aercoustics

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ASSESSMENT REPORT - **Project: 16227.02**

Niagara Region Wind Farm
2nd Transformer Acoustic Audit

REA Number 4353-9HMP2R
100 Simcoe St, No. 105
Toronto, Ontario, M5H 3G2

Prepared for:

1021702 B.C. Ltd
as general partner for and on behalf of FWRN LP

Prepared by:

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April 30, 2019

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1 Introduction

Aercoustics Engineering Limited ("Aercoustics") has been retained by 1021702 B.C. Ltd as general partner for and on behalf of FWRN LP ("Boralex") to complete a post construction audit of the Niagara Region Wind Farm ("NRWF") transformer substation. NRWF operates under Renewable Energy Approval ("REA") #4353-9HMP2R, issued on November 6, 2014 [1] and further modified on November 23, 2015, May 6, 2016 and May 12, 2016.

A report entitled Niagara Region Wind Farm – 2nd Transformer Acoustic Audit report dated November 17th , 2017 was submitted to the MECP to satisfy the requirement of the REA to complete a post construction audit. This initial test report was prepared as per IEEE 57.12.90-2010 standard and testing was conducted under a low load condition as prescribed by IEEE 57.12.90-2010 for acoustic measurements.

The MECP has requested that testing be conducted again as per the latest version of the IEEE 57.12.90-2015 standard under a minimum of 85% turbine load. This report summarizes the results of the acoustic test on transformer ST2 under load conducted on March 28, 2019 as per IEEE 57.12.90-2015 standard.

2 Measurement Instrumentation

The following acoustic measurement equipment was utilized for the acoustic audit, equipment was field calibrated before site measurements:

Near-field Intensity Measurements

- Sound Level Meter: Larson Davis 2900 Integrating Sound Level Meter, SN 2900B1054, Calibrated January 18, 2019;
- Microphones: G.R.A.S. Type 40 GK, SN 112784 and 104771, Calibrated February 11, 2018;
- Preamps: G.R.A.S. 26 CB, SN 104361 and 112774, Calibrated February 11, 2018

Far-field Measurements

- Sound Level Meter: Bruel & Kjaer 2250 Sound Level Meter, SN 2630244, Calibrated September 17, 2018
- Microphone: Bruel & Kjaer 4189 2386059, Calibrated September 17, 2018;
- Calibrator: Larson Davis CAL200, SN 0352, Calibrated October 16, 2018

Calibration certificates are provided in Appendix A.

3 Site Details

Aercoustics personnel completed a site visit on March 28, 2019 and observed transformer ST2 located in the substation yard located north of Jenny Jump Road and west of Wainfleet Dunnville Townline Road in the town of Wellandport, Ontario. A layout of the substation ST2 is included in Figure 1.

During the measurement period on March 28, 2019 the temperature was around 4°C with windy conditions with wind speeds of approximately 20-30km/hr from the South-west. The IEEE 57.12.90-2015 requires testing under load conditions which necessitates the need for measurements to be conducted during windy conditions when the turbines would be operating and providing load to the transformer.

It should be noted that there was negligible wind interference at the measurement locations due to shielding provided by the surrounding acoustic barriers.

Turbine T65 was turned off for the duration of the testing at transformer ST2.

4 Transformer Operation

The specifications of transformer ST2 are summarized in Table 1.

Table 1 Transformer Parameters

Parameter	Transformer ST2
Capacity	69/92/115 MVA
Rated Voltage	34.5 kV - 115 kV
Phase	3 Phase
Frequency	60 Hz
Manufacturer	Pennsylvania Transformer Tech. Inc.

During the testing period, the transformer ST2 was operating at rated voltage. Since the wind turbine farm was operational during the acoustic test, the load was noted as approximately 92MW for transformer ST2, this is greater than 85% of turbine load on the transformer. This parameter has been agreed to by the MECP to represent the loaded condition prescribed in IEEE 57.12.90-2015 for acoustic measurements [2].

As per IEEE 57.12.90-2015 measurements were done under load in two conditions: with the external cooling fans operating (ONAF) and non-operational (ONAN). The transformer noise measured consisted of cooling fan noise and generator core hum. A two (2) sided barrier 5.3m high acoustic barrier was in place (south and west side of transformer) during the measurement. It should be noted that the barrier height exceeds the height specified in the REA, for more detail please refer to the letter in Appendix B.

5 Near Field Measurements

5.1 Measurement Procedure

Sound level measurements were taken between 8:43 AM and 10:33 AM on March 28, 2019. Sound intensity levels were measured in accordance with ISO 9614-1 [3]. Sound power level was determined from the measured sound intensity in accordance with IEEE C57.12.90-2015 [2].

Measurement points were taken at intervals 1 m apart, 0.3 m from the surface of the transformer casing or 1 m near cooling fans, at 1/3 and 2/3 total height of the transformer, as stipulated by IEEE C57.12.90-2015. The sound power levels were then calculated in accordance with the procedures set out in IEEE C57.12.90-2015.

A summary of the measurement parameters is provided in Table 2. The transformer sits on a 0.3 m high concrete curb, the height of which has been considered accordingly. See Figure 2 for a picture of the installed transformer ST2. See Figure 3 and Figure 4 for the plan view of transformer ST2, including source and measurement locations for ONAN and ONAF. See Figure 7 for a photo of the near-field measurement setup.

Table 2 Measurement Details

Parameter	Transformer ST2
Measurement Distance	0.3 m 1 m from cooling fans
Horizontal Spacing Between Measurement Locations	1 m
Height of Transformer (H)	4.7 m
Height of Microphone 1 above ground	1.9 m (0.3 m + 1/3H)
Height of Microphone 2 above ground	3.4 m (0.3 m + 2/3H)

5.2 Measurement Results

5.2.1 Sound Intensity Level Measurements

The average sound intensity measured for transformer ST2 for ONAN and ONAF operations was 67 dBA (Leq) and 76 dBA (Leq) respectively. Spectral data is summarized in Table 3, while overall data from each measurement location around the transformer is provided in Table 4 and Table 5.

Table 3 Measured Transformer Averaged Spectrum

	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1000	2000	4000	8000	Total (dBA)
ONAN Transformer ST2 Sound Intensity Level (dB)	61	56	79	58	63	62	36	29	25	67
ONAF Transformer ST2 Sound Intensity Level (dB)	71	74	80	76	73	72	67	54	41	76

Table 4 Measured Sound Intensity Levels - ONAN

SiL (dBA), as per IEEE 57.12.90-2015/ ISO 9614-1		
Transformer ST2		
Position*	**1/3 Height**	**2/3 Height**
1	68	65
2	68	63
3	68	69
4	69	72
5	64	73
6	63	68
7	62	67
8	57	67
9	60	62
10	68	65
11	63	65
12	62	67
13	65	71
14	60	63
15	58	61
16	58	62
17	67	65
18	66	68
19	66	63
20	61	61
21	66	65
22	67	68
23	62	68
24	68	68
TOTAL	**Total Energy Average SiL: 67 dBA**	

*Measurement locations are shown in Figure 3

The difference in measured sound intensity level at position 5 and position 8 at 1/3 height and 2/3 heights varied by 9 dB and 10 dB respectively. Measurements in the near field of large noise sources such as a transformer can vary considerably as different individual parts of the transformer can generate more noise than others (radiators, coolers, tubes, switch compartments and terminal chambers). The difference in the measured sound levels can be attributed to varying localized sources of noise of the transformer at the 1/3 and 2/3 height.

Table 5 Measured Sound Intensity Levels - ONAF

SiL (dBA), as per IEEE 57.12.90-2015/ ISO 9614-1		
Transformer ST2		
Position*	**1/3 Height**	**2/3 Height**
1	70	69
2	67	68
3	67	70
4	68	67
5	73	67
6	69	69
7	70	74
8	71	77
9	72	79
10	73	76
11	71	73
12	72	74
13	74	78
14	77	80
15	78	81
16	74	77
17	76	80
18	77	84
19	76	80
20	73	76
21	75	78
22	77	81
23	78	78
24	75	73
25	68	71
26	68	70
TOTAL	**Total Energy Average SiL: 76 dBA**	

*Measurement locations are shown in Figure 4

5.2.2 Evaluation of Sound Power Level - ONAN

Based on the evaluation procedures outlined in IEEE C57.12.90:2015, the transformer ST2 had sound power levels of 94 dBA for ONAN. The parameters used to determine the overall sound power level are provided in Table 6. The calculated sound power spectra for ONAN are included in Table 7.

The primary noise source was the core hum of the transformer. Based on Aercoustics observations of the site and the subjective tonality assessment at the source measurement location, a 5dB tonal penalty has been applied to the transformer core calculated sound power level.

Table 6 Sound Power Calculations - ONAN

Parameter	Transformer ST2
Perimeter Area of Enclosing Measurement Surface	141.0 m^2
Top Area	46.0 m^2
Total Measurement Surface Area	187.0 m^2
Average Sound Intensity Level	67 dBA

Table 7 Calculated Transformer Sound Power Spectra - ONAN

	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1000	2000	4000	8000	Total (dBA)
Transformer Core	84	78	102	81	86	85	59	52	47	89
Transformer Core Only [with +5 dB Penalty]	89	83	107	86	91	90	64	57	52	94*

*Sound Power Levels include the +5dB tonal adjustment applied to the transformer core

5.2.3 Evaluation of Sound Power Level - ONAF

Based on the evaluation procedures outlined in IEEE C57.12.90, the transformer ST2 had sound power levels of 100 dBA for ONAF. The parameters used to determine the overall sound power level are provided in Table 8. The calculated sound power spectra are included in Table 9. For transformer ST2 during the ONAF operating condition the cooling fan noise is dominant and drives the overall sound power level of the transformer. As the tonal penalty is applicable to the tonal nature of the transformer core only (the cooling fan noise is broadband), the tonal penalty has been applied only to the transformer core noise and not to the Transformer Fans Only noise. The total sound power of the transformer under ONAF conditions has been calculated by logarithmically adding the contribution of the transformer core only under load with tonal penalty and the transformer cooling fans only.

Table 8 Sound Power Calculations - ONAF

Parameter	Transformer ST2
Perimeter Area of Enclosing Measurement Surface	159.8 m^2
Top Area	58.0 m^2
Total Measurement Surface Area	217.8 m^2
Average Sound Intensity Level	76 dBA

Table 9 Calculated Transformer Sound Power Spectra - ONAF

	Octave Band Centre Frequency (Hz)									
	31.5	63	125	250	500	1000	2000	4000	8000	Total (dBA)
Transformer Core Only	84	78	102	81	86	85	59	52	47	89
Transformer Core Only [with +5 dB Penalty]	89	83	107	86	91	90	64	57	52	94
Transformer Fans Only [with Transformer Core Subtracted]	94	97	94	99	96	95	90	77	65	99
Transformer Substation* [Transformer Core* + Cooling Fans]	95	98	107	99	97	96	90	77	65	100

*Sound Power Levels include the +5dB tonal adjustment applied to the transformer core

6 Far Field Measurements

Far field noise measurements were taken on March 28, 2019 as requested by the MECP. The measurements were taken at multiple locations in the northeast and southwest directions from the transformer substation ST2; west of Wainfleet Dunnville Townline Road and north of Jenny Jump Road. The far field measurements were taken at ground level using a ground plane and wind screen – similar to that used for measurements of wind turbine noise in accordance with IEC 61400-11. This was done to minimize the influence of wind induced noise on the measurements. A 6dB correction accounts for the approximate pressure doubling that occurs for the sound level measurements on a measurement board as per IEC 61400-11. The 1/3 octave band insertion loss of the secondary windscreen has been tested and was accounted for in the data analysis.

The far field measurement locations and nearby receptors are indicated in Figure 5, and photo at the far field measurement location Sc5 is shown in Figure 6. The measured sound levels at the various locations is summarized in Table 10 below.

Table 10 Measured Sound Levels

Measurement Location	Distance from Transformer ST2 (m)	Total Leq (dBA)*	Comments	UTM Coordinates (17T)	
				X (m)	Y (m)
Sc1	535	38.6	ST2 not audible	622478	4754287
Sc2	285	37.0	ST2 not audible	622749	4754412
Sc3	144	35.0	ST2 faintly audible	622741	4754573
Sc4	139	40.1	ST2 audible	622862	4754817
Sc5	283	39.0	ST2 faintly audible	622889	4754951
Sc6	559	37.2	ST2 not audible	622939	4755232

*Includes 6dB correction to measured sound pressure level due to ground plane measurements

The measured level at the close setback measurement distance points (~140m) Sc3 and Sc4 were 35 and 40 dBA respectively. The transformer was noted to be audible at measurement location Sc4 and faintly audible at measurement location Sc3. It should be noted that the noise mitigation barrier shielded the measurement location Sc3.

The measured levels at medium setback distance points (~280m) Sc2 and Sc5 were 37 and 39 dBA respectively. The transformer was noted to be inaudible at measurement

location Sc2 and faintly audible at Sc5. The measured level was noted to be influenced by ambient noise from nearby trees and birds at measurement points Sc2 and Sc5.

The measured levels at the furthest setback distance points (~560m) Sc1 and Sc6 were 38.6 and 37.2 dBA respectively. The transformer was noted to be inaudible at measurement locations Sc1 and Sc6. The measured level was noted to be influenced by ambient noise from nearby trees and birds at measurement points Sc1 and Sc6.

7 Assessment of Compliance

The following table compares the facility's Renewable Energy Approval (REA) defined sound power limits for the transformers with the measured values.

Table 11 Assessment of Compliance – Transformer Sound Power Level

Parameter	Sound Power Level (dBA)
PWL: Transformer Substation* (ONAF) [Transformer Core + Cooling Fans]	100
PWL: used in REA permitted acoustic model	**103.2**

* Sound Power Level (PWL) includes +5db tonal adjustment for transformer core tonal hum

The acoustic emission testing indicates that the overall sound power level of the transformer substation ST2 satisfies the specified sound power level used in the REA permitted acoustic model.

8 Conclusion

Based on the acoustic audit conducted on March 28, 2019, the acoustic impact of the Niagara Region Wind Farm Transformer substation ST2, REA#4353-9HMP2R is in compliance with the sound level limits specified in MECP's NPC-232.

9 References

1. V. Schroter, "Renewable Energy Approval # 4353-9HMP2R", Ontario Ministry of the Environment, Toronto, ON, November 6, 2014.

2. IEEE Standard C57.12.90-2015, Test Code for Liquid Immersed Distribution Power and Regulating Transformers

3. ISO Standard 9614-1:1993, Acoustics -- Determination of sound power levels of noise sources using sound intensity -- Part 1: Measurement at discrete points

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Project ID: 16227.02

Scale: NTS
Drawn by: DEA
Reviewed by: AM
Date: April 24, 2019
Revision: 1

Project Name

Niagara Region Wind Farm - Transformer Acoustic Audit

Figure Title

Transformer Substation T2 Yard Layout

Figure 1

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Revision: 1

Project Name

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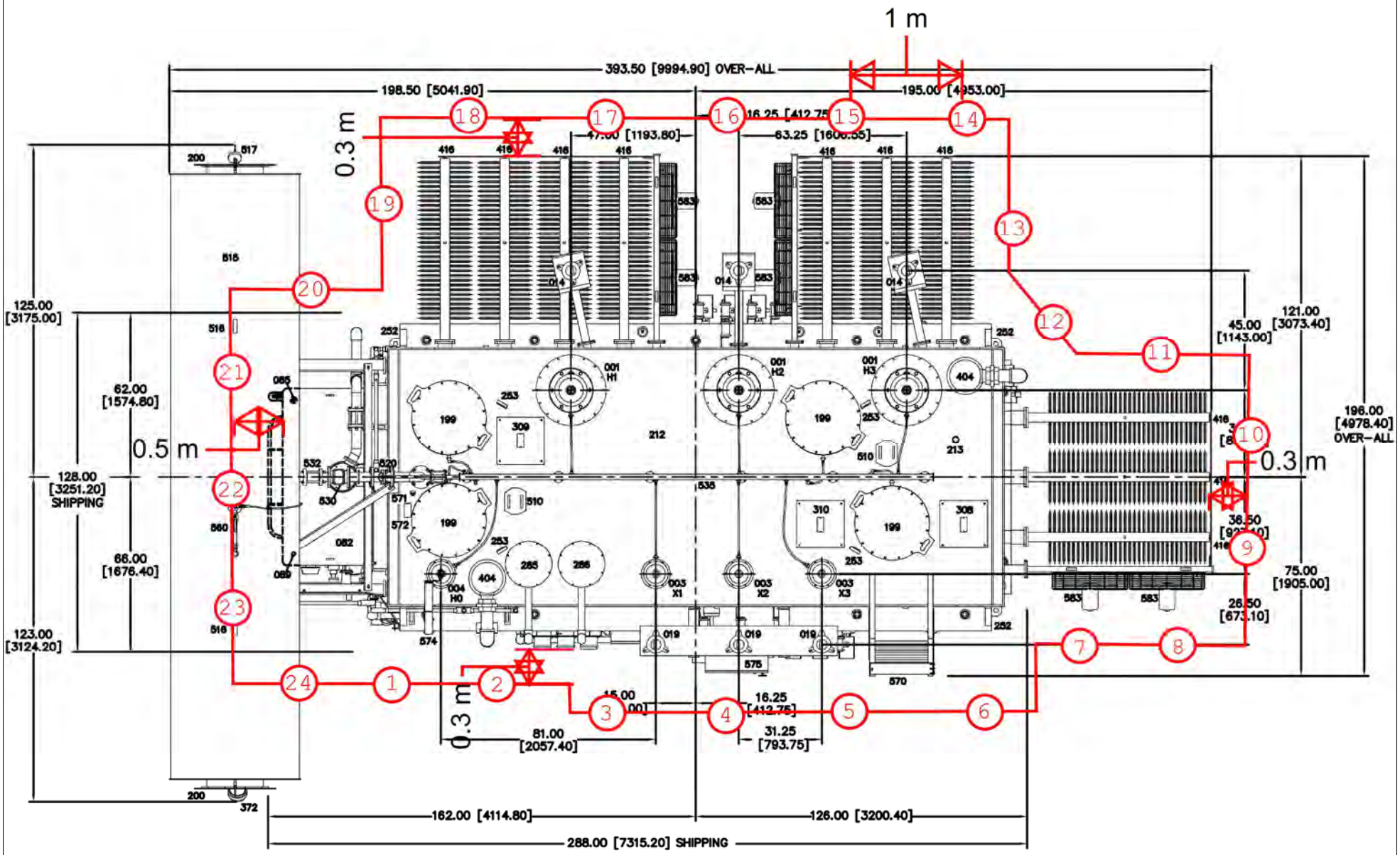
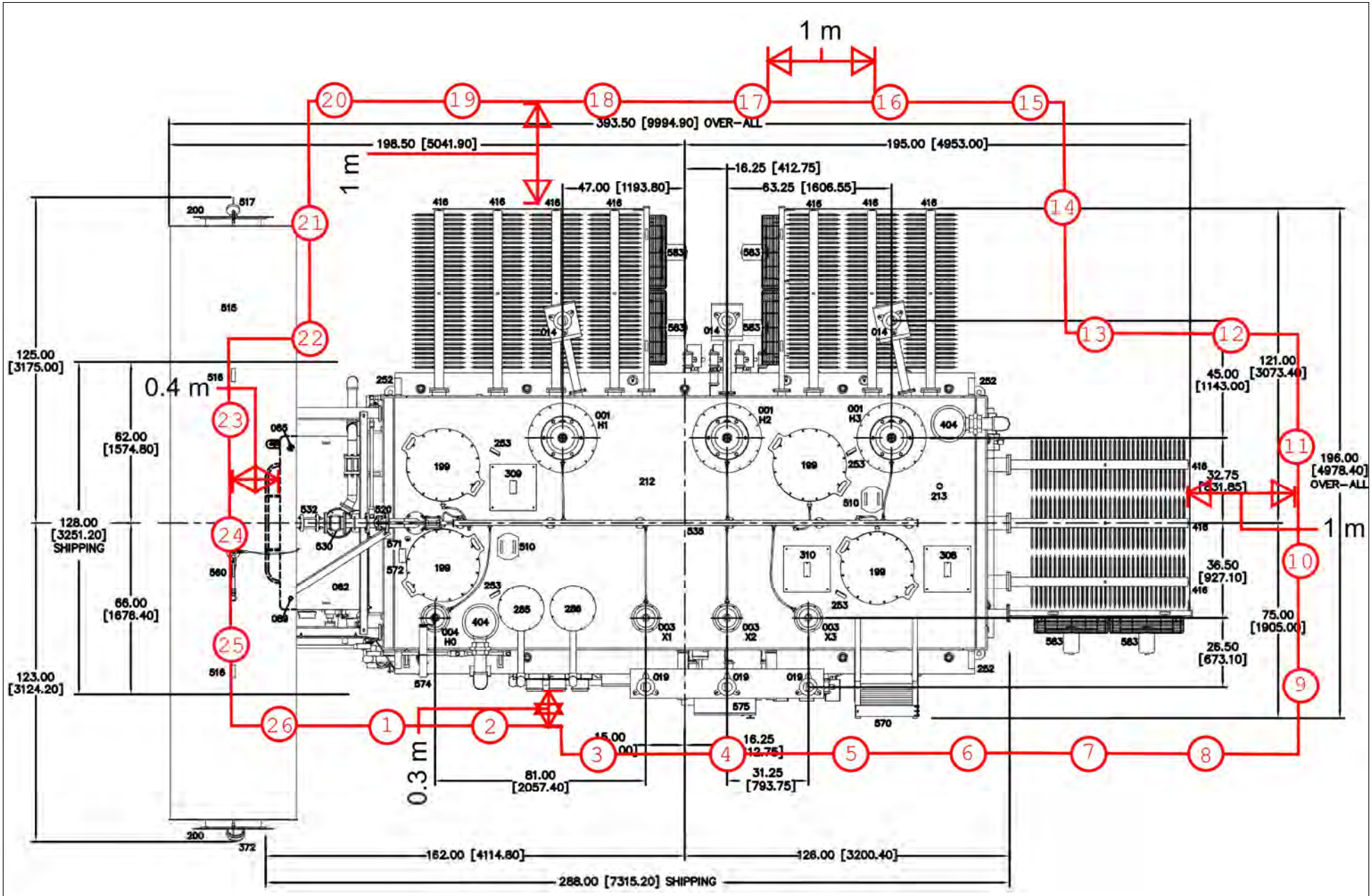
Figure Title

Transformer T2 As-built

Figure 2



aercoustics	Project ID: 16227.02 Scale: NTS Drawn by: DEA Reviewed by: AM Date: April 24, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm - Transformer Acoustic Audit	
		Figure Title Transformer T2 Plan View with Measurement Locations - ONAN	**Figure 3**



aercoustics	Project ID: 16227.02 Scale: NTS Drawn by: DEA Reviewed by: AM Date: April 24, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm - Transformer Acoustic Audit **Figure Title** Transformer T2 Plan View with Measurement Locations - ONAF

Figure 4

aercoustics	Project ID: 16227.02 Scale: NTS Drawn by: DEA Reviewed by: AM Date: April 24, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm - Transformer Acoustic Audit	
		Figure Title Far Field Measurement Locations	**Figure 5**

aercoustics	Project ID: 16227.02	**Project Name** Niagara Region Wind Farm - Transformer Acoustic Audit	
	Scale: NTS Drawn by: DEA Reviewed by: AM Date: April 24, 2019 Revision: 1	**Figure Title** Far Field Measurement Site Photo	**Figure 6**

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Scale: NTS
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Reviewed by: AM
Date: Apr 30, 2019
Revision: 1

Project Name

Niagara Region Wind Farm - Transformer Acoustic Audit

Figure Title

Site Photo - Near-Field Measurements

Figure 7

Appendix A
Instrument Calibration Certificates

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

REALTIME FREQUENCY ANALYZER SLM

Manufactured by:	LARSON DAVIS
Model No:	2900B
Serial No:	1045
Calibration Recall No:	29349

Submitted By:

Customer:

Company: Aercoustics Engineering LTD.

Address:

The subject instrument was calibrated to the indicated specification using standards traceable to 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. 2900B LARS

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

Outside (X)

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.
West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025.

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

Approved by:

James Zhu

Quality Manager
ISO/IEC 17025:2005

Calibration Date: 18-Jan-19

Certificate No: 29349 -1

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

ACCREDITED

Calibration Lab. Cert. # 1533.01

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

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

Larson Davis Real Time Analyzer

Model No.: 2900B **Serial No.: 1045**
Company: Aercoustics Engineering LTD. **I. D. No.: XXXX**

Calibration results:
Before data: ..... **After data:** ...X.....
Before & after data same: .....

All tested parameters: Pass

For details see "Calibration Data Record"

Laboratory Environment:		
Ambient Temperature:	20.2	°C
Ambient Humidity:	29.6	% RH
Ambient Pressure:	99.225	kPa
Calibration Date:	18-Jan-2019	
Calibration Due:	18-Jan-2020	
Report Number:	29349 -1	
Control Number:	29349	

The above listed instrument meets or exceeds the tested manufacturer's specifications.
This Calibration is traceable through NIST test numbers listed below.
The absolute uncertainty of calibration: See last page. Unless otherwise noted, the reported values are both "as found" and "as left" data.

The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 2900BLD**
Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2015, ISO 17025

NIST Traceable Instruments:			Date of Cal.	Traceability No.	Re-cal. Due Date
HP	34401A	S/N US361025	19-Jul-2018	,1010733	19-Jul-2019
HP	33120A	S/N SG400116	19-Jul-2018	,1010733	19-Jul-2019
Brüel & Kjær	4231	S/N 2205492	16-Jul-2018	683/290345-18	16-Jul-2019

Cal. Date: 18-Jan-2019 Measurements performed by: MS
Matthew Smith

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.

1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

Manufacturer: Larson Davis

Real Time Analyzer — Model No.: 2900B — S/N: 1045

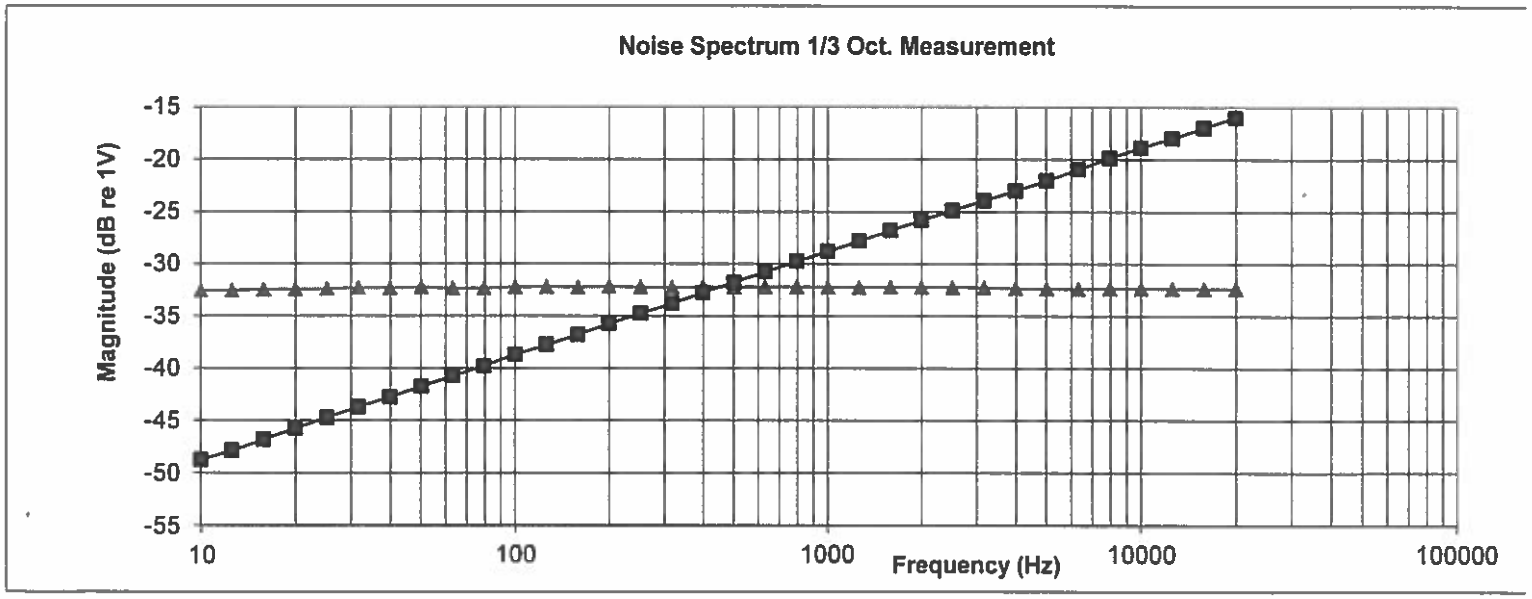
Preamp Model No.: PRM900B — S/N: 3887

Submitted by, — Company: Aercoustics Engineering LTD.

Test	Function		Tolerance Min	Tolerance Max		Measured values Before	Out	After	Out
,1.	Attenuator accuracy	FSD			READING				
	Ch.1	150dB	127.5	128.5	128	128.0		128.0	
		140dB	127.5	128.5	128	128.0		128.0	
		130dB	127.5	128.5	128	128.0		128.0	
		120dB	117.5	118.5	118	118.0		118.0	
		110dB	107.5	108.5	108	108.0		108.0	
		100dB	97.5	98.5	98	98.0		98.0	
		90dB	87.5	88.5	88	88.0		88.0	
		80dB	77.5	78.5	78	78.0		78.0	
		70dB	67.5	68.5	68	68.0		68.0	
		60dB	57.5	58.5	58	58.0		58.0	
		50dB	47.5	48.5	48	48.0		48.0	
		40dB	37.5	38.5	38	38.0		38.0	
		FSD			READING				
	Ch. 2	150dB	127.5	128.5	128	128.0		128.0	
		140dB	127.5	128.5	128	128.0		128.0	
		130dB	127.5	128.5	128	128.0		128.0	
		120dB	117.5	118.5	118	118.0		118.0	
		110dB	107.5	108.5	108	108.0		108.0	
		100dB	97.5	98.5	98	98.0		98.0	
		90dB	87.5	88.5	88	88.0		88.0	
		80dB	77.5	78.5	78	78.0		78.0	
		70dB	67.5	68.5	68	68.0		68.0	
		60dB	57.5	58.5	58	58.0		58.0	
		50dB	47.5	48.5	48	48.0		48.0	
		40dB	37.5	38.5	38	38.0		38.0	

Test	Function	Tolerance			Measured values			
		Min	Max		Before	Out	After	Out
,2a	Frequency Response SLM Mode Ch. 1							
	A Weighting	0.0	90.4	16kHz	87.3		87.3	
		89.9	94.4	8kHz	92.8		92.8	
		94.0	96.0	4kHz	95.0		95.0	
		94.2	96.2	2kHz	95.2		95.2	
	Ref	93.0	95.0	1kHz	94.0		94.0	
		89.8	91.8	500Hz	90.8		90.8	
		84.4	86.4	250Hz	85.4		85.4	
		76.9	78.9	125Hz	77.9		77.9	
		66.8	68.8	63Hz	67.8		67.8	
		53.1	56.1	31.5Hz	54.5		54.5	
	C weighting	0.0	88.5	16kHz	85.4		85.4	
		88.0	92.5	8kHz	91.0		91.0	
		92.2	94.2	4kHz	93.2		93.2	
		92.8	94.8	2kHz	93.9		93.9	
	Ref	93.0	95.0	1kHz	94.0		94.0	
		93.0	95.0	500Hz	94.0		94.0	
		93.0	95.0	250Hz	94.0		94.0	
		92.8	94.8	125Hz	93.9		93.9	
		92.2	94.2	63Hz	93.3		93.3	
		89.5	92.5	31.5Hz	91.1		91.1	
,2b	Frequency Response SLM Mode Ch. 2							
	A Weighting	0.0	90.4	16kHz	87.2		87.2	
		89.9	94.4	8kHz	92.9		92.9	
		94.0	96.0	4kHz	94.9		94.9	
		94.2	96.2	2kHz	95.2		95.2	
	Ref	93.0	95.0	1kHz	94.0		94.0	
		89.8	91.8	500Hz	90.8		90.8	
		84.4	86.4	250Hz	85.4		85.4	
		76.9	78.9	125Hz	78.0		78.0	
		66.8	68.8	63Hz	68.0		68.0	
		53.1	56.1	31.5Hz	54.8		54.8	
	C weighting	0.0	88.5	16kHz	85.3		85.3	
		88.0	92.5	8kHz	90.9		90.9	
		92.2	94.2	4kHz	93.1		93.1	
		92.8	94.8	2kHz	93.8		93.8	
	Ref	93.0	95.0	1kHz	94.0		94.0	
		93.0	95.0	500Hz	94.0		94.0	
		93.0	95.0	250Hz	94.0		94.0	
		92.8	94.8	125Hz	93.8		93.8	
		92.2	94.2	63Hz	93.2		93.2	
		89.5	92.5	31.5Hz	91.1		91.1	

Test	Function	Tolerance Min	Tolerance Max	Measured values Before	Out	After	Out
3a	Ch.1 Noise			16.2		16.2	
	Ch.2 Noise			14.2		14.2	
3b	Mic. input						
	Ch. 1			Pass		Pass	
	Ch. 2			Pass		Pass	
4	Generator						
	White Noise			Pass		Pass	
	Pink Noise			Pass		Pass	
	Sine			Pass		Pass	



Ch .1	1/3 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
25	92.7	93.9	86.5	
31.5	92.6	93.9	87.2	
40	92.4	93.9	86.9	
50	92.4	93.9	87.7	
63	92.3	93.9	88.0	
80	92.2	94.0	88.1	
100	92.1	94.0	88.1	
125	92.2	94.0	88.6	
160	92.0	94.0	88.9	
200	91.8	94.0	89.3	
250	91.7	94.0	89.6	
315	91.6	94.0	89.9	
400	91.3	94.0	90.1	
500	91.3	94.0	90.4	
630	91.1	94.0	90.4	
800	91.0	94.0	90.8	
1K	90.8	94.0	90.7	
1.25K	90.9	94.0	90.9	
1.6K	90.7	94.0	91.3	
2K	90.4	94.0	91.4	
2.5k	90.3	94.0	91.5	
3.15k	90.0	94.0	91.9	
4k	89.6	94.0	91.9	
5k	89.6	94.0	91.9	
6.3k	89.3	93.9	92.1	
8k	89.1	93.9	92.3	
10k	88.8	93.9	92.0	
12.5k	88.9	93.8	92.4	
16k	88.5	93.8	92.6	
20k	88.2	93.8	92.3	
Ch .1	1/1 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
31.5	92.3	93.9	86.9	
63	92.1	94.0	88.3	
125	91.8	94.0	89.1	
250	91.6	94.0	89.7	
500	91.4	94.0	90.5	
1K	91.1	94.0	91.0	
2K	90.9	94.0	91.5	
4k	90.6	94.0	92.1	
8k	90.1	93.9	92.3	
16k	89.7	93.9	92.4	

Ch .2	1/3 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
25	92.9	94.0	86.5	
31.5	92.7	94.0	87.2	
40	92.5	94.0	87.0	
50	92.4	93.9	87.7	
63	92.3	94.0	88.0	
80	92.2	94.0	88.1	
100	92.1	94.0	88.2	
125	92.2	94.0	88.6	
160	92.0	94.0	88.9	
200	91.8	94.0	89.3	
250	91.8	94.0	89.6	
315	91.6	94.0	89.9	
400	91.3	94.0	90.1	
500	91.3	94.0	90.4	
630	91.1	94.0	90.4	
800	91.0	94.0	90.8	
1K	90.8	94.0	90.7	
1.25K	90.9	94.0	90.9	
1.6K	90.7	94.0	91.3	
2K	90.4	94.0	91.4	
2.5k	90.3	94.0	91.5	
3.15k	90.0	94.0	91.9	
4k	89.6	94.0	91.9	
5k	89.6	94.0	92.0	
6.3k	89.3	93.9	92.2	
8k	89.1	93.9	92.3	
10k	88.8	93.9	92.1	
12.5k	88.9	93.8	92.4	
16k	88.6	93.9	92.6	
20k	88.3	93.9	92.4	
Ch .2	1/1 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
31.5	92.4	94.0	86.9	
63	92.1	94.0	88.3	
125	91.8	94.0	89.2	
250	91.6	94.0	89.7	
500	91.4	94.0	90.5	
1K	91.1	94.0	91.0	
2K	90.9	94.0	91.5	
4k	90.6	94.0	92.1	
8k	90.1	93.9	92.3	
16k	89.7	93.9	92.4	

The expanded uncertainty of calibration at 95% confidence level with a coverage factor of k=2.

Parameter	Test Instrumentation Uncertainty	DUT Uncertainty	Total DUT Uncertainty
Reading with mic. @ 1 kHz:	0.11	0.1	0.21
Meter linearity:	0.46	0.1	0.56
Attenuator accuracy:	0.46	0.1	0.56
Electrical Freq. Resp.: 20 Hz to 20 kHz	0.024	0.1	0.12
Inherent noise level:	0.11	0.1	0.21
Overload:	0.11	0.1	0.21
Functions:	0.11	0.1	0.21
1/3 & 1/1 Filters:	0.024	0.1	0.12

Measurements performed by:

Calibration Date: 18-Jan-2019

Matthew Smith

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

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

LIMITED USE

for

Larson Davis Real Time Analyzer

Model No.: 2900B **Serial No.: 1045**
Company: Aercoustics Engineering LTD. **I. D. No.: XXXX**

Calibration results:
Before data: ...X..... **After data:** .....
Before & after data same: .....
All tested parameters: **Fail**

For details see "Calibration Data Record"

Laboratory Environment:		
Ambient Temperature:	20.2	°C
Ambient Humidity:	42.7	% RH
Ambient Pressure:	97.854	kPa
Calibration Date:	2-Nov-2018	
Calibration Due:	2-Nov-2019	
Report Number:	29349 -1	
Control Number:	29349	

Fault #1: Channel 2 bad signal

The above listed instrument failed the test. (see above)

This Calibration is traceable through NIST test numbers listed below.

The absolute uncertainty of calibration: See last page. Unless otherwise noted, the reported values are both "as found" and "as left" data.

The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 2900BLD**

Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

NIST Traceable Instruments:			Date of Cal.	Traceablity No.	Re-cal. Due Date
HP	34401A	S/N US361009	19-Jul-2018	,1010733	19-Jul-2019
HP	33120A	S/N SG400116	19-Jul-2018	,1010733	19-Jul-2019
Brüel & Kjær	4231	S/N 2205492	16-Jul-2018	683/290345-18	16-Jul-2019

Cal. Date: **2-Nov-2018**

Measurements performed by: MS
Matthew Smith

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.

1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

LIMITED USE

for

Manufacturer: Larson Davis

Real Time Analyzer — Model No.: 2900B S/N: 1045

Preamp Model No.: PRM900B S/N: 3887

Submitted by, Company: Aercoustics Engineering LTD.

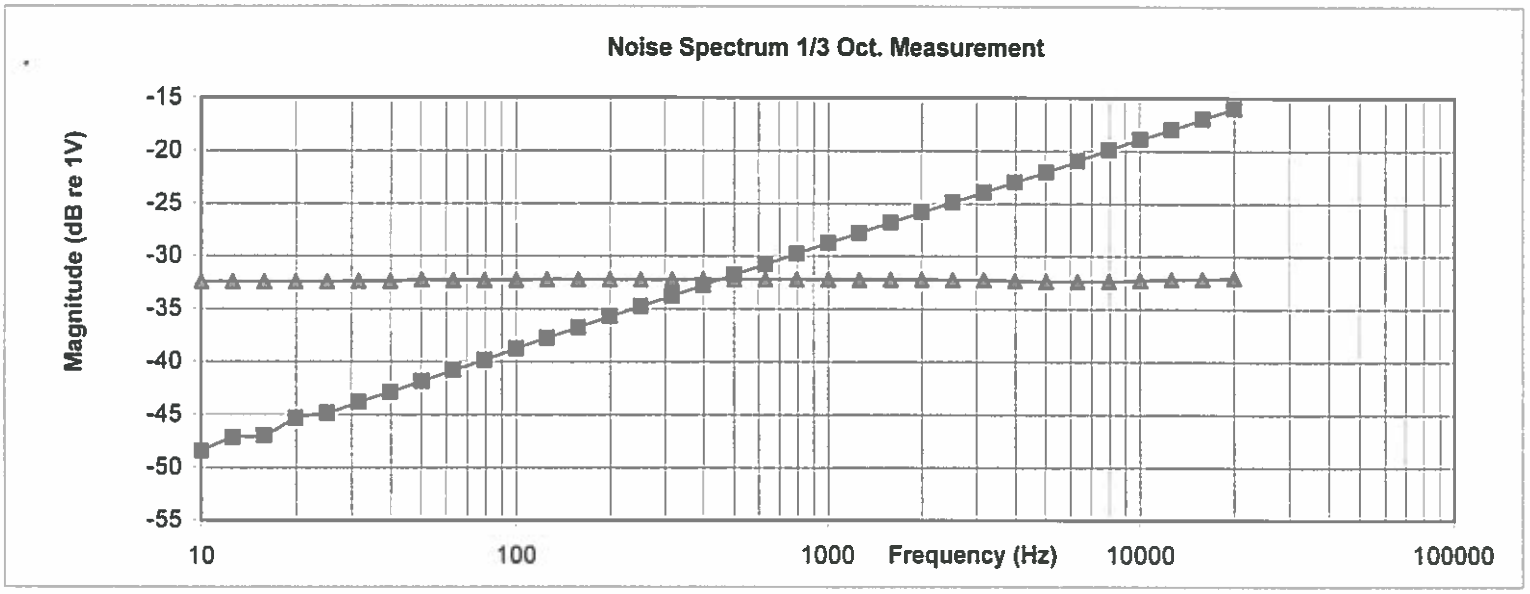
Test	Function		Tolerance Min	Tolerance Max		Measured values Before	Out	After	Out
,1.	Attenuator accuracy	FSD			READING				
	Ch.1	150dB	127.5	128.5	128	128.0		128.0	
		140dB	127.5	128.5	128	128.0		128.0	
		130dB	127.5	128.5	128	128.1		128.1	
		120dB	117.5	118.5	118	118.0		118.0	
		110dB	107.5	108.5	108	108.0		108.0	
		100dB	97.5	98.5	98	98.0		98.0	
		90dB	87.5	88.5	88	88.0		88.0	
		80dB	77.5	78.5	78	78.0		78.0	
		70dB	67.5	68.5	68	68.0		68.0	
		60dB	57.5	58.5	58	58.0		58.0	
		50dB	47.5	48.5	48	48.0		48.0	
		40dB	37.5	38.5	38	38.0		38.0	
		30dB	27.5	28.5	28	28.0		28.0	
		FSD			READING				
	Ch. 2	150dB	127.5	128.5	128	116.8	X	116.8	X
		140dB	127.5	128.5	128	116.7	X	116.7	X
		130dB	127.5	128.5	128	116.7	X	116.7	X
		120dB	117.5	118.5	118	108.6	X	108.6	X
		110dB	107.5	108.5	108	106.5	X	106.5	X
		100dB	97.5	98.5	98	97.5		97.5	
		90dB	87.5	88.5	88	93.8	X	93.8	X
		80dB	77.5	78.5	78	75.4	X	75.4	X
		70dB	67.5	68.5	68	63.7	X	63.7	X
		60dB	57.5	58.5	58	53.6	X	53.6	X
		50dB	47.5	48.5	48	44.2	X	44.2	X
		40dB	37.5	38.5	38	37.8		37.8	
		30dB	27.5	28.5	28	36.4	X	36.4	X

LIMITED USE

Test	Function	Tolerance			Measured values			
		Min	Max		Before	Out	After	Out
,2a	Frequency Response SLM Mode Ch. 1							
	A Weighting	0.0	90.4	16kHz	87.2		87.2	
		89.9	94.4	8kHz	92.9		92.9	
		94.0	96.0	4kHz	95.0		95.0	
		94.2	96.2	2kHz	95.2		95.2	
	Ref	93.0	95.0	1kHz	94.0		94.0	
		89.8	91.8	500Hz	90.8		90.8	
		84.4	86.4	250Hz	85.4		85.4	
		76.9	78.9	125Hz	77.9		77.9	
		66.8	68.8	63Hz	67.9		67.9	
		53.1	56.1	31.5Hz	54.8		54.8	
	C weighting	0.0	88.5	16kHz	85.2		85.2	
		88.0	92.5	8kHz	90.9		90.9	
		92.2	94.2	4kHz	93.2		93.2	
		92.8	94.8	2kHz	93.8		93.8	
	Ref	93.0	95.0	1kHz	94.0		94.0	
		93.0	95.0	500Hz	94.0		94.0	
		93.0	95.0	250Hz	94.0		94.0	
		92.8	94.8	125Hz	93.8		93.8	
		92.2	94.2	63Hz	93.2		93.2	
		89.5	92.5	31.5Hz	91.1		91.1	
,2b	Frequency Response SLM Mode Ch. 2							
	A Weighting	0.0	90.4	16kHz	77.9		77.9	
		89.9	94.4	8kHz	102.0	X	102.0	X
		94.0	96.0	4kHz	94.4		94.4	
		94.2	96.2	2kHz	95.4		95.4	
	Ref	93.0	95.0	1kHz	94.8		94.8	
		89.8	91.8	500Hz	97.6	X	97.6	X
		84.4	86.4	250Hz	95.7	X	95.7	X
		76.9	78.9	125Hz	91.8	X	91.8	X
		66.8	68.8	63Hz	103.5	X	103.5	X
		53.1	56.1	31.5Hz	106.5	X	106.5	X
	C weighting	0.0	88.5	16kHz	52.0		52.0	
		88.0	92.5	8kHz	70.2	X	70.2	X
		92.2	94.2	4kHz	80.7	X	80.7	X
		92.8	94.8	2kHz	87.1	X	87.1	X
	Ref	93.0	95.0	1kHz	93.5		93.5	
		93.0	95.0	500Hz	95.3	X	95.3	X
		93.0	95.0	250Hz	96.3	X	96.3	X
		92.8	94.8	125Hz	96.0	X	96.0	X
		92.2	94.2	63Hz	77.8	X	77.8	X
		89.5	92.5	31.5Hz	76.0	X	76.0	X

LIMITED USE

Test	Function	Tolerance Min	Tolerance Max	Measured values Before	Out	After	Out
3a	Ch.1 Noise			8.4		8.4	
	Ch.2 Noise			55.2		55.2	
3b	Mic. input						
	Ch. 1			Pass		Pass	
	Ch. 2			Fail	X	Fail	X
4	Generator						
	White Noise			Pass		Pass	
	Pink Noise			Pass		Pass	
	Sine			Pass		Pass	



Ch .1	1/3 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
25	92.8	93.9	86.5	
31.5	92.6	93.9	87.2	
40	92.4	94.0	87.0	
50	92.4	93.9	87.7	
63	92.3	94.0	88.0	
80	92.3	94.0	88.2	
100	92.1	94.0	88.2	
125	92.2	94.0	88.7	
160	92.1	94.1	88.9	
200	91.9	94.0	89.3	
250	91.8	94.0	89.7	
315	91.7	94.1	89.9	
400	91.4	94.0	90.1	
500	91.3	94.0	90.5	
630	91.2	94.1	90.4	
800	91.0	94.0	90.8	
1K	90.8	94.0	90.7	
1.25K	90.9	94.1	90.9	
1.6K	90.7	94.0	91.3	
2K	90.4	94.0	91.5	
2.5k	90.3	94.0	91.5	
3.15k	90.0	94.0	92.0	
4k	89.6	94.0	92.0	
5k	89.6	94.0	92.0	
6.3k	89.3	93.9	92.2	
8k	89.1	93.9	92.3	
10k	88.9	93.9	92.1	
12.5k	88.9	93.8	92.4	
16k	88.6	93.8	92.6	
20k	88.3	93.8	92.4	
Ch .1	1/1 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
31.5	92.8	93.9	86.6	
63	92.5	94.0	88.1	
125	92.2	94.0	88.9	
250	91.9	94.0	89.5	
500	91.6	94.0	90.3	
1K	91.1	94.0	90.9	
2K	90.7	94.0	91.4	
4k	90.2	94.0	92.0	
8k	89.3	93.9	92.2	
16k	88.7	93.8	92.3	

Ch .2	1/3 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
25	75.8	77.5	70.8	X
31.5	77.0	79.0	73.2	X
40	78.5	80.9	74.7	X
50	80.2	82.4	76.8	X
63	81.4	83.7	78.4	X
80	82.7	85.1	79.7	X
100	83.7	85.8	80.3	X
125	84.3	86.3	81.2	X
160	84.6	86.9	81.9	X
200	84.9	87.3	82.9	X
250	85.3	87.9	83.9	X
315	85.8	88.6	84.8	X
400	86.3	89.4	85.9	X
500	87.1	90.3	87.2	X
630	87.9	91.4	88.3	X
800	88.9	92.6	90.1	X
1K	90.1	94.0	91.5	
1.25K	91.7	95.9	93.7	X
1.6K	93.5	97.4	95.1	X
2K	94.1	98.1	95.8	X
2.5k	94.6	98.0	96.3	X
3.15k	94.8	99.0	97.1	X
4k	94.8	99.3	97.4	X
5k	95.1	99.7	98.0	X
6.3k	95.4	100.4	99.2	X
8k	96.1	101.4	100.2	X
10k	96.7	102.1	100.6	X
12.5k	97.5	102.6	101.0	X
16k	97.6	103.1	102.0	X
20k	97.6	103.3	101.9	X
Ch .2	1/1 Octave Filters			
Filter Hz	85.5 to 93.0	93.5 to 94.5	85.5 to 93.0	Out
31.5	77.3	79.0	74.6	X
63	80.6	83.7	79.8	X
125	83.4	86.3	82.1	X
250	84.6	87.8	84.6	X
500	86.5	90.2	88.4	X
1K	89.1	93.9	93.9	X
2K	94.0	98.1	96.3	X
4k	95.6	99.3	98.2	X
8k	96.1	101.4	100.9	X
16k	98.5	103.1	102.0	X

LIMITED USE

The expanded uncertainty of calibration at 95% confidence level with a coverage factor of k=2.

Parameter	Test Instrumentation Uncertainty	DUT Uncertainty	Total DUT Uncertainty
Reading with mic. @ 1 kHz:	0.11	0.1	0.21
Meter linearity:	0.46	0.1	0.56
Attenuator accuracy:	0.46	0.1	0.56
Electrical Freq. Resp.: 20 Hz to 20 kHz	0.024	0.1	0.12
Inherent noise level:	0.11	0.1	0.21
Overload:	0.11	0.1	0.21
Functions:	0.11	0.1	0.21
1/3 & 1/1 Filters:	0.024	0.1	0.12

Measurements performed by:

Calibration Date: 1-Nov-2018

Matthew Smith

CERTIFICATE of CALIBRATION

Make : G.R.A.S

Model : 50GI

Descr. : CCP Intensity Probe

Serial # : 112774-112784, 104771-104781

Reference # : 151500

Customer : Aercoustics Engineering Ltd
Mississauga, ON

P. Order : Visa-Iwona Stasiew

Asset # :

Cal. status : Received in spec's, no adjustment made.
System test 40GIs#112774/26CBs#104771 40GIs#112784/26CBs#104781

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 : Feb 11, 2018

Cal. Due : Feb 11, 2019

By : J. Raposo

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

Standards used : J-163 J-216 J-333

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST
6375 Dixie Rd Mississauga, ON, L5T 2E7
Phone 905 565 1584 Fax 905 565 8325
http // www navair com
e-Mail service @ navair com

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

Form:50GI	Approved by:.	Jan-18	Ver 1.0

Calibration Report for Certificate : **151500**

Make			Model	Serial		Asset
G.R.A.S.			50GI	nsn		nan
G.R.A.S.			40GI	112774		nan
G.R.A.S.			40GI	112784		nan
G.R.A.S.			26CB	104771		nan
G.R.A.S.			26CB	104781		nan

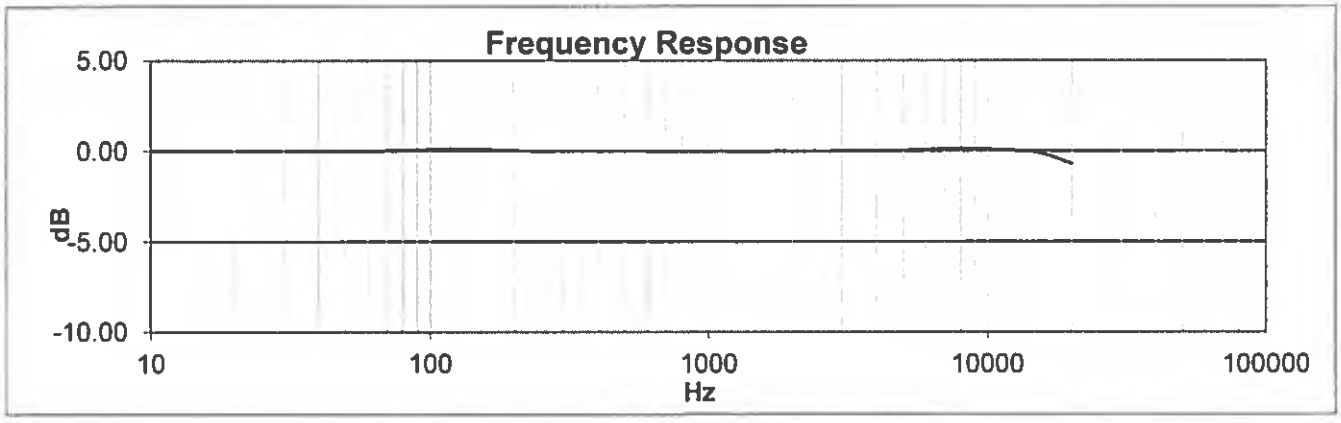
System test of microphone /preamp pairs
CH1 40GI s#112784 26CB S#104361
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
10	mV/Pa	Nom	13.31	Non	Pass
-26.02	dB re 1V/Pa	Nom -40dB	-37.52	Nom -40dB	Pass
0	dB re 10mV/Pa	-2	-11.50	2	Pass

Ambient Conditions: Static Pressure 100.2 kPa Tem 23.4°C RH 20%

Frequency response

Freq	Actuator
Hz	dB
31.5	0.02
63.1	0.03
125.9	0.15
251.3	0.00
502.5	-0.01
1005.1	-0.03
1978.7	-0.03
3957.5	0.02
7914.9	0.15
12663	0.05
15830	-0.15
20000	-0.71



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

System test of microphone /preamp pairs

CH2 40GI s#104771 26CB S#112774

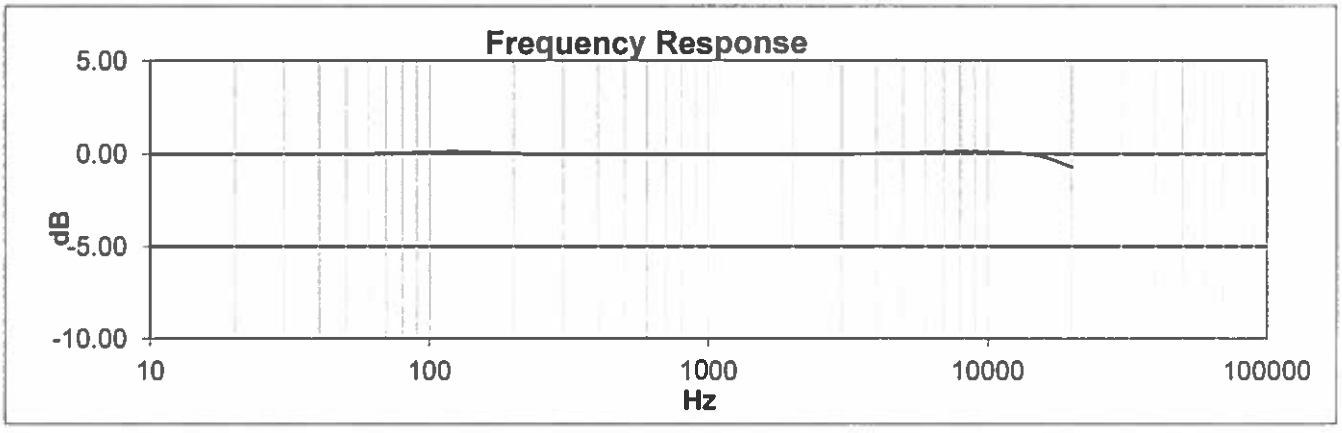
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
10	mV/Pa	Nom	10.01	Non	Pass
-26.02	dB re 1V/Pa	Nom -40dB	-39.99	Nom -40dB	Pass
0	dB re 10mV/Pa	-2	-13.97	2	Pass

Ambient Conditions: Static Pressure 100.2 kPa
Temperature 23.4°C
Rel.Humidity 20.0%

Frequency response

Freq	Actuator	
Hz	dB	
31.5	0.02	
63.1	0.03	
125.9	0.15	
251.3	0.00	ref
502.5	-0.01	
1005.1	-0.03	
1978.7	-0.03	
3957.5	0.02	
7914.9	0.15	
12683	0.05	
15830	-0.15	
20000	-0.71	



CERTIFICATE of CALIBRATION

Make :	Bruel & Kjaer	Reference # :	153924
Model :	2250	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Sound Level Meter Type 1		
Serial # :	2630244	P. Order :	2018.08.31C
Asset # :	00020		

Cal. status : Received in spec's, no adjustment made.
With mike 4189 s#2386059 and preamp ZC0032 s#7946.

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 : Sep 17, 2018 By : T. Beilin

Cal. Due : Sep 17, 2019

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 http: // www.navair.com
Phone : 905 565 1584 Fax: 905 565 8325 e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

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

Form:BK2250	Approved by:JR	Date:May/09	ver1.0

Calibration Report part of Certificate: 153924

Make	Model	Serial	Asset
Bruel&Kjaer	2250	2630244	00020

With mike 4189 s#2386059 preamp ZC0032 S# 7946

TYPE 1 Specs

Test	Reading	In/Out

Freq.Response
Tested with dummy mike IEC61672-1 limits
WTG Curve Check

kHz	Min	dBA	Max	
0.0315	72.6	74.5	76.6	In
0.063	86.3	87.8	89.3	In
0.125	96.4	97.8	99.4	In
0.25	103.9	105.3	106.8	In
0.5	109.4	110.7	112.2	In
1	112.9	114.0	115.1	In
2	113.6	115.2	116.8	In
4	113.4	115.0	116.6	In
8	109.8	112.8	115.0	In
12.5	103.7	109.3	112.7	In
		dBC		
0.0315	109.0	111.0	113.0	In
0.063	111.7	113.2	114.7	In
0.125	112.3	113.8	115.3	In
0.25	112.5	114.0	115.4	In
0.5	112.6	114.0	115.4	In
1	112.9	114.0	115.1	In
2	112.2	113.8	115.4	In
4	111.6	113.2	114.8	In
8	107.9	110.9	113.1	In
12.5	101.8	107.4	110.8	In

NT NAVAIR TECHNOLOGIES

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

153924

Test				In/Out
		dBZ		
0.0315	112.0	114.1	116.0	In
0.063	112.5	114.0	115.5	In
0.125	112.5	114.0	115.5	In
0.25	112.5	114.0	115.4	In
0.5	112.6	114.0	115.4	In
1	112.9	114.0	115.1	In
2	112.4	114.0	115.6	In
4	112.4	114.0	115.6	In
8	110.9	114.0	116.1	In
12.5	108.0	113.5	117.0	In
Scale Test with microphone				
Scale				
dBc @1kHz				
I/P dB				
20 - 140dB Range				
114	113.5	113.9	114.5	In
104	103.5	103.9	104.5	In
94	93.5	94.0	94.5	In
Impulse Test				Pass
Fast/Slow				Pass
AC O/P				Pass
Source operation				Pass

CERTIFICATE of CALIBRATION

Make : Larson Davis

Model : CAL200

Descr. : Sound cal 94/114dB 1KHz

Serial # : 0352

Asset # : 00417

Reference # : 154353

Customer : Aercoustics Engineering Ltd
Mississauga, ON

P. Order : 2018.10.02C

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 : Oct 16, 2018

Cal. Due : Oct 16, 2020

By : J. Raposo

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

Standards used : J-163 J-261 J-282 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
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Mississauga, ON L5T 2E7
Tel: (905)565-1583
Fax: (905)565-8325

Form:CAL200	Approved By:JR Jan/04	ver 1.0

Calibration Report part of Certificate #: 154353

Make	Model	Serial	Asset	Cal. By
Larson Davis	CAL200	352	20-Feb	JR

Test		Reading	Spec's	In/Out
SPL				
94dB	99.8kPa	94.0	±0.2dB	In
114dB	99.8kPa	114.0	±0.2dB	In
Freq. Accuracy				
1000Hz		999.8	±10Hz	In

Appendix B
Response Letter to MECP re: transformer substation E-audits

Boralex Inc.
36 Lajeunesse Street
Kingsey Falls, Québec J0A 1B0
Canada

T. 819.363.6363
F. 819.363.6399
boralex.com

BORALEX

March 26, 2018

Attention : Mahdi Zangeneh
Senior Noise Engineer
Team 5 (Renewable Energy), Approval Services Section
Environmental Assessment & Permissions Branch
Ministry of the Environment and Climate Change
135 St. Clair Avenue West
Toronto, Ontario M4V 1P5

Dear Mahdi Zangeneh

Reference : Response to the MOECC's questions on the transformer substation E-Audits, March 1 2018

REA 4353-9HMP2R was executed in favour of the Niagara Region Wind Corporation on November 6, 2014 for the construction and operation of the Niagara Region Wind Farm. The REA was further modified on November 23, 2015, May 5, 2016 and May 12 2016. The last update of the Acoustic Assessment Report was refered to in the May 12, 2016 amendment of the REA and is dated April 8, 2016.

Condition E3 of the REA stipulates that the Company shall submit to the MOECC an Acoustic Audit Report for the two (2) Tranformer Susbstations built for the Project. The reports were presented to the MOECC on November 1, 2017.

The present letter is in response to questions received from Anoop Thamarasseril on March 1, 2018 by Stéphanie Bujold. Please note that although responses were required for March 13, 2018, an extension was obtained in an email to Stéphanie on March 14, 2018 (extension until March 23, 2018). Discussions occurred with the MOECC and the Niagara Region Wind Farm (FWRN) on March 22, 2018 and this letter follows the discussions.

Questions from the MOECC are in italic characters below. Responses follow the questions.

1. The response to comment # 4 (Response letter attached to this email) provided to the Ministry does not address our previous comment. Transformer ST2 is over the REA limit by about 15 dB (113.0 – 98.2 = 14.8 dB). Transformer ST1 is over the REA limit by about 5 dB (103.0 – 98.2 = 4.8 dB)

a. Please provide a cumulative impact assessment at the identified receptors (38 receptors) by completing the following table (Table 1). A statement of compliance with the applicable sound level limit (40 dBA) is also required for each of the receptors identified below.

During the March 22 phone conference between the MOECC and FWRN, it was disclosed that work was performed on ST2 and resulted in a marked decrease in acoustic emissions of the transformer. The MOECC requested a written explanation of what was done on the transformer. Below is a description of the work performed by GE, the manufacturer of the transformer and its subcontractor during the week of March 19, 2018.

The preventative maintenance work on T2 was warranty work to discover why the transformer was "gassing". The term "gassing" is used whenthere are high levels of combustible gases forming inside a transformer tank commonly caused from arching. An issue was found that the main core ground was missing internally. Due to the presence of a sign on the transformer beside the external core ground location, the main core was never grounded externally which lead to the core not being grounded at all. This lack of grounding of the main core was found to have a resistance to ground of 4 G Ohm, while this reading should have been zero Ohms when grounded. GE confirmed that this caused the main gassing issue and could also provide an explanation for the measured exceedance of the permitted REA sound power levels that was evaluated during the e-audit of the transformer. Once the work was completed and the transformer was placed back in service, there was an immediate sound difference observed by onsite employees under no load. The onsite team then revisited the south substation (ST2) the following day and confirmed the same observations while the transformer was under load.

The below results are not representative of the sound power of the transformer under normal operational conditions. Further emission testing of the transformer shall be completed upon the MOECC's approval.

It is important to note that no tonal audibility of the transformer was detected in the far-field location. A tonal penalty was applied to the sound power levels in the acoustic model for the predicted sound level at the receptors provided in the table below. As such the below modelled sound levels do not reflect the measured levels on site and at the receptors. In addition transformer ST2 was noted to be inaudible at far-field measurement location at a distance closer than the closest receptor and the measured levels were significantly less (34.5dBA) than predicted in the acoustic model.

The below sound level at receptors are not those associated with a normal operation of the transformer.

Table 1: Transformer ST2, Cumulative effect[2]

REA: 98.2 dBA, Measured: 113.0 dBA[1]							
Receptor ID	**Contribution (dBA)**		**Total (dBA)**	**Receptor ID**	**Contribution (dBA)**		**Total (dBA)**
	ST2	**Other Noise Sources**			**ST2**	**Other Noise Sources**	
O_1668	44.6	38.2	45.5	O_1524	39.5	37.2	41.5
O_1642	42.3	36.4	43.3	V_1516	39.6	38.5	42.1
O_1546	41.1	39.0	43.2	O_1628	40.0	35.4	41.3
O_1783	41.3	35.9	42.4	O_1288	33.7	38.7	39.9
V_1545	40.8	36.6	42.2	V_1568	39.5	36.3	41.2
O_1514	40.5	37.0	42.1	O_1608	39.6	35.8	41.1
O_1466	36.2	37.5	39.9	V_1272	33.2	39.1	40.1
O_1500	36.4	37.3	39.9	V_1276	33.7	38.3	39.6
O_1527	40.4	37.2	42.1	O_1643	39.2	35.4	40.7
O_1735	41.0	35.1	42.0	O_1955	39.3	34.3	40.5
O_1372	35.9	37.7	39.9	V_1689	39.0	34.4	40.3
O_1345	35.5	37.8	39.8	O_1956	39.1	33.7	40.2
O_1470	35.8	37.6	39.8	O_1725	38.9	34.3	40.2
V_1506	39.9	37.3	41.8	V_1452	37.0	38.6	40.9
O_1337	34.7	38.5	40.0	O_1794	38.8	33.8	40.0
O_1359	34.8	38.4	40.0	O_1903	34.8	33.5	37.2
V_1354	34.3	38.9	40.2	O_1754	38.6	33.6	39.8
O_1316	34.4	38.7	40.1	V_1847	34.7	33.4	37.1
O_1796	43.7	38.7	44.9				
O_1307	34.6	38.2	39.8				

[1] This value represents the sound measured before grounding of the main core of the transformer
[2] Table prepared by Aercoustics Engineering Limited

The below table was not requested in the March 1 2018 email from Anoop Thamarasseril. A cumulative impact assessment at the identified receptors, was evaluated for ST1 in view of the discrepancy between the REA levels and the measured levels. The below results show compliance with the applicable sound level limit (40 dBA) for each of the receptors identified below. A tonal penalty was applied to the sound power at each receptor.

Transformer ST1, Cumulative effect at receptors[3]

REA: 98.2 dBA, Measured: 98+5dB tonal penalty = 103 dBA							
Receptor ID	Contribution (dBA)		Total (dBA)	Receptor ID	Contribution (dBA)		Total (dBA)
	ST1	Other Noise Sources			ST1	Other Noise Sources	
O_1278	31.1	34.6	36.2	O_1250	28.5	32.1	33.7
O_1277	31.1	34.6	36.2	O_1254	28.8	32.3	33.9
O_1492	31.1	35.7	37	O_1258	28.8	32.1	33.8
O_1532	30.7	35.4	36.7	O_1259	29.9	33.7	35.2
P_1554	32	35.9	37.4				
P_1375	35.4	34.5	38				
V_1498	30.5	36.8	37.7				
V_1443	30.8	35.9	37.1				
O_1478	30.8	36.5	37.5				
O_1471	30.9	36.3	37.4				
O_1459	30.8	36.1	37.2				
O_1458	30.8	36.1	37.2				
O_1373	31.2	34.8	36.4				
O_1428	30.9	35.8	37				
O_1381	31.1	35.0	36.5				
O_1427	30.9	35.8	37				
O_1392	31.1	35.4	36.8				
O_1388	31.1	35.2	36.6				
O_1387	31.1	35.2	36.6				
O_1382	31.1	35.0	36.5				

[3] Table prepared by Aercoustics Engineering Limited

b. Please also provide UTM coordinates of the microphone locations (for ST1 and ST2) and a map showing the microphone locations, nearby turbines, and nearby receptors.

A map and photographs of the measurement locations/microphone locations are provided in the Transformer Audit Report at ST2:

- Figure 1: Transformer Substation T2 Yard Layout, including UTM coordinates
- Figure 3: Transformer T2 Plan View with Measurement Locations or Microphone Positions
- Figure 4: Far Field Measurement Location

UTM coordinates were not recorded during the site visit for the far-field measurement locations. The approximate UTM coordinates for the far field locations are provided in the table below.

	Zone 17T	
	Easting (m)	**Northing (m)**
ST2 far-field measurement location	623423.19	4754629.83
ST1 far-field measurement location	621997.00	4761596.00

c. Please provide UTM coordinates for barriers used in two transformers (as built coordinates) and superimposed barrier layout and transformer in two aerial maps (one for ST1 transformer and one for ST2 transformer). Compare as built coordinates with Appendix F of Noise Report dated May 9, 2014.

The latest Acoustic Assessment Report that was included in the REA and where the UTM coordinates for the barriers are presented is dated April 8, 2016. The as-built coordinates in the below table are compared to the coordinates of the April 2016 report.

	As-Built		**REA[1]**	
	Zone 17T		**Zone 17T**	
	Easting (m)	**Northing (m)**	**Easting (m)**	**Northing (m)**
ST2 – barrier location SW corner	622831.65	4754671.937	622832	4754670
ST2 – barrier location SE corner	622842.350	4754671.937	622842	4754671
ST2 – barrier location NW corner	622831.650	4754686.237	622832	4754687
ST1 – barrier location SW corner	621952.906	4761722.650	621957	4761723
ST1 – barrier location SE corner	621967.206	4761722.650	621964	4761723
ST1 – barrier location NW corner	621952.906	4761733.350	621957	4761731

ST1 – barrier location NE corner	621967.206	4761733.350	621964	4761732

1: REA coordinats from Appendix F of Acoustic Assessment Report dated April 8, 2016 (Stantec)

Please find attached a pdf document titled NRWF_Barrier Corners Location.pdf which shows the corners as per REA (red symbols) and the as-built corners (yellow symbols).

Also included, a kmz file containing the same information that you may visualize in Google Earth.

Additional items:

2. The height of the acoustic barrier for ST2 must be 5.0 meters as per Schedule C of the REA. The current barrier height does not break line of sight. Please see details listed in Table 2 below. Please ensure the height of the acoustic barrier increased to 5m to be in compliance with the REA.

The barrier height that was used in the Audit Report by Aercoustics was that of the latest REA amendment dated April 8, 2016 (Stantec). The barrier height was not measured on site by Aercoustics.

The height of the transformer in the below table comes from the manufacturer of the transformer. The height of the barrier walls come from the shop drawings of Durisol, the manufacturer of the walls. Note that the height of the foundation of the transformers and the barrier walls are identical with a height above gravel of 300 mm.

Table 2: Barrier heights

	ST1 Height (m)	ST2 Height (m)	Barrier Height (m)
REA (May 12, 2016)	3.7	3.7	4.5
Manufacturer design	4.73710	4.61009	5.347 m

You will also find photographs taken on site, at the south substation attached with the present letter. Those photographs, along with the above measurements will demonstrate that the as-built barriers do break line of sight.

Please address the discrepancy noted in Table below:

Table 3: Transformer power ratings

Transformer	Power Rating in REA (MVA)	Power Rating as per Audit Report (MVA)
ST1	90	150
ST2	69	115

The power rating of the transformers presented in section 2.2 of the Acoustic Assessment Report (April 8, 2016, Stantec) was 90 MVA at the north substation and 69 MVA at the sound substation, base load capacity. It was also indicated that there would be 2 stages of cooling (section 3.1 of AAR) on each transformer which adds about 33% of capacity per stage of cooling hence:

- Base load of north substation is 90 MVA, plus 2 stages of cooling (90/120/150 ONAN/ONAF/ ONAF MVA);
- Base load of south substation is 69 MVA, plus two stages of cooling (69/92/115 ONAN/ONAF/ONAF MVA)

The power rating or capacity of the transformer that was indicated in the Audit Report for ST2 (Aercoustics), Table 1 is also 69/92/115 MVA, consistent with the information found in the AAR of April 8, 2016.

The transformer parameters presented in Table 1 of the Audit Report at ST1 (Aercoustics) is 90/120/150 MVA, again consistent with the information found in the AAR of Arpil 8, 2016, document used to obtain the final amendment to the REA for the Project on May 5, 2016.

It is believed that the above information has responded to the questions received in the March 1 2018 email from Anoop Thamarasseril. If you have further questions, do not hesitate to let us know.

Sincerely,

Stéphanie Bujold, biol., M.Sc Environment

c. Mohsen Keyvani (MOECC), Denton Miller (MOECC), Anoop Thamarasseril (MOECC), Kuruparan Satkunanathan (MOECC), Michael Durst (MOECC), Paul Widmeyer (MOECC), Stephen Burt (MOECC)

Jason Weir (Boralex), Alain Pouliot (Boralex)

Payam Ashtiani (Aercoustics), Allan Munro (Aercoustics)

Encl.

Niagara Region Wind Farm

North Substation Barrier Corners Location

Légende

- Corner from As-Built Drawings
- Corner from REA Noise Assessment
- North Substation

Google earth

30 m

Niagara Region Wind Farm

South Substation Barrier Corners Location

Légende

- Corner from As-Built Drawings
- Corner from REA Noise Assessment
- South Substation

Google earth

30 m

N

1. Substation ST1 (100/133/166 ONAN/ONAF/ONAF MVA Transformer noise source modeled at a height of 3.7m with UTM Coordinates 621960, 4761728) will require a four sided barrier of 5 metres in height above grade. Barrier corner coordinates are:

Four sided barrier's 4 corner points are provided below

4 corners	Easting [m]	Northing [m]
Corner 1	621957	4761731
Corner 2	621957	4761723
Corner 3	621964	4761723
Corner 4	621964	4761732

2. Substation ST2 (100/133/166 ONAN/ONAF/ONAF MVA Transformer noise source modeled at a height of 3.7m with UTM Coordinates 622837, 4754679) will require a two sided barrier of 5 metres in height above grade. This barrier should be placed on south and west side of the transformer and extended at least 2 meters beyond the transformer such that noise flanking is negligible. Barrier corner coordinates are:

Two sided barrier's 3 corner points are provided below

3 corners	Easting [m]	Northing [m]
Corner 1	622832	4754687
Corner 2	622832	4754670
Corner 3	622842	4754671

COORDINATE ARE BASE ON ACAD
SURVEY DRAWING
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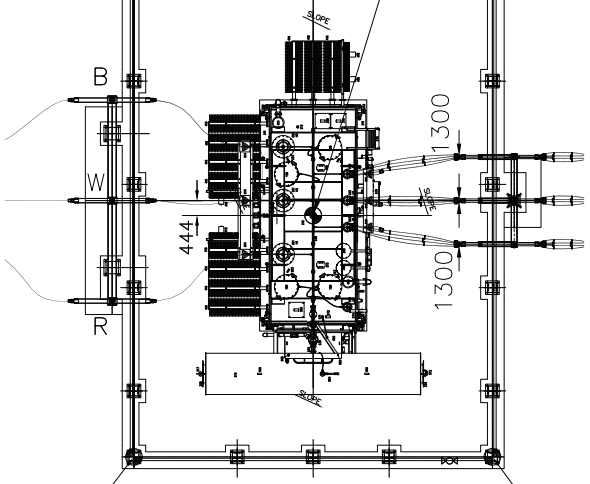
N=4761728.000

E=621952.906
N=4761722.650

E=621952.906
N=4761733.350



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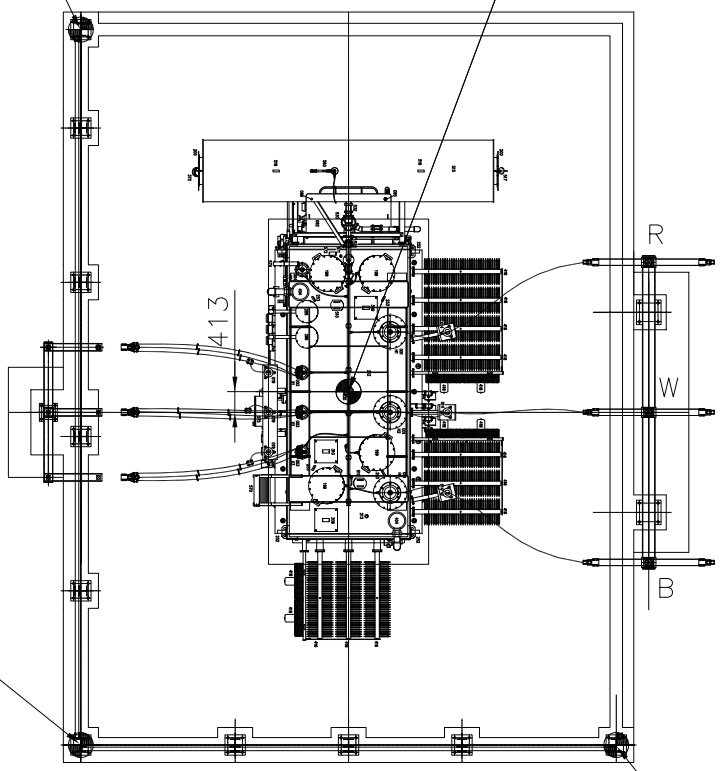
N=4761722.650

E=621967.206
N=4761733.350

NORTH STATION

SCALE 1:200



SOUTH STATION

SCALE 1:150

NOTES:

1. FOR OVERALL SITE PLAN, SEE DWG# 1524–E100.
2. FOR SECTION VIEW, SEE DWG# 1524–E102.
3. ALL DIMENSIONS ARE IN MILLIMETERS U.N.O.

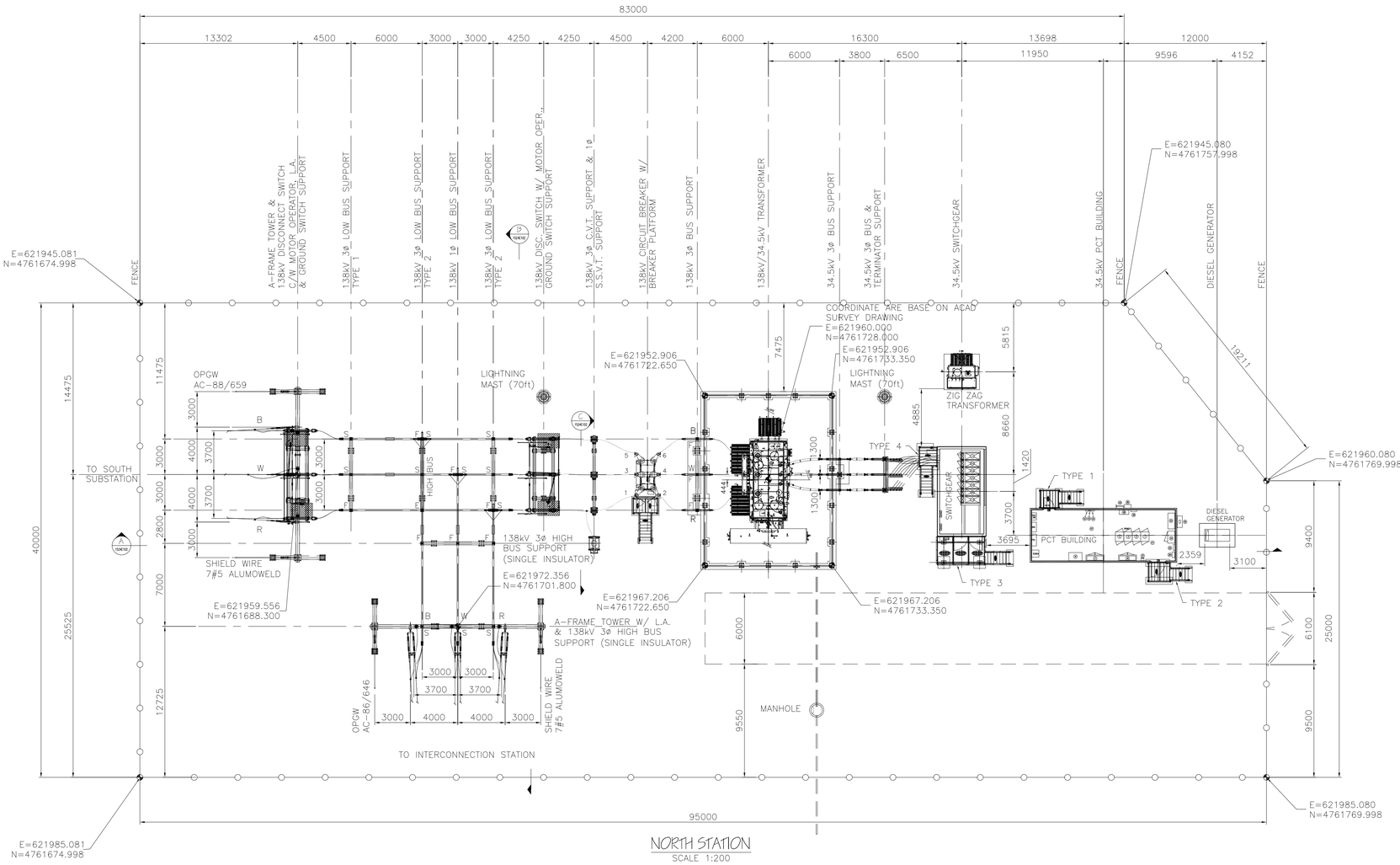
LEGEND:

E – EXPANSION SUPPORT
F – RIGID SUPPORT
S – SLIDE SUPPORT

AS–BUILT DRAWING

THIS AS–BUILT DRAWING IS PREPARED BASED ON INFORMATION PROVIDED BY THE CONTRACTOR/QUALITY CONTROL PERSONNEL AND IS INTENDED TO REPRESENT THE CONSTRUCTION IN GENERAL, AS OPPOSED TO PRECISE CONFORMITY WITH THE DESIGN PREPARED BY THE ENGINEER. IT IS NOT A REPRESENTATION THAT THE CONSTRUCTION IS IN CONFORMITY WITH THE DESIGN

THE ENGINEER SHALL NOT BE HELD RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF THE INFORMATION PROVIDED.



NORTH STATION
SCALE 1:200

REV	D/M/Y	REVISION	DR	CHK	APP	APP	APP	APP
1	04/11/16	AS BUILT	E.H.	W.L.	K.W.			
0	30/10/15	ISSUED FOR CONSTRUCTION	M.W.	W.L.	K.W.			
E	30/09/15	REVISED AS NOTED	E.H.	W.L.	K.W.			
D	04/09/15	ISSUED FOR REVIEW & REVISED AS NOTED	E.H.	W.L.	K.W.			
C	18/08/15	ISSUED FOR REVIEW	E.H.	W.L.	K.W.			
B	06/08/15	ISSUED FOR REVIEW	E.H.	W.L.	K.W.			
A	28/07/15	PRELIMINARY ISSUED	E.H.	W.L.	K.W.			

ISS	D/M/Y	APP	ISSUED FOR
1	04/11/16		AS BUILT
0	30/10/15		ISSUED FOR CONSTRUCTION
E	30/09/15		REVISED AS NOTED
D	04/09/15		ISSUED FOR REVIEW & REVISED AS NOTED
C	18/08/15		ISSUED FOR REVIEW
B	06/08/15		ISSUED FOR REVIEW
A	28/07/15		PRELIMINARY ISSUED

REF	NUMBER	TITLE

REFERENCES

STAMP/SEAL

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR. DEPARTMENT MGR. PROJECT MGR.

PROJECT PHASE

PROJECT NO. | ACTIVITY NO. | PACKAGE CODE

SCALE N.T.S.

	BY	D/M/Y
DSN.	K.WONG	28/07/15
DRN.	E.HO	28/07/15

NIAGARA
Region Wind Farm

AREA: NIAGARA REGION WIND FARM

SUBJECT: NIAGARA REGION WIND FARM
115kV/34.5kV NORTH SUBSTATION
LAYOUT PLAN

CLIENT DWG. NO.

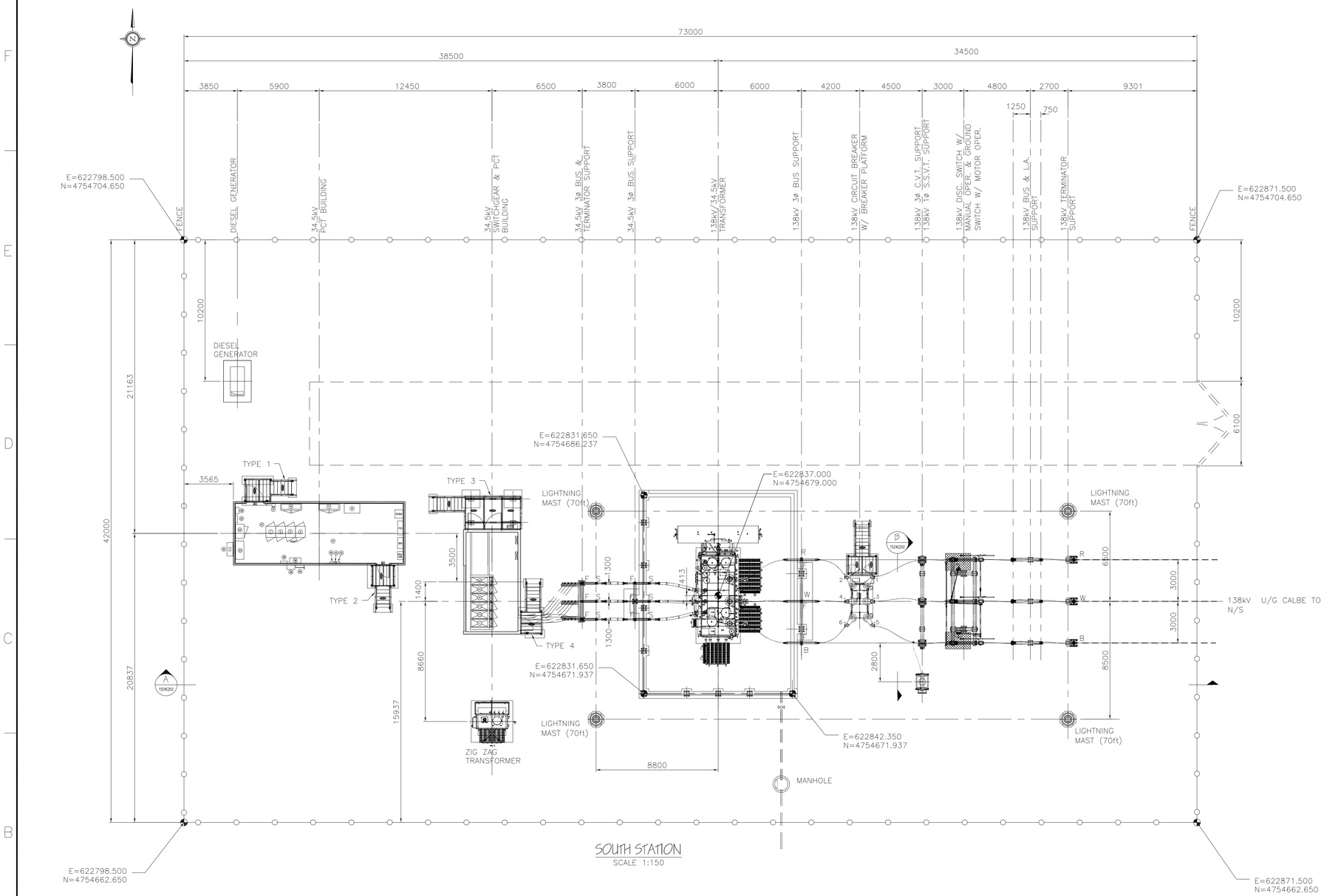
DRAWING NO. 1524–E101

REV. 1

CADD FILE ADDRESS 1524–E101–1

EPTCON LTD. ELECTRICAL POWER & TRANSMISSION CONSTRUCTION
560 SHELDON DRIVE, UNIT #1, CAMBRIDGE, ONTARIO N1T 0A4
TEL: (519) 620-4414 FAX: (519) 620-4413

Chimax Inc.
Engineering Company
3950 Fourteenth Ave. East, Suite 506
Markham, On., L3R 0A9
Email: chimax@chimax.ca



SOUTH STATION
SCALE 1:150

NOTES:

1. FOR OVERALL SITE PLAN, SEE DWG# 1524-E200.
2. FOR SECTION VIEW, SEE DWG# 1524-E202.
3. ALL DIMENSIONS ARE IN MILLIMETERS U.N.O.

LEGEND:

E – EXPANSION SUPPORT
F – RIGID SUPPORT
S – SLIDE SUPPORT

AS-BUILT DRAWING

THIS AS-BUILT DRAWING IS PREPARED BASED ON INFORMATION PROVIDED BY THE CONTRACTOR/QUALITY CONTROL PERSONNEL AND IS INTENDED TO REPRESENT THE CONSTRUCTION IN GENERAL, AS OPPOSED TO PRECISE CONFORMITY WITH THE DESIGN PREPARED BY THE ENGINEER. IT IS NOT A REPRESENTATION THAT THE CONSTRUCTION IS IN CONFORMITY WITH THE DESIGN

THE ENGINEER SHALL NOT BE HELD RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF THE INFORMATION PROVIDED.

REV	D/M/Y	REVISION	DR	CHK	APP	APP	APP	APP
2	04/11/16	AS BUILT	E.H.	W.L.	K.W.			
1	02/02/16	REVISED AS NOTED	E.H.	W.L.	K.W.			
0	30/10/15	ISSUED FOR CONSTRUCTION	E.H.	W.L.	K.W.			
E	07/10/15	REVISED AS NOTED	E.H.	W.L.	K.W.			
D	04/09/15	ISSUED FOR REVIEW & REVISED AS NOTED	E.H.	W.L.	K.W.			
C	18/08/15	ISSUED FOR REVIEW	E.H.	W.L.	K.W.			
B	06/08/15	ISSUED FOR REVIEW	E.H.	W.L.	K.W.			
A	28/07/15	PRELIMINARY ISSUED	E.H.	W.L.	K.W.			

ISS	D/M/Y	APP	ISSUED FOR
2	04/11/16		AS BUILT
1	02/02/16		REVISED AS NOTED
0	10/30/15		ISSUED FOR CONSTRUCTION
E	07/10/15		REVISED AS NOTED
D	04/09/15		ISSUED FOR REVIEW & REVISED AS NOTED
C	18/08/15		ISSUED FOR REVIEW
B	06/08/15		ISSUED FOR REVIEW
A	28/07/15		PRELIMINARY ISSUED

REF	NUMBER	TITLE

REFERENCES

STAMP/SEAL

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APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR. DEPARTMENT MGR. PROJECT MGR.

PROJECT PHASE

PROJECT NO. | ACTIVITY NO. | PACKAGE CODE

SCALE: N.T.S.

	BY	D/M/Y
DSN.	K.WONG	28/07/15
DRN.	E.HO	28/07/15

NIAGARA
Region Wind Farm

AREA: NIAGARA REGION WIND FARM

SUBJECT: NIAGARA REGION WIND FARM
115kV/34.5kV SOUTH SUBSTATION
LAYOUT PLAN

DRAWING NO. 1524-E201

REV. 2

CADD FILE ADDRESS 1524-E201-2

CLIENT DWG. NO.

EPTCON LTD. ELECTRICAL POWER & TRANSMISSION CONSTRUCTION
560 SHELDON DRIVE, UNIT #1, CAMBRIDGE, ONTARIO N1T 0A4
TEL: (519) 620-4414 FAX: (519) 620-4413

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Picture 1 : South Substation Walls, Looking South

Picture 2 : South Substation Walls, Looking West