considers our documentation commitments to have been fully met when our customer has received the final documents listed in Table 1.

Installation & Commissioning

During the Installation & Commissioning phase of the project, Solar's field service personnel may mark-up one or more of Solar's "As-Shipped" drawings to reflect any material changes in the design or configuration of the equipment in connection with installation. Solar will issue an As-Installed version of these drawings in order to capture the field mark-ups. These As-Installed drawings will be available 12 weeks after receipt of marked-up drawings in San Diego, California. As a safety check, Solar also requires the updated field software to make sure that all documents are synchronized. Drawing revisions that are necessitated by changes in scope that are either requested by the customer or required due to

unexpected site conditions will be evaluated on a case by case basis and may require additional time and/or involve additional cost to the customer.

Customer Approval of Documents

As defined in the project execution timeline above, project definition is considered complete following the passing of Tollgate 1 and the documents will reflect the design agreed to at that time. The design will proceed based on this definition without further approval of the documents by the customer.

Solar Document List

NOTES:

1. Timing of the initial issue requires Customer to confirm scope and definition no later than CKOM1w.
2. Final project Spare Parts list is submitted when firm definition has been received and bills of materials completed.
3. Initial release reflects the standard package configuration. Excludes supplier OEM definition and custom features. Electric Motor Drive applications are committed to on a project-by-project basis.
4. Generic document is issued with proposal. Initial document requires Customer input & firm P&IDs no later than CKOM1w.
5. Languages other than English require an additional price plus an additional 30 days for drawings, and an additonal 90 days for Solar manuals, beyond deliverable stated below.

KEY:

w = Work weeks
P = Document submitted with the Solar proposal representing a standard or typical configuration
CKOM = Customer Kickoff Meeting
EXW = Final unit is completed and ready for shipment from Solar's factory in San Diego, California

ITEM	DESCRIPTION	PROJECT DELIVERABLE TIMING		
		PROPOSAL	INITIAL	FINAL/AS-SHIPPED
A	**GENERAL**			
A01	Utility List (Reference Only)	P	-	-
A02	Inspection & Test Plan	P	CKOM	-
A04	API 617 Centrifugal Compressor Data Sheets (Solar Prime)	P	-	-
A06	Gas Compressor Performance Curves (Solar Prime)	P	-	-
A07	Recommended Spare Parts List	P	-	(2)
A08	ISO Certificates	P	-	-
A09	General Package Outline (Reference Only)	P	-	-
A10	Document Transmittal Record (SDRL)	-	CKOM	-
A11	Mechanical Interface Drawing (MID)	-	CKOM (3)	EXW+4w (5)
	2nd Submittal		CKOM+7w (1)	
A12	Process & Instrumentation Diagram (P&ID) Lube Oil and Seal systems	-	CKOM+7w (1)	EXW+4w (5)
A13	Unit Control Balance of Plant	P (4)	CKOM+7w (1) (4)	EXW+4w (5)

A14	Anti-Surge Design (Solar Surge Control)	-	CKOM+7w (1)	EXW+4w (5)
A15	Electrical Loop Schematic	-	CKOM+7w (1)	EXW+4w (5)
A16	Field Cable/Wire Report	-	CKOM+7w (1)	EXW+4w (5)
A17	Cause & Effect Drawing	-	-	EXW+4w (5)
A18	Turbotronic Software (Single Display only)	-	-	EXW+4w (5)
B	**MANUALS & QUALITY ASSURANCE**			
B01	Operation & Maintenance Instruction Manual (Solar Equipment)	-	-	EXW+4w (5)
B02	Quality Assurance Data Book (English only)	-	-	EXW+6w
C	**MISCELLANEOUS**			
C02	Paint Specification (ES9-58)	P	-	-
-	Additional Specifications & OEM Supplier Documents	(As agreed)	-	-

Solar Document Aligned with Customer Needs	
Solar Document	Meets the following Customer needs:
I. MECHANICAL	
Mechanical Interface Drawing (A11)	• Mechanical Outline Drawings • General Arrangement Drawings • Skid General Assembly Drawings • Package Tie-Down Details • Dynamic/Static Loads, Center of Gravity • List & Dimensions of Connections • Piping Connections • Anchor Bolt Location Drawings • Equipment Weights • Lube Oil Cooler Drawings • Local & Remote Unit Control Panel Outline • Alignment Data • Lifting Details
Process & Instrumentation Diagram (P&ID) (A12) Lube Oil, Seal, and Motor systems	• Piping & Instrument Diagram • Flow Diagrams • Piping Schematics & Arrangement Drawings • Instrument List • Instrument Index
Utility List (A01)	• Utility Load List • Utilities Schedule • Utilities Consumption Data • Electrical Power Requirements • Electric Load List
II. ELECTRICAL	
Electrical Loop Schematic (A15)	• Electrical Schematic • Electrical Loop Diagram • I/O List • Instrument List • Instrument Index
Field Cable/Wire Report (A16)	• Cable Schedule • System Interconnection Information

	• Wiring Interconnections
Turbotronic Software (A18)	• Control System Software Documentation • Ladder Logic • Software Listing
Unit Control Balance of Plant (A13)	• Control of Devices Outside of the Turbomachinery Package (As agreed) • Inputs/Outputs to Solar Control System
Anti-Surge Design (A14) (Solar Surge Control Only)	• Anti-Surge System • Anti-Surge Valve Sizing Calculations
Cause & Effect Drawing (A17)	• Cause & Effect Diagram • HAZOP Study Information • Alarms & Shutdowns
II. INSPECTION, TEST & QUALITY	
Inspection and Test Plan (A02)	• Factory/Supplier Testing & Inspections Performed • Shop Testing Program • Observe Points • 3rd Party Inspectorate (As Applicable)
Quality Assurance Data Book (B02)	• Quality Data Book • Certified Test Report • Statutory Certification (As Required) • Certificate of Compliance
IV. OPERATION & MAINTENANCE	
Operation & Maintenance Instruction Manuals (B01)	• Systems Operator's Guide • Maintenance Instructions • Supplementary Data • Illustrated Parts List • Process Control Instructions (As Agreed) • Supervisory Control Instructions (As Agreed)
V. DATA SHEETS & CURVES	
API 617 Gas Compressor Data Sheets (A04)	• Compressor Data • Performance Data
Gas Compressor Performance Curves (A06)	• Performance Data • Surge Line

CD-ROM Quality Control Data Books, Quantity 4

Quality Control Data Books are submitted in the Adobe PDF format on CD-ROM.

Hard Paper Copy Quality Control Data Books, Quantity 4

Quality Control Data Books are submitted in hard paper copy.

The Quality Control data book typically includes the following:

- Inspection and test plan (ITP)
  - Describes the quality assurance requirements for each product on a project basis.

  - Lists the primary controlling and verifying documents, codes and standards used to define the quality requirements, and identifies inspection points.
- Package certified test report
- Compressor acceptance test report
- American Society of Mechanical Engineers (ASME) data reports for lube oil filters and lube oil coolers, as applicable
- Solar's Package Certificate of Compliance

If specified on the final project ITP, the Quality Control data book may also include the following documents at additional cost and increased delivery time:

- Documentation from suppliers of major package components such as oil coolers, oil filters, gearboxes and driven equipment
- Third-Party Certificates and Declarations of Conformity when applicable

Torsional Analysis Report

A torsional analysis will be performed on the entire drive train to determine if there are any significant torsional resonance conditions within ±10% of the operating speed range. If a resonance condition (interference) is found, then a fatigue analysis is performed to confirm the resonance will not cause fatigue failure in the shafting. If an interference is determined to be potentially harmful then changes to the coupling(s) may be made to either eliminate the interference or reduce its harmful effects.

Lateral Analysis Report

A lateral forced response analysis of the driven equipment will be performed to confirm that any lateral critical speeds aren’t close enough to the operating speed range to cause lateral vibration problems.

CD-ROM Operation & Maintenance Instruction Manuals, Quantity 4

Operation & Maintenance Instruction Manuals are submitted in the Adobe PDF format on CD-ROM in English.

Hard Copy Operation & Maintenance Instruction Manuals, Quantity 4

Operation & Maintenance Instruction Manuals are submitted in hard paper copy in English.

Operation and Maintenance Instruction Manual

The Operation and Maintenance Instruction Manual (OMI) provides descriptive and instructional data for operating and servicing the package. General, functional, and component descriptions of the package systems with supporting illustrations are included in four volumes:

- Systems Operator's Guide - Intended for the equipment operator, the systems operator's guide provides familiarization with controls and indicators, operating procedures, and safety precautions to ensure safe equipment operation.
- Maintenance Instructions - Intended for maintenance and field service personnel, the maintenance instructions include preventive and corrective procedures, including periodic inspection requirements, alignment procedures, cleaning procedures, removal and installation procedures, adjustment procedures, and tolerances.
- Supplementary Data - Provided in the form of supplier manuals and data sheets, the supplementary data provides descriptions of components and assemblies not covered or fully discussed in the Maintenance Instructions volume. Due to copyright restrictions, supplementary data from suppliers is available in English only.

- Illustrated Parts List - Provides part numbers, part names, quantities, reference designators, and illustrations for locating and ordering parts.

The OMI manual typically includes the following features:

- Electronic viewing of data in a Windows environment
- All volumes of the manual set on one CD-ROM
- Search feature including full text search for supplier data
- Graphics in a separate window for simultaneous viewing of text with associated illustration
- PDF version for printing

2.10 CERTIFICATION

General Description

Solar's leadership in the gas compressor industry is supported by its ability to comply with regulations, codes, and standards required by industry and/or regional authorities around the world. Solar continually evaluates compliance requirements to ensure conformance with applicable standards.

NRTL (U.S.) Certification – Hazardous Locations – Unit Inspection

Evaluation, testing and certification is provided by an OSHA approved Nationally Recognized Testing Laboratory (NRTL) to standards applicable to equipment in hazardous locations. Field evaluation of each unit can be performed either at a Solar facility or at the customer’s site. Equipment certification will be available upon completion of field evaluation by NRTL.

Summary

Solar has a continuing program to support customers in ensuring that Solar's products conform to applicable codes and regulations. Solar also has the resources to provide customer guidance and assistance in this process.

3 PERFORMANCE

3.1 EXPECTED PERFORMANCE

3.1.1 DRIVER EQUIPMENT PERFORMANCE DATA

Refer to the appendix section for technical details.

--- Run by R. Zamotorin on: 03 AUG. 2015 at 16:16:27, file = 150803 HO15-0023 T60-C335 Weymouth.sav ---

Compressor No.= 1 Family = C33-6
Case(kcx) 55, Type 0 Operation Driven End= suction
EOS used= REDLICH-KWONG(properties input) Seals= Dry Gas
Reynolds Correction: Old_Gen Mach: RG,Every Driver= Taurus 60

Stages: [309] 2CF 1CM 1CM 1CM 2BM 1BR
Stage Diam.: 12.86 12.86 12.86 12.86 12.86 12.86

Point#	1	2	3		
P1	469.70	509.70	509.70	psia	
P2	1264.70	1264.70	1454.70	psia	
HEAD, ISEN	50948.8	46038.2	54126.5	ft-lbf/lbm	
HEAD, POLY	52508.1	47480.7	55970.6	ft-lbf/lbm	
INLET FLOW	1990.58	1380.45	1687.04	acfm	
STANDARD FLOW	98.26	74.39	90.91	mmscfd	
MASS FLOW	49.40	37.40	45.71	lbm/sec	
POWER	6010.	4206.	5998.	Hp	Min perf @100 F +0.2%
SPEED	13598.	12329.	13497.	rpm	
PRESS. RATIO	2.693	2.481	2.854		
T1	60.0	60.0	60.0	Deg F	
T2	229.0	217.0	241.6	Deg F	
EFF, ISEN	76.9	75.1	75.7	percent	
EFF, POLY	79.2	77.5	78.3	percent	
SURGE MARGIN	29.0	11.0	17.3	percent	
TURNDOWN	35.8	11.8	20.0	percent	
SPEC. GRAVITY	0.5690	0.5690	0.5690		
K1	1.418	1.428	1.428		
K2	1.374	1.384	1.378		
PCP	672.4	672.4	672.4	psia	
PCT	349.0	349.0	349.0	Deg R	
Z1	0.9321	0.9266	0.9266		
Z2	0.9529	0.9484	0.9541		
K - 50 DEG F	1.310	1.310	1.310		
K - 300 DEG F	1.247	1.247	1.247		
OPTIMUM POWER	0.	0.	5999.	hp	
OPTIMUM SPEED	0.	0.	13682.	rpm	
RECIRC:					
DIA(BP)	8.499	8.499	8.499	inches	
RCL(BP)	0.0035	0.0035	0.0035	inches	
DP(BP)	20.00	20.00	20.00	psi	
TEMP	61.8	62.1	62.3	Deg F	
SQ-INTERNAL	99.44	75.57	92.23	mmscfd	
SQ-LEAK	1.18	1.18	1.35	mmscfd	
API Output:					
Molecular Wt.	16.481	16.481	16.481		
Gas Components (Mol.%):					

3.1.2 GAS TURBINE PERFORMANCE MAP

GCASE REV 3.9.9: DB239.00
ESTIMATED COMPRESSOR PERFORMANCE
C33-6
[309] 2CF 1CM 1CM 2BM 1BR

HFHR = 0.500

SG	K50	K300	PCP	PCT
0.5690	1.310	1.247	672.4	349.0

SUCTION TEMPERATURE 60.0 F
SUCTION PRESSURE 469.70 PSIA

Solar® Turbines
A Caterpillar Company

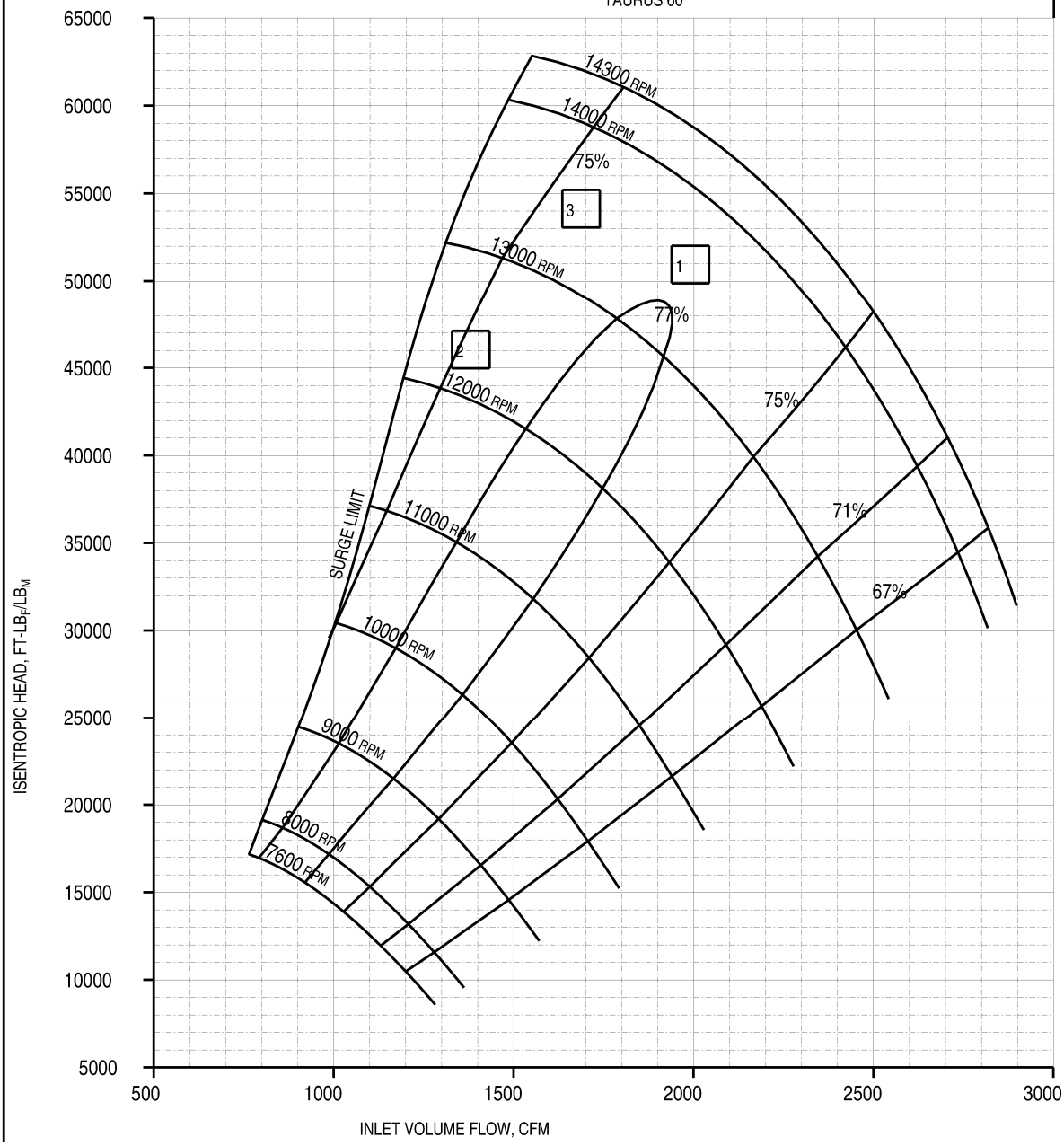
CONTROL NO.
I-36972 SHT.1
ISSUE DATE
12 AUG. 2015
ENGINEER
R. ZAMOTORIN

SPECTRA

WEYMOUTH CS

HO15-0023

TAURUS 60



GCASE REV 3.9.9: DB239.00
ESTIMATED COMPRESSOR PERFORMANCE
C33-6
[309] 2CF 1CM 1CM 1CM 2BM 1BR

HFHR = 0.500

SG	K50	K300	PCP	PCT
0.5690	1.310	1.247	672.4	349.0

SUCTION TEMPERATURE 60.0 F
SUCTION PRESSURE 469.70 PSIA

Solar Turbines
A Caterpillar Company

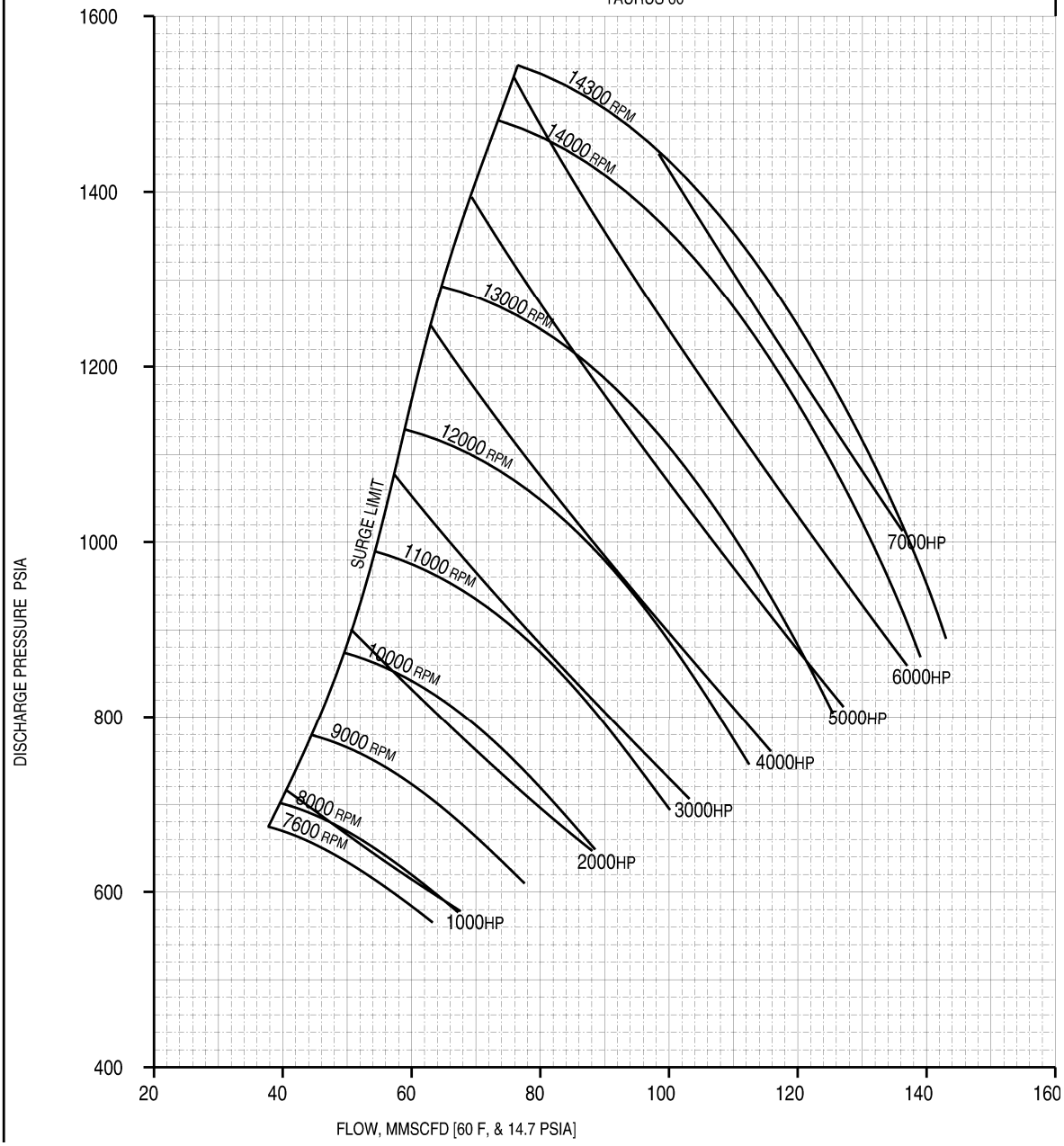
CONTROL NO.
I-36972 SHT.2
ISSUE DATE
12 AUG. 2015
ENGINEER
R. ZAMOTORIN

SPECTRA

WEYMOUTH CS

HO15-0023

TAURUS 60



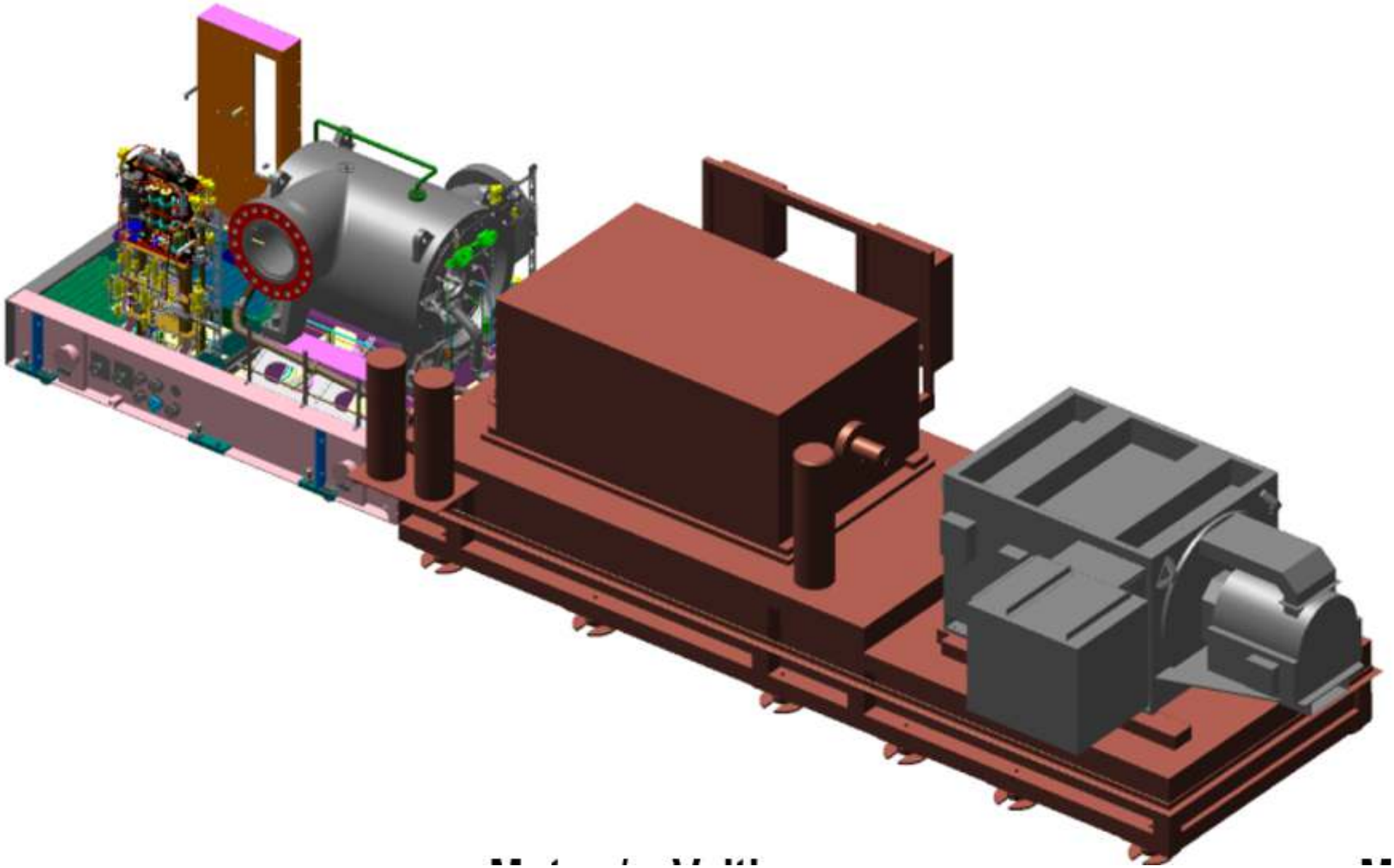
3.1.3 DRIVEN EQUIPMENT PERFORMANCE DATA

Motor Drive Power Requirements: 7,004 HP (5223 KW)

Comp. Requirements:														
							Select HP or kW:	HP						
Compressor #1:	C335EH						Data points Max Power:	6,010	HP	4,482	kW			
Compressor #2:	None						Data Points Min Speed:	12,329	RPM	By Voith	% Turn Down			
Compressor #3:	None						Max Select Speed:	13,500	RPM					
Comp. Configuration:	Single Body						Max Continous Speed:	14,175	RPM					
Preliminary Motor Rating:	7,004	HP	5,223	kW			Preliminary GB ratio:	Voith		Actual Ratio		Voith		
Operating Conditions:	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Comp. Power points:	6,010	4,206	5,998											
Comp. Speed Points:	13,500	12,329	13,497											
Motor Power:	7,004	4,902	6,990	0	0	0	0	0	0	0	0	0	0	0
Motor Speed:	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800

Utility, Motor, Gearbox and Margin requirements:						
Utility Voltage:	13,800 V			Motor Slip in RPM	0	Changed to 0 per Thayer
Utility Frequency (hz):	60			Motor Service Factor:	1.00	
Motor Voltage:	By Supplier			API Power margin in %:	1.10	
Motor Freq. (hz) & # Poles:	60	4	Poles	Voith/Gearbox Losses in %:	1.0595	
Motor Type:	Induction			Motor Speed:	1800	RPM
Motor enclosure type:	TEPV - std			Motor MCOS:	1,800	RPM
				VFD/Motor Max Torque @:	1350	RPM

4 TYPICAL DRAWINGS



5 APPENDICES

VOITH TECHNICAL PROPOSAL

Scope of Supply:

Voith geared variable speed drives Vorecon as centrifugal compressor drives for design data as below:

Gear rated power:	Acc to drive motor ratings: RWE 11
Output power:	As per compressor speed / motor design data.
Drive motor speed:	Suitable for 60 Hz 4-pole motors acc to motor type selection induction or synchronous.
Compressor speed:	As per compressor speed / motor design data.
Regulating range:	As per attached preliminary operating maps.
Counter torque curve:	To be determined.
Gear design	For both the revolving planetary gear and the stationary gear according to DIN 3990 / ISO 6336.
Oil specification	Mineral oil grade ISO VG 46.
Site condition design:	Indoor, unheated, max ambient temperature 110 °F (43 °C), min ambient temperature 15 °F (-9 °C), min start-up temperature 75 °F (24 °C)
Area classification:	Class 1, Div. 2, Group C/D. Refer also to the instrument list.
Voith coating system:	D-0251 for high protection requirements at installations in industrial areas with high humidity, aggressive atmosphere and coastal areas with moderate salinity. That satisfies the requirements of EN ISO 12944-5 for corrosivity category C4 –high or C5-I very high (industrial), durability medium (M). Voith standard top color shade is “ultramarine blue” RAL 5002.
Voith wiring system:	D-0227 terminal boxes of stainless steel (NEMA 4X) Ölflex cables (UL/CSA) cables laid in Anaconda flexible conduit galvanized cable trays heat-shrinkable sleeve cable marker

I&O Manual language: English

Instrumentation

As per attached preliminary P&ID and instrument list suitable for Class I Div 2.

All instruments are connected to an Allan Bradley Flex I/O Box delivered to Voith Turbo Crailsheim works by Solar Turbines.

The modules for RTDs, pressure and level transmitters are mounted inside and scope of Solar Turbines, while proximitors for the Bently Nevada vibration probes will be supplied and installed inside by Voith Turbo.

Actuator

- 1 Electro-hydraulic actuator type VEHS (make Voith), including:

- integrated positioner with input signal 4-20 mA

- integrated feedback transmitter with output signal 4-20 mA

Supply voltage: 24 V DC, max. 3.0 A from an uninterrupted power supply

Protection: NEMA 4

Compressor side connection coupling

- 1 High speed connecting coupling including spacer and diaphragm. The hub at the compressor side is customized acc to the compressor shaft end.

- 1 Coupling guard over rotating parts. The guard is fabricated from Aluminum alloy and coated from outside against corrosion. A vent connection is provided and a drain connected to the oil reservoir. The coupling guard is closed on both ends and therefore oil tight.

Base frame

- 1 Base frame for the VORECON and the main drive motor made of welded carbon steel. The oil tank of the Vorecon will be an integral part of this base frame.

Voith designs the base frame including a structural analysis (static and dynamic calculations).

Oil supply system

Integrated working oil system

The working oil system is an integral part of the VORECON and provides the oil for power transmission in the torque converter. It includes

- 1 Piping in carbon steel

- 1 Oil sump heater with thermostat

- 1 Shaft driven submerged centrifugal oil pump

- 1 Temperature control valve (fully closed at 131 °F / 55°C), as loose supply.

Design temperature of above components shall be at least 266 °F / 130 °C,

Design pressure including frame size RWC 710 M 9 shall be 145 PSI / 10 bar (150 lbs), frame size RWC 800 M 9 and above requires 232 PSI / 16 bar (300 PSI).

An oil cooler is included and sized according to the data from the compressor speed / motor rating matrix and ambient conditions.

The pressure loss across the cooler shall not exceed 12 PSI / 0.8 bar (22 PSI / 1.5 bar including piping) at operating temperature and 29 PSI / 2.0 bar in cold condition (44 PSI / 3.0 bar including piping).

Integrated lube oil system

The lube oil system is an integral part of the VORECON and provides lubrication for all rotating equipment of the drive train (main motor, VORECON and driven machine).

The reservoir is split up into two sections, one for lube oil and one for working oil. Both sections of the reservoir are interconnected to maintain the same oil level.

Lube oil supply quantity for main motor and driven equipment as per compressor speed / motor rating matrix.

Lube oil supply to compressor and drive motor will be provided at max 129°F and at the pressure required reduced by orifices from the Vorecon system pressure of 46.4 PSI / 3.2 bar. Further instrument set points for alarms and trips are provided in the instrument list.

The lube oil system comprises

- 1 Oil tank and piping before filter in carbon steel, after filter in stainless steel grade 316L.

- 1 Oil sump heater with thermostat, max 2 heaters acc to ambient conditions.

- 1 Main lube oil pump, three spindle type, driven by the gear input shaft.

- 1 Auxiliary lube oil pump, three spindle type, including an AC motor.

- 1 Temperature control valve (fully closed at 111 °F / 44°C), as loose supply

- 1 Pressure control valve to maintain constant lube oil pressure.

- 1 Double filter with manual switchover at 10 microns (10/1000) nominal filtration grade, with

carbon steel housing and stainless steel internals.

Design temperature of above components shall be at least 212 °F / 100 °C, design pressure 145 PSI / 10 bar.

An oil cooler is included and sized according to the data from the compressor speed / motor data and ambient conditions.

The pressure loss across the cooler shall not exceed 12 PSI / 0.8 bar (22 PSI / 1.5 bar including piping) at operating temperature and 29 PSI / 2.0 bar in cold condition (44 PSI / 3.0 bar including piping).

Miscellaneous

Control Unit (PLC)

For all RWC type Vorecons, a control unit type CompactLogix System 5370 L3 (make Allan Bradley) for start-up control of the hydrodynamic system and speed control is included.

The control cubicle with its Flex I/O modules inside is mounted on the instrument rack and suitable for Class I Div 2 environment. the PanelView Plus 6 color LCD serves as HMI.

Torsional vibration analysis

Standard calculation of the torsional vibration behavior of the whole drive train. The torsional vibration analysis of the whole drive train consists of drive motor, Voith variable speed drive and driven machine, including the calculation of the natural frequencies and natural vibration modes, simulation of the startup from standstill, simulation of the double phase fault, simulation of the three-phase short-circuit (additionally for asynchronous motors: Simulation of the restarting after a voltage interruption).

Bending vibration analysis

Calculation of the bending vibration behavior of the main shafts of the Voith variable speed drive, including the decisive critical bending speeds as well as the calculation and graphical presentation of the vibration amplitudes as a function of the shaft speed (Response Analysis),

Testing

Tests are performed on materials and parts acc to the QCP. A mechanical part load test run will be conducted with up to 6000 kW input power, 4h duration at different speed levels. For details refer to the test run description.

Motor side connection coupling

• Low speed (1800 rpm) connecting coupling including spacer and flexible elements. The hubs on both sides are suitable for cylindrical straight shaft ends with a single key.

• Coupling guard over rotating parts. The guard is fabricated from Aluminum alloy and coated from outside against corrosion. A drain connected to the oil reservoir is provided. The fixed end at the Vorecon side is closed, while the motor side end is loose.

Heat Exchanger assembly

Additionally we offer a single frame air-to-oil heat exchanger with two sections, one for the working oil system and one for the lube oil system.

Spare Parts Option:

Additionally we offer the following kit of spare parts suitable for commissioning including:

• one set of seals and gaskets for commissioning

• one set of filter inserts for the lube oil filter

Comments and Exceptions to Specifications:

This offer comprises the scope of supply described above and in the attached documents. Should we receive further specification at a later date, we reserve the right to change the offer in design, scope and price.

The basic machine internal mechanical design, pipework, valves and pumps are as per DIN, EN, ISO and Voith Standard as described in the offer. API Standards or other standards are not applicable for this Voith Standard Design.

This offer and the herein mentioned technical description as well as Voith documents and standards shall be understood as an exception to the specifications and shall become part of the contract.

No project-specific specifications have been submitted.

Comments on and Exceptions to API 613

The machine is a combination of shafts, bearings, epicyclic gears, impellers in the hydrodynamic oil circuit, actuator, oil system and shaft driven oil pumps.

This complete basic unit is designed, calculated and manufactured according to DIN and Voith Standard, but not to API.

API 613 does not apply to this machine design and its accessories.

Also the bearings are designed to DIN and Voith Standard. The specific load on the bearings is higher than the allowable values of API. The l/d of the pinion might be higher than 1.6.

Quality assurance and testing is made acc. to Voith Standard. See Voith Quality Control Plan and Test Run Description.

Comments on and Exceptions to API 614

The integrated working oil system is according to Voith standard, but not to API 614. The working oil circuit provides oil to the hydrodynamic torque converter.

As this is a special application, API 614 does not apply to it and it is designed to Voith Standard. The working oil pump is a shaft driven design to Voith Standard but not to API 614.

Other main components like oil tank and pipework are integrated parts of the unit. The design is to Voith's Standard, but not to API 614.

The working oil system has no oil filter nor pressure control.

Comments on and Exceptions to API 670

The bearing temperatures and vibrations are measured as per Voith Standard.

API 670 is not applicable.

Comments on and Exceptions to API 671

Please note that the final sub-supplier for the couplings and guards will be decided earliest during engineering phase. Therefore the comments and exceptions on API 671 will follow later on.

Pipework design

The internal pipework including fittings, welded connections and flanges is made according to EN and Voith Standard due to space reasons. All bolts and threads are as per EN standard. For flange connections we will use hexagonal bolts but not stud bolts. The design of the pipework is described in the Voith Description of Pipework D-0153. Gaskets are designed according to Voith proven standard. Small vent and drain valves are in stainless steel with ½“ NPT connections, but not flanged. Instrument tubing size will be 12 x 1.5 mm. Instrument tubing will be connected by compression fittings (not seal welded). Instrument valves will be made of stainless steel.

Threaded connections with compression fittings are used for instrument tubing and external vent piping in stainless steel. The compression fittings are not seal welded. The working oil piping, the valves and the oil pumps integrated in this piping system are made of carbon steel or grey cast iron.

Quality assurance

Voith has an Integrated Quality Management System (quality, health, environment, safety) which is based on DIN EN ISO 9001, DIN EN ISO 14001 and OHSAS 18001.

Quality management, quality control, NDT and NDE operator's qualification, welding and welder's qualification are based on the applicable DIN, EN and ISO standards. The tests and documentation indicated in our Quality Control Plan (QCP) are included in the scope of testing performed by us. Tests exceeding the above are to be specified by you. We would check their feasibility and confirm any extra charges. Our QA program is based on ISO 9001.

Qualification of NDT personal

Voith has its own qualification procedure for NDT personal. Our testing and test supervisory personnel are instructed and trained in conformity with EN 473 / EN ISO 9712 and/or ASNT-SNT-TC-1A.

NDE operator’s qualification: ASNT-TC-1A Level I

Personnel for evaluation of results: ASNT-TC-1A Level II or III

The periods required therein with regard to practice and re-certification are adhered to.

Qualification for welding procedures and personnel

Voith’s welding procedure qualification is according to DIN EN ISO 3834-2 (Comprehensive quality requirements) and AD 2000 Rules HP 0 / TRD 201 (German rules for welding of pressurized parts).

Welding personnel is qualified according to DIN EN ISO 9606-1 / DIN EN ISO 14732 and/or TRD 201/ AD 2000-Rules HP3. Welding quality is evaluated according to DIN EN ISO 5817.

Vibration

Vibration evaluation according to DIN ISO, VDI and API but with exceptions to Voith Data Sheet c 081.

Preservation

Preservation is described in Voith directives D-0800 and D-0801, which can be provided upon request.

Bearing temperature measurement

The bearing temperatures are measured as per Voith Standard. The bearings in the planetary gear which are not accessible have no temperature probes. These bearings are indirectly monitored by the vibration probes

Operating fluids

An oil from our list 3625-008394 or one, which meets the requirements of this document shall be used.

Exclusions:

Voith Scope of Supply is described in the aforementioned Chapter " Scope of Supply". If not mentioned explicit within this offer nothing else will be in Voith Scope of Supply and responsibility.

Limits of Voith scope of supply are the shaft ends (resp. connection coupling - if offered), pipework connections and junction box of our machine. The following is NOT included in our prices:

- Initial oil filling.

- Heat exchanger

- Interconnecting piping between the unit and heat exchangers as well as flange adaptions.

- Water-side pipework, valves or instrumentation.

- Monitoring equipment and logic processing of signals

- Wiring to the control room as well as any interconnecting wiring.

- Power wiring for devices like actuator, motor or heater.

- Tackles or Lifting Equipment

- Main motor drive

- Concrete foundation

- Installation, commissioning or field service.

Attachments:

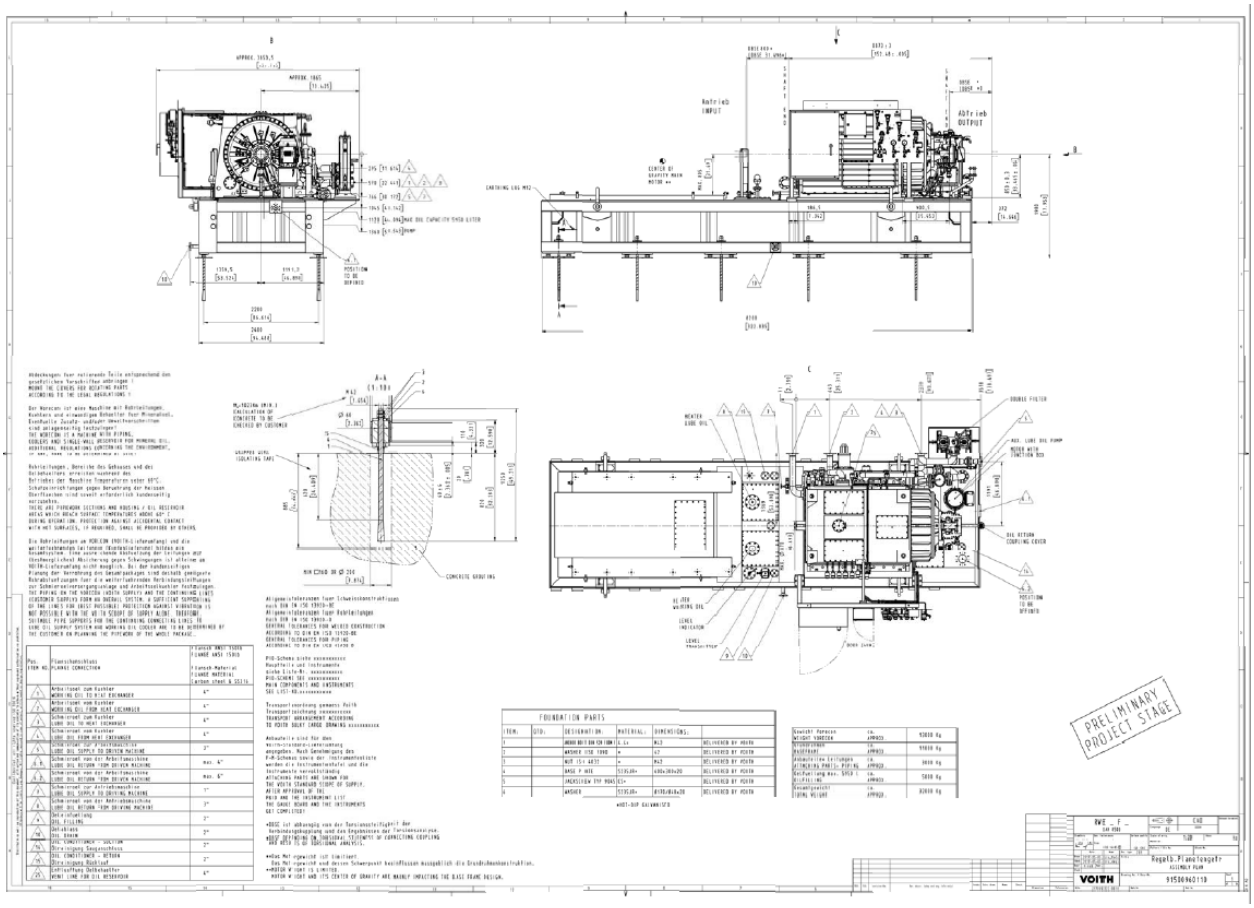
- Preliminary Vorecon general arrangement.

- Preliminary P&ID

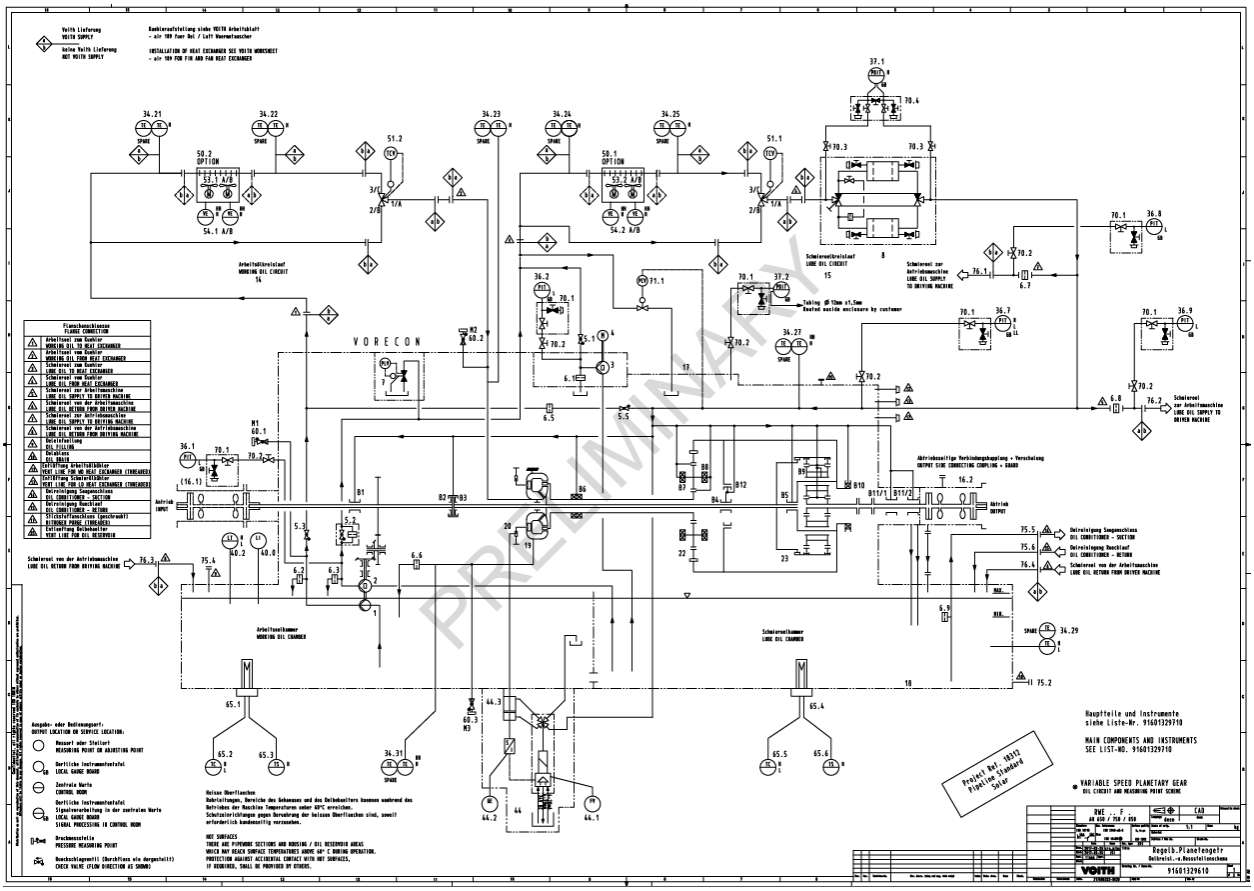
- Preliminary instrument list

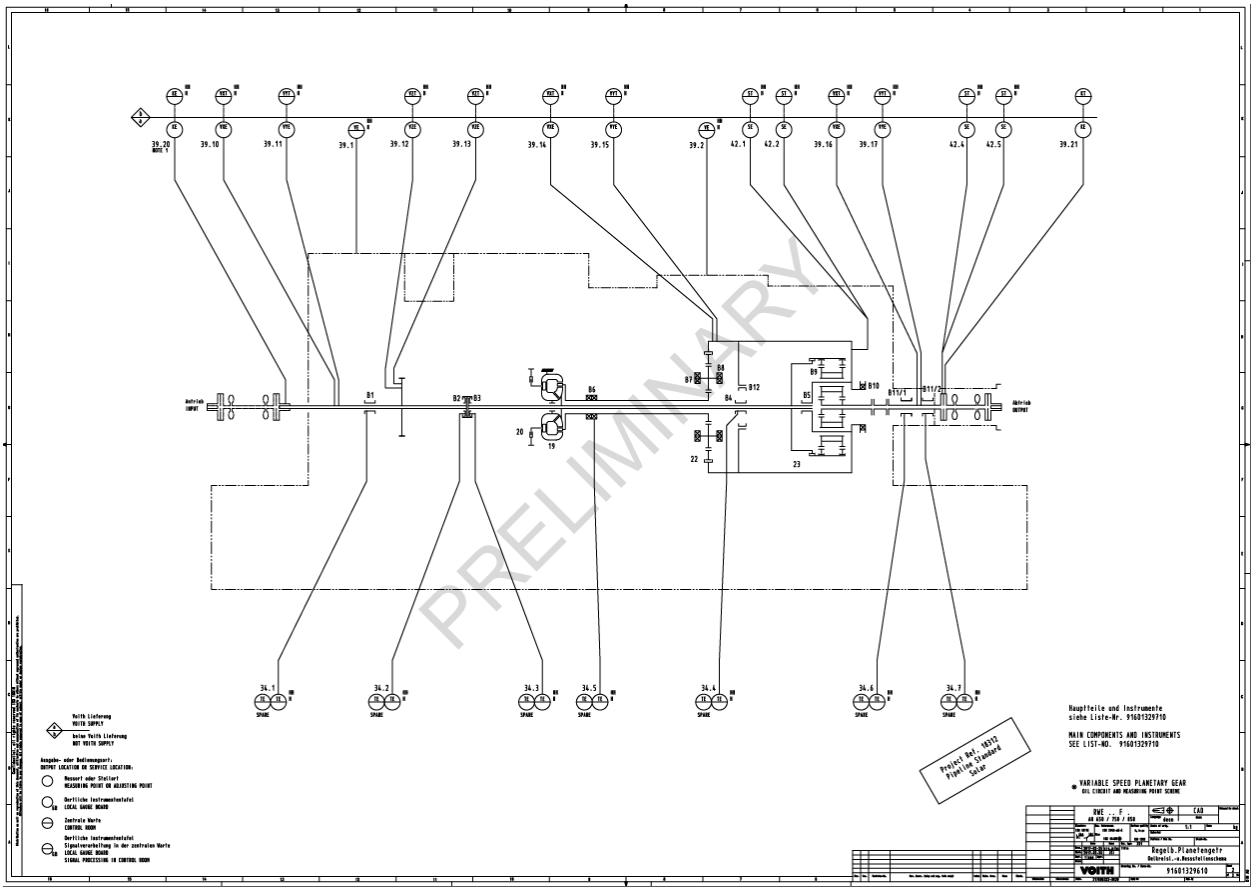
In the event of an order Voith needs the approval of Operating Map, QCP and the direction of rotation.

Preliminary Vorecon General Arrangement



Preliminary P&ID





PRELIMINARY

Voith Lieferung
VOITH SUPPLY

Seitens Voith Lieferung
NOT VOITH SUPPLY

Angabe- oder Bedienungsort.
OUTPUT LOCATION OR SERVICE LOCATION.

Messort oder Stellort
MEASURING POINT OR ADJUSTING POINT

Örtliche Instrumententafel
LOCAL GAUGE BOARD

Zentrale Warte
CONTROL ROOM

Örtliche Instrumententafel
Signalverarbeitung in der zentralen Warte
LOCAL GAUGE BOARD
SIGNAL PROCESSING IN CONTROL ROOM

Hauptteile und Instrumente
siehe Liste-Nr. 91601329710

MAIN COMPONENTS AND INSTRUMENTS
SEE LIST-NO. 91601329710

Project Ref. 19322
Pipeline Standard
Solar

VARIABLE SPEED PLANETARY GEAR
OIL CIRCUIT AND MEASURING POINT SCHEME

RWE .. F
AR 650 / 750 / 850

CAD

Regelb.Planetengetr.
Oelkreisl.u.Messstellenschema

VOITH

91601329610

Preliminary Instruments List

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range --- Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	B 1	-	Radial bearing	-	-	-	Main input shaft	-	-	-
-	B 2	-	Thrust bearing	-	-	-	Main input shaft	-	-	-
-	B 3	-	Thrust bearing	-	-	-	Main input shaft	-	-	-
-	B 4	-	Radial bearing	-		-	Main input shaft	-	-	-
-	B 5	-	Radial bearing	-	-	-	Main input shaft	-	-	-
-	B 6	-	Antifriction bearing	-	-	-	Fixed planetary gear	-	-	-
-	B 7	-	Antifriction bearing	-	-	-	Fixed planetary gear	-	-	-
-	B 8	-	Antifriction bearing	-	-	-	Fixed planetary gear	-	-	-
-	B 9	-	Radial bearing	-	-	-	Planet pin	-	-	-
-	B 10	-	Antifriction bearing	-	-	-	Revolving planetary gear	-	-	-
-	B 11/1	-	Radial bearing	-	-	-	Output shaft	-	-	-
-	B 11/2	-	Radial bearing	-	-	-	Output shaft	-	-	-
-	B 12	-	Radial bearing	-	-	-	Damping disc	-	-	-
-	1	-	Mech. driven working oil pump	-	-	-	Working oil	-	-	-

PRELIMINARY

VOITH	Scheme No.	Order No	Code	Date	Type	Revision	Document No.
Voith Turbo GmbH & Co. KG D - Crailsheim	91601329610		Project Ref. 18312 Pipeline Standard Solar	2017-05-03 tipps-miha	**RWE .. F .** AH 650 / 750 / 850		**91601329710en**

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	2	-	Mech. driven lube oil pump	-	-	-	Lube oil	-	-	-
-	3	-	Auxiliary lube oil pump Type: ___ Make: ___	-	-	-	Lube oil	-	-	-
-	4	-	Electric motor Type: ___ Make: ___	-	Class I, Div 2, Group C ,D T4	NEMA	Auxiliary lube oil pump	-	-	___ V, 3 Ph, AC Power : __ kW Ex type of protection depends on project requirements.
-	5.1	-	Check valve	-	-	-	Auxiliary lube oil pump	-	-	-
-	5.2	-	Check valve (with bore)	-	-	-	Lube oil pump	-	-	-
-	5.3	-	Check valve	-	-	-	Working oil pump	-	-	-
-	5.5	-	Check valve	-	-	-	By-pass working oil	-	-	-
-	6.1	-	Orifice	-	-	-	Auxiliary lube oil pump	-	-	-
-	6.2	-	Orifice (Bore in pipe)	-	-	-	Working oil pump	-	-	-
-	6.3	-	Orifice (Bore in pipe)	-	-	-	Lube oil pump	-	-	-
-	6.5	-	Orifice	-	-	-	By-pass working oil	-	-	-
-	6.6	-	Orifice	-	-	-	Working oil down-stream of torque converter	-	-	-

PRELIMINARY

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	6.7	-	Orifice	-	-	-	Lube oil upstream of motor	-	-	-
-	6.8	-	Orifice	-	-	-	Lube oil upstream of driven machine	-	-	-
-	6.9	-	Orifice (Bore in pipe)	-	-	-	Siphon breaker bore / suction pipe for oil conditioner	-	-	-
-	7	-	Pressure limiting valve Make: Voith	-	-	-	Lube oil	94.2 PSI / 6,5 bar	-	
-	8	-	Duplex oil filter Type: ___ Make: ___	-	-	-	Lube oil	-	-	Housing material: GGG (spheroidal graphite cast iron Filter elements: Filtration level: β10>10 and β15 > 200 acc. to ISO 16889 Cleanliness grade: -/15/12 acc. to ISO 4406
-	14	-	Working oil pipework	-	-	-	-	-	-	Material: carbon steel
-	15	-	Lube oil pipework	-	-	-	-	-	-	Material: carbon steel, downstream filter stainless steel
-	(16.1)	-	OPTION: Input side connecting coupling with guard Type: ___ Make: ___	-	-	-	-	-	-	Guard material: aluminum (non sparking)
-	16.2	-	Output side connecting coupling with guard Type: ___ Make: ___	-	-	-	-	-	-	Guard material: aluminum (non sparking)

PRELIMINARY

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	17	-	VORECON housing	-	-	-	-	-	-	Material: EN-GJL-300 (grey cast iron)
-	18	-	Oil reservoir	-	-	-	-	-	-	Material: carbon steel.
-	19	-	Torque converter	-	-	-	-	-	-	-
-	20	-	Guide vane adjustment	-	-	-	Torque converter	-	-	-
-	22	-	Fixed planetary gear	-	-	-	-	-	-	-
-	23	-	Revolving planetary gear	-	-	-	-	-	-	-
-	34.1	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Bearing temperature / Radial bearing 1 B 1	Alarm ↑ 194 °F / 90 °C --- Trip ↑ 203 °F / 95 °C	< 194 °F / < 90 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1.
-	34.2	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Bearing temperature / Thrust bearing 2 B 2	Alarm ↑ 194 °F / 90 °C --- Trip ↑ 203 °F / 95 °C	< 194 °F / < 90 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1.
-	34.3	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Bearing temperature / Thrust bearing 3 B 3	Alarm ↑ 194 °F / 90 °C --- Trip ↑ 203 °F / 95 °C	< 194 °F / < 90 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1.

PRELIMINARY

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	34.4	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Bearing temperature / Radial bearing 4 B 4	Alarm ↑ 194 °F / 90 °C ---------- Trip ↑ 203 °F / 95 °C	< 194 °F / < 90 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1.
-	34.5	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Bearing temperature / Antifriction bearing B 6	Alarm ↑ 203 °F / 95 °C ---------- Trip ↑ 212 °F / 100 °C	< 203 °F / < 95 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1.
-	34.6	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Bearing temperature / Radial bearing 11/1 B 11/1	Alarm ↑ 194 °F / 90 °C ---------- Trip ↑ 203°F / 95°C	< 194 °F / < 90 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1.
-	34.7	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Bearing temperature / Radial bearing 11/2 B 11/2	Alarm ↑ 194 °F / 90 °C ---------- Trip ↑ 203°F / 95°C	< 194 °F / < 90 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1.
-	34.21	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Working oil temperature / Upstream of heat exchanger	Heat exchanger fan control.	< (203°F) / < (95°C)	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell. Loose supply to be installed in customer's pipework by others. Temperature and action have to be defined with customer

PRELIMINARY

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	34.22	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Working oil temperature / Downstream of heat exchanger	Heat exchanger fan control.	< (150°F) / < (65°C)	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell. Loose supply to be installed in customer's pipework by others. Temperature and action have to be defined with customer
-	34.23	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Working oil temperature / Upstream of Vorecon	Alarm ↑ 149°F / 65°C	< 150°F / < 65°C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell.
-	34.24	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Lube oil temperature / Upstream of heat exchanger	Heat exchanger fan control.	< (158 °F) / < (70 °C)	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell. Loose supply to be installed in customer's pipework by others. Temperature and action have to be defined with customer
-	34.25	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Lube oil temperature / Downstream of heat exchanger	Heat exchanger fan control.	< (122 °F) / < (50 °C)	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell. Loose supply to be installed in customer's pipework by others. Temperature and action have to be defined with customer

PRELIMINARY

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range --- Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	34.27	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Lube oil temperature / Upstream of Vorecon	Main Motor ON ↑ __ °F / ___ °C --- Alarm ↑ 131 °F / 55 °C --- Trip ↑ 140 °F / 60 °C	< 122 °F / < 50 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell.
-	34.29	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Lube oil temperature / Oil reservoir, lube oil chamber	Aux. lube oil pump OFF ↓ 44.6 °F / 7 °C --- Aux. lube oil pump ON ↑ 50 °F / 10 °C		Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell. Logic depends on project requirements.
-	34.31	-	Resistance thermometer Type: 2x PT 100, 3-wire DIN IEC 751, Class B Make: Wika / Emerson - Rosemount	32 – 356 °F / 0 – 180 °C	Simple apparatus acc. NEC 504.2	IP 66 (NEMA 4X)	Working oil temperature / Downstream of torque converter	Alarm ↑ 230 °F / 110 °C --- Trip ↑ 266 °F / 130 °C	< 212 °F / <100 °C	Voith standard connection head Material: aluminum, painted Wired to customer's Flex I/O box Details for Simple apparatus see Note 1. With thermowell.
-	36.1	-	Pressure transmitter with indicator (LCD display) Type: 3051 TG.... (with HART protocol) Make: Emerson - Rosemount	-14 to 150 PSI -1.01 to 10.3 bar --- 0 to 145 PSI 0 to 10 bar = 4 - 20 mA	FM certified Class I, Division 2, Group A,B,C,D "non incendive"	NEMA 4X	Lube oil pressure / Downstream of mech. driven lube oil pump	Alarm ↓ ___ PSI / ___ bar	87 PSI ±29 PSI / 6 bar ± 2 bar	Gauge board mounted. With two valve manifold. Housing material: aluminum, epoxy coated. Wired to customer's Flex I/O box

PRELIMINARY

Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range --- Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	36.2	-	Pressure transmitter with indicator (LCD display) Type: 3051 TG.... (with HART protocol) Make: Emerson - Rosemount	-14 to 150 PSI -1.01 to 10.3 bar --- 0 to 145 PSI 0 to 10 bar = 4 - 20 mA	FM certified Class I, Division 2, Group A,B,C,D "non incendive"	NEMA 4X	Lube oil pressure / Downstream of aux. lube oil pump	Alarm ↓ ___ PSI / ___ bar	87 PSI ±29 PSI / 6 bar ± 2 bar	Gauge board mounted. With two valve manifold. Housing material: aluminum, epoxy coated. Wired to customer's Flex I/O box
-	36.7	-	Pressure transmitter with indicator (LCD display) Type: 3051 TG.... (with HART protocol) Make: Emerson - Rosemount	-14 to 150 PSI -1.01 to 10.3 bar --- 0 to 87 PSI 0 to 6 bar = 4 - 20 mA	FM certified Class I, Division 2, Group A,B,C,D "non incendive"	NEMA 4X	Lube oil pressure / Downstream of filter	Main motor ON ↑ 39 PSI / 2,7 bar --- Aux. lube oil pump motor OFF, with timer 30 sec. after completed motor start-up ↑ 39 PSI / 2,7 bar --- Alarm ↓ 34,8 PSI / 2.4 bar --- Trip Aux. lube oil pump motor ON ↓ 23,2 PSI /1,6 bar	46.4 PSI ±7.25 PSI / 3,2 bar ±0,5 bar	Gauge board mounted. With two valve manifold. Housing material: aluminum, epoxy coated. Wired to customer's Flex I/O box
	36.8	-	Pressure transmitter with indicator (LCD display) Type: 3051 TG.... (with HART protocol) Make: Emerson - Rosemount	-14 to 150 PSI -1.01 to 10.3 bar --- 0 to 87 PSI 0 to 6 bar = 4 - 20 mA	FM certified Class I, Division 2, Group A,B,C,D "non incendive"	NEMA 4X	Lube oil pressure / upstream of driving machine	Alarm: Lube oil pressure driving machine low: ↓ __ PSI / ___ bar	>___PSI / >___bar	Gauge board mounted. With two valve manifold. Housing material: aluminum, epoxy coated. Wired to customer's Flex I/O box Note: Oil pressure set value and action to be defined with customer in detail engineering phase

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
	36.9	-	Pressure transmitter with indicator (LCD display) Type: 3051 TG.... (with HART protocol) Make: Emerson - Rosemount	-14 to 150 PSI -1.01 to 10.3 bar — 0 to 87 PSI 0 to 6 bar = 4 - 20 mA	FM certified Class I, Division 2, Group A,B,C,D "non incendive"	NEMA 4X	Lube oil pressure / upstream of driven machine	Alarm: Lube oil pressure driven machine low: ↓ __ PSI / ___ bar	___PSI / ___bar	Gauge board mounted. With two valve manifold. Housing material: aluminum, epoxy coated. Wired to customer's Flex I/O box Note: Oil pressure set value and action to be defined with customer in detail engineering phase
-	37.1	-	Differential pressure transmitter with indicator (LCD display) Type: 2051 CD..... (with HART protocol) Make: Emerson - Rosemount	-36 to 36 PSI -2,5 to 2,5 bar — 0 to 29 PSI 0 to 2,0 bar = 4 - 20 mA	FM certified Class I, Division 2, Group A,B,C,D "non incendive"	NEMA 4X	Diff. pressure / Lube oil filter	Alarm If main motor is off and during 5 minutes after motor start ↑ 22 PSI / 1,5 bar --- Alarm During normal operation ↑ 12 PSI / 0,8 bar	< 11,6 PSI / < 0,8 bar	Gauge board mounted. With integrated five valve manifold. Housing material: aluminum, epoxy coated. Wired to customer's Flex I/O box
-	37.2	-	Differential pressure transmitter with indicator (LCD display) Type: 2051 CD..... (with HART protocol) Make: Emerson - Rosemount	-0,902 to 0,902 PSI -62,2 to 62,2 mbar — -0,87 to 0,87 PSI -6 to 6 mbar = 4 - 20 mA	FM certified Class I, Division 2, Group A,B,C,D "non incendive"	NEMA 4X	Vorecon housing pressure		±0,058 PSI / ± 4 mbar	Gauge board mounted. with 2- valve manifold Housing material: aluminum, epoxy coated. Wired to customer's Flex I/O box

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	39.1	-	Accelerometer Type: 330 400 Make: Bently Nevada	-	CSA certified, Class 1, Division 1, 2 Groups A,B,C,D "non incendive"	NEMA 4X	Housing vibration / VORECON housing Input side	Alarm: ↑ Vrms ___ mil/s ___ mm/s --- Trip: ↑ Vrms ___ mil/s ___ mm/s	< Vrms ___ mil/s / ___ mm/s	Vibration limits are according to VOITH Work Sheet C081. Monitoring system is not VOITH scope of supply Mounted with protection housing Material: aluminum Wired to customer´s Flex I/O box
-	39.2	-	Accelerometer Type: 330 400 Make: Bently Nevada	-	CSA certified, Class 1, Division 1, 2 Groups A,B,C,D "non incendive"	NEMA 4X	Housing vibration / VORECON housing Gear zone	Alarm: ↑ Vrms ___ mil/s ___ mm/s --- Trip: ↑ Vrms ___ mil/s ___ mm/s	< Vrms ___ mil/s / ___ mm/s	Vibration limits are according to VOITH Work Sheet C081. Monitoring system is not VOITH scope of supply Mounted with protection housing Material: aluminum Wired to customer´s Flex I/O box
-	39.10	-	Shaft vibration pick-up X for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft vibration / Input shaft B 1	Alarm S pp ↑ ___ µm ___ mil --- Trip S pp ↑ ___ µm ___ mil	< Spp ___ µm / ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Vibration limits are according to Voith Work Sheet C081. Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	39.11	-	Shaft vibration pick-up Y for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft vibration / Input shaft B 1	Alarm S pp ↑ ___ µm ___ mil --- Trip S pp ↑ ___ µm ___ mil	< Spp ___ µm / ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Vibration limits are according to Voith Work Sheet C081. Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	39.12	-	Axial position pick-up Z for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Axial position / Input shaft B 2/3	Alarm S z ↑ ± ___ mm ± ___ mil --- Trip S z ↑ ± ___ mm ± ___ mil	< Sz ± ___ mm / ± ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	39.13	-	Axial position pick-up Z for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Axial position / Input shaft B 2/3	Alarm S z ↑ ± ___ mm ± ___ mil --- Trip S z ↑ ± ___ mm ± ___ mil	< Sz ± ___ mm / ± ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	39.14	-	Shaft vibration pick-up X for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft vibration / Coupling sleeve	Alarm S pp ↑ ___ µm ___ mil --- Trip S pp ↑ ___ µm ___ mil	< Spp ___ µm / ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Vibration limits are according to Voith Work Sheet C081. Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	39.15	-	Shaft vibration pick-up Y for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft vibration / Coupling sleeve	Alarm S pp ↑ ___ µm ___ mil --- Trip S pp ↑ ___ µm ___ mil	< Spp ___ µm / ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Vibration limits are according to Voith Work Sheet C081. Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	39.16	-	Shaft vibration pick-up X for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft vibration / Output shaft B 11	Alarm S pp ↑ ___ µm ___ mil --- Trip S pp ↑ ___ µm ___ mil	< Spp ___ µm / ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Vibration limits are according to Voith Work Sheet C081. Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	39.17	-	Shaft vibration pick-up Y for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft vibration / Output shaft B 11	Alarm S pp ↑ ___ µm ___ mil --- Trip S pp ↑ ___ µm ___ mil	< Spp ___ µm / ___ mil	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Vibration limits are according to Voith Work Sheet C081. Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	39.20	-	Keyphasor for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft phase angle / Input shaft	-	-	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	39.21	-	Keyphasor for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Shaft phase angle / Output shaft	-	-	Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	40.0	-	Oil level indicator Type: UTN with magnetic roller display Make: Kuebler	___ mm	-	-	Oil level / oil reservoir	-	Between min. and max. oil level	Housing material: stainless steel
-	40.2	-	Oil level transmitter Type: 5301 guided radar with coaxial probe (with HART protocol) Make: Emerson Rosemount	See assembly plan — ___ mm = 4 - 20 mA	FM- certified Class I, Division 2 Groups A,B,C,D "non incendive"	NEMA 4X	Oil level / Oil reservoir	Alarm ↑ ___ mA ---------- Alarm Heater power supply off ↓ ___ mA ---------- Main motor start prohibited ↓ ___ mA	See as- sembly plan	Top mounted on oil reservoir. Housing material: aluminum, polyurethane covered For details of range and settings see assembly plan Wired to customer´s Flex I/O box

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Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	42.1	-	Speed pick-up for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Superimposing speed / Coupling sleeve	Alarm ±↑ ___ RPM ---------- Trip ±↑ ___ RPM	-	Number of teeth / holes: __ Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	42.2	-	Speed pick-up for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Superimposing speed / Coupling sleeve	Alarm ±↑ ___ RPM ---------- Trip ±↑ ___ RPM	-	Number of teeth / holes: __ Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	42.4	-	Speed pick-up for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Output speed / Output shaft	Alarm ↑ ___ RPM ---------- Trip ↑ ___ RPM	See characteristic curve	Number of teeth / holes: __ Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	42.5	-	Speed pick-up for FLEX I/O module Type: 3300 XL Make: Bently Nevada	-	CSA certified Class I, Division 2, Groups A, B, C, D "non incendive" when installed without barriers per drawing 140979.	(IP 66) NEMA 4X	Output speed / Output shaft	Alarm ↑ ___ RPM ---------- Trip ↑ ___ RPM	See char-acteristic curve	Number of teeth / holes: __ Mounted with Proximity probe housing acc. to Voith design Housing material: aluminum, painted Wired to customer´s Flex I/O box Proximitor and monitoring system do not belong to Voith´s scope of supply. Proximitor for „9" meter total cable length wired to Flex I/O box (purchaser´s scope)
-	44	-	Voith electrohydr. actuator (VEHS)	-	-	IP 65	Torque converter	-	-	-
-	44.1	-	4/3-way valve with solenoid control system Type: ___ Make: Voith	-	FM certified Class 1, Division 1,2 Groups B,C,D "explosion proof"	-	VEHS	-	-	-
-	44.2	-	Electr. position pick-up Make: MTS HPH housing with RHB sensor Voith No. 206.00042300	0 - 100 % guide vane position = 4 - 20 mA	UL certified Class 1, Division 1,2 Groups A,B,C,D "explosion proof"	-	Guide vane position / VEHS	-	-	-
-	44.3	-	Guide vane positioning cylinder	-	-	-	Guide vane position / VEHS	-	-	-
-	50.1	-	OPTION: Lube oil heat exchanger Type: Fin & Fan Make: ___	-	-	-	-	-	-	-

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	50.2	-	OPTION: Working oil heat exchanger Type: Fin & Fan Make: ___	-	-	-	-	-	-	-
-	51.1	-	Temperature control valve Type: ___ Make: MVA or AMOT	-	-	-	Lube oil supply to VORECON / Lube oil circuit	(109 °F) (43 °C)	(< 109 °F) (< 43 °C)	Loose supply to be piped by customer Direct acting. Housing material: GGG (spheroidal graphite cast iron).
-	51.2	-	Temperature control valve Type: ___ Make: MVA or AMOT	-	-	-	Working oil supply to VORECON / Working oil circuit	(129 °F) (54 °C)	(< 129 °F) (< 54 °C)	Loose supply to be piped by customer Direct acting. Housing material: GGG (spheroidal graphite cast iron).
-	53.1 A/B		Fan drive	-	-	-	Working oil heat exchanger	-	-	Provided with heat exchanger by heat exchanger supplier
-	53.2 A/B		Fan drive	-	-	-	Lube oil heat exchanger	-	-	Provided with heat exchanger by heat exchanger supplier
-	54.1 A/B	-	Vibration Switch	-	-	-	Van drive vibration / Working oil heat exchanger	Alarm: acc. to cooler manufacturer		Provided with heat exchanger by heat exchanger supplier
-	54.2 A/B	-	Vibration Switch	-	-	-	Van drive vibration / Lube oil heat exchanger	Alarm: acc. to cooler manufacturer		Provided with heat exchanger by heat exchanger supplier
-	60.1	-	Test connection M1 Type: EMA3 Make: Parker Ermeto	-	-	-	Working oil pressure / Downstream of working oil pump	-	-	-

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Main Components and Instrument List

Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	60.2	-	Test connection M2 Type: EMA3 Make: Parker Ermeto	-	-	-	Working oil pressure / Upstream of torque converter inlet	-	-	-
-	60.3	-	Test connection M3 Type: EMA3 Make: Parker Ermeto	-	-	-	Working oil pressure / Downstream of torque converter outlet	-	-	-
-	65.1	-	Heating rod electrical immersion heater Type: TLI Make: CCI Thermal Technologies INC.	-	CSA certified Class 1, Division 1, Group B,C,D T3 "explosion proof"	IP 66	Working oil temperature / Oil reservoir, working oil chamber	-	-	Heating bundle: 316 stainless steel. Junction box and seal fitting: aluminum epoxy coated. Flange: carbon steel Power: __ kW 460V
-	65.2	-	Temperature controller (integrated in heater head)	-	-	-	Working oil temperature / Oil reservoir, working oil chamber	Heater ON: ↓ __ °F / __ °C --- Heater OFF ↑ __ °F / __ °C	-	The temperature controller is designed as a single pole potential free control contact and is intended for integration into an electrical power control by means of power contactors. Power contactors and wiring are not part of Voith's scope of supply.
-	65.3	-	Temperature limiter (integrated in heater head)	-	-	-	Working oil temperature / Oil reservoir, working oil chamber	Heater OFF ↑ 266 °F / 130 °C	-	The temperature limiter is designed as a single pole potential free control contact and is intended for integration into an electrical power control by means of power contactors. Power contactors and wiring are not part of Voith's scope of supply.

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Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	65.4	-	Heating rod electrical immersion heater Type: TLI Make: CCI Thermal Technologies INC.	-	CSA certified Class 1, Division 1, Group B,C,D T3 "explosion proof"	IP 66	Lube oil temperature / Oil reservoir, lube oil chamber	-	-	Heating bundle: 316 Stainless steel. Junction box and seal fitting: aluminum epoxy coated. Flange: carbon steel Power: __ kW 460V
-	65.5	-	Temperature controller (integrated in heater head)	-	-	-	Lube oil temperature / Oil reservoir, lube oil chamber	Heater ON: ↓ __ °F / __ °C ---------- Heater OFF ↑ __ °F / __ °C	-	The temperature controller is designed as a single pole potential free control contact and is intended for integration into an electrical power control by means of power contactors. Power contactors and wiring are not part of Voith's scope of supply.
-	65.6	-	Temperature limiter (integrated in heater head)	-	-	-	Lube oil temperature / Oil reservoir, lube oil chamber	Heater OFF ↑ 266 °F / 130 °C	-	The temperature limiter is designed as a single pole potential free control contact and is intended for integration into an electrical power control by means of power contactors. Power contactors and wiring are not part of Voith's scope of supply.
-	70.1	-	2-valve manifold Type: PYAASA-N4N4-A001 Make: Schneider	-	-	-	Pressure Instrument		-	Valve housing material: 316 Stainless steel. Gauge board mounted. Connections: Process: ½ NPT Venting/Test: ¼ NPT
-	70.2	-	Shutoff valve Type: HAFFSB-N4N4-0001VT Make: Schneider	-	-	-	Primary shutoff measuring line	-	-	Valve housing material: 316 stainless steel. Connection:. 2x ½ NPT

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Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	70.3	-	Shutoff valve Type: HAFFSB-N4N4-0001VT Make: Schneider or alternative type provided by filter manufacturer	-	-	-	Primary shutoff measuring line	-	-	Valve housing material: 316 stainless steel.
-	70.4	-	Integrated five-valve manifold Type: W5RASAN4TFA Make: Schneider	-	-	-	Differential pressure instrument	-	-	Valve housing material: 316 Stainless steel. Gauge board mounted. Connections: Process: ½ NPT Venting/Test: ¼ NPT
-	71.1	-	Pressure control valve Type: ___ Make: Emerson Fisher	-	-	-	Lube oil	Pressure set value see pos. 36.7	-	Direct acting. Valve housing material: cast iron
-	75.2	-	Oil drain at side	-	-	-	Oil reservoir	-	-	-
-	75.4	-	Filling connection	-	-	-	Oil reservoir	-	-	-
-	75.5	-	Suction connection for oil conditioner	-	-	-	Oil reservoir	-	-	
-	75.6	-	Return connection for oil conditioner	-	-	-	Oil reservoir	-	-	
-	76.1	-	Connection for lube oil supply to driving machine	-	-	-	-	-	-	-
-	76.2	-	Connection for lube oil supply to driven machine	-	-	-	-	-	-	-
-	76.3	-	Connection for lube oil return from driving machine	-	-	-	-	-	-	-

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Revision	Item No. Voith	Item No. Client's TAG No.	Component or instrument, Type: Make:	Measuring range — Adjusted range	Explosion protection	Ingress Protection	Measurement / Measuring point, Location	Set value	Nominal value during operation	Remarks
-	76.4	-	Connection for lube oil return from driven machine	-	-	-	-	-	-	-

Note1:
RTD are simple apparatus acc. NEC 504.2
Ambient temperature max. 60 °C
The RTD has to be operated in a intrinsic safe circuit.
The Barrier is not Voith scope of supply and has to be located in safe area by customer.
Acc. to NEC 504.4 a certificate of compliance or a manufacturers declaration will not be provided.
Only one element can be operated, the other element is spare.

Note 2:
-For parts made of stainless steel, material acc. to DIN / EN or ASTM dep. on availability and supplier's standard is used

Hazardous area classification at site:
Class I, Div. 2, Gas Group C&D, Temp. ClassT3

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TECHNICAL SPECIFICATION FOR BRUSHLESS SYNCHRONOUS MOTOR

CLIENT : Solar Turbines Inc
PROJECT : Solar PSA Fixed speed
TYPE : AMS 800L4P BSNT
OUR REFERENCE : USSM170081-03
DRIVEN EQUIPMENT : Compressor
DATE : 2018-04-26
SERIALNUMBER : TBD

INDEX

1. Technical Specification

ABB type AMS 800L4P BSNT brushless synchronous Motor rated
Power =9000 HP,
PF =1
Voltage =13200 V,
Frequency =60 Hz,
Speed =1800 rpm,
for installation in Class I Division 2 Group B, C & D T3 (NEC or CEC) hazardous area.
Designed for FCMA-starting. Designed according to NEMA MG1.

2. Included accessories

2.1 Standards and Site Conditions

- API 546 (standard design)
- Class I Division 2 Group B, C & D T3 (NEC or CEC) (one covering all identical units)

2.2 Main Mechanical Data

- Bi-direction of rotation at drive end, facing shaft end.
- Protection of machine IP00. Final IP degree depending on final duct and filter design
- Temperature rise, rotor within class B
- Temperature rise, stator within class B

2.3 Excitation

- Main brushless exciter type GLB 600A for DC excitation complete with diode bridge, thyristors, RC-circuits and control box.

2.4 Cooling System

- Air screens with limited mesh

2.5 Shaft Extensions

- Flange diameter 383 mm
- Flanged shaft end with internal spigot in DE

2.6 Bearings

- All-welded Separate oil connections at both bearings, stainless in- and outlet, ANSI
- Bearing size GL280
- Both DE and NDE bearings insulated, DE grounded with cable.
- Forced lubricated sleeve bearing. Bearing provided with loose oil ring.
- Identical sleeve bearings
- Oil connections at right side of machine seen from DE, locations close to machine edges.
- Oil inlet flange: ANSI 3/4" Cl 150
- Oil outlet flanges: ANSI 2" Cl 150
- Orifice plates for reduction of oil pressure
- The lube oil drain pressure must be less than or equal to the machine ambient pressure. An oil drain pressure of 200-1000 Pa lower than the bearing ambient is recommended.

2.7 Main Terminal Boxes and Related Accessories

- Main terminal box located on the left side, seen from DE
- MainTerminal Box supply cable entry from below. Gland plate is removable, undrilled and of non magnetic material.
- Standard small air insulated Main Terminal Box
- The main terminal box is delivered as a loose item, assembly on site is not included in ABB's scope of supply.

2.8 Monitoring and Protection Accessories

RTD's according to IEC 60751, class B
- 1 extra Stainless steel junction box
- 1x RTD per Bearing Shell, duplex (Pt100), 3 wire, shielded
- 9x RTD's in stator windings, single (Pt100), 3 wire, shielded, safe and hazardous area
- Bonding straps on external covers.
- External wiring, except for armoured cables, is protected by liquid tight conduit acc. to API670
- Heaters in both main machine and exciter, hazardous area, 230 VAC 1 phase supply. The heaters should always be connected during stand still to avoid condensation.
- Motor prepared for MACHsense-R: 1x stator RTD installed in each phase, wired to same auxilliary box as std stator RTD's
- Stainless steel junction boxes provided with undrilled gland plates. Located at left side of machine facing DE.
- Vibration control proximity type BN 3300XL (2 probes per bearing mounted, 90deg apart, outboard the bearing centerline) including 2 keyphasors.

2.9 Foundation and Installation

- Mounting kit including fastening screws, jacking screws and dowel pins.
- Stainless steel mounting and alignment shim pack

2.10 Special Design and Accessories

- Burnishing shaft hub surface for proximity type of vibration probes, maximum combined electrical and mechanical run out 12.5 µm (0.5 mils) peak-to-peak.
- Inorganic electrical steel sheet insulating coating.
- Nameplate in Stainless Steel with additional API nameplates in Stainless Steel
- Plugged and threaded drain holes
- Rotor sliding tool - RST1 (one covering all identical units)
- Shaft end with surface rougness acc. to API546
- Stainless steel bolts (M12 or smaller) on external covers.
- Stress relief treatment for welded steel plate constructions
- Varnish of rotor coils
- Vibration level according to ABB standard (MDD 3AAM100425)

Rotor sliding tool, RST 1
Sliding plates for rotor removal of rotor by sliding,
requires one hook lifting with a capacity which can handle the rotor weight,
the hook motion must be along the shaft. No slings, lifting jack or rotor storage support included.

2.11 Painting and corrosion protection

- Epoxy-Industrial and Coastal coating acc. to ISO 12944 C5I
- Standard gray colour (RAL 7032)

2.12 Packing and Transportation

- Seaworthy shrink film packing with corrosion protection.

2.13 Standard API 546, 3rd Edition, features and accessories

- Special electrical design (2.2)
- Vibration levels according to API 546, 3rd Edition requirements (4.3.3)
- Burnishing probe track shaft surface, max. run out 12.7 µm (2.4.5.1.7)
- Premium forged steel shaft and rotor body (2.4.5.1.4)
- Sealed winding (conformance test when specified) (2.3.1.1)
- Identical DE & NDE sleeve bearings (2.4.7.1.2)
- Water-to-air and air-to-air heat exchangers according to API 546 (2.4.1.2.4 and 2.4.10.8) Minimum temperature rise excluded
- Stainless steel air screens with limited mesh (on applicable enclosures) (2.4.10.5)
- Conduits for external cabling according to API 670
- Bonding straps between external covers and frame (2.4.1.1.d)
- Sole plates (when specified) according to API 546 (2.4.2.7)
- Nameplate material: Stainless Steel (2.4.11.1)
- Threaded and plugged drain holes (2.4.1.2.3)
- Shaft end with surface roughness according to API 546 (2.4.5.1.9)
- C-5 quality electrical steel sheet varnish (2.4.10.7)
- Stainless steel bolts on external covers (2.4.1.1.c)

- Rotor sliding tool RST1 (2.1.11)
- Stainless steel balance weights on rotor (2.4.6.3.2)
- Pressure balancing of shaft seals from the cooling fan with copper tubing (2.4.7.3.a)
- Analog signal wires in excitation system are twisted pairs (2.5.2.2)
- Silver solder in rotor coils
- C-5I Epoxy surface preparation and finish, Industrial and coastal coating according to ISO12944
- Routine tests according to API 546 (4.3.2). All other tests available when specified.
- Additional features, accessories, and tests as specified on API 546 datasheets

3. Position notes, Specification comments and Validation notes

Starting at DOL 80%U, considering voltage recovery
Also uitable for FCMA start, current limiter 2pu

4. Documentation

- Installation and maintenance manual in English language. (one covering all identical units)
- Outline drawing 3D (one covering all identical units)
- Rating plate drawing (one covering all identical units)
- Standard documents for Machine according to MDD 3AAM100439
- User's manual on CD, (1 copies) (one covering all identical units)

5. Tests and Certificates

- API 546 complete test, not observed
- CSA field Certified for hazardous area (one covering all identical units)
- Runout measurement in assembled machine, not observed

5.1 Routine tests

- Air gap measurement, not observed
- Bearing heat run, not observed
- Dielectric test with fault simulation of high voltage equipment, not observed
- Dielectric test, not observed
- Magnetic neutral pos., axial play in bearing and distance shaft-end to footplate, not observed
- Measurement of insulation resistance before and after dielectric test, not observed
- No-load characteristics, not observed
- Overspeed test, not observed
- Phase sequence and terminal marking, not observed
- Resistance measurement, not observed
- Settings list for machine protection, not observed
- Short-circuit characteristics, not observed
- Verification of the continuity of the protective bonding circuit, not observed
- Vibration measurement during retardation or acceleration, not observed
- Vibration measurements, not observed
- Visual inspection of complete machine, not observed

5.2 Type tests

- Determination of efficiency at rated P.F. and 100, 75, 50 and 25% load, not observed (one covering all identical units)
- Determination of rated excitation current, not observed (one covering all identical units)
- Heat run at P.F. = 0, not observed (one covering all identical units)

5.3 Special tests

- Adjustment of pressure reducing valve/orifice plate, not observed
- Balancing of rotor complete, not observed
- Bearing inspection, not observed (one covering all identical units)
- Control of proximity vibration units, not observed
- Determination of Locked rotor current and torquet, not observed (one covering all identical units)
- Measurement on burnish surface at rotor shaft with rotor journaled in vee-block, not observed
- Oil filters on test stand oil system, not observed (one covering all identical units)
- Polarization index measurement, not observed (one covering all identical units)
- Soft feet check, not observed (one covering all identical units)
- Sound level measurement, not observed (one covering all identical units)
- Test of main terminal box, not observed
- V-curve, not observed (one covering all identical units)

5.4 Certificates

- Material check of blank for rotorbody
- Material check of blank to pole tips

A. Rated data

at cooling air temperature 40 °C/ 104 F				
Machine type		AMS 800L4P BSNT		
Output	kW	6711	HP	9000
Power factor (overexcited)		1.00		
Voltage	*) V (±10.0 %)	13200		
Frequency	*) Hz (±5.0 %)	60		
Speed	rpm	1800		
Current	A	301		
Nema locked rotor letter code		C		
Exciter type		GLB 600A		
Excitation	V / A	66 / 9		
*) Note: A combination in voltage and frequency of max. 10% (sum of absolute values) of rated values.				

B. Standards

Applicable standards		NEMA
Insulation class stator and exciter		F
Insulation class main rotor		H
Temperature rise, stator within class		B
Temperature rise, rotor within class		B
Increased safety, Standards/Form		Class I Division 2 Group B, C, D TX (NEC or CEC)
Ex gas group		Group B
Ex temperature class		T3

C. Other performance data

Guaranteed efficiency at P.F. 1 and 100 / 75 / 50 / 25 % load	%	97.24 96.93 96.07 92.94
Reactances:		
- X_d	(±15) %	118.2
- X_d' unsat/sat	" %	30.2 / 27.4
- X_d" unsat/sat	" %	23.0 / 20.2
- X_q unsat/sat	" %	73.3 / 69.4
- X_q" unsat/sat	" %	34.5 / 30.3
- X_0	%	8.6
- X_2	%	26.4
- X_L	%	16.7
Pull out torque	%	154

D. Site conditions

Ambient temperature range	°C	-20 - 40	F	-4 - 104
Altitude	m a.s.l.	1000	ft.a.s.l.	3280
Hazardous area classification		Class I Division 2 Group A, B, C, D TX (NEC or CEC)		
Ex gas group		Group B		
Ex temperature class		T3		
Seismic zone		Acc. to UBC, Zone 4		

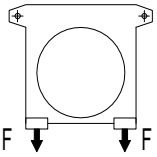
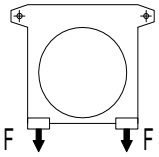
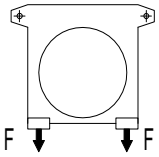
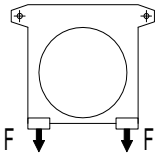
E. Starting characteristics

Load data					
- Load break away torque	%	2			
- Load torque at full speed	%	44			
- Load inertia J (at motor speed)	kgm²	195	lb-ft²	4637	
Starting current maximum value is guaranteed at given net					
Start data with infinite net					
- Terminal voltage		100			
- Current at n=0	%	489			
- Torque at break away mean/osc	%	94 / 54			
- Torque at 95 % speed mean/osc	%	96 / 51			
- Synchronizing torque mean	%	68			
- (Total) Starting time	(+20%) s	4			
Start with starting method FCMA					
Net data					
- Motor bus short circuit capacity	MVA	140			
Starting method					
Start resistor connected at speed	%	80			
Start data with 140 MVA net		Motor terminal		Motor bus	
- Voltage at 0 % speed	%	48		90	
- Current at 0 % speed	%	200			
- Torque at break away mean/osc	%	23 / 13			
- Torque at 95 % speed mean/osc	%	69 / 34			
- Synchronizing torque mean	%	59			
- (Total) Starting time	(+20%) s	17			
Number of successive starts from cold		3 with >30 min betw. each start			
Number of successive starts from warm		2 with >30 min betw. each start			
Starting equipment data used in calculations					

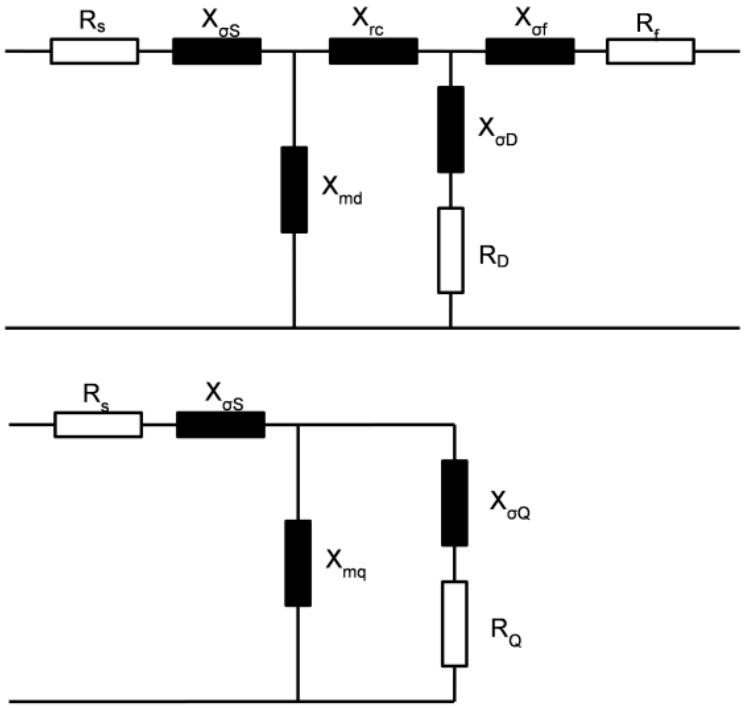
F. Installation data

Protection form/cooling form		IP00 TEPV with sep. fans			
Cooling air:					
- Max external pressure drop in cooling ducts	Pa	300			
- Min cooling air flow	m³/s	5.2			
Heat losses:					
- Cooling air	kW	167			
- Lubrication oil at 50 °C	kW	18.7			
Power of external fans	kW	6			
Arrangement form		IM 1001			
Shaft end according to drawing		3BSY200008-EKT			
Sleeve bearings:					
- Max. permissible axial play towards D-end	mm	6.0	in.	0.236	
- Max. permissible axial play towards N-	mm	6.0	in.	0.236	

end					
- Max. permissible axial thrust	kN	0	lbf	0
- Min. barring speed	rpm	30		
- Required oil flow to bearings (Total)	l/min	31	gpm	8.2
- Oil temperature range to bearings	°C	40 - 65	F	104 - 149
- Required oil pressure at 50 °C	kPa	75	psi	11
- Supply oil pressure		To be advised by customer*)		
*)For setting of pressure reduction valve/orifice				
Default oil pressure*)	kPa	150	psi	21.8
*)Used if no value received from customer before FAT				
- Max supply oil pressure	kPa	500	psi	72.5
- Type of oil		ISO VG 46		
- Degree of purity for oil		17/15/12 acc. to ISO 4406:1999		
Weights (estimated):				
- Total (complete machine, excluding terminal box)	kg	17800	lb	39300
- Stator	kg	6100	lb	13500
- Rotor	kg	6900	lb	15100
Rotor inertia ($J=m*r_m^2$)	kgm²	398	lb-ft²	9437
First bending lateral critical speed	rpm	>2070		
Direction of rotation (at drive end, facing shaft end)		Bi-directional		
Noise level (based on totally enclosed machine, at 1m, rated speed and no load acc.to ISO 3744)	dB(A)	78, Tol. +3 dB(A)		

Forces on the foundation per stator side			
Static	Direct On Line Start	Rated torque	2-phase short circuit
			
F = 87.3 kN	F = 87.3 kN ± 18.5 kN	F = 87.3 kN ± 19.8 kN	F = 87.3 kN ± 122.7 kN
F = 19619 lbf	F = 19619 lbf ± 4159 lbf	F = 19619 lbf ± 4447 lbf	F = 19619 lbf ± 27580 lbf

Motor type code: AMS 800L4P BSNT
Equivalent circuit between phase and neutral (equivalent star)



REMARKS:
- All parameters have been calculated from design data. The stated values of the armature to rotor mutual inductances correspond to unsaturated operating conditions.
- The model is suitable only for dynamic simulations where the rotor speed remains close to synchronous speed at all times.

Stator resistance R_s	p.u.	0.0059
d-axis stator leakage reactance $X_{\sigma S}$	p.u.	0.1671
Canay reactance X_{rc}	p.u.	-0.0448
Field winding leakage reactance $X_{\sigma f}$	p.u.	0.2408
Field winding resistance R_f	p.u.	0.0013
d-axis main reactance X_{md}	p.u.	1.0146
d-axis leakage reactance of damper winding $X_{\sigma D}$	p.u.	0.2077
d-axis damper winding resistance R_D	p.u.	0.1434
Stator resistance R_s	p.u.	0.0059
q-axis stator leakage reactance $X_{\sigma S}$	p.u.	0.1671
q-axis leakage reactance of damper winding $X_{\sigma Q}$	p.u.	0.0770
q-axis main reactance X_{mq}	p.u.	0.5655
q-axis damper winding resistance R_Q	p.u.	0.1099

Airgap torque equation - 3-phase short circuit

$T_e(t) = M_0 e^{-t/\tau_0} \sin \omega t + M_1 e^{-t/\tau_1}$

$M_0 = 4.9$; $M_1 = 0.825$; $\tau_0 = 0.0895$ s ; $\tau_1 = 0.0862$ s ; $\omega = 377$ rad/s

Maximum value of torque 5.46 * T_N, when t = 4.07 ms

Airgap torque equation - 2-phase short circuit

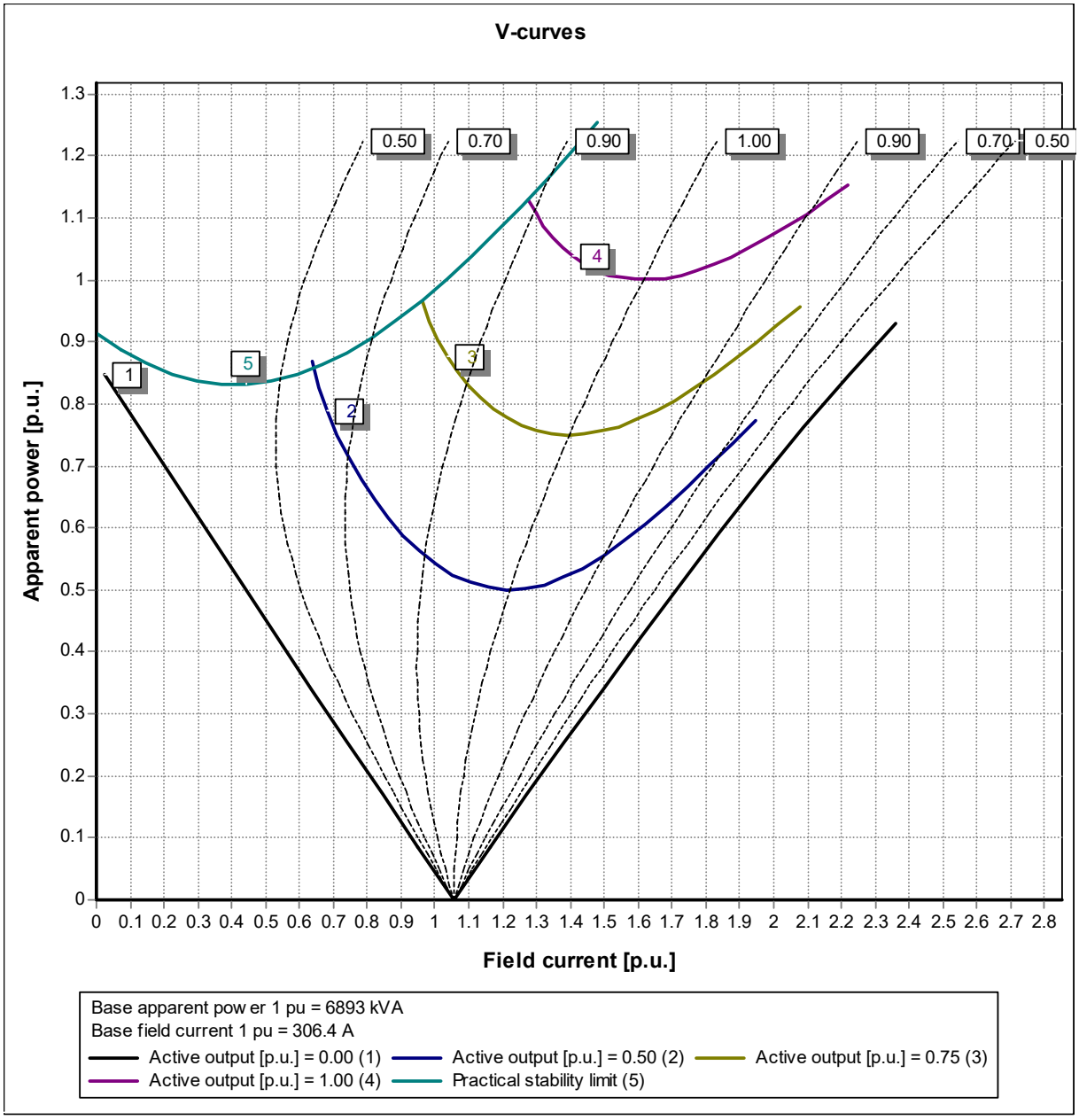
$T_e(t) = M_0 e^{-t/\tau_0} \sin \omega t - M_1 e^{-t/\tau_1} \sin 2\omega t + M_2 e^{-t/\tau_2}$

$M_0 = 4.21$; $M_1 = 2.12$; $M_2 = 0.914$; $\tau_0 = 0.124$ s ; $\tau_1 = 0.561$ s ; $\tau_2 = 0.294$; $\omega = 377$ rad/s

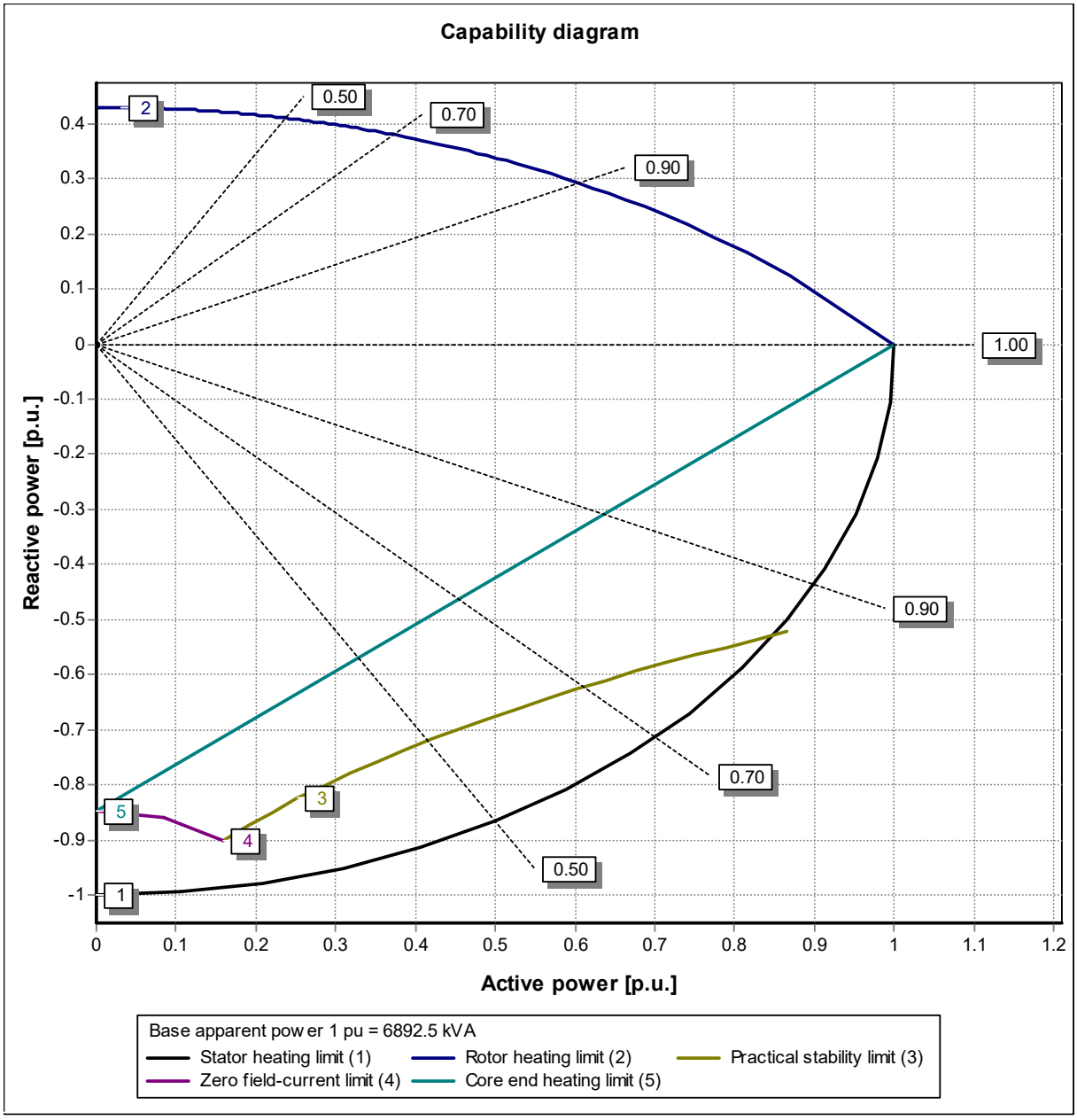
Maximum value of torque 6.2 * T_N, when t = 5.55 ms

Rated torque T_N = 35.6 kNm

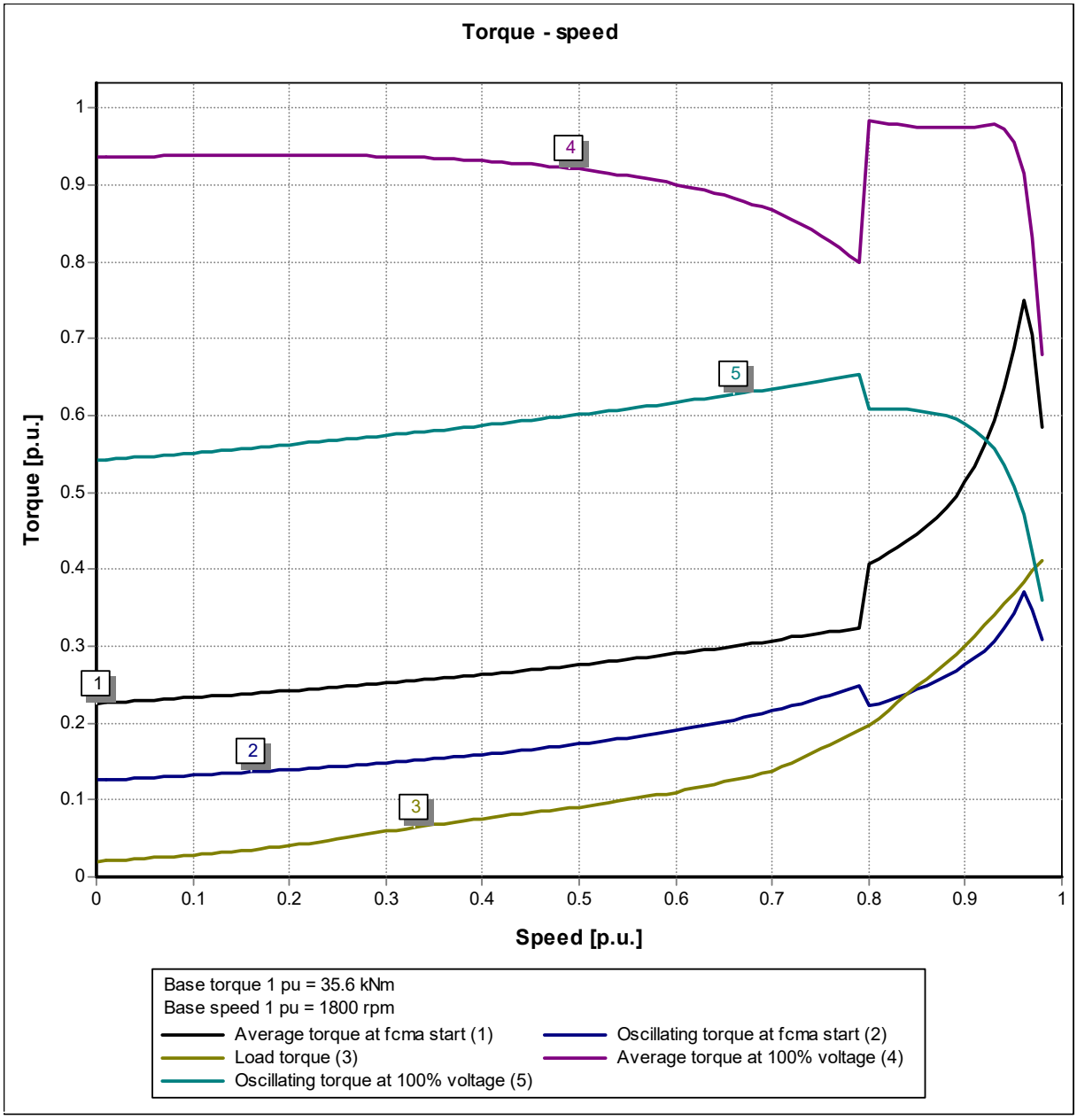
Motor type code: AMS 800L4P BSNT



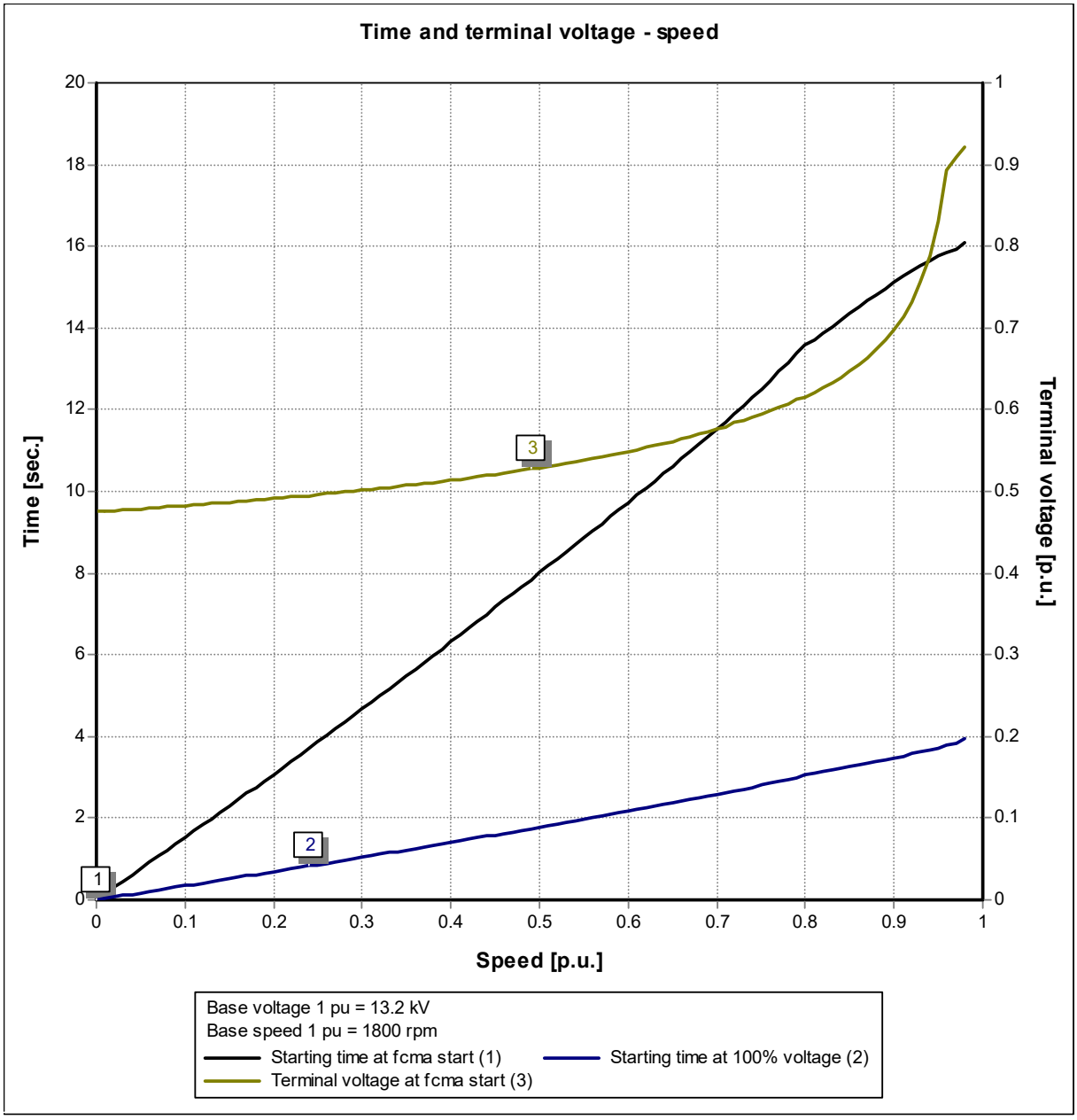
Motor type code: AMS 800L4P BSNT



Motor type code: AMS 800L4P BSNT



Motor type code: AMS 800L4P BSNT



Motor type code: AMS 800L4P BSNT

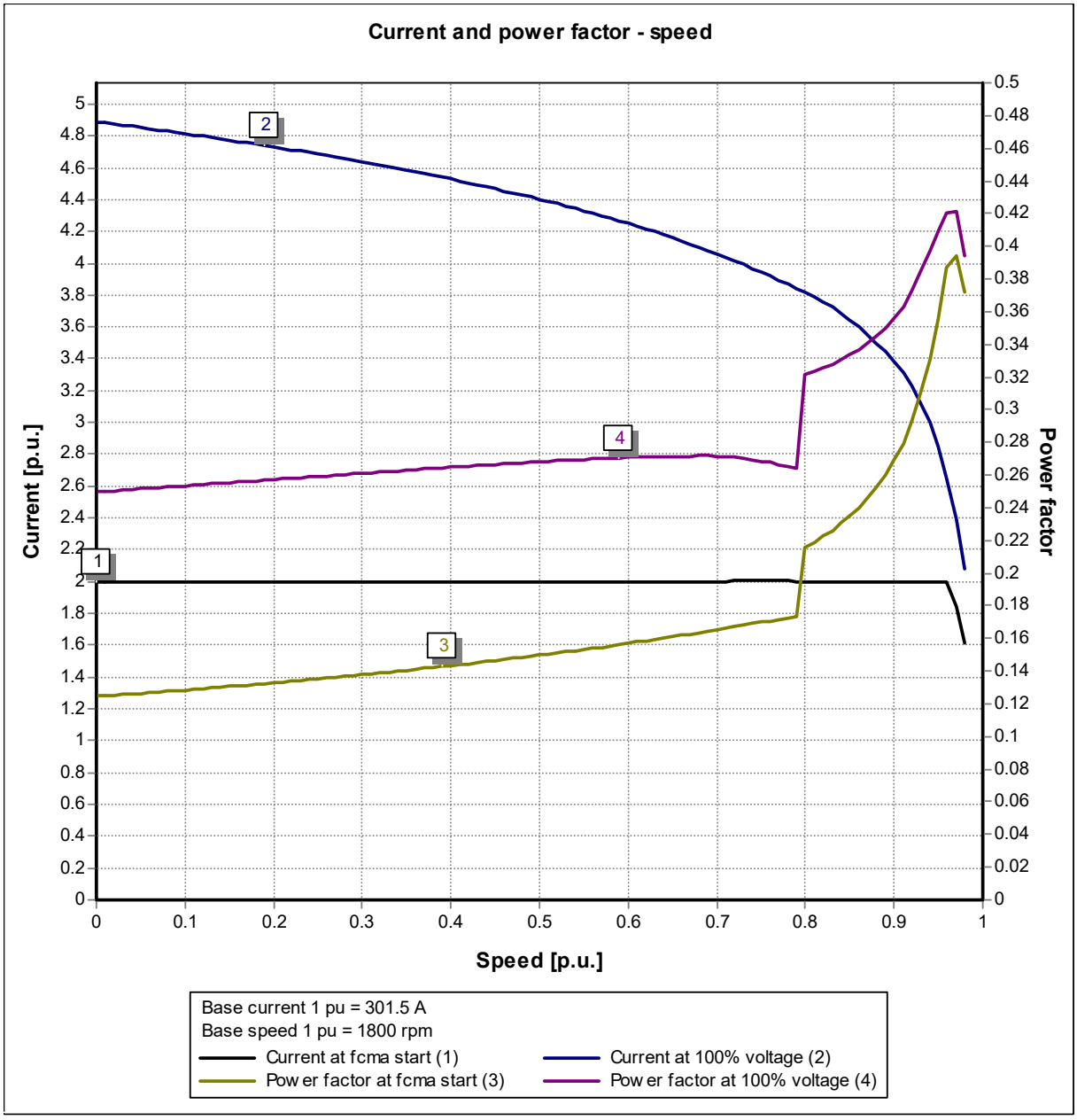


EXHIBIT 1

Solar Turbines

A Caterpillar Company

Solar Turbines, Inc.
10203 Sam Houston Park Dr
Suite 300
Houston, Texas 77064

Date 7-23-2020

To: Mr. John Heintz

Re: 3W102-HO15-0023-Weymouth-Technical Proposal-160201

Dear Mr. Heintz,

Regarding the question on the Electric Motor Drive alternative to drive the Taurus 60-C33 Compressor Set for the Weymouth Compressor Station. Solar has selected a Spartan Electric Motor Drive Compressor Set which allows for standard power margins to be applied when driving the C33 compressor in substitution of a Taurus 60 Compressor Set. The cost estimate for hardware differences between the two compressor solutions is $2,358,087.00 USD with the Motor Drive being less.

Thank you for your consideration.

Best Regards,
Mike Clay
Account Manager
Solar Turbines Inc.

Caterpillar: Confidential Green

EXHIBIT 2

DASHIELL CORPORATION

ENGINEERS - CONSTRUCTORS

12301 Kurland Drive
Suite 400
Houston, Texas 77034
PHONE: (713) 558-6600
FAX: (713) 558-6663

June 17, 2020

Enbridge
5400 Westheimer Court
Houston, TX 77056

TRANSMITTED VIA EMAIL

Attention: Mr. Larry Smith – laurence.smith@enbridge.com
Electrical Engineer, Facilities Project Engineering

Reference: Enbridge – Weymouth, MA
115 kV, 30 MVA Substation for Weymouth Compressor Station
REV 2

Dear Mr. Smith:

Dashiell is pleased to present the following Revised Budgetary Estimate Proposal for the 115 kV Substation at the Enbridge Weymouth Compressor Station in Weymouth, MA. Our quotation is as follows:

SCOPE OF WORK

Dashiell will provide the engineering, procurement, and construction services for the following:

1. 115 kV, 30 MVA Weymouth CS Substation based on the Opelousas CS Substation provided by Dashiell in 2016 with the following changes:
    a. Primary voltage: 115 kV
    b. Transformer: 30 MVA
    c. Incoming Utility Line: Underground
2. 115 kV underground transmission line from Edgar Substation to the Weymouth CS Substation, approximately 2,600' long.
3. 115 kV breaker addition at the Eversource Edgar Substation

BUDGETARY ESTIMATE

Our Budgetary Estimate to provide the services specified herein is broken down by scope of work as follows:

	115 kV CS Sub	115 kV Line	115 kV Breaker	TOTAL
Engineering	$ 230,000	$ 300,000	$ 200,000	$ 730,000
Material	$ 1,800,000	$ 5,450,000	$ 550,000	$ 7,800,000
Labor / Equipment	$ 1,670,000	$ 2,000,000	$ 470,000	$ 4,140,000
Testing / Commissioning	$ 140,000	$ 400,000	$ 50,000	$ 590,000
Sales Tax	$ 110,000	$ 350,000	$ 30,000	$ 490,000
TOTAL	**$ 3,950,000**	**$ 8,500,000**	**$ 1,300,000**	**$ 13,750,000**

PERFORMANCE AND PAYMENT BOND

Our Budgetary Estimate above does not include a Performance and Payment Bond. If a Performance and Payment Bond is required, please advise, and we will modify our Budgetary Estimate accordingly.

PROVISIONS FOR STATE AND LOCAL TAXES

Our Budgetary Estimate includes state sales and use taxes, based on a rate of 6.25%. If we should not compute and add taxes to our pricing, please advise, and we will remove taxes from our Budgetary Estimate.

COMMENTS AND CLARIFICATIONS

Our proposal is based on the following comments and clarifications:

1. Our Budgetary Estimate does not include any allowances for elevating the substation equipment 6-8 feet above finished grade.
2. Foundation estimates are based on the geotechnical criteria provided.

TERMS OF SALE

Our Base Price is based on work being performed per previously agreed to Terms and Conditions between our companies. If these are not acceptable, please advise, and we will provide a redlined copy Enbridge's Terms and Conditions. We are confident we can come to an equitable agreement for this project.

We appreciate the opportunity to submit this proposal. Please let us know how we should proceed and if you have any questions or comments.

Sincerely,

CHARLES M. JARRELL II, P.E.
Sales Engineer

EXHIBIT 3

J L ALLEN SERVICES, Inc.
P. O. Box 347 ● 980N CR 610 E. ● Tuscola, IL 61953 ● P: 217.253.3371 ● F: 217.253.2834

6/12/2020

Enbridge
890 Winter Street,
Suite 300
Waltham, MA 02451

Attn: John Heintz

Subject: Weymouth EMD Compressor Installation

Mr. Heintz,
J.L. Allen Services, Inc. is pleased to have the opportunity to present this proposal for the installation of the following items:

1. Installation of high voltage duct bank from Calpine Fore River Energy Center to new Enbridge Substation $7,806,803
2. Procure and install high voltage cable $630,000
3. Substation construction and civil work (including rigid inclusions) $1,335,220
4. Installation of medium voltage duct bank and cable from new substation to EMD compressor station $693,764

Total estimated cost is $10,465,787

Please note: This estimate excludes procurement of all piping materials, compressor/ancillary equipment and buildings, and substation structures/equipment/buildings. If substation work is performed by others and the civil portion is required to be performed by J.L. Allen the cost is $768,000.

Respectfully,

Rob Birchenough
President
J.L. Allen Services, Inc.

EXHIBIT 6

Fuel Gas System Capital + Installation Cost			
	Capital Cost	Installation Cost	Enbridge PO #
Waterbath Heater	$92,856.00	$198,823.00	3100026341
Regulators	$30,200.00		3100038392
Dry Filter	$5,300.00		3100038012
Filter Separator	$63,300.00		3100028313
Orifice Meter	$18,100.00		3100036557
Total Capital Cost	$209,756.00		
Total Cost	$408,579.00		

EXHIBIT 6A

Buyer: CARRI WALLIS
Phone: 713-627-5537
Email: Carri.Wallis@enbridge.com

Bill To: Algonquin Gas Transmission, LLC
APUSinvoices@spectraenergy.com
OR
P.O. Box 2549
Detroit, MI 48202-2549

PURCHASE ORDER (PO)

Vendor:	**Vendor No. 9000004802**
SIVALLS, INC 2200 EAST SECOND STREET ODESSA TX 79760 Phone: 432-337-3571 Fax: 432-337-2624 Attention:	

Ship To: ALGONQUIN GAS TRANSMISSION, LLC

1600 WASHINGTON
HOLLISTON MA 01746

Attention:

General Information

P.O. Number	:	**3100026341**
Rev. No.	:	24
Date	:	10/29/2015
Currency Code	:	USD
Payment Terms	:	Net 0 Days
Ship Date	:	See below
Shipping Terms	:	FOB ORIGIN - FREIGHT COLLECT

P.O.Number and Line number must mirror the PO on your invoice and must be referenced on all invoices and related correspondence.

****
CHANGER ORDER NO. 5: CREATED ON 6/10/16 CLW

CHANGING THE "SHIP TO" ADDRESS TO 1600 WASHINGTON ST., HOLLISTON, MA 01746 PER WAYNE RACICOT AND BILL WELCH'S EMAIL DATED 6/10/16
****
CHANGE ORDER NO. 4: CREATED ON 4/5/16 CLW

CHANGING THE INLET AND OUTLET FLANGES FROM 600# TO 900# @ $292.00 AND CREATING NEW COIL DWG FOR WEYMOUTH DUE TO NEW FLANGE RATINGS & LABEL INLET/OUTLET OF COIL ON ASSEMBLY PRINT @ N/C PER SIVALLS QUOTE NO. 1705/ECN2442 DATED 3/10/16
****
CHANGE ORDER NO. 3: CREATED ON 2/9/16

ADDING PRESSURE & TEMPERATURE COMPENSATION, PROVIDE DOWNDRAFT DIVERTER & 120 VAC AND 24 VAC POWER PER SIVALLS C/O REQUEST NO. 1704/ECN 2435 & 2436 REV. 1 DATED 1/15 & 1/25
****
CHANGE ORDER NO. 2: CREATED ON 12/15/15

CHANGING THE ROS DATE FROM 6/25/17 TO 3/1/17 PER DAVID COX DURING THE PRE-PRODUCTION MEETING HELD ON 12/15/15
****
11/30/15 - PER NOWERY SMITH'S EMAIL DATED 11/30, THE APPROVAL DWGS WILL BE SUBMITTED BY 12/8
****
CHANGE ORDER NO. 1: CREATED ON 11/5/15

CORRECTING THE DRAWING LEAD TIME AND ADDING PROGRESS PAYMENTS PER NOWERY SMITH'S REQUEST @ SIVALLS DATED 11/4/15
****
WBS: CE.000089.005 ATLANTIC BRIDGE WEYMOUTH

REQUIRED MATERIAL ON-SITE DELIVERY DATE: 6/30/2017

MATERIAL LEAD TIME: 16-18 WEEKS ARAD

DRAWING LEAD TIME: 4 WEEKS ARO (12/3/15)
SPECTRA TO RETURN DRAWINGS: 2 WEEKS (12/17/15)

THIS EQUIPMENT REQUIRES INSPECTION. PLEASE SEE ATTACHED INSPECTION TEST PLAN (ITP)

INVOICES MUST MATCH THE PO LINE PER LINE IN ORDER TO BE ACCEPTED AND PAID

THIS ORDER CONFIRMS ORDER: 3100026341
PLACED ON: NOVEMBER 2, 2015
TO: NOWERY SMITH - 713-823-4653 - HOUSTON@SIVALLS.COM
BY: CARRI WALLIS

LEAD ENGINEER: DAVID COX - 902-490-2203
DSCOX@SPECTRAENERGY.COM

General Notes:

THIS PURCHASE ORDER IS IN REFERENCE TO SIVALLS QUOTE NUMBER 2015-337 DATED 9/9/15. PRICING VALID THROUGH 11/9/15. SPECTRA ENERGY TERMS & CONDITIONS INCLUDED AS PART OF THIS PURCHASE ORDER SHALL BE THE ONLY TERMS APPLICABLE TO THIS PURCHASE ORDER.

ONE (1) HARD COPY AND (1) ELECTRONIC COPY OF DOCUMENTATION, WHICH INCLUDES MTR'S, JOB BOOKS AND O&M MANUALS, ***MUST BE MAILED TO THE LEAD ENGINEER***. ONLY SEND 1 ELECTRONIC COPY TO CARRI WALLIS AT THE FOLLOWING ADDRESS:
SPECTRA ENERGY - 5400 WESTHEIMER COURT, HOUSTON, TX 77056
THE PO NUMBER AND LINE ITEM MUST BE REFERENCED ON EACH MTR

ONE (1) GAS FIRED WATER BATH HEATER - $87,676.00
PER SPEC NO. ES-VH1.2 REV. 2

PAYMENT TERMS: NET 45

CANCELLATION SCHEDULE:
10% IF CANCELLED UP TO 4 WEEKS ARO
25% IF CANCELLED UP TO 8 WEEKS ARO
100% IF CANCELLED AFTER 8 WEEKS ARO

WARRANTY: 12 MONTHS FROM DATE OF STARTUP OR 18 MONTHS FROM DATE OF SHIPMENT; WHICHEVER OCCURS FIRST.

FACILITY WHERE PRODUCT WILL BE MANUFACTURED: ODESSA, TX

SPECTRA REQUIRES DELIVERY 6/30/2017; SIVALLS FREE TO ADJUST PRODUCTION SCHEDULE, BUT SPECTRA NOT TO BE CHARGED STORAGE FEES NOR ARE WE TO BE INVOICED IF HEATER IS MANUFACTURED EARLIER THAN IS REQUIRED TO MEET THE 6/30/17 DELIVERY DATE.

Escalation Clause: If material is not needed on-site within 1 year

Direct & Indirect Fired Heater Material Escalation:
It is understood that t he contract price for the Direct & Indirect Fired Heater has been calculated based on the current prices for raw materials. However, due to Spectra Energy's request for delayed equipment delivery of June 30, 2017, the market for the raw materials may shift and price increases and/or decreases could occur. Sivalls agrees to use their best efforts to obtain the lowest possible prices from available material suppliers, but should there be an increase and/or decrease in the prices of materials that are purchased after execution of this purchase order, Spectra agrees to pay that

cost increase to Sivalls and Sivalls agrees to discount their pricing should any decreases occur. In addition, said increase and/or decrease in material pricing of said purchase order shall be capped at +/- 5%. Any claim by Sivalls for payment of a cost increase and/or decrease, as stated above, shall require written notice by Sivalls to Spectra Energy stating the increased and/or decrease cost, of the materials in question, including the source of supply, fully supported by invoices, bills of sales, and current published industry material pricing indices.
DESCRIPTION: MASSACHUSETTS EXEMPT AGT

Notes: SHIPPING INSTRUCTIONS

FREIGHT COLLECT - PLEASE CONTACT KELLEY ELKINS AT 713-989-8395 OR E-MAIL KMELKINS@SPECTRAENERGY.COM FOR ROUTING INSTRUCTIONS.

TAX NOTE: THE COMMODITY(S) PURCHASED UNDER THIS PURCHASE ORDER IS/ARE TAX EXEMPT IN THE STATE OF MASSACHUSETTS. DO NOT INVOICE SALES TAX.

ROUTING INSTRUCTIONS ARE AN INTEGRAL PART OF THIS PURCHASE ORDER. FAILURE TO COMPLY WITH THESE INSTRUCTIONS IN ANY MANNER WITHOUT PRIOR APPROVAL OF SPECTRA ENERGY MATERIALS MANAGEMENT/TRAFFIC DIVISION WILL BE CONSTRUED AS A DIRECT VIOLATION OF THIS CONTRACT. IN THE EVENT ROUTING INSTRUCTIONS CANNOT OR SHOULD NOT BE EXECUTED AS INSTRUCTED IN THIS PURCHASE ORDER, VENDOR IS INSTRUCTED TO CONTACT THE BUYER OR SPECTRA ENERGY TRAFFIC FOR REVISED ROUTING INSTRUCTIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS WILL RESULT IN FREIGHT CHARGES BEING FOR VENDOR'S ACCOUNT.

GUIDELINES FOR WOOD PACKING MATERIALS U.S., CANADA AND MEXICO ARE STRICTLY ENFORCING INTERNATIONAL STANDARDS FOR PHYTO-SANITARY MEASURES PUBLICATION NO. 15 (ISPM 15). WOOD PACKING FOR ALL SHIPMENTS THAT REQUIRE CUSTOMS CLEARANCE, INCLUDING SKIDS, CRATES AND PIPE DUNNAGE MUST BE TREATED TO THE ISPM 15 STANDARD AND IS REQUIRED TO BEAR THE UNIQUE CERTIFICATION STAMP. SELLER WILL BE RESPONSIBLE TO INSURE ALL GOODS SHIPPED MEET ISPM STANDARDS.

NOTE: SHIPMENTS ROUTED VIA FEDEX OR U.P.S. ARE NOT TO EXCEED 125 LBS. AND 100 LBS RESPECTIVELY FOR THE TOTAL SHIPMENT. WEIGHTS EXCEEDING THESE LIMITS ARE TO BE REFERRED TO THE BUYER FOR REVISED SHIPPING INSTRUCTIONS. USE OF MULTIPLE BILLS/SHIPMENTS TO CIRCUMVENT THESE WEIGHT LIMITS ARE NOT ACCEPTABLE, AND IF SO USED WILL BE FOR THE VENDOR'S ACCOUNT.

IN THE EVENT THE MATERIAL IS PURCHASED ON A PREPAY AND ADD BASIS, THE VENDOR MUST INCLUDE A COPY OF THE FREIGHT BILL WITH THEIR INVOICE BEFORE PAYMENT WILL BE AUTHORIZED.

INVOICE TERMS: INVOICE PAYMENT TERMS WILL BE CALCULATED FROM THE DATE RECEIVED IN OUR CORPORATE OFFICE UNLESS OTHERWISE INDICATED IN THE BODY OF THE PURCHASE ORDER.

COMPANY RESERVES THE RIGHT TO HAVE AN EMPLOYEE AND/OR AN APPOINTED AGENT VISIT VENDOR'S MANUFACTURING PLANT/ FACILITIES AND/OR SUB-VENDORS MANUFACTURING PLANT AND FACILITIES TO EXPEDITE OR INSPECT MATERIALS GOODS AND SERVICES COVERED BY THIS PURCHASE ORDER. SUCH VISITS WILL BE DURING VENDOR'S NORMAL WORKING HOURS AND SUBJECT TO ANY REASONABLE AND NORMAL PROCEDURES OF THE VENDOR. THESE RIGHTS SHALL BE RESERVED AND SO INDICATED ON ANY AND ALL ORDERS TO SUB-VENDORS.

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
20		COMMISSIONING SERVICES	1	LOT	03/31/2018	0.01	0.01
COMMISSIONING SERVICES: THE VENDOR WILL PERFORM THE START UP AND COMMISSIONING OF THE GOODS PER THE MANUFACTURER'S RECOMMENDED PROCEDURE.# THE SCOPE OF THE SERVICES PROVIDED BY VENDOR INCLUDES THE REQUIRED PERSONNEL, EQUIPMENT AND TIME TO PROPERLY AND COMPLETELY COMMISSION THE GOODS. IN ACCORDANCE WITH SET SPEC ES-DOT.3. GL 1004 8500128 Project / WBS CE.000089.005.10.07							
30		COMPLETION OF FABRICATION DRAWINGS	1	EA	12/18/2015	1,416.67	1,416.67
COMPLETION OF FABRICATION DRAWINGS GL 1004 8500201 Project / WBS CE.000089.005.04.02							
40		PROGRESS PAYMENT #1 - 25%	1	EA	11/15/2016	21,564.83	21,564.83
PROGRESS PAYMENT #1: 25% OF PURCHASE ORDER AMOUNT AFTER RECEIPT OF MAJOR MATERIALS (COIL MATERIAL AND BURNER PANEL) GL 1004 8500201 Project / WBS CE.000089.005.04.02							
50		PROGRESS PAYMENT #2 - 25%	1	EA	01/13/2017	21,564.83	21,564.83
PROGRESS PAYMENT #2: 25% OF PURCHASE ORDER AMOUNT AFTER COMPLETION OF VESSEL IN WELDING SHOP (HYDROTEST OF COILS) GL 1004 8500201 Project / WBS CE.000089.005.04.02							
60		PROGRESS PAYMENT #3 - 50%	1	EA	04/07/2017	43,129.66	43,129.66
PROGRESS PAYMENT #3: BALANCE UPON COMPLETION AND FUNCTION TESTING IN SIVALL'S YARD GL 1004 8500201 Project / WBS CE.000089.005.04.02							
70		PRESSURE & TEMP. COMPENSATION	1	EA	03/01/2017	4,150.00	4,150.00
ADDING PRESSURE & TEMPERATURE COMPENSATION FEATURE FOR ROOTS METER USING MINI-MAX CORRECTORS GL 1004 8500201 Project / WBS CE.000089.005.04.02							
80		DOWNDRAFT DIVERTER	1	EA	03/01/2017	230.00	230.00
PROVIDE DOWNDRAFT DIVERTER THAT EXTENDS 32" ABOVE TOP OF STACK. DELETE RAIN CAP BUT INCLUDE CONE TYPE BIRD SCREEN GL 1004 8500201 Project / WBS CE.000089.005.04.02							
90		120VAC & 24VAC POWER	1	EA	03/01/2017	508.00	508.00
ADDING 120 VAC & 24 VAC POWER WILL BE PROVIDED FROM BMS PANEL WITH MODULES GL 1004 8500201 Project / WBS CE.000089.005.04.02							

Algonquin Gas Transmission, LLC

P.O. Number 3100026341

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
100		CHANGE INLET/OUTLET FLANGES TO 900#	1	EA	03/01/2017	292.00	292.00

CHANGING THE INLET AND OUTLET FLANGES FROM 600# TO 900# AND CREATING NEW COIL DWG FOR WEYMOUTH DUE TO NEW FLANGE RATINGS & LABEL INLET/OUTLET OF COIL ON ASSEMBLY PRINT @ N/C PER SIVALLS QUOTE NO. 1705/ECN2442 DATED 3/10/16
GL 1004 8500201 Project / WBS CE.000089.005.04.02

Total: **92,856.00 USD**

STANDARD PURCHASE ORDER TERMS AND CONDITIONS
(United States - Issue Version: May 2018)

1. **General.** This purchase order ("**Order**") comprises the face of the Order, these purchase order terms and conditions and such other documents incorporated by reference on the face of the Order. The "Seller", "Supplier" or "Vendor" ("**Supplier"**) identified on the face of the Order agrees to sell, and the Enbridge entity identified on the face of the Order ("**Company**") agrees to buy, the goods, articles, and materials described in the Order (together with such documentation as specified on the face of the Order, collectively, "**Goods**") and services related thereto.

2. **Acceptance of the Order. Supplier's acceptance of the Order, whether in writing or by performance, will be only upon these terms and conditions, which are incorporated into and made a part of each Order; no other terms or conditions shall be binding on Company unless: (i) conspicuously referenced on the face of the Order to which such other terms and conditions apply; and (ii) expressly agreed to by Company. Any quote, invoice, acknowledgement or other form or communication issued by Supplier in connection with the Order will be for Supplier's record and accounting purposes only and any terms and conditions referenced therein will not apply to the Order.**

3. **Order Number.** Company's Order number and corresponding item line number(s) as shown on the face of the Order must appear on all invoices, correspondence, shipping documents, packages and any other documents relating to the Order.

4. **Delivery, Risk and Title.** Supplier shall deliver the Goods to the location(s) designated by Company in the order ("**Delivery Point**"). Supplier shall prepay transportation costs for delivery of the Goods to the Delivery Point, unless otherwise specified in the Order, and if so specified, the transportation charges will be included as a separate item in the invoice for the applicable Goods, and not in an additional or separate invoice. Title transfers to Company upon: (i) Company's acceptance of the Goods; or (ii) Company's payment for the Goods (in whole or in part); whichever occurs first. Risk of loss for the Goods shall transfer in accordance with the 2010 Incoterm set out on the face of this Order. Supplier warrants it will have good and transferable title to the Goods at the time of title transfer to Company, and further that title to the Goods will transfer to Company free and clear of any and all liens or encumbrances.

5. **Warranty.** Supplier warrants that the Goods, and the services related thereto, will (i) conform in all respects to the requirements of the Order; (ii) comply with the more stringent of industry or Company's standards; (iii) conform strictly to applicable specifications, drawings, samples or other description upon which the Order is based; (iv) be fit, safe and effective for their intended use and purpose, and operate as intended; and (v) be merchantable and free from defects in material, workmanship, and design. All warranties set forth in the Order will remain in effect for one (1) year from the date of Company's acceptance, or eighteen (18) months from delivery of the Goods, whichever occurs latest, or as stated on the face of the Order. All warranties will not be deemed waived by reason of Company's receipt, inspection, or by payment for the Goods. Supplier shall assign and transfer all assignable warranties it receives from its vendors and manufacturers to Company.

In the event of a breach of warranty, Supplier shall repair and/or replace the defective Goods at no cost to Company (including, without limitation, shipping costs). Goods will not be considered in breach of this warranty if a defect is caused primarily by Company's improper installation, operation or maintenance.

6. **Delay.** Supplier shall deliver the Goods on the date(s) specified in the Order, during Company's normal business hours or as otherwise instructed by Company. Timely completion and delivery is a material term of the Order. Timely delivery is delivery of Goods, which conform to requirements of the Order, to the Delivery Point on or before the agreed delivery date. If Supplier is unable to make a timely delivery, it shall notify Company of the anticipated delay as soon as it learns of same, such notice becoming effective upon receipt by Company. Supplier's notice shall state the reasons for the delay and the anticipated date of delivery. If the delay (a) is not caused in whole or in part by the negligence or intentional fault of Supplier and (b) will not contribute to a delay in Company's schedule or otherwise cause damages to Company or any entity to whom Company is providing services, then Company may, but is not obligated to, agree to extend the date of delivery, without additional liability to Supplier, to the earlier of: (i) the anticipated date of delivery stated in Supplier's notice, or (ii) ten (10) business days after the original agreed delivery date. If delivery is not accomplished before the agreed delivery date, as such may be extended by these terms, then Supplier will be liable to Company for all direct damages caused by the delay.

7. **Rejection and Acceptance of Goods.** Company may reject any Goods that do not conform to the requirements of this Order and to return non-conforming Goods to Supplier at Supplier's expense. Company's acceptance or inspection of any Goods is not a waiver of any of Company's rights hereunder, at law or otherwise. Receipt of the Goods, acknowledgement of receipt of the Goods, or payment of Supplier's invoices does not constitute acceptance of the Goods.

8. **Invoicing.** Company shall pay all invoice amounts pursuant to the payment terms on the face of the Order upon receipt of undisputed invoice(s). Company and Supplier shall work together in good faith to resolve all invoice disputes. Each of the parties shall be responsible for the payment of all taxes, duties, levies, charges and contributions for which the respective party is liable as imposed by any appropriate government or regulatory authority ("**Tax**" or "**Taxes**") in connection with the Order. Taxes imposed on Company that Supplier is required to collect shall be separately stated and identified on each invoice issued by Supplier in compliance with appropriate tax laws or regulations. Company shall provide Supplier with exemption documentation as required by the applicable governmental authority where exemption from Taxes is claimed. For further clarification, Supplier will be responsible for paying its income taxes and any other taxes of any kind in any jurisdiction that might become payable in relation to the sale of goods. Company shall bear no responsibility for any income, gross margin, franchise, capital, net worth or other type of direct tax that may inure to Supplier as a result of the Order.

9. **Liens.** Supplier shall timely pay its subcontractors and vendors, and indemnifies and defends Company from and against all claims by third-parties and liens and encumbrances on Company's property related in any way to Supplier's performance of the Order.

10. **Changes.** Company may at any time make reasonable changes in any one or more of the following: (1) drawings, plans, designs and specifications; (2) quantities; (3) delivery schedule; or (4) place, manner or time of delivery. If any such change increases or decreases the cost of the Goods to be provided or results in an extension of the shipping schedule, Supplier shall give Company written notice stating the effect of such change within ten (10) days after receipt of the change request. No claim for an increase in price or schedule extension will be recognized unless such was authorized in advance and in writing by Company.

11. **Compliance.** Supplier shall comply with all applicable federal, state and local laws and regulations that affect the Order. All deliveries to Company's premises must be carried out in a safe manner, and Supplier shall comply with, and cause all other parties acting on Supplier's behalf to comply with all safety policies, rules and warnings communicated by Company.

12. **Insurance Requirements.**

(a) Supplier shall maintain at its own expense, the insurance coverage outlined herein with licensed, reputable and reliable insurers: i) **Workers' Compensation and/or Occupational Disease** coverage that fully complies with all applicable laws where activity related to this Order is performed, where Supplier's employees reside, and in all states where Supplier is domiciled. **As applicable**, coverage shall include an alternate employer's endorsement and voluntary compensation endorsement; ii) **Employer's Liability** coverage with limits of One Million Dollars ($1,000,000) each accident, by disease each employee, and by disease policy limit; iii) **Commercial General Liability** coverage with a limit of Two Million Dollars ($2,000,000) each occurrence for bodily injury and property damage arising out of or relating to Supplier's activities under this Order. The policy shall include coverage for, contractual liability, cross liability, severability of interests, products and completed operations; iv) **As applicable, Commercial Auto Liability** covering all vehicles used by Supplier under this Order with a combined single limit of Two Millions Dollars ($2,000,000) for injury or death of one or more persons or damage to or destruction of property as a result of each accident; and v) **As applicable, All Risk Property Damage** insurance on a replacement cost basis covering loss of or damage to property owned by or in the care custody and control of the Supplier. Supplier shall ensure that each insurance policy hereunder: A) with exception of 12(a) i) and v) includes Company as additional insured; B) provides a waiver of insurers' rights of subrogation in favor of Company; and C) is written to respond on a primary and non-contributory basis. Insurance shall not be canceled without thirty (30) days' prior written notice to Company.

(b) Upon execution of this Agreement, and on an annual basis thereafter until this Agreement is terminated, Supplier shall provide to Company Certificate(s) of Insurance certifying Supplier's compliance with this Order. In the event of a reduction in Supplier insurance limits during the Term which may otherwise reduce the limits of insurance required to comply with this Order, the Supplier shall promptly provide Company with notice of same, and immediately thereafter secure such additional insurance as is required to comply with the terms of this Order. Company's acceptance of certificates or correspondence associated thereto does not constitute a waiver, release or modification of the requirements under this Order. "Certificate Holder" shall be: Enbridge (U.S.) Inc. and U.S. affiliates.

(c) In the event Supplier fails to comply with insurance requirements under this Order, at its sole discretion, Company may, but shall not be obligated to, obtain such insurance for Company's sole benefit as Company deems necessary to address any failure on the part of the Supplier to obtain the insurance required pursuant to this Order. Any cost thereof shall be payable by the Supplier to Company on demand and Company may, at its election, deduct the cost thereof or set-off from any monies which are due or may become due to Supplier. No liability shall attach to Company for any decision on the part of Company to forego the purchase of additional insurance under this Section 12, nor does Company's decision not to purchase additional insurance pursuant to this Section 12 constitute a waiver, release or modification of the requirements under this Order, or constitute a

statement by Company that Supplier's insurance coverage at any time during the Term hereof is in compliance with the requirements under this Order.

(d) Company will not be responsible for any premiums, deductibles, self-insured retentions or any other costs for the insurance provided by Supplier in this Order.

13. **INDEMNITY. NOTWITHSTANDING ANYTHING ELSE IN THE ORDER TO THE CONTRARY, SUPPLIER SHALL INDEMNIFY, RELEASE, HOLD HARMLESS, AND DEFEND COMPANY, ITS PARENT, SUBSIDIARY AND AFFILIATED COMPANIES, AND ITS AND THEIR OFFICERS, DIRECTORS, EMPLOYEES, AGENTS, ASSIGNS AND SUCCESSORS IN INTEREST FROM AND AGAINST ALL CLAIMS, DISPUTES, SUITS, COMPLAINTS, LIABILITIES, DAMAGES, AND EXPENSES OF WHATEVER NATURE (*including,without limitation, attorneys' fees*), INCLUDING, WITHOUT LIMITATION, FOR INJURY TO ANY PERSON (INCLUDING DEATH) OR DAMAGE TO ANY PROPERTY, RESULTING FROM OR IN ANY WAY CONNECTED WITH SUPPLIER'S PERFORMANCE OF THE ORDER, EXCEPT THAT THE OBLIGATIONS HEREUNDER DO NOT APPLY TO COMPANY'S SOLE NEGLIGENCE OR WILLFUL MISCONDUCT.**

14. **Intellectual Property Warranty and Indemnity.** Supplier warrants that the Goods and the related services do not infringe or misappropriate any letters patent, trademark or copyright or any other intellectual property rights of any third party. **Supplier shall release, indemnify, save harmless and defend Company from and against all claims, liabilities, damages, and expenses (including, without limitation, attorneys' fees) arising in favor of any person or entity and based on misappropriation of trade secrets, infringement or claim of infringement of a patent, trademark, trade name, copyright or other proprietary right in the Goods provided by Supplier, except to the extent directly caused by specifications expressly provided by Company.**

15. **Intellectual Property Ownership and License.** All ideas, concepts, drawings and similar items created by Supplier in connection with the performance of the Order shall be the property of Company and shall be immediately delivered by Supplier to Company, with all compensation to Supplier for such ideas, concepts, drawings and similar items being included in the price(s) stated in the Order. Supplier grants to Company a non-exclusive, royalty-free, transferable, irrevocable license under all foreign and domestic patents now or hereafter owned by Supplier to use (for any purpose) and sell the Goods purchased under the Order.

16. **Confidentiality.** Both Company and Supplier, on behalf of themselves and their employees, agree that any ideas, concepts, or proprietary information received from the other in connection with the performance of the Order will not be disclosed to third persons except to the extent necessary for the proper performance of the Order.

17. **Termination for Cause.** Company may terminate all or any part of the Order for: (i) Supplier's failure to make deliveries by the date(s) specified; (ii) Supplier's breach of any of the terms hereof, including, without limitation, the warranties of Supplier; (iii) change in price of the Goods; (iv) Supplier's failure to provide adequate assurance of its ability to meet quality standards; (v) Supplier's failure to make progress on any Goods so as to endanger performance of the Order; or (vi) in the event of any proceeding by or against Supplier in bankruptcy or insolvency or for the appointment of a receiver or trustee or an assignment for the benefit of creditors. Upon termination for cause, Company shall provide written notice of termination and have no further obligation to Supplier. Upon receipt of notice of termination, Supplier shall discontinue all work pertaining to the Order and use its best efforts to mitigate additional costs resulting from the termination. Supplier shall preserve and protect materials in supply, work in progress, and finished work, the disposition of which shall be as directed by Company. Supplier is not entitled to any prospective profits or damages.

18. **Termination for Convenience.** Company may terminate all or any part of the Order for convenience upon written notice to Supplier. Company shall accept and pay for materials in supply, work in progress and finished work, as well as reasonable additional costs caused by the termination. Supplier is not entitled to any prospective profits or damages. In no event will the total amount paid to Supplier under a terminated Order exceed the original value of the Order.

19. **Notice.** All notices, consents and requests hereunder must be in writing and served by personal service, by mail or by e-mail to the address of the receiving Party set forth on the face of this Order (or such different address as may be designated by such Party in a notice to the other Party, from time to time). Notices, consents and requests served by personal service shall be deemed served when delivered. Notices, consents and requests served by mail must be sent by registered mail, return receipt requested, and shall be deemed served 10 business days after mailing. Notices, consents and requests served by e-mail shall be deemed served on the date of sending, provided: (i) no incomplete or bounce-back error transmission is received by the sending Party; and (ii) if such day is not a business day or if the notice or communication is received after 5:00 PM (at the place of receipt) on any business day, the notice or communication shall be deemed to have been sent and received on the immediately following business day.

20. **Independent Contractor.** Supplier is an independent contractor in all respects pertaining to its performance of the Order.

21. **Waiver.** Waiver by Company of any provision hereof shall not constitute a continuing waiver or a waiver of any other provision, nor shall it affect in any manner any right or remedy to which Company is entitled for any breach or default by Supplier, whether or not similar.

22. **Remedies Cumulative.** All rights and remedies reserved under the Order and these Terms shall be cumulative and in addition to any further rights and remedies provided in law or equity.

23. **Assignment.** Supplier shall not assign or transfer any right or obligation under the Order without Company's prior written consent.

24. **Venue, Choice of Law and Jury Trial Waiver.** The Order shall be governed by and construed in accordance with the laws of Texas, without reference to its conflict of laws rules or principles. Each party irrevocably submits to the exclusive jurisdiction of the state and federal courts of Texas seated in Harris County for the interpretation and enforcement of this Order, and unconditionally waives any defense of an inconvenient forum to the maintenance of any action or proceeding in any such court, any objection to venue with respect to any such action or proceeding and any right of jurisdiction on account of the place of residence or domicile of either party. A final judgment on any such dispute, as to which all appeals, if any, have been exhausted, shall be conclusive and may be enforced in other jurisdictions in any manner provided by law. EACH PARTY WAIVES ALL RIGHTS TO TRIAL BY JURY IN ANY PROCEEDING BROUGHT BY EITHER PARTY AGAINST THE OTHER PARTY ON ANY MATTER WHATSOEVER ARISING OUT OF, IN CONNECTION WITH OR RELATED TO THIS ORDER.

25. **Set Off.** Company may set-off and deduct from any amounts payable to Supplier any amounts owing by Supplier to Company pursuant to this Order or any other agreement between Supplier and Company. The failure by Company to set-off or deduct any amount from an invoiced payment will not constitute a waiver of Company's right to set-off, deduct or collect such amount.

26. **Severability.** If any provision of this Agreement is finally determined by any court of competent jurisdiction to be illegal or unenforceable, that provision will be severed from this Agreement and the remaining provisions will continue in full force and effect.

27. **Survival.** The provisions of this Order which are intended to extend beyond its termination, including the liability, indemnity, compliance, warranty, intellectual property and confidentiality provisions, and the provisions applicable to the enforcement of those provisions and/or the enforcement of rights and obligations incurred hereunder that are not fully discharged prior to the termination of this Order, will survive termination to the extent necessary to effect the intent of the parties and enforce such rights and obligations.

28. **Audit.** Company and its authorized representatives shall have the right to audit all costs and records of Supplier (and any subcontractors retained by Supplier) related solely to performance of this Order, upon fifteen (15) days' written notice to Supplier (or subcontractor), including access to Supplier's (and subcontractor's) books, records and documentation supporting all billed amounts. This right to audit shall remain in effect for a period of one year from the date the Goods are accepted by Company. Company through its employees or agents shall have reasonable access to Supplier's facilities and during normal business hours at all times to observe and inspect the fabrication, manufacturing, assembly, coating, testing, loading, transportation and stockpiling of the Goods. Supplier will respond to such information requests as Company may reasonably request in connection with such inspection and observation. Each party agrees, while at the other's facilities, to comply with all applicable federal, state and local laws and to observe such safety rules as that party may prescribe for the protection of personnel and property.

29. **Interpretation.** Headings used herein are for the convenience of reference only and shall not be considered in construing or interpreting this Agreement. The words "herein", "hereunder", "hereof" and other similar words refer to this Order as a whole and not to any particular paragraph or part of the Order. "Includes", "including" and similar terms shall mean "including (or includes, as applicable) without limitation".

30. **Counterparts.** This Order, and any amendment, supplement or schedule to this Order, may be executed in any number of counterparts, and may be executed using electronic signatures. The executed signature page(s) from each counterpart may be joined together and attached to an original and together shall constitute one and the same instrument. Exchange of counterparts of a document of this Order may be provided by fax or other electronic means, including email delivery.

[END OF TERMS AND CONDITIONS]

EXHIBIT 6B

Buyer: MICHAEL CRAYMER
Phone: 713-627-4841
Email: Michael.Craymer@enbridge.com

Bill To: Algonquin Gas Transmission, LLC
APUSinvoices@spectraenergy.com
OR
P.O. Box 2549
Detroit, MI 48202-2549

PURCHASE ORDER (PO)

Vendor:	**Vendor No. 9000000338**
PUFFER SWEIVEN LP 4230 GREENBRIAR DRIVE STAFFORD TX 77477-2000 Phone: 281-240-2000 Fax: 281-274-6419 Attention:	

Ship To: ALGONQUIN GAS TRANSMISSION LLC

1600 WASHINGTON STREET
HOLLISTON MA 01746

Attention:

General Information		
P.O. Number	:	**3100038392**
Rev. No.	:	5
Date	:	05/18/2017
Currency Code	:	USD
Payment Terms	:	Net 45 Days
Ship Date	:	07/24/2017
Shipping Terms	:	FOB ORIGIN

P.O.Number and Line number must mirror the PO on your invoice and must be referenced on all invoices and related correspondence.

E_CE.000089.005_AB WEYMOUTH_KW_M21

FREIGHT COLLECT - CONTACTS FOR ROUTING INSTRUCTIONS:
TATIANA PARIS AT 713-627-5052 TATIANA.PARIS@ENBRIDGE.COM

EXPEDITE ONLY NO INSPECTION REQUIRED BY QAE

General Notes

DESCRIPTION: MAINE TAXABLE

Notes:

TAX NOTE: THE COMMODITY(S) PURCHASED UNDER THIS PURCHASE ORDER IS/ARE TAXABLE AND ARE TO BE USED IN THE STATE OF MAINE. PLEASE INVOICE APPLICABLE MAINE STATE TAX IF YOU ARE REGISTERED TO COLLECT SALES TAX IN MAINE.

IF TAX IS BILLED INCORRECTLY THE ENTIRE TAX AMOUNT WILL BE DELETED FROM THE INVOICE AND TAX WILL BE ACCRUED. WHEN TAX IS DELETED FROM AN INVOICE, A NOTE WILL BE PLACED ON THE CHECK STUB STATING "TAX DELETED REFER TO PURCHASE ORDER". NO ADDITIONAL CONTACT WILL BE MADE WITH THE SUPPLIERS.

SHIPPING POINT:ORIGIN

THIS ORDER CONFIRMS ORDER 3100038392
PLACED ON MAY 18, 2017
TO LINDSAY LAFLEY
BY MICHAEL CRAYMER.

ROUTING INSTRUCTIONS ARE AN INTEGRAL PART OF THIS PURCHASE ORDER. FAILURE TO COMPLY WITH THESE INSTRUCTIONS IN ANY MANNER WITHOUT PRIOR APPROVAL OF SPECTRA ENERGY MATERIALS MANAGEMENT/TRAFFIC DIVISION WILL BE CONSTRUED AS A DIRECT VIOLATION OF THIS CONTRACT. IN THE EVENT ROUTING INSTRUCTIONS CANNOT OR SHOULD NOT BE EXECUTED AS INSTRUCTED IN THIS

PURCHASE ORDER, VENDOR IS INSTRUCTED TO CONTACT THE BUYER OR SPECTRA ENERGY TRAFFIC FOR REVISED ROUTING INSTRUCTIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS WILL RESULT IN FREIGHT CHARGES BEING FOR VENDOR'S ACCOUNT.

GUIDELINES FOR WOOD PACKING MATERIALS U.S., CANADA AND MEXICO ARE STRICTLY ENFORCING INTERNATIONAL STANDARDS FOR PHYTO-SANITARY MEASURES PUBLICATION NO. 15 (ISPM 15). WOOD PACKING FOR ALL SHIPMENTS THAT REQUIRE CUSTOMS CLEARANCE, INCLUDING SKIDS, CRATES AND PIPE DUNNAGE MUST BE TREATED TO THE ISPM 15 STANDARD AND IS REQUIRED TO BEAR THE UNIQUE CERTIFICATION STAMP. SELLER WILL BE RESPONSIBLE TO INSURE ALL GOODS SHIPPED MEET ISPM STANDARDS.

NOTE: SHIPMENTS ROUTED VIA FEDEX OR U.P.S. ARE NOT TO EXCEED 125 LBS AND 100 LBS RESPECTIVELY FOR THE TOTAL SHIPMENT. WEIGHTS EXCEEDING THESE LIMITS ARE TO BE REFERRED TO THE BUYER FOR REVISED SHIPPING INSTRUCTIONS. USE OF MULTIPLE BILLS/SHIPMENTS TO CIRCUMVENT THESE WEIGHT LIMITS ARE NOT ACCEPTABLE, AND IF SO USED WILL BE FOR THE VENDOR'S ACCOUNT.

IN THE EVENT THE MATERIAL IS PURCHASED ON A PREPAY AND ADD BASIS, THE VENDOR MUST INCLUDE A COPY OF THE FREIGHT BILL WITH THEIR INVOICE BEFORE PAYMENT WILL BE AUTHORIZED.

INVOICE TERMS: INVOICE PAYMENT TERMS WILL BE CALCULATED FROM THE DATE RECEIVED IN OUR CORPORATE OFFICE UNLESS OTHERWISE INDICATED IN THE BODY OF THE PURCHASE ORDER.

COMPANY RESERVES THE RIGHT TO HAVE AN EMPLOYEE AND/OR AN APPOINTED AGENT VISIT VENDOR'S MANUFACTURING PLANT/ FACILITIES AND/OR SUB-VENDORS MANUFACTURING PLANT AND FACILITIES TO EXPEDITE OR INSPECT MATERIALS GOODS AND SERVICES COVERED BY THIS PURCHASE ORDER. SUCH VISITS WILL BE DURING VENDOR'S NORMAL WORKING HOURS AND SUBJECT TO ANY REASONABLE AND NORMAL PROCEDURES OF THE VENDOR. THESE RIGHTS SHALL BE RESERVED AND SO INDICATED ON ANY AND ALL ORDERS TO SUB-VENDORS.

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
10		VALVE, REGULATOR, PILOT OPERATED, 2" A	2	EA	07/24/2017	7,166.90	14,333.80

VALVE, REGULATOR, PILOT OPERATED, 2" ANSI 600# R/F INLET AND OUTLET, WCCSTEEL BODY, NITRILE DIAPHRAGM, DISC MATERIAL AND O-RING, FISHER MODELEZH, FAIL CLOSED
PRESSURE REDUCER SET @ 340 PSIG, _____ TAG: PCV-921-A1, PCV-921-B1,_____ DRAWING: WEYM-P-1128 (MARK NO. 27, QNT. 2) BOM TAG: FG062
GL 1004 8500201 Project / WBS CE.000089.005.06.03

20		VALVE, REGULATOR, PILOT OPERATED, 2" A	1	EA	07/24/2017	7,929.84	7,929.84

VALVE, REGULATOR, PILOT OPERATED, 2" ANSI 600# R/F INLET AND OUTLET, WCCSTEEL BODY, NITRILE DIAPHRAGM, DISC MATERIAL AND O-RING, FISHER MODELEZHSO, FAIL OPEN
PRESSURE REDUCER SET @ 350 PSIG, _____ TAG: PCV-922-A1,_____DRAWING: WEYM-P-1128 (MARK NO. 29, QNT. 1) BOM TAG: FG063

Algonquin Gas Transmission, LLC

P.O. Number 3100038392

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
GL 1004 8500201 Project / WBS CE.000089.005.06.03							
30		VALVE, REGULATOR, PILOT OPERATED, 2" A	1	EA	07/24/2017	7,929.84	7,929.84
VALVE, REGULATOR, PILOT OPERATED, 2" ANSI 600# R/F INLET AND OUTLET, WCCSTEEL BODY, NITRILE DIAPHRAGM, DISC MATERIAL AND O-RING, FISHER MODELEZHSO, FAIL OPEN PRESSURE REDUCER SET @ 360 PSIG, _____ TAG: PCV-922-B1, _____DRAWING: WEYM-P-1128 (MARK NO. 28, QNT. 1) BOM TAG: FG064							
GL 1004 8500201 Project / WBS CE.000089.005.06.03							
40		VALVE, REGULATOR, PILOT OPERATED, 2" A	2	EA	07/24/2017	11,333.84	22,667.68
VALVE, REGULATOR, PILOT OPERATED, 2" ANSI 600# R/F INLET AND OUTLET, WCCSTEEL BODY, NITRILE DIAPHRAGM, DISC MATERIAL AND O-RING, FISHER MODELEZHSO, FAIL OPEN PRESSURE REDUCER SET @ 45 PSIG, _____ TAG: PCV-932-A1, PCV-932-B1,_____ DRAWING: WEYM-P-0013 (MARK NO. 7, QNT. 2) BOM TAG: GL056							
GL 1004 8500201 Project / WBS CE.000089.005.06.03							
50		VALVE, REGULATOR, PILOT OPERATED, 2" A	2	EA	07/24/2017	10,642.68	21,285.36
VALVE, REGULATOR, PILOT OPERATED, 2" ANSI 600# R/F INLET AND OUTLET, WCCSTEEL BODY, NITRILE DIAPHRAGM, DISC MATERIAL AND O-RING, FISHER MODELEZH, FAIL CLOSED PRESSURE REDUCER SET @ 40 PSIG, _____ TAG: PCV-931-A1, PCV-931-B1,_____ DRAWING: WEYM-P-0013 (MARK NO. 6, QNT. 2) BOM TAG: GL057							
GL 1004 8500201 Project / WBS CE.000089.005.06.03							

Total: 74,146.52 USD

STANDARD PURCHASE ORDER TERMS AND CONDITIONS
(United States - Issue Version: May 2018)

1. **General.** This purchase order ("**Order**") comprises the face of the Order, these purchase order terms and conditions and such other documents incorporated by reference on the face of the Order. The "Seller", "Supplier" or "Vendor" ("**Supplier"**) identified on the face of the Order agrees to sell, and the Enbridge entity identified on the face of the Order ("**Company**") agrees to buy, the goods, articles, and materials described in the Order (together with such documentation as specified on the face of the Order, collectively, "**Goods**") and services related thereto.

2. **Acceptance of the Order. Supplier's acceptance of the Order, whether in writing or by performance, will be only upon these terms and conditions, which are incorporated into and made a part of each Order; no other terms or conditions shall be binding on Company unless: (i) conspicuously referenced on the face of the Order to which such other terms and conditions apply; and (ii) expressly agreed to by Company. Any quote, invoice, acknowledgement or other form or communication issued by Supplier in connection with the Order will be for Supplier's record and accounting purposes only and any terms and conditions referenced therein will not apply to the Order.**

3. **Order Number.** Company's Order number and corresponding item line number(s) as shown on the face of the Order must appear on all invoices, correspondence, shipping documents, packages and any other documents relating to the Order.

4. **Delivery, Risk and Title.** Supplier shall deliver the Goods to the location(s) designated by Company in the order ("**Delivery Point**"). Supplier shall prepay transportation costs for delivery of the Goods to the Delivery Point, unless otherwise specified in the Order, and if so specified, the transportation charges will be included as a separate item in the invoice for the applicable Goods, and not in an additional or separate invoice. Title transfers to Company upon: (i) Company's acceptance of the Goods; or (ii) Company's payment for the Goods (in whole or in part); whichever occurs first. Risk of loss for the Goods shall transfer in accordance with the 2010 Incoterm set out on the face of this Order. Supplier warrants it will have good and transferable title to the Goods at the time of title transfer to Company, and further that title to the Goods will transfer to Company free and clear of any and all liens or encumbrances.

5. **Warranty.** Supplier warrants that the Goods, and the services related thereto, will (i) conform in all respects to the requirements of the Order; (ii) comply with the more stringent of industry or Company's standards; (iii) conform strictly to applicable specifications, drawings, samples or other description upon which the Order is based; (iv) be fit, safe and effective for their intended use and purpose, and operate as intended; and (v) be merchantable and free from defects in material, workmanship, and design. All warranties set forth in the Order will remain in effect for one (1) year from the date of Company's acceptance, or eighteen (18) months from delivery of the Goods, whichever occurs latest, or as stated on the face of the Order. All warranties will not be deemed waived by reason of Company's receipt, inspection, or by payment for the Goods. Supplier shall assign and transfer all assignable warranties it receives from its vendors and manufacturers to Company.

In the event of a breach of warranty, Supplier shall repair and/or replace the defective Goods at no cost to Company (including, without limitation, shipping costs). Goods will not be considered in breach of this warranty if a defect is caused primarily by Company's improper installation, operation or maintenance.

6. **Delay.** Supplier shall deliver the Goods on the date(s) specified in the Order, during Company's normal business hours or as otherwise instructed by Company. Timely completion and delivery is a material term of the Order. Timely delivery is delivery of Goods, which conform to requirements of the Order, to the Delivery Point on or before the agreed delivery date. If Supplier is unable to make a timely delivery, it shall notify Company of the anticipated delay as soon as it learns of same, such notice becoming effective upon receipt by Company. Supplier's notice shall state the reasons for the delay and the anticipated date of delivery. If the delay (a) is not caused in whole or in part by the negligence or intentional fault of Supplier and (b) will not contribute to a delay in Company's schedule or otherwise cause damages to Company or any entity to whom Company is providing services, then Company may, but is not obligated to, agree to extend the date of delivery, without additional liability to Supplier, to the earlier of: (i) the anticipated date of delivery stated in Supplier's notice, or (ii) ten (10) business days after the original agreed delivery date. If delivery is not accomplished before the agreed delivery date, as such may be extended by these terms, then Supplier will be liable to Company for all direct damages caused by the delay.

7. **Rejection and Acceptance of Goods.** Company may reject any Goods that do not conform to the requirements of this Order and to return non-conforming Goods to Supplier at Supplier's expense. Company's acceptance or inspection of any Goods is not a waiver of any of Company's rights hereunder, at law or otherwise. Receipt of the Goods, acknowledgement of receipt of the Goods, or payment of Supplier's invoices does not constitute acceptance of the Goods.

8. **Invoicing.** Company shall pay all invoice amounts pursuant to the payment terms on the face of the Order upon receipt of undisputed invoice(s). Company and Supplier shall work together in good faith to resolve all invoice disputes. Each of the parties shall be responsible for the payment of all taxes, duties, levies, charges and contributions for which the respective party is liable as imposed by any appropriate government or regulatory authority ("**Tax**" or "**Taxes**") in connection with the Order. Taxes imposed on Company that Supplier is required to collect shall be separately stated and identified on each invoice issued by Supplier in compliance with appropriate tax laws or regulations. Company shall provide Supplier with exemption documentation as required by the applicable governmental authority where exemption from Taxes is claimed. For further clarification, Supplier will be responsible for paying its income taxes and any other taxes of any kind in any jurisdiction that might become payable in relation to the sale of goods. Company shall bear no responsibility for any income, gross margin, franchise, capital, net worth or other type of direct tax that may inure to Supplier as a result of the Order.

9. **Liens.** Supplier shall timely pay its subcontractors and vendors, and indemnifies and defends Company from and against all claims by third-parties and liens and encumbrances on Company's property related in any way to Supplier's performance of the Order.

10. **Changes.** Company may at any time make reasonable changes in any one or more of the following: (1) drawings, plans, designs and specifications; (2) quantities; (3) delivery schedule; or (4) place, manner or time of delivery. If any such change increases or decreases the cost of the Goods to be provided or results in an extension of the shipping schedule, Supplier shall give Company written notice stating the effect of such change within ten (10) days after receipt of the change request. No claim for an increase in price or schedule extension will be recognized unless such was authorized in advance and in writing by Company.

11. **Compliance.** Supplier shall comply with all applicable federal, state and local laws and regulations that affect the Order. All deliveries to Company's premises must be carried out in a safe manner, and Supplier shall comply with, and cause all other parties acting on Supplier's behalf to comply with all safety policies, rules and warnings communicated by Company.

12. **Insurance Requirements.**

(a) Supplier shall maintain at its own expense, the insurance coverage outlined herein with licensed, reputable and reliable insurers: i) **Workers' Compensation and/or Occupational Disease** coverage that fully complies with all applicable laws where activity related to this Order is performed, where Supplier's employees reside, and in all states where Supplier is domiciled. **As applicable**, coverage shall include an alternate employer's endorsement and voluntary compensation endorsement; ii) **Employer's Liability** coverage with limits of One Million Dollars ($1,000,000) each accident, by disease each employee, and by disease policy limit; iii) **Commercial General Liability** coverage with a limit of Two Million Dollars ($2,000,000) each occurrence for bodily injury and property damage arising out of or relating to Supplier's activities under this Order. The policy shall include coverage for, contractual liability, cross liability, severability of interests, products and completed operations; iv) **As applicable, Commercial Auto Liability** covering all vehicles used by Supplier under this Order with a combined single limit of Two Millions Dollars ($2,000,000) for injury or death of one or more persons or damage to or destruction of property as a result of each accident; and v) **As applicable, All Risk Property Damage** insurance on a replacement cost basis covering loss of or damage to property owned by or in the care custody and control of the Supplier. Supplier shall ensure that each insurance policy hereunder: A) with exception of 12(a) i) and v) includes Company as additional insured; B) provides a waiver of insurers' rights of subrogation in favor of Company; and C) is written to respond on a primary and non-contributory basis. Insurance shall not be canceled without thirty (30) days' prior written notice to Company.

(b) Upon execution of this Agreement, and on an annual basis thereafter until this Agreement is terminated, Supplier shall provide to Company Certificate(s) of Insurance certifying Supplier's compliance with this Order. In the event of a reduction in Supplier insurance limits during the Term which may otherwise reduce the limits of insurance required to comply with this Order, the Supplier shall promptly provide Company with notice of same, and immediately thereafter secure such additional insurance as is required to comply with the terms of this Order. Company's acceptance of certificates or correspondence associated thereto does not constitute a waiver, release or modification of the requirements under this Order. "Certificate Holder" shall be: Enbridge (U.S.) Inc. and U.S. affiliates.

(c) In the event Supplier fails to comply with insurance requirements under this Order, at its sole discretion, Company may, but shall not be obligated to, obtain such insurance for Company's sole benefit as Company deems necessary to address any failure on the part of the Supplier to obtain the insurance required pursuant to this Order. Any cost thereof shall be payable by the Supplier to Company on demand and Company may, at its election, deduct the cost thereof or set-off from any monies which are due or may become due to Supplier. No liability shall attach to Company for any decision on the part of Company to forego the purchase of additional insurance under this Section 12, nor does Company's decision not to purchase additional insurance pursuant to this Section 12 constitute a waiver, release or modification of the requirements under this Order, or constitute a

statement by Company that Supplier's insurance coverage at any time during the Term hereof is in compliance with the requirements under this Order.

(d) Company will not be responsible for any premiums, deductibles, self-insured retentions or any other costs for the insurance provided by Supplier in this Order.

13. **INDEMNITY. NOTWITHSTANDING ANYTHING ELSE IN THE ORDER TO THE CONTRARY, SUPPLIER SHALL INDEMNIFY, RELEASE, HOLD HARMLESS, AND DEFEND COMPANY, ITS PARENT, SUBSIDIARY AND AFFILIATED COMPANIES, AND ITS AND THEIR OFFICERS, DIRECTORS, EMPLOYEES, AGENTS, ASSIGNS AND SUCCESSORS IN INTEREST FROM AND AGAINST ALL CLAIMS, DISPUTES, SUITS, COMPLAINTS, LIABILITIES, DAMAGES, AND EXPENSES OF WHATEVER NATURE (*including,without limitation, attorneys' fees*), INCLUDING, WITHOUT LIMITATION, FOR INJURY TO ANY PERSON (INCLUDING DEATH) OR DAMAGE TO ANY PROPERTY, RESULTING FROM OR IN ANY WAY CONNECTED WITH SUPPLIER'S PERFORMANCE OF THE ORDER, EXCEPT THAT THE OBLIGATIONS HEREUNDER DO NOT APPLY TO COMPANY'S SOLE NEGLIGENCE OR WILLFUL MISCONDUCT.**

14. **Intellectual Property Warranty and Indemnity.** Supplier warrants that the Goods and the related services do not infringe or misappropriate any letters patent, trademark or copyright or any other intellectual property rights of any third party. **Supplier shall release, indemnify, save harmless and defend Company from and against all claims, liabilities, damages, and expenses (including, without limitation, attorneys' fees) arising in favor of any person or entity and based on misappropriation of trade secrets, infringement or claim of infringement of a patent, trademark, trade name, copyright or other proprietary right in the Goods provided by Supplier, except to the extent directly caused by specifications expressly provided by Company.**

15. **Intellectual Property Ownership and License.** All ideas, concepts, drawings and similar items created by Supplier in connection with the performance of the Order shall be the property of Company and shall be immediately delivered by Supplier to Company, with all compensation to Supplier for such ideas, concepts, drawings and similar items being included in the price(s) stated in the Order. Supplier grants to Company a non-exclusive, royalty-free, transferable, irrevocable license under all foreign and domestic patents now or hereafter owned by Supplier to use (for any purpose) and sell the Goods purchased under the Order.

16. **Confidentiality.** Both Company and Supplier, on behalf of themselves and their employees, agree that any ideas, concepts, or proprietary information received from the other in connection with the performance of the Order will not be disclosed to third persons except to the extent necessary for the proper performance of the Order.

17. **Termination for Cause.** Company may terminate all or any part of the Order for: (i) Supplier's failure to make deliveries by the date(s) specified; (ii) Supplier's breach of any of the terms hereof, including, without limitation, the warranties of Supplier; (iii) change in price of the Goods; (iv) Supplier's failure to provide adequate assurance of its ability to meet quality standards; (v) Supplier's failure to make progress on any Goods so as to endanger performance of the Order; or (vi) in the event of any proceeding by or against Supplier in bankruptcy or insolvency or for the appointment of a receiver or trustee or an assignment for the benefit of creditors. Upon termination for cause, Company shall provide written notice of termination and have no further obligation to Supplier. Upon receipt of notice of termination, Supplier shall discontinue all work pertaining to the Order and use its best efforts to mitigate additional costs resulting from the termination. Supplier shall preserve and protect materials in supply, work in progress, and finished work, the disposition of which shall be as directed by Company. Supplier is not entitled to any prospective profits or damages.

18. **Termination for Convenience.** Company may terminate all or any part of the Order for convenience upon written notice to Supplier. Company shall accept and pay for materials in supply, work in progress and finished work, as well as reasonable additional costs caused by the termination. Supplier is not entitled to any prospective profits or damages. In no event will the total amount paid to Supplier under a terminated Order exceed the original value of the Order.

19. **Notice.** All notices, consents and requests hereunder must be in writing and served by personal service, by mail or by e-mail to the address of the receiving Party set forth on the face of this Order (or such different address as may be designated by such Party in a notice to the other Party, from time to time). Notices, consents and requests served by personal service shall be deemed served when delivered. Notices, consents and requests served by mail must be sent by registered mail, return receipt requested, and shall be deemed served 10 business days after mailing. Notices, consents and requests served by e-mail shall be deemed served on the date of sending, provided: (i) no incomplete or bounce-back error transmission is received by the sending Party; and (ii) if such day is not a business day or if the notice or communication is received after 5:00 PM (at the place of receipt) on any business day, the notice or communication shall be deemed to have been sent and received on the immediately following business day.

20. **Independent Contractor.** Supplier is an independent contractor in all respects pertaining to its performance of the Order.

21. **Waiver.** Waiver by Company of any provision hereof shall not constitute a continuing waiver or a waiver of any other provision, nor shall it affect in any manner any right or remedy to which Company is entitled for any breach or default by Supplier, whether or not similar.

22. **Remedies Cumulative.** All rights and remedies reserved under the Order and these Terms shall be cumulative and in addition to any further rights and remedies provided in law or equity.

23. **Assignment.** Supplier shall not assign or transfer any right or obligation under the Order without Company's prior written consent.

24. **Venue, Choice of Law and Jury Trial Waiver.** The Order shall be governed by and construed in accordance with the laws of Texas, without reference to its conflict of laws rules or principles. Each party irrevocably submits to the exclusive jurisdiction of the state and federal courts of Texas seated in Harris County for the interpretation and enforcement of this Order, and unconditionally waives any defense of an inconvenient forum to the maintenance of any action or proceeding in any such court, any objection to venue with respect to any such action or proceeding and any right of jurisdiction on account of the place of residence or domicile of either party. A final judgment on any such dispute, as to which all appeals, if any, have been exhausted, shall be conclusive and may be enforced in other jurisdictions in any manner provided by law. EACH PARTY WAIVES ALL RIGHTS TO TRIAL BY JURY IN ANY PROCEEDING BROUGHT BY EITHER PARTY AGAINST THE OTHER PARTY ON ANY MATTER WHATSOEVER ARISING OUT OF, IN CONNECTION WITH OR RELATED TO THIS ORDER.

25. **Set Off.** Company may set-off and deduct from any amounts payable to Supplier any amounts owing by Supplier to Company pursuant to this Order or any other agreement between Supplier and Company. The failure by Company to set-off or deduct any amount from an invoiced payment will not constitute a waiver of Company's right to set-off, deduct or collect such amount.

26. **Severability.** If any provision of this Agreement is finally determined by any court of competent jurisdiction to be illegal or unenforceable, that provision will be severed from this Agreement and the remaining provisions will continue in full force and effect.

27. **Survival.** The provisions of this Order which are intended to extend beyond its termination, including the liability, indemnity, compliance, warranty, intellectual property and confidentiality provisions, and the provisions applicable to the enforcement of those provisions and/or the enforcement of rights and obligations incurred hereunder that are not fully discharged prior to the termination of this Order, will survive termination to the extent necessary to effect the intent of the parties and enforce such rights and obligations.

28. **Audit.** Company and its authorized representatives shall have the right to audit all costs and records of Supplier (and any subcontractors retained by Supplier) related solely to performance of this Order, upon fifteen (15) days' written notice to Supplier (or subcontractor), including access to Supplier's (and subcontractor's) books, records and documentation supporting all billed amounts. This right to audit shall remain in effect for a period of one year from the date the Goods are accepted by Company. Company through its employees or agents shall have reasonable access to Supplier's facilities and during normal business hours at all times to observe and inspect the fabrication, manufacturing, assembly, coating, testing, loading, transportation and stockpiling of the Goods. Supplier will respond to such information requests as Company may reasonably request in connection with such inspection and observation. Each party agrees, while at the other's facilities, to comply with all applicable federal, state and local laws and to observe such safety rules as that party may prescribe for the protection of personnel and property.

29. **Interpretation.** Headings used herein are for the convenience of reference only and shall not be considered in construing or interpreting this Agreement. The words "herein", "hereunder", "hereof" and other similar words refer to this Order as a whole and not to any particular paragraph or part of the Order. "Includes", "including" and similar terms shall mean "including (or includes, as applicable) without limitation".

30. **Counterparts.** This Order, and any amendment, supplement or schedule to this Order, may be executed in any number of counterparts, and may be executed using electronic signatures. The executed signature page(s) from each counterpart may be joined together and attached to an original and together shall constitute one and the same instrument. Exchange of counterparts of a document of this Order may be provided by fax or other electronic means, including email delivery.

[END OF TERMS AND CONDITIONS]

EXHIBIT 6C

Buyer: RICKY FLORES
Phone: 713-627-4340
Email: Ricardo.Flores@enbridge.com

Bill To: Algonquin Gas Transmission, LLC
APUSinvoices@spectraenergy.com
OR
P.O. Box 2549
Detroit, MI 48202-2549

PURCHASE ORDER (PO)

Vendor:	**Vendor No. 9000000300**
PECOFACET USA 8400 N. SAM HOUSTON PKWY WEST HOUSTON TX 77064-3461 Phone: Fax: Attention:	

Ship To: ALGONQUIN GAS TRANSMISSION, LLC

1600 WASHINGTON STREET
HOLLISTON MA 01746

Attention:

General Information

P.O. Number	**:**	**3100038012**
Rev. No.	**:**	3
Date	**:**	05/01/2017
Currency Code	**:**	USD
Payment Terms	**:**	Net 30 Days
Ship Date	**:**	See below
Shipping Terms	**:**	FOB ORIGIN

P.O.Number and Line number must mirror the PO on your invoice and must be referenced on all invoices and related correspondence.

E_CE.000089.005_AB WEYMOUTH_KW_M33, ATLANTIC BRIDGE-WEYMOUTH

****

SHIPPING INSTRUCTIONS:

FREIGHT COLLECT- CONTACTS FOR ROUTING INSTRUCTIONS:

TATIANA PARIS 713-627-5052 TATIANA.PARIS@ENBRIDGE.COM
LANNIE MILLS 713-627-5827 LANIE.MILLS@ENBRIDGE.COM

****

PLEASE PROVIDE ANY OTHER ASSOCIATED BROCHURES, DRAWINGS, MSDS, CDS, MATERIAL TEST REPORTS, OR ANY OTHER DOCUMENTATION WHICH PERTAINS TO THESE ITEMS.

****

General Notes

DESCRIPTION: MASSACHUSETTS EXEMPT AGT

Notes:

TAX NOTE: THE COMMODITY(S) PURCHASED UNDER THIS PURCHASE ORDER IS/ARE TAX EXEMPT IN THE STATE OF MASSACHUSETTS. DO NOT INVOICE SALES TAX.

THIS ORDER CONFIRMS ORDER NO. 3100038012

PLACED ON MAY 02, 2017
TO COLLEEN HORD @ COLHOR@PECOFACET.COM

BY RICK FLORES

ROUTING INSTRUCTIONS ARE AN INTEGRAL PART OF THIS PURCHASE ORDER. FAILURE TO COMPLY WITH THESE INSTRUCTIONS IN ANY MANNER WITHOUT PRIOR APPROVAL OF SPECTRA ENERGY MATERIALS MANAGEMENT/TRAFFIC DIVISION WILL BE CONSTRUED AS A DIRECT VIOLATION OF THIS CONTRACT. IN THE EVENT ROUTING INSTRUCTIONS CANNOT OR SHOULD NOT BE EXECUTED AS INSTRUCTED IN THIS PURCHASE ORDER, VENDOR IS INSTRUCTED TO CONTACT THE BUYER OR SPECTRA ENERGY TRAFFIC FOR REVISED ROUTING INSTRUCTIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS WILL RESULT IN FREIGHT CHARGES BEING FOR VENDOR'S ACCOUNT.

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FILTER, DRY GAS, 3" ANSI 600#, RF, PECO FACET MODEL 30F-1-559-8-1480-3 CARBON STEEL BODY WITH 10 MICRON FILTER, 1" DRAIN CONNECTION, 1440 PSIG OPERATING PRESSURE, 2 PSID @ 84,000 SCFH,

DRAWING: WEYM-P-1151 (MARK NO.3, QNT. 1)

BOM TAG: FG004

MTR'S REQUIRED

GL 1004 8500201 Project / WBS CE.000089.005.04.07

Algonquin Gas Transmission, LLC

P.O. Number 3100038012

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
20		FILTER, DRY GAS, 2" ANSI 150#, RF, PEC	1	EA	05/15/2017	2,615.00	2,615.00

FILTER, DRY GAS, 2" ANSI 150#, RF, PECO FACET MODEL 30-2-150 CARBON STEEL BODY WITH 10 MICRON FILTER, 1" DRAIN CONNECTION, 75 PSIG OPERATING PRESSURE, 2 PSID @ 10,000 SCFH,

DRAWING: WEYM-P-0131 (MARK NO.3, QNT. 1)

BOM TAG: GL007

MTR'S REQUIRED

GL 1004 8500201 Project / WBS CE.000089.005.04.07

Total: 7,885.00 USD

STANDARD PURCHASE ORDER TERMS AND CONDITIONS
(United States - Issue Version: May 2018)

1. **General.** This purchase order ("**Order**") comprises the face of the Order, these purchase order terms and conditions and such other documents incorporated by reference on the face of the Order. The "Seller", "Supplier" or "Vendor" ("**Supplier"**) identified on the face of the Order agrees to sell, and the Enbridge entity identified on the face of the Order ("**Company**") agrees to buy, the goods, articles, and materials described in the Order (together with such documentation as specified on the face of the Order, collectively, "**Goods**") and services related thereto.

2. **Acceptance of the Order. Supplier's acceptance of the Order, whether in writing or by performance, will be only upon these terms and conditions, which are incorporated into and made a part of each Order; no other terms or conditions shall be binding on Company unless: (i) conspicuously referenced on the face of the Order to which such other terms and conditions apply; and (ii) expressly agreed to by Company. Any quote, invoice, acknowledgement or other form or communication issued by Supplier in connection with the Order will be for Supplier's record and accounting purposes only and any terms and conditions referenced therein will not apply to the Order.**

3. **Order Number.** Company's Order number and corresponding item line number(s) as shown on the face of the Order must appear on all invoices, correspondence, shipping documents, packages and any other documents relating to the Order.

4. **Delivery, Risk and Title.** Supplier shall deliver the Goods to the location(s) designated by Company in the order ("**Delivery Point**"). Supplier shall prepay transportation costs for delivery of the Goods to the Delivery Point, unless otherwise specified in the Order, and if so specified, the transportation charges will be included as a separate item in the invoice for the applicable Goods, and not in an additional or separate invoice. Title transfers to Company upon: (i) Company's acceptance of the Goods; or (ii) Company's payment for the Goods (in whole or in part); whichever occurs first. Risk of loss for the Goods shall transfer in accordance with the 2010 Incoterm set out on the face of this Order. Supplier warrants it will have good and transferable title to the Goods at the time of title transfer to Company, and further that title to the Goods will transfer to Company free and clear of any and all liens or encumbrances.

5. **Warranty.** Supplier warrants that the Goods, and the services related thereto, will (i) conform in all respects to the requirements of the Order; (ii) comply with the more stringent of industry or Company's standards; (iii) conform strictly to applicable specifications, drawings, samples or other description upon which the Order is based; (iv) be fit, safe and effective for their intended use and purpose, and operate as intended; and (v) be merchantable and free from defects in material, workmanship, and design. All warranties set forth in the Order will remain in effect for one (1) year from the date of Company's acceptance, or eighteen (18) months from delivery of the Goods, whichever occurs latest, or as stated on the face of the Order. All warranties will not be deemed waived by reason of Company's receipt, inspection, or by payment for the Goods. Supplier shall assign and transfer all assignable warranties it receives from its vendors and manufacturers to Company.

In the event of a breach of warranty, Supplier shall repair and/or replace the defective Goods at no cost to Company (including, without limitation, shipping costs). Goods will not be considered in breach of this warranty if a defect is caused primarily by Company's improper installation, operation or maintenance.

6. **Delay.** Supplier shall deliver the Goods on the date(s) specified in the Order, during Company's normal business hours or as otherwise instructed by Company. Timely completion and delivery is a material term of the Order. Timely delivery is delivery of Goods, which conform to requirements of the Order, to the Delivery Point on or before the agreed delivery date. If Supplier is unable to make a timely delivery, it shall notify Company of the anticipated delay as soon as it learns of same, such notice becoming effective upon receipt by Company. Supplier's notice shall state the reasons for the delay and the anticipated date of delivery. If the delay (a) is not caused in whole or in part by the negligence or intentional fault of Supplier and (b) will not contribute to a delay in Company's schedule or otherwise cause damages to Company or any entity to whom Company is providing services, then Company may, but is not obligated to, agree to extend the date of delivery, without additional liability to Supplier, to the earlier of: (i) the anticipated date of delivery stated in Supplier's notice, or (ii) ten (10) business days after the original agreed delivery date. If delivery is not accomplished before the agreed delivery date, as such may be extended by these terms, then Supplier will be liable to Company for all direct damages caused by the delay.

7. **Rejection and Acceptance of Goods.** Company may reject any Goods that do not conform to the requirements of this Order and to return non-conforming Goods to Supplier at Supplier's expense. Company's acceptance or inspection of any Goods is not a waiver of any of Company's rights hereunder, at law or otherwise. Receipt of the Goods, acknowledgement of receipt of the Goods, or payment of Supplier's invoices does not constitute acceptance of the Goods.

8. **Invoicing.** Company shall pay all invoice amounts pursuant to the payment terms on the face of the Order upon receipt of undisputed invoice(s). Company and Supplier shall work together in good faith to resolve all invoice disputes. Each of the parties shall be responsible for the payment of all taxes, duties, levies, charges and contributions for which the respective party is liable as imposed by any appropriate government or regulatory authority ("**Tax**" or "**Taxes**") in connection with the Order. Taxes imposed on Company that Supplier is required to collect shall be separately stated and identified on each invoice issued by Supplier in compliance with appropriate tax laws or regulations. Company shall provide Supplier with exemption documentation as required by the applicable governmental authority where exemption from Taxes is claimed. For further clarification, Supplier will be responsible for paying its income taxes and any other taxes of any kind in any jurisdiction that might become payable in relation to the sale of goods. Company shall bear no responsibility for any income, gross margin, franchise, capital, net worth or other type of direct tax that may inure to Supplier as a result of the Order.

9. **Liens.** Supplier shall timely pay its subcontractors and vendors, and indemnifies and defends Company from and against all claims by third-parties and liens and encumbrances on Company's property related in any way to Supplier's performance of the Order.

10. **Changes.** Company may at any time make reasonable changes in any one or more of the following: (1) drawings, plans, designs and specifications; (2) quantities; (3) delivery schedule; or (4) place, manner or time of delivery. If any such change increases or decreases the cost of the Goods to be provided or results in an extension of the shipping schedule, Supplier shall give Company written notice stating the effect of such change within ten (10) days after receipt of the change request. No claim for an increase in price or schedule extension will be recognized unless such was authorized in advance and in writing by Company.

11. **Compliance.** Supplier shall comply with all applicable federal, state and local laws and regulations that affect the Order. All deliveries to Company's premises must be carried out in a safe manner, and Supplier shall comply with, and cause all other parties acting on Supplier's behalf to comply with all safety policies, rules and warnings communicated by Company.

12. **Insurance Requirements.**

(a) Supplier shall maintain at its own expense, the insurance coverage outlined herein with licensed, reputable and reliable insurers: i) **Workers' Compensation and/or Occupational Disease** coverage that fully complies with all applicable laws where activity related to this Order is performed, where Supplier's employees reside, and in all states where Supplier is domiciled. **As applicable**, coverage shall include an alternate employer's endorsement and voluntary compensation endorsement; ii) **Employer's Liability** coverage with limits of One Million Dollars ($1,000,000) each accident, by disease each employee, and by disease policy limit; iii) **Commercial General Liability** coverage with a limit of Two Million Dollars ($2,000,000) each occurrence for bodily injury and property damage arising out of or relating to Supplier's activities under this Order. The policy shall include coverage for, contractual liability, cross liability, severability of interests, products and completed operations; iv) **As applicable, Commercial Auto Liability** covering all vehicles used by Supplier under this Order with a combined single limit of Two Millions Dollars ($2,000,000) for injury or death of one or more persons or damage to or destruction of property as a result of each accident; and v) **As applicable, All Risk Property Damage** insurance on a replacement cost basis covering loss of or damage to property owned by or in the care custody and control of the Supplier. Supplier shall ensure that each insurance policy hereunder: A) with exception of 12(a) i) and v) includes Company as additional insured; B) provides a waiver of insurers' rights of subrogation in favor of Company; and C) is written to respond on a primary and non-contributory basis. Insurance shall not be canceled without thirty (30) days' prior written notice to Company.

(b) Upon execution of this Agreement, and on an annual basis thereafter until this Agreement is terminated, Supplier shall provide to Company Certificate(s) of Insurance certifying Supplier's compliance with this Order. In the event of a reduction in Supplier insurance limits during the Term which may otherwise reduce the limits of insurance required to comply with this Order, the Supplier shall promptly provide Company with notice of same, and immediately thereafter secure such additional insurance as is required to comply with the terms of this Order. Company's acceptance of certificates or correspondence associated thereto does not constitute a waiver, release or modification of the requirements under this Order. "Certificate Holder" shall be: Enbridge (U.S.) Inc. and U.S. affiliates.

(c) In the event Supplier fails to comply with insurance requirements under this Order, at its sole discretion, Company may, but shall not be obligated to, obtain such insurance for Company's sole benefit as Company deems necessary to address any failure on the part of the Supplier to obtain the insurance required pursuant to this Order. Any cost thereof shall be payable by the Supplier to Company on demand and Company may, at its election, deduct the cost thereof or set-off from any monies which are due or may become due to Supplier. No liability shall attach to Company for any decision on the part of Company to forego the purchase of additional insurance under this Section 12, nor does Company's decision not to purchase additional insurance pursuant to this Section 12 constitute a waiver, release or modification of the requirements under this Order, or constitute a

statement by Company that Supplier's insurance coverage at any time during the Term hereof is in compliance with the requirements under this Order.

(d) Company will not be responsible for any premiums, deductibles, self-insured retentions or any other costs for the insurance provided by Supplier in this Order.

13. **INDEMNITY. NOTWITHSTANDING ANYTHING ELSE IN THE ORDER TO THE CONTRARY, SUPPLIER SHALL INDEMNIFY, RELEASE, HOLD HARMLESS, AND DEFEND COMPANY, ITS PARENT, SUBSIDIARY AND AFFILIATED COMPANIES, AND ITS AND THEIR OFFICERS, DIRECTORS, EMPLOYEES, AGENTS, ASSIGNS AND SUCCESSORS IN INTEREST FROM AND AGAINST ALL CLAIMS, DISPUTES, SUITS, COMPLAINTS, LIABILITIES, DAMAGES, AND EXPENSES OF WHATEVER NATURE (*including,without limitation, attorneys' fees*), INCLUDING, WITHOUT LIMITATION, FOR INJURY TO ANY PERSON (INCLUDING DEATH) OR DAMAGE TO ANY PROPERTY, RESULTING FROM OR IN ANY WAY CONNECTED WITH SUPPLIER'S PERFORMANCE OF THE ORDER, EXCEPT THAT THE OBLIGATIONS HEREUNDER DO NOT APPLY TO COMPANY'S SOLE NEGLIGENCE OR WILLFUL MISCONDUCT.**

14. **Intellectual Property Warranty and Indemnity.** Supplier warrants that the Goods and the related services do not infringe or misappropriate any letters patent, trademark or copyright or any other intellectual property rights of any third party. **Supplier shall release, indemnify, save harmless and defend Company from and against all claims, liabilities, damages, and expenses (including, without limitation, attorneys' fees) arising in favor of any person or entity and based on misappropriation of trade secrets, infringement or claim of infringement of a patent, trademark, trade name, copyright or other proprietary right in the Goods provided by Supplier, except to the extent directly caused by specifications expressly provided by Company.**

15. **Intellectual Property Ownership and License.** All ideas, concepts, drawings and similar items created by Supplier in connection with the performance of the Order shall be the property of Company and shall be immediately delivered by Supplier to Company, with all compensation to Supplier for such ideas, concepts, drawings and similar items being included in the price(s) stated in the Order. Supplier grants to Company a non-exclusive, royalty-free, transferable, irrevocable license under all foreign and domestic patents now or hereafter owned by Supplier to use (for any purpose) and sell the Goods purchased under the Order.

16. **Confidentiality.** Both Company and Supplier, on behalf of themselves and their employees, agree that any ideas, concepts, or proprietary information received from the other in connection with the performance of the Order will not be disclosed to third persons except to the extent necessary for the proper performance of the Order.

17. **Termination for Cause.** Company may terminate all or any part of the Order for: (i) Supplier's failure to make deliveries by the date(s) specified; (ii) Supplier's breach of any of the terms hereof, including, without limitation, the warranties of Supplier; (iii) change in price of the Goods; (iv) Supplier's failure to provide adequate assurance of its ability to meet quality standards; (v) Supplier's failure to make progress on any Goods so as to endanger performance of the Order; or (vi) in the event of any proceeding by or against Supplier in bankruptcy or insolvency or for the appointment of a receiver or trustee or an assignment for the benefit of creditors. Upon termination for cause, Company shall provide written notice of termination and have no further obligation to Supplier. Upon receipt of notice of termination, Supplier shall discontinue all work pertaining to the Order and use its best efforts to mitigate additional costs resulting from the termination. Supplier shall preserve and protect materials in supply, work in progress, and finished work, the disposition of which shall be as directed by Company. Supplier is not entitled to any prospective profits or damages.

18. **Termination for Convenience.** Company may terminate all or any part of the Order for convenience upon written notice to Supplier. Company shall accept and pay for materials in supply, work in progress and finished work, as well as reasonable additional costs caused by the termination. Supplier is not entitled to any prospective profits or damages. In no event will the total amount paid to Supplier under a terminated Order exceed the original value of the Order.

19. **Notice.** All notices, consents and requests hereunder must be in writing and served by personal service, by mail or by e-mail to the address of the receiving Party set forth on the face of this Order (or such different address as may be designated by such Party in a notice to the other Party, from time to time). Notices, consents and requests served by personal service shall be deemed served when delivered. Notices, consents and requests served by mail must be sent by registered mail, return receipt requested, and shall be deemed served 10 business days after mailing. Notices, consents and requests served by e-mail shall be deemed served on the date of sending, provided: (i) no incomplete or bounce-back error transmission is received by the sending Party; and (ii) if such day is not a business day or if the notice or communication is received after 5:00 PM (at the place of receipt) on any business day, the notice or communication shall be deemed to have been sent and received on the immediately following business day.

20. **Independent Contractor.** Supplier is an independent contractor in all respects pertaining to its performance of the Order.

21. **Waiver.** Waiver by Company of any provision hereof shall not constitute a continuing waiver or a waiver of any other provision, nor shall it affect in any manner any right or remedy to which Company is entitled for any breach or default by Supplier, whether or not similar.

22. **Remedies Cumulative.** All rights and remedies reserved under the Order and these Terms shall be cumulative and in addition to any further rights and remedies provided in law or equity.

23. **Assignment.** Supplier shall not assign or transfer any right or obligation under the Order without Company's prior written consent.

24. **Venue, Choice of Law and Jury Trial Waiver.** The Order shall be governed by and construed in accordance with the laws of Texas, without reference to its conflict of laws rules or principles. Each party irrevocably submits to the exclusive jurisdiction of the state and federal courts of Texas seated in Harris County for the interpretation and enforcement of this Order, and unconditionally waives any defense of an inconvenient forum to the maintenance of any action or proceeding in any such court, any objection to venue with respect to any such action or proceeding and any right of jurisdiction on account of the place of residence or domicile of either party. A final judgment on any such dispute, as to which all appeals, if any, have been exhausted, shall be conclusive and may be enforced in other jurisdictions in any manner provided by law. EACH PARTY WAIVES ALL RIGHTS TO TRIAL BY JURY IN ANY PROCEEDING BROUGHT BY EITHER PARTY AGAINST THE OTHER PARTY ON ANY MATTER WHATSOEVER ARISING OUT OF, IN CONNECTION WITH OR RELATED TO THIS ORDER.

25. **Set Off.** Company may set-off and deduct from any amounts payable to Supplier any amounts owing by Supplier to Company pursuant to this Order or any other agreement between Supplier and Company. The failure by Company to set-off or deduct any amount from an invoiced payment will not constitute a waiver of Company's right to set-off, deduct or collect such amount.

26. **Severability.** If any provision of this Agreement is finally determined by any court of competent jurisdiction to be illegal or unenforceable, that provision will be severed from this Agreement and the remaining provisions will continue in full force and effect.

27. **Survival.** The provisions of this Order which are intended to extend beyond its termination, including the liability, indemnity, compliance, warranty, intellectual property and confidentiality provisions, and the provisions applicable to the enforcement of those provisions and/or the enforcement of rights and obligations incurred hereunder that are not fully discharged prior to the termination of this Order, will survive termination to the extent necessary to effect the intent of the parties and enforce such rights and obligations.

28. **Audit.** Company and its authorized representatives shall have the right to audit all costs and records of Supplier (and any subcontractors retained by Supplier) related solely to performance of this Order, upon fifteen (15) days' written notice to Supplier (or subcontractor), including access to Supplier's (and subcontractor's) books, records and documentation supporting all billed amounts. This right to audit shall remain in effect for a period of one year from the date the Goods are accepted by Company. Company through its employees or agents shall have reasonable access to Supplier's facilities and during normal business hours at all times to observe and inspect the fabrication, manufacturing, assembly, coating, testing, loading, transportation and stockpiling of the Goods. Supplier will respond to such information requests as Company may reasonably request in connection with such inspection and observation. Each party agrees, while at the other's facilities, to comply with all applicable federal, state and local laws and to observe such safety rules as that party may prescribe for the protection of personnel and property.

29. **Interpretation.** Headings used herein are for the convenience of reference only and shall not be considered in construing or interpreting this Agreement. The words "herein", "hereunder", "hereof" and other similar words refer to this Order as a whole and not to any particular paragraph or part of the Order. "Includes", "including" and similar terms shall mean "including (or includes, as applicable) without limitation".

30. **Counterparts.** This Order, and any amendment, supplement or schedule to this Order, may be executed in any number of counterparts, and may be executed using electronic signatures. The executed signature page(s) from each counterpart may be joined together and attached to an original and together shall constitute one and the same instrument. Exchange of counterparts of a document of this Order may be provided by fax or other electronic means, including email delivery.

[END OF TERMS AND CONDITIONS]

EXHIBIT 6D

Buyer: CARRI WALLIS
Phone: 713-627-5537
Email: Carri.Wallis@enbridge.com

Bill To: Algonquin Gas Transmission, LLC
APUSinvoices@spectraenergy.com
OR
P.O. Box 2549
Detroit, MI 48202-2549

PURCHASE ORDER (PO)

Vendor:	**Vendor No. 9000000240**
KINGTOOL COMPANY	
LONGVIEW TX 75615-0128	
Phone: Fax:	
Attention:	

Ship To: ALGONQUIN GAS TRANSMISSION, LLC
HOLLISTON STORAGE FACILITY
1600 WASHINGTON STREET
HOLLISTON MA 01746

Attention:

General Information		
P.O. Number	:	**3100028313**
Rev. No.	:	14
Date	:	02/01/2016
Currency Code	:	USD
Payment Terms	:	Net 45 Days
Ship Date	:	See below
Shipping Terms	:	

P.O.Number and Line number must mirror the PO on your invoice and must be referenced on all invoices and related correspondence.

****
6/6/17 - THIS ORDER HAS BEEN DELAYED DUE TO HAVING TO SHIP UNIT BACK TO SUPPLIER FOR REPAIRS THAT HAVE TAKEN AN ENORMOUS AMOUNT OF TIME TO COMPLETE. THIS ORDER WILL NOT BE APPROVED FOR PAYMENT UNTIL THE UNIT IS DELIVERED BACK TO THE SITE. ESTIMATED SHIP DATE 6/15/17 CLW
****
1/25/17 - CORRECTING THE "SHIP TO" ADDRESS TO SHIP TO THE HOLLISTON STORAGE FACILITY PER BONITA LEHMAN'S EMAIL DATED 1/24/17. WAYNE RACICOT HAS APPROVED THE NEW "SHIP TO" LOCATIONS CLW
****
5/16/16CHANGE ORDER 1***S.SERNA***
LINE 70- ADD 2EA - 1" NORDSTROM FIGURE 3045 ASME CLASS 1500 FLANGED PLUG VALVES AND ASSOCIATED FLANGES TO DUMP VALVE BYPASS LINE
END NOTE
.
REQUIRED ON SITE 3/1/2017
.
.
RFQ CW-15-0061
KINGTOOL QUOTE 1015-200, DATED 10/12/2015

WBS: CE.000089.005 ATLANTIC BRIDGE WEYMOUTH
.
.
REQUIRED MATERIAL ON-SITE DELIVERY DATE: 03/01/2017
DRAWING LEAD TIME: 2 WEEKS ARO (2/17/2016)
SPECTRA TO RETURN DRAWINGS: 2 WEEKS (3/1/2016)
MATERIAL LEAD TIME: 12-14 WEEKS ARAD (06/12/2016 EST.)

INSPECTION:
THIS EQUIPMENT REQUIRES INSPECTION. PLEASE SEE ATTACHED INSPECTION TEST PLAN (ITP)

CONTACT: QAE - LEANNE KESSLER, LKESSLER@QAEWORLD.COM.

INVOICES MUST MATCH THE PO LINE PER LINE IN ORDER TO BE ACCEPTED AND PAID

THIS ORDER CONFIRMS ORDER: 3100028313
PLACED ON: FEBRUARY 3, 2016
TO: KINGTOOL
ATTN: DAMIEN PENN
PHONE:713-278-8330
EMAIL: DPENN@KINGTOOL.COM
BY: SCIANNA SERNA

LEAD ENGINEER: DAVID COX
PHONE: 902-490-2203
EMAIL: DSCOX@SPECTRAENERGY.COM

GENERAL NOTES:
THIS PURCHASE ORDER IS IN REFERENCE TO SUPPLIER QUOTE NUMBER 1015-200, DATED 10/12/2016.
PRICING VALID THROUGH 02/28/2016.

SPECTRA ENERGY TERMS & CONDITIONS INCLUDED AS PART OF THIS PURCHASE ORDER SHALL BE THE ONLY TERMS APPLICABLE TO THIS PURCHASE ORDER.

DOCUMENTATION:
THE PO NUMBER AND LINE ITEM MUST BE REFERENCED ON EACH MTR

ONE (1) HARD COPY AND (1) ELECTRONIC COPY OF DOCUMENTATION, WHICH INCLUDES MTR'S, JOB BOOKS AND O&M MANUALS, MUST BE MAILED TO THE LEAD ENGINEER.

SPECTRA ENERGY
ATTN: DAVID COX
5400 WESTHEIMER COURT
HOUSTON, TX 77056

ONLY SEND 1 ELECTRONIC COPY TO SCIANNA SERNA AT THE FOLLOWING ADDRESS:
SSERNA@SPECTRAENERGY.COM

DESCRIPTION:
ALL MATERIAL MUST BE IN ACCORDANCE PER SPECTRA’S APPROVED MANUFACTURER’S LIST (AML, LAST UPDATE 2/18/2016).

ONE (1) FUEL GAS FILTER SEPARATOR - $54,115.00/EA
LOT (1) INSTRUMENTATION/VALVES & CONTROLS (INCLUDED)
ONE (1) ENGINEERED DRAWINGS (INCLUDED)
SET (1) SPARE SET FILTER ELEMENTS-3 FT LONG - $68.00/SET
ONE (1) 316 STAINLESS STEEL VANE MIST EXTRACTOR - $395.00/EA
ONE (1) 4" 900#RF HANDHOLE FOR SUMP INSPECTION - $1,520.00/EA
TOTAL AMOUNT - $56,098.00

PAYMENT TERMS: NET 30

CANCELLATION SCHEDULE:
60% AFTER MATERIALS ARE ORDERED
80% AFTER CONSTRUCTION START
100% AFTER MIDWAY OF COMPLETION OF FABRICATION

WARRANTY: 12 MONTHS FROM DATE OF STARTUP OR 18 MONTHS FROM DATE OF SHIPMENT; WHICHEVER OCCURS FIRST.

MANUFACTURED IN: LONGVIEW, TX
.
.
SHIPPING INSTRUCTIONS:
FREIGHT COLLECT-CONTACT KELLEY ELKINS AT 713-989-8395
OR E-MAIL KMELKINS@SPECTRAENERGY.COM FOR ROUTING INSTRUCTIONS.

DESTINATION: WEYMOUTH, MA

SPECTRA REQUIRES DELIVERY 3/1/2017; KINGTOOL FREE TO ADJUST PRODUCTION SCHEDULE, BUT SPECTRA NOT TO BE CHARGED STORAGE FEES NOR ARE WE TO BE INVOICED IF FILTER SEPARATORS ARE MANUFACTURED EARLIER THAN IS REQUIRED TO MEET THE 3/1/17 DELIVERY DATE.

ESCALATION CLAUSE: If material is not needed on-site within 1 year

FUEL GAS FILTER SEPARATOR Material Escalation:

It is understood that the contract price for the FUEL GAS FILTER SEPARATOR has been calculated based on the current prices for raw materials. However, due to Spectra Energy's request for delayed equipment delivery of March 1, 2017, the market for the raw materials may shift and price increases and/or decreases could occur. KINGTOOL agrees to use their best efforts to obtain the lowest possible prices from available material suppliers, but should there be an increase and/or decrease in the prices of materials that are purchased after execution of this purchase order, Spectra agrees to pay that cost increase to KINGTOOL and KINGTOOL agrees to discount their pricing should any decreases occur. In addition, said increase and/or decrease in material pricing of said purchase order shall be capped at +/- 5%. Any claim by KINGTOOL for payment of a cost increase and/or decrease, as stated above, shall require written notice by KINGTOOL to Spectra Energy stating the increased and/or decrease cost, of the materials in question, including the source of supply, fully supported by invoices, bills of sales, and current published industry material pricing indices.

DESCRIPTION: MASSACHUSETTS EXEMPT AGT

TAX NOTE: THE COMMODITY(S) PURCHASED UNDER THIS PURCHASE ORDER IS/ARE TAX EXEMPT IN THE STATE OF MASSACHUSETTS. DO NOT INVOICE SALES TAX.

ROUTING INSTRUCTIONS ARE AN INTEGRAL PART OF THIS PURCHASE ORDER. FAILURE TO COMPLY WITH THESE INSTRUCTIONS IN ANY MANNER WITHOUT PRIOR APPROVAL OF SPECTRA ENERGY MATERIALS MANAGEMENT/TRAFFIC DIVISION WILL BE CONSTRUED AS A DIRECT VIOLATION OF THIS CONTRACT. IN THE EVENT ROUTING INSTRUCTIONS CANNOT OR SHOULD NOT BE EXECUTED AS INSTRUCTED IN THIS PURCHASE ORDER, VENDOR IS INSTRUCTED TO CONTACT THE BUYER OR SPECTRA ENERGY TRAFFIC FOR REVISED ROUTING INSTRUCTIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS WILL RESULT IN FREIGHT CHARGES BEING FOR VENDOR'S ACCOUNT.

GUIDELINES FOR WOOD PACKING MATERIALS U.S., CANADA AND MEXICO ARE STRICTLY ENFORCING INTERNATIONAL STANDARDS FOR PHYTO-SANITARY MEASURES PUBLICATION NO. 15 (ISPM 15). WOOD PACKING FOR ALL SHIPMENTS THAT REQUIRE CUSTOMS CLEARANCE, INCLUDING SKIDS, CRATES AND PIPE DUNNAGE MUST BE TREATED TO THE ISPM 15 STANDARD AND IS REQUIRED TO BEAR THE UNIQUE CERTIFICATION STAMP. SELLER WILL BE RESPONSIBLE TO INSURE ALL GOODS SHIPPED MEET ISPM STANDARDS.

NOTE: SHIPMENTS ROUTED VIA FEDEX OR U.P.S. ARE NOT TO EXCEED 125 LBS. AND 100 LBS RESPECTIVELY FOR THE TOTAL SHIPMENT. WEIGHTS EXCEEDING THESE LIMITS ARE TO BE REFERRED TO THE BUYER FOR REVISED SHIPPING INSTRUCTIONS. USE OF MULTIPLE BILLS/SHIPMENTS TO CIRCUMVENT THESE WEIGHT LIMITS ARE NOT ACCEPTABLE, AND IF SO USED WILL BE FOR THE VENDOR'S ACCOUNT.

IN THE EVENT THE MATERIAL IS PURCHASED ON A PREPAY AND ADD BASIS, THE VENDOR MUST INCLUDE A COPY OF THE FREIGHT BILL WITH THEIR INVOICE BEFORE PAYMENT WILL BE AUTHORIZED.

INVOICE TERMS: INVOICE PAYMENT TERMS WILL BE CALCULATED FROM THE DATE RECEIVED IN OUR CORPORATE OFFICE UNLESS OTHERWISE INDICATED IN THE BODY OF THE PURCHASE ORDER.

COMPANY RESERVES THE RIGHT TO HAVE AN EMPLOYEE AND/OR AN APPOINTED AGENT VISIT VENDOR'S MANUFACTURING PLANT/ FACILITIES AND/OR SUB-VENDORS MANUFACTURING PLANT AND FACILITIES TO EXPEDITE OR INSPECT MATERIALS GOODS AND SERVICES COVERED BY THIS PURCHASE ORDER. SUCH VISITS WILL BE DURING VENDOR'S NORMAL WORKING HOURS AND SUBJECT TO ANY REASONABLE AND NORMAL PROCEDURES OF THE VENDOR. THESE RIGHTS SHALL BE RESERVED AND SO INDICATED ON ANY AND ALL ORDERS TO SUB-VENDORS.

Purchase Order Updates

Line item	Item Changed	Old	New	Date Changed
50	Item Delivery Date	12/30/2017	02/28/2018	12/28/2017

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
10		FILTER SEPARATOR, FUEL GAS VERTICAL	1	EA	06/15/2017	54,115.00	54,115.00

FUEL GAS VERTICAL FILTER SEPARATOR, PER THE ATTACHED SPECTRA ENERGY GAS TRANSMISSION SPECIFICATION NO. ES-VV2.9 FOR NATURAL GAS SERVICE AND THE FOLLOWING CONDITIONS:
CAPACITY: 84 MSCFH
DESIGN PRESSURE: 1480 PSIG
OPERATING PRESSURE: 455 - 605 PSIG
DESIGN TEMP: -20 TO 200 DEGREES F
OPERATING TEMPERATURE: 120 DEGREES F
DELTA P: 0.5 PSID
PERFORMANCE: 99.5% LIQUID DROPLETS 1 MICRONS AND LARGER. 99.5% SOLIDSPARTICLES 1 MICRONS AND LARGER.
ASME CODE STAMP REQUIRED.
ALL AUXILIARY CONNECTIONS SHALL BE 6000# NPT FOR STANDARD INSTRUMENTATION AND DRAINS. CONNECTIONS LARGER THAN 2" SHALL BE FLANGED.
FINISH: SSPC-SP10 NEAR WHITE SANDBLAST, INORGANIC ZINC PRIMER EPOXY INTERMEDIATE COAT AND POLYURETHANE FINISH PAINT COLOR FSC#37200., PER SET SPEC ES-DOT.4.
****
ACCESSORIES TO INCLUDE:
- TWO (2) LIQUID LEVEL GAUGE, PENBERTHY MODEL 1RL7 3/4" GAUGE VALVE
- ONE (1) PRESSURE RELIEF VALVE, AGCO
- ONE (1) DIFFERENTIAL PRESSURE INDICATOR TRANSMITTER, EXPL. PROOF ENCLOSURE, ROSEMOUNT

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
3051CD WITH 5-WAY MANIFOLD VALVE - TWO (2) AUTOMATIC DUMP VALVE, FISHER D4 GLOBE BODY STYLE WITH 1/2"PORT, 1" 900# RF, FAIL CLOSURE ACTUATOR - TWO (2) LIQUID LEVEL CONTROLLER, FISHER MODEL L2, 1-1/2" RF, AND FISHER 67CFR FILTER REGULATOR - TWO (2) LEVEL SWITCH, JERGUSON MODEL JMS100-311-S00 ULTRASONIC - FOUR (4) 1-1/2" 900# RF BALL VALVES - SIX (6) 1" 900# RF BALL VALVES - ONE (1) 1" SW BALL VALVE - ONE (1) 3/4" SW BALL VALVE - ELEVEN (11) 1/2" SW BALL VALVES ---------- TAG: V-3-1 BOM TAG: FG003 GL 1004 8500201 Project / WBS CE.000089.005.04.05							
20		SPARE SET FILTER ELEMENTS-3 FT LONG	1	EA	06/15/2017	68.00	68.00
ADD FOR EACH SPARE SET FILTER ELEMENTS-3 FT LONG, PER SET SPEC ES-DOT.4. GL 1004 8500201 Project / WBS CE.000089.005.04.05							
30		316 STAINLESS STEEL VANE MIST EXTRACTOR	1	EA	06/15/2017	395.00	395.00
316 STAINLESS STEEL VANE MIST EXTRACTOR, PER SET SPEC ES-DOT.4. GL 1004 8500201 Project / WBS CE.000089.005.04.05							
40		4" 900#RF HANDHOLE FOR SUMP INSPECTION	1	EA	06/15/2017	1,520.00	1,520.00
4" 900#RF HANDHOLE FOR SUMP INSPECTION, PER SET SPEC ES-DOT.4. GL 1004 8500201 Project / WBS CE.000089.005.04.05							
50		PREAPPROVED COMMISSIONING SERVICES:	1	LOT	02/28/2018	0.01	0.01
THE VENDOR WILL PERFORM THE START UP AND COMMISSIONING OF THE GOODS PER THE MANUFACTURER'S RECOMMENDED PROCEDURE. THE SCOPE OF THE SERVICES PROVIDED BY VENDOR INCLUDES THE REQUIRED PERSONNEL, EQUIPMENT AND TIME TO PROPERLY AND COMPLETELY COMMISSION THE GOODS._____BUYER NOTE:INCLUDE THE FOLLOWING INFORMATION ON THE P.O. (1) NAME AND ADDRESS OF SUPPLIER THAT WILL HANDLE THE COMMISSIONING (2) CONTACT, PHONE NUMBERS(OFFICE AND CELL), EMAILS FOR THE SUPPLIER (3) CONTACT, PHONE NUMBERS(OFFICE AND CELL), EMAILS FOR THE SPECTRA FIELD CONTACT THAT WILL BE RESPONSIBLE FOR THE COMMISSIONING. (4) ESTIMATED TIMEFRAME OF WHEN THE COMMISSIONING IS REQUIRED (5) NOTE THAT THE INVOICES WILL BE SENT TO THE SPECTRA BILL TO ADDRESS (6) E-MAIL NOTIFICATION FROM SUPPLIER PROVIDING COMMISSIONING TO BUYER ONCE COMMISSIONING IS COMPLETE PER SET SPEC ES-DOT.4. GL 1004 8500128 Project / WBS CE.000089.005.10.07							
60		APPROVAL DRAWINGS	1	LOT	02/17/2016	0.01	0.01

Algonquin Gas Transmission, LLC

P.O. Number 3100028313

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
APPROVAL DRAWINGS 2 WEEKS 2/17/2016 GL 1004 8500128 Project / WBS CE.000089.005.10.07							
70		1" NORDSTRP, FIGURE 3045	2	EA	06/15/2017	3,587.00	7,174.00
1" NORDSTROM FIGURE 3045 ASME CLASS 1500 FLANGED PLUG VALVES AND ASSOCIATED FLANGES TO DUMP VALVE BYPASS LINE, PER SET SPEC ES-DOT.4. GL 1004 8500201 Project / WBS CE.000089.005.04.05							
					Total:		**63,272.02 USD**

STANDARD PURCHASE ORDER TERMS AND CONDITIONS
(United States - Issue Version: May 2018)

1. **General.** This purchase order ("**Order**") comprises the face of the Order, these purchase order terms and conditions and such other documents incorporated by reference on the face of the Order. The "Seller", "Supplier" or "Vendor" ("**Supplier"**) identified on the face of the Order agrees to sell, and the Enbridge entity identified on the face of the Order ("**Company**") agrees to buy, the goods, articles, and materials described in the Order (together with such documentation as specified on the face of the Order, collectively, "**Goods**") and services related thereto.

2. **Acceptance of the Order. Supplier's acceptance of the Order, whether in writing or by performance, will be only upon these terms and conditions, which are incorporated into and made a part of each Order; no other terms or conditions shall be binding on Company unless: (i) conspicuously referenced on the face of the Order to which such other terms and conditions apply; and (ii) expressly agreed to by Company. Any quote, invoice, acknowledgement or other form or communication issued by Supplier in connection with the Order will be for Supplier's record and accounting purposes only and any terms and conditions referenced therein will not apply to the Order.**

3. **Order Number.** Company's Order number and corresponding item line number(s) as shown on the face of the Order must appear on all invoices, correspondence, shipping documents, packages and any other documents relating to the Order.

4. **Delivery, Risk and Title.** Supplier shall deliver the Goods to the location(s) designated by Company in the order ("**Delivery Point**"). Supplier shall prepay transportation costs for delivery of the Goods to the Delivery Point, unless otherwise specified in the Order, and if so specified, the transportation charges will be included as a separate item in the invoice for the applicable Goods, and not in an additional or separate invoice. Title transfers to Company upon: (i) Company's acceptance of the Goods; or (ii) Company's payment for the Goods (in whole or in part); whichever occurs first. Risk of loss for the Goods shall transfer in accordance with the 2010 Incoterm set out on the face of this Order. Supplier warrants it will have good and transferable title to the Goods at the time of title transfer to Company, and further that title to the Goods will transfer to Company free and clear of any and all liens or encumbrances.

5. **Warranty.** Supplier warrants that the Goods, and the services related thereto, will (i) conform in all respects to the requirements of the Order; (ii) comply with the more stringent of industry or Company's standards; (iii) conform strictly to applicable specifications, drawings, samples or other description upon which the Order is based; (iv) be fit, safe and effective for their intended use and purpose, and operate as intended; and (v) be merchantable and free from defects in material, workmanship, and design. All warranties set forth in the Order will remain in effect for one (1) year from the date of Company's acceptance, or eighteen (18) months from delivery of the Goods, whichever occurs latest, or as stated on the face of the Order. All warranties will not be deemed waived by reason of Company's receipt, inspection, or by payment for the Goods. Supplier shall assign and transfer all assignable warranties it receives from its vendors and manufacturers to Company.

In the event of a breach of warranty, Supplier shall repair and/or replace the defective Goods at no cost to Company (including, without limitation, shipping costs). Goods will not be considered in breach of this warranty if a defect is caused primarily by Company's improper installation, operation or maintenance.

6. **Delay.** Supplier shall deliver the Goods on the date(s) specified in the Order, during Company's normal business hours or as otherwise instructed by Company. Timely completion and delivery is a material term of the Order. Timely delivery is delivery of Goods, which conform to requirements of the Order, to the Delivery Point on or before the agreed delivery date. If Supplier is unable to make a timely delivery, it shall notify Company of the anticipated delay as soon as it learns of same, such notice becoming effective upon receipt by Company. Supplier's notice shall state the reasons for the delay and the anticipated date of delivery. If the delay (a) is not caused in whole or in part by the negligence or intentional fault of Supplier and (b) will not contribute to a delay in Company's schedule or otherwise cause damages to Company or any entity to whom Company is providing services, then Company may, but is not obligated to, agree to extend the date of delivery, without additional liability to Supplier, to the earlier of: (i) the anticipated date of delivery stated in Supplier's notice, or (ii) ten (10) business days after the original agreed delivery date. If delivery is not accomplished before the agreed delivery date, as such may be extended by these terms, then Supplier will be liable to Company for all direct damages caused by the delay.

7. **Rejection and Acceptance of Goods.** Company may reject any Goods that do not conform to the requirements of this Order and to return non-conforming Goods to Supplier at Supplier's expense. Company's acceptance or inspection of any Goods is not a waiver of any of Company's rights hereunder, at law or otherwise. Receipt of the Goods, acknowledgement of receipt of the Goods, or payment of Supplier's invoices does not constitute acceptance of the Goods.

8. **Invoicing.** Company shall pay all invoice amounts pursuant to the payment terms on the face of the Order upon receipt of undisputed invoice(s). Company and Supplier shall work together in good faith to resolve all invoice disputes. Each of the parties shall be responsible for the payment of all taxes, duties, levies, charges and contributions for which the respective party is liable as imposed by any appropriate government or regulatory authority ("**Tax**" or "**Taxes**") in connection with the Order. Taxes imposed on Company that Supplier is required to collect shall be separately stated and identified on each invoice issued by Supplier in compliance with appropriate tax laws or regulations. Company shall provide Supplier with exemption documentation as required by the applicable governmental authority where exemption from Taxes is claimed. For further clarification, Supplier will be responsible for paying its income taxes and any other taxes of any kind in any jurisdiction that might become payable in relation to the sale of goods. Company shall bear no responsibility for any income, gross margin, franchise, capital, net worth or other type of direct tax that may inure to Supplier as a result of the Order.

9. **Liens.** Supplier shall timely pay its subcontractors and vendors, and indemnifies and defends Company from and against all claims by third-parties and liens and encumbrances on Company's property related in any way to Supplier's performance of the Order.

10. **Changes.** Company may at any time make reasonable changes in any one or more of the following: (1) drawings, plans, designs and specifications; (2) quantities; (3) delivery schedule; or (4) place, manner or time of delivery. If any such change increases or decreases the cost of the Goods to be provided or results in an extension of the shipping schedule, Supplier shall give Company written notice stating the effect of such change within ten (10) days after receipt of the change request. No claim for an increase in price or schedule extension will be recognized unless such was authorized in advance and in writing by Company.

11. **Compliance.** Supplier shall comply with all applicable federal, state and local laws and regulations that affect the Order. All deliveries to Company's premises must be carried out in a safe manner, and Supplier shall comply with, and cause all other parties acting on Supplier's behalf to comply with all safety policies, rules and warnings communicated by Company.

12. **Insurance Requirements.**

(a) Supplier shall maintain at its own expense, the insurance coverage outlined herein with licensed, reputable and reliable insurers: i) **Workers' Compensation and/or Occupational Disease** coverage that fully complies with all applicable laws where activity related to this Order is performed, where Supplier's employees reside, and in all states where Supplier is domiciled. **As applicable**, coverage shall include an alternate employer's endorsement and voluntary compensation endorsement; ii) **Employer's Liability** coverage with limits of One Million Dollars ($1,000,000) each accident, by disease each employee, and by disease policy limit; iii) **Commercial General Liability** coverage with a limit of Two Million Dollars ($2,000,000) each occurrence for bodily injury and property damage arising out of or relating to Supplier's activities under this Order. The policy shall include coverage for, contractual liability, cross liability, severability of interests, products and completed operations; iv) **As applicable, Commercial Auto Liability** covering all vehicles used by Supplier under this Order with a combined single limit of Two Millions Dollars ($2,000,000) for injury or death of one or more persons or damage to or destruction of property as a result of each accident; and v) **As applicable, All Risk Property Damage** insurance on a replacement cost basis covering loss of or damage to property owned by or in the care custody and control of the Supplier. Supplier shall ensure that each insurance policy hereunder: A) with exception of 12(a) i) and v) includes Company as additional insured; B) provides a waiver of insurers' rights of subrogation in favor of Company; and C) is written to respond on a primary and non-contributory basis. Insurance shall not be canceled without thirty (30) days' prior written notice to Company.

(b) Upon execution of this Agreement, and on an annual basis thereafter until this Agreement is terminated, Supplier shall provide to Company Certificate(s) of Insurance certifying Supplier's compliance with this Order. In the event of a reduction in Supplier insurance limits during the Term which may otherwise reduce the limits of insurance required to comply with this Order, the Supplier shall promptly provide Company with notice of same, and immediately thereafter secure such additional insurance as is required to comply with the terms of this Order. Company's acceptance of certificates or correspondence associated thereto does not constitute a waiver, release or modification of the requirements under this Order. "Certificate Holder" shall be: Enbridge (U.S.) Inc. and U.S. affiliates.

(c) In the event Supplier fails to comply with insurance requirements under this Order, at its sole discretion, Company may, but shall not be obligated to, obtain such insurance for Company's sole benefit as Company deems necessary to address any failure on the part of the Supplier to obtain the insurance required pursuant to this Order. Any cost thereof shall be payable by the Supplier to Company on demand and Company may, at its election, deduct the cost thereof or set-off from any monies which are due or may become due to Supplier. No liability shall attach to Company for any decision on the part of Company to forego the purchase of additional insurance under this Section 12, nor does Company's decision not to purchase additional insurance pursuant to this Section 12 constitute a waiver, release or modification of the requirements under this Order, or constitute a

statement by Company that Supplier's insurance coverage at any time during the Term hereof is in compliance with the requirements under this Order.

(d) Company will not be responsible for any premiums, deductibles, self-insured retentions or any other costs for the insurance provided by Supplier in this Order.

13. **INDEMNITY. NOTWITHSTANDING ANYTHING ELSE IN THE ORDER TO THE CONTRARY, SUPPLIER SHALL INDEMNIFY, RELEASE, HOLD HARMLESS, AND DEFEND COMPANY, ITS PARENT, SUBSIDIARY AND AFFILIATED COMPANIES, AND ITS AND THEIR OFFICERS, DIRECTORS, EMPLOYEES, AGENTS, ASSIGNS AND SUCCESSORS IN INTEREST FROM AND AGAINST ALL CLAIMS, DISPUTES, SUITS, COMPLAINTS, LIABILITIES, DAMAGES, AND EXPENSES OF WHATEVER NATURE (*including,without limitation, attorneys' fees*), INCLUDING, WITHOUT LIMITATION, FOR INJURY TO ANY PERSON (INCLUDING DEATH) OR DAMAGE TO ANY PROPERTY, RESULTING FROM OR IN ANY WAY CONNECTED WITH SUPPLIER'S PERFORMANCE OF THE ORDER, EXCEPT THAT THE OBLIGATIONS HEREUNDER DO NOT APPLY TO COMPANY'S SOLE NEGLIGENCE OR WILLFUL MISCONDUCT.**

14. **Intellectual Property Warranty and Indemnity.** Supplier warrants that the Goods and the related services do not infringe or misappropriate any letters patent, trademark or copyright or any other intellectual property rights of any third party. **Supplier shall release, indemnify, save harmless and defend Company from and against all claims, liabilities, damages, and expenses (including, without limitation, attorneys' fees) arising in favor of any person or entity and based on misappropriation of trade secrets, infringement or claim of infringement of a patent, trademark, trade name, copyright or other proprietary right in the Goods provided by Supplier, except to the extent directly caused by specifications expressly provided by Company.**

15. **Intellectual Property Ownership and License.** All ideas, concepts, drawings and similar items created by Supplier in connection with the performance of the Order shall be the property of Company and shall be immediately delivered by Supplier to Company, with all compensation to Supplier for such ideas, concepts, drawings and similar items being included in the price(s) stated in the Order. Supplier grants to Company a non-exclusive, royalty-free, transferable, irrevocable license under all foreign and domestic patents now or hereafter owned by Supplier to use (for any purpose) and sell the Goods purchased under the Order.

16. **Confidentiality.** Both Company and Supplier, on behalf of themselves and their employees, agree that any ideas, concepts, or proprietary information received from the other in connection with the performance of the Order will not be disclosed to third persons except to the extent necessary for the proper performance of the Order.

17. **Termination for Cause.** Company may terminate all or any part of the Order for: (i) Supplier's failure to make deliveries by the date(s) specified; (ii) Supplier's breach of any of the terms hereof, including, without limitation, the warranties of Supplier; (iii) change in price of the Goods; (iv) Supplier's failure to provide adequate assurance of its ability to meet quality standards; (v) Supplier's failure to make progress on any Goods so as to endanger performance of the Order; or (vi) in the event of any proceeding by or against Supplier in bankruptcy or insolvency or for the appointment of a receiver or trustee or an assignment for the benefit of creditors. Upon termination for cause, Company shall provide written notice of termination and have no further obligation to Supplier. Upon receipt of notice of termination, Supplier shall discontinue all work pertaining to the Order and use its best efforts to mitigate additional costs resulting from the termination. Supplier shall preserve and protect materials in supply, work in progress, and finished work, the disposition of which shall be as directed by Company. Supplier is not entitled to any prospective profits or damages.

18. **Termination for Convenience.** Company may terminate all or any part of the Order for convenience upon written notice to Supplier. Company shall accept and pay for materials in supply, work in progress and finished work, as well as reasonable additional costs caused by the termination. Supplier is not entitled to any prospective profits or damages. In no event will the total amount paid to Supplier under a terminated Order exceed the original value of the Order.

19. **Notice.** All notices, consents and requests hereunder must be in writing and served by personal service, by mail or by e-mail to the address of the receiving Party set forth on the face of this Order (or such different address as may be designated by such Party in a notice to the other Party, from time to time). Notices, consents and requests served by personal service shall be deemed served when delivered. Notices, consents and requests served by mail must be sent by registered mail, return receipt requested, and shall be deemed served 10 business days after mailing. Notices, consents and requests served by e-mail shall be deemed served on the date of sending, provided: (i) no incomplete or bounce-back error transmission is received by the sending Party; and (ii) if such day is not a business day or if the notice or communication is received after 5:00 PM (at the place of receipt) on any business day, the notice or communication shall be deemed to have been sent and received on the immediately following business day.

20. **Independent Contractor.** Supplier is an independent contractor in all respects pertaining to its performance of the Order.

21. **Waiver.** Waiver by Company of any provision hereof shall not constitute a continuing waiver or a waiver of any other provision, nor shall it affect in any manner any right or remedy to which Company is entitled for any breach or default by Supplier, whether or not similar.

22. **Remedies Cumulative.** All rights and remedies reserved under the Order and these Terms shall be cumulative and in addition to any further rights and remedies provided in law or equity.

23. **Assignment.** Supplier shall not assign or transfer any right or obligation under the Order without Company's prior written consent.

24. **Venue, Choice of Law and Jury Trial Waiver.** The Order shall be governed by and construed in accordance with the laws of Texas, without reference to its conflict of laws rules or principles. Each party irrevocably submits to the exclusive jurisdiction of the state and federal courts of Texas seated in Harris County for the interpretation and enforcement of this Order, and unconditionally waives any defense of an inconvenient forum to the maintenance of any action or proceeding in any such court, any objection to venue with respect to any such action or proceeding and any right of jurisdiction on account of the place of residence or domicile of either party. A final judgment on any such dispute, as to which all appeals, if any, have been exhausted, shall be conclusive and may be enforced in other jurisdictions in any manner provided by law. EACH PARTY WAIVES ALL RIGHTS TO TRIAL BY JURY IN ANY PROCEEDING BROUGHT BY EITHER PARTY AGAINST THE OTHER PARTY ON ANY MATTER WHATSOEVER ARISING OUT OF, IN CONNECTION WITH OR RELATED TO THIS ORDER.

25. **Set Off.** Company may set-off and deduct from any amounts payable to Supplier any amounts owing by Supplier to Company pursuant to this Order or any other agreement between Supplier and Company. The failure by Company to set-off or deduct any amount from an invoiced payment will not constitute a waiver of Company's right to set-off, deduct or collect such amount.

26. **Severability.** If any provision of this Agreement is finally determined by any court of competent jurisdiction to be illegal or unenforceable, that provision will be severed from this Agreement and the remaining provisions will continue in full force and effect.

27. **Survival.** The provisions of this Order which are intended to extend beyond its termination, including the liability, indemnity, compliance, warranty, intellectual property and confidentiality provisions, and the provisions applicable to the enforcement of those provisions and/or the enforcement of rights and obligations incurred hereunder that are not fully discharged prior to the termination of this Order, will survive termination to the extent necessary to effect the intent of the parties and enforce such rights and obligations.

28. **Audit.** Company and its authorized representatives shall have the right to audit all costs and records of Supplier (and any subcontractors retained by Supplier) related solely to performance of this Order, upon fifteen (15) days' written notice to Supplier (or subcontractor), including access to Supplier's (and subcontractor's) books, records and documentation supporting all billed amounts. This right to audit shall remain in effect for a period of one year from the date the Goods are accepted by Company. Company through its employees or agents shall have reasonable access to Supplier's facilities and during normal business hours at all times to observe and inspect the fabrication, manufacturing, assembly, coating, testing, loading, transportation and stockpiling of the Goods. Supplier will respond to such information requests as Company may reasonably request in connection with such inspection and observation. Each party agrees, while at the other's facilities, to comply with all applicable federal, state and local laws and to observe such safety rules as that party may prescribe for the protection of personnel and property.

29. **Interpretation.** Headings used herein are for the convenience of reference only and shall not be considered in construing or interpreting this Agreement. The words "herein", "hereunder", "hereof" and other similar words refer to this Order as a whole and not to any particular paragraph or part of the Order. "Includes", "including" and similar terms shall mean "including (or includes, as applicable) without limitation".

30. **Counterparts.** This Order, and any amendment, supplement or schedule to this Order, may be executed in any number of counterparts, and may be executed using electronic signatures. The executed signature page(s) from each counterpart may be joined together and attached to an original and together shall constitute one and the same instrument. Exchange of counterparts of a document of this Order may be provided by fax or other electronic means, including email delivery.

[END OF TERMS AND CONDITIONS]

EXHIBIT 6E

Buyer: MICHAEL CRAYMER
Phone: 713-627-4841
Email: Michael.Craymer@enbridge.com

Bill To: Algonquin Gas Transmission, LLC
APUSinvoices@spectraenergy.com
OR
P.O. Box 2549
Detroit, MI 48202-2549

PURCHASE ORDER (PO)

Vendor:	**Vendor No. 9000000568**
DANIEL MEASUREMENT SERVICES IN 11100 BRITTMORE PARK DR HOUSTON TX 77041-6930 Phone: 713-827-6312 Fax: Attention:	

Ship To: ALGONQUIN GAS TRANSMISSION LLC

1600 WASHINGTON STREET
HOLLISTON MA 01746

Attention:

General Information		
P.O. Number	:	**3100036557**
Rev. No.	:	5
Date	:	02/15/2017
Currency Code	:	USD
Payment Terms	:	Net 45 Days
Ship Date	:	06/30/2017
Shipping Terms	:	FOB ORIGIN

P.O.Number and Line number must mirror the PO on your invoice and must be referenced on all invoices and related correspondence.

WBS:CE.000089.005.07.02
A. BRIDGE WEYMOUTH
BILL WELCH

FREIGHT COLLECT - CONTACTS FOR ROUTING INSTRUCTIONS:
TATIANA PARIS AT 713-627-5052 TPARIS@SPECTRAENERGY.COM

General Notes

DESCRIPTION: MASSACHUSETTS EXEMPT AGT

Notes:

TAX NOTE: THE COMMODITY(S) PURCHASED UNDER THIS PURCHASE ORDER IS/ARE TAX EXEMPT IN THE STATE OF MASSACHUSETTS. DO NOT INVOICE SALES TAX.

SHIPPING POINT:ORIGIN

THIS ORDER CONFIRMS ORDER 3100036557
PLACED ON FEBRUARY 15, 2017
TO JAMES HUTER
BY MICHAEL CRAYMER

ROUTING INSTRUCTIONS ARE AN INTEGRAL PART OF THIS PURCHASE ORDER. FAILURE TO COMPLY WITH THESE INSTRUCTIONS IN ANY MANNER WITHOUT PRIOR APPROVAL OF SPECTRA ENERGY MATERIALS MANAGEMENT/TRAFFIC DIVISION WILL BE CONSTRUED AS A DIRECT VIOLATION OF THIS CONTRACT. IN THE EVENT ROUTING INSTRUCTIONS CANNOT OR SHOULD NOT BE EXECUTED AS INSTRUCTED IN THIS PURCHASE ORDER, VENDOR IS INSTRUCTED TO CONTACT THE BUYER OR SPECTRA ENERGY TRAFFIC FOR REVISED ROUTING INSTRUCTIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS WILL RESULT IN FREIGHT CHARGES BEING FOR VENDOR'S ACCOUNT.

GUIDELINES FOR WOOD PACKING MATERIALS U.S., CANADA AND MEXICO ARE STRICTLY ENFORCING INTERNATIONAL STANDARDS FOR PHYTO-SANITARY MEASURES PUBLICATION NO. 15 (ISPM 15). WOOD

PACKING FOR ALL SHIPMENTS THAT REQUIRE CUSTOMS CLEARANCE, INCLUDING SKIDS, CRATES AND PIPE DUNNAGE MUST BE TREATED TO THE ISPM 15 STANDARD AND IS REQUIRED TO BEAR THE UNIQUE CERTIFICATION STAMP. SELLER WILL BE RESPONSIBLE TO INSURE ALL GOODS SHIPPED MEET ISPM STANDARDS.

NOTE: SHIPMENTS ROUTED VIA FEDEX OR U.P.S. ARE NOT TO EXCEED 125 LBS. AND 100 LBS RESPECTIVELY FOR THE TOTAL SHIPMENT. WEIGHTS EXCEEDING THESE LIMITS ARE TO BE REFERRED TO THE BUYER FOR REVISED SHIPPING INSTRUCTIONS. USE OF MULTIPLE BILLS/SHIPMENTS TO CIRCUMVENT THESE WEIGHT LIMITS ARE NOT ACCEPTABLE, AND IF SO USED WILL BE FOR THE VENDOR'S ACCOUNT.

IN THE EVENT THE MATERIAL IS PURCHASED ON A PREPAY AND ADD BASIS, THE VENDOR MUST INCLUDE A COPY OF THE FREIGHT BILL WITH THEIR INVOICE BEFORE PAYMENT WILL BE AUTHORIZED.

INVOICE TERMS: INVOICE PAYMENT TERMS WILL BE CALCULATED FROM THE DATE RECEIVED IN OUR CORPORATE OFFICE UNLESS OTHERWISE INDICATED IN THE BODY OF THE PURCHASE ORDER.

COMPANY RESERVES THE RIGHT TO HAVE AN EMPLOYEE AND/OR AN APPOINTED AGENT VISIT VENDOR'S MANUFACTURING PLANT/ FACILITIES AND/OR SUB-VENDORS MANUFACTURING PLANT AND FACILITIES TO EXPEDITE OR INSPECT MATERIALS GOODS AND SERVICES COVERED BY THIS PURCHASE ORDER. SUCH VISITS WILL BE DURING VENDOR'S NORMAL WORKING HOURS AND SUBJECT TO ANY REASONABLE AND NORMAL PROCEDURES OF THE VENDOR. THESE RIGHTS SHALL BE RESERVED AND SO INDICATED ON ANY AND ALL ORDERS TO SUB-VENDORS.

Purchase Order Updates

Line item	Item Changed	Old	New	Date Changed
10	Item Delivery Date	06/22/2017	06/30/2017	06/21/2017

Line	Material Number	Description	Quantity	UoM	Ship Date	Unit Cost	Net Amount
10		"SENIOR ORIFICE FITTING, 2"" ANSI 300#,	1	EA	06/30/2017	18,050.00	18,050.00

SENIOR ORIFICE FITTING, 2" ANSI 300#, B.T.M. 0.218" W.T. GR. B PIPE, WITH STUD BOLTS AND FLEXITALLIC GASKETS, WITH VTD" DIA. ORIFICE PLATE, 304SS, DANIEL CATALOG NO. VTD, COMPLETE WITH FLANGED SENIOR METER TUBE, CATALOG NO. VTD,
- FOUR (4) 1" 3000# INSTRUMENT TAPS REQUIRED DOWNSTREAM,
- TWO (2) 3000# INSTRUMENT TAPS REQUIRED UPSTREAM - ONE (1) 1" TAP, ONE(1) 1/2" TAP._____
METER RUN ASSEMBLY PER SPECTRA ENERGY STANDARD SP-5000. TAG: FE-520-1
DRAWING: WEYM-P-1128 (MARK NO. 4, QNT. 1)
BOM TAG: FG006
GL 1004 8500201 Project / WBS CE.000089.005.07.02

Total: **18,050.00 USD**

STANDARD PURCHASE ORDER TERMS AND CONDITIONS
(United States - Issue Version: May 2018)

1. **General.** This purchase order ("**Order**") comprises the face of the Order, these purchase order terms and conditions and such other documents incorporated by reference on the face of the Order. The "Seller", "Supplier" or "Vendor" ("**Supplier"**) identified on the face of the Order agrees to sell, and the Enbridge entity identified on the face of the Order ("**Company**") agrees to buy, the goods, articles, and materials described in the Order (together with such documentation as specified on the face of the Order, collectively, "**Goods**") and services related thereto.

2. **Acceptance of the Order. Supplier's acceptance of the Order, whether in writing or by performance, will be only upon these terms and conditions, which are incorporated into and made a part of each Order; no other terms or conditions shall be binding on Company unless: (i) conspicuously referenced on the face of the Order to which such other terms and conditions apply; and (ii) expressly agreed to by Company. Any quote, invoice, acknowledgement or other form or communication issued by Supplier in connection with the Order will be for Supplier's record and accounting purposes only and any terms and conditions referenced therein will not apply to the Order.**

3. **Order Number.** Company's Order number and corresponding item line number(s) as shown on the face of the Order must appear on all invoices, correspondence, shipping documents, packages and any other documents relating to the Order.

4. **Delivery, Risk and Title.** Supplier shall deliver the Goods to the location(s) designated by Company in the order ("**Delivery Point**"). Supplier shall prepay transportation costs for delivery of the Goods to the Delivery Point, unless otherwise specified in the Order, and if so specified, the transportation charges will be included as a separate item in the invoice for the applicable Goods, and not in an additional or separate invoice. Title transfers to Company upon: (i) Company's acceptance of the Goods; or (ii) Company's payment for the Goods (in whole or in part); whichever occurs first. Risk of loss for the Goods shall transfer in accordance with the 2010 Incoterm set out on the face of this Order. Supplier warrants it will have good and transferable title to the Goods at the time of title transfer to Company, and further that title to the Goods will transfer to Company free and clear of any and all liens or encumbrances.

5. **Warranty.** Supplier warrants that the Goods, and the services related thereto, will (i) conform in all respects to the requirements of the Order; (ii) comply with the more stringent of industry or Company's standards; (iii) conform strictly to applicable specifications, drawings, samples or other description upon which the Order is based; (iv) be fit, safe and effective for their intended use and purpose, and operate as intended; and (v) be merchantable and free from defects in material, workmanship, and design. All warranties set forth in the Order will remain in effect for one (1) year from the date of Company's acceptance, or eighteen (18) months from delivery of the Goods, whichever occurs latest, or as stated on the face of the Order. All warranties will not be deemed waived by reason of Company's receipt, inspection, or by payment for the Goods. Supplier shall assign and transfer all assignable warranties it receives from its vendors and manufacturers to Company.

In the event of a breach of warranty, Supplier shall repair and/or replace the defective Goods at no cost to Company (including, without limitation, shipping costs). Goods will not be considered in breach of this warranty if a defect is caused primarily by Company's improper installation, operation or maintenance.

6. **Delay.** Supplier shall deliver the Goods on the date(s) specified in the Order, during Company's normal business hours or as otherwise instructed by Company. Timely completion and delivery is a material term of the Order. Timely delivery is delivery of Goods, which conform to requirements of the Order, to the Delivery Point on or before the agreed delivery date. If Supplier is unable to make a timely delivery, it shall notify Company of the anticipated delay as soon as it learns of same, such notice becoming effective upon receipt by Company. Supplier's notice shall state the reasons for the delay and the anticipated date of delivery. If the delay (a) is not caused in whole or in part by the negligence or intentional fault of Supplier and (b) will not contribute to a delay in Company's schedule or otherwise cause damages to Company or any entity to whom Company is providing services, then Company may, but is not obligated to, agree to extend the date of delivery, without additional liability to Supplier, to the earlier of: (i) the anticipated date of delivery stated in Supplier's notice, or (ii) ten (10) business days after the original agreed delivery date. If delivery is not accomplished before the agreed delivery date, as such may be extended by these terms, then Supplier will be liable to Company for all direct damages caused by the delay.

7. **Rejection and Acceptance of Goods.** Company may reject any Goods that do not conform to the requirements of this Order and to return non-conforming Goods to Supplier at Supplier's expense. Company's acceptance or inspection of any Goods is not a waiver of any of Company's rights hereunder, at law or otherwise. Receipt of the Goods, acknowledgement of receipt of the Goods, or payment of Supplier's invoices does not constitute acceptance of the Goods.

8. **Invoicing.** Company shall pay all invoice amounts pursuant to the payment terms on the face of the Order upon receipt of undisputed invoice(s). Company and Supplier shall work together in good faith to resolve all invoice disputes. Each of the parties shall be responsible for the payment of all taxes, duties, levies, charges and contributions for which the respective party is liable as imposed by any appropriate government or regulatory authority ("**Tax**" or "**Taxes**") in connection with the Order. Taxes imposed on Company that Supplier is required to collect shall be separately stated and identified on each invoice issued by Supplier in compliance with appropriate tax laws or regulations. Company shall provide Supplier with exemption documentation as required by the applicable governmental authority where exemption from Taxes is claimed. For further clarification, Supplier will be responsible for paying its income taxes and any other taxes of any kind in any jurisdiction that might become payable in relation to the sale of goods. Company shall bear no responsibility for any income, gross margin, franchise, capital, net worth or other type of direct tax that may inure to Supplier as a result of the Order.

9. **Liens.** Supplier shall timely pay its subcontractors and vendors, and indemnifies and defends Company from and against all claims by third-parties and liens and encumbrances on Company's property related in any way to Supplier's performance of the Order.

10. **Changes.** Company may at any time make reasonable changes in any one or more of the following: (1) drawings, plans, designs and specifications; (2) quantities; (3) delivery schedule; or (4) place, manner or time of delivery. If any such change increases or decreases the cost of the Goods to be provided or results in an extension of the shipping schedule, Supplier shall give Company written notice stating the effect of such change within ten (10) days after receipt of the change request. No claim for an increase in price or schedule extension will be recognized unless such was authorized in advance and in writing by Company.

11. **Compliance.** Supplier shall comply with all applicable federal, state and local laws and regulations that affect the Order. All deliveries to Company's premises must be carried out in a safe manner, and Supplier shall comply with, and cause all other parties acting on Supplier's behalf to comply with all safety policies, rules and warnings communicated by Company.

12. **Insurance Requirements.**

(a) Supplier shall maintain at its own expense, the insurance coverage outlined herein with licensed, reputable and reliable insurers: i) **Workers' Compensation and/or Occupational Disease** coverage that fully complies with all applicable laws where activity related to this Order is performed, where Supplier's employees reside, and in all states where Supplier is domiciled. **As applicable**, coverage shall include an alternate employer's endorsement and voluntary compensation endorsement; ii) **Employer's Liability** coverage with limits of One Million Dollars ($1,000,000) each accident, by disease each employee, and by disease policy limit; iii) **Commercial General Liability** coverage with a limit of Two Million Dollars ($2,000,000) each occurrence for bodily injury and property damage arising out of or relating to Supplier's activities under this Order. The policy shall include coverage for, contractual liability, cross liability, severability of interests, products and completed operations; iv) **As applicable, Commercial Auto Liability** covering all vehicles used by Supplier under this Order with a combined single limit of Two Millions Dollars ($2,000,000) for injury or death of one or more persons or damage to or destruction of property as a result of each accident; and v) **As applicable, All Risk Property Damage** insurance on a replacement cost basis covering loss of or damage to property owned by or in the care custody and control of the Supplier. Supplier shall ensure that each insurance policy hereunder: A) with exception of 12(a) i) and v) includes Company as additional insured; B) provides a waiver of insurers' rights of subrogation in favor of Company; and C) is written to respond on a primary and non-contributory basis. Insurance shall not be canceled without thirty (30) days' prior written notice to Company.

(b) Upon execution of this Agreement, and on an annual basis thereafter until this Agreement is terminated, Supplier shall provide to Company Certificate(s) of Insurance certifying Supplier's compliance with this Order. In the event of a reduction in Supplier insurance limits during the Term which may otherwise reduce the limits of insurance required to comply with this Order, the Supplier shall promptly provide Company with notice of same, and immediately thereafter secure such additional insurance as is required to comply with the terms of this Order. Company's acceptance of certificates or correspondence associated thereto does not constitute a waiver, release or modification of the requirements under this Order. "Certificate Holder" shall be: Enbridge (U.S.) Inc. and U.S. affiliates.

(c) In the event Supplier fails to comply with insurance requirements under this Order, at its sole discretion, Company may, but shall not be obligated to, obtain such insurance for Company's sole benefit as Company deems necessary to address any failure on the part of the Supplier to obtain the insurance required pursuant to this Order. Any cost thereof shall be payable by the Supplier to Company on demand and Company may, at its election, deduct the cost thereof or set-off from any monies which are due or may become due to Supplier. No liability shall attach to Company for any decision on the part of Company to forego the purchase of additional insurance under this Section 12, nor does Company's decision not to purchase additional insurance pursuant to this Section 12 constitute a waiver, release or modification of the requirements under this Order, or constitute a

statement by Company that Supplier's insurance coverage at any time during the Term hereof is in compliance with the requirements under this Order.

(d) Company will not be responsible for any premiums, deductibles, self-insured retentions or any other costs for the insurance provided by Supplier in this Order.

13. **INDEMNITY. NOTWITHSTANDING ANYTHING ELSE IN THE ORDER TO THE CONTRARY, SUPPLIER SHALL INDEMNIFY, RELEASE, HOLD HARMLESS, AND DEFEND COMPANY, ITS PARENT, SUBSIDIARY AND AFFILIATED COMPANIES, AND ITS AND THEIR OFFICERS, DIRECTORS, EMPLOYEES, AGENTS, ASSIGNS AND SUCCESSORS IN INTEREST FROM AND AGAINST ALL CLAIMS, DISPUTES, SUITS, COMPLAINTS, LIABILITIES, DAMAGES, AND EXPENSES OF WHATEVER NATURE (*including,without limitation, attorneys' fees*), INCLUDING, WITHOUT LIMITATION, FOR INJURY TO ANY PERSON (INCLUDING DEATH) OR DAMAGE TO ANY PROPERTY, RESULTING FROM OR IN ANY WAY CONNECTED WITH SUPPLIER'S PERFORMANCE OF THE ORDER, EXCEPT THAT THE OBLIGATIONS HEREUNDER DO NOT APPLY TO COMPANY'S SOLE NEGLIGENCE OR WILLFUL MISCONDUCT.**

14. **Intellectual Property Warranty and Indemnity.** Supplier warrants that the Goods and the related services do not infringe or misappropriate any letters patent, trademark or copyright or any other intellectual property rights of any third party. **Supplier shall release, indemnify, save harmless and defend Company from and against all claims, liabilities, damages, and expenses (including, without limitation, attorneys' fees) arising in favor of any person or entity and based on misappropriation of trade secrets, infringement or claim of infringement of a patent, trademark, trade name, copyright or other proprietary right in the Goods provided by Supplier, except to the extent directly caused by specifications expressly provided by Company.**

15. **Intellectual Property Ownership and License.** All ideas, concepts, drawings and similar items created by Supplier in connection with the performance of the Order shall be the property of Company and shall be immediately delivered by Supplier to Company, with all compensation to Supplier for such ideas, concepts, drawings and similar items being included in the price(s) stated in the Order. Supplier grants to Company a non-exclusive, royalty-free, transferable, irrevocable license under all foreign and domestic patents now or hereafter owned by Supplier to use (for any purpose) and sell the Goods purchased under the Order.

16. **Confidentiality.** Both Company and Supplier, on behalf of themselves and their employees, agree that any ideas, concepts, or proprietary information received from the other in connection with the performance of the Order will not be disclosed to third persons except to the extent necessary for the proper performance of the Order.

17. **Termination for Cause.** Company may terminate all or any part of the Order for: (i) Supplier's failure to make deliveries by the date(s) specified; (ii) Supplier's breach of any of the terms hereof, including, without limitation, the warranties of Supplier; (iii) change in price of the Goods; (iv) Supplier's failure to provide adequate assurance of its ability to meet quality standards; (v) Supplier's failure to make progress on any Goods so as to endanger performance of the Order; or (vi) in the event of any proceeding by or against Supplier in bankruptcy or insolvency or for the appointment of a receiver or trustee or an assignment for the benefit of creditors. Upon termination for cause, Company shall provide written notice of termination and have no further obligation to Supplier. Upon receipt of notice of termination, Supplier shall discontinue all work pertaining to the Order and use its best efforts to mitigate additional costs resulting from the termination. Supplier shall preserve and protect materials in supply, work in progress, and finished work, the disposition of which shall be as directed by Company. Supplier is not entitled to any prospective profits or damages.

18. **Termination for Convenience.** Company may terminate all or any part of the Order for convenience upon written notice to Supplier. Company shall accept and pay for materials in supply, work in progress and finished work, as well as reasonable additional costs caused by the termination. Supplier is not entitled to any prospective profits or damages. In no event will the total amount paid to Supplier under a terminated Order exceed the original value of the Order.

19. **Notice.** All notices, consents and requests hereunder must be in writing and served by personal service, by mail or by e-mail to the address of the receiving Party set forth on the face of this Order (or such different address as may be designated by such Party in a notice to the other Party, from time to time). Notices, consents and requests served by personal service shall be deemed served when delivered. Notices, consents and requests served by mail must be sent by registered mail, return receipt requested, and shall be deemed served 10 business days after mailing. Notices, consents and requests served by e-mail shall be deemed served on the date of sending, provided: (i) no incomplete or bounce-back error transmission is received by the sending Party; and (ii) if such day is not a business day or if the notice or communication is received after 5:00 PM (at the place of receipt) on any business day, the notice or communication shall be deemed to have been sent and received on the immediately following business day.

20. **Independent Contractor.** Supplier is an independent contractor in all respects pertaining to its performance of the Order.

21. **Waiver.** Waiver by Company of any provision hereof shall not constitute a continuing waiver or a waiver of any other provision, nor shall it affect in any manner any right or remedy to which Company is entitled for any breach or default by Supplier, whether or not similar.

22. **Remedies Cumulative.** All rights and remedies reserved under the Order and these Terms shall be cumulative and in addition to any further rights and remedies provided in law or equity.

23. **Assignment.** Supplier shall not assign or transfer any right or obligation under the Order without Company's prior written consent.

24. **Venue, Choice of Law and Jury Trial Waiver.** The Order shall be governed by and construed in accordance with the laws of Texas, without reference to its conflict of laws rules or principles. Each party irrevocably submits to the exclusive jurisdiction of the state and federal courts of Texas seated in Harris County for the interpretation and enforcement of this Order, and unconditionally waives any defense of an inconvenient forum to the maintenance of any action or proceeding in any such court, any objection to venue with respect to any such action or proceeding and any right of jurisdiction on account of the place of residence or domicile of either party. A final judgment on any such dispute, as to which all appeals, if any, have been exhausted, shall be conclusive and may be enforced in other jurisdictions in any manner provided by law. EACH PARTY WAIVES ALL RIGHTS TO TRIAL BY JURY IN ANY PROCEEDING BROUGHT BY EITHER PARTY AGAINST THE OTHER PARTY ON ANY MATTER WHATSOEVER ARISING OUT OF, IN CONNECTION WITH OR RELATED TO THIS ORDER.

25. **Set Off.** Company may set-off and deduct from any amounts payable to Supplier any amounts owing by Supplier to Company pursuant to this Order or any other agreement between Supplier and Company. The failure by Company to set-off or deduct any amount from an invoiced payment will not constitute a waiver of Company's right to set-off, deduct or collect such amount.

26. **Severability.** If any provision of this Agreement is finally determined by any court of competent jurisdiction to be illegal or unenforceable, that provision will be severed from this Agreement and the remaining provisions will continue in full force and effect.

27. **Survival.** The provisions of this Order which are intended to extend beyond its termination, including the liability, indemnity, compliance, warranty, intellectual property and confidentiality provisions, and the provisions applicable to the enforcement of those provisions and/or the enforcement of rights and obligations incurred hereunder that are not fully discharged prior to the termination of this Order, will survive termination to the extent necessary to effect the intent of the parties and enforce such rights and obligations.

28. **Audit.** Company and its authorized representatives shall have the right to audit all costs and records of Supplier (and any subcontractors retained by Supplier) related solely to performance of this Order, upon fifteen (15) days' written notice to Supplier (or subcontractor), including access to Supplier's (and subcontractor's) books, records and documentation supporting all billed amounts. This right to audit shall remain in effect for a period of one year from the date the Goods are accepted by Company. Company through its employees or agents shall have reasonable access to Supplier's facilities and during normal business hours at all times to observe and inspect the fabrication, manufacturing, assembly, coating, testing, loading, transportation and stockpiling of the Goods. Supplier will respond to such information requests as Company may reasonably request in connection with such inspection and observation. Each party agrees, while at the other's facilities, to comply with all applicable federal, state and local laws and to observe such safety rules as that party may prescribe for the protection of personnel and property.

29. **Interpretation.** Headings used herein are for the convenience of reference only and shall not be considered in construing or interpreting this Agreement. The words "herein", "hereunder", "hereof" and other similar words refer to this Order as a whole and not to any particular paragraph or part of the Order. "Includes", "including" and similar terms shall mean "including (or includes, as applicable) without limitation".

30. **Counterparts.** This Order, and any amendment, supplement or schedule to this Order, may be executed in any number of counterparts, and may be executed using electronic signatures. The executed signature page(s) from each counterpart may be joined together and attached to an original and together shall constitute one and the same instrument. Exchange of counterparts of a document of this Order may be provided by fax or other electronic means, including email delivery.

[END OF TERMS AND CONDITIONS]

EXHIBIT 7

J L ALLEN SERVICES, Inc.
P. O. Box 347 ● 980N CR 610 E. ● Tuscola, IL 61953 ● P: 217.253.3371 ● F: 217.253.2834

7/21/2020

Enbridge
890 Winter Street,
Suite 300
Waltham, MA 02451

Attn: John Heintz

Subject: Weymouth Fuel Gas System, Turbine Exhaust/Intake

Mr. Heintz,
J.L. Allen Services, Inc. is pleased to have the opportunity to present this proposal for the installation of the following items:

1. Installation of complete fuel gas system civil, mechanical, electrical, painting/coating, and insulation. $198,823.00
2. Installation of complete turbine air intake system civil and mechanical $306,405.80
3. Installation of complete turbine exhaust system civil, mechanical, insulation $516,075.00

Total estimated cost is $1,021,303.80

Please note: This estimate excludes procurement of all piping materials, compressor/ancillary equipment and buildings, and substation structures/equipment/buildings.

Respectfully,

Rob Birchenough
President
J.L. Allen Services, Inc.

PO Box 941
Simsbury, CT 06070

canomara LLC

(860) 865-1166
www.canomara.com

June 17, 2020

Mr. Frank Pike
Enbridge, Inc.
890 Winter Street
Waltham, MA 02451

Re: Weymouth Initial Performance Testing
Project Id: ENBR2020-11

Dear Mr. Pike:

Canomara LLC (CM) is pleased to submit this proposal to Enbridge, Inc. (Enbridge) to conduct initial performance emissions testing on one Solar Taurus 60 natural gas fired turbine at the Weymouth, MA compressor station. Tests will be conducted to determine concentrations of nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds (VOC), particulate matter (PM), formaldehyde (HCHO) and benzene. This test program is being conducted to satisfy the requirements of Massachusetts Department of Environmental Protection (MassDEP) Plan Approval Application No. SE-15-027 and 40 CFR 60 Subpart KKKK.

The three founding members of CM have over six decades of combined technical and project management experience in the air measurements field. CM uses this great depth of knowledge to provide high quality and cost effective stack testing services to our clients across a full range of applications and industries.

The following sections outline the scope of work, schedule, personnel, funding, and conditions of this proposal.

SCOPE OF WORK

Test Protocol

CM will prepare a test protocol suitable for submission to MassDEP. The protocol will include the scope of work, descriptions of the process, test methods and CM's quality assurance measures. CM will submit the protocol to MassDEP at least 30 days prior to the compliance testing in accordance with the air permit.

Compliance Testing
Emissions will be measured according to US EPA test methods. Three 60-minute tests will be performed for NO_x, CO, VOC, HCHO and benzene. Three 240-minute tests will be performed for PM. During emissions testing, the turbine will be operating within plus or minus 25% of 100% peak load. CM will provide a manlift to access the sample ports.

Source	Parameters	Methods	Measurement Units
Turbine	PM, NO_x, CO, VOC, HCHO and Benzene	EPA 1-5/202, 7E, 10, 25A/18, 323 and TO-15	ppm@15% O_2 lb/MMBtu lb/hr, tpm

Test Report
A report for suitable for submission to MassDEP will be drafted and submitted to Enbridge for review and comment. The report will include a summary and discussion of results, and a description of test methods, process operations, and quality assurance. Copies of all associated test data will be included.

SCHEDULE & PERSONNEL

Schedule
The turbine will be tested over a 4-day period in a single field efforts as shown below.

Day	Activity	Crew	Hours
1	Travel and Equipment Set-Up	4	8
2	Two 240-minute Compliance Tests	4	10
3	One 240-minute Compliance Test	4	8
4	Contingency and Return Travel	3	8

Personnel
Evan Bali will be the manager for this project. He has 15-years of technical and project management experience in the air measurements field and is a Qualified Source Testing Individual (QSTI) for all four method groups provided by the Source Evaluation Society (SES).

Alex Canora and Edward Gutfran will provide field support for the emissions testing. They have a combined 16-years of air measurement experience and are QIs for method groups I and III. Additional quality assurance and technical support for this project will be provided by Jim Canora. Mr. Canora has over 36 years of experience in the industry.

FUNDING

CM will provide these services on a time and materials (T&M) basis not to exceed **$27,500** in accordance with the following billing tables.

Personnel	Hourly Rate
Jim Canora	$120
Mike Maraghy	$120
Evan Bali	$120
Alex Canora	$95
Edward Gutfran	$95

Item	Cost
Daily Equipment Charge	$1,500
Man Lift	Cost + 10%
Project Supplies	Cost + 10%
Meals	Cost + 10%
Lodging	Cost + 10%

Any work resulting from this proposal shall be governed by mutually acceptable terms and conditions. Delays beyond the direct control of CM will be considered out of scope and will be billed according to the T&M rates.

Once a field effort is scheduled, at least 10 days' notice of cancellation is required to avoid mobilization charges. However, no additional charges will be incurred without prior approval.

CONDITIONS

Enbridge will be expected to provide the following:

1. Sampling ports, platforms and safe access thereto
2. 120 VAC @ 20 amps electrical power within 100-feet of sampling location
3. 220 or 480 VAC @ 50 amps single phase electrical power within 100-feet of trailer
4. Personnel to record / report pertinent process data and coordinate testing

We greatly appreciate the opportunity to provide these services to Enbridge. If you have any questions please contact me at any time.

Respectfully,
Canomara LLC

Evan Bali

Evan Bali, QSTI
Project Manager

Solar Turbines
A Caterpillar Company

Solar Turbines, Inc.
10203 Sam Houston Park Dr
Suite 300
Houston, Texas 77064

Date 8-3-2020

To: Mr. Barry Goodrich

Re: 3W102-HO15-0023-Weymouth – CO Catalyst Replacement

Dear Mr. Goodrich,

Regarding the question on the cost of a spare set of CO Catalyst media for the system installed at Weymouth, the budgetary pricing is $93,000.00 with delivery of 16-18 weeks after order.

Thank you for your consideration.

Best Regards,
Mike Clay
Account Manager
Solar Turbines Inc.

Caterpillar: Confidential Green

APPENDIX E. MASSDEP BACT FORM

Massachusetts Department of Environmental Protection
Bureau of Waste Prevention – Air Quality

BWP AQ BACT

Determination of Best Available Control Technology (BACT)

Submit with Form CPA-FUEL and/or CPA-PROCESS, as applicable, when performing a top-down, case-by-case BACT analysis for your proposed Comprehensive Plan Application (CPA) project.

X266786
Transmittal Number

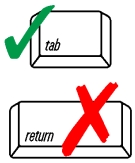
Facility ID (if known)

Per 310 CMR 7.02(8)(a), this Form is not required to be submitted if:

- The proposed project will utilize Top-Case BACT (as defined by MassDEP); or
- Emissions from the proposed project are less than 18 tons of Volatile Organic Compounds and Halogenated Organic Compounds combined, less than 18 tons of total organic material Hazardous Air Pollutants (HAPs), and/or less than 10 tons of a single organic material HAP – all tonnages being per consecutive 12-month time period – AND the project proponent proposes a combination of best management practices, pollution prevention and a limitation on hours of operation and/or raw materials usage.

See the MassDEP BACT Guidance for additional information.

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



A. Project Information

1. Complete the table below to summarize your proposed air pollution control technology(ies)/ technique(s) to be used to deliver BACT for your proposed project, derived using a top-down BACT analysis as determined via Sections B, C, and D below:

Table 1		
Emission Unit No.(s) Being Controlled	**Proposed Air Pollution Control Device(s)/Technique(s)**	**Proposed Emission(s) Limit(s)**
EU1	Dry Low-NOx (DLN) Combustion Technology (SoLoNOx)	9 ppmvd NO_X @ 15% O_2 (at steady state)
EU1	Oxidation Catalyst	1.25 ppmvd CO @ 15% O_2 (at steady state) 2.4 ppmvd VOC @ 15% O_2 (at steady state)
EU1	Use of pipeline quality natural gas and good combustion and operating practices	0.0066 lb/MMBtu (HHV) for PM/PM_{10}/$PM_{2.5}$ (at steady state) 14.29 lb/MMscf (HHV) for SO_2 (at steady state)

B. Air Pollution Control Technology/Technique Options

Complete the table beginning on the next page for available, demonstrated in use, air pollution control technologies/techniques for this proposed project. List in order of lowest to highest resulting air contaminant(s) emissions.

To ensure a sufficiently broad and comprehensive search of control alternatives, sources other than the U.S. Environmental Protection Agency (EPA) RACT/BACT/LAER Clearinghouse database should be investigated and documented.

Copy and complete Table 2 as needed for your top options. Do not include any air pollution control technologies/techniques that result in higher air contaminant emissions than the technology/technique you are proposing.

Continue to Next Page ►

B. Air Pollution Control Technology/Technique Options (continued)

Table 2			
	Option 1:	**Option 2:**	**Option 3:**
Description of Available Air Pollution Control Technologies/Techniques	EMD		
Pollutant(s) Controlled[1] (e.g. PM, NO_x, CO, SO_2, VOC, HAP)	See BACT Analysis for EMD Alternative		
Potential Emissions Before Control (Pounds Per Hour, Pounds Per Million British Thermal Units, or Parts Per Million, Dry Volume Basis)	See BACT Analysis for EMD Alternative		
Resulting Emissions After Control (Pounds Per Hour, Pounds Per Million Btu, or Parts Per Million, Dry Volume Basis)	See BACT Analysis for EMD Alternative		
Annualized Cost in U.S. Dollars Per Ton of Pollutant Removed[2]	See BACT Analysis for EMD Alternative		

[1] NO_x = nitrogen oxides, SO_2 = sulfur dioxide, VOC = volatile organic compounds, HAP = hazardous air pollutant, PM = particulate matter, CO = carbon monoxide

[2] Complete Section C of this Form to determine annualized costs.

Continue to Next Page ►

C. Annualized Cost Analysis

Complete the table below for each air pollution control technology/technique being evaluated for this proposed project. Whenever possible, use vendor quotes. Do not complete this table for those air pollution control technologies/techniques that result in higher air contaminant emissions than those you are proposing.

Table 3			
	Option 1	**Option 2**	**Option 3**
Total Capital Investment (TCI)[1]			
Direct Purchase Cost			
1. Primary Control Device & Auxiliary Equipment	$	$	$
2. Fans	$	$	$
3. Ducts	$	$	$
4. Other – Specify:	$	$	$
5. Instrumentation/Controls	$	$	$
Indirect Capital Cost			
6. Construction	$	$	$
7. Labor	$	$	$
8. Sales Taxes	$	$	$
9. Freight Charges	$	$	$
Engineering/Planning			
10. Contracting Fees	$	$	$
11. Testing	$	$	$
12. Supervision	$	$	$
13. Total Capital Investment (Add 1 Through 12)	$	$	$
14. Annualized Capital Cost: $C[i(1+i)^n]/[(1+i)^n - 1]$*	$	$	$

* C = Total Capital Investment (Line 13) i = Interest Rate (Assume 10%) n = Life of Equipment (Assume 10 Years or Less)

[1] See BACT Analysis for EMD Alternative

C. Annualized Cost Analysis (continued)

Table 3 (Continued)			
	Option 1	**Option 2**	**Option 3**
Annual Operating & Maintenance Costs[2]			
Direct Operating Cost			
15. Labor	$	$	$
16. Maintenance	$	$	$
17. Replacement Parts	$	$	$
Indirect Cost			
18. Property Taxes*	$	$	$
19. Insurance	$	$	$
20. Fees	$	$	$
21. Total Annual Operating Costs (Add 15 Through 20)	$	$	$
Energy Cost			
22. Annual Electrical Energy Expense	$	$	$
23. Annual Auxiliary Fuel Cost	$	$	$
24. Total Annual Energy Cost (Add 22 and 23)	$	$	$
25. Annual Waste Treatment & Disposal Costs	$	$	$
26. Miscellaneous Annual Expenses	$	$	$
27. Annual Resource Recovery & Resale	$	$	$
28. Total Annualized Control Costs (14+21+24+25+26) - 27	$	$	$
29. Amount of Pollutant Controlled Over Baseline Emissions** (Tons Per Year)			
30. Cost of Control (Dollars Per Ton) (Divide 28 By 29)	$	$	$

*State and federal law may provide for certain tax exemptions and special loans for the purchase of control equipment. Contact the Massachusetts Industrial Finance Agency (MIFA) or Federal Small Business Association (SBA).

[2] See BACT Analysis for EMD Alternative

** Baseline Emissions are essentially uncontrolled emissions, calculated using realistic upper boundary operating assumptions.

D. Option Feasibility

Complete the table below to summarize the basis for elimination of each of the air pollution control technologies/techniques used to determine BACT for your proposed project:

Table 4	
Description of Air Pollution Control Technology/Technique Option	**Explain the Basis for Elimination[1]**
EMD	See BACT Analysis for EMD Alternative

[1] **Note:** BACT is defined as an emission limitation based on the maximum degree of reduction of any regulated air contaminant emitted from or which results from any regulated facility which MassDEP, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable. Explanations will be based upon the following:

Technical Reasons. Must specifically state the reason(s) why the option is not technically feasible and specifically why the option cannot be modified to accommodate the proposed emission unit(s).

Economic Reason. Final determination will be based on U.S. Environmental Protection Agency methods or other methods approved by MassDEP.

Other Reasons. Must specifically state the reason(s) why the option is not feasible and specifically why the option cannot be modified to accommodate the proposed emission unit(s).

E. Professional Engineer's Stamp

The seal or stamp and signature of a Massachusetts Registered Professional Engineer (P.E.) must be entered below. Both the seal or stamp impression and the P.E. signature must be original. This is to certify that the information contained in this Form has been checked for accuracy, and that the design represents good air pollution control engineering practice.

Lynne P. Santos
P.E. Name (Type or Print)

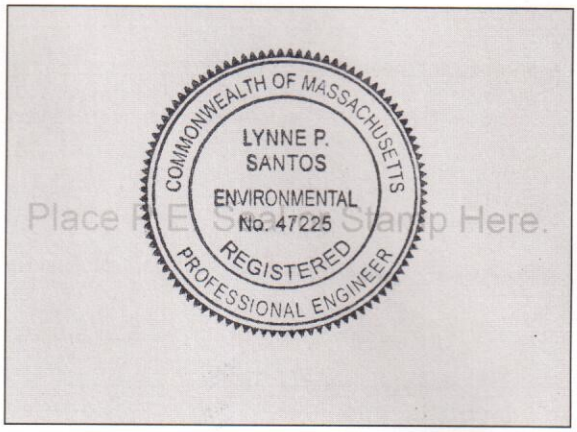
Lynne P Santos
P.E. Signature

Managing Consultant
Position/Title

Trinity Consultants
Company

07/23/2020
Date (MM/DD/YYYY)

47225
P.E. Number



F. Certification by Responsible Official

The signature below provides the affirmative demonstration pursuant to 310 CMR 7.02(5)(c)8 that any facility(ies) in Massachusetts, owned or operated by the proponent for this project (or by an entity controlling, controlled by or under common control with such proponent) that is subject to 310 CMR 7.00, et seq., is in compliance with, or on a MassDEP approved compliance schedule to meet, all provisions of 310 CMR 7.00, et seq., and any plan approval, order, notice of noncompliance or permit issued thereunder. This Form must be signed by a Responsible Official working at the location of the proposed new or modified facility. Even if an agent has been designated to fill out this Form, the Responsible Official must sign it. (Refer to the definition given in 310 CMR 7.00.)

I certify that I have personally examined the foregoing and am familiar with the information contained in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including possible fines and imprisonment.

Mr. Brad Shamla
Responsible Official Name (Type or Print)

Responsible Official Signature

Vice President, U.S. Operations
Responsible Official Title

Algonquin Gas Transmission, LLC
Responsible Official Company/Organization Name

07/23/2020
Date (MM/DD/YYYY)

This Space Reserved for MassDEP Approval Stamp.