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ACOUSTIC AUDIT - TRANSFORMER SUBSTATION

Project: 16115.01

Nation Rise Wind Farm

North Stormont, ON

Prepared for:

Nation Rise Wind Farm Limited
Dufferin Liberty Centre
219 Dufferin St., Unit 217C
Toronto, Ontario
M6K 3J1

Prepared by:

Kohl Clark, B.Eng.,

Duncan Halstead, B.A.Sc., P.Eng.

January 24, 2023

Revision History

Version	Description	Author	Reviewed	Date
- -	Initial Report	KC	DH	December 9, 2022
R1	Revised Report based on MECP Comments: - Included supplementary documentation related to equipment calibration in Appendix A. - Added clarity regarding the assessed transformer height of 5.1 m in Appendix B. - Corrected typos related to measurement surface areas in Appendix D and Figure 3.	KC	DH	January 24, 2023

Important Notice and Disclaimer

Table of Contents

1 Introduction

Aercoustics Engineering Limited ("Aercoustics") has been retained by EDP Renewables ("EDPR") to complete a post construction audit of the Nation Rise Wind Farm ("Nation Rise") transformer substation. Nation Rise operates under REA #0871-AV3TFM [1], originally issued on May 4, 2018.

The testing methodology and data analysis outlined in this report follows the IEEE C57.12.90-2015 standard [2] and prepared in accordance with Ministry Publication NPC-233. The testing was performed while the wind farm was under high power production and adjusted to be representative of the full load noise output of the transformer.

This report is prepared in support of Condition E3 of the Nation Rise REA and summarises the results of the acoustic testing performed on November 21, 2022. The measured sound power level of the transformer substation is compared to the limits outlined in the Nation Rise Wind Farm Acoustic Audit Report ("AAR") [3] and REA.

2 Measurement Instrumentation

The acoustic audit was performed using the following acoustic intensity measurement equipment. The measurement equipment was field calibrated before and after site measurements. Sound pressure and sound intensity measurements were conducted simultaneously using the same equipment as indicated in Table 1.

Table 1: Equipment List for Transformer Acoustic Audit Measurements

Equipment	Make/Model	Serial Number	Date of Last Calibration	Calibration Certificate Expiry
Sound Level Meter	Larson Davis LD2900B Integrating Sound Level Meter	1054	August 5, 2021	August 5, 2023
Microphones[1]	GRAS Type 26 CB 1/2" Intensity Microphone Pair	104771, 104781	May 12, 2022	May 12, 2024
Pre-Amplifiers[1]	GRAS Type 40 GK 1/4" CCP Preamplifier Set	112774, 112784	May 12, 2022	May 12, 2024
Acoustic Calibrator	Bruel & Kjaer 4231 Sound Calibrator	2513184	March 14, 2022	March 14, 2023

[1] The microphones and pre-amplifiers included in Table 1 are calibrated as an associated set; the calibration certificate in Appendix A reflects the calibration of the listed microphones and pre-amplifiers.

All equipment listed in Table 1 has undergone laboratory calibration verifications within a two-year interval and reflects valid calibration during the testing. Calibration certificates for the equipment used in the audit are included in Appendix A.

3 Site Details

The transformer substation is located to the southwest of the town of Crysler, to the east of Nine Mile Road between County Road 13 and Ouderkirk Road. The transformer is located on the substation yard surrounded by an absorptive acoustic barrier on all sides with a small access opening in the barrier between the junction of the south and west walls.

This acoustic barrier is positioned such that it completely interrupts the line of sight between the noise-producing transformer components and the noise sensitive Points of Reception continuously without holes, gaps and other penetrations[1], and having surface mass of at least 20 kilograms per square metre. The heights and lengths of the barrier segments are provided in Table 2 and rounded to the nearest decimal point. Appendix B includes additional schematic drawings of the transformer and barrier.

Table 2: Nation Rise Transformer Noise Barrier Dimensions

Wall Segment	Segment Height (m)		Segment Length (m)	
	2019 AAR	As-Built	2019 AAR	As-Built
North	5.0	4.6	15.5	14.4
East	5.5	5.2	9.0	10.3
South	6.0	5.6	13.2	12.1
West	5.0	4.6	7.5	8.9

The as-built barrier dimensions are based on measurements carried out by EDP in-situ. Differences in the barrier dimensions between the final AAR dated October 21, 2019 and those constructed on site reflect the difference between the final design and the final construction. These differences may be related to site-specific constraints encountered during construction of the substation yard and/or the transformer installation and considered to be minor adjustments to the barrier position.

Any change in the receptor noise impact from the transformer due to the differences in as-built barrier heights are insignificant; the predicted impact from the Nation Rise transformer is below 30 dBA for all receptors and the measured sound power levels of the transformer were below those used in the Acoustic Assessment Report (see Table 12).

Sound level measurements were taken between 10:10 and 11:20 on November 21, 2022. At the time of the testing the ambient temperature was -9 °C with an atmospheric pressure of 102.1 kPa. The ground-level winds during the time of the testing were roughly 23 km/hr

[1] The nearest Point of Reception in the direction of the noted opening in the transformer barrier wall is over 2 km away, with a predicted noise impact from the Transformer of less than 20 dBA.

(6.4 m/s) from the southwest. The shielding of the transformer from the barrier walls ensured that the high winds did not interfere with the near field measurements.

4 Transformer Operation

The transformer is a three-phase step-up transformer manufactured by ProlecGE Inc. who are headquartered in Apodaca, Nuevo León, Mexico. The nameplate specifications of the transformer are summarized in Table 3.

Table 3: Transformer Nameplate Parameters

Parameter	Transformer
Serial Number	G4086
Rated Power	69 / 92 / 115 MVA
Rated Voltage	240 kV
Voltage Ratio	230 kV / 34.5 kV
Phase	3 Phase
Frequency	60 Hz
Manufacturer	Prolec General Electric

The load audible sound level was measured with the transformer in the ONAF2 and ONAN operating conditions. The cooling modes of the transformer are described in Table 4 below.

Table 4: Transformer Cooling Operating Modes

Cooling Mode	Cooling Fan Operation
ONAN	No Fans Operating
ONAF1	50% of fans operating
ONAF2	100% of fans operating

The ONAF2 operating mode measurement included in this report represents worst-case noise output of the transformer.

As per standard IEEE C57.12.90-2015, during the time of the testing the transformer was confirmed by facility operations staff to be operating at the rated voltage with the wind farm producing a load as indicated in Table 5 for each cooling operating mode.

Table 5: Transformer Operation During Testing

Cooling Operating Mode	Transformer Load (MVA)		
	Min	Max	Average
ONAN	84	91	87
ONAF2	88	91	89

From Section 13.3.3.2 of the IEEE standard, determination of the transformer's load audible sound output can be based on measurements where the transformer is operating below the rated load, so long as the measurements correspond to loads between 60% and 130% of the rated load. The measurements of the Nation Rise transformer represent approximately 75% of the maximum rated load, which is 115 MVA[2], and the load audible sound level of the transformer at rated load has been calculated using equation (33) of IEEE C57.12.90-2015.

5 Transformer Audit Measurements

5.1 Measurement Procedure

Sound intensity levels were measured in accordance with IEEE C57.12.90-2015 in the determination of the transformer sound power levels along the ONAN and ONAF2 measurement contours.

ONAN measurement points were taken at intervals 0.9 m apart, 0.3 m from the surface of the transformer casing and external cooling fans. ONAF2 measurement points were taken at intervals 1 m apart, 2 m from the surface of the transformer casing and external cooling fans. As the transformer is greater than 2.4 m tall, the measurements were taken at two heights, 1/3 and 2/3 the height of the transformer.

The transformer height determined using the dimensioned drawings from the Prolec GE Engineering, dated May 31, 2019 [4] which have been included in Appendix B. The height of 5.1 m used for the measurement surfaces is based on the height of the low voltage bushing and represents a conservative assessment; the major noise-producing sources on the transformer (the core and fans) are at heights of 4.2 m or lower. The low voltage bushing height and cover height are illustrated on the schematic included in Appendix B.

These key physical parameters are detailed below in Table 6.

[2] The 115 MVA rated load for the Nation Rise transformer refers to the 'apparent power' load on the transformer. The apparent power load is determined by calculating the vector of the 'real power' load on the transformer (i.e. the production of the wind farm, with a maximum of 99.76 MW) and the maximum 'reactive power' load that can be placed on the transformer by the Independent Electricity System Operator (IESO), which is 60 MVAR. It is important to note that this maximum reactive load has only been achieved during IESO testing of the transformer, and thus the rated 115 MVA load is understood to be unlikely to occur during normal operation of the wind farm, even at the maximum 99.76 MW production of the site.

Table 6: Nation Rise Transformer – Key Physical Parameters

Parameter	Measurement Value
Measurement Distance from all vertical noise-producing surfaces (ONAN / ONAF2)	0.3 m / 2 m
Horizontal Spacing between Measurement Locations (ONAN / ONAF2)	0.9 m / 1.0 m
Height of Transformer (H)	5.1 m
Height of microphone 1 above ground	1.7 m (1/3H)
Height of microphone 2 above ground	3.4 m (2/3H)

5.1.1 Deviations from IEEE C57.12.90-2015

It is noted that the horizontal spacing between measurement locations of 0.9 for the ONAN measurement series differs from the 1.0 m separation distance stipulated by the standard. The IEEE C57.12.90-2015 standard stipulates a minimum number of measurement points but does not stipulate a maximum number. The spacing used between measurement locations has the effect of increasing the total number of measurement locations across the measurement surface, which provides a higher resolution determination of the average surface sound intensity level. As such, this deviation is not expected to have any material impact on the calculated sound power output of the transformer.

5.1.2 Far-Field Measurements

The transformer audit measurements were conducted during periods of high winds in order to achieve the apparent power ratings required to assess the worst-case operation of the transformer. As a result, the transformer noise impact in the far-field was observed to be dominated by noise from the wind. Aercoustics' personnel noted that the transformer was inaudible at 5 m from the outside of the noise barrier. The tone associated with transformer operation was also noted to be inaudible at a short distance from the substation walls.

5.2 Measurement Results

5.2.1 Sound Intensity Level measurements

The average sound intensity measured for the transformer was 64 dBA and 68 dBA for the ONAN and ONAF2 operating modes, respectively. Spectral data is summarized in Table 7 while overall sound levels for each measurement location around the transformer is provided in Appendix C for measurement locations as shown in Figures 2 and 3. The summary of results for sound pressure and sound-intensity is provided in Table 7 and Table 8.

Table 7: Average Measured Transformer Sound Intensity Spectra

Transformer Sound Intensity Level (dB)	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1000	2000	4000	8000	Total (dBA)
ONAN	76	66	75	63	66	47	41	38	35	64
ONAF2	75	67	74	67	69	61	54	42	35	68

Table 8: Averaged Sound Pressure and Sound Intensity Measurements

Compilation of Transformer Results	ONAN	ONAF2
Logarithmic average of sound pressure measurements (dBA)	67	69
Logarithmic average of sound-intensity measurements (dBA)	64	68
(Pressure – Intensity) index (dB)	3.3	1.9
Environmental Correction (dB)	0	0
Measured sound level corrected for environmental correction (dBA)	65	68

5.2.2 Evaluation of Sound Power Level

The determination for the total transformer sound power level at the rated 115 MVA load according to the IEEE C57.12.90-2015 standard is based on the average measured sound intensity levels for the ONAN and ONAF2 measurement series and additional adjustments and conversions per the IEEE standard as detailed below:

1. Average sound intensity levels from the ONAN and ONAF2 measurement series are converted to sound power levels using Equation 36 of the standard, correcting for the surface area of the measurement test surface for each series.

2. The contribution from the transformer's core noise is scaled from the load observed during testing to the transformer's maximum rated 115 MVA load using Equation 33 of the standard.

3. A 5 dB tonal penalty[3] is applied to the core noise according to NPC-104.

4. The contribution from the transformer fans is determined by subtracting the measured ONAN sound level from the measured ONAF2 sound level.

[3] The core noise from the transformer was observed to be audibly tonal in the nearfield but was not observed to be tonal even at close distances away beyond the transformer walls. The addition of a tonal penalty therefore represents a conservative determination of the transformer noise as it relates to the receptor sound level.

5. The total transformer sound power level is determined by logarithmically summing the scaled core noise with tonal penalty (3) and the fan noise (4).

Key adjustments made in the determination of the worst-case transformer noise output have been detailed below with additional information included in the form of a sample calculation in Appendix D

Adjustment for Measurement Surfaces

The measurement surface used includes the vertical planes as well as the horizontal top plane. In this report, the top plane is calculated based the actual surface area, rather than a 25% correction as noted in equation 36 the IEEE C57.12.90-2015 standard. This approach is based on previous comments from the regulator indicating this as the preferred method for calculating the total measurement surface. The parameters used to calculate the ONAN and ONAF2 sound power levels are provided in Table 9 and illustrated in Figures 2 and 3.

Table 9: Sound Power Calculations

Parameter	ONAN	ONAF2
Height of Sound Measuring Surface	5.1 m	5.1 m
Length of Sound Measuring Surface	27 m	37 m
Vertical Measurement Surface Area	137 m^2	188 m^2
Top Measurement Surface Area	45 m^2	92 m^2
Total measurement Surface Area	182 m^2	280 m^2
Average Sound Power Level at Test Load	87 dBA	93 dBA

Adjustment from Test Load to Rated Load

To represent the maximum noise output of the transformer, an adjustment to the ONAN sound power level is made according to Equation 33 of the IEEE standard as detailed in Table 10. The load on the Nation Rise transformer during the audit measurement period is illustrated in Appendix E

Table 10: Sound Level Adjustment to Rated Load

Parameter	ONAN
Transformer Maximum Operational Load	115 MVA
Average Load during Measurement	87 MVA
Sound Power Adjustment to Rated Load	4.5 dB
Adjusted Core Noise Sound Power Level at Rated Load	91 dBA

Determination of Worst-Case Transformer Noise Output

The transformer total sound power level at rated load is the logarithmic sum of the transformer core noise level at rated load and the transformer fan noise as detailed above and further detailed in Appendix D.

Based on the evaluation procedures outlined in IEEE C57.12.90:2015, the transformer had a sound power level of 98 dBA in the worst-case operating condition. The calculated sound power spectrum is shown in Table 11 and includes a tonal penalty of +5 dB as outlined by NPC-104. As noted earlier, the transformer was observed to be inaudible when standing beyond the noise barriers and as such it is not expected that any tone emitted from the transformer will be audible at receptor locations. Incorporation of a tonal penalty therefore reflects a conservative determination of the transformer sound power output.

Table 11: Calculated Transformer Total Sound Power Level at Rated Load

	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1000	2000	4000	8000	Total [dBA]
Transformer Core Noise at Rated Load[1] (ONAN) [dB]	108	98	107	95	98	79	73	70	67	96
Transformer Fan Noise[2] [dB]	92	89	93	91	92	85	78	65	55	91
Transformer Total Sound Power Level at Rated Load [dB]	**108**	**98**	**107**	**97**	**99**	**86**	**79**	**71**	**67**	**98**

[1] – Including 5 dB Tonal Penalty per NPC-104

[2] – ONAF2 measurement with core noise logarithmically subtracted to get fan-only noise level.

6 Compliance Summary

Table 12 compares the sound power level limit[4] for the transformer with the sound power levels measured as part of this acoustic audit.

Table 12: Measured vs. REA Transformer Sound Power Level

Parameter	Sound Power Level (dBA)*
PWL: Transformer Substation	98
PWL: Most Recent AAR [3]	101.7
PWL: Schedule B of REA #0871-AV3TFM	109.9

[4] It is noted that the estimated transformer sound power level was revised down in subsequent versions of the Nation Rise AAR from 109.9 dBA [3] to a final sound level of 101.7 dBA in a later AAR [5] and subsequently acknowledged by the MECP in a letter dated August 16, 2019 [6].

* All Sound Power Level (PWL) values include a +5 dB tonal adjustment.

The acoustic emission testing indicates that the overall sound power level of the transformer substation complies with the maximum sound power level permitted in Schedule B of the Nation Rise REA #0871-AV3TFM as well as that of the most recent AAR.

6.1 Compliance Summary

Per the requirements of REA condition E4, the following compliance summary is provided.

Table 13: Compliance Summary – Sound Power Levels (overall level and frequency spectra in octave bands)

Octave Band Centre Frequency (Hz)	31.5	63	125	250	500	1000	2000	4000	8000	Total dBA
Transformer Total Sound Power Level (dB), including +5 tonal penalty	108	98	107	97	99	86	79	71	67	98

Based on the above table, and the results presented in this report, the overall A-weighted sound power level of the transformer does not exceed the maximum sound power level specified in Schedule B of REA #0871-AV3TFM and that which was included in the most recent AAR.

7 Conclusion

Based on the results of the acoustic audit conducted on November 21, 2022, the overall measured transformer sound power level for the worst-case operating mode is 98 dBA with the associated octave band frequency spectra in Table 13. The acoustic emission of the Nation Rise transformer substation was found to be in compliance with the sound level limits provided in the Nation Rise REA #0871-AV3TFM and the most recent AAR.

8 References

[1] P. Mohsen Keyvani, "Renewable Energy Approval Number #0871-AV3TFM," Ministry of the Environment and Climate Change, Toronto, ON, 2018.

[2] IEEE Standards Association , "IEEE Standard C57.12-90-2015, Test Code for Liquid Immersed Distribution Power and Regulating Transformers," IEEE Standards Association , New York, 2015.

[3] A. Nercissian and K. Varnik, "Nation Rise Wind Farm - Renewable Energy Approval Application - Noise Impact Assessment," DNV-GL Energy, Montreal, 2019.

[4] Prolec GE Engineering Power Devision, "Drawing No. G408601D801," Prolec GE, 2019.

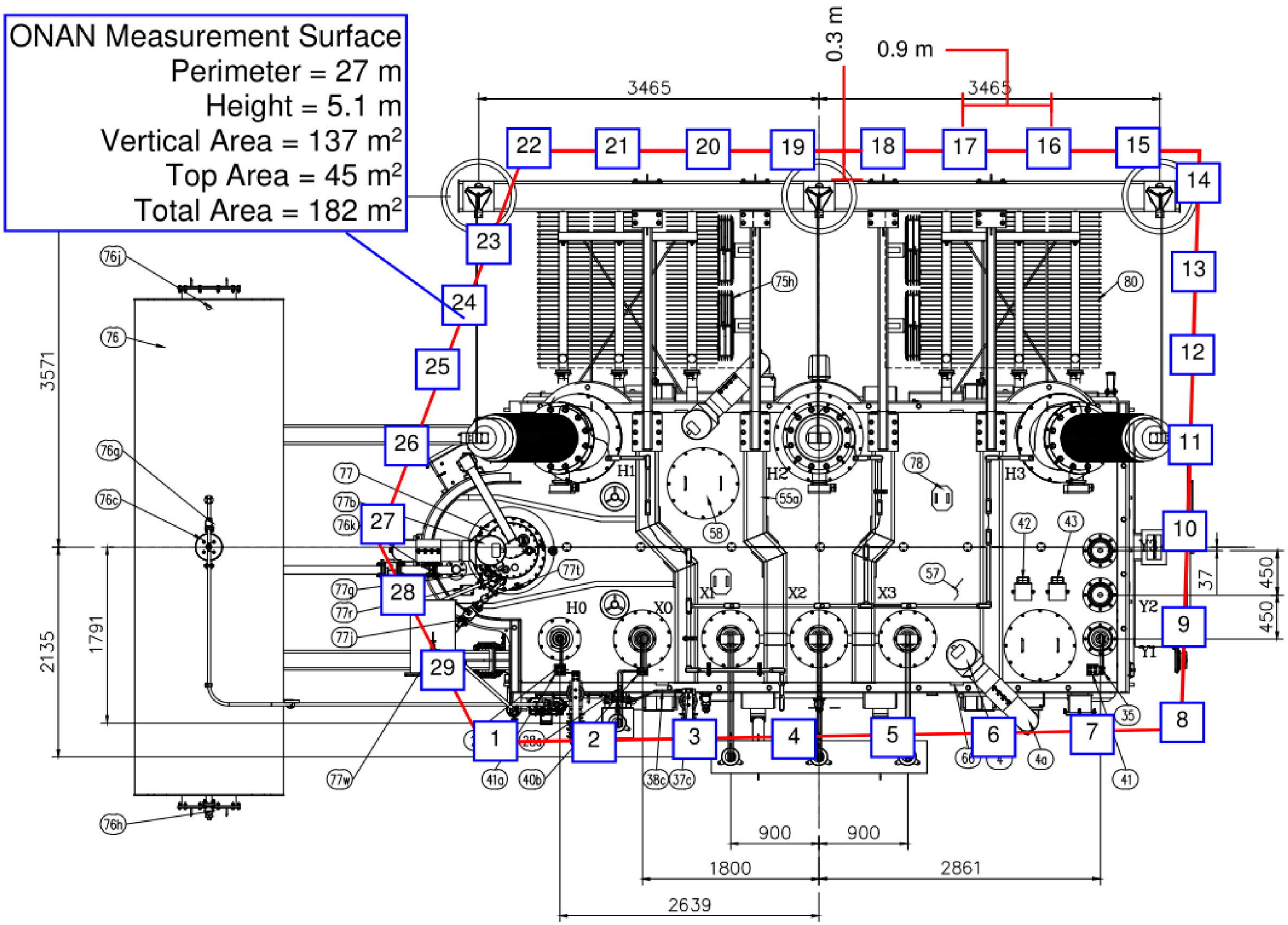
[5] A. Nercessian and S. Dokouzian, "Nation Rise Wind Farm - Renewable Energy Approval Application - Noise Impact Assessment," DNV-GL Energy, Montreal, 2017.

[6] P. Mohsen Kevyani, "Acknowledgement Letter - Condition A9 and Schedule C Requirements of REA #0871-AV3TFM," Ministry of the Environment, Conservation, and Parks, Toronto, 2019.

aercoustics

Project ID: 16115.01	**Project Name**
Scale: As Indicated Drawn by: KC Reviewed by: DH Date: Dec 7, 2022 Revision: 1	Nation Rise Wind Farm - Transformer Acoustic Audit
	Figure Title
	Nation Rise Transformer - Site Photo

Figure 1



Project ID: 16115.01

Scale: As Indicated
Drawn by: KC
Reviewed by: DH
Date: Dec 7, 2022
Revision: 1

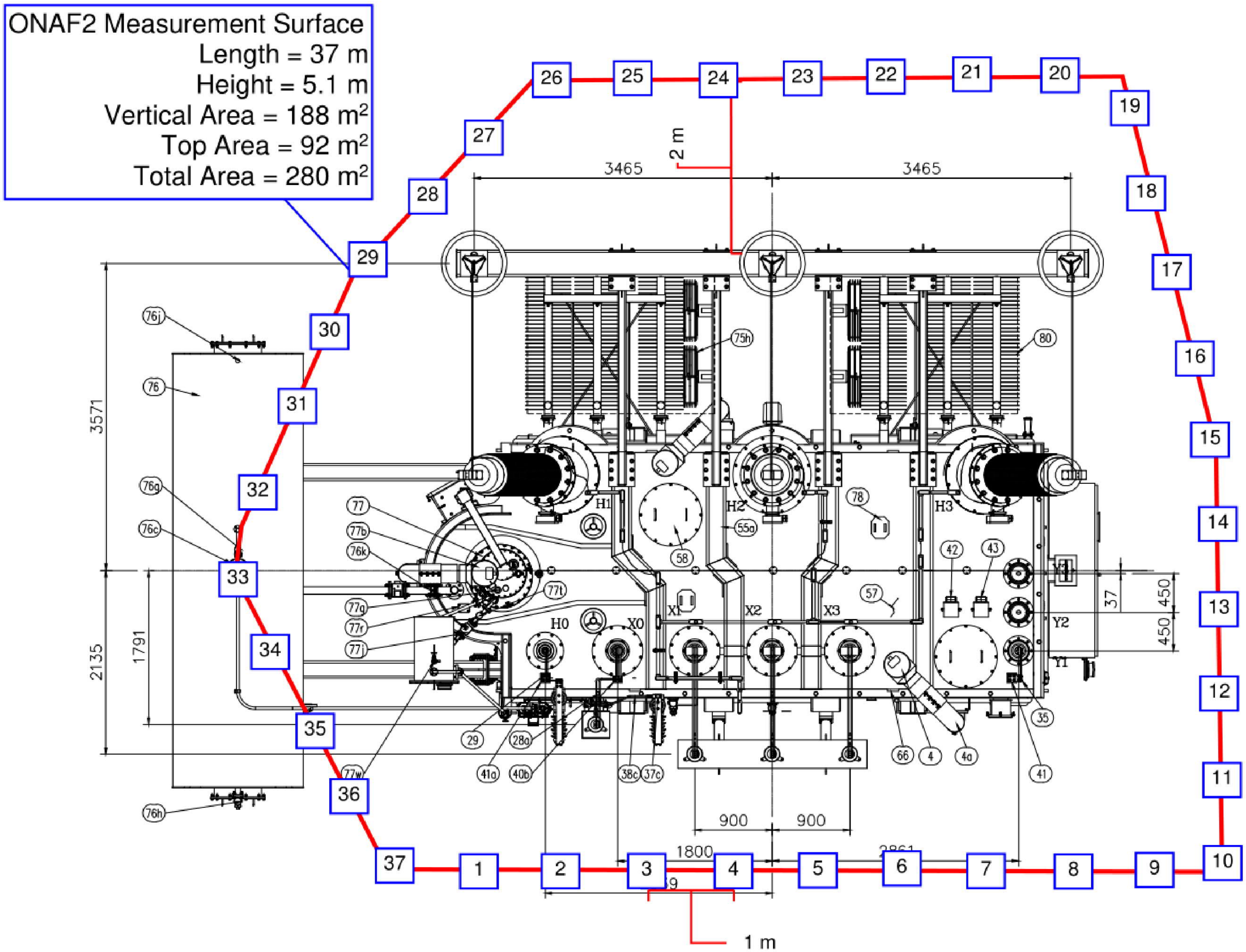
Project Name

Nation Rise Wind Farm - Transformer Acoustic Audit

Figure Title

Nation Rise Transformer in Plan View with ONAN Measurement Locations

Figure 2



aercoustics	Project ID: 16115.01	**Project Name** Nation Rise Wind Farm - Transformer Acoustic Audit
	Scale: As Indicated Drawn by: KC Reviewed by: DH Date: Jan 11, 2023 Revision: R1	**Figure Title** Nation Rise Transformer in Plan View with ONAF2 Measurement Locations
		Figure 3

Appendix A
Instrument Calibration Certificates

CERTIFICATE of CALIBRATION

Make : Larson Davis

Reference # : 166953

Model : 2900B

Customer : Aercoustics Engineering Ltd
Mississauga, ON

Descr. : Sound Level Meter Type 1/ 2 ch Spec Ana

Serial # : 1054

P. Order : 2021.07.28C

Asset # : 00081

Cal. status : Received in spec's, no adjustment made.
With 4190 s#2133476 and PRM900B s#3887.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-9001-2015 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Aug 05, 2021

By : T. Beilin

Cal. Due : Aug 05, 2023

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 800-668-7440
Fax: 905 565 8325
http: // www.navair.com
e-Mail: service @ navair.com

CERTIFICATE of CALIBRATION

Make :	G.R.A.S	Reference # :	170647
Model :	50GI	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	CCP Intensity Probe		
Serial # :	112774-112784	P. Order :	2020.04.07C
Asset # :	NAN		

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : May 12, 2022 By :

Cal. Due : May 12, 2024 Petro Onasko

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-163 J-216 J-324 J-333 J-420 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
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NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit # 7
Mississauga ON L5T 2E7
Tel: (905) 565-1583
Fax: (905) 565-8325

Form: GRAS 50GI	Approved by: J.R.	Jan-18	Ver 2.0

Calibration Report for Certificate # 170647

Make		Model	Serial №	Asset	Cal by
G.R.A.S.		50GI	nsn	NAN	P.O.
G.R.A.S.	CH1	40GI	112774		
G.R.A.S.	CH1	26CB	104781		
G.R.A.S.	CH2	40GI	112784		
G.R.A.S.	CH2	26CB	104771		

Ambient Conditions:

Barometric Pressure	*100.5 kPa*
Temperature	*23.4°C*
Relative Humidity	*23%*

System Test of CH1 Microphone/Preamp Pair

40GI	Serial №	112774
26CB	Serial №	104781

Sensitivity at 250 Hz

Specs Nom	Unit	Min	Reading	Max		In/Out
10.0 mV/Pa		Nom	*13.3 mV/Pa*	Nom		Pass
−40 dB	re 1 V/Pa	Nom	*−37.5 dB*	Nom		Pass
0 dB	re 10 mV/Pa	Nom	*+2.5 dB*	Nom		Pass

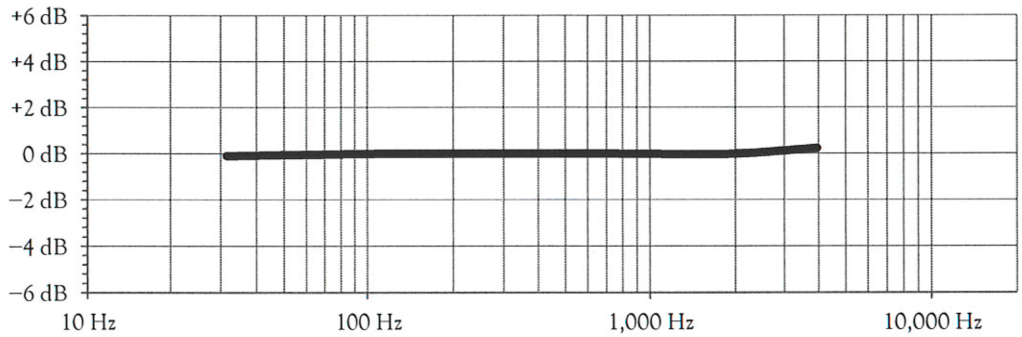
Frequency Response

	Frequency	Pressure
	32 Hz	*−0.10 dB*
	63 Hz	*−0.04 dB*
	126 Hz	*−0.01 dB*
Reference	251 Hz	*0.00 dB*
	503 Hz	*0.00 dB*
	1005 Hz	*−0.02 dB*
	1979 Hz	*−0.02 dB*
	3958 Hz	*+0.23 dB*

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit # 7
Mississauga ON L5T 2E7
Tel: (905) 565-1583
Fax: (905) 565-8325

Form: GRAS 50GI	Approved by: J.R.	Jan-18	Ver 2.0



System Test of CH2 Microphone/Preamp Pair

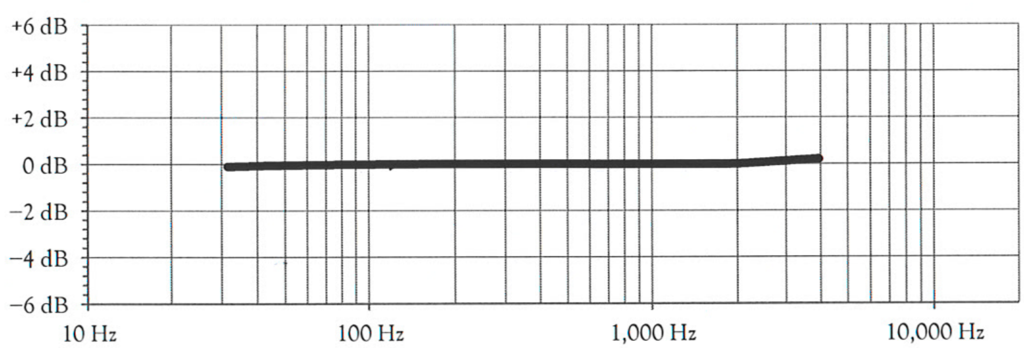
40GI	Serial №	**112784**
26CB	Serial №	**104771**

Sensitivity at 250 Hz

Specs Nom	Unit	Min	Reading	Max		In/Out
10.0 mV/Pa		Nom	*10.0 mV/Pa*	Nom		Pass
-40 dB	re 1 V/Pa	Nom	*−40.0 dB*	Nom		Pass
0 dB	re 10 mV/Pa	Nom	*−0.0 dB*	Nom		Pass

Frequency Response

	Frequency	Pressure
	32 Hz	*−0.11 dB*
	63 Hz	*−0.04 dB*
	126 Hz	*−0.01 dB*
Reference	251 Hz	*0.00 dB*
	503 Hz	*0.00 dB*
	1005 Hz	*−0.01 dB*
	1979 Hz	*+0.01 dB*
	3958 Hz	*+0.22 dB*



West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

SOUND CALIBRATOR

Manufactured by:	BRUEL & KJAER
Model No:	4231
Serial No:	2513184
Calibration Recall No:	32879

Submitted By:

Customer: Iwona Stasiewicz

Company: Aercoustics Engineering Ltd
Address: 1004 Middlegate Road, Unit 1100
Mississauga, ON. Canada L4Z 4A9

The subject instrument was calibrated to the indicated specification using standards traceable to the SI through the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. 4231 BRUE

Upon receipt for Calibration, the instrument was found to be:

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied certifies that the item listed above meets acceptance criteria under the decision rule: A=(L-(U95)), where A is the acceptance criteria, L is manufacturer specifications, and U95 is confidence level of 95% at k=2. The decision rule has been communicated and approved by customer during contract review. Measurements marked with (*) are not covered by the scope of current A2LA accreditation.

West Caldwell Calibration Laboratories' calibration control system meets the following requirements: ANSI/NCSL Z540-1, ISO 9001, and ISO 17025.

Note: With this Certificate, Report of Calibration is included.

Approved by:

James Zhu
Quality Manager

Calibration Date:	14-Mar-22
Certificate Issue Date:	16-Mar-22
Certificate No:	32879 - 1

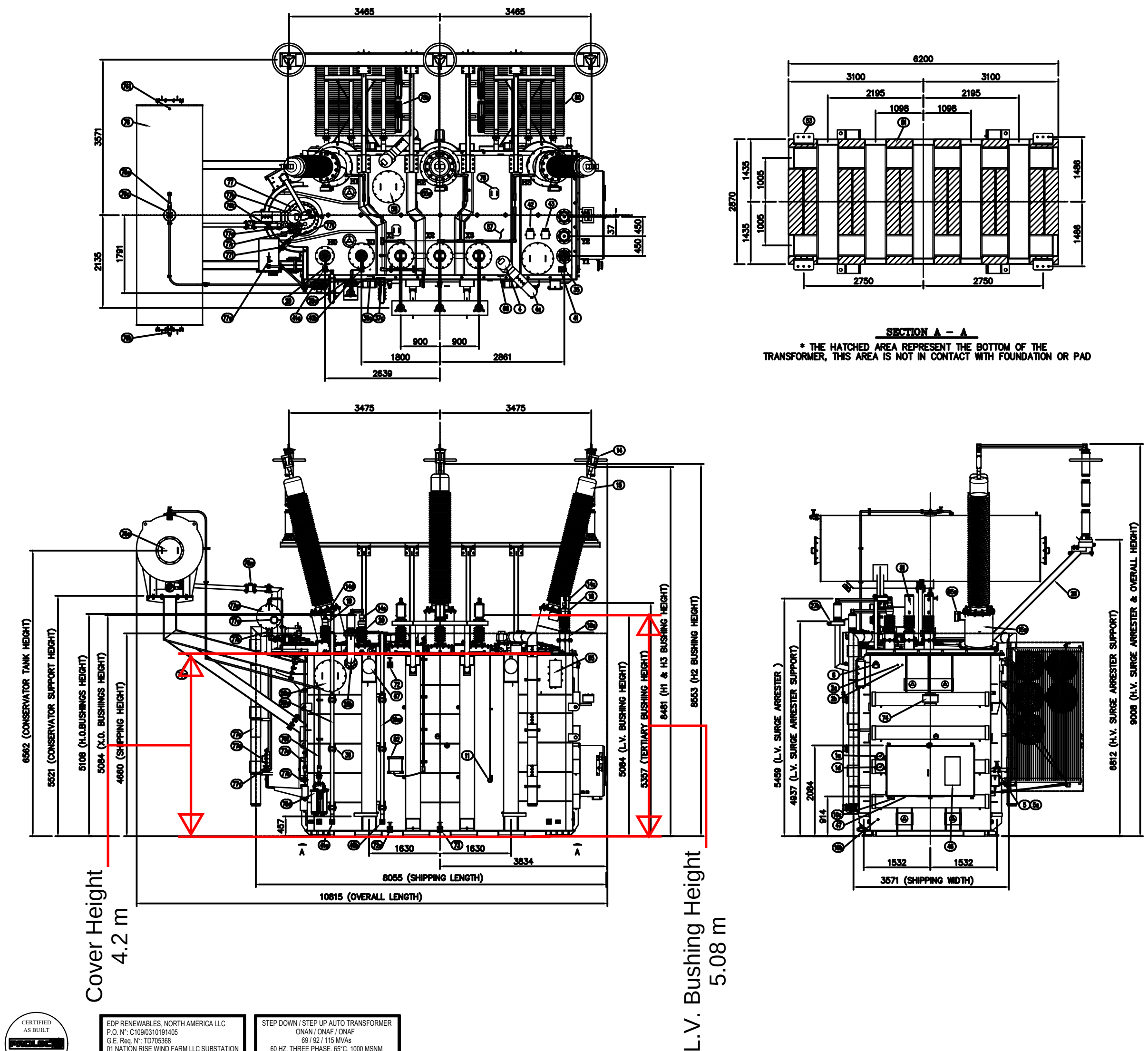
QA Doc. #1051 Rev. 3.0 5/29/20

ISO/IEC 17025

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

ACCREDITED
Calibration Lab. Cert. # 1533.01

Appendix B
Transformer Substation Drawings



GUIDE		QTY.	ITEM	DESCRIPTION	CAT./MOD.
5.1		1	1a	L.V. WINDING TEMPERATURE INDICATOR (49T-1)	MESSKO, MT-ST160W/4/6M/RM
5.1		1	1d	LIQUID TEMPERATURE INDICATOR (26Q-1)	MESSKO, MT-ST160SK/4/4M/RM
		1	2a	THERMO-WELL FOR WINDING TEMPERATURE INDICATOR	
		1	2b	THERMO-WELL FOR LIQUID TEMPERATURE INDICATOR	
5.4	*	2	4	PRESSURE RELIEF DEVICE WITH SEMAPHORE (63PR-1/2)	QUALITROL, XPRD00-00019548
	*	2	4a	DISCHARGE PIPE FOR PRESSURE RELIEF DEVICE	
5.6	*	1	5	RAPID PRESSURE RELAY OIL (63FP-1)	QUALITROL, 900-003-02
		1	5a	RAPID PRESSURE RELAY VALVE (2.00 ø) GATE-TYPE	
		1	6	THERMAL PLATE (TPT-1)	QUALITROL, 1WTL-1026-1
	*	1	9	HYDRAN MONITOR (94H-1)	HYDRAN M2-X
		1	9c	HYDRAN (1.50 ø) VALVE BALL-TYPE (FULL PORT)	
		1	11	PRESSURE-VACUUM GAUGE FOR SHIPPING	
		1	10a	RESISTANCE TEMPERATURE DEVICE FOR ETM (TOP OIL)	QUALITROL, 103-023-01
		1	10b	RESISTANCE TEMPERATURE DEVICE FOR ETM (BOTTOM OIL)	QUALITROL, 103-023-01
		1	10c	RESISTANCE TEMPERATURE DEVICE FOR ETM (AMBIENT)	QUALITROL, 103-047-01
		1	10d	RESISTANCE TEMPERATURE DEVICE FOR ETM WINDING	QUALITROL, 103-023-01
5.15	*	3	14	H.V. BUSHING EXTERNAL CONNECTOR	PCORE, B63056-AF
5.15	*	3	14a	L.V. BUSHING EXTERNAL CONNECTOR	LAPP, B63071-70
5.15	*	1	14c	TERTIARY BUSHING EXTERNAL CONNECTOR	DELTA, PM60C12-1-422-M1-E
5.15	*	1	14d	NEUTRAL BUSHING H0 EXTERNAL CONNECTOR	DELTA, PM59C12-1-4N4-E
5.15	*	1	14e	NEUTRAL BUSHING X0 EXTERNAL CONNECTOR	DELTA, PM62C12-1-M3-E
3.2	*	3	15	H.V. BUSHING	ABB, 300G0600AK
	*	3	15a	H.V. REMOVABLE BUSHING TURRET	
3.2	*	3	16	L.V. BUSHING	ABB, 035G3000JA
3.2	*	3	18	TERTIARY BUSHING	ABB, 035G2000HA
	*	3	18a	TERTIARY REMOVABLE BUSHING TURRET	
3.2	*	1	19	NEUTRAL BUSHING H0	ABB, 035G0400CA
3.2	*	1	20	NEUTRAL BUSHING X0	ABB, 035G3000JA
4.2	*	3	25	H.V. SURGE-ARRESTERS	GE, 9L11XPA180AS
	*	3	25a	H.V. BUSHING TO SURGE-ARRESTER FLEXIBLE CONNECTOR	
	*	1	26	H.V. SURGE-ARRESTER SUPPORT	
4.2	*	3	27	L.V. SURGE-ARRESTERS	GE, 9L11XPA030AS
	*	6	27a	L.V. BUSHING TO SURGE-ARRESTER FLEXIBLE CONNECTOR	
	*	1	27b	L.V. SURGE-ARRESTER SUPPORT	
4.2	*	1	28	X.O. SURGE-ARRESTERS	GE, 9L11XPA030AS
	*	2	28a	X.O. BUSHING TO SURGE-ARRESTER FLEXIBLE CONNECTOR	
	*	1	28b	X.O. SURGE-ARRESTER SUPPORT	
	*	1	29	NEUTRAL BUSHING H0 TO GROUND FLEXIBLE CONNECTOR	
	*	1	35	TERTIARY GROUND PAD (SET)	
	*	8	36	GROUND BAR INSULATOR	
5.11	*	1	36hn	H0 COPPER GROUND BAR (SET)	
5.11	*	1	36xn	X0 COPPER GROUND BAR (SET)	
	*	1	37c	X0 GROUND CABLE CONNECTOR	
	*	1	38c	X0 COPPER GROUND CABLE	
		4	40	GROUND PAD (COPPER)	
		4	40a	GROUND PAD (COPPER)	
		2	40b	NEUTRAL X0 GROUND PAD (COPPER)	
		1	41	TERTIARY GROUND PAD (COPPER)	
		2	41a	NEUTRAL H0 GROUND PAD (COPPER)	
		1	42	CORE GROUND BUSHING TERMINAL BOX (MAIN UNIT)	
		1	43	FRAME GROUND BUSHING TERMINAL BOX	
		1	46	NAMEPLATE	
5.3		1	47	CONTROL CABINET	
		1	51	REINFORCED BASE WELDED TO TANK	
		4	53	TRANSFORMER ANCHOR PADS	
		19	55	TANK BRACES	
		4	55a	COVER BRACES	
		4	56	JACKING PADS AND PULLING EYES	
		1	57	MAIN COVER	
		2	58	INSPECTION MANHOLE/COVER (632ø)	
		1	58a	INSPECTION MANHOLE/WALL (632ø)	
		1	65	CT TERMINAL BOX	
		3	65a	CT TERMINAL BOX	
		4	66	LIFTING EYE COVER ONLY	
		4	67	LIFTING HOOK FOR LIFTING COMPLETE UNIT	
		3	68	SHIPPING LUGS FOR SECURING THE UNIT LONGITUDINALLY (SHORT LUGS)	
		5	68a	SHIPPING LUGS FOR SECURING THE UNIT LONGITUDINALLY (LONG LUGS)	
		1	72	TOP FILTER PRESS VALVE (50.8 ø) GLOBE-TYPE	
	*	1	72a	BOTTOM FILTER PRESS VALVE (50.8 ø) GLOBE-TYPE WITH SAMPLING DEVICE (9.5ø) AND PLUG	
	*	1	73	COMPLETE DRAIN VALVE (50.8 ø) GLOBE-TYPE WITH SAMPLING DEVICE (9.5ø) AND PLUG	
		1	74	IMPACT RECORDER FOR SHIPPING	
		1	74a	ELECTRONIC IMPACT RECORDER FOR SHIPPING	
1.3	*	6	75	COOLING RADIATORS	
		12	75b	RADIATOR VENT AND DRAIN PLUG (25.4 ø)	
1.1		12	75d	RADIATOR VALVE BUTTERFLY-TYPE (76.2 ø)	
	*	10	75h	COOLING FAN	KRENZ, F26D-A7836
	*	4	75i	RADIATOR SUPPORT	
1.4	*	4	75n	TOP/BOTTOM RADIATOR SUPPORTS	
1.2	*	4	75o	RADIATOR BRACE	
2.3	*	1	76	CONSERVATOR TANK WITH INTERNAL BLADDER	
2.1	*	2	76a	CONSERVATOR TANK SUPPORT	
2.2	*	1	76b	CONSERVATOR MAGNETIC LIQUID LEVEL GAUGE	MESSKO, 643-309950-08
		1	76c	HANDHOLE TO INSTALL BLADDER	
5.8	*	1	76d	SILICA-GEL BREATHER WITH PIPE	MESSKO, DB200RM-D-T-HT
		2	76e	CONSERVATOR MANHOLE	
5.8	*	1	76f	SILICA-GEL SHUT OFF VALVE (25.4 ø) GLOBE-TYPE	
		1	76g	CONSERVATOR PRESSURE EQUALIZATION VALVE (25.4 ø) GLOBE-TYPE	
		1	76h	CONSERVATOR FILL VALVE (50.8 ø) GLOBE-TYPE	
		1	76i	CONSERVATOR DRAIN VALVE (50.8 ø) GLOBE-TYPE	
		1	76j	CONSERVATOR TANK COUPLE FOR VENT WITH CAP.	
2.2	*	2	76k	CONSERVATOR TANK TO MAIN TANK VALVE BUTTERFLY-TYPE (76.2 ø)	
		1	76l	GAS SAMPLING DEVICE	
2.4	*	1	76m	PROTECTIVE RELAY FOR GAS ACCUMULATION (BUCHHOLZ) (63BH-1)	EMB, 53-6.28.44-0336
		1	77	ON-LOAD TAP-CHANGER	MR, VMIII350Y-72.5/B14273W
		1	77a	LTC MAGNETIC LIQUID LEVEL GAUGE (71Q-4)	MESSKO, MTO-STF160/1CO/RM
5.4	*	1	77b	LTC PRESSURE RELIEF DEVICE (63PR-4)	
	*	1	77c	DISCHARGE PIPE FOR LTC PRESSURE RELIEF DEVICE	
		1	77q	LTC INSPECTION RECTANGULAR MANHOLE (WALL)	
5.8	*	1	77k	LTC SILICA-GEL BREATHER WITH PIPE	MESSKO, DB100RM-HT
		1	77l	LTC MOTOR DRIVE CABINET	
	*	1	77n	LTC CONSERVATOR TANK SUPPORT	
5.7	*	1	77m	LTC CONSERVATOR TANK	
		1	77g	LTC THERMO-WELL LIQUID TEMPERATURE INDICATOR	
		1	77h	LTC DRAIN VALVE (25.4 ø) GLOBE-TYPE WITH SAMPLING DEVICE AND PLUG	
5.8	*	1	77j	LTC PROTECTIVE RELAY (63BH-4)	
		1	77r	LTC WARNING NAMEPLATE	
		2	77t	LTC PROTECTIVE RELAY VALVE (25.4 ø) GLOBE-TYPE	
	*	1	77u	LTC SILICA-GEL VALVE (25.4 ø) GLOBE-TYPE	
		1	77v	LTC SUCTION VALVE (25.4 ø) GLOBE-TYPE WITH PIPE	
		1	77w	LTC TOP FILTER PRESS VALVE (25.4 ø) GLOBE-TYPE	
		2	78	TETHER POLE MOUNTING PLATE	
	*	2	80	BIRD NETTING	
	*	2	81	TERTIARY BUSHING CONNECTION PROTECTION COVER (Y2 & Y3)	RAYCHEM , BCAC-1C-10.5D / 20
	*	1	82	DOBLE PRIME SAFETY BOX FOR SHORTING BLOCKS	

CERTIFIED AS BUILT
PROLEC
ENGINEERING DEPARTMENT

EDP RENEWABLES, NORTH AMERICA LLC
P.O. N°: C109/0310191405
G.E. Req. N°: TD705368
01 NATION RISE WIND FARM LLC SUBSTATION
PROLEC GE Serial N°: G4086-01

STEP DOWN / STEP UP AUTO TRANSFORMER
ONAN / ONAF / ONAF
69 / 92 / 115 MVAs
60 HZ, THREE PHASE, 65°C, 1000 MSNM
230 / 132.8 KV - 34.5 / 19.92 KV
TERTIARY: 24.15 / 32.2 / 40.25 MVAs, 13.75 KV

REV	DESCRIPTION
5	CHANGES BY CUSTOMER COMMENTS FGC 04/09/19
4	ITEM 36,36hn & 36xn WERE ADDED. FGC 03/07/19
3	ITEM 82 WAS ADDED FGC 11/01/18
2	ITEM 9C WAS CHANGED FGC 10/11/18
1	APPROXIMATE WEIGHTS WERE CORRECTED FGC 08/17/18

DESIGN GROUP LPT-04

PROLEC GE

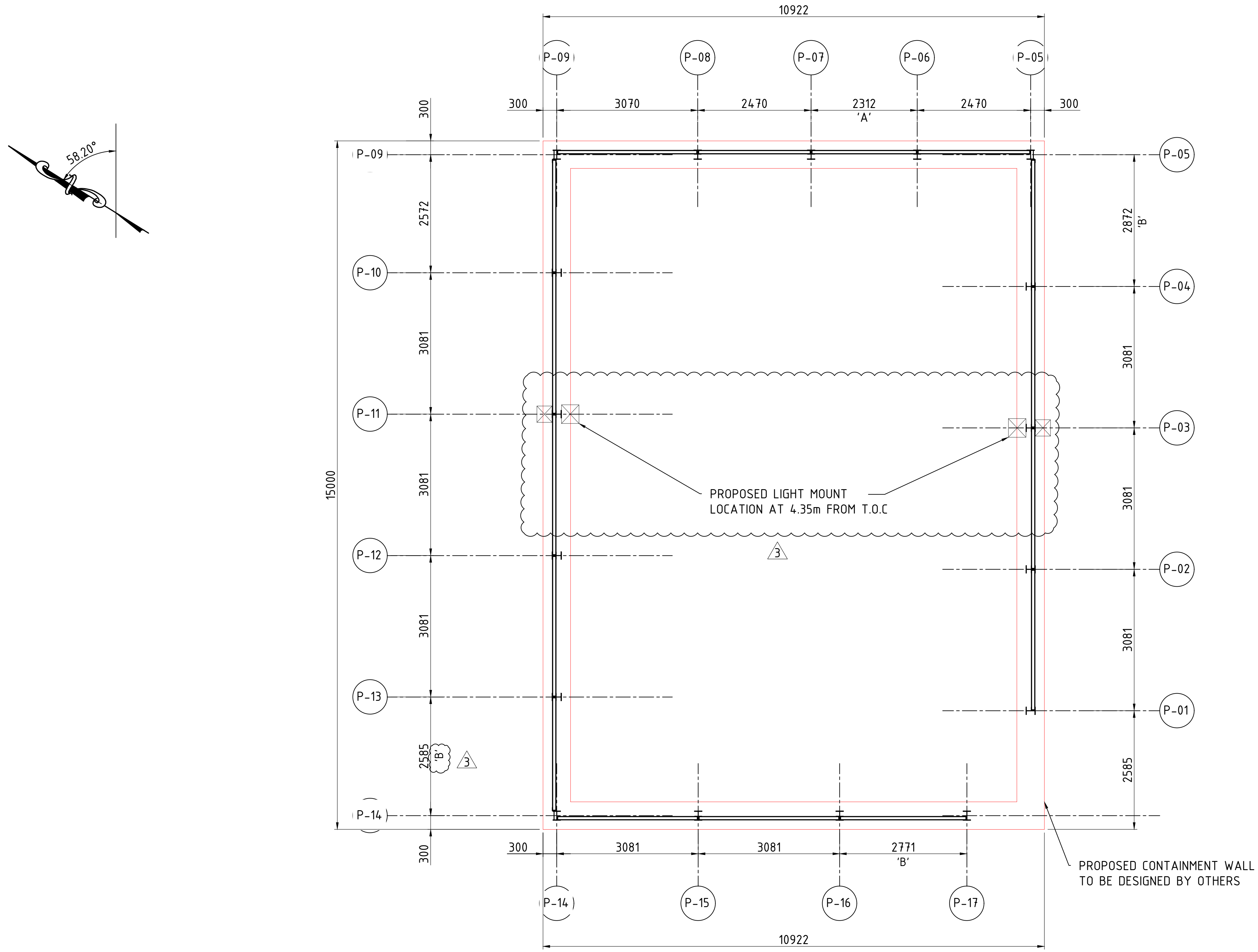
PROLEC GE ENGINEERING POWER DIVISION
http://www.prolecge.com

TITLE: TRANSFORMER'S OUTLINE

DFTM: FGC 08/10/18
CHKD: AOGU 08/10/18

PROJECTION
SCALE: 1:50
DIMENSIONS: MM
REVISION: INDICATED
DRAWING NO.: G408601D801
sheet: 1 of 2

CUTTING INSTRUCTIONS:
'A' CUT FROM ONE END OF 95.5" PANEL-REINFORCE CUT END ACCORDING TO DETAIL B/5A.
'B' CUT FROM ONE END OF 119.5" PANEL-REINFORCE CUT END ACCORDING TO DETAIL B/5A.



PLAN VIEW
SCALE NTS

PATRICK ZHANG
Monday, May 13, 2019 5:10:26 PM

REV NO.	DATE	BY	DESCRIPTION
3	13 MAY 19	LX	ISSUED FOR CONSTRUCTION
2	09 MAY 19	LX	RE-ISSUED FOR APPROVAL
1	02 MAY 19	LX	RE-ISSUED FOR APPROVAL
0	29 MAR 19	LX	ISSUED FOR APPROVAL

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NORTH STORMONT WIND FARM
SUBSTATION
PLAN VIEW

DESIGNED	RJ	28 MAR 13
DES. CHK	PAS	28 MAR 13
DRAWN BY	LX	28 MAR 13
DWG. CHK	PAS	28 MAR 13

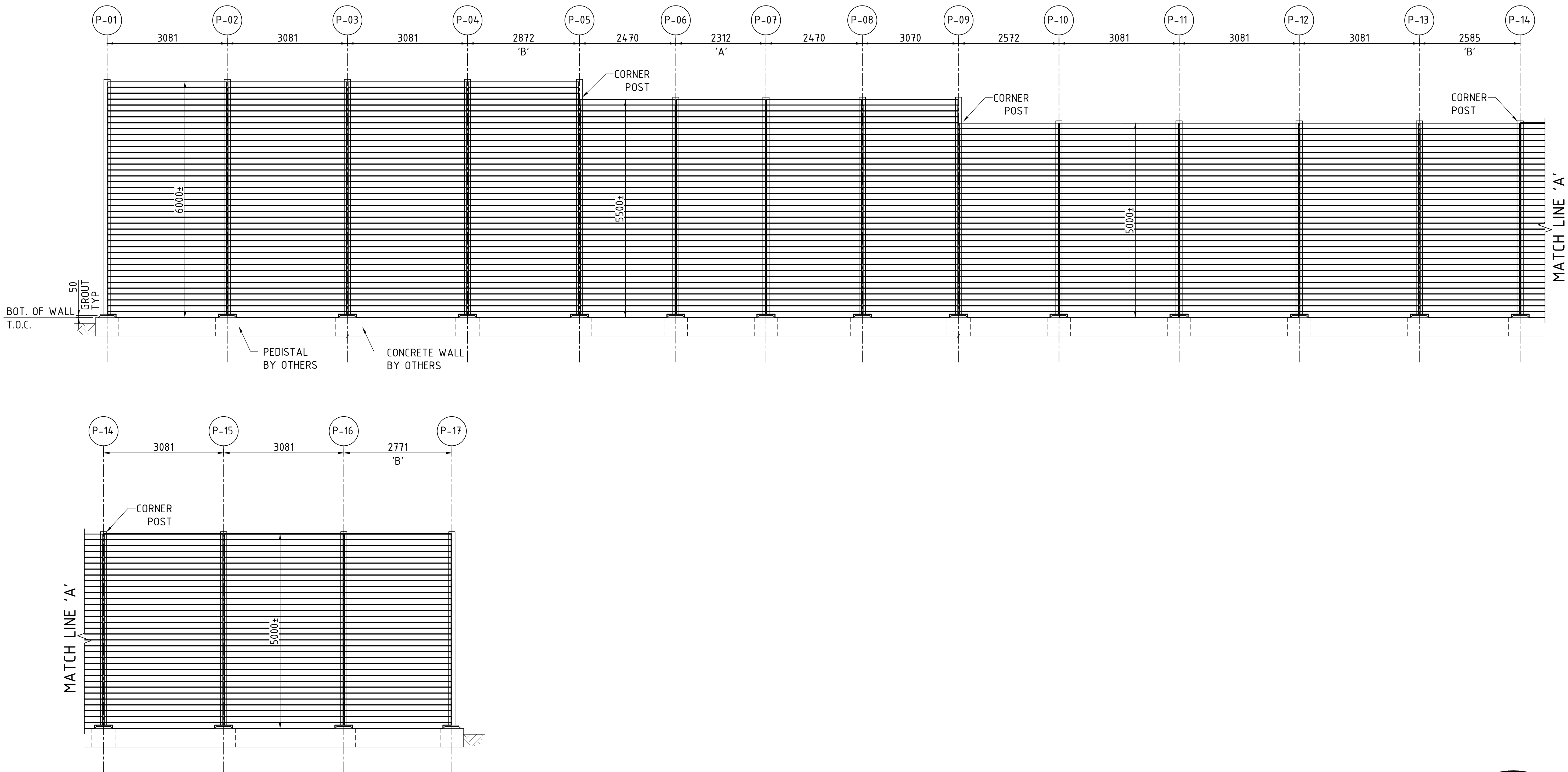
BRANCH P.O.	CUSTOMER REF.
-	-

PROJECT NUMBER 2018-00893A DWG NO. 1A REV. 3

P:\2019\- AIL SOUND WALLS\2018-00893 NORTH STORMONT WIND FARM\DRAFTING\2018-00893A-IFC-20190510-R3

PATRICK ZHANG

Monday, May 13, 2019 5:10:31 PM



ELEVATION

SCALE 1:100

CUTTING INSTRUCTIONS:
'A' CUT FROM ONE END OF 95.5" PANEL-REINFORCE CUT END ACCORDING TO DETAIL B/5A.
'B' CUT FROM ONE END OF 119.5" PANEL-REINFORCE CUT END ACCORDING TO DETAIL B/5A.

LICENSED PROFESSIONAL ENGINEER
R.L.JING
100076054
13/05/2019
PROVINCE OF ONTARIO

REV NO.	DATE	BY	DESCRIPTION
3	13 MAY 19	LX	ISSUED FOR CONSTRUCTION
2	09 MAY 19	LX	RE-ISSUED FOR APPROVAL
1	02 MAY 19	LX	RE-ISSUED FOR APPROVAL
0	29 MAR 19	LX	ISSUED FOR APPROVAL

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NORTH STORMONT WIND FARM
SUBSTATION
ELEVATION

DESIGNED	RJ	28 MAR 13
DES. CHK	PAS	28 MAR 13
DRAWN BY	LX	28 MAR 13
DWG. CHK	PAS	28 MAR 13

BRANCH P.O.: -

CUSTOMER REF.: -

PROJECT NUMBER: 2018-00893A

DWG NO.: 1B

REV.: 3

Appendix C
Transformer Measurement Data

Table C-1: Average Measured Sound Pressure and Intensity Levels – ONAN Operation

Measurement Position	SPL / SIL (dBA), as per IEEE 57.12.90-2015			
	Sound Pressure measurements		Sound-intensity measurements	
	1/3 Height	2/3 Height	1/3 Height	2/3 Height
1	67	65	65	63
2	65	70	63	67
3	72	69	65	66
4	67	67	66	64
5	68	68	67	65
6	66	66	64	65
7	59	64	55	59
8	69	69	67	70
9	69	68	67	66
10	67	65	63	65
11	69	67	68	65
12	66	63	63	64
13	67	63	65	64
14	65	59	64	59
15	58	65	58	64
16	61	62	58	59
17	63	63	63	61
18	65	65	64	63
19	60	65	59	66
20	66	64	61	60
21	60	60	59	59
22	61	58	60	59
23	65	60	63	61
24	72	67	65	65
25	74	71	68	69
26	71	67	65	65
27	72	68	69	64
28	66	66	64	65
29	59	64	55	59

* Measurement locations are shown in Figure 2

Table C-2: Average Measured Sound Pressure and Intensity Levels – ONAF2 Operation

Measurement Position	SPL / SiL (dBA), as per IEEE 57.12.90-2015 Sound Pressure measurements		Sound-intensity measurements	
	1/3 Height	2/3 Height	1/3 Height	2/3 Height
1	65	64	63	62
2	68	67	61	63
3	68	69	64	68
4	68	66	67	62
5	65	66	64	63
6	65	66	63	63
7	62	66	61	64
8	70	73	67	72
9	68	66	69	63
10	66	66	66	66
11	68	68	68	66
12	69	70	69	69
13	70	69	68	67
14	71	71	71	71
15	71	71	72	71
16	70	70	69	69
17	71	70	70	69
18	72	72	72	71
19	74	73	73	72
20	74	73	73	72
21	73	72	72	71
22	71	72	70	69
23	70	70	69	69
24	71	71	71	70
25	70	70	70	70
26	70	70	69	70
27	70	71	69	70
28	68	71	68	71
29	67	68	68	66
30	66	68	63	68
31	68	69	67	68
32	65	64	62	61
33	65	64	64	61

SPL / SiL (dBA), as per IEEE 57.12.90-2015				
34	65	63	65	60
35	65	63	65	60
36	65	68	65	65
37	64	67	63	65

* Measurement locations are shown in Figure 3

Appendix D
Sample Calculation – Transformer Sound Power

Appendix D - Sample Calculation - Determination of Transformer Total Sound Power Level at Rated Load

Nation Rise 115 MVA Transformer - Transformer Core Noise

Transformer Rated Load	115 MVA
Average Load during ONAN Measurements	89 MVA
ONAN Measurement Surface Area	182 m^2

Parameter	Octave Band Centre Frequency [Hz] 31.5	63	125	250	500	1000	2000	4000	8000	Total [dBA]
Average Measured Sound Intensity Level - ONAN [dB]	76	66	75	63	66	47	41	38	35	**64**
Conversion from SIL to PWL [1]	**+23 dB**									
Sound Power Level - Core Noise at Test Load [dB]	99	88	97	86	88	69	64	60	57	**87**
Correction from Test Load to Rated Load [2]	**+4.5 dB**									
Sound Power Level - Core Noise at Rated Current [dB]	103	93	102	90	93	74	68	65	62	**91**
5 dB Tonal Penalty [3]	**+ 5 dB**									
Sound Power Level - Transformer Core Noise at Rated Load [dB]	**108**	**98**	**107**	**95**	**98**	**79**	**73**	**70**	**67**	**96**

[1] - Equation (39) of the IEEE Standard
[2] - Equaiton (33) of the IEEE Standard
[3] - Tonal penalty added per NPC-104. Tones from the transformer noise were observed to be inaudible even at short distances away from the transformer substation; this represents a conservative assessment.

Nation Rise 115 MVA Transformer - Transformer Fan Noise

ONAF2 Measurement Surface Area	280 m^2

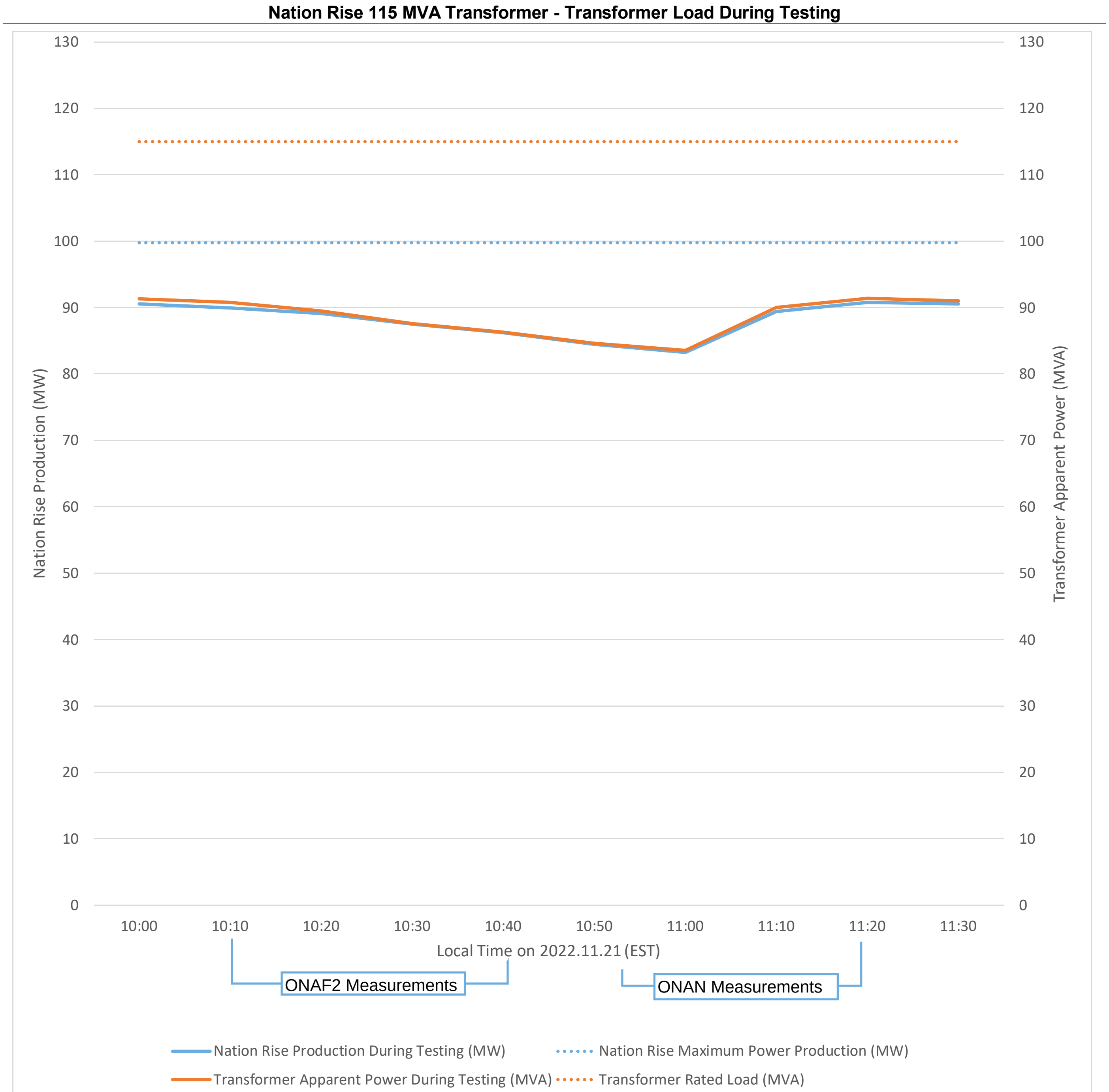
Parameter	Octave Band Centre Frequency [Hz] 31.5	63	125	250	500	1000	2000	4000	8000	Total [dBA]
Average Measured Sound Intensity Level (ONAF2) [dB]	75	67	74	67	69	61	54	42	35	**68**
Conversion from SIL to PWL [1]	**+24 dB**									
Sound Power Level at Test Load - Fans and Core (ONAF2) [dB]	100	92	99	92	94	85	78	66	59	**93**
Sound Power Level - Fan Noise Only [dB] [2]	**92**	**89**	**93**	**91**	**92**	**85**	**78**	**65**	**55**	**91**

[1] - Equation (39) of the IEEE Standard
[4] - Logarithmic subtraction of *Sound Power Level - Transformer Core Noise at Test Load* from *Sound Power Level at Test Load - Fans and Core (ONAF2)*; this result represents the acoustic contribution from the cooling fans, which spin at a fixed speed. Fan noise does not scale with transformer load in the way that core noise does.

Nation Rise 115 MVA Transformer - Transformer Total Noise at Rated Load

Parameter	Octave Band Centre Frequency [Hz] 31.5	63	125	250	500	1000	2000	4000	8000	Total [dBA]
Sound Power Level - Transformer Core Noise at Rated Load [dB]	108	98	107	95	98	79	73	70	67	**96**
Sound Power Level - Fan Noise Only [dB]	92	89	93	91	92	85	78	65	55	**91**
Transformer Total Sound Power Level at Rated Load [dB]	**108**	**98**	**107**	**97**	**99**	**86**	**79**	**71**	**67**	**98**

Appendix E
Nation Rise Production Data During Testing



Please Note - the determination of the Transformer Total Sound Power Level at Rated Load is based on adjustments per the IEEE C57.12.90-2015 standard and is reflective of the transformer operation at the rated 115 MVA load. Please see Section 5.2.2 and Appendix D for further details.

End of Report