HGC ENGINEERING

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DETERMINATION OF SOUND POWER LEVELS OF A TRANSFORMER AND A REACTOR

Prepared for:

Grand Bend Wind Limited Partnership
Northland Power Inc.
30 St. Clair Avenue West, Unit 1700
Toronto, Ontario
M4V 3Al

October 20, 2016

1 INTRODUCTION

HGC Engineering was retained by Northland Power Inc. to complete acoustic measurements of the Grand Bend Wind Farm project transformer and reactor, to satisfy Condition E3 of the Renewable Energy Approval ("REA") Number 5186-9HBJXR issued to the site by the Ontario Ministry of Environment and Climate Change ("MOECC"), dated June 26, 2014.

The audit condition in the REA requires the determination of the sound power levels of the substation transformer and reactor, for comparison with the specification included in the Environmental Noise Impact Assessment, dated April 15, 2014 [1], completed by others and Schedule B of the REA. The sound power levels of the transformer and reactor were measured on September 22, 2016, utilizing methods from IEC Standard 60076-10 titled Power transformers – Part 10: Determination of sound levels [2].

2 SOUND SOURCE UNDER TEST

The components of the substation include a transformer manufactured by Prolec and a reactor manufactured by ABB. The station is situated approximately 4 km southwest of the town of Zurich, Ontario, next to the T20 project turbine. The transformer is nominally rated at 75/100/125 MVA, and the reactor is rated at 40 MVAR. The transformer utilizes cooling fans and the reactor utilizes natural cooling without fans. The overall dimensions of the transformer, including the affixed cooling fans and radiators, are approximately 5.7 metres wide, 8.2 metres in length and 4.9 metres in height. The overall dimensions of the reactor, including the affixed radiators, are approximately 2.7 metres wide, 11.3 metres in length and 2.7 metres in height. Photos of the transformer and reactor are provided in Figures 1 and 2.

Acoustically, the sound of both the transformer core and reactor were found to be tonal in the nearfield (the transformer fans emitted broadband sound). A tonal sound is defined as one which has a "pronounced audible tonal quality such as a whine, screech, buzz or hum". A/C transformers and reactors typically exhibit a humming character at twice the line frequency (120 Hz) and harmonics thereof, as a result of magnetostrictive forces in the windings and semiconductors. The sound level measurements indicated tones at 120 Hz and harmonics thereof. The unit was operating normally during the test period.

3 ACOUSTIC ENVIRONMENT

The measurements were conducted outdoors at the Grand Bend Wind Farm substation, in Huron County, Ontario. The sound of the substation was steady, with little background sound in the vicinity, and the weather conditions during the test period remained relatively constant with clear skies, an air temperature of approximately 25° Celsius, and negligible wind at the site. Accordingly, the environment was suitable to conduct acoustical measurements.

4 INSTRUMENTATION

The sound level measurements were conducted using a Brüel & Kjær Hand-held Analyzer Type 2270, equipped with Sound Intensity software BZ-7233, a Brüel & Kjær model 3654 Sound Intensity Probe and a pair of phase-matched model 4197 microphones. The calibration of instrumentation was field verified before and after the measurements using a Brüel & Kjær model 4231 sound level calibrator with a dual microphone coupler. Laboratory calibration certificates for the equipment are included as Appendix A.

5 MEASUREMENT PROCEDURE

A sketch of the measurement setup is appended as Figure 3. As per the IEC Standard 60076-10, measurements of sound intensity were conducted at 1/2 height of the transformer and reactor at 1 meter intervals around all four sides of the units. Measurements were conducted at an offset distance of 0.3 meters from the tank and radiator surfaces without the cooling fans operating. With the fans operating, the measurements were conducted 0.3 metres from the tank, and at 2 metres from the fans and radiator surfaces. Note that recent research into methods of measuring sound levels from electrical transformers indicates that measurements completed utilizing sound intensity methods provide results which are more accurate than measurements of sound pressure [3]. Unlike a simple sound level meter with an omni-directional microphone, sound intensity instrumentation utilizes a highly directional probe and sophisticated analyzer to measure both the magnitude and direction of sound. This approach therefore has excellent immunity to background noise, acoustical reflections and cross-interference from sources located close together.

6 MEASUREMENT RESULTS

Table I provides the average octave band sound intensity levels of the transformer and reactor, measured utilizing methods from IEC Standard 60076-10. Note that, without the cooling fans operating, measurements were conducted at 25 unique locations around the transformer, and with the cooling fans operating, the transformer was measured at 30 unique locations, as described in the previous section. Measurements were conducted in 18 unique locations around the reactor, also as described in the previous section.

Table I: Sound Intensity Levels [dBA & dB]

Octave Band Centre Frequency [Hz]	63	125	250	500	1k	2k	4k	8k	Overall
75/100/125 MVA Transformer (dBA) (Without Fans Operating)	33.5	47.4	42.1	49.4	41.5	32.3	26.9	18.9	**52.6**
75/100/125 MVA Transformer (dB) (Without Fans Operating)	59.7	63.5	50.7	52.6	41.5	31.1	25.9	20.0	**65.4**
75/100/125 MVA Transformer (dBA) (With Fans Operating)	37.4	46.1	47.3	52.1	47.3	40.7	34.3	26.7	**55.2**
75/100/125 MVA Transformer (dB) (With Fans Operating)	63.6	62.2	55.9	55.3	47.3	39.5	33.3	27.8	**66.8**
40 MVAR Reactor (dBA)	36.3	53.3	37.8	43.7	45.3	33.1	32.0	23.3	**54.7**
40 MVAR Reactor (dB)	62.5	69.4	46.4	46.9	45.3	31.9	31.0	24.4	**70.3**

Appendix B contains the detailed one-third octave band sound intensity level results.

The conversion from sound intensity level to sound power level is based on the area of the imaginary surface enclosing the source, at the specified reference distance from the equipment. In this case, the enclosing surface areas for the transformer without and with the fans operating are 204 m^2 and 322 m^2, respectively, and the enclosing surface area of the reactor is 82 m^2, including the top surfaces.

The overall octave band sound power level calculated from the measured sound intensity levels of the substation are presented in Table II, below.

Table II: Measured Sound Power Levels [dBA & dB re 10^{-12} Watts], Calculated Using Sound Intensity Measurements

Octave Band Centre Frequency [Hz]	63	125	250	500	1k	2k	4k	8k	Overall
75/100/125 MVA Transformer (dBA)	64.4	75.8	73.9	79.6	73.7	66.6	60.3	52.7	**82.7**
75/100/125 MVA Transformer (dB)	90.6	91.9	82.5	82.8	73.7	65.4	59.3	53.8	**94.9**
40 MVAR Reactor (dBA)	60.5	77.5	61.9	67.9	69.4	57.3	56.1	47.4	**78.8**
40 MVAR Reactor (dB)	86.7	93.6	70.5	71.1	69.4	56.1	55.1	48.5	**94.4**

*sound power levels include the +5 dBA tonal adjustment applied to transformer core & reactor

Table III shows the sound power levels utilized in the assessment of the transformer substation, as outlined in [1]. Further details are provided in Appendix B.

Table III: Specified Sound Power Level [dBA & dB re 10^{-12} Watts]

Octave Band Centre Frequency [Hz]	63	125	250	500	1k	2k	4k	8k	Overall
75/100/125 MVA Transformer (dBA)	72.5	84.6	87.1	92.5	89.7	85.9	80.7	71.6	**96.1**
75/100/125 MVA Transformer (dB)	98.7	101	95.7	95.7	89.7	84.7	79.7	72.7	**105.5**
40 MVAR Reactor (dBA)	70.0	81.0	96.0	98.0	65.0	60.0	55.0	50.0	**100.2**
40 MVAR Reactor (dB)	96.2	97.1	104.6	101.2	65.0	58.8	54.0	51.1	**107.1**

*sound power levels include the +5 dBA tonal adjustment

The sound level measurements indicate that the octave band and overall A-weighted sound power levels of both the transformer and reactor meet the specified sound power levels outlined in [1] and Schedule B of the REA.

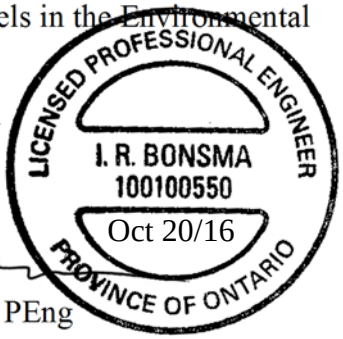
7 CONCLUSIONS

HGC Engineering completed an Acoustic Audit of the Grand Bend Wind Farm substation transformer and reactor, located in Huron County, Ontario. Sound level measurements were completed on September 22, 2016 utilizing methods from IEC Standard 60076-10 titled Power transformers – Part 10: Determination of sound levels. The sound level measurements and calculations indicate the octave band and overall A-weighted sound power levels of both the transformer and reactor are significantly less than the specified sound levels in the Environmental Noise Impact Assessment [1] and Schedule B of the REA.

Howe Gastmeier Chapnik Limited

Andrew Dobson, BSc, INCE

Reviewed by



Ian Bonsma, PEng

REFERENCES

[1] Aercoustics, "Environmental Noise Impact Assessment – Grand Bend Wind Farm", April 15, 2014.

[2] IEC Standard 60076-10 titled Power transformers – Part 10: Determination of sound levels.

[3] Andrew Dobson, "Addressing the Complexities, Limitations and Benefits Involved in Conducting Near-Field Sound Power Measurements of Large Electrical Transformers", Internoise Innsbruck, September 2013.

Figure 1: Transformer

Figure 2: Reactor

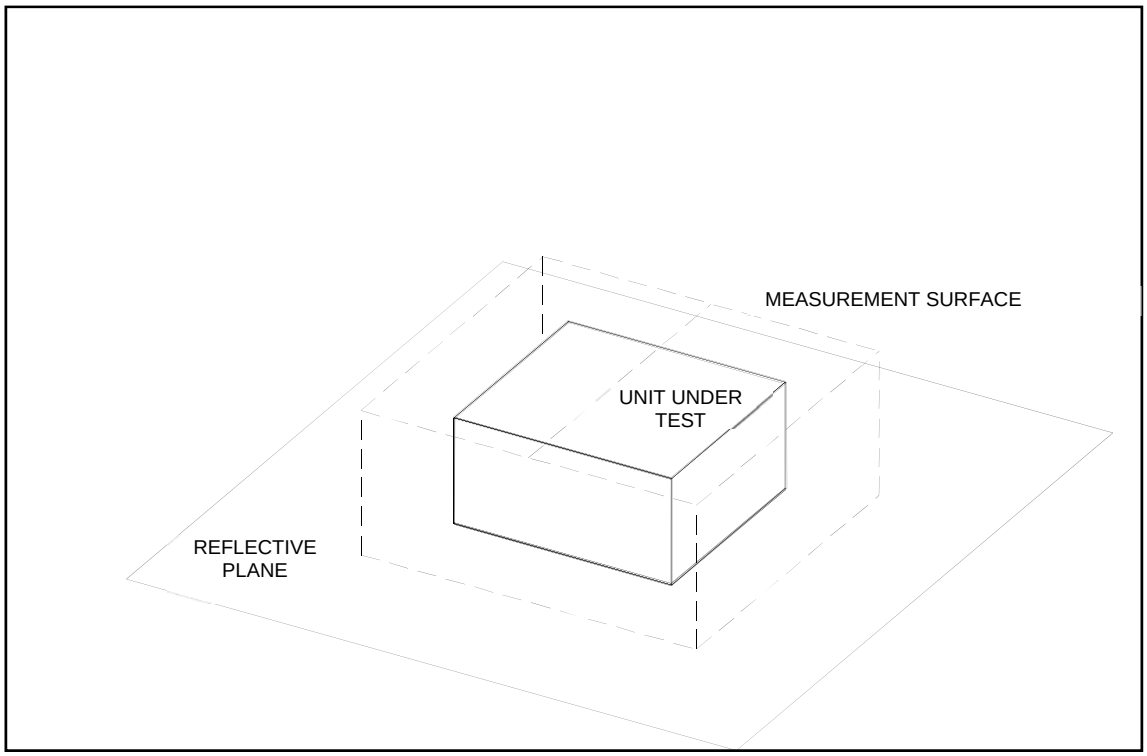


Figure 3: Sketch of Measurement Surface

Figure 4A: Sound Power and Sound Intensity Levels
Transformer, Measured September 22, 2016

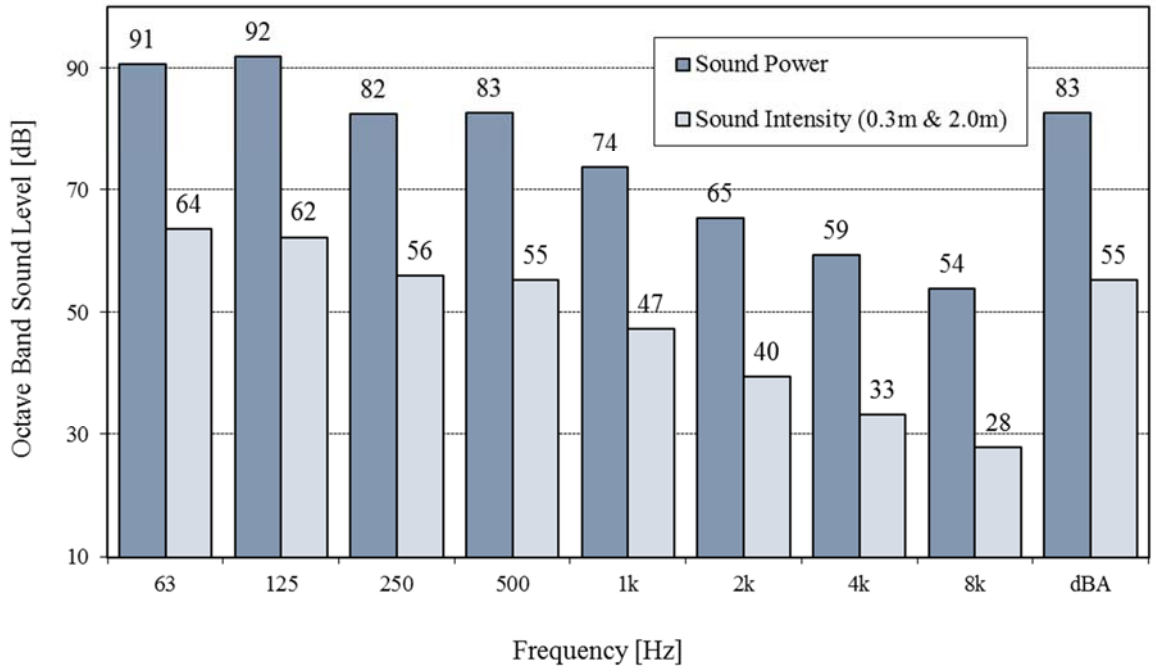
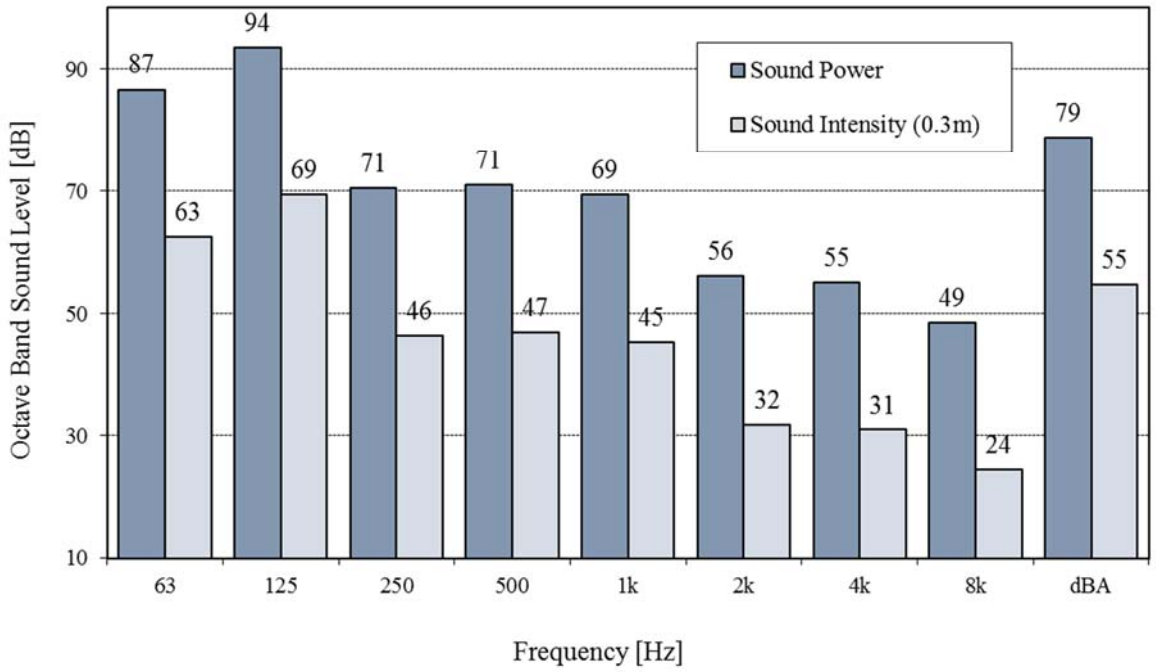


Figure 4B: Sound Power and Sound Intensity Levels
Reactor, Measured September 22, 2016



APPENDIX A
Instrument Calibration Certificates

CERTIFICATE of CALIBRATION

Make : Bruel & Kjaer

Model : 2270

Descr. : Sound Level Meter Type 1

Serial # : 3003000

Asset # : 1

Reference # : 142244

Customer : HGC Engineering
Mississauga, ON

P. Order : Sean Richarson

Cal. status : Received in spec's, no adjustment made. 4 JAN 2016
System with 2683 s#2792546

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 : Dec 30, 2015

Cal. Due : Dec 30, 2016

By : J. Raposo

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

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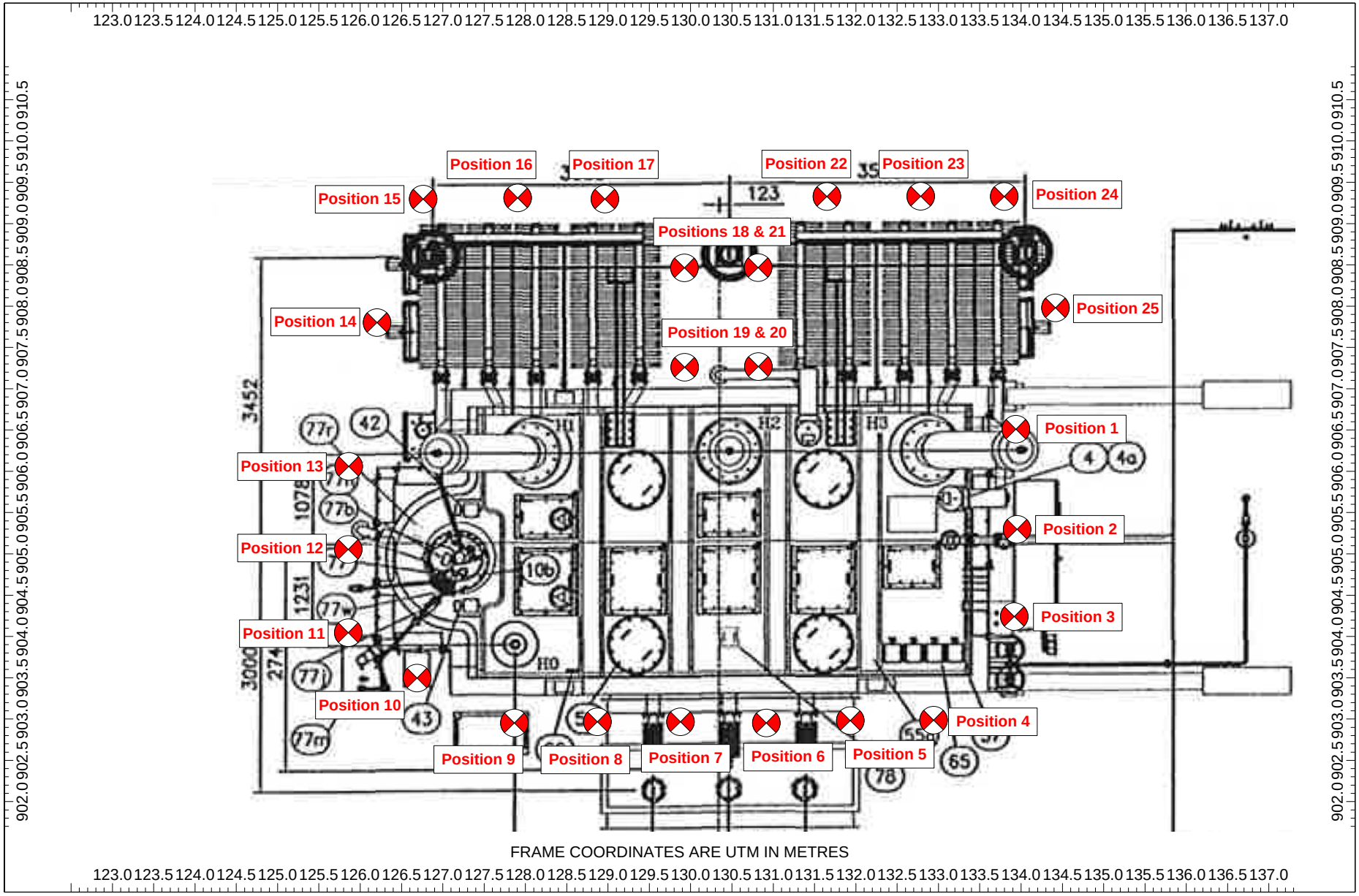
APPENDIX B
Detailed Measurement Results & Equipment Drawings

One-Third Octave Frequency [Hz]	Measured Transformer Sound Intensity Levels - Without Fans Operating [dB] Microphone Location (Height = 2.5 Metres Above Grade)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	nil	nil	54	nil	nil	46	60	nil	nil	40	nil	nil	nil	nil	81	nil	nil	nil	nil	57	nil	nil	nil	nil	nil
32	nil	60	nil	nil	nil	nil	55	nil	nil	nil	nil	nil	nil	nil	79	nil	47	nil	nil	nil	52	47	nil	nil	nil
40	nil	nil	nil	nil	nil	56	52	nil	nil	51	nil	nil	nil	nil	77	nil	nil	nil	nil	46	nil	42	53	nil	nil
50	nil	nil	45	57	nil	45	50	nil	49	48	nil	45	nil	nil	72	nil	nil	29	44	nil	nil	43	nil	nil	nil
63	53	49	nil	52	48	nil	56	nil	nil	48	54	nil	nil	nil	67	nil	nil	42	46	41	49	34	nil	nil	nil
80	nil	46	nil	45	nil	nil	nil	nil	nil	39	nil	nil	nil	nil	60	nil	nil	nil	nil	nil	41	nil	nil	nil	nil
100	53	nil	51	47	50	48	47	nil	nil	44	47	51	51	43	50	nil	42	39	51	55	43	51	45	49	48
125	68	nil	66	60	65	63	62	nil	nil	60	61	66	56	62	58	59	56	53	66	70	57	66	60	65	64
160	37	37	nil	41	41	40	40	nil	34	38	nil	42	nil	40	37	nil	35	nil	42	46	36	40	35	32	39
200	34	nil	nil	34	nil	nil	nil	39	46	40	30	33	41	37	37	31	34	24	33	40	nil	32	36	nil	32
250	nil	43	50	54	nil	nil	nil	44	59	37	50	35	53	50	46	41	46	43	49	50	nil	44	45	45	41
315	42	50	42	48	44	47	41	42	42	45	47	39	52	48	43	42	45	48	48	41	nil	33	31	36	44
400	47	55	46	53	50	nil	48	44	47	49	51	44	57	52	48	46	50	53	53	45	nil	40	34	42	48
500	47	49	45	49	59	nil	nil	nil	55	43	44	42	48	39	36	47	34	48	49	nil	nil	49	44	50	40
630	39	37	nil	44	39	45	36	nil	43	42	41	43	50	39	34	33	38	37	37	37	nil	29	20	34	38
800	37	nil	31	47	42	45	44	nil	42	37	40	35	33	40	35	29	30	35	40	41	nil	29	34	30	35
1000	30	38	36	37	32	39	38	36	42	45	39	26	34	29	27	22	25	20	32	32	nil	19	24	26	27
1250	13	25	24	29	nil	25	29	32	38	43	30	22	24	nil	23	10	12	18	14	14	nil	nil	10	10	nil
1600	nil	21	19	27	nil	nil	20	29	35	42	28	24	17	nil	21	nil	16	19	7	14	nil	6	nil	17	13
2000	nil	14	13	22	nil	nil	nil	24	30	36	25	20	18	nil	17	nil	7	17	nil	nil	nil	nil	nil	18	nil
2500	nil	18	nil	19	nil	21	25	21	28	34	24	16	20	nil	14	nil	nil	20	nil	10	nil	12	nil	21	nil
3150	nil	13	nil	20	nil	nil	19	24	27	34	22	15	17	nil	6	nil	9	24	nil	nil	nil	nil	nil	23	nil
4000	nil	nil	nil	nil	14	18	nil	20	nil	28	nil	8	22	nil	nil	nil	13	28	nil	nil	nil	nil	nil	29	31
5000	nil	nil	nil	nil	15	2	20	18	3	23	10	18	12	nil	nil	nil	nil	26	nil	nil	nil	nil	nil	28	27
6300	nil	nil	nil	nil	16	2	18	9	15	18	16	13	12	nil	nil	nil	nil	25	nil	nil	nil	nil	nil	24	10
8000	nil	nil	nil	nil	nil	1	8	4	16	19	21	22	nil	nil	nil	nil	nil	22	nil	nil	nil	nil	nil	23	23
10000	nil	nil	nil	14	nil	nil	15	nil	nil	19	19	21	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	20	24



Microphone Positions Around Transformer (Fans Not Operating)
Microphone Height = 2.5 Metres, Offset = 0.3 Metre

One-Third Octave Frequency [Hz]	Measured Transformer Sound Intensity Levels - With Fans Operating [dB] Microphone Location (Height = 2.5 Metres Above Grade)																													
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
25	nil	53	75	67	72	nil	nil	nil	72	nil	nil	nil	nil	nil	nil	44	77	nil	68	63	63	nil	67	60	77	77	65	nil	nil	nil
32	58	57	68	74	74	70	nil	62	68	nil	nil	nil	nil	nil	nil	63	76	nil	67	nil	59	nil	62	35	66	76	61	45	nil	nil
40	56	48	nil	71	nil	52	nil	nil	63	nil	nil	nil	nil	nil	nil	nil	73	nil	57	nil	53	47	51	nil	57	73	58	nil	54	nil
50	nil	46	53	nil	70	56	58	nil	60	nil	nil	nil	45	nil	nil	59	69	59	61	55	nil	41	52	nil	63	72	53	45	41	nil
63	54	52	55	nil	51	66	nil	nil	50	56	nil	nil	34	nil	46	58	67	59	53	50	47	33	nil	49	56	67	55	nil	48	54
80	nil	nil	nil	59	62	59	nil	nil	26	41	44	42	41	46	48	nil	60	54	53	39	49	51	51	48	57	60	nil	27	43	48
100	nil	52	nil	54	59	47	nil	44	47	48	52	46	49	49	48	53	55	56	53	54	55	54	54	50	50	51	51	51	51	52
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200	nil	46	43	38	35	nil	40	47	45	40	41	47	50	50	48	51	53	52	51	53	53	52	54	51	49	48	49	48	46	51
250	40	50	54	54	43	nil	57	59	49	51	41	49	51	52	49	52	53	54	53	55	55	53	55	53	51	49	49	47	47	52
315	49	46	42	36	nil	44	42	45	51	48	44	49	52	51	51	53	53	55	54	55	54	55	54	52	51	52	50	51	47	51
400	53	43	39	43	nil	50	50	51	56	52	47	49	52	51	50	51	50	52	51	51	52	51	50	52	52	54	49	54	47	49
500	47	47	43	55	57	60	60	55	49	48	43	50	48	50	50	51	48	51	50	51	51	49	51	49	50	50	50	46	49	44
630	nil	48	38	51	45	nil	nil	43	47	41	41	47	49	48	47	47	47	47	46	47	48	45	46	46	47	48	48	45	44	45
800	31	43	40	39	40	36	38	42	47	40	37	46	47	47	45	44	43	43	42	44	44	41	42	44	46	47	47	44	42	42
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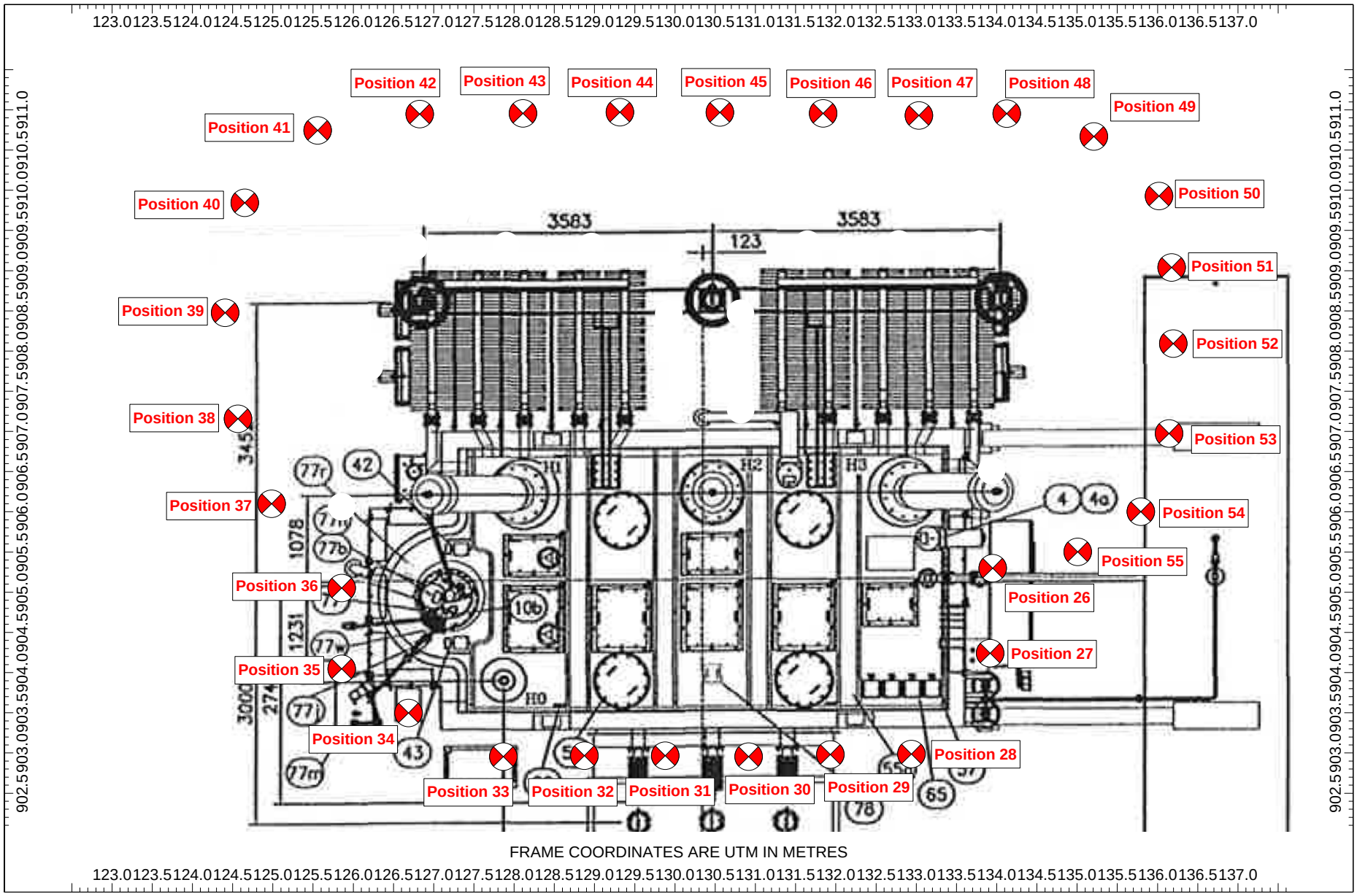
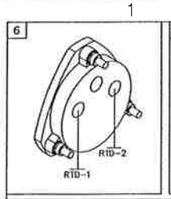
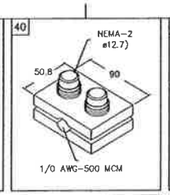
1250	28	28	29	23	18	nil	nil	36	48	34	34	43	44	44	42	41	38	39	38	38	38	39	38	39	42	43	44	41	38	37
1600	21	nil	25	25	21	nil	nil	33	45	33	31	40	41	41	39	37	34	35	34	34	35	36	35	36	39	40	41	38	35	34
2000	19	nil	22	20	nil	nil	nil	29	37	29	27	37	38	38	36	34	31	32	31	30	33	32	32	34	37	38	39	37	33	32
2500	21	nil	24	20	1	nil	nil	28	35	26	24	35	36	36	34	33	29	28	27	27	30	29	30	32	35	36	37	34	31	30
3150	20	nil	19	13	14	18	nil	28	36	27	22	33	35	34	32	31	28	27	26	26	28	27	29	31	33	34	35	32	29	28
4000	16	nil	nil	19	24	25	nil	21	32	24	nil	nil	29	27	nil	nil	nil	nil	31	28	28	26	31	32	32	34	34	33	29	26
5000	11	nil	nil	21	7	18	nil	nil	26	23	26	nil	29	23	12	nil	nil	nil	27	27	25	23	29	31	31	32	32	31	27	24
6300	nil	nil	8	7	7	nil	nil	16	22	17	20	29	30	29	28	26	21	14	8	nil	24	17	23	26	28	29	30	29	25	23
8000	nil	6	nil	8	nil	nil	nil	nil	21	14	nil	26	26	20	21	nil	nil	nil	nil	nil	21	nil	25	26	27	28	29	28	24	23
10000	nil	14	11	14	nil	nil	nil	nil	24	nil	22	nil	nil	nil	nil	nil	nil	nil	nil	nil	11	nil	27	27	26	28	29	27	23	24
A-Weighted	51	53	48	55	56	57	58	56	58	52	52	54	56	56	54	55	55	55	54	56	56	55	55	55	55	56	56	55	53	53

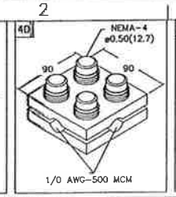


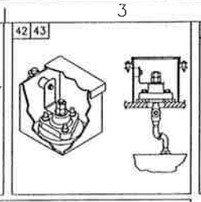
Microphone Positions Around Transformer (Fans Operating)

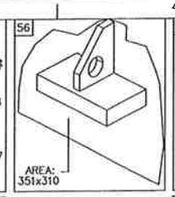
Microphone Height = 2.5 Metres, Offset = 0.3 Metre From Tank & 2.0 Metres from Fans/Rads

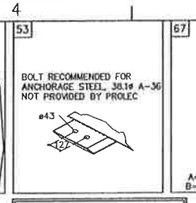


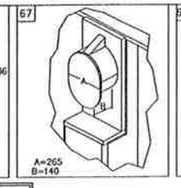


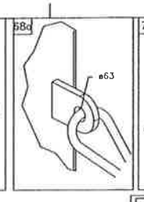


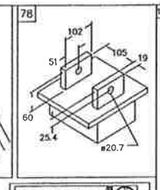


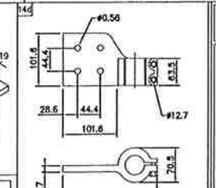




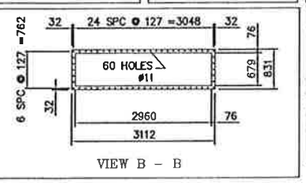




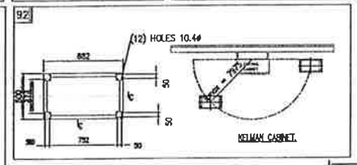




CONNECTOR: DELTA-PWR60C12-1-4N4-E	
BUSHING	HO
STUD	2.00ø 12 UNF
MATERIAL	BRONZE RED
TIGHT TORQUE RECOMMENDED	40 LBS-FT



VIEW B – B



WARNING

THIS UNIT SHALL BE MOUNTED OVER ANTI-VIBRATION PADS

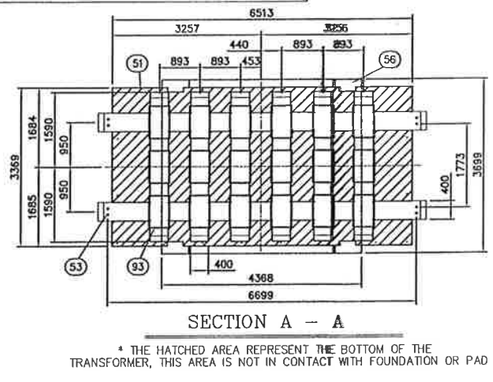
POSITION PADS ON FOUNDATION BEFORE TRANSFORMER OFFLOAD

PROLEC GE

APPROVAL DRAWING

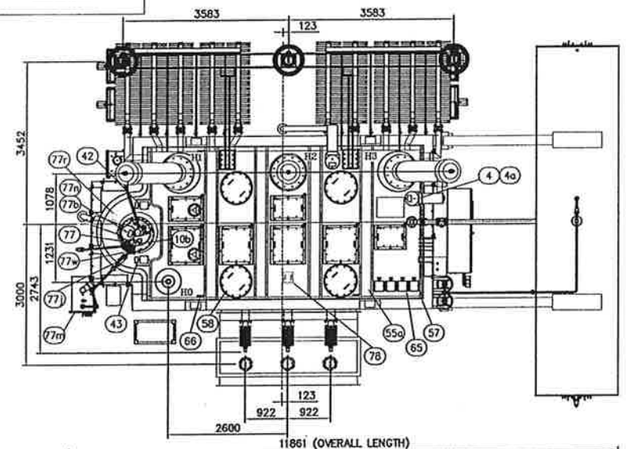
MAR/27/2015

DEAR CUSTOMER :
WE WANT TO SERVE YOU BETTER, PLEASE REVIEW THIS DRAWING AND SEND BACK WITH YOUR COMMENTS TO PROLEC-GE IN THE TIMEFRAME OF 10 DAYS AFTER THE DATE MARKED IN THIS STAMP.



SECTION A – A

* THE HATCHED AREA REPRESENT THE BOTTOM OF THE TRANSFORMER, THIS AREA IS NOT IN CONTACT WITH FOUNDATION OR PAD

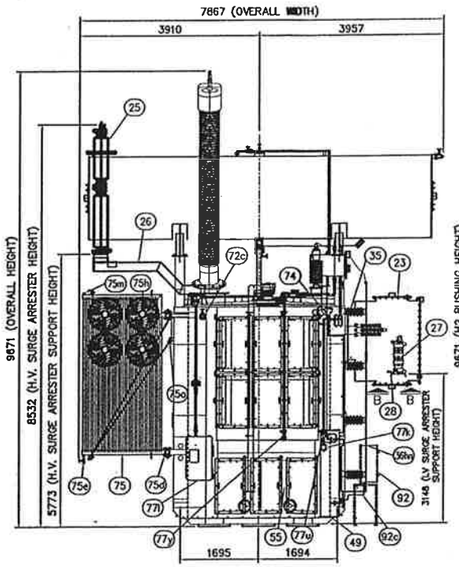


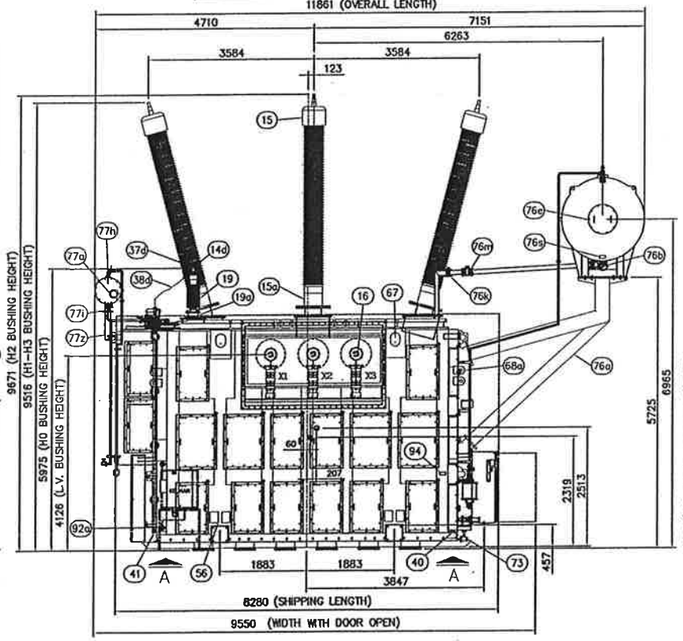
APPROXIMATE WEIGHTS (KGS)	
CORE AND COILS	86360
TANK AND FITTINGS	51155
MAIN TANK INSULATING LIQUID (69110 LTS)	62200
COOLING EQUIPMENT INSULATING LIQUID (3900 LTS)	3510
CONSERVATOR TANK INSULATING LIQUID (4685 LTS)	4395
LTC CONSERVATOR TANK INSULATING LIQUID (90 LTS)	90
LTC TANK INSULATING LIQUID (140 LTS)	125
TOTAL WEIGHT	207835
UNTANKING WEIGHT (HEAVIEST PIECE)	86360
SHIPPING WEIGHT (WITHOUT INSULATING LIQUID)	114575

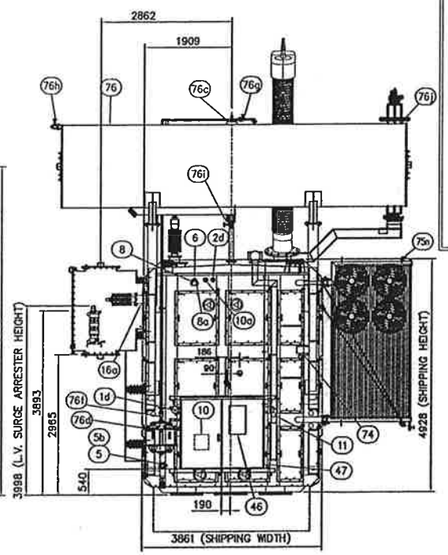
GE CANADA
P.O. No: 5500131950
GE Req No: 642117041
PROLEC GE Serial No: G3387-01

STEP DOWN/STEP UP TRANSFORMER
ONAN/ONAF/ONAF
75/100/125 MVA
60 HZ. THREE PHASE, 65°C, 1000 MASL
230/132.79 KV⅄ – 34.5 KV◁

GUIDE		QTY.	ITEM	DESCRIPTION	CAT./MOD.
		1	1d	LIQUID TEMPERATURE INDICATOR (26Q-1)	QUALITROL, TR6000B-00246709
		1	2d	THERMO-WELL FOR LIQUID TEMPERATURE INDICATOR	
5.4	*	2	4	PRESSURE RELIEF DEVICE WITH SEMAPHORE (63PR-1,2)	QUALITROL, XPR000-00246524
5.4	*	2	4a	DISCHARGE PIPE FOR PRESSURE RELIEF DEVICE	
5.6	*	1	5	RAPID PRESSURE RELAY (OIL) (63PR-1)	QUALITROL, 900-003-02
		1	5b	RAPID PRESSURE RELAY VALVE [50.8 ø] BALL-TYPE	
		1	6	THERMAL PLATE (TPT-1)	QUALITROL, 2WTL-1027-1
		1	8	WINDING TEMPERATURE RESISTANCE (RTD-1)	QUALITROL, 103-001-02
		1	8a	LIQUID TEMPERATURE RESISTANCE (RTD-2)	QUALITROL, 103-001-02
		1	10	ELECTRONIC TEMPERATURE MONITOR (ETM)	QUALITROL, 509-00074982
		1	10a	RESISTANCE TEMPERATURE DEVICE FOR ETM (RTD-3)	
		1	10b	RESISTANCE TEMPERATURE DEVICE FOR ETM (RTD-4)	
		1	11	PRESSURE-VACUUM GAUGE FOR SHIPPING	
5.15	*	1	14d	NEUTRAL BUSHING H0 EXTERNAL CONNECTOR	DELTA, PWR60C12-1-4N4-E
3.2	*	3	15	H.V. BUSHING	TRENCH, 500HC470
3.1/3.3	*	3	15a	H.V. REMOVABLE BUSHING TURRET	
3.2	*	3	16	L.V. BUSHING	ECI, 250-030-T-905-00
3.1	*	3	16a	L.V. REMOVABLE BUSHING TURRET	
3.2	*	1	19	NEUTRAL BUSHING H0	ABB, 046W2000UD
3.1	*	1	19a	NEUTRAL REMOVABLE BUSHING H0 TURRET	
5.9	*	1	23	SECONDARY BUSHING BUS DUCT COMPARTMENT BOTTOM ACCESS	
4.2	*	3	25	H.V. SURGE-ARRESTERS	GE Tranquell, 9L11ZTA240AS
4.1	*	1	26	H.V. SURGE-ARRESTER SUPPORT	
4.2	*	3	27	L.V. SURGE-ARRESTER	GE Tranquell, 9L11ZGA039S
4.1	*	1	28	L.V. SURGE-ARRESTER SUPPORT	
5.12	*	4	35	GROUND BAR INSULATOR	
5.11	*	1	36hn	H0 COPPER GROUND BAR (SET)	
	*	2	37d	H0 BUSHING GROUND CABLE CONNECTOR	
	*	1	38d	H0 COPPER GROUND CABLE	
		2	40	GROUND PAD	
		1	41	NEUTRAL H0 GROUND PAD	
		1	42	CORE GROUND BUSHING TERMINAL BOX (MAIN UNIT)	
		1	43	FRAME GROUND BUSHING BOX	
		1	46	NAMEPLATE	
		1	47	CONTROL CABINET	
		1	49	AUTOMATIC NITROGEN EQUIPMENT FOR SHIPMENT	
		1	51	REINFORCED BASE WELDED TO TANK	
		4	53	TRANSFORMER ANCHOR PADS	
		15	55	TANK BRACES	
		4	55a	COVER BRACES	
		4	56	JACKING PADS AND PULLING EYES	
		1	57	MAIN COVER	
		4	58	INSPECTION MANHOLE (COVER)	
		4	65	CT TERMINAL BOX	
		4	66	LIFTING EYE COVER ONLY	
		4	67	LIFTING HOOK FOR LIFTING COMPLETE UNIT	
		4	68a	SHIPPING LUGS FOR SECURING THE UNIT LONGITUDINALLY (LONG LUGS)	
		1	72c	TOP FILTER PRESS VALVE (2.00 ø) [50.8 ø] GLOBE-TYPE	
		1	73	MAIN TANK DRAIN VALVE (2.00 ø) [50.8ø] GLOBE-TYPE WITH SAMPLING DEVICE (0.38 ø) [9.65] AND PLUG	
		1	74	IMPACT RECORDER FOR SHIPPING	
		1	74a	ELECTRONIC IMPACT RECORDER FOR SHIPPING	
1.3	•	10	75	**COOLING RADIATORS**	
1.1		20	75d	**RADIATOR VALVE BUTTERFLY-TYPE [101.6 ø]**	
		10	75e	**RADIATOR VALVE FOR DRAIN GLOBE-TYPE [25.4 ø]**	
	•	8	75h	**COOLING FAN**	KRENZ, F280-A0698
		10	75m	**RADIATOR VENT PLUG [25.4 ø]**	
1.4	•	4	75n	**TOP/BOTTOM RADIATOR SUPPORTS**	
1.2	•	8	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 (71Q-1)	QUALITROL
		1	76c	HANDHOLE TO INSTALL BLADDER	
5.8	*	1	76d	SILICA-GEL BREATHER WITH PIPE	
		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 NIPPLE FOR VENT WITH CAP	
2.2	*	2	76k	CONSERVATOR TANK TO MAIN TANK VALVE [76.2 ø] BUTTERFLY-TYPE	
		1	76l	GAS SAMPLING DEVICE	
2.4	*	1	76m	PROTECTIVE RELAY FOR GAS ACCUMULATION (BUCHHOLZ) (63BH-1)	EMB, 53-6.28.44,-0336
		1	76s	INFORMATION NAMEPLATE	
		1	77	ON-LOAD TAP-CHANGER	MR, VM1500Y-72.5/C-18353WR
		1	77a	LTC MAGNETIC LIQUID LEVEL GAUGE (71Q-2)	
5.4	*	1	77b	LTC PRESSURE RELIEF DEVICE (63PR-4)	
		1	77h	LTC TOP FILTER PRESS VALVE [25.4 ø] BALL-TYPE	
		1	77l	LTC DRAIN VALVE [25.4 ø] BALL-TYPE	
	•	1	77j	LTC PROTECTIVE RELAY (63BH-2)	
5.8	•	1	77k	LTC SILICA-GEL BREATHER WITH PIPE	
		1	77l	LTC MOTOR DRIVE CABINET	
5.7	•	1	77m	LTC CONSERVATOR TANK	
5.4	•	1	77n	LTC DISCHARGE PIPE FOR PRESSURE RELIEF DEVICE	
		1	77r	LTC WARNING NAMEPLATE	
	•	1	77u	SILICA-GEL SHUT OFF VALVE [25.4 ø] GLOBE-TYPE	
	•	2	77w	LTC PROTECTIVE RELAY VALVE [25.4 ø] BALL-TYPE	
	•	1	77y	LTC SUCTION VALVE [25.4 ø] GLOBE-TYPE WITH PIPE	
	•	1	77z	LTC CONSERVATOR TANK SUPPORT	
		1	78	TETHER POLE MOUNTING PLATE	







NOTES:

a) ITEMS REMOVED FOR SHIPMENT ARE MARKED WITH (*).

b) NUMBERING IS ACCORDING WITH G.E. PROLEC STD. LIST.

c) THE NUMBER IN COLUMN "GUIDE" CORRESPONDS TO THE "IN-FIELD ASSEMBLY GUIDE"

OPERATION CENTER OF GRAVITY
SHIPPING CENTER OF GRAVITY
SHIPPING CENTER OF GRAVITY WITHOUT OIL

TOLERANCES

Centerline distance of not inclined bushings		[±6]
Centerline distance of inclined bushings		[±25]
		[−15]
Bushings height (distance to floor)		[±12]
Outlet of control cabinet distance		[±6]
Hv & Lv bushings center line		[±6]
Bushings & surge arrester center line		[±6]
Surge arrester height (distance to floor)		[±12]
Center tank distance to short side		[±12]
Center tank distance to large side		[±12]
Conservator height		[±12]
Anchoring center line		[±3]
Bracing base center line		[±3]
Pattern distance		[+1]
		[−4]
Outline	[0–3000]	[±25]
Dimensions	[3000–5000]	[±40]
	[5000 & Above]	[±50]

THIS DRAWING CONTAINS PROPRIETARY INFORMATION WHICH CAN NOT BE REPRODUCED WITHOUT PERMISSION OF PROLEC GE.

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

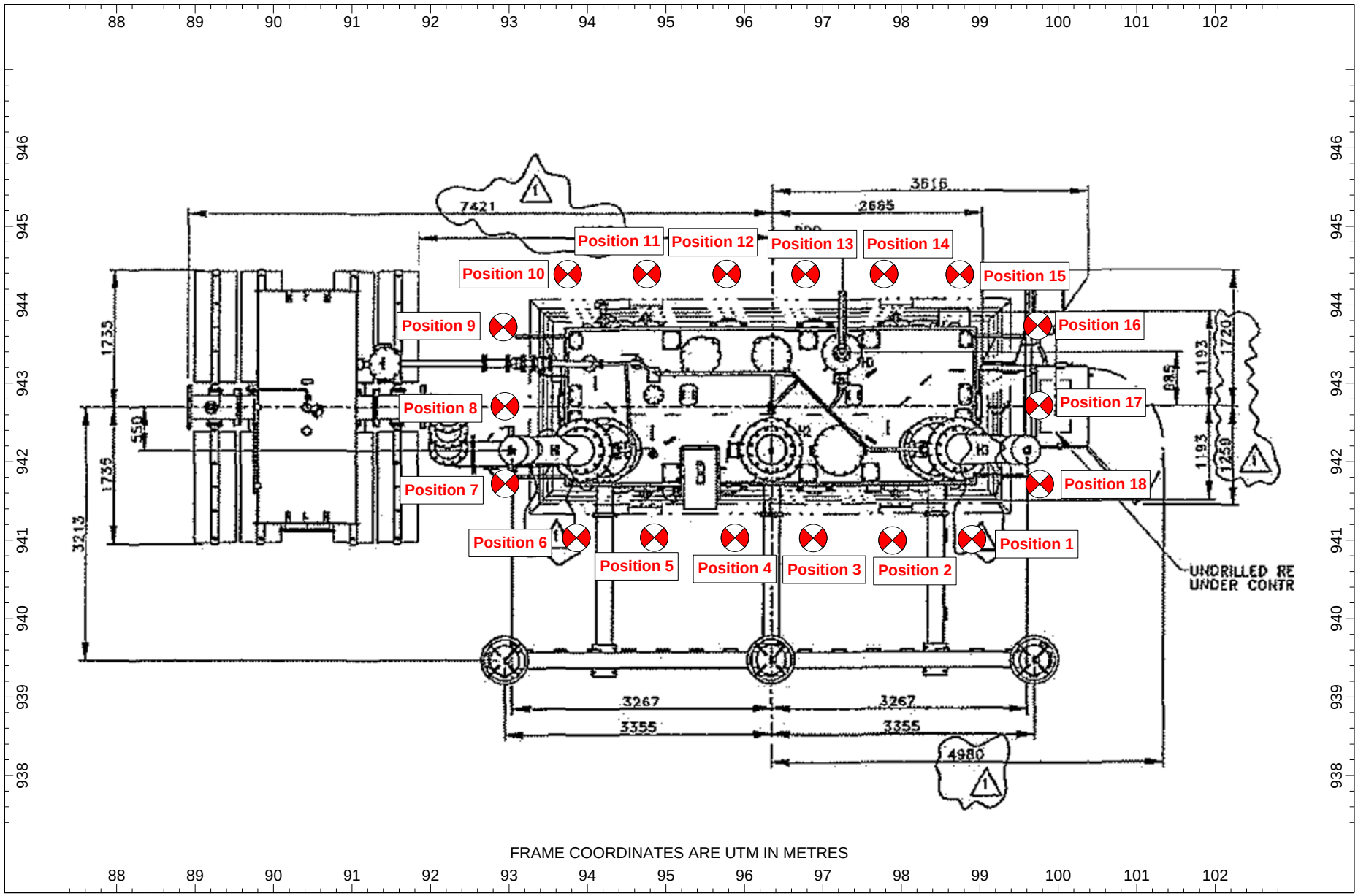
TITLE: TRANSFORMER'S OUTLINE

DRAWN: JFTR 03/27/15
CHKD: LJGG 03/25/15

PROJECTION
SCALE: 1:60
DIMENSIONS: [MM]
REVISION: INDICATED
DRAWING NO.: G338701D801
sheet: 1 of 1

REV | DESCRIPTION | DESIGN GROUP | DATE

One-Third Octave Frequency [Hz]	Measured Reactor Sound Intensity Levels [dB] Microphone Location (Height = 1.5 Metres Above Grade)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
25	nil	nil	nil	nil	nil	nil	81	nil	66	nil	nil	nil	41	nil	nil	nil	nil	67
32	nil	nil	nil	nil	nil	nil	78	nil	60	nil	nil	nil	48	nil	nil	nil	nil	67
40	nil	nil	nil	56	nil	nil	76	nil	61	nil	nil	nil	51	nil	nil	nil	nil	nil
50	nil	nil	nil	nil	nil	nil	72	nil	50	nil	nil	nil	nil	nil	nil	37	nil	47
63	nil	nil	nil	42	43	nil	71	nil	50	nil	48	nil	nil	nil	nil	40	nil	47
80	nil	nil	33	45	27	nil	66	nil	nil	nil	nil	27	nil	nil	nil	27	nil	48
100	nil	56	55	56	53	57	61	55	51	52	53	56	53	42	48	55	55	45
125	66	71	70	71	68	71	72	71	66	67	68	72	68	55	63	70	71	62
160	40	46	45	46	44	46	51	47	36	42	42	47	42	nil	24	46	45	35
200	31	29	32	31	32	36	46	nil	33	24	nil	29	34	nil	28	34	38	33
250	47	37	46	41	42	47	47	42	46	45	31	42	49	45	47	48	50	nil
315	nil	39	nil	nil	nil	nil	nil	nil	37	31	35	32	40	37	35	40	35	35
400	32	44	nil	nil	nil	nil	nil	nil	40	33	40	35	43	42	40	48	40	39
500	nil	39	nil	nil	nil	nil	36	38	42	38	37	nil	31	38	45	51	43	45
630	44	nil	40	nil	41	40	nil	nil	38	35	33	33	34	37	41	55	38	45
800	32	nil	nil	nil	nil	33	31	23	nil	26	nil	21	29	35	45	53	47	38
1000	22	nil	nil	nil	27	25	21	nil	22	19	nil	nil	29	36	47	52	49	43
1250	16	nil	nil	nil	nil	nil	18	nil	13	19	nil	nil	22	29	35	41	36	35
1600	18	nil	nil	nil	nil	nil	nil	nil	3	18	nil	nil	17	26	30	37	34	30
2000	10	nil	nil	nil	9	1	7	9	2	12	15	14	15	22	25	39	31	31
2500	nil	nil	nil	nil	nil	nil	nil	nil	0	12	15	21	10	23	24	36	26	28
3150	nil	nil	nil	nil	nil	nil	nil	nil	nil	14	4	23	14	28	24	38	28	32
4000	13	31	22	25	18	nil	nil	nil	nil	19	nil	26	11	33	18	35	27	28
5000	nil	23	nil	23	nil	nil	nil	nil	nil	19	nil	28	nil	32	14	30	24	26
6300	nil	nil	23	nil	nil	nil	4	nil	nil	14	nil	28	15	32	14	28	14	19
8000	nil	nil	nil	nil	nil	nil	nil	nil	nil	15	nil	26	nil	nil	10	24	nil	16
10000	18	14	21	14	nil	14	nil	nil	15	18	nil	5	nil	26	18	21	nil	18
A-Weighted	51	55	54	55	53	55	57	55	51	51	52	56	53	46	52	60	57	50

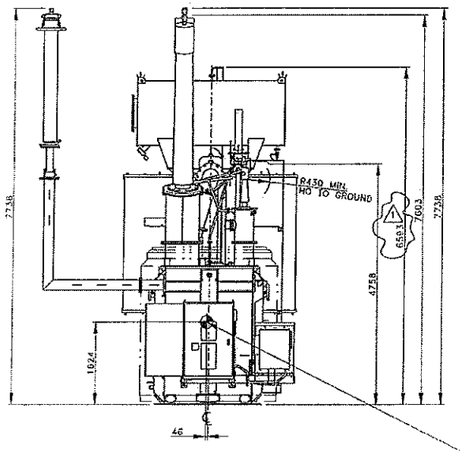


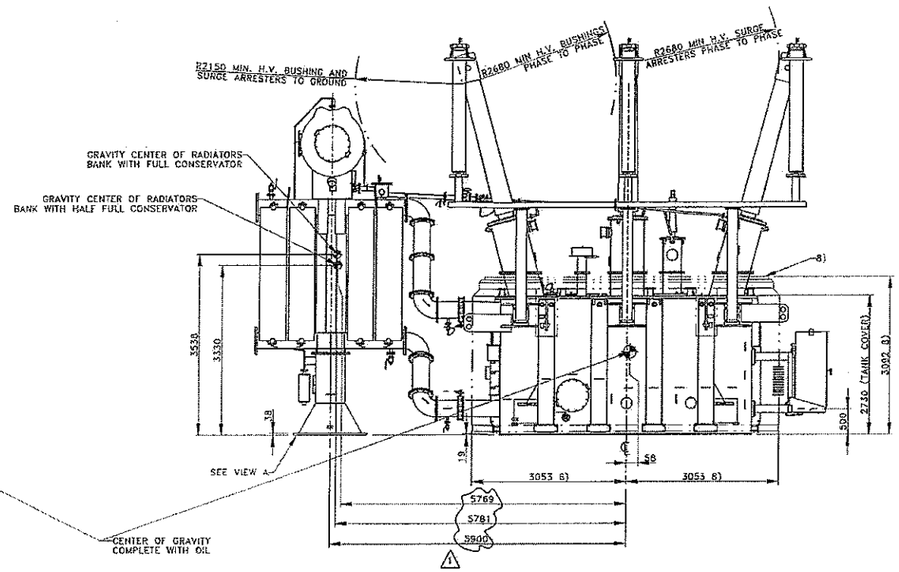
Microphone Positions Around Reactor

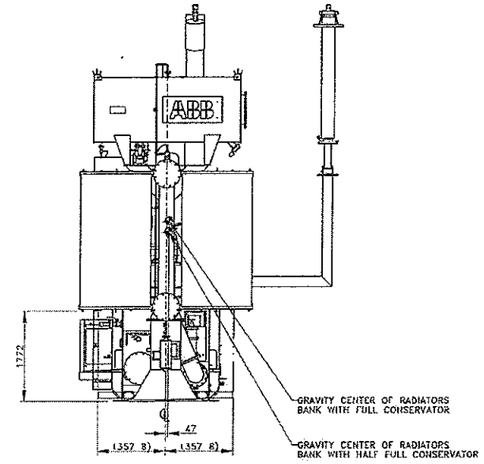
Microphone Height = 1.5 Metres, Offset = 0.3 Metre

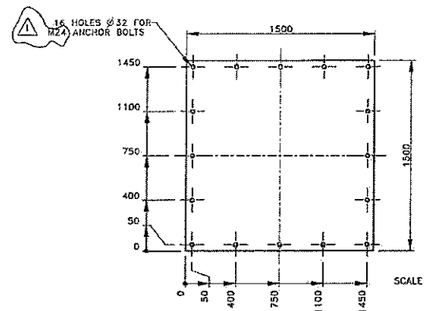
8) SOUND ENCLOSURE OUTLINE

FINAL

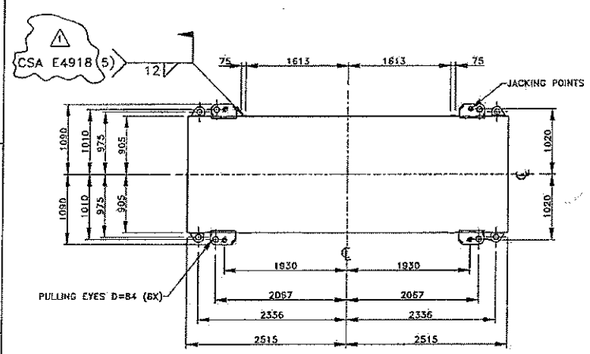


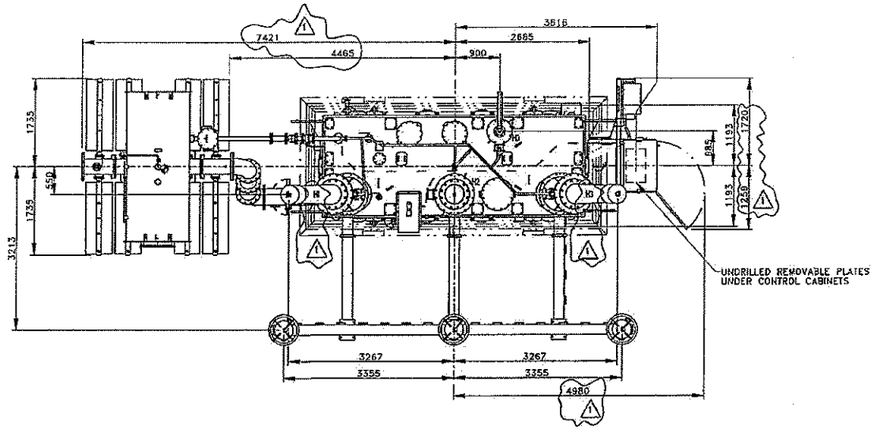






VIEW A





BOTTOM DIMENSIONS

RADIATORS BANK MASS WITH FULL CONSERVATOR. (±10%)	16633 kg

WEIGHT (±10%)		OIL QUANTITY AT 15°C (±2%)	
CORE AND COILS.....:	31458 kg	TANK.....:	19961 L
TANK AND ACCESSORIES:	19699 kg		
OIL* (TANK).....:	17327 kg		
SOUND ENCLOSURE..... :	2800 kg	* OIL DENSITY 868 (kg/m3) AT 15°C	
TOTAL(TRANSFORMER).....:	71284 kg	TOTAL(TANK).....:	19961 L
BANK AND ACCESSORIES:	10978 kg	BANK.....:	875 L
OIL* (BANK).....:	4097 kg	RADIATORS.....:	2050 L
		CONSERVATOR(S) (50%)..	1795 L
TOTAL(BANK).....:	15075 kg	TOTAL(BANK).....:	4720 L
		TOTAL(TRANSFORMER)..:	24681 L

NOTES:

1- THIS DRAWING WAS CREATED FOR THE CUSTOMER TO START THE CIVIL ENGINEERING WORK AS SOON AS POSSIBLE AND TO GIVE INFORMATION ABOUT THE GENERAL LOCATIONS OF MAJOR ACCESSORIES.

REV.1

4- TOLERANCES: ±50mm ON DIMENSIONS > 1000 mm.
±13mm ON DIMENSIONS < 1000 mm.

5- RECOMMENDED ANCHORING IS 4 WELDED JOINTS 75 LONG EACH.

6- CONSTRUCTION TOLERANCES FOR CONCRETE FOUNDATION
A MAXIMUM ELEVATION CHANGE OF 2.5mm FOR ANY 2 POINTS SPACED BY 1 m. A MAXIMUM ELEVATION CHANGE OF 8mm FOR ANY TWO POINTS ON TOP OF FOUNDATION. TOLERANCES MEASUREMENTS SHALL BE ACCORDING TO ASTM E 1155 M. ANY DEVIATION TO THE TOLERANCES MENTIONNED ABOVE SHALL BE SUBMITTED TO AND APPROVED BY ABB VARENNES MECHANICAL ENGINEERING.

PROJECT REVIEW DECAL amec
GRAND BEND WIND PROJECT
PO/CONTRACT No. 174714-P006 | DESCRIPTION: SHUNT REACTOR
SECONDARY SDDRL CODE(S): B03/B04/D13
EQUIPMENT TAG NUMBERS: 15082-01
PERMISSION TO PROCEED DOES NOT CONSTITUTE ACCEPTANCE OF DESIGN, CALCULATIONS, TEST METHODS OR MATERIALS DEVELOPED OR SELECTED BY SELLER AND DOES NOT RELIEVE SELLER FROM FULL COMPLIANCE WITH CONTRACTUAL OR OTHER OBLIGATIONS.
☒ 1. REVIEWED - NO COMMENT.
☐ 2. REVISE AND RESUBMIT. WORK MAY PROCEED SUBJECT TO INCORPORATION OF COMMENTS.
☐ 3. REVISE AND RESUBMIT. WORK MAY NOT PROCEED.
☐ 4. REVIEW NOT REQUIRED - FOR INFORMATION ONLY.

AMEC PROJECT DOCUMENT NUMBER	AMEC ISSUE No.
174714-P006-B04-D001.001	002

AMEC SIGNATURE: [signature] DATE: Apr 21/2015

AMEC

CUSTOMER ORDER NO. 174714-P006

SHUNT REACTOR 43.7 MVAr
230 GRD Y/132.8 kV
SERIAL No. 15082-01
GRAND BEND WIND

Rev.	Revisions	Appd	Date
1	Weld symbol CSA was AWS: notes table amended;dimensions changed for the radiators bank and control cabinet.Final was preliminary; views updated; transformer weight was 69246. H1 and H3 ident. reversed.	JMR/SA	2015/04/02

Design Verified by	JMR 2015-03-06	Drawn Checked by	ZKK
Design Approved by	S.A.	Drawn Approved by	ZKK
Manufacturer	ABB	Project No.	15082
Drawing No.	XV15082004-C	Sheet No.	1
		Total Sheets	1

Title: CIVIL OUTLINE
Scale: 0.020
Units: mm

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