COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

In the Matter of	)	**OADR Docket Nos. 2019-008 - 2019-013**
	)	**DEP File No.: Air Quality Application**
	)	**No. SE-15-027**
Algonquin Gas Transmission, LLC	)	**Weymouth, MA**

SUPPLEMENTAL PRE-FILED DIRECT TESTIMONY OF L. BARRY GOODRICH

I, L. Barry Goodrich, hereby state as follows:

1. I am a Senior Engineer in the Air Permitting group at Enbridge, Inc. ("Enbridge"). My business address is 5400 Westheimer Court, Houston, TX 77056.

2. I am providing this supplemental testimony on behalf of the Applicant, Algonquin Gas Transmission, LLC ("Algonquin"), to support the Massachusetts Department of Environmental Protection ("MassDEP") South Eastern Regional Office's ("SERO") administrative and technical review of Algonquin's Addendum to its Non-major Comprehensive Plan Application.[1/]

3. Attached hereto as Exhibit 1 is a copy of Algonquin's August 3, 2020 response (the "August 3 Response") to SERO's July 29, 2020 information request. I participated in or directed the development of the response in consultation with other Enbridge employees and/or consultants and determined that the substance of the responses is accurate and appropriate for this purpose.

4. Exhibit 1 includes an updated BWP AQ BACT Form, Table 1. I reviewed the

1/ Algonquin is a subsidiary of Enbridge.

updated BWP AQ BACT Form, Table 1 and determined that its substance was accurate and appropriate for this purpose.

5. Attached hereto as Exhibit 2 is Algonquin's August 5, 2020 response (the "August 5 Response") to SERO's August 3, 2020 information request, as resubmitted on August 7, 2020, with corrected table references. I participated in or directed the development of the response in consultation with other Enbridge employees and/or consultants and determined that the substance of the responses is accurate and appropriate for this purpose.

6. Attachment 1 to Exhibit 2 is an updated copy of the June 6, 2020 "Solar Technical Proposal for Electric Motor Drive Compressor Set - June 6, 2020," which includes gearbox performance data on page 45.

7. Attachment 2 to Exhibit 2 contains cost calculations revised to include costs associated with periodic oxidation catalyst change outs and testing for the SoLoNOx Taurus 60 turbine. I participated in or directed the development of Attachment 2 in consultation with other Enbridge employees and/or consultants and determined that the substance of Attachment 2 is accurate and appropriate for this purpose.

8. Attachment 3 to Exhibit 2 contains an August 3, 2020 letter from Solar Turbines, Inc. reflecting the "cost of a spare set of CO Catalyst media" in the amount of $93,000.

9. Attachment 4 to Exhibit 2 contains a June 17, 2020 proposal from Canomara LLC, an environmental consulting company specializing in stack testing, in the amount of $27,500.

10. Attachment 5 to Exhibit 2 contains excerpts from a Stipulation and Agreement filed by Algonquin with the Federal Energy Regulatory Commission (FERC), on May 15, 2020, and

approved by FERC Order on July 2, 2020, Docket No. RP19-57-000. Schedule 4 identifies Algonquin's 2.00% Transmission Plant depreciation rate.

11. Attached hereto as Exhibit 3 is Algonquin's August 7, 2020 response (the "August 7 Response") to SERO's August 5, 2020 information requests. I participated in or directed the development of the response in consultation with other Enbridge employees and/or consultants and determined that the substance of the response is accurate and appropriate for this purpose.

12. Exhibit 1 to Exhibit 3 is a copy of a June 11, 2020 email from Joseph Murphy (National Grid) to Laurence Smith (Enbridge).

13. Exhibit 2 to Exhibit 3 is a copy of the Atlantic Bridge Project Figure RR10 – Response 2C, created February 9, 2016, which identifies the approximate route of the underground cable that was used for costing purposes.

14. Along with this testimony, Algonquin will provide MassDEP with an Amended Addendum to its Non-major Comprehensive Plan Application ("Amended Addendum"), reflecting the updated information contained in Algonquin's responses to SERO's information requests. All amendments will be highlighted for ease of reference. The Amended Addendum demonstrates that an electric motor drive (EMD) alternative is not BACT for the Taurus 60 turbine element of the Facility. I personally participated in and directed the completion of the Amended Addendum and determined that the substance of the Addendum was accurate and appropriate for the purpose of making this demonstration.

Signed under the pains and penalties of perjury on August 7, 2020.

L. Barry Goodrich

Exhibit 1

From: Kate Brown <Kate.Brown@enbridge.com>
Sent: Monday, August 3, 2020 6:14 PM
To: Cushing, Thomas (DEP)
Cc: Barry Goodrich
Subject: RE: Algonquin Addendum questions
Attachments: Appendix E BWP AQ BACT_Table 1.pdf

Tom,
Please find attached the BWP AQ BACT Form, Table 1, which has been updated as you requested such that it identifies the proposed BACT limit for all pollutants.

Additionally, Algonquin provides the following response to your request. Please let me or Barry know if you need any additional information.

MassDEP Request: *In document "ADDENDUM TO NON-MAJOR COMPREHENSIVE PLAN APPROVAL APPLICATION" page 4-17 states "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." Please substantiate the assumption that there is not significant variability in costs.*

Algonquin Response: Indirect annual costs of property taxes, insurance, and the administration costs are defined in EPA's OAQPS Cost Control Manual in Section 1 Chapter 2.6.5.8. as follows:

> *[Property taxes, insurance, and administrative costs] are factored from the system **total capital investment**, at 1, 1, and 2%, respectively. Property taxes and insurance are self-explanatory. Administrative charges cover sales, research and development, accounting, and other home office expenses. […] For simplicity, the three items are usually combined into a single, 4% factor. These estimates can serve for cost estimates if sources do not have any reliable and accurate information on these indirect operating costs.*

Total Capital Investment is defined in Section 1 Chapter 2.4.1 of EPA's OAQPS Cost Control Manual as:

> *Total capital investment (TCI) includes all costs required to purchase equipment needed for the control system (purchased equipment costs), the costs of labor and materials for installing that equipment (direct installation costs), costs for site preparation and buildings, and certain other costs (indirect installation costs). TCI also includes costs for land, working capital, and off-site facilities.[4] Taxes, permitting costs, and other administrative costs are covered in Section 2.6.5.8.*

The 4% factor for property taxes, insurance and administration costs, identified in the Cost Control Manual assumes that these costs are variable only as a factor of the total TCI of the option being evaluated. In its Addendum, Algonquin determined that the TCI associated with an EMD alternative would exceed the TCI associated with the SoLoNOx turbine by $12,242,077, while conservatively assuming that the property taxes, insurance, and administrative costs would be the same (i.e., zero differential) for both options. *See* Addendum § 4.4.3.1. and Table 4-6. Applying the 4% rate from the Cost Control Manual would have increased the difference in TCI between the EMD and the SoLoNOx turbine by $489,683 ($12,242,077*.04=$489,683). *See* Addendum, Table 4.6. Therefore, including the property taxes, insurance, and administrative costs at the OAQPS rate of 4% would have resulted in a higher cost per ton of emissions removed for the EMD alternative than calculated by Algonquin. Because Algonquin did not have a basis to conclude that property taxes, insurance and administration costs for the EMD alternative in this case would actually exceed those costs for

the SoLoNOx turbine, it made the more conservative assumption that they would not vary significantly and that these costs for an EMD alternative would not be greater than those associated with a SoLoNOx turbine.

Kate Brown
Consulting Scientist
Air Permitting

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TEL: 207-274-2607 | CELL: 207-232-0095 | Kate.Brown@enbridge.com
6 Ashley Drive, Scarborough, ME 04074

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Safety. Integrity. Respect.

From: Cushing, Thomas (DEP) <thomas.cushing@state.ma.us>
Sent: Wednesday, July 29, 2020 2:59 PM
To: Barry Goodrich <Barry.Goodrich@enbridge.com>
Cc: Kate Brown <Kate.Brown@enbridge.com>
Subject: [External] Algonquin Addendum questions

Barry,
Based on my review to date, I am requesting the following clarifications:

1. In document "ADDENDUM TO NON-MAJOR COMPREHENSIVE PLAN APPROVAL APPLICATION" page 4-17 states "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." Please substantiate the assumption that there is not significant variability in costs.
2. Department form "BWP AQ BACT," which was included as Appendix E in the Addendum only identifies the proposed emission limit (i.e. BACT) for NOx. Please update Table 1 such that it identifies the proposed BACT limit for all pollutants.

I may request additional documentation or clarifications as necessary as my review of your submittal progresses.

Thomas Cushing
Permit Section Chief
MassDEP, Southeast Region
(508) 946-2824

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

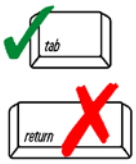
Facility ID (if known)

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 ►

Exhibit 2

From: Barry Goodrich <Barry.Goodrich@enbridge.com>
Sent: Friday, August 7, 2020 11:19 AM
To: Cushing, Thomas (DEP); Kate Brown
Cc: Brad Shamla; Lynne Santos
Subject: RE: Algonquin request for clarifying information
Attachments: Response to MassDEP 08-03-20 Data Request-TABLE UPDATE.pdf

Tom –

Attached please find Algonquin's updated response to your information request dated August 3, 2020. This update aligns the table numbers in this memo with those in the BACT addendum for clarity purposes.

If you have any questions, please let me know.

Thanks,

Barry Goodrich,
Senior Engineer
Air Projects

ENBRIDGE
TEL: 713-627-4484 | CELL: 281-806-8181 | FAX: 713-989-8347 | barry.goodrich@enbridge.com
5400 Westheimer Ct, Houston, Tx 77056

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Safety. Integrity. Respect.

From: Cushing, Thomas (DEP) <thomas.cushing@state.ma.us>
Sent: Monday, August 3, 2020 4:56 PM
To: Barry Goodrich <Barry.Goodrich@enbridge.com>; Kate Brown <Kate.Brown@enbridge.com>
Subject: [External] Algonquin request for clarifying information

Based on my continuing review of your BACT addendum and supporting information, I am requesting clarification on the following:

1. In the "Addendum to nonMajor CPA" (file name Final Algonquin Atlantic Bridge Weymouth…) Table 4-1 identified a gearbox efficiency and a motor efficiency 94.4% and 97.13% respectively. Please identify the basis of these efficiencies.
2. Certain Capital costs such as, but not necessarily limited to costs associated with periodic CO catalyst change out were not included in the BACT cost analysis. Please ensure that costs associated with periodic CO catalyst change out and any other capital costs associated with the EMD or the turbine are included in the BACT cost analysis.
3. Certain annual costs, such as routine compliance testing were not included in the BACT cost analysis. Please ensure that all annual costs associated with the EMD or turbine are included in the BACT cost analysis.
4. The pre-filed testimony of Barry Goodrich, Appendix 1 consists of a letter from Solar dated July 23, 2020 which states the annual maintenance cost differential between the EMD and the turbine is $207,403.11 per

year. Please identify the types of maintenance costs associated with the turbine and the EMD that were included in this cost differential.

5. The BACT analysis for the EMD used a project life expectancy of 50 years and an interest rate of 10.137% whereas the BACT analysis for the SCR in the initial application was based on equipment life expectancy of 20 years and an interest rate of 7%. Please explain the basis for the change in assumptions.
6. The BACT addendum, Table 4-9 establishes baseline emissions based on emission limits in Table 8A of the August 29, 2019 Plan Approval. Section 4.4.3.3.1 of the BACT Addendum discusses the basis for the baseline emissions for NOx. Please provide a discussion of baseline emissions for each pollutant. In particular, please discuss why the baseline for CO and VOC are based on emissions post control (oxidation catalyst).

To aid in my timely review, please submit the response to each item as soon as it is ready.

Please contact me if you have any questions.

Thomas Cushing
Permit Section Chief
MassDEP, Southeast Region
(508) 946-2824

memo

Date: August 7, 2020

To: Mr. Thomas Cushing, MassDEP Southeast Regional Office

From: Mr. Barry Goodrich, Enbridge

Cc: Mr. Brad Shamla, Enbridge
Ms. Kate Brown, Enbridge

Re: **Response to MassDEP Request for Clarifying Information on BACT Analysis for EMD Alternative Weymouth Compressor Station (Transmittal No. X266786)**

Below and attached please find Algonquin Gas Transmission, LLC's (Algonquin) response to your August 3, 2020 email requesting clarifying information on certain aspects of the BACT Analysis for EMD Alternative, which was submitted on July 24, 2020 as an Addendum to the Non-Major Comprehensive Plan Approval Application for the Weymouth Compressor Station (Addendum).

MassDEP Request 1: *In the "Addendum to non Major CPA" (file name Final Algonquin Atlantic Bridge Weymouth…) Table 4-1 identified a gearbox efficiency and a motor efficiency 94.4% and 97.13% respectively. Please identify the basis of these efficiencies.*

Algonquin Response: Appendix D of the Addendum submitted on July 24, 2020 contains "Solar Technical Proposal for Electric Motor Drive Compressor Set – June 6, 2020." An updated version of the proposal is provided in Attachment 1 and includes gearbox performance data on page 45. Voith/gearbox losses are listed as 1.0595%. Therefore, the gearbox efficiency is calculated as:

$$Gearbox\ Efficiency = \frac{1}{1.0595} = 94.4\%$$

Table 4-1 of the Addendum outlines the derivation of EMD electricity requirements starting from the maximum mechanical output to the compressor shaft specified for the SoLoNO$_X$ Taurus 60 turbine (7,758 HP). The EMD proposal is for a 9,000 HP (mechanical output) unit. Therefore, the motor output required to deliver 7,758 HP to the compressor shaft, taking into account gearbox efficiency losses, is:

$$Maximum\ Motor\ Output = \frac{7{,}758\ HP}{94.4\%} = 8220\ HP$$

Therefore, the EMD will operate at 91.3% load (8220 HP/9000 HP). On page 85 of "Solar Technical Proposal for Electric Motor Drive Compressor Set – June 6, 2020," the technical specifications for the EMD list the following efficiency data:

Load	Efficiency
100%	97.24%
75%	96.93%

A linear interpolation of this data provides the motor efficiency at 91.3% load:

$$Motor\ Efficiency\ @\ 91.3\%\ Load = 97.24\% - \frac{(100\% - 91.3\%)}{(100\% - 75\%)} \times (97.24\% - 96.93\%) = 97.13\%$$

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MassDEP Request 2: *Certain Capital costs such as, but not necessarily limited to costs associated with periodic CO catalyst change out were not included in the BACT cost analysis. Please ensure that costs associated with periodic CO catalyst change out and any other capital costs associated with the EMD or the turbine are included in the BACT cost analysis.*

Algonquin Response: Below is an updated Table 4-7 of the Addendum which includes the costs associated with periodic CO catalyst change out. Algonquin has conservatively assumed the catalyst life span to be three years 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. Please see Attachment 2 for the revised cost calculations and Attachment 3 for the catalyst cost quote. This revision to annual operating costs for the gas turbine impacts the resulting $/ton values. Algonquin has not identified any additional capital costs associated with the turbine or EMD.

Table 4-7. Direct Annual Costs Comparison of EMD Driver vs. SoLoNO$_X$ Taurus 60 Turbine Driver[1]

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**	

MassDEP Request 3: *Certain annual costs, such as routine compliance testing were not included in the BACT cost analysis. Please ensure that all annual costs associated with the EMD or turbine are included in the BACT cost analysis.*

Algonquin Response: Algonquin has also updated Table 4-7 of the Addendum to include the costs associated with routine compliance testing for the SoLoNOx Taurus 60 turbine. Attachment 4 contains a quote in the amount of $27,500 for the turbine stack testing to be performed at the Weymouth Compressor Station to demonstrate initial compliance. 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. Please see Attachment 2 for the revised cost calculations. This revision to annual operating costs for the gas turbine impacts the resulting total annual cost of the EMD driver and $/ton values. Therefore, Addendum Tables 4-8, 4-10, 4-11, 4-13 and 4-14 have been updated accordingly and are provided below. These updates also impact the cost sensitivity analysis provided in Figures 4-2 and 4-3 of the Addendum which are also provided below. Algonquin has not identified any additional annual costs associated with the EMD or turbine.

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**

[1] See Attachment 2 for detailed cost analysis with references for each line item.

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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

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

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

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Figure 4-2. Average Cost Analysis Sensitivity

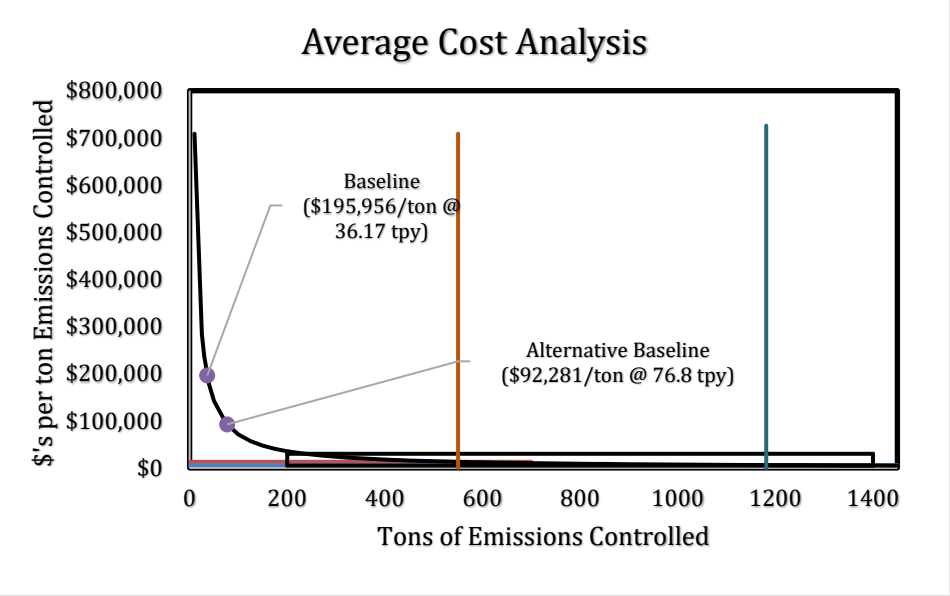
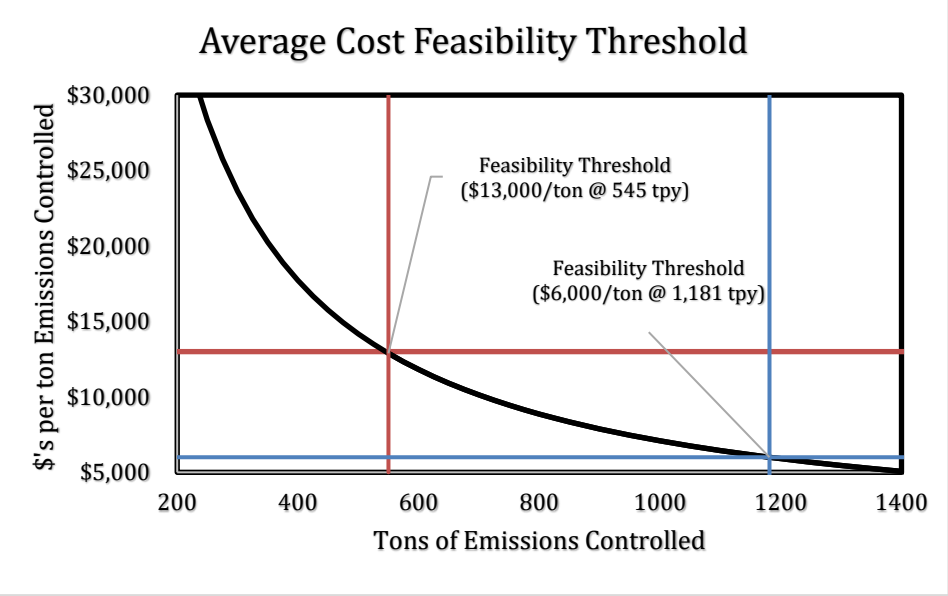


Figure 4-3. Up-Close Average Cost Feasibility Threshold Sensitivity



Algonquin will supply an amended Addendum reflecting the updated information contained herein. All amendments will be highlighted for ease of reference.

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MassDEP Request 4: *The pre-filed testimony of Barry Goodrich, Appendix 1 consists of a letter from Solar dated July 23, 2020 which states the annual maintenance cost differential between the EMD and the turbine is $207,403.11 per year. Please identify the types of maintenance costs associated with the turbine and the EMD that were included in this cost differential.*

Algonquin Response: The maintenance costs of $207,403 represent the cost differential between the higher cost complete maintenance contract for the gas turbine, which includes manufacturer recommended maintenance inspections, tuning and periodic overhauls, and the complete maintenance contract for the EMD's more limited maintenance requirements.

MassDEP Request 5: *The BACT analysis for the EMD used a project life expectancy of 50 years and an interest rate of 10.137% whereas the BACT analysis for the SCR in the initial application was based on equipment life expectancy of 20 years and an interest rate of 7%. Please explain the basis for the change in assumptions.*

Algonquin Response: The SCR BACT analysis was last updated in May 2018 and utilized default values in the OAQPS Cost Manual's SCR chapter available at the time the analysis was performed. "NMCPA Update Permit Application Transmittal No X266786 (Revised May 2018)" provided the cost analysis for SCR in Attachment E. According to Table 1, Attachment E, the 7% interest rate was based on OAQPS Manual, Section 4.2, Chapter 2, page 2-50 and the 20-year equipment life was based on OAQPS Manual, Section 4, Chapter 2, page 2-48. This section of the OAQPS Manual was updated in June 2019.

The Addendum submitted on July 24, 2020, provides details related to the cost analysis for EMD in Appendix C. As set forth in Section 4.4.3.2.2 of the Addendum narrative and Table 1, Appendix C, the 10.137% nominal interest rate represents Algonquin's current after-tax real rate of return, as calculated using Algonquin's 2019 FERC Financial Report Form No.2. According to the OAQPS Manual, Section 1, Chapter 2 (pp. 14 – 17), company-specific nominal interest rates should be used if available. While this rate was not used for the SCR cost analysis provided in 2018, the use of a lower interest rate of 7% resulted in a more conservative assessment of costs related to SCR control.

The 50-year equipment life is based on Algonquin's 2.00% Transmission Plant depreciation rate. This depreciation rate is the latest approved depreciation rate and was part of the Stipulation and Agreement filed on May 15, 2020 and approved by FERC Order on July 2, 2020. Excerpts from the Stipulation and Agreement are attached hereto as Attachment 5 (*see* Schedule 4 thereto). Algonquin used the facility wide depreciation schedule of 50 years because the EMD alterative involves the replacement of the entire gas turbine system and is expected to have a substantially longer equipment life. For the SCR system, Algonquin used a shorter time frame because the expected equipment life for an SCR system is significantly shorter due to the use of corrosive materials (e.g., ammonia or urea) inherent to SCR air pollution control technology.

MassDEP Request 6: *The BACT addendum, Table 4-9 establishes baseline emissions based on emission limits in Table 8A of the August 29, 2019 Plan Approval. Section 4.4.3.3.1 of the BACT Addendum discusses the basis for the baseline emissions for NOx. Please provide a discussion of baseline emissions for each pollutant. In particular, please discuss why the baseline for CO and VOC are based on emissions post control (oxidation catalyst).*

Algonquin Response: Section 4.4.3.3.1 of the Addendum provides the following excerpt from the NSR Workshop Manual (pp. 37-38) as justification for the use of the permitted emission levels for the SoLoNO$_X$ Taurus 60 at Weymouth:

> *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 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.*

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The evaluation of EMD as a “control technology” is actually the replacement of the proposed SoLoNO$_X$ Taurus 60 equipped with oxidation catalyst. Therefore, the baseline should take into account the proposed constraints on emissions for the proposed source (i.e., the SoLoNO$_X$ Taurus 60 equipped with oxidation catalyst.). Furthermore, the proposed source would be subject to enforceable permit limits resulting in the potential emission rates provided in Table 4-9 of the Addendum, which are not achievable without the oxidation catalyst installed. Therefore, these are the realistic upper-bound baseline emission levels in the EMD scenario.

Nonetheless, while lean premix technology is an inherent combustion design feature of modern gas turbines, oxidation catalysts are add-on air pollution control devices. Therefore, a more conservative analysis would not take the oxidation catalyst into account. In addition, not all gas turbines are provided the emissions guarantees provided by Solar Turbines, which are the basis for the NO$_X$, CO and VOC baseline emission values in Table 4-9. Accordingly, the Addendum provides alternative, more conservative, baseline potential emissions in Table 4-12 which are calculated based on emission rates provided in AP-42, Chapter 3.1. *See* Addendum, Section 4.4.3.3.3. MassDEP may use these alternative rates for assessment of CO and VOC baseline emissions in particular, as they are representative of steady-state emission levels measured from a broader population of gas turbines (limited only to lean, premix design for NO$_X$ and CO factors) with no add-on controls. As noted in the Addendum, since AP-42 factors only consider steady-state operation, emissions during startup, shutdown and low temperature operation have also been accounted for in the alternative baseline values and assume no add-on controls as well.

Attachment 1 – Updated Solar Technical Proposal for Electric Motor Drive Compressor Set

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

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.

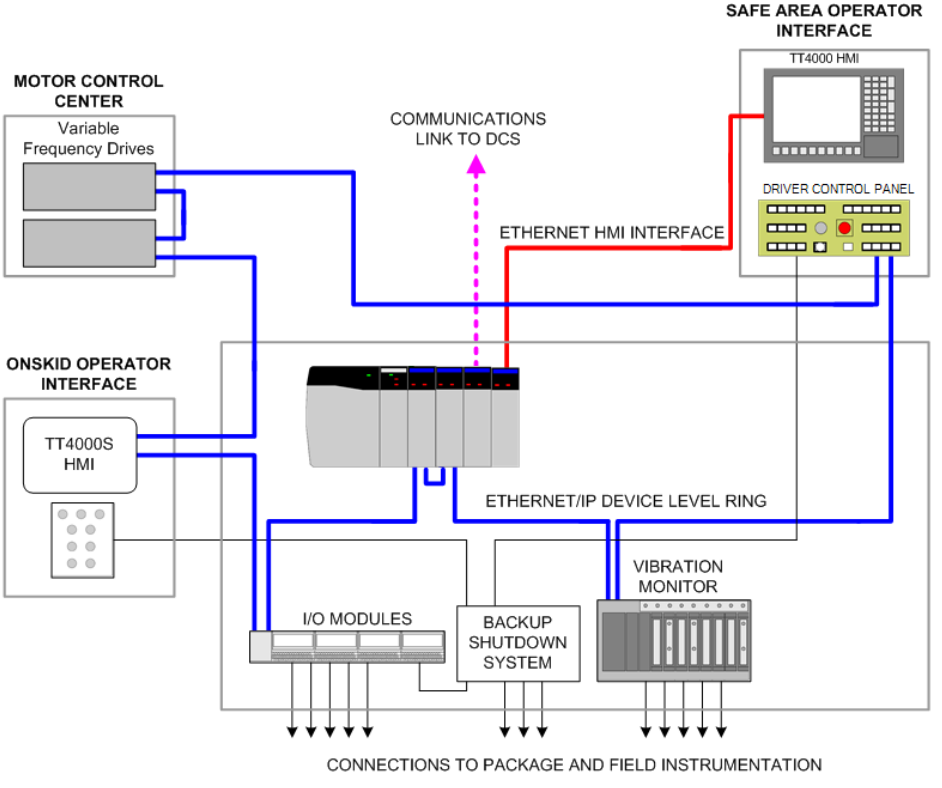
System Architecture

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)

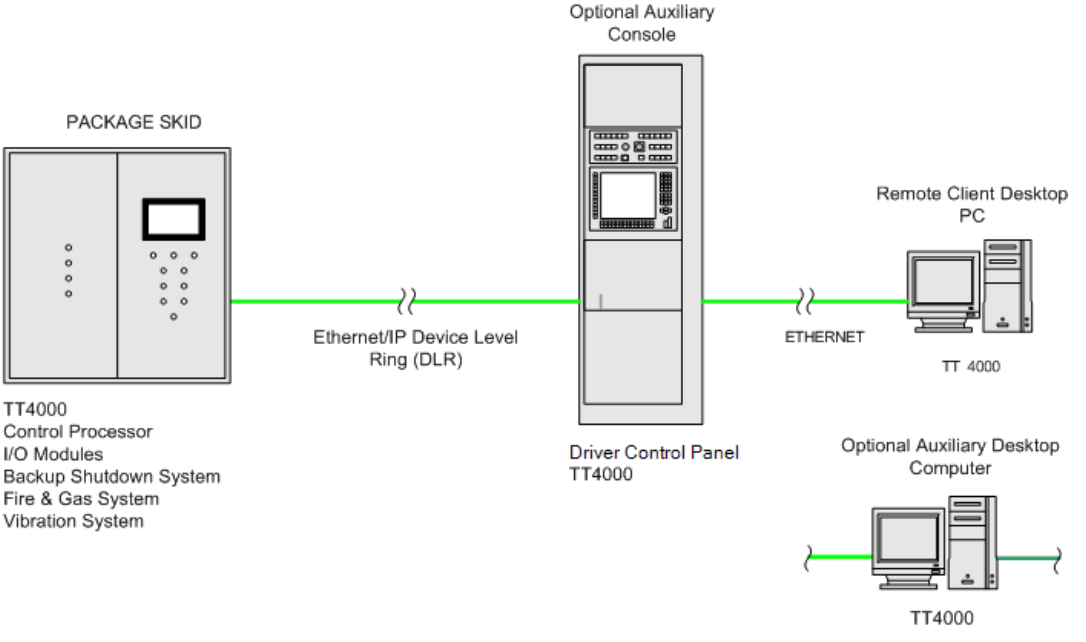
Cooldown and fast stops correspond to the manual normal and emergency stops respectively. Lockout stops inhibit operation of the control system and prevent restarting until the malfunction is reset. Lockout stops result from serious malfunctions that require corrective action before the system can be 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.

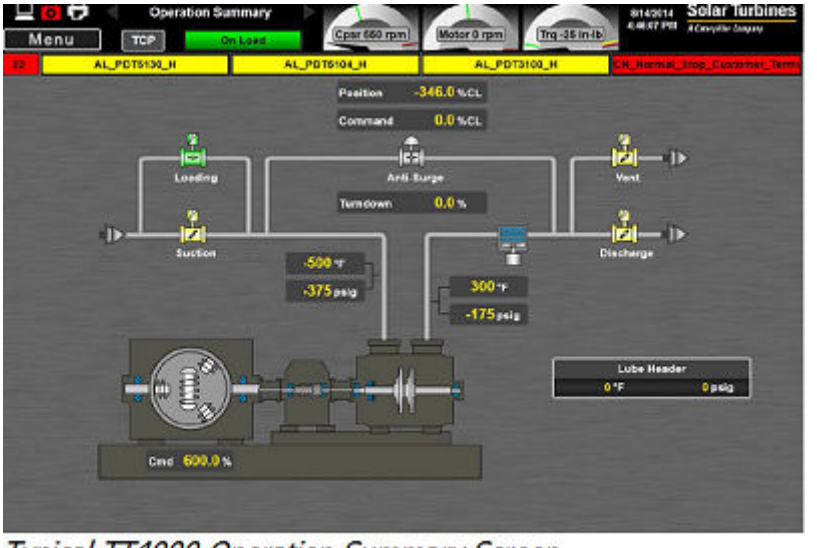
Trigger Log - data are read at one-second intervals for 6 minutes before a “trigger” event that is defined in the software. The standard trigger is a shutdown. Six minutes before the trigger of data are written to a file. Up to 50 trigger logs files can be stored.

TT4000 Display Screens

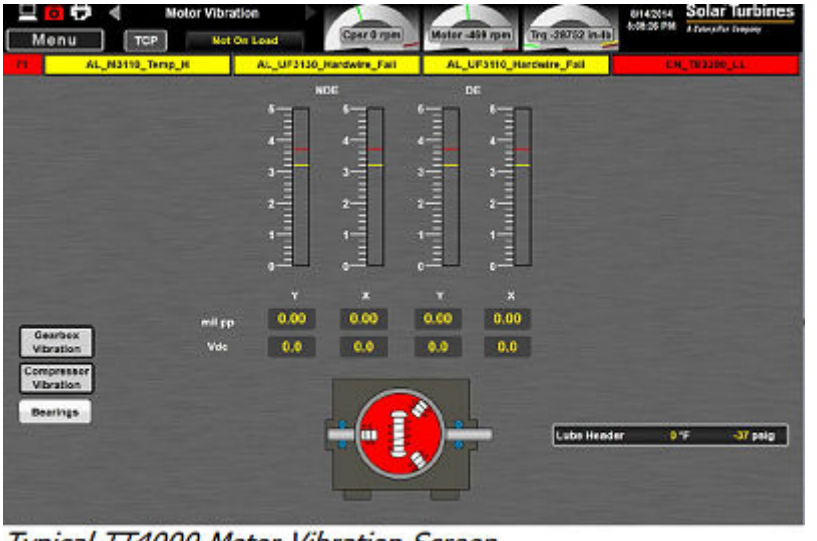
A status bar at the top of every screen displays up to four alarm conditions. Standard display screens include:

- 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

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.

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.

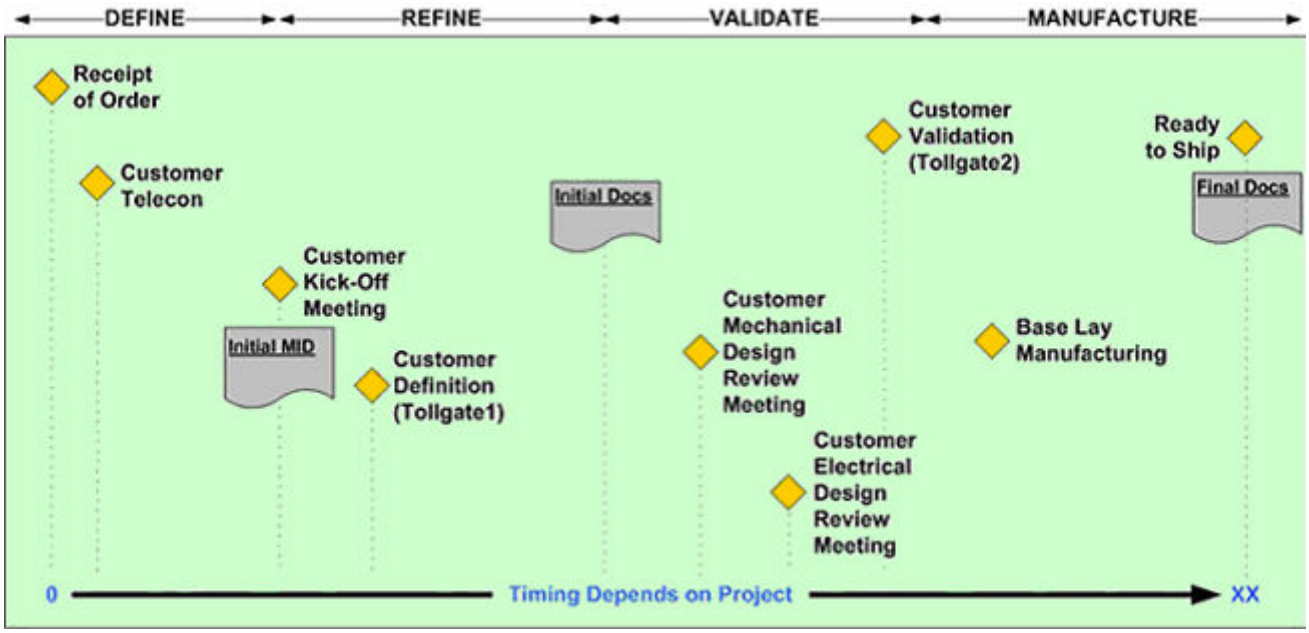
The tooling will include:

- 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

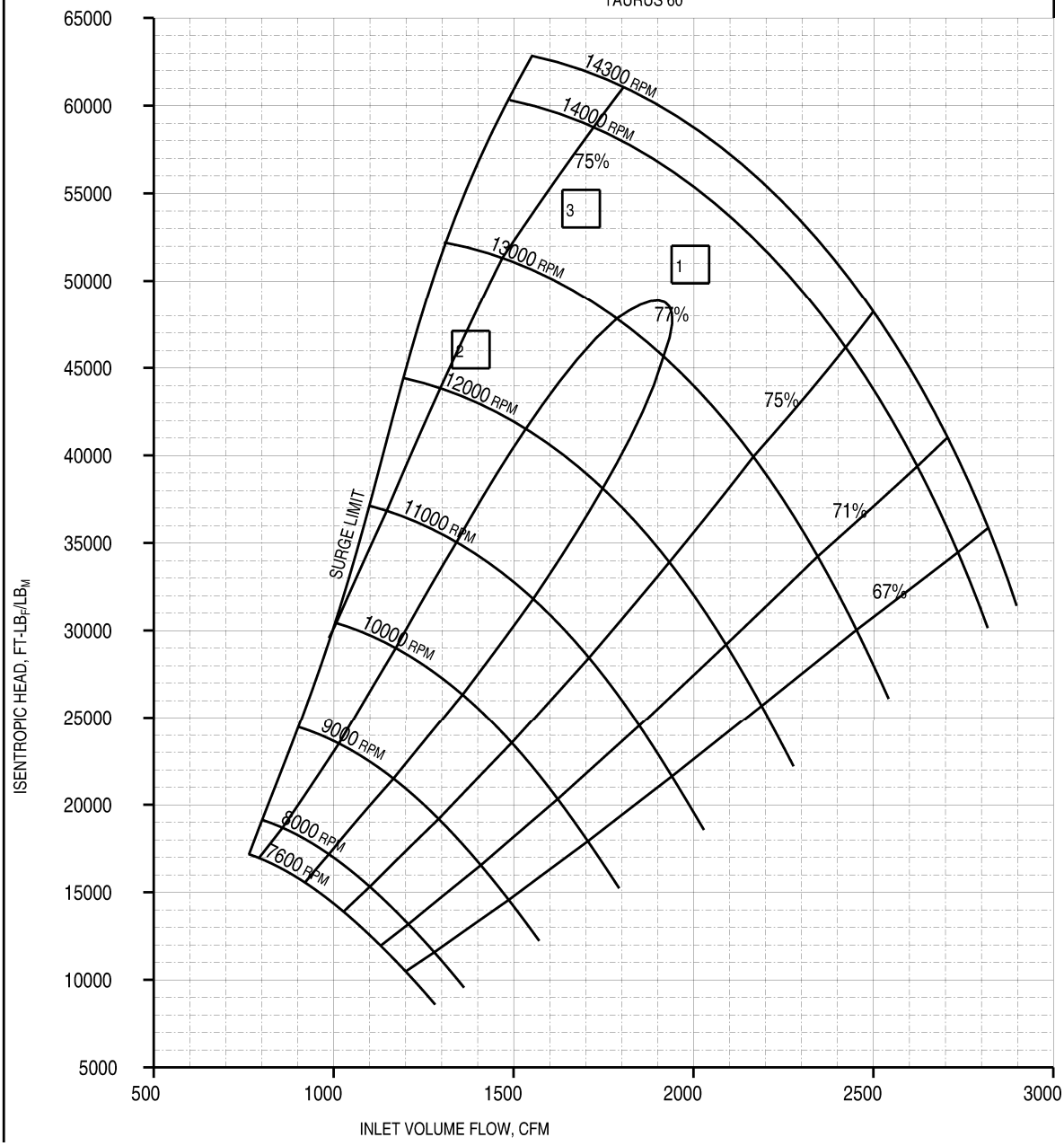
CONTROL NO.
I-36972 SHT.1
ISSUE DATE
12 AUG. 2015
ENGINEER
R. ZAMOTORIN

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

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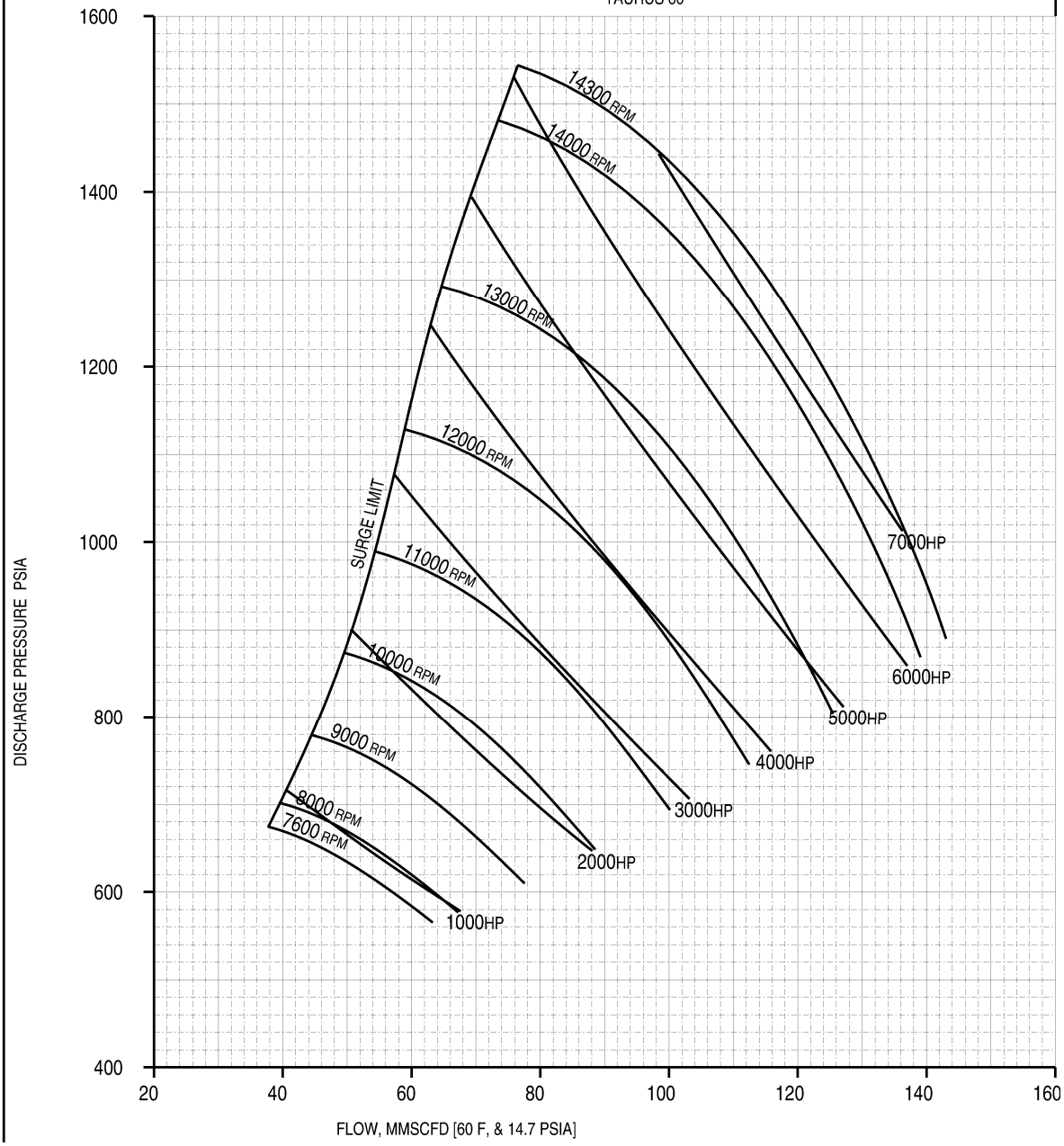
TAURUS 60



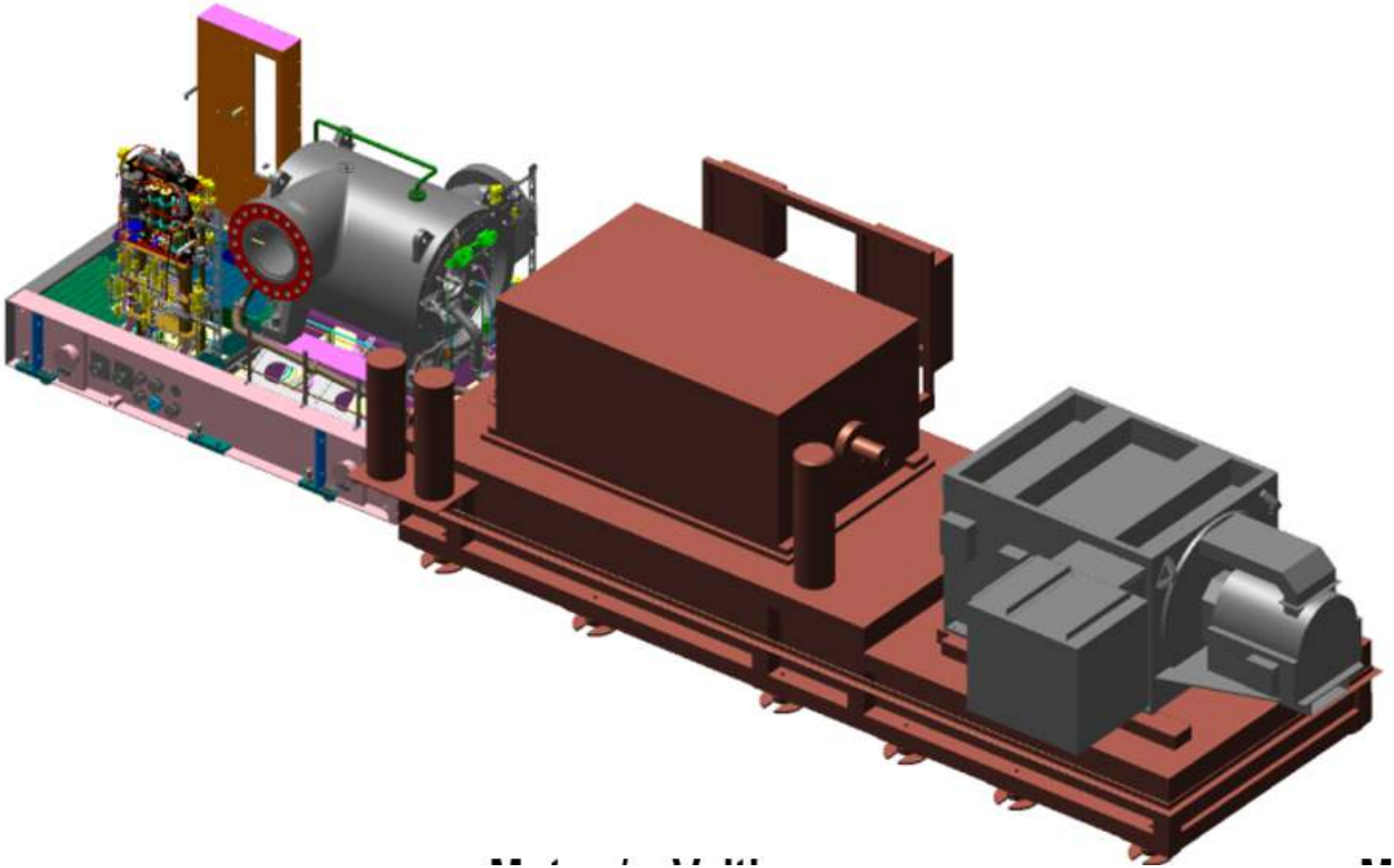
3.1.3 DRIVEN EQUIPMENT PERFORMANCE DATA

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:

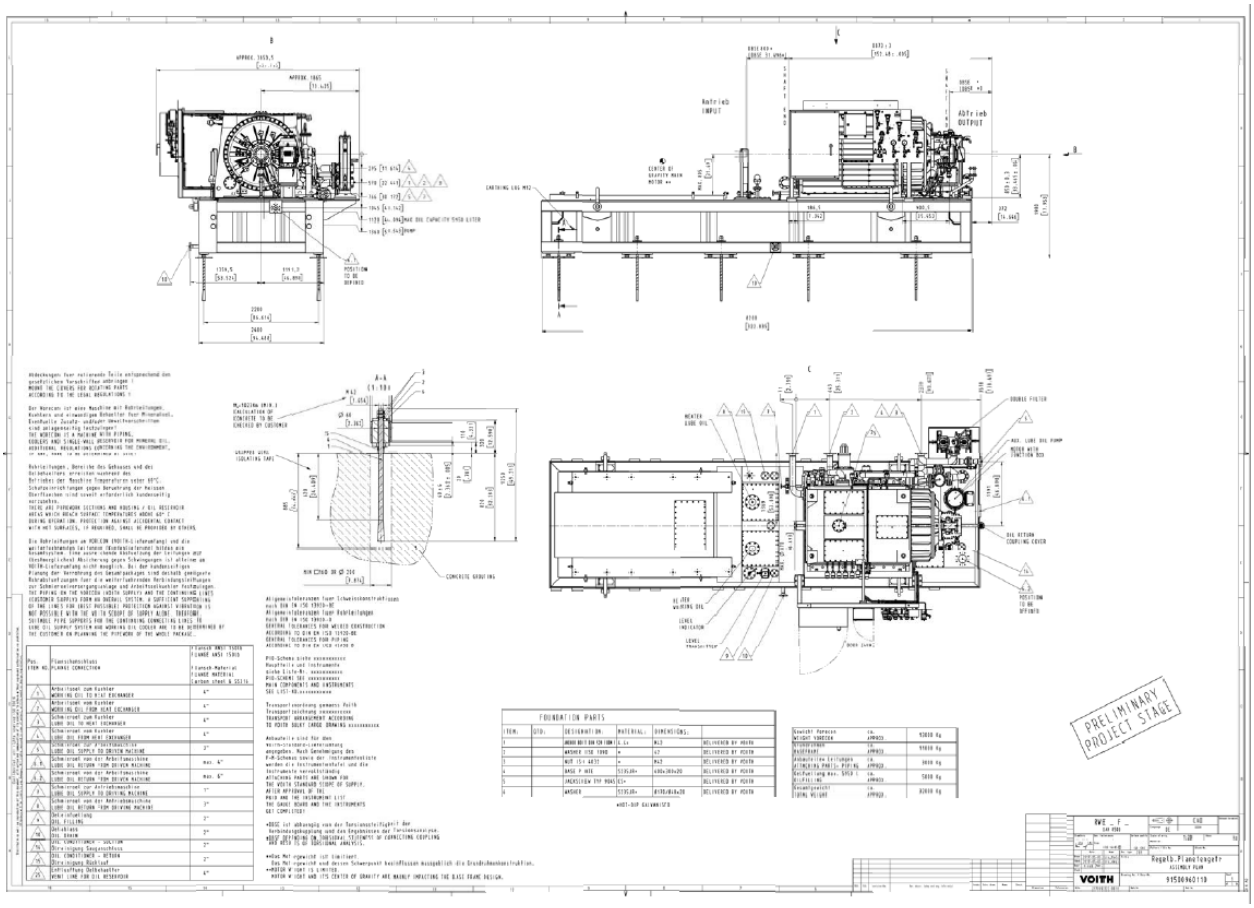
- Preliminary Vorecon general arrangement.

- Preliminary P&ID

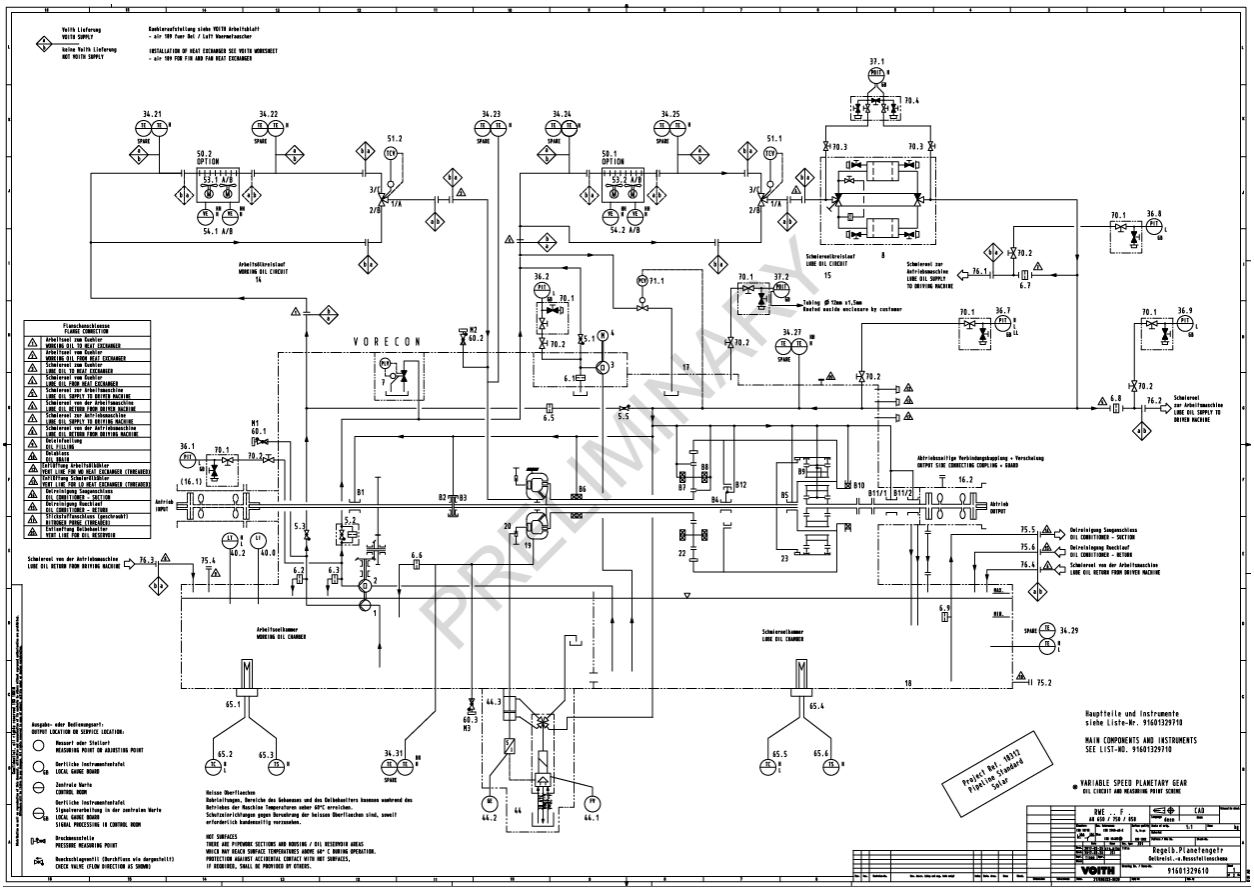
- Preliminary instrument list

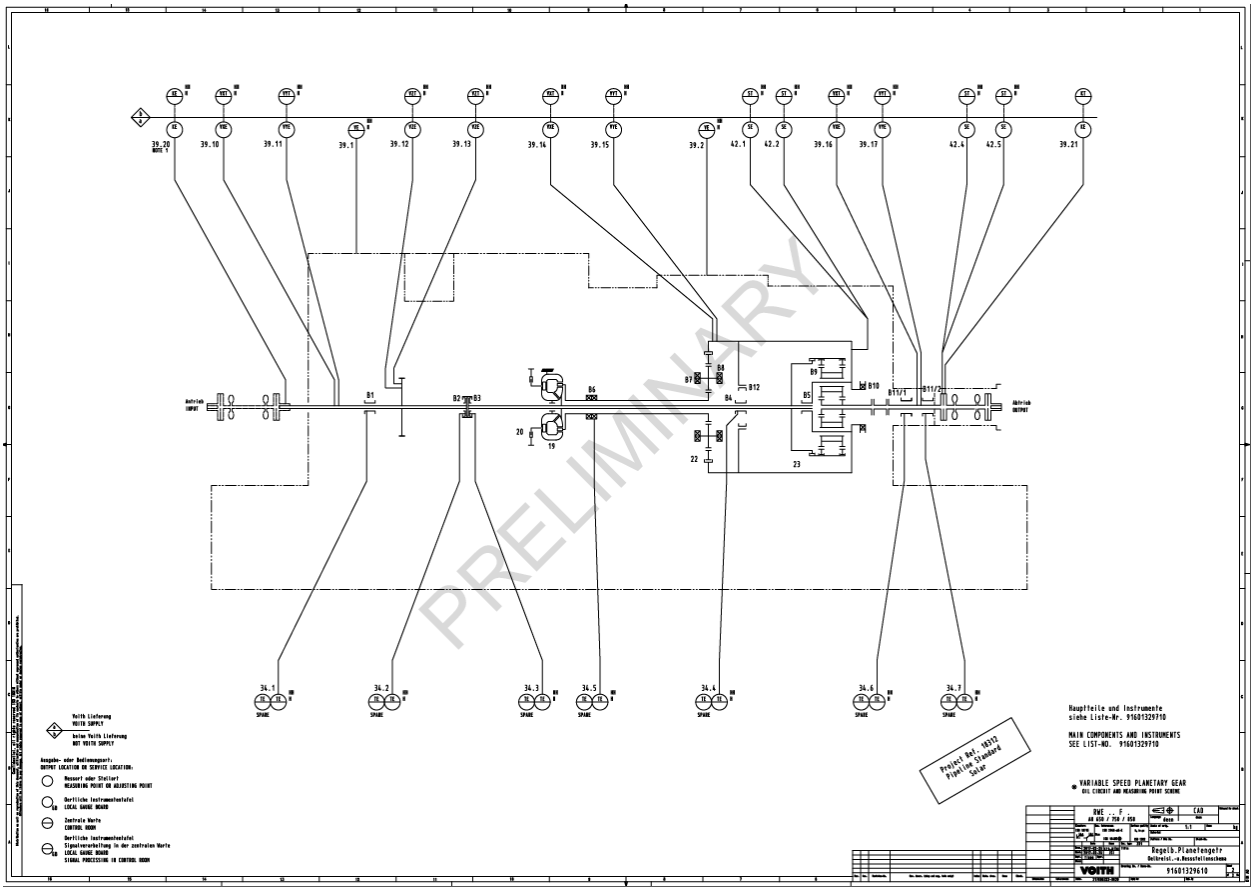
In the event of an order Voith needs the approval of Operating Map, QCP and the direction of rotation.

Preliminary Vorecon General Arrangement



Preliminary P&ID





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	-	-	-

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	-	-	-

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)

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.

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

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

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

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

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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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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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)

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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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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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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-	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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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.

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
-	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

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
-	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	-	-	-	-	-	-	-

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
-	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

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		

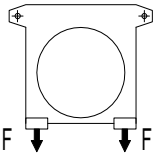
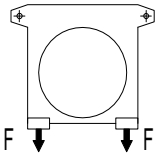
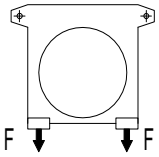
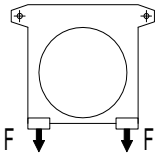
E. Starting characteristics

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					

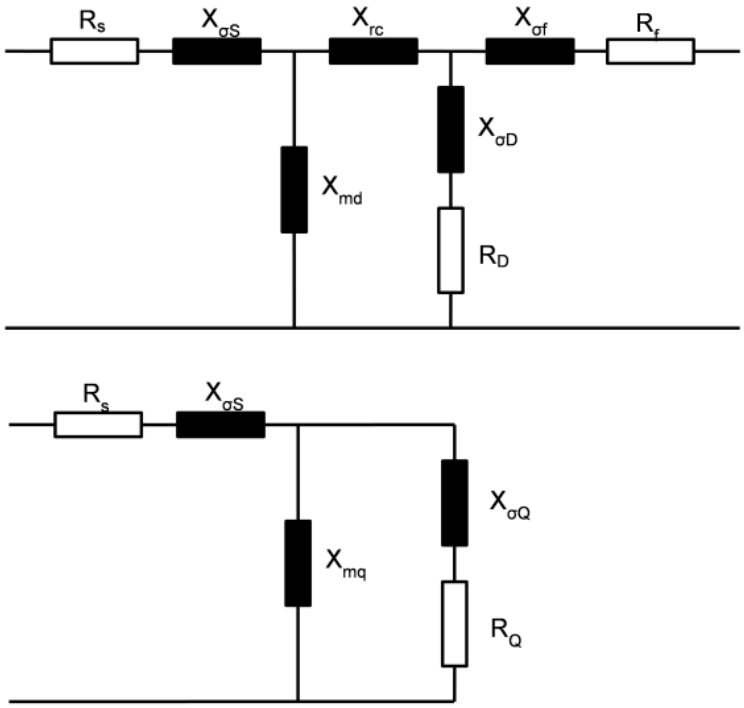
F. Installation data

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

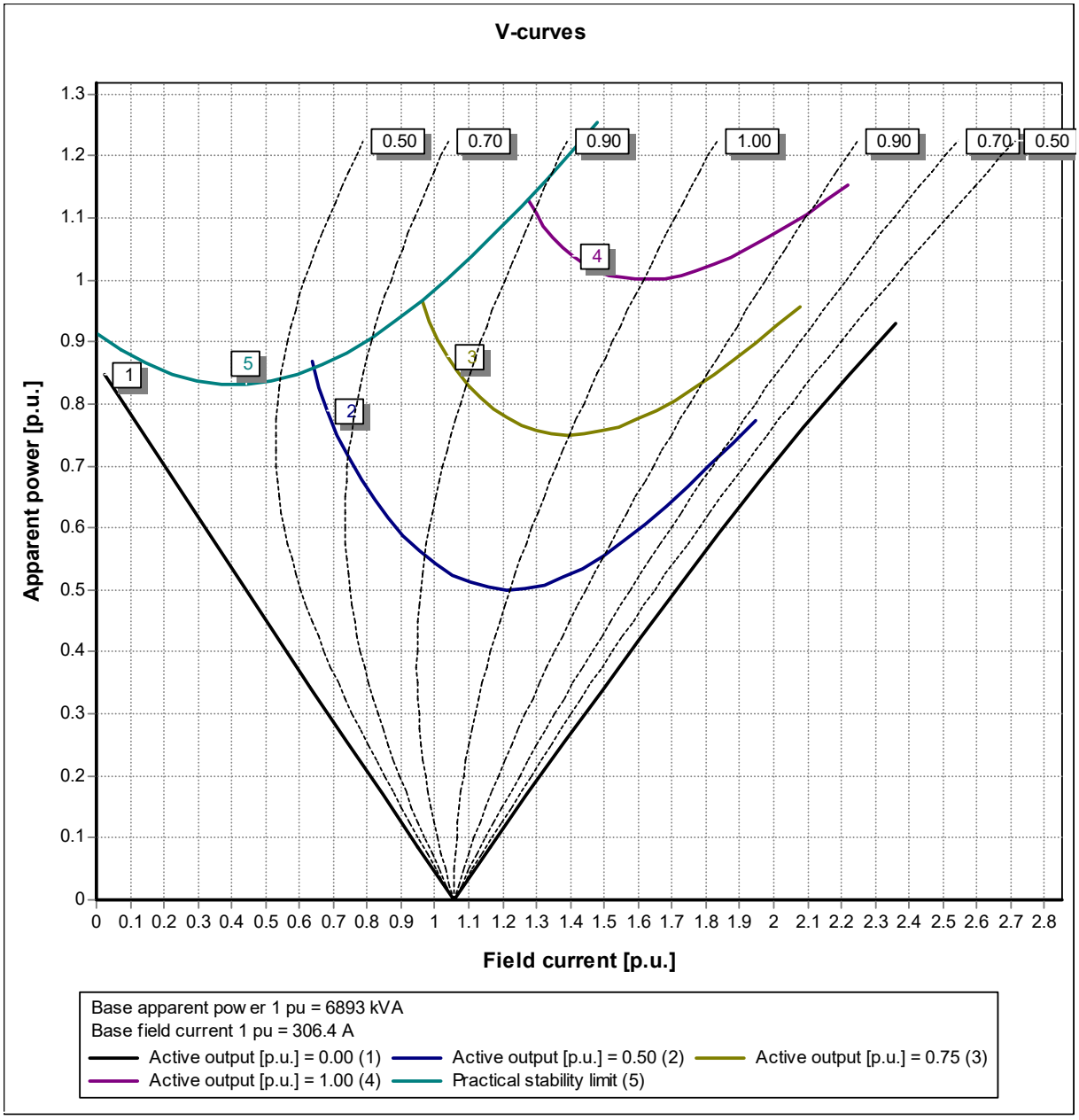
$T_e(t) = M_0 e^{-t/\tau_0} \sin \omega t - M_1 e^{-t/\tau_1} \sin 2\omega t + M_2 e^{-t/\tau_2}$

$M_0 = 4.21$; $M_1 = 2.12$; $M_2 = 0.914$; $\tau_0 = 0.124$ s ; $\tau_1 = 0.561$ s ; $\tau_2 = 0.294$; $\omega = 377$ rad/s

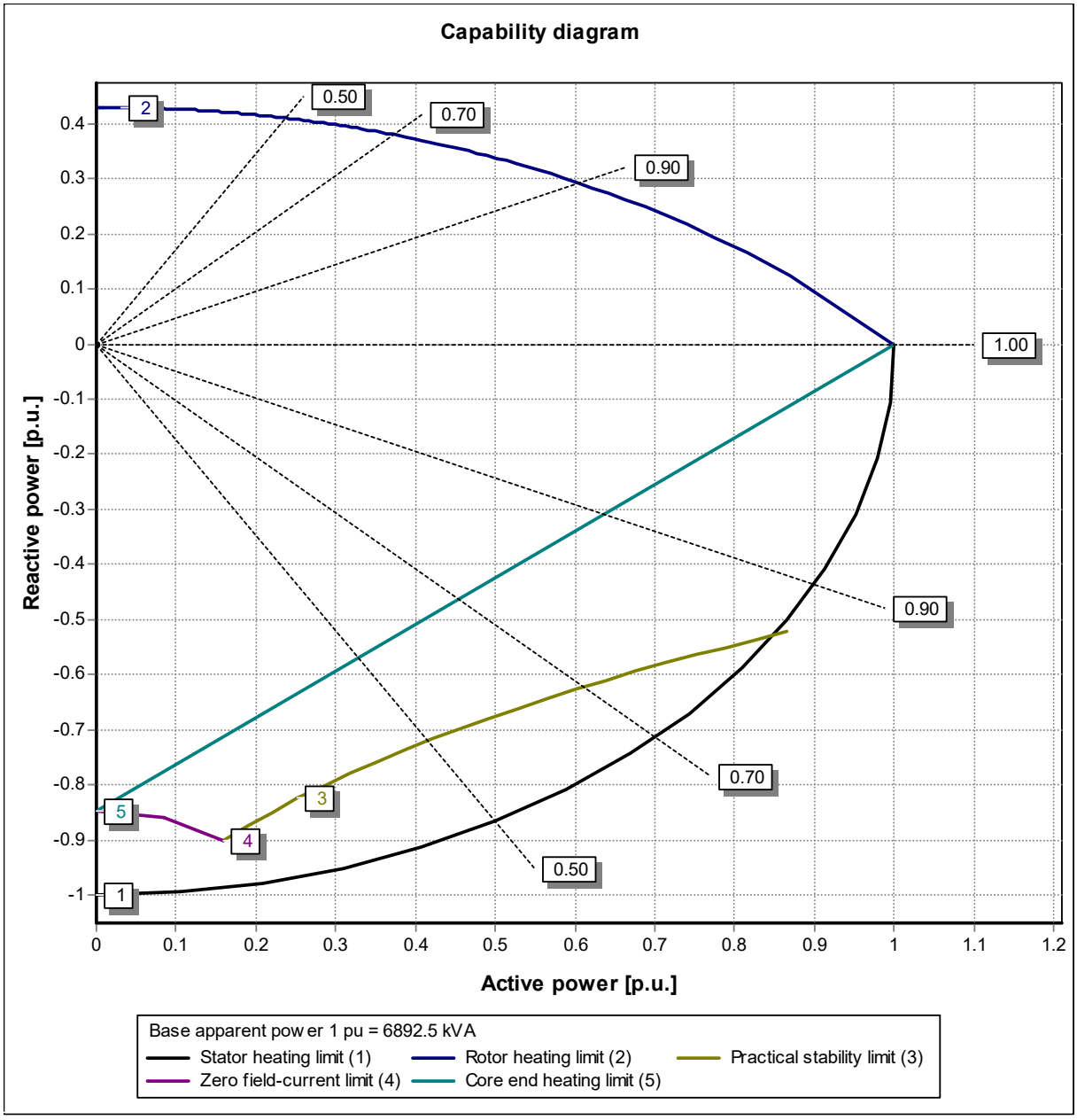
Maximum value of torque 6.2 * T_N, when t = 5.55 ms

Rated torque T_N = 35.6 kNm

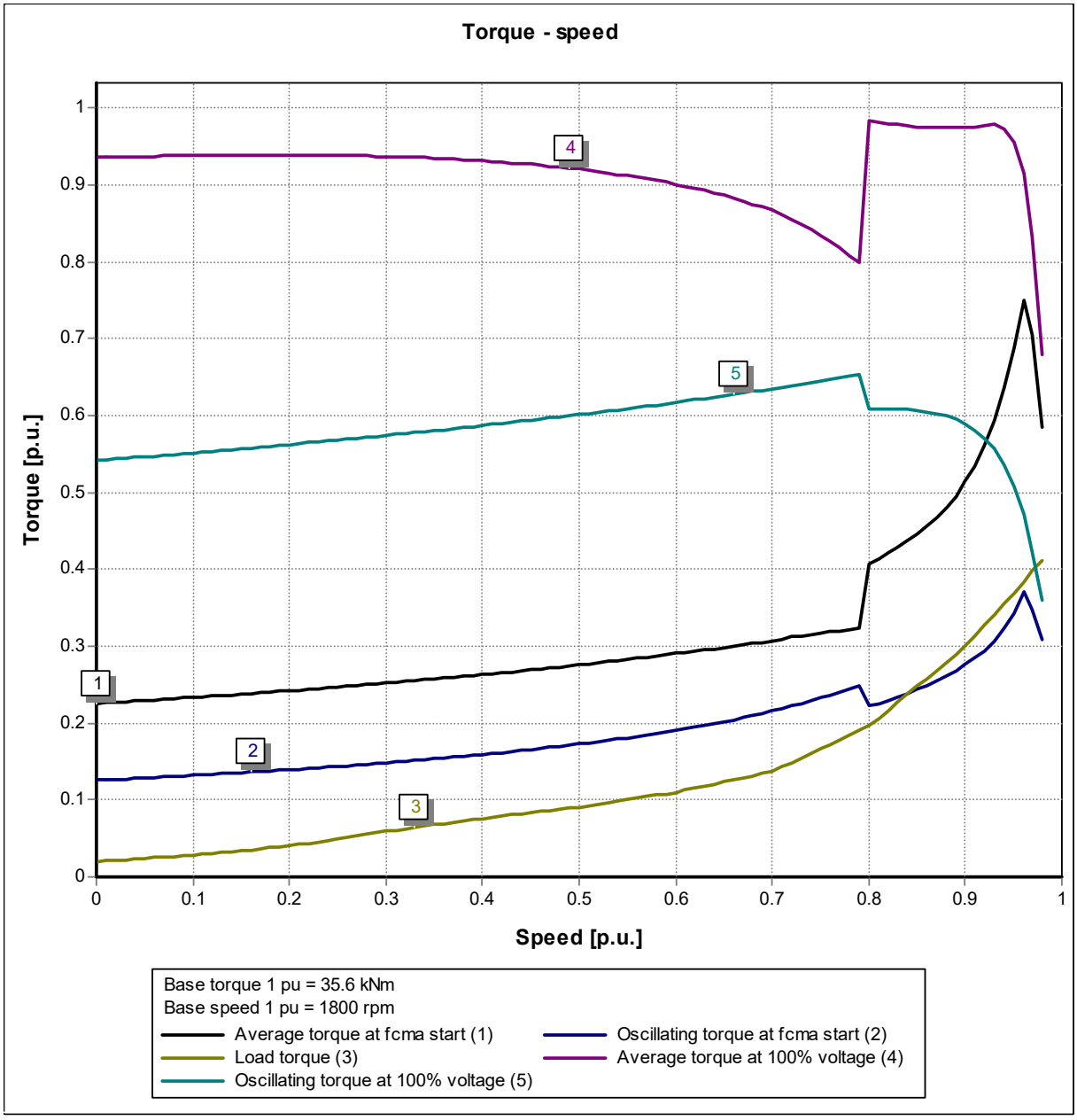
Motor type code: AMS 800L4P BSNT



Motor type code: AMS 800L4P BSNT



Motor type code: AMS 800L4P BSNT



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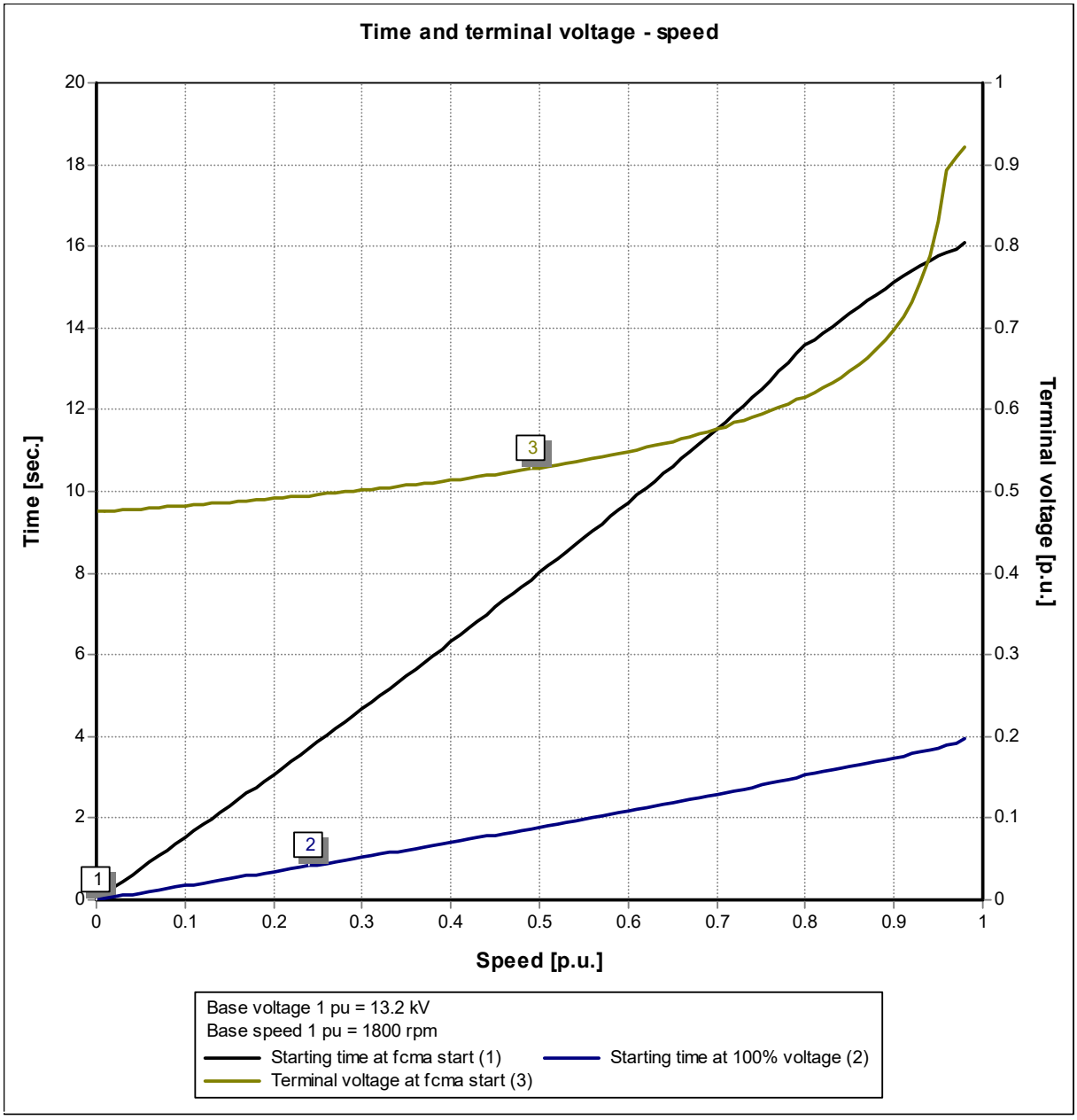

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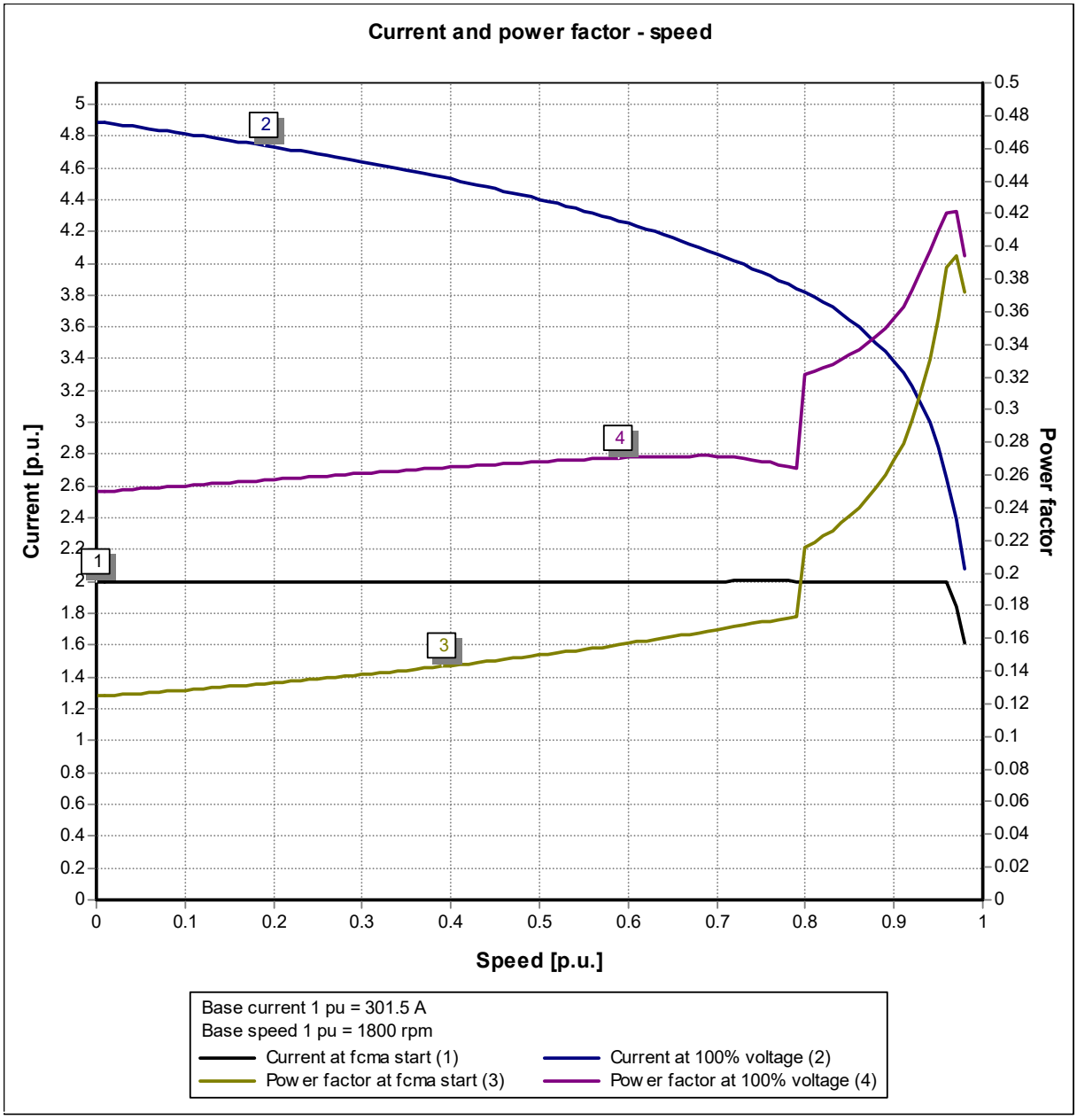

Attachment 2 – Revised Addendum Appendix C, Tables 1, 2, 3, and 4

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 3. 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**			

Attachment 3 – Catalyst Vendor Information

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.

Attachment 4 – Stack Testing Quote

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

Attachment 5 – Excerpts from Stipulation and Agreement Document showing Depreciation Rate

Algonquin Gas Transmission, LLC
5400 Westheimer Court
Houston, TX 77056-5310
(713) 627-5400

May 15, 2020

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: *Algonquin Gas Transmission, LLC*, Docket No. RP19-57-000
Offer of Settlement

Dear Ms. Bose:

Pursuant to Rule 602 of the Rules of Practice and Procedure of the Federal Energy Regulatory Commission ("Commission"), 18 C.F.R. § 385.602 (2019), Algonquin Gas Transmission, LLC ("Algonquin") hereby submits for filing a Stipulation and Agreement ("Settlement") and related materials that would resolve all remaining issues arising in Docket No. RP19-57-000. All participants listed on Schedule 1 to the Settlement either support or do not oppose the Settlement. The Settlement is the result of numerous discussions among Algonquin, its customers, and other interested stakeholders following Algonquin's submission of its FERC Form No. 501-G pursuant to the Commission's Order No. 849.[1]

The Settlement, which is the result of extensive negotiations among Algonquin and the active participants in this proceeding, should be considered as an integrated package. Any modification to, or condition placed upon, the Settlement could jeopardize the careful balance of various interests that is reflected in the Settlement, potentially resulting in further litigation and the expenditure of Commission and participant resources.

Prompt consideration and approval of this Settlement will provide certainty to Algonquin and its customers.

In accordance with Rule 602(c),[2] included with this filing are the following materials:

- Explanatory Statement;
- Stipulation and Agreement, including *pro forma* tariff records; and
- Certificate of Service.

[1] *Interstate and Intrastate Natural Gas Pipelines; Rate Changes Relating to Federal Income Tax Rate*, Order No. 849, 83 Fed. Reg. 36,672 (July 30, 2018), FERC Stats. & Regs. ¶ 31,404 (cross-referenced at 164 FERC ¶ 61,031).
[2] 18 C.F.R. § 385.602(c) (2019).

If there are any questions concerning this filing, please contact me at (713) 627-5215.

Sincerely,

/s/ Steven E. Hellman
Steven E. Hellman
Associate General Counsel
Algonquin Gas Transmission, LLC

cc: All Parties

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Algonquin Gas Transmission, LLC	)	Docket No. RP19-57-000

EXPLANATORY STATEMENT OF
STIPULATION AND AGREEMENT

Pursuant to Rule 602 of the Federal Energy Regulatory Commission's ("FERC" or "Commission") Rules of Practice and Procedure[1] Algonquin Gas Transmission, LLC ("Algonquin") hereby files this Explanatory Statement relating to the Stipulation and Agreement appended hereto (the "Settlement") on behalf of itself and all shippers and other interested parties listed on Schedule 1 to the Settlement ("Party" individually, or "Parties" collectively).

I. BACKGROUND

The purpose of the Settlement is to resolve issues related to Algonquin's Form No. 501-G informational filing ("One-time Report") filed on October 11, 2018 pursuant to the Commission's "Final Rule" issued in Order No. 849,[2] and addressing rate changes relating to federal income tax rates and the Commission's Revised Policy Statement on Treatment of Income Taxes.[3] Pursuant to the Final Rule, Algonquin elected Option 3, and filed an explanation of why no rate change is needed. After the One-time Report, Algonquin subsequently held settlement conferences with its customers on June 21, 2019; July 16, 2019; August 22, 2019; December 9, 2019; January 16, 2020; February 6, 2020; and February 12, 2020. A settlement in principle was reached among the vast majority of the participants on February 12, 2020, and additional participants subsequently joined

[1] 18 C.F.R. § 385.602 (2019).
[2] *Interstate and Intrastate Natural Gas Pipelines; Rate Changes Relating to Federal Income Tax Rate*, 164 FERC ¶ 61,031 (2018).
[3] *Inquiry Regarding the Commission's Policy for Recovery of Income Tax Costs*, Revised Policy Statement on Treatment of Income Taxes, 162 FERC ¶ 61,227, *order on reh'g*, 164 FERC ¶ 61,030 (2018).

as supporting or non-opposing parties following limited modifications to the settlement terms. Based on the settlement discussions to date, Algonquin understands that the Settlement is uncontested.

II.
DESCRIPTION OF SETTLEMENT

The Settlement provides for a complete resolution of the issues in the above-captioned docket. The Settlement, if approved, will benefit all parties by saving valuable time and resources through the avoidance of further litigation, will lead to certainty for the parties at an earlier date, and will remove the uncertainty involved in obtaining a Commission order on the merits. The following is a brief description of the terms of the Settlement.

Section 2.1(A) states that the Settlement shall become effective on the Settlement Effective Date. The "Effective Date" is the first day of the first calendar month following the date on which Algonquin receives an Acceptable Order.

Section 2.1(B) defines "Acceptable Order" as a final Commission order, no longer subject to rehearing or appeal, approving the Settlement: (i) as filed and without modification or condition, with the exception of ministerial conditions, (ii) with modification or condition that does not materially and adversely affect a Party; (iii) with a modification or condition that materially and adversely affects a Party, if such Party does not provide notice that it either no longer supports or now opposes the Settlement due to such modification or condition ("Notice of Opposition to FERC Condition"); or (iv) with a modification or condition that materially and adversely affects a Party, and such Party provides a Notice of Opposition to FERC Condition, if the Parties have agreed to modify the Settlement consistent with the FERC order or the Settlement becomes effective without the provision modified by the FERC order.

Section 2.1(C) provides that in the event that any Party provides a Notice of Opposition to FERC Condition, the Parties have agreed to meet and negotiate in good faith to modify the Settlement in a way that preserves the intent of the Parties as closely as possible; and, if the Parties cannot achieve mutual agreement on modifications consistent with the Commission order, the Settlement will become effective without the provision modified by the FERC order, provided that deletion of the provision does not increase the Settlement rates.

Section 2.1(D) discusses when an order shall be considered final and no longer subject to rehearing or appeal.

Section 2.2 provides that all discovery requests and responses exchanged to facilitate the Settlement negotiations, and all Settlement discussions, shall be treated as privileged and confidential.

Section 3.1 provides that the rates established pursuant to the Settlement will be set out in Schedule 3-A of the Settlement, which consists of the *pro forma* Settlement Tariff Records containing the agreed-upon rates necessary to implement the settlement, to be effective on June 1, 2020. The tariff records in Schedule 3-A reflect the rolled-in rate treatment of certain mainline incremental services, including the conversion of Rate Schedule AFT-4 to Rate Schedule AFT-1 service and the Rate Schedule AFT-4 shipper receiving the attendant Rate Schedule AFT-1 secondary point rights.

Section 3.2 provides that the terms established pursuant to the settlement will be set out in Schedules 3-B and 3-C of the Settlement, which consist of the *pro forma* Settlement Tariff Records containing the terms necessary to implement the settlement, to be effective as defined in Section 3.3 of the Settlement.

Section 3.3 requires that Algonquin file revised tariff records substantively identical to those included in Schedule 3 as soon as reasonably practicable, but no later than twenty (20) days following the Settlement Effective Date to implement the Settlement and that Algonquin request the filed tariff records on Schedule 3-A become effective on June 1, 2020; the filed tariff records on Schedule 3-B become effective the first day of the first month following the date of the Settlement Compliance Filing; and the filed tariff records on Schedule 3-C become effective on the earlier of October 1, 2020, or the first day of the first month following the date of the Settlement Compliance Filing.

Section 3.4 describes the procedure by which Algonquin will refund each shipper. Algonquin shall provide, as applicable, refunds for the period extending from June 1, 2020 until the Settlement Effective Date. The refunds shall be calculated on a customer by customer basis with any rate increases netted against any rate decreases without regard to service, or type of rate, or rate component, and all refund amounts shall include interest at the FERC interest rate, and be reported on a refund report filed with the Commission within thirty (30) days of the date the refunds are made.

Section 3.5 describes the procedure by which Algonquin will collect from each shipper the difference, if any, between (i) the amounts collected for service provided during the Refund Period (as defined in the Settlement) and (ii) the amounts that would have been collected during the Refund Period had the Settlement Rates been effective as of June 1, 2020. The collections are calculated with the same netting procedures and inclusion of interest as refunds pursuant to Section 3.4.

Section 4.1 provides that the Settlement depreciation and negative salvage rates are set forth on Schedule 4.

Section 4.2 governs Algonquin's amortization of Excess Deferred Income Taxes ("EDIT"). Algonquin shall amortize $22,789,328 (before income tax gross-up) of unprotected EDIT over a 5 year period and it will amortize $302,278,897 (before income tax gross-up) of protected EDIT over a 32.27 year period. The amortization of these amounts shall start June 1, 2020.

Section 4.3 provides that the Settlement Rates reflect an allocation of costs in the amount of $1,833,284 to the interruptible rate schedules, Rate Schedules AIT-1 and PAL.

Section 4.4 provides that Algonquin shall continue its current practice of conducting meetings with its customers on an annual basis and specifies Algonquin's obligations related to transparency regarding its maintenance management program.

Section 4.5 provides that if the first Rate Change Filing (as defined in Section 4.5) subsequent to the Settlement Effective Date is a Natural Gas Act ("NGA") Section 4 rate case, the witness sponsoring the intercompany and corporate allocations in support of Algonquin's as-filed case shall sponsor and include as support for such costs and allocations all applicable intercompany service agreements governing the service company structure for operations and administration.

Section 4.6 requires that Algonquin apply a 12.50 percent return on equity component in the calculation of incremental rates for new Algonquin projects.

Section 4.7 describes the procedure by which Algonquin will make certain payments to the Verplanck Fire District and the procedure by which Algonquin will recover such payments through the administration of a monthly demand surcharge that will apply to all contracts between Algonquin and a local distribution company regulated by the New York State Public Service Commission.

Section 4.8 requires that Algonquin and the other Parties engage in a formal consultation process related to the review and recovery of actual integrity and modernization costs and potential

new and mutually agreed to reliability and modernization programs. Section 4.8 also addresses the Commission's Policy Statement on Cost Recovery Mechanisms for Modernization of Natural Gas Facilities in Docket No. PL15-1.

Article V provides that neither Algonquin nor any Party may file under Section 4 or Section 5 of the NGA to revise any provision of the Settlement with an effective date that occurs, following any applicable suspension period, before October 1, 2021. Article V also includes a comeback provision stating that Algonquin shall file a general Section 4 NGA rate case with a filing date that is no later than June 1, 2024.

Article VI contains various miscellaneous provisions.

Article VII describes the effect of the approval of the Settlement, including the fact that such approval terminates the proceeding and sets forth rights reserved by the Parties. Article VII also establishes that the applicable standard of review for any future modification of the Settlement shall be the "just and reasonable" standard.

III.
INFORMATION TO BE PROVIDED WITH SETTLEMENT AGREEMENTS

On December 15, 2016, the Chief Administrative Law Judge issued an Amended Notice to the Public requiring that each settlement filed with the Commission address the following four questions:

(A) whether the settlement affects other pending cases;

(B) whether the settlement involves issues of first impression;

(C) whether the settlement departs from Commission precedent; and

(D) whether the settlement seeks to impose a standard of review other than the ordinary just and reasonable standard with respect to any changes to the settlement that might be sought by either a third party or the Commission acting sua sponte.

A. Impact on Other Pending Cases

The Settlement does not impact other pending cases.

B. Issues of First Impression

The Settlement addresses no issues of first impression. There have been no known previous reversals on the issues involved in the Settlement.

C. Departures from Commission Precedent

The Settlement is not contrary to Commission precedent.

D. Standard of Review

The applicable standard of review for changes to the terms of the Settlement during the term of this Settlement shall be the just and reasonable standard and not the public interest standard.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Algonquin Gas Transmission, LLC Docket No. RP19-57-000

STIPULATION AND AGREEMENT

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Algonquin Gas Transmission, LLC	)	Docket No. RP19-57-000

STIPULATION AND AGREEMENT

Pursuant to Rule 602 of the Rules of Practice and Procedure of the Federal Energy Regulatory Commission ("**FERC**" or "**Commission**"), 18 C.F.R. § 385.602 (2019), Algonquin Gas Transmission, LLC ("**Algonquin**") hereby submits for approval this Stipulation and Agreement ("**Settlement**") as an integrated and comprehensive settlement of the issues raised in the above-captioned docket and, upon receipt of an Acceptable Order (as defined in Section 2.1.B), the proceeding in this docket shall terminate. Each of the customers and other participants listed on Schedule 1 has affirmatively agreed that such participant either supports this Settlement in full or does not oppose this Settlement ("**Supporting or Non-Opposing Parties**"). Algonquin and the Supporting or Non-Opposing Parties are referred to herein individually as a "**Party**" or collectively as the "**Parties**." Algonquin respectfully requests that the Commission (i) approve the Settlement in its entirety without modification or condition, and (ii) grant any necessary authorizations under the Natural Gas Act ("**NGA**")[1] and any waivers of its regulations, rules, orders, or policies or any currently-effective Algonquin tariff record necessary to effectuate the Settlement set forth herein.

[1] 15 U.S.C. § 717, *et seq.* (2018).

ARTICLE I
BACKGROUND AND DEFINITIONS

1.1 Background

On October 11, 2018, Algonquin filed its Form No. 501-G informational filing ("**One-time Report**") pursuant to the Commission's "Final Rule" issued in Order No. 849.[2] The Final Rule established new Commission regulations that require interstate natural gas pipelines to provide an informational filing, the Form No. 501-G, addressing rate changes relating to federal income tax rates and the Commission's Revised Policy Statement on Treatment of Income Taxes,[3] and to choose one of four options: (1) file a limited NGA Section 4 rate reduction filing, (2) make a commitment to file a general section 4 rate case in the near future, (3) file an explanation of why no rate change is needed, or (4) take no action (other than filing the Form No. 501-G).[4] The Commission issued a 501-G Implementation Guide setting forth filing deadlines for each pipeline.[5] In its filing of the One-time Report, Algonquin elected Option 3 and provided an explanation of why no rate change was needed. Multiple parties submitted comments on the One-time Report, and Algonquin thereafter hosted an informational session with interested customers to provide additional cost information.[6]

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[2] *Interstate and Intrastate Natural Gas Pipelines; Rate Changes Relating to Federal Income Tax Rate*, 164 FERC ¶ 61,031 (2018).
[3] *Inquiry Regarding the Commission's Policy for Recovery of Income Tax Costs*, Revised Policy Statement, 162 FERC ¶ 61,227, *order on reh'g*, 164 FERC ¶ 61,030 (2018).
[4] 18 C.F.R. § 360.402.
[5] Implementation Guide for One-time Report on Rate Effect of the Tax Cuts and Jobs Act, Version: August 1, 2018, available at: https://www.ferc.gov/whats-new/comm-meet/2018/031518/G-1-guide.pdf (establishing the October 11, 2018 filing deadline for Algonquin).
[6] Supplemental Information of Algonquin Gas Transmission, LLC, Docket No. RP19-57-000 (submitted Dec. 19, 2018).

Algonquin subsequently held settlement conferences with its customers and other participants on June 21, 2019; July 16, 2019; August 22, 2019; December 9, 2019; January 16, 2020; February 6, 2020; and February 12, 2020. A settlement in principle was reached among the vast majority of the participants on February 12, 2020, and additional participants subsequently joined as supporting or non-opposing parties following limited modifications to the settlement terms. This Settlement memorializes the specific terms of the agreement reached by the Parties.

1.2 Definitions

The terms defined in the Settlement are listed on Schedule 2.

ARTICLE II
SETTLEMENT EFFECTIVENESS

2.1 Settlement Effective Date

A. This Settlement shall become effective on the Settlement Effective Date. The "**Settlement Effective Date**" of this Settlement shall be the first (1st) day of the first (1st) calendar month following the date on which a Commission order approving the Settlement becomes an Acceptable Order.

B. For purposes of this Settlement, an "**Acceptable Order**" shall mean a final Commission order, no longer subject to rehearing or appeal:

(i) approving the Settlement as filed and without modification or condition, with the exception of ministerial conditions necessary to implement the Settlement (referred to herein as "without modification or condition"); or

(ii) approving the Settlement with a modification or condition beyond a ministerial condition, but such condition or modification does not materially and adversely affect a Party; or

(iii) approving the Settlement with a modification or condition that materially and adversely affects a Party, if no such Party has provided written notice to the other Parties by the tenth (10^{th}) business day following the issuance of such Commission order that it either no longer supports or now opposes the Settlement due to such modification or condition ("**Notice of Opposition to FERC Condition**"); or

(iv) approving the Settlement with a modification or condition that materially and adversely affects a Party, in the event that such Party provides a Notice of Opposition to FERC Condition, provided, however, that the Parties have agreed to modify the Settlement consistent with the FERC order or the Settlement becomes effective without the provision modified by the FERC order pursuant to Section 2.1.C.

C. In the event that any Party provides a Notice of Opposition to FERC Condition, the Parties shall meet and negotiate in good faith to modify the Settlement in a way that preserves the intent of the Parties as closely as possible given any limitations in the Commission order; provided, however, that if the Parties cannot

achieve mutual agreement in these good faith negotiations on modifications consistent with the Commission order, the Settlement will become effective without the provision modified by the FERC order, provided that deletion of the provision does not increase the Settlement Rates.

D. For purposes of this Settlement, an order shall be considered final and no longer subject to rehearing or appeal on the first (1st) day after either (i) the thirtieth (30th) day from the issuance date of the order, in the event that no request(s) for rehearing of the order have been filed; or (ii) the sixtieth (60th) day from the issuance date of an order on rehearing of the order, in the event a request for rehearing was filed and no petition(s) for review of the relevant order(s) has been filed with a circuit court of appeals on or before the sixtieth (60th) day; *provided*, in the event that the thirtieth (30th) day or the sixtieth (60th) day, as applicable, is not a business day, then the order shall be considered final and no longer subject to rehearing or appeal on the first (1st) business day after the thirtieth (30th) day or the sixtieth (60th) day, as applicable.

2.2 Privileged Status of Settlement

All discovery requests and responses exchanged to facilitate the Settlement negotiations, and all Settlement discussions, shall be treated as privileged and confidential and as if they were an offer of settlement that is not approved by the Commission for

purposes of Rule 602 and shall not be (i) utilized as evidence in any other case or proceeding, or (ii) deemed an admission by any Party of any principle contained herein.

ARTICLE III
SETTLEMENT RATES, TARIFF RECORDS, REFUNDS AND COLLECTIONS

3.1 Settlement Rates

The settlement rates established pursuant to this Settlement ("**Settlement Rates**") are set out on the *pro forma* tariff records included in Schedule 3-A. The Settlement Rates will be effective on June 1, 2020.

3.2 Other Tariff Changes

Schedules 3-B and 3-C include *pro forma* tariff records reflecting other changes related to the Settlement terms (the *pro forma* tariff records included in Schedules 3-A, 3-B and 3-C are collectively referred to as the "**Settlement Tariff Records**"). The other tariff changes include, but are not limited to, revisions to implement the roll-in of certain incremental rate schedules and to modify Section 50 of the GT&C, Reservation Charge Adjustment. The other tariff changes will be effective as set forth in Section 3.3 below.

3.3 Compliance Filing to Implement Settlement Rates and Other Tariff Changes

Algonquin shall file revised tariff records to implement this Settlement as soon as reasonably practicable, but no later than twenty (20) days following the Settlement Effective Date, with such tariff records being in substance identical to the Settlement Tariff Records included in Schedules 3-A, 3-B and 3-C attached hereto ("**Settlement Compliance Filing**"). Algonquin shall request in the Settlement Compliance Filing that (i) the Settlement Rates on the tariff records included in Schedule 3-A become effective on June 1, 2020, (ii) the other tariff changes on the tariff records included on Schedule 3-B

become effective on the first day of the first month following the date of the Settlement Compliance Filing, and (iii) the other tariff changes on the tariff records included on Schedule 3-C become effective on the earlier of October 1, 2020 or the first day of the first month following the date of the Settlement Compliance Filing.

3.4 Refunds

As soon as practicable, but no later than sixty (60) days following the Settlement Effective Date, for the period extending from June 1, 2020, until the Settlement Effective Date ("**Refund Period**"), Algonquin will, as applicable, refund the difference, if any, between (i) the amounts collected for service provided during the Refund Period and (ii) the amounts that would have been collected during the Refund Period had the Settlement Rates been effective as of June 1, 2020. All refunds described in this Section 3.4 shall be calculated for each individual customer, such that Algonquin shall net any over-collections against any under-collections on a customer-by-customer basis without regard to service, or type of rate, or rate component. Refunds shall be (1) calculated in accordance with this Section 3.4 and shall include interest pursuant to Section 154.501(d) of the Commission's regulations[7] ("**FERC interest rate**"), which shall be calculated after netting when Algonquin nets over-collections against under-collections by customer, and (2) reported on a refund report filed with the Commission within thirty (30) days of the date the refunds are made.

3.5 Collections

As soon as practicable, but no later than sixty (60) days following the Settlement Effective Date, for the Refund Period, Algonquin will, as applicable, charge the difference,

[7] 18 C.F.R. § 154.501(d) (2019).

if any, between (i) the amounts collected for service provided during the Refund Period and (ii) the amounts that would have been collected during the Refund Period had the Settlement Rates been effective as of June 1, 2020. All charges described in this Section 3.5 shall be calculated for each individual customer, such that Algonquin shall net any over-collections against any under-collections on a customer-by-customer basis without regard to service, or type of rate, or rate component. Charges shall be calculated in accordance with this Section 3.5 and shall include interest at the FERC interest rate, which shall be calculated after netting when Algonquin nets over-collections against under-collections by customer.

ARTICLE IV
MATTERS SETTLED

4.1 Depreciation and Negative Salvage Rates

A list of all of the settlement depreciation rates and negative salvage rates to which the Parties have agreed as part of this Settlement, inclusive of the transmission depreciation and negative salvage rates, is set forth on Schedule 4 attached hereto.

4.2 Amortization of Regulatory Liabilities and Regulatory Assets

A. The total amount of unprotected Excess Deferred Income Taxes ("**EDIT**") to be amortized in accordance with the period set forth in Section 4.2.B of this Settlement shall be $22,789,328 (before income tax gross-up) for purposes of this Settlement. The total amount of protected EDIT to be amortized in accordance with the period set forth in Section 4.2.B of this Settlement shall be $302,278,897 (before income tax gross-up) for purposes of this

Settlement. For the avoidance of doubt, the income tax gross-up is included in the rates stated in Schedule 3-A.

B. The amortization period for unprotected EDIT shall be 5 years. The amortization period for protected EDIT shall be 32.27 years.

C. A schedule of EDIT flowback amounts is set forth in Schedule 5 to this Settlement.

D. The amortization of the amounts set forth above in Section 4.2.A shall start June 1, 2020.

4.3 Interruptible Transportation Costs Allocation

The Settlement Rates reflect an allocation of costs in the amount of $1,833,284 to the interruptible rate schedules, Rate Schedules AIT-1 and PAL.

4.4 Maintenance Management Program

Algonquin shall continue its current practice of conducting meetings with its customers on an annual basis for the purpose of increasing the transparency of Algonquin's maintenance management program. Algonquin's maintenance management program discussions shall initially include the following, which may be updated from time to time based on collaboration with the customers as the annual process evolves:

A. By May 31st of the first calendar year subsequent to the Settlement Effective Date and at least once annually thereafter, Algonquin shall present, by meeting, webcast, or conference call with its customers, its planned maintenance activities by purpose, type, location and estimated costs, for the subsequent calendar year, and engage in discussions regarding such presentation; *provided*, if the Settlement

Effective Date occurs after May 31, 2020, but during calendar year 2020, Algonquin shall hold the first such meeting, webcast, or conference call with its customers as soon as practicable prior to the end of calendar year 2020.

B. Annually, in the second quarter of each year, Algonquin shall provide its customers with a reconciliation of actual to estimated costs of the maintenance activities undertaken in the previous calendar year, explaining any material variances.

C. Algonquin shall begin to track reliability metrics for firm service availability, compressor availability/rate, force majeure outages, and outage time associated with unplanned incidents, with the results reported annually to customers in the subsequent year's meeting. Algonquin is willing to discuss tracking of any proposed additional appropriate metrics on a prospective basis to be presented in a subsequent annual process.

4.5 Intercompany Agreements

In the event that a Rate Change Filing (as defined below) during the term of this Settlement is an NGA general Section 4 rate case filing, then the witness sponsoring the intercompany and corporate allocations in support of Algonquin's as-filed case shall sponsor all applicable intercompany service agreements governing the service company structure for operations and administration as an exhibit to the testimony of the sponsoring witness. A "**Rate Change Filing**" shall mean an NGA general Section 4 rate case, NGA

Section 5 rate case proceeding, or approved prepackaged settlement in lieu of filing an NGA general Section 4 rate case.

4.6 Return on Equity for New Projects

After the Settlement Effective Date, Algonquin shall apply a 12.50 percent return on equity component in the calculation of rates for new Algonquin incremental expansion projects, to the extent that Algonquin is proposing incremental rates for service on the capacity created by the applicable project or the Commission requires incremental rates for such incremental service.

4.7 New York Delivery Surcharge

A. At the request of the New York Department of Public Service Staff, Algonquin will make certain payments to the Verplanck Fire District, and Algonquin will recover such payments through the administration of a monthly demand surcharge ("**New York Delivery Surcharge**") that will apply to all contracts between Algonquin and a local distribution company regulated by the New York State Public Service Commission, including contracts with negotiated and discount rates, with the following Primary Points of Delivery: Meter Nos. 00039, 00040, 99831, 00041, 00045, 00047, 00048, 00811, 99824, 00084, and 00851 ("**Surcharge Delivery Points**"). The New York Delivery Surcharge will be assessed on the Maximum Daily Delivery Obligations at the Surcharge Delivery Points of the contracts with each local distribution company regulated by the New York State Public Service Commission.

B. The New York Delivery Surcharge will apply for a term beginning on January 1, 2021, and ending on December 31, 2023, and is designed to collect the following amounts: $55,000 in 2021, $175,000 in 2022 and $300,000 in 2023.

C. On or before November 30 prior to each year of the term set forth in Section 4.7.B, Algonquin will submit a limited NGA Section 4 compliance filing to establish the New York Delivery Surcharge to be effective on January 1 of the following year. Each year, the New York Delivery Surcharge will be calculated to recover the applicable amount referenced above, based on the aggregate Maximum Daily Delivery Obligations of local distribution companies regulated by the New York State Public Service Commission at the Surcharge Delivery Points projected for the following year.

4.8 Integrity Costs

Algonquin and the other Parties shall engage in a formal consultation process for discussing (i) the review and recovery of actual integrity and modernization costs; and (ii) potential new and mutually agreed to (between Algonquin and firm shippers) reliability and modernization programs designed to enhance system reliability. For purposes of satisfying the standards required in the Commission's Policy Statement in *Cost Recovery Mechanisms for Modernization of Natural Gas Facilities* in Docket No. PL15-1, this Settlement shall not constitute a "Review of Existing Rates" nor shall it be used to demonstrate the appropriateness of Algonquin's Base Rates. Furthermore, Algonquin agrees that discussions related to integrity costs or other modernization during the formal

consultation process set forth in this provision do not constitute the collaborative effort required by the policy statement set forth in Docket No. PL15-1 unless agreed to by the other Parties.

ARTICLE V
MORATORIUM AND COMEBACK

5.1 Moratorium

Neither Algonquin nor any other Party may file under Section 4 or Section 5 of the NGA, respectively, to revise any provision of the Settlement with an effective date that occurs, following any applicable suspension period, before October 1, 2021 ("**Moratorium Period**"). Algonquin will not seek to implement a surcharge mechanism designed to recover incremental capital expenditures during the Moratorium Period.

5.2 Rate Case Comeback

Provided that an NGA Section 5 proceeding has not been initiated by the Commission, Algonquin shall file an NGA general Section 4 rate case with a filing date that is no later than June 1, 2024.

ARTICLE VI
MISCELLANEOUS

6.1 Schedules

This Settlement includes the information contained in each of the Schedules attached hereto and referred to herein, all of which are incorporated herein by reference, but if there is any conflict or inconsistency between the main body of this Settlement and any Schedule hereto, then the provisions of the main body of this Settlement shall control.

6.2 Entireties Clause

This Settlement represents a negotiated resolution of only the specific matters addressed herein, and except as specifically provided in this Settlement, no Party shall be deemed to have waived any claim or right in a future proceeding. There are no other agreements or understandings between the Parties to this Settlement related to this Settlement except as stated herein, and this Settlement represents the entire agreement of the Parties with respect to the matters resolved in this proceeding. This Settlement is not intended to resolve or affect any other proceeding pending before the Commission, courts or any other governmental authority, nor does Commission approval of this Settlement constitute approval of, or precedent regarding, any principle or issue in this proceeding (recognizing that the terms of this Settlement are intended to remain in effect for the duration of this Settlement). Likewise, in consideration of all elements of this negotiated Settlement, no Party intends that any provision of this Settlement constitutes precedent or should be deemed "settled practice," as the term "settled practice" was interpreted in *Public Service Comm'n of N.Y. v. FERC,* 642 F.2d 1335 (D.C. Cir. 1980), cert. denied, 454 U.S. 879 (1981) or a "long-standing practice" as that term was used in *Columbia Gas Transmission Corp. v. FERC,* 628 F.2d 578 (D.C. Cir. 1979).

6.3 Term of Settlement

A. This Settlement shall become effective on the Settlement Effective Date and shall terminate on the date on which new rates go into effect pursuant to the first Rate Change Filing subsequent to the date of this Settlement filing (whether or not such rates are placed into effect subject to refund) (the "**Rate Change Effective Date**");

provided, however, that if the Settlement Effective Date occurs after the Rate Change Effective Date, then this Settlement shall be deemed effective for the period from June 1, 2020 until the Rate Change Effective Date, including the Settlement Rates and rights and obligations related to refunds through the Rate Change Effective Date pursuant to Section 3.4 and collections through the Rate Change Effective Date pursuant to Section 3.5.

B. Notwithstanding Section 6.3.A, the following provisions shall survive the termination of this Settlement only to the extent required to implement this Settlement: Section 2.2 (Privileged Status of Settlement), Section 6.5 (Successors and Assigns), and Section 6.7 (State or Federal Regulatory Proceedings).

6.4 Nature of Settlement

The terms of this Settlement are contractual, not a mere recital, and this Settlement is the result of negotiations between the Parties, each of which has participated in the drafting of this Settlement through its respective attorneys. No Party shall be deemed the drafter of this Settlement, and this Settlement shall not be construed against any Party as the drafter. In the event of a conflict between the terms of this Settlement and the "Explanatory Statement of Stipulation and Agreement," the Settlement shall control. Nothing contained in this Settlement shall be deemed an admission of any kind, whether of guilt, liability, or fact, by or against any Party to this Settlement, or their directors, officers, shareholders, agents, employees, representatives, principals, successors, predecessors, assigns, and heirs.

6.5 Successors and Assigns

The provisions of this Settlement shall be binding upon and inure to the benefit of the Parties and their respective successors and permitted assigns.

6.6 Authority to Enter Settlement

Each of the Parties to the Settlement represents and warrants to the other Parties that it has the power and authority to enter into and perform this Settlement.

6.7 State Regulatory Proceedings

No Party shall oppose the rates and charges under this Settlement in a state regulatory proceeding.

ARTICLE VII
EFFECT OF APPROVAL

7.1 Settlement Rates in Public Interest

This Settlement represents a negotiated settlement of all the issues in this proceeding, resolved in a manner that is just and reasonable and in the public interest. The benefits accruing to the Parties hereto represent delicate compromises by each Party on many interrelated matters so that a balance could be achieved among competing interests.

7.2 Termination of Proceedings and Waivers

Commission approval of this Settlement shall constitute termination of the proceeding in the above-captioned docket. Even if not specifically stated, Commission approval of this Settlement shall constitute granting the request contained in this Settlement for any and all waivers of the Commission's rules and regulations that may be necessary to effectuate the Settlement in accordance with its terms, including a waiver of Section 154.207 of the Commission's regulations, 18 C.F.R. § 154.207 (2019), to the extent necessary to implement the terms and provisions agreed to in this Settlement.

7.3 Rights Reserved

A. The provisions of this Settlement relate only to the specific matters referred to in this Settlement. No Party waives any claim or right that it otherwise may have with respect to any matters not expressly provided for in this Settlement.

B. Except to the extent explicitly set forth in this Settlement, neither the Commission, nor any of the Parties to this Settlement shall be deemed to have approved, accepted, agreed to or consented to any policy, methodology or other principle underlying or supposed to underlie any of the matters provided for in this Settlement.

C. No Party shall take any action that would impede Commission approval of this Settlement without modification or condition. Prior to an Acceptable Order and an order accepting the Settlement Compliance Filing, no Party shall take any action, including making any filings with the Commission addressing the subject matter of this Settlement as it applies to Algonquin, which action is designed to impede Commission approval and Algonquin's implementation of this Settlement or the Settlement Compliance Filing, provided that Algonquin's implementation of this Settlement and/or the Settlement Compliance Filing, as applicable, is consistent with, and does not deviate from or extend beyond the scope of, the Settlement as filed. Notwithstanding the foregoing, a Party may seek rehearing, or petition for review, of a Commission order that modifies or

conditions approval of this Settlement if such condition or modification materially and adversely affects such Party and such Party has provided the other Parties with a Notice of Opposition to FERC Condition.

D. Nothing in this Settlement shall preclude Algonquin from filing changes in its FERC Gas Tariff that are consistent with its specific obligations under this Settlement, or preclude any Party from responding thereto or seeking changes in Algonquin's FERC Gas Tariff pursuant to NGA Section 5 that are consistent with its specific obligations under this Settlement.

7.4 Standard of Review

The standard of review for any changes to the terms of this Settlement during the term of this Settlement shall be the just and reasonable standard and not the public interest standard.

WHEREFORE, Algonquin respectfully requests that the Commission approve this Settlement in its entirety, without modification or condition.

Respectfully submitted,

/s/ Steven E. Hellman
Steven E. Hellman
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5400 Westheimer Court
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ATTORNEYS FOR
Algonquin Gas Transmission, LLC

May 15, 2020

SCHEDULE 4
DEPRECIATION AND NEGATIVE SALVAGE RATES

		Depreciation	Negative Salvage
1	ACCOUNT 403 - DEPRECIATION		
2	Land	N/A	N/A
3	TRANSMISSION PLANT	2.000%	0.200%
4	TRANSMISSION PLANT_Incremental*	4.000%	0.200%
5	TRANSMISSION PLANT_Incremental*	5.000%	0.200%
6	TRANSMISSION PLANT_Incremental*	5.880%	0.200%
7	TRANSMISSION PLANT_Incremental*	6.670%	0.200%
8	TRANSMISSION PLANT_Incremental*	7.143%	0.200%
9	TRANSMISSION PLANT_Fully Depreciated_Incremental*	10.000%	0.200%
10	GENERAL PLANT		
11	Structures & Improvements(390)	2.000%	N/A
12	Office Furniture & Equipment(391)	6.670%	N/A
13	Tools, Shop, and Garage Equipment(394.10)	6.670%	N/A
14	Miscellaneous Equipment - 398	5.000%	N/A
15	Structures & Improvements- Fully Depreciated(390.04) Incremental	0.000%	N/A
16	Transportation Equipment	6.670%	N/A
17	Transportation Equipment - Fully Depreciated(392)	0.000%	N/A
18	Power Operated Equipment - Fully Depreciated(396)	0.000%	N/A
19	Communication Equipment - Fully Depreciated		
20	Miscellaneous Equipment - Fully Depreciated		
21	Total Account 403 - Depreciation		
22	ACCOUNT 404 - AMORTIZATION		
23	Intangible Plant - Organization Costs	0.000%	0.000%
24	Intangible Plant - Software	20.000%	0.000%
25	Intangible Plant - Miscellaneous_ROW_50yrs	2.000%	0.000%

* Incremental Detail:

4.000% Northeast Gateway Lateral

5.000% Middletown Lateral, Lake Road Lateral, J-2 Facility, Bellingham Lateral

5.880% Tiverton Project

6.670% Cape Cod Lateral, Kleen Energy Lateral, Salem Lateral, West Roxbury Lateral

7.143% Canal Lateral

10.000% Cleary

Exhibit 3

From: Barry Goodrich <Barry.Goodrich@enbridge.com>
Sent: Friday, August 7, 2020 11:19 AM
To: Cushing, Thomas (DEP); Kate Brown
Cc: Brad Shamla; Lynne Santos
Subject: RE: request for supporting documentation
Attachments: Response to MassDEP 08-05-20 Data Request.pdf

Tom –

Attached please find Algonquin's response to your information request dated August 5, 2020.

If you have any questions, please let me know.

Thanks,

Barry Goodrich,
Senior Engineer
Air Projects

ENBRIDGE
TEL: 713-627-4484 | CELL: 281-806-8181 | FAX: 713-989-8347 | barry.goodrich@enbridge.com
5400 Westheimer Ct, Houston, Tx 77056

enbridge.com
Safety. Integrity. Respect.

From: Cushing, Thomas (DEP) <thomas.cushing@state.ma.us>
Sent: Wednesday, August 5, 2020 4:35 PM
To: Barry Goodrich <Barry.Goodrich@enbridge.com>; Kate Brown <Kate.Brown@enbridge.com>
Subject: [External] request for supporting documentation

Based on my review, I am requesting the following information:

1. A copy of the June 2020 communication from National Grid, which is referenced in the prefiled direct testimony of Mr. John Heintz . During conversations on or about July 29 and again on August 5, you indicated this document, which supports the necessity to upgrade the Edgar substation is considered confidential by National Grid and consequently, Algonquin may not be able to provide the requested document. Should you be unable to provide either the requested document or sufficient alternative documentation regarding the necessity for upgrades to the Edgar substation, MassDEP may consider excluding the costs associated the Edgar substation from the BACT analysis.

2. Please provide a discussion of using 115 kV transmission line power as opposed to 13.8 kV distribution line power for the electric motor drive under consideration.

3. Please provide a map, which identifies the proposed route of the underground cable that was used for costing purposes.

4. Please identify to what extent National Grid would be responsible for costs referenced in the EMD BACT.

memo

Date: August 7, 2020

To: Mr. Thomas Cushing, MassDEP Southeast Regional Office

From: Mr. Barry Goodrich, Enbridge
Cc: Ms. Kate Brown, Enbridge

Re: **Response to MassDEP Request for Clarifying Information on BACT Analysis for EMD Alternative Weymouth Compressor Station (Transmittal No. X266786)**

Below and attached please find Algonquin Gas Transmission, LLC's (Algonquin) response to your August 5, 2020 email requesting clarifying information on certain aspects of the BACT Analysis for EMD Alternative, which was submitted on July 24, 2020 as an Addendum to the Non-Major Comprehensive Plan Approval Application for the Weymouth Compressor Station (Addendum).

MassDEP Request 1: *A copy of the June 2020 communication from National Grid, which is referenced in the prefiled direct testimony of Mr. John Heintz. During conversations on or about July 29 and again on August 5, you indicated this document, which supports the necessity to upgrade the Edgar substation is considered confidential by National Grid and consequently, Algonquin may not be able to provide the requested document. Should you be unable to provide either the requested document or sufficient alternative documentation regarding the necessity for upgrades to the Edgar substation, MassDEP may consider excluding the costs associated the Edgar substation from the BACT analysis.*

Algonquin Response: Please find attached as Exhibit 1 hereto, a copy of the June 2020 communication from National Grid referenced in the prefiled direct testimony of Mr. John Heintz.

Enbridge provided Eversource and National Grid with specifications to supply power to a 30 MVA substation. Although the specifications that were provided were those that are necessary to support a single EMD unit, as noted in the communication, a 30 MVA substation would also be sufficient for an additional unit.

While Enbridge would normally use a soft start (or reduced voltage start) for the EMD, it would require the ability to conduct an across the line start (at motor rated terminal volatge) in the event that the soft start is unavailable. The across the line start requires a facility with capacity of approximately 27 Megavolt Amperes (MVA). Accordingly, Enbridge

specified a 30 MVA facility as the capacity required to prevent any adverse impact to the incoming utility service due to the starting conditions of the electric motor.

MassDEP Request 2: Please provide a discussion of using 115 kV transmission line power as opposed to 13.8 kV distribution line power for the electric motor drive under consideration.

Algonquin would require 115kV transmission line power to support an EMD alternative consistent with Enbridge's standard practice. Enbridge has exclusively provided transmission line power (69-250kV) to support its EMD installations in the U.S. since 2008. The following list identifies the service voltage provided for those projects.

Year	FERC Project Name	Station/Location	Service Voltage
2008	TIEMS II	Heidlersburg/PA	138kV
		Uniontown/PA	138kV
2010	TEMAX	Chambersburg/PA	115kV
	TIEMS III	Heidlersburg/PA	138kV
	TIEMS III	Uniontown/PA	138kV
2012	TEAM	Bedford/PA	138kV
2014	TEAM 2014	Delmont/PA	138kV
2016	GME	Opelousas/LA	138kV
	Access Adair South	Tompkinsville/KY	167kV
	Stratton Ridge	Angleton/TX	138kV

It is Enbridge's standard practive to utilize federally regulated transmission service for EMDs because it considers that more reliable than distribution service (<69kV) with respect to adequacy and operating reliability and thus closer to the fuel reliability that a gas turbine can provide for compression.

ENBRIDGE

memo

MassDEP Request 3: *Please provide a map, which identifies the proposed route of the underground cable that was used for costing purposes.*

Algonquin Response: Attached as Exhibit 2 hereto, please find a copy of the Atlantic Bridge Project Figure RR10 – Response 2C, created February 9, 2016, which identifies the approximate route of the underground cable that was used for costing purposes.

MassDEP Request 4: *Please identify to what extent National Grid would be responsible for costs referenced in the EMD BACT.*

Algonquin Response: Algonquin would be responsible for the costs referenced in the EMD BACT, not National Grid. *See, e.g.*, June 11, 2020 email from Joseph Murphy (National Grid) to Laurence Smith (Enbridge), attached hereto as Exhibit 1 ("Eversource would be responsible for designing and constructing any Substation modifications. Enbridge would be responsible for all the costs associated[ed] with the service.")

Exhibit 1 – Email Correspondence

Subject: FW: Enbridge Weymouth Compressor Station 138kV Transmission Service from Edgar Substation

From: Murphy, Joseph <Joseph.Murphy3@nationalgrid.com>
Sent: Thursday, June 11, 2020 12:45 PM
To: Laurence Smith <Laurence.Smith@enbridge.com>
Cc: Andy Nakanishi <Andy.Nakanishi@enbridge.com>; Paul Krawczyk <paul.krawczyk@eversource.com>; Thompson, Michael A. (Tx Commercial Svcs.) <Michael.Thompson@nationalgrid.com>; Reardon, Kevin C. <Kevin.Reardon@nationalgrid.com>
Subject: [External] RE: EXT || FW: Enbridge Weymouth Compressor Station 138kV Transmission Service from Edgar Substation

Hi Larry/ Andy,

I agree with Paul, that NGrid would provide the service, but it would be subject to an Agreement between Eversource and National Grid. Eversource would be responsible for designing and constructing any Substation modifications. Enbridge would be responsible for all the costs associate with the service. As mentioned, a formal review would require a System Impact Study and a PPA submittal at the ISO. We can't confirm Paul's number below, but concur that it is a recent/ reasonable example, assuming there is a open bay for a new Breaker. If not, the price would be more expensive to provide the service.

Given your need for an immediate answer and not knowing what would be involved with the requirements of a circuit, (particularly underground unknowns) unfortunately, it is not possible to develop an estimate specific to your project by Friday. I can confirm that the circuit between Edgar and the Point of service would be constructed, owned and operated by National Grid. All substation modifications would be constructed, owned and operated by Eversource.

If you wish to proceed with a formal request, let us know and we can start that process.

Thanks
Joe

From: Laurence Smith <Laurence.Smith@enbridge.com>
Sent: Thursday, June 11, 2020 10:29 AM
To: Murphy, Joseph <Joseph.Murphy3@nationalgrid.com>

Cc: Andy Nakanishi <Andy.Nakanishi@enbridge.com>
Subject: EXT || FW: Enbridge Weymouth Compressor Station 138kV Transmission Service from Edgar Substation

Joe,

Based on the below clarification from Eversource and the attached information previously provided by Enbridge, would it be possible for NG to provide a high level, nonbinding estimate for the cost to perform the work highlighted in yellow?

Please advise,
Larry

Laurence S. Smith

Sr. Electrical Engineer, Facilities Project Engineering
Engineering & Construction
Assigned to: Enbridge
Employee of: Aerotek
—

ENBRIDGE
TEL-713-989-8437 laurence.smith@enbridge.com
Office 5D43, 5400 Westheimer Court, Houston, TX 77056

From: Krawczyk, Paul H <paul.krawczyk@eversource.com>
Sent: Thursday, June 11, 2020 9:00 AM
To: Laurence Smith <Laurence.Smith@enbridge.com>
Cc: Andy Nakanishi <Andy.Nakanishi@enbridge.com>; Lucas, Jacob E <jacob.lucas@eversource.com>
Subject: [External] RE: Enbridge Weymouth Compressor Station 138kV Transmission Service from Edgar Substation

Larry,

This is a follow-up to my conversation with Andy regarding the below. As I noted to Andy, Enbridge's Weymouth station is in National Grids territory. So, National Grid would provide the retail service and be responsible for the underground line from Edgar Station to the Weymouth pump plant and would have to develop that cost. National Grid would also need to contract with Eversource for the 115 kV connection at Eversource's Edgar station. Engineering has not performed any review of the potential connection, but it appears that the connection would at least require the addition of one breaker. Unfortunately, it is not possible to develop an estimate specific to your project by Friday. A contract would be required, most likely with National Grid, outlining the scope and cost to perform the study and it would require following our internal cost estimating process. However, to give Enbridge an idea of the potential costs, a high level non-binding cost estimate of $3.4 million was provided to a customer in early 2015 for the addition of one breaker. While that estimate is not specific to Enbridge's project, it can give you an indication of the cost of adding a breaker.

Hope this is helpful.

Thanks,
Paul

Paul Krawczyk
Lead Transmission Analyst
Eversource Energy

(508) 441-5140

From: Laurence Smith <Laurence.Smith@enbridge.com>
Sent: Wednesday, June 10, 2020 1:57 PM
To: Krawczyk, Paul H <paul.krawczyk@eversource.com>
Cc: Andy Nakanishi <Andy.Nakanishi@enbridge.com>
Subject: Enbridge Weymouth Compressor Station 138kV Transmission Service from Edgar Substation

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Paul,

This is a follow up email to the VM Andy left you earlier today concerning the above subject. The following information should be sufficient for you to understand our needs and start a conversation with your transmission planning group:

- 9000HP Synchronist Motor Operating at Unity PF
- Normally Soft Started with 3X inrush Limit
- Occasional Across the Line Start in the event the soft starter is not available with Pre-start Notification to Eversource
- Enbridge Provided 30MVA, 138kV/13.8kV Substation with Capacity ALS and potential future HP expansion (2nd unit) included
- See attached for Arial View of proposed Line route to the Weymouth Station

As I'm sure Andy indicated in his VM, Enbridge is looking for rapid turnaround response for a high level (-50 to +200%) estimate for a scope and associated cost required for infrastructure upgrades and transmission line underground routing as noted on the attached that would be needed to support the above load addition to your Edgar substation. This request to Eversource is being driven by an urgent request from Enbridge's Air Permitting Team for engineering support in responding to certain regulatory time sensitive requests for information.

As such, it would be greatly appreciated if a call could be set up with Andy to discuss Eversource's ability to support this request.

With best regards,
Larry

Laurence S. Smith

Sr. Electrical Engineer, Facilities Project Engineering
Engineering & Construction
Assigned to: Enbridge
Employee of: Aerotek
—

ENBRIDGE
TEL-713-989-8437 laurence.smith@enbridge.com
Office 5D43, 5400 Westheimer Court, Houston, TX 77056

Exhibit 2 – Atlantic Bridge Project Figure RR10 – Response 2C

Legend

- New Electrical Substation
- 0.5 Mile Route for Electrical Supply

Sources: ESRI, SPECTRA

Spectra Energy Partners

Algonquin Gas Transmission, LLC
Maritimes & Northeast Pipeline, L.L.C.

Atlantic Bridge Project

Figure RR10 - Response 2C

Weymouth Compressor Station

Routes to Existing Electrical Substation

Created: 2/9/2016

TRC

14 Gabriel Drive
Augusta, ME 04330

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