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# Environmental Noise Monitoring

For

# Northeast Stoney Trail in Calgary, AB

Prepared for: Alberta Transportation

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> aci Project #: 10-031 April 30, 2011

#### **Executive Summary**

aci Acoustical Consultants Inc., of Edmonton AB, was retained by Alberta Transportation (AT) to conduct a environmental noise monitorings along the northeast and northwest sections of Stoney Trail in Calgary, Alberta. The purpose of this work was to conduct 24-hour noise monitorings at a total of 25 locations along Stoney Trail to be used as a calibration tool for a computer noise model of the study area. This report pertains to the 9 noise monitoring locations along the northeast section of Stoney Trail. The site work was conducted for act by P. Froment, B.Sc., B.Ed. under the supervision of S. Bilawchuk, M.Sc., P.Eng.

The results of the baseline noise monitoring indicated sound levels ranging from 53.3 - 60.2 dBA  $L_{eq}24^{1}$ . At all locations, the noise climate was dominated by Stoney Trail or by local traffic on the adjacent roads. The monitoring indicated the noise climate was generally broadband in nature with no tonal components and no dominant stationary sources. Finally, it has been indicated by Alberta Transportation that additional noise monitoring are to be conducted along Stoney Trail near 17 Avenue SE upon completion of the interchange at 17 Avenue SE.

<sup>&</sup>lt;sup>1</sup> The term  $L_{eq}$  represents the energy equivalent sound level. This is a measure of the equivalent sound level for a specified period of time accounting for fluctuations.



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### 1.0 Introduction

aci Acoustical Consultants Inc., of Edmonton AB, was retained by Alberta Transportation (AT) to conduct a environmental noise monitorings along the northeast and northwest sections of Stoney Trail in Calgary, Alberta. The purpose of this work was to conduct 24-hour noise monitorings at a total of 25 locations along Stoney Trail to be used as a calibration tool for a computer noise model of the study area. This report pertains to the 9 noise monitoring locations along the northeast section of Stoney Trail. The site work was conducted for acci by P. Froment, B.Sc., B.Ed. under the supervision of S. Bilawchuk, M.Sc., P.Eng.

# 2.0 Location Description

The current sections of Stoney Trail span from 17 Avenue SE (on the east side of Calgary) to Highway 1 NW (on the west side of Calgary), as indicated in Figs. 1A & 1B. Throughout the entire span (approximately 45 km), Stoney Trail is a twinned road with at least 2-lanes in each direction and some sections with 3-lanes in each direction. The posted speed limit throughout is 100 km/hr. The current and future interchanges/intersections are as follows:

- 17 Avenue SE (currently a light-controlled intersection. Scheduled to be an interchange in the near future)
- 16 Avenue NE (grade separated interchange)
- McKnight Blvd NE (grade separated interchange)
- Airport Trail NE (grade separated interchange not yet operational)
- Country Hills Blvd NE (grade separated interchange)
- Deerfoot Trail (grade separated interchange)
- 11 Street NE (currently no intersection. Future grade separated interchange)
- Harvest Hills Blvd NE (currently a light-controlled intersection. Grade separated interchange under construction)
- 14 Street NW (currently no intersection. Future grade separated interchange)
- Beddington Trail NW (grade separated interchange)
- Shaganappi Trail NW (Fly-over with westbound Stoney Trail Access. Full interchange access under construction)
- Sarcee Trail NW (grade separated interchange)
- Country Hills Blvd NW (grade separated interchange)
- Crowchild Trail NW (currently a light-controlled intersection. Grade separated interchange under construction)
- Scenic Acres Link (grade separated interchange with modifications related to the Crowchild Trail Interchange)



- Nose Hill Drive (currently a light-controlled intersection. Scheduled to be an interchange in the near future)
- Highway 1 (grade separated interchange)

There will therefore be 18 grade separated interchanges within the study area for the future case assessment scenario<sup>1</sup>.

The study area is primarily composed of single family detached residential areas with houses that back onto Stoney Trail. At some locations, there are houses that side or front onto Stoney Trail. There are also sections with multi-family 3 and 4 storey residential buildings adjacent to Stoney Trail. Finally, there are commercial areas and areas which have yet to be developed. In particular, there are no residential receptors adjacent to Stoney Trail between Airport Trail NE and 11 Street NE.

Topographically, the land in between Stoney Trail and the residential receptors for northeast Stoney Trail is relatively flat with no significant berms for shielding. Most of the residential lots have direct line-of-sight to Stoney Trail. For the northwest portion of Stoney Trail, there are sections with relatively flat ground in between the road and the adjacent houses and other sections with significant berms blocking the line-of-sight. In addition, for the northwest section, there are significant changes in elevation throughout. The vegetation in the areas between the residential locations and Stoney Trail consists mainly of field grasses with small sections of bushes and trees.

<sup>&</sup>lt;sup>1</sup> The Interchange at Metis Trail has been ignored because it is too far from the NE and NW residential study areas to have an impact on the noise climate.



#### 3.0 <u>Measurement Methods</u>

As part of the study a total of twenty-five (25) 24-hour environmental noise monitorings were conducted throughout the study area. Nine (9) of these locations were in the northeast portion of Stoney Trail. The noise monitoring locations, as indicated in Fig. 1, were selected based on their proximity to Stoney Trail and adjacent interchanges. A detailed description of each location for northeast Stoney Trail is provided below. Refer to Appendix I for a detailed description of the measurement equipment used, Appendix II for a description of the acoustical terminology, and Appendix III for a list of common noise sources. All noise measurement instrumentation was calibrated at the start of the measurements and then checked afterwards to ensure that there had been negligible calibration drift over the duration of the measurements.

#### Monitor 1

Noise Monitor 1 was located on public land approximately 110 m west of Stoney Trail SB and 500 m north of 17 Ave SE as shown in Figs. 1 and 2. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 13:15 on Wednesday June 23, 2010 and ran for 24-hours until 13:15 on Thursday June 24, 2010.

### Monitor 2

Noise Monitor 2 was located on public land approximately 140 m west of Stoney Trail SB and 1.2 km north of 17 Ave SE as shown in Figs. 1 and 3. At this location there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 13:30 on Wednesday June 23, 2010 and ran for 24-hours until 13:30 on Thursday June 24, 2010.

### Monitor 3

Noise Monitor 3 was located on public land approximately 180 m west of Stoney Trail SB and 900 km south of Hwy. 1 NE as shown in Figs. 1 and 4. At this location there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 13:50 on Wednesday June 23, 2010 and ran for 24-hours until 13:50 on Thursday June 24, 2010.



#### Monitor 4

Noise Monitor 4 was located approximately 60 m south of Hwy. 1 NE (16 Ave NE) and 400 m east 68 Street as shown in Figs. 1 and 5. At this location the monitor was placed at the foot of a slight berm and therefore did not have direct line-of-sight to Hwy.1. There was no significant vegetation between the monitor and the road. The noise monitor was started at 15:40 on Thursday October 21, 2010 and ran for 24-hours until 15:40 on Friday October 22, 2010.

#### Monitor 5

Noise Monitor 5 was located on public land approximately 135 m east of Stoney Trail NB and 750 m south of Hwy. 1 NE as shown in Figs. 1 and 6. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 14:30 on Thursday July 29, 2010 and ran for 24-hours until 14:30 on Friday July 30, 2010.

#### Monitor 6

Noise Monitor 6 was located on public land approximately 130 m west of Stoney Trail SB and 1.5 km north of Hwy. 1 NE as shown in Figs. 1 and 7. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 14:32 on Wednesday June 23, 2010 and ran for 24-hours until 14:32 on Thursday June 24, 2010.

#### Monitor 7

Noise Monitor 7 was located on public land approximately 270 m west of Stoney Trail SB and 1.1 km south of McKnight Blvd NE as shown in Figs. 1 and 8. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 15:00 on Wednesday June 23, 2010 and ran for 24-hours until 15:00 on Thursday June 24, 2010.



#### Monitor 8

Noise Monitor 8 was located on public land approximately 190 m west of Stoney Trail SB and 1.2 km north of McKnight Blvd. NE as shown in Figs. 1 and 9. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 15:30 on Wednesday June 23, 2010 and ran for 24-hours until 15:30 on Thursday June 24, 2010.

#### Monitor 9

Noise Monitor 9 was located on public land approximately 150 m west of Stoney Trail SB and 170 m south of 80 Ave NE. as shown in Figs. 1 and 10. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 16:30 on Wednesday June 23, 2010 and ran for 24-hours until 16:10 on Thursday June 24, 2010.



### 4.0 <u>Results and Discussion</u>

#### 4.1. Noise Monitoring

The results obtained from the environmental noise monitorings are shown in Table 1 and Figs. 11 - 28 (broadband A-weighted L<sub>eq</sub> sound levels and 1/3 octave band L<sub>eq</sub> sound levels provided). It should be noted that the data have been adjusted by the removal of non-typical noise events such as loud aircraft flyovers (the noise modeling does not account for aircraft), pedestrians making noise nearby, abnormally loud vehicle passages, etc.

Monitor	L <sub>eq</sub> 24 (dBA)	L <sub>eq</sub> Day (dBA)	L <sub>eq</sub> Night (dBA)
M1	57.9	58.9	55.5
M2	60.0	60.8	57.9
M3	55.0	55.8	53.0
M4	55.5	56.5	52.9
M5	54.6	55.4	53.0
M6	60.2	61.2	57.6
M7	53.3	54.4	50.5
M8	55.1	56.1	52.9
M9	56.1	57.2	53.3

Table 1. Baseline Noise Monitoring Results

For Monitors 1 - 3 and 5 - 9, traffic from Stoney Trail was the dominant noise source. This was expected due to the current traffic volumes on Stoney Trail and the absence of any other major noise sources. Locations 2 & 6 resulted in higher levels due their relative distance and direct line-of-sight to Stoney Trail while Monitor 7 had lower levels due to its increased distance from Stoney Trail.

Monitor 4 was dominated by traffic along Highway 1 NE (16 Ave NE). Lower noise levels at this location can be attributed to the monitor being placed at the foot of a small berm which obstructed its line-of-sight to Hwy 1 NE.

At all locations, the resultant 1/3 octave band  $L_{eq}$  sound levels were very similar. All locations show the typical trend of low frequency noise (near 63 - 80 Hz) resulting from engines and exhaust, mid-high frequency noise (near 1,000 Hz) resulting from tire noise. These results confirm that the noise levels being measured by the noise monitors were largely attributed to Stoney Trail in addition to the other major roadways.



#### 4.2. <u>Weather Conditions</u>

Subjectively, the weather conditions for Monitors 1 - 3 and 6 - 9 were clear and calm to start and eventually becoming cloudy with stronger winds from the east. The weather for Monitor 5 started with an overcast sky and a calm west wind. The wind periodically increased but remained predominantly from the west for the entire monitoring period. The weather conditions for Monitor 4 were partially cloudy to start with a light northwest wind. The wind shifted from various directions but remained predominantly from the north. There was partial sun and calm conditions the following afternoon. Weather data for the duration of the environmental noise monitorings is presented in Appendix IV.



#### 5.0 Conclusion

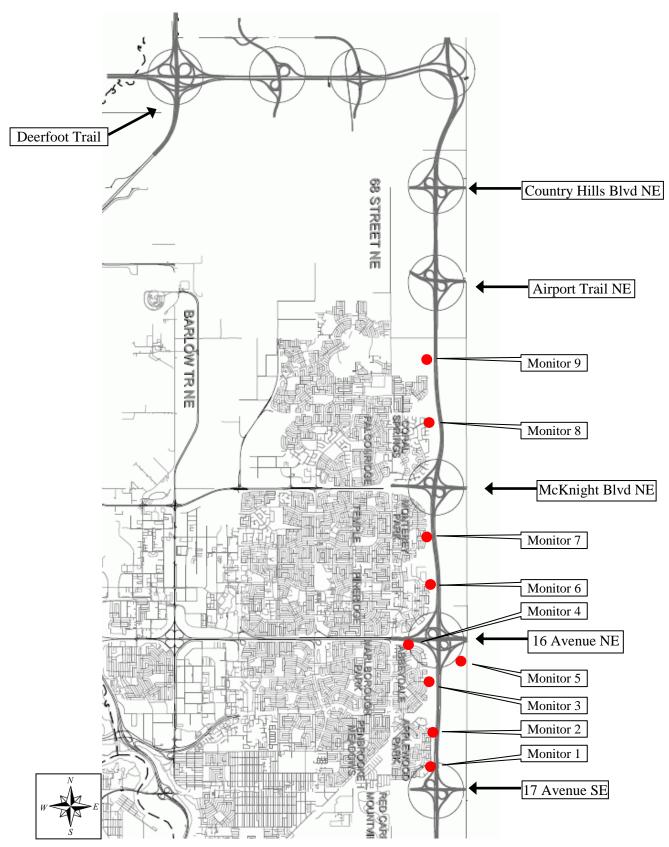
The results of the baseline noise monitoring indicated sound levels ranging from 53.3 - 60.2 dBA L<sub>eq</sub>24. At all locations, the noise climate was dominated by Stoney Trail or by local traffic on the adjacent roads. The monitoring indicated the noise climate was generally broadband in nature with no tonal components and no dominant stationary sources. Finally, it has been indicated by Alberta Transportation that additional noise monitoring are to be conducted along Stoney Trail near 17 Avenue SE upon completion of the interchange at 17 Avenue SE.

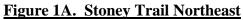


#### 6.0 <u>References</u>

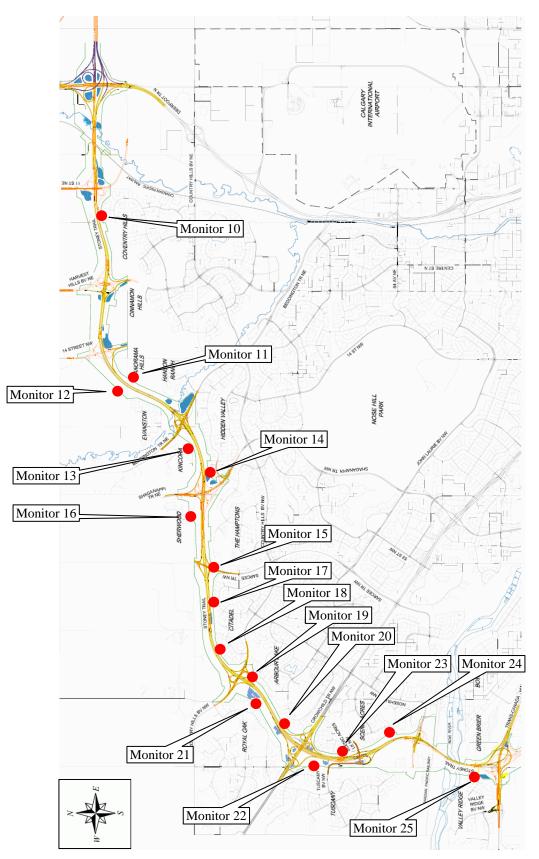
- International Organization for Standardization (ISO), Standard 1996-1, Acoustics Description, measurement and assessment of environmental noise Part 1: Basic quantities and assessment procedures, 2003, Geneva Switzerland.
- International Organization for Standardization (ISO), Standard 9613-1, Acoustics Attenuation of sound during propagation outdoors Part 1: Calculation of absorption of sound by the atmosphere, 1993, Geneva Switzerland.
- International Organization for Standardization (ISO), Standard 9613-2, Acoustics Attenuation of sound during propagation outdoors – Part 2: General method of calculation, 1996, Geneva Switzerland.

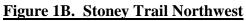














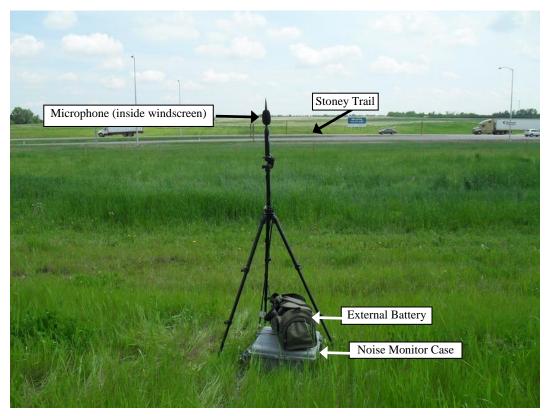


Figure 2. Noise Monitor at Location 1

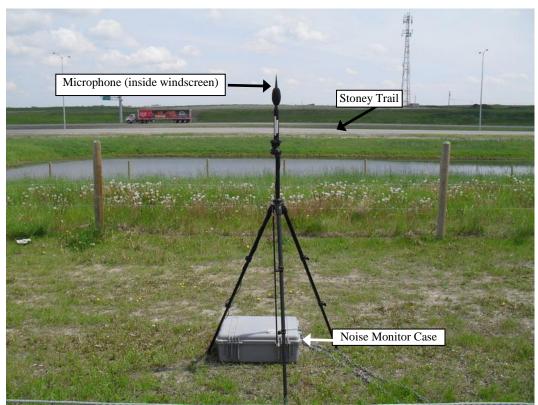


Figure 3. Noise Monitor at Location 2



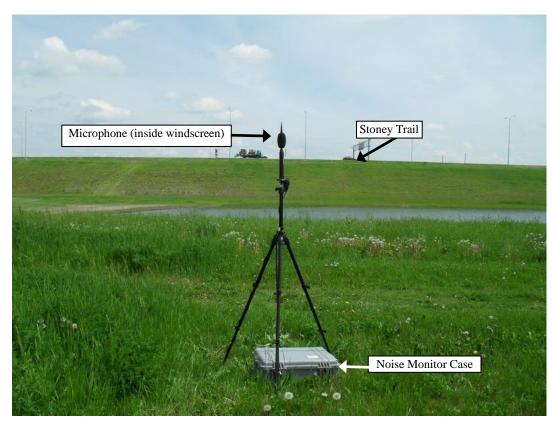


Figure 4. Noise Monitor at Location 3



Figure 5. Noise Monitor at Location 4



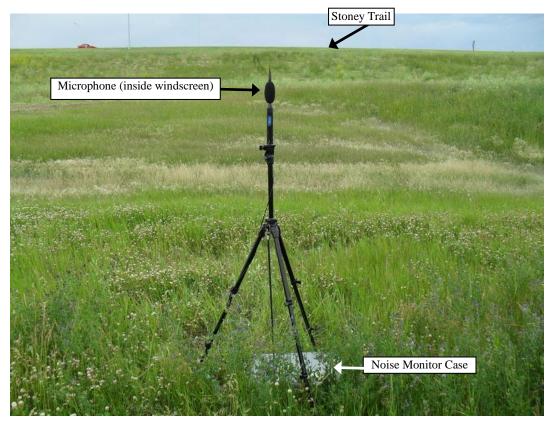


Figure 6. Noise Monitor at Location 5

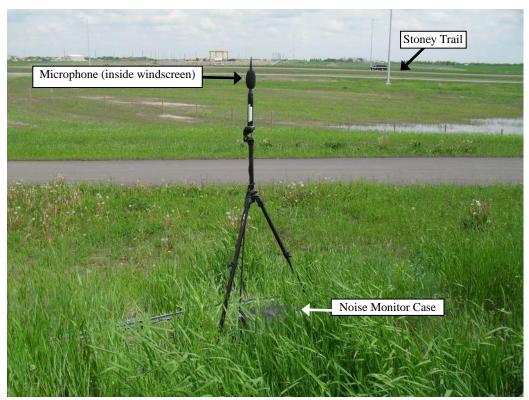


Figure 7. Noise Monitor at Location 6



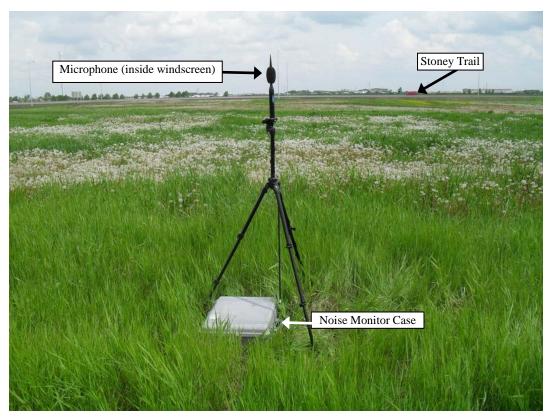


Figure 8. Noise Monitor at Location 7

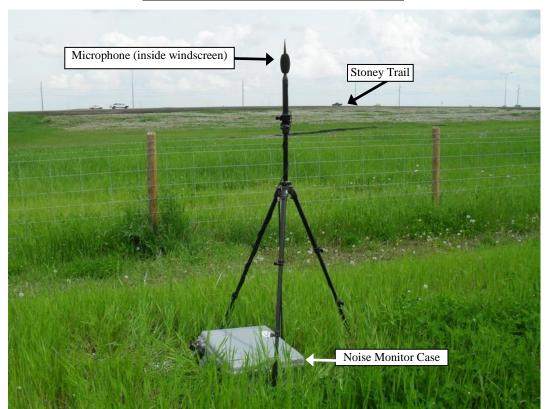


Figure 9. Noise Monitor at Location 8



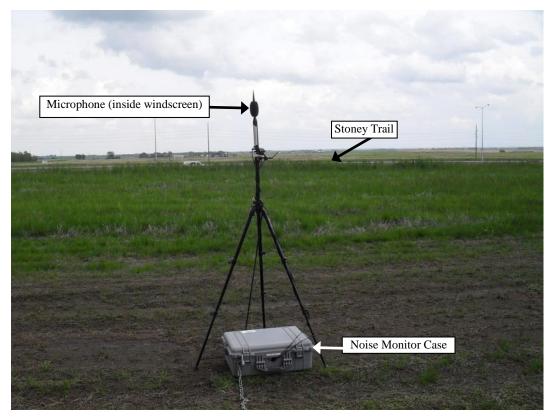


Figure 10. Noise Monitor at Location 9



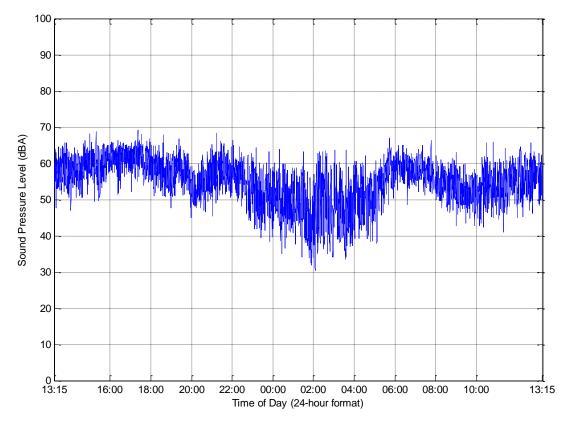
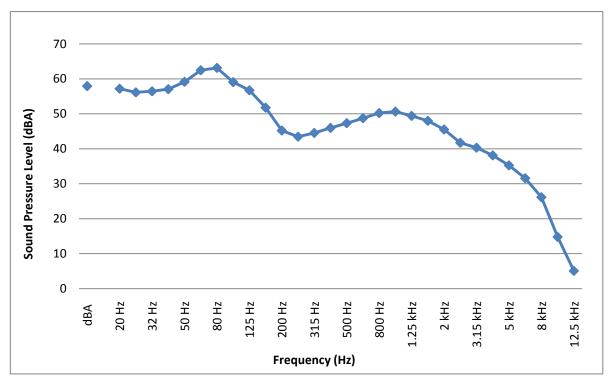


Figure 11. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 1







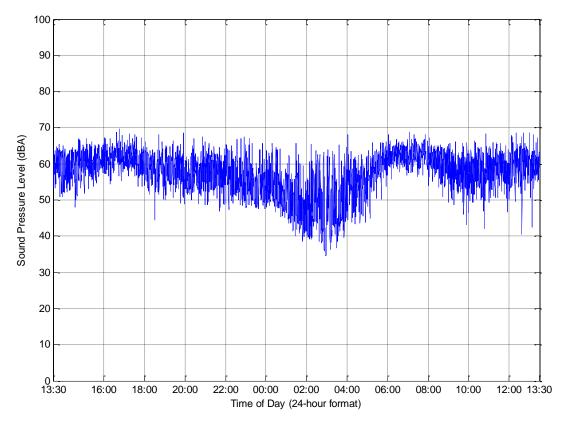


Figure 13. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 2

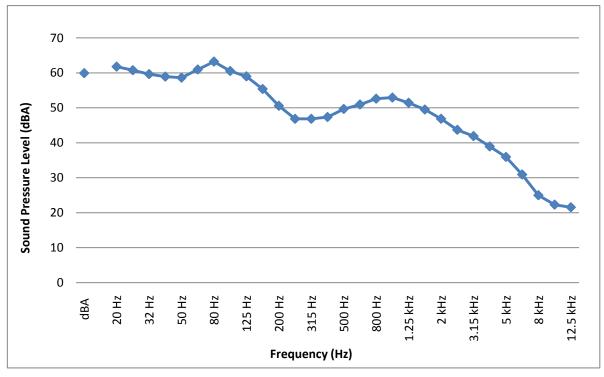


Figure 14. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 2



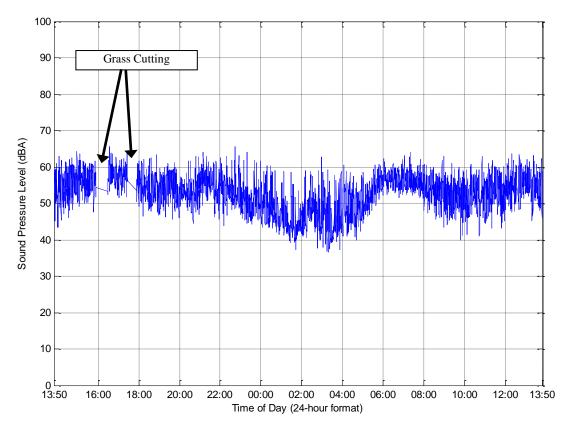


Figure 15. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 3

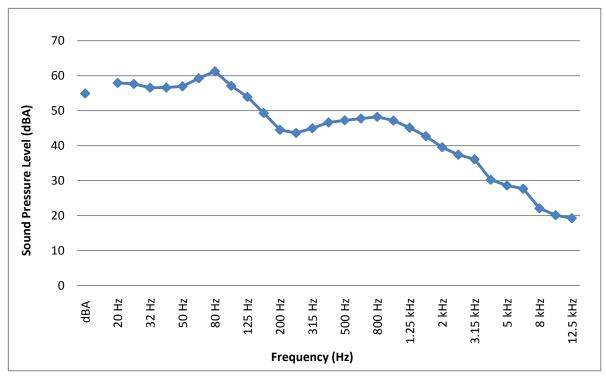


Figure 16. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 3



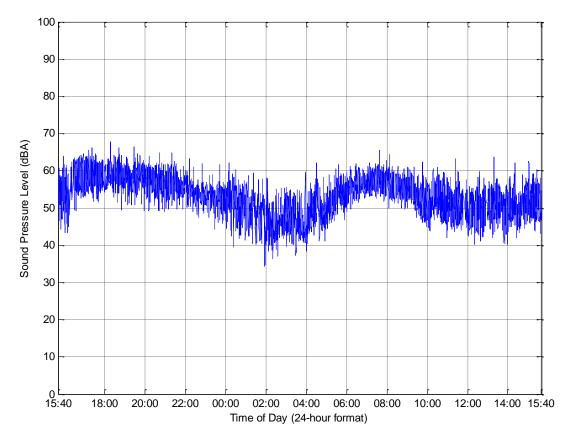
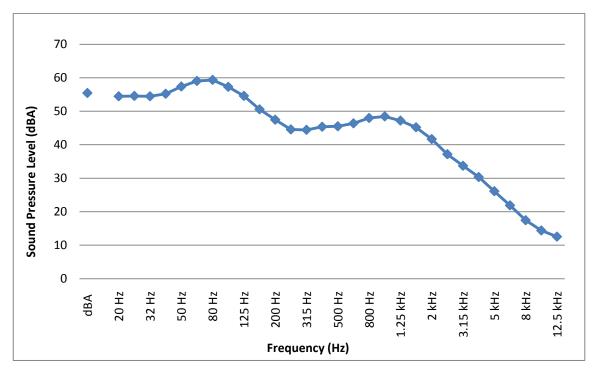


Figure 17. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 4







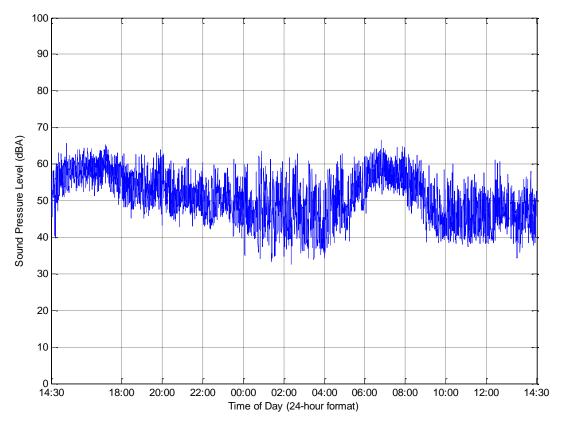


Figure 19. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 5

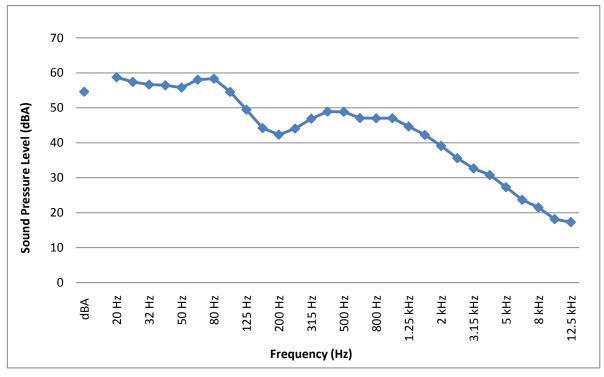


Figure 20. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 5



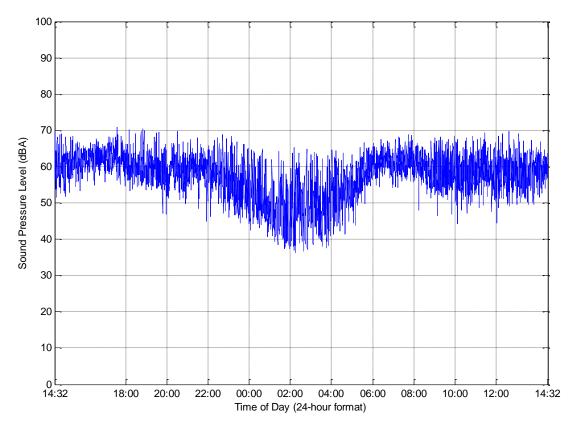
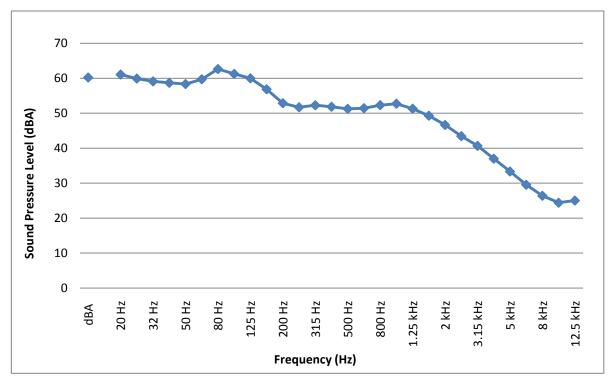


Figure 21. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 6







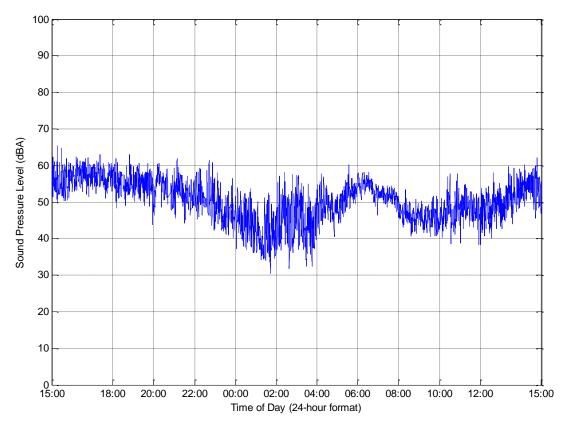


Figure 23. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 7

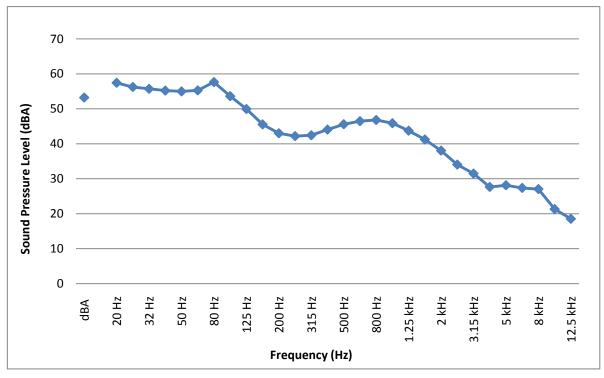


Figure 24. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 7



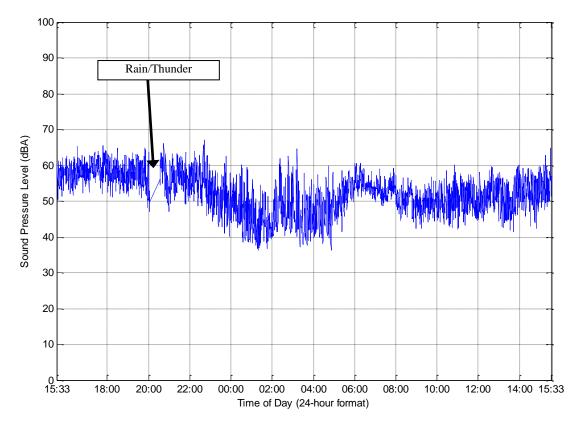


Figure 25. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 8

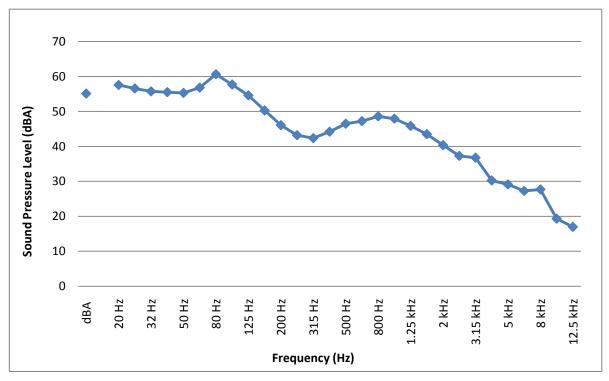


Figure 26. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 8



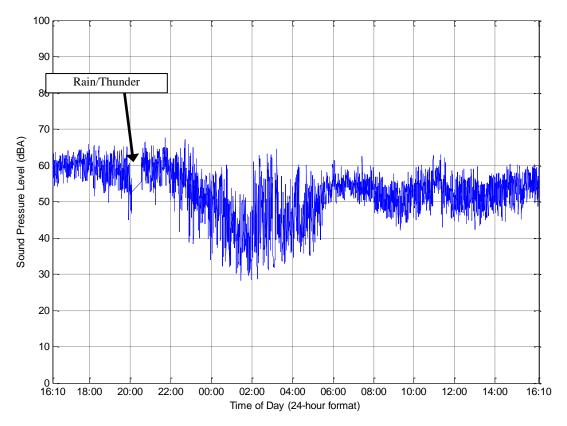


Figure 27. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 9

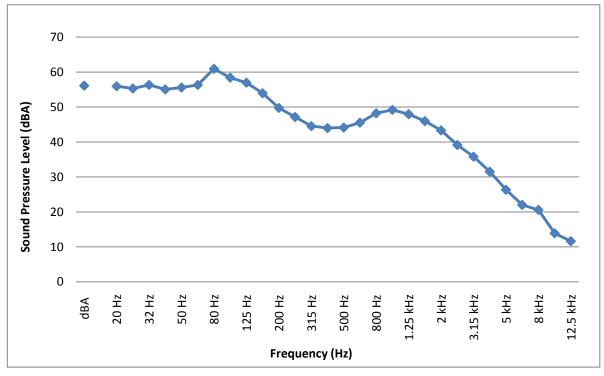


Figure 28. 24-Hour 1/3 Octave Band Levels at Monitor Location 9



# Appendix I. MEASUREMENT EQUIPMENT USED

# Brüel and Kjær 2250/2270 (Unit 1 / Unit 2/ Unit 3/ Unit 4 / Unit 5 / Unit 6 / Unit 7)

The environmental noise monitoring equipment used during the monitorings consisted of a Brüel and Kjær Type 2250 Precision Integrating Sound Level Meter enclosed in an environmental case, a tripod, a weather protective microphone hood. The system acquired data in 15-second  $L_{eq}$  samples using 1/3 octave band frequency analysis and overall A-weighted and C-weighted sound levels. The sound level meter conforms to Type 1, ANSI S1.4, ANSI S1.43, IEC 61672-1, IEC 60651, IEC 60804 and DIN 45657. The 1/3 octave filters conform to S1.11 – Type 0-C, and IEC 61260 – Class 0. The calibrator conforms to IEC 942 and ANSI S1.40. The sound level meter, pre-amplifier and microphone were certified on May 29, 2009 / May 15, 2009 / November 2, 2009 / August 13, 2008 / October 27, 2008 / October 27, 2008 / June 29, 2010 and the calibrator (type B&K 4231) was certified on June 21, 2010 / June 21, 2010 / November 2, 2009 / November 3, 2009 / November 2, 2009 / November 3, 2009 / November 2, 2009 / Novemb

# Brüel and Kjær 2260

The environmental noise monitoring equipment used during the monitorings consisted of a Brüel and Kjær Type 2260 Precision Integrating Sound Level Meter enclosed in an environmental case, a tripod, a weather protective microphone hood, and an external battery. The system acquired data in 15-second  $L_{eq}$  samples using 1/3 octave band frequency analysis and overall A-weighted and C-weighted sound levels. The sound level meter conforms to Type 1, ANSI S1.4, ANSI S1.43, IEC 61672-1, IEC 60651, IEC 60804 and DIN 45657. The 1/3 octave filters conform to S1.11 – Type 0-C, and IEC 61260 – Class 0. The calibrator conforms to IEC 942 and ANSI S1.40. The sound level meter, pre-amplifier, and microphone were certified on January 16, 2009 by a NIST NVLAP Accredited Calibration Laboratory for all requirements of ISO 17025: 1999 and relevant requirements of ISO 9002:1994, ISO 9001:2000 and ANSI/NCSL Z540: 1994 Part 1. Simultaneous digital audio recording was conducted with a Marantz PMD-670 professional grade audio recorder utilizing a sample rate of 48 kHz and an MP3 conversion rate of 80 kbps. The audio signal was passed directly from the sound level meter. Refer to the next section in the Appendix for a detailed description of the various acoustical descriptive terms used.



Description	Date	Time	Pre / Post	Calibration Level	Calibrator Model	Serial Number
Location #1 Noise Monitor	June 23 2010	13:00	Pre	93.9 dBA	B&K 4231	2575493
Location #1 Noise Monitor	June 24 2010	13:30	Post	94.0 dBA	B&K 4231	2575493
			_		<b>D</b> 014 400 4	
Location #2 Noise Monitor	June 23 2010	13:15	Pre	93.9 dBA	B&K 4231	2575493
Location #2 Noise Monitor	June 24 2010	13:45	Post	93.9 dBA	B&K 4231	2575493
Location #3 Noise Monitor	June 23 2010	13:45	Pre	93.9 dBA	B&K 4231	2575493
Location #3 Noise Monitor	June 24 2010	14:00	Post	93.9 dBA	B&K 4231	2575493
Location #4 Noise Monitor	October 21 2010	15:10	Pre	93.9 dBA	B&K 4231	2478139
Location #4 Noise Monitor	October 22 2010	15:40	Post	93.8 dBA	B&K 4231	2478139
Location #4 Noise Monitor	October 22 2010	15.40	FUSI	93.0 UDA	Dan 4231	2470139
Location #5 Noise Monitor	July 29 2010	14:05	Pre	93.9 dBA	B&K 4231	2575493
Location #5 Noise Monitor	July 30 2010	14:55	Post	93.9 dBA	B&K 4231	2575493
Location #6 Noise Monitor	June 23 2010	14:30	Pre	93.9 dBA	B&K 4231	2575493
Location #6 Noise Monitor	June 24 2010	14:32	Post	93.8 dBA	B&K 4231	2575493
			_			
Location #7 Noise Monitor	June 23 2010	15:00	Pre	93.9 dBA	B&K 4231	2575493
Location #7 Noise Monitor	June 24 2010	15:05	Post	93.8 dBA	B&K 4231	2575493
Location #8 Noise Monitor	June 23 2010	15:30	Pre	93.9 dBA	B&K 4231	2575493
Location #8 Noise Monitor	June 24 2010	15:35	Post	93.8 dBA	B&K 4231	2575493
Location #9 Noise Monitor	June 23 2010	16:10	Pre	93.9 dBA	B&K 4231	2575493
Location #9 Noise Monitor	June 24 2010	16:15	Post	93.8 dBA	B&K 4231	2575493

# **Record of Calibration Results**



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			, []][]					െ്
			ORATORY			7/12	//11///	
ISO 17025: 20 relevant requirer by NVLA	nents of I	SO 9002:	1994 ACC	REDITED	1	NVLAP I	Lab Code: 2000	525-0
Са	alib	ratio	on C	ertific	cate N	lo.1	9848	
Instrument: Model:	Sound 2250	Level M	leter		Date Calibro Status:		5/29/20 Received	09 Sent
Manufacturer:	Brüel	and Kjæ	r		In tolerance.		X	X
Serial number:	24884		100 / 21	51122	Out of tolera			
Tested with:			189 s/n 24 C0032 s/n		See commen Contains not	n-accredi	ited tests: <u> </u> Y	es <u>X</u> No
Type (class):	1						Basic X	Standard
Customer:	Acous	tical Cor	sultants I	nc.		,	9920-63 Ave a, Alberta	
Tel/Fax:	780-4	14-6373/	-6376				T6E 0G9	
Instrumentati	on use			Scantek Inc., 0 Nor-1504 No			bility evidence	
Instrumen Manufactu		Des	cription	S/N	Cal. Date	Cal. La	b / Accreditation	Cal. Due
483B-Norsonic		SME Cal U		25747	Jan 2, 2009		Inc./NVLAP	Jan 2, 2010
DS-360-SRS		Function (		61646	Nov 19, 2007		/ NVLAP	Nov 19, 2009 Nov 13, 2009
34401A-Agilent Tec	hnologies	Digital Mu		MY41022043	Nov 13, 2008 Nov 21, 2008		/ NVLAP	Nov 21, 2010
DPI 141-Druck HMP233-Vaisala Oy	<i>i</i>	Pressure In Humidity	& Temp.	790/00-04 V3820001	May 7, 2008	Vaisala /		Nov 7, 2009
PC Program 1019 N		Transmitte		v.46	Validated Dec			-
i C LIOSIMII IVI 2 IN		Calibrator		25726	2006 Jan 2, 2009	Scantek,	Inc./NVLAP	Jan 2, 2010
1253-Norsonic	ion and	test res d by NIS	ults are t ST (USA)	raceable to and NPL (U	SI (Internatio K).	nal Sys	tem of Units	through
1253-Norsonic Instrumentati standards ma	aintaine							v (9/ )
standards ma Environment	al cond							y ( /0)
Instrumentati standards ma Environment Temper	al cond ature (°(		Baror	metric pressu	. ,	Re	lative Humidit	
Instrumentati standards ma Environment Temper	al cond		Baror	metric pressu 99.377 kP	. ,	Re	65.2 %RH	
Instrumentati standards ma Environment Temper	al cond ature (°( 3 °C	C)	Baror alentin Bu	99.377 kP	a Checked I	by		Buzduga
Instrumentati standards ma Environment Temper 23.	al cond ature (°0 3 °C ed by	C)		99.377 kP	a Checked I Signature	by	65.2 %RH Mariana E	
Instrumentati standards ma Environment Temper 23. Calibrat	al cond ature (°( 3 °C ed by ture	C)		99.377 kP	a Checked I	by	65.2 %RH Mariana E	Buzduga



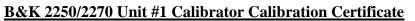


# <u>B&K 2250/2270 Unit #1 Microphone Calibration Certificate</u>

CALIBRATIC ISO 17025: 2005, AN and relevant require ACCREDITED by NV	ments of ISO 9002:1	7 994 Part 1 1994	R	]V	7 ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) (	₽5-0 (R) (R) (R) (R) (R) (R) (R) (R)
Calib	oration (	Certif	icate	No.	19849	)
Instrument: Microj Model: 4189 Manufacturer: Brüel Serial number: 247113	& Kjær		Date Calibrat Status: In tolerance: Out of toleran See comments Contains non-	] nce:	5/29/20 Received X ed tests: Ye	Sent X
	ical Consultants In 4-6373/ -6376	nc.	Address: S E	uite 107, dmonto	9920-63 Ave n, Alberta T6E 0G9	<u> </u>
Tested in accordance Procedure for Calit Instrumentation used	oration of Measure	ement Micro	phones, Scar	ntek Inc. stem:		
Instrument - Manufacturer	Description	S/N	Cal. Date		bility evidence / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	25747	Jan 2, 2009		Inc./NVLAP	Jan 2, 2010
DS-360-SRS	Function Generator	61646	Nov 19, 2007	Davis In	otek / A2LA	Nov 19, 2009
34401A-Agilent Technologies		MY41022043			/ NVLAP	Nov 13, 2009
DPI 141-Druck	Pressure Indicator	790/00-04	Nov 21, 2008	Iranscat	/ NVLAP	Nov 21, 2010
HMP233-Vaisala Oyj	Humidity & Temp. Transmitter	V3820001	May 7, 2008	Vaisala /	A2LA	Nov 7, 2009
PC Program 1017 Norsonic	Calibration software	v.46	Validated Feb 2006	-		-
1253-Norsonic	Calibrator	28326	Feb 16, 2009	Scantek	, Inc. / NVLAP	Feb 16, 2010
	Preamplifier	14051	Jan 2, 2009		Inc./ NVLAP	Jan 2, 2010
1203-Norsonic					) / UKAS	Mar 7, 2010
	Microphone	2246115	Mar 7, 2008	INPL (UN	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
1203-Norsonic 4180-Bruel&Kjaer Instrumentation and t by NPL (UK) and NIST	Microphone est results are tr (USA)	aceable to	SI - BIPM thr	ough st	andards mai	ntained
1203-Norsonic 4180-Bruel&Kjaer Instrumentation and t by NPL (UK) and NIST Calibrated by	Microphone est results are tr	aceable to	SI - BIPM thr Checked I	ough st		ntained
1203-Norsonic 4180-Bruel&Kjaer Instrumentation and t by NPL (UK) and NIST Calibrated by Signature	Microphone est results are tr (USA)	aceable to	SI - BIPM thr Checked I Signature	ough st	andards mai Mariana E Jut	ntained Buzduga
1203-Norsonic 4180-Bruel&Kjaer Instrumentation and t by NPL (UK) and NIST Calibrated by	Microphone est results are tr (USA)	aceable to	SI - BIPM thr Checked I	ough st	andards mai	ntained Buzduga



CALIBRATI ISO 17025: 2005, AN relevant requirements of IS		Y 94 Part 1 and REDITED by			Lab Code: 20	00625-0 ®
Calibi	ation C	ertific	ate N	1. J.	San	
Model: 42 Manufacturer: Bi	oustical Calibrato 31 üel and Kjær 78139	Sta In Or Se	ate Calibrated atus: tolerance: ut of toleranc e comments: ontains non-a	 e:	6/21/20 eceived X sts:Yes _	Sent X
	coustical Consultar 0-414-6373 / -6376	n <b>ts Inc.</b> Ac	ldress:	5031 - 210 Edmonto Canada T	n, Alberta	
Tested in accordance Calibration of Acoustic Instrumentation used	al Calibrators, Sca	intek Inc., 06	6/06/2005	System:		
	Description	S/N	Cal. Date		ity evidence	Cal. Due
Instrument - Manufacture	Description	Section 24 and the second		Gal. Lab//	Accreditation	에 위한 것을 가 많습니다.
483B-Norsonic	SME Cal Unit	31052	Jan 20, 2010	Scantek, Ind	c./NVLAP	Jan 20, 2011
483B-Norsonic DS-360-SRS	SME Cal Unit Function Generator	33584	Oct 5, 2009	Scantek, Ind ACR. Env /	c./NVLAP A2LA	Oct 5, 2011
483B-Norsonic DS-360-SRS 34401A-Agilent	SME Cal Unit Function Generator Digital Voltmeter	33584 US36120731	Oct 5, 2009 Aug 27, 2009	Scantek, Ind ACR. Env / ACR Env. /	c./NVLAP A2LA A2LA	Oct 5, 2011 Aug 27, 2010
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen	SME Cal Unit Function Generator Digital Voltmeter Meteo Station	33584 US36120731 1040170/3963	Oct 5, 2009 Aug 27, 2009 3 Jul 10, 2009	Scantek, Ind ACR. Env / ACR Env. / Transcat / A	c./NVLAP A2LA A2LA A2LA	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer	33584 US36120731 1040170/39633 2514A05691	Oct 5, 2009 Aug 27, 2009	Scantek, Ind ACR. Env / ACR Env. /	c./NVLAP A2LA A2LA A2LA	Oct 5, 2011 Aug 27, 2010
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software	33584 US36120731 1040170/3963 2514A05691 v.5.0	Oct 5, 2009 Aug 27, 2009 3Jul 10, 2009 Jan 2, 2008 Validated July 2009	Scantek, Ind ACR. Env / ACR Env. / Transcat / A Transcat / A	C./NVLAP A2LA A2LA A2LA A2LA	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 -
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator	33584 US36120731 1040170/39633 2514A05691 v.5.0 31959	Oct 5, 2009 Aug 27, 2009 Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009	Scantek, Ind ACR. Env / ACR Env. / Transcat / A Transcat / A - Scantek, Ind	c./NVLAP A2LA A2LA V2LA V2LA V2LA	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software	33584 US36120731 1040170/3963 2514A05691 v.5.0	Oct 5, 2009 Aug 27, 2009 3Jul 10, 2009 Jan 2, 2008 Validated July 2009	Scantek, Ind ACR. Env / ACR Env. / Transcat / A Transcat / A - Scantek, Ind Scantek, Ind	c./NVLAP A2LA A2LA V2LA V2LA C./ NVLAP c./ NVLAP	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 -
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier Microphone	33584 US36120731 1040170/3963: 2514A05691 v.5.0 31959 14059 2246115 caceable to \$	Oct 5, 2009 Aug 27, 2009 Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Jan 4, 2010 Dec 14, 2009	Scantek, Ind ACR. Env / ACR Env. / Transcat / A - Scantek, Ind Scantek, Ind NPL (UK) /	C./NVLAP A2LA A2LA A2LA A2LA A2LA A2LA C./ NVLAP C./ NVLAP UKAS	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011 Dec 14, 2011
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier Microphone	33584 US36120731 1040170/3963: 2514A05691 v.5.0 31959 14059 2246115 raceable to S and NPL (UP	Oct 5, 2009 Aug 27, 2009 Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Jan 4, 2010 Dec 14, 2009	Scantek, Ind ACR. Env / ACR Env. / Transcat / A - Scantek, Ind Scantek, Ind NPL (UK) /	C./NVLAP A2LA A2LA A2LA A2LA A2LA A2LA C./ NVLAP C./ NVLAP UKAS	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011 Dec 14, 2011 <b>bec 14, 2011</b>
483B-Norsonic DS-360-SRS 34401A-Aglient HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and standards maintained	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier Microphone	33584 US36120731 1040170/3963: 2514A05691 v.5.0 31959 14059 2246115 raceable to S and NPL (UP	Oct 5, 2009 Aug 27, 2009 3Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Jan 4, 2010 Dec 14, 2009 SI (Internati ()	Scantek, Ind ACR. Env / ACR Env. / Transcat / A - Scantek, Ind Scantek, Ind NPL (UK) /	c./NVLAP A2LA A2LA I2LA I2LA c./ NVLAP c./ NVLAP UKAS em of Units	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011 Dec 14, 2011 <b>bec 14, 2011</b>
483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and standards maintained Calibrated by	SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier Microphone	33584 US36120731 1040170/3963: 2514A05691 v.5.0 31959 14059 2246115 raceable to S and NPL (UP	Oct 5, 2009 Aug 27, 2009 Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Jan 4, 2010 Dec 14, 2009 SI (Internati SI (Internati	Scantek, Ind ACR. Env / ACR Env. / Transcat / A - Scantek, Ind Scantek, Ind NPL (UK) /	C/NVLAP A2LA A2LA A2LA A2LA A2LA A2LA A2LA C/NVLAP C/NVLAP C/NVLAP UKAS em of Units Mariana I	Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011 Dec 14, 2011 <b>bec 14, 2011</b>





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			ORATOR					$\bigcirc$
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ISO 17025: 20 relevant requirer	05, AN	SI/NCSL	22540:19 1994 ACC	94 Part I and REDITED		J U		5
by NVLA	P (an ILA	AC and A	PLAC sign	natory)	e de la companya de l La companya de la comp		~	
					N	NVLAP Lat	Code: 200	625-0
Ca	alib	ratio	on C	ertifi	cate N	lo.19	785	
Instrument:	Sound 2250	Level M	leter		Date Calibra Status:		5/15/20 ceived	09 Sent
Model: Manufacturer:		and Kjæ	er		In tolerance:		X	X
Serial number:	25757	74			Out of tolera	nce:		
Tested with:			189 s/n 25		See comment		I donte i	W N-
Tuna (alana).		plifier Z	CC0032 s/n	1 5842	Contains nor Calibration s			
Type (class):	1							
Customer:	Acous	tical Cor	isultants I	nc.		uite 107, 99 dmonton, 2		
Tel/Fax:	780-4	14-6373/	-6376			ANADA T		
Instrumen		Des	cription	S/N	Cal. Date		ity evidence Accreditation	Cal. Due
Manufactur 483B-Norsonic	rer	SME Cal I	Unit	25747	Jan 2, 2009	Scantek, Inc		Jan 2, 2010
DS-360-SRS	an and a second	Function (	Generator	61646	Nov 19, 2007	Davis Inotek	A2LA	Nov 19, 2009
34401A-Agilent Tec	hnologies	Digital Mu	ultimeter	MY4102204		Transcat / N		Nov 13, 2009
DPI 141-Druck	2 A. A.	Pressure In		790/00-04	Nov 21, 2008	Transcat / N	VLAP	Nov 21, 2010
HMP233-Vaisala Oy	/j	Humidity Transmitte		V3820001	May 7, 2008	Vaisala / A2	LA	Nov 7, 2009
PC Program 1019 N	orsonic	Calibratio	n software	v.46	Validated Dec 2006	-		
1253-Norsonic		Calibrator		25726	Jan 2, 2009	Scantek, Inc	./NVLAP	Jan 2, 2010
Instrumentati standards ma Environment	aintaine	d by NIS	ults are t ST (USA)	and NPL (	o SI (Internatio UK).	nal Syste	m of Units	) through
Temper			Baro	metric pres	sure (kPa)	Relat	ive Humidi	ty (%)
	.1 °C	- /		101.069			59.1 %RH	
20.			1	~			an a suit Muu anna anna	an ann an
	ed by		/alenting	uzduga	Checked b		Mariana I	Buzduga
Calibrat			1/2	_	Signature	Э.	lub	Contractor and the second
Calibrat Signat			12	-		1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	Filaia	2350200 Nu11-
	ture	3	115/20	209	Date		5118120	9





CALIBRATIO ISO 17025: 2005, AN and relevant requiren ACCREDITED by NVI	nents of ISO 9002:19	994 Part 1 994	R		Code: 20062	
Calib	ration C	Certifi	cate I	No.1	9786	
Instrument: Microp Model: 4189 Manufacturer: Brüel & Serial number: 257376	& Kjær		Date Calibrat Status: In tolerance: Out of toleran See comments Contains non-	R	5/15/200 eceived X d tests:Yes	Sent X
010101101	ical Consultants In 4-6373/ -6376	nc.	Address: S E		9920-63 Ave , Alberta	
	for calibration:	1 4 5 0 4 Nora				
Instrumentation used	Description	S/N	Cal. Date	Traceab	ility evidence / Accreditation	Cal. Due
		<b>S/N</b> 25747	Cal. Date Jan 2, 2009	Traceab Cal. Lab Scantek,	/ Accreditation Inc./NVLAP	Jan 2, 2010
Instrument - Manufacturer 483B-Norsonic DS-360-SRS	Description SME Cal Unit Function Generator	<b>S/N</b> 25747 61646	Cal. Date Jan 2, 2009 Nov 19, 2007	Traceab Cal. Lab Scantek, Davis Ino	/ Accreditation Inc./NVLAP tek / A2LA	Jan 2, 2010 Nov 19, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies	Description SME Cal Unit Function Generator Digital Multimeter	S/N 25747 61646 MY41022043	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008	Traceab Cal. Lab Scantek, Davis Ino Transcat	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp.	<b>S/N</b> 25747 61646	Cal. Date Jan 2, 2009 Nov 19, 2007	Traceab Cal. Lab Scantek, Davis Ino	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP	Jan 2, 2010 Nov 19, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator	S/N 25747 61646 MY41022043 790/00-04	Cal. Date           Jan 2, 2009           Nov 19, 2007           Nov 13, 2008           Nov 21, 2008           May 7, 2008           Validated Feb	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software	S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46	Cal. Date           Jan 2, 2009           Nov 19, 2007           Nov 13, 2008           Nov 21, 2008           May 7, 2008           Validated Feb           2006	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / -	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator	S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326	Cal. Date           Jan 2, 2009           Nov 19, 2007           Nov 13, 2008           Nov 21, 2008           May 7, 2008           Validated Feb           2006           Feb 16, 2009	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / - Scantek,	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software	S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46	Cal. Date           Jan 2, 2009           Nov 19, 2007           Nov 13, 2008           Nov 21, 2008           May 7, 2008           Validated Feb           2006	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / - Scantek,	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA Inc. / NVLAP Inc./ NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone est results are tr	S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115	Cal. Date           Jan 2, 2009           Nov 19, 2007           Nov 13, 2008           Nov 21, 2008           May 7, 2008           Validated Feb           2006           Feb 16, 2009           Jan 2, 2009           Mar 7, 2008	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / - Scantek, NPL (UK rough states)	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP A2LA Inc. / NVLAP Inc./ NVLAP Inc./ NVLAP ) / UKAS andards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and t by NPL (UK) and NIST	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibration software Calibrator Preamplifier Microphone est results are tr (USA)	S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008 SI - BIPM thr	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / - Scantek, NPL (UK rough states)	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP A2LA A2LA Inc. / NVLAP Inc./ NVLAP Inc./ NVLAP ) / UKAS andards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and t by NPL (UK) and NIST Calibrated by Signature	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone est results are tr (USA)	S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115	Cal. Date           Jan 2, 2009           Nov 19, 2007           Nov 13, 2008           Nov 21, 2008           May 7, 2008           Validated Feb           2006           Feb 16, 2009           Jan 2, 2009           Mar 7, 2008           SI - BIPM thr           Checked           Signature	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / - Scantek, NPL (UK rough states)	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA Inc. / NVLAP Inc./ NVLAP // UKAS andards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained Buzduga
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and t by NPL (UK) and NIST Calibrated by	Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone est results are tr (USA)	S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008 SI - BIPM thr Checked	Traceab Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / - Scantek, NPL (UK rough states)	/ Accreditation Inc./NVLAP tek / A2LA / NVLAP A2LA Inc. / NVLAP Inc./ NVLAP Inc./ NVLAP ) / UKAS andards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained Buzduga





## <u>B&K 2250/2270 Unit #2 Calibrator Calibration Certificate</u>

CALIBRA ISO 17025: 2005, A relevant requirements of		RY 994 Part 1 and REDITED by		NVLAP	Lab Code: 24	00625-0
Calib	ration C	ertific	cate N	<b>l</b> o.2	1910	
Model: 4 Manufacturer: 1	Acoustical Calibrato 231 3rüel and Kjær 575493	91	Date Calibra Status: In tolerance: Out of tolera See comment Contains nor	 nce: ts:	6/21/2 Received X d tests:Ye	Sent X
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Instrument - Manufactur	er Description	S/N	Cal. Date	Traceabi Cal. Lab /	Accreditation	
Instrument - Manufactur 483B-Norsonic		S/N 31052	1.18	Traceabi Cal. Lab /	Accreditation	Cal. Due Jan 20, 2011 Oct 5, 2011
Instrument - Manufactur 483B-Norsonic DS-360-SRS	er Description SME Cal Unit	S/N 31052	Cal. Date Jan 20, 2010	Traceabi Cal. Lab / Scantek, Ir ACR. Env /	Accreditation nc./NVLAP / A2LA	Jan 20, 2011
Instrument - Manufactur 483B-Norsonic DS-360-SRS 34401A-Agilent	er Description SME Cal Unit Function Generator	S/N 31052 r 33584 US36120731	Cal. Date Jan 20, 2010 Oct 5, 2009	Traceabi Cal. Lab / Scantek, Ir ACR. Env /	Accreditation hc./NVLAP / A2LA / A2LA	Jan 20, 2011 Oct 5, 2011
Instrument - Manufactur 483B-Norsonic DS-360-SRS 34401A-Agilent	er Description SME Cal Unit Function Generator Digital Voltmeter	S/N 31052 r 33584 US36120731	Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009 3Jul 10, 2009 Jan 2, 2008	Traceabi Cal. Lab / Scantek, Ir ACR. Env / ACR Env.	Accreditation nc./NVLAP / A2LA / A2LA A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010
Instrument - Manufactur 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP	er Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer	S/N 31052 r 33584 US36120731 1040170/3963 2514A05691	Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009 3 Jul 10, 2009 Jan 2, 2008 Validated	Traceabi Cal. Lab / Scantek, Irr ACR. Env / ACR Env. / Transcat /	Accreditation nc./NVLAP / A2LA / A2LA A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010
Instrument - Manufactur 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen	er Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer	S/N 31052 r 33584 US36120731 1040170/3963 2514A05691	Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009 3Jul 10, 2009 Jan 2, 2008	Traceabi Cal. Lab / Scantek, Irr ACR. Env / ACR Env. / Transcat /	Accreditation hc./NVLAP / A2LA / A2LA A2LA A2LA A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010
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Instrument - Manufactur 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norson 1253-Norsonic	er Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer c Calibration software Calibrator	S/N 31052 r 33584 US36120731 1040170/3963 2514A05691 ev.5.0 31959	Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009	Traceabi Cal. Lab / Scantek, Irr ACR. Env. / ACR Env. / Transcat / - Scantek, Irr Scantek, Irr	Accreditation nc./NVLAP / A2LA / A2LA A2LA A2LA A2LA A2LA nc./ NVLAP nc./ NVLAP	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010
Instrument - Manufactur 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norson 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and standards maintain Calibrated by	er Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer c Calibration software Calibrator Preamplifier Microphone	S/N 31052 r 33584 US36120731 1040170/3963 2514A05691 e v.5.0 31959 14059 2246115 raceable to and NPL (U	Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009 3 Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Dec 14, 2009 Dec 14, 2009 SI (Internati K) Checked	Traceabi Cal. Lab / Scantek, Ir ACR. Env. / ACR Env. / Transcat / Transcat / - Scantek, Ir Scantek, Ir NPL (UK) /	Accreditation nc./NVLAP / A2LA A2LA A2LA A2LA A2LA nc./ NVLAP nc./ NVLAP / UKAS	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011 Dec 14, 2011 s) through
Instrument - Manufactur 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norson 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and standards maintain	er Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier Microphone Itest results are t ed by NIST (USA)	S/N 31052 r 33584 US36120731 1040170/3963 2514A05691 e v.5.0 31959 14059 2246115 raceable to and NPL (U	Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009 3 Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Jan 4, 2010 Dec 14, 2009 SI (Internati K)	Traceabi Cal. Lab / Scantek, Ir ACR. Env. / ACR Env. / Transcat / Transcat / - Scantek, Ir Scantek, Ir NPL (UK) /	Accreditation nc/NVLAP / A2LA A2LA A2LA A2LA A2LA A2LA A2LA A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011 Dec 14, 2011 s) through



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and relevant	1.1.1							
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Instrument: 5 Model: 7 Manufacturer: 1 Serial number: 7 Tested with: 1	Sound 2250 Brüel 26004 Micro	l Level M and Kjæ	leter r 189 s/n 2	2595637	Date Calil Status: In tolerand Out of tole See comme Contains r	ce: X erance:	/2009 Sent X _Yes X_No	
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Tel/Fax:	780-4	14-6373/ -	-6376			Edmonton, Alberta CANADA T6E 0G9		
Calibration of SLM & Dosime	Sound eters -	d Level Me - Acoustic	eters, Sc al Tests,	antek Inc., 06/ Scantek Inc.,	06/15/2005			
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- T ST ST T T T T T T T T T T T T T T T		-6373/ -6376	ic.			n, Alberta	
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Procedure for Instrumentation Instrument - Manufact 483B-Norsonic DS-360-SRS 34401A-Agilent Techn DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Nor 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation	rsonic and ted d NIST	ation of Measure for calibration: N Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone st results are tr	N-1504 Nors           S/N           25747           61646           MY41022043           790/00-04           V3820001           v.46           28326           14051           2246115           aceable to 3	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008	tek Inc. stem: Tracea Cal. Lat Scantek Davis In Transca Transca Vaisala - Scantek Scantek NPL (UH ough St	bility evidence b / Accreditation , Inc./NVLAP t / NVLAP t / NVLAP t / NVLAP / A2LA k, Inc. / NVLAP , Inc./ NVLAP k) / UKAS	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained
Procedure for Instrumentation Instrument - Manufact 483B-Norsonic DS-360-SRS 34401A-Agilent Techn DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Nor 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation by NPL (UK) and	or Calibr used f cturer nologies rsonic and te d NIST by	ation of Measure for calibration: N Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone st results are tr (USA)	N-1504 Nors           S/N           25747           61646           MY41022043           790/00-04           V3820001           v.46           28326           14051           2246115           aceable to 3	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008 SI - BIPM thr	tek Inc. stem: Tracea Cal. Lat Scantek Davis In Transca Vaisala - Scantek Scantek NPL (UP ough st	bility evidence b / Accreditation , Inc./NVLAP t / NVLAP t / NVLAP / A2LA , Inc. / NVLAP , Inc./ NVLAP , Inc./ NVLAP , Inc./ NVLAP tandards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained
Procedure for Instrumentation Instrument - Manufact 483B-Norsonic DS-360-SRS 34401A-Agilent Techn DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Nor 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation by NPL (UK) and Calibrated	or Calibr used f cturer nologies rsonic and te d NIST by	ation of Measure or calibration: N Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone st results are tr (USA)	N-1504 Nors           S/N           25747           61646           MY41022043           790/00-04           V3820001           v.46           28326           14051           2246115           aceable to 3	Checked	tek Inc. stem: Tracea Cal. Lat Scantek Davis In Transca Vaisala - Scantek Scantek NPL (UP ough st	bility evidence b / Accreditation , Inc./NVLAP t / NVLAP t / NVLAP / A2LA , Inc. / NVLAP , Inc./ NVLAP , Inc./ NVLAP , Inc./ NVLAP tandards mai Mariana E	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained





Calibration Certificate No.20671
Instrument:       Acoustical Calibrator       Date Calibrated:       11/2/2009         Model:       4231       Status:       Received       Set         Manufacturer:       Brüel and Kjær       In tolerance:       X       X         Serial number:       2594693       Out of tolerance:
Customer:Acoustical Consultants Inc.Address:Suite 107, 9920-63 AveTel/Fax:780-414-6373/-6376Edmonton, AlbertaCANADA T6E 0G9
Tested in accordance with the following procedures and standards: Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005 Instrumentation used for calibration: Nor-1504 Norsonic Test System:
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2,
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, Ds-360-SRS       Function       61646       Nov 19, 2007       Davis Inotek / A2LA       Nov 19
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, Jan 2, 2007       Davis Inotek / A2LA       Nov 19 Javis Inotek / A2LA       Nov 19 Nov 13
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Davis Inotek / A2LA       Nov 19 Jan 2, Jan 2, 2009       Jan 2, 2009       Jan 2, Jan 2, 2009
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, DS-360-SRS       Function       61646       Nov 19, 2007       Davis Inotek / A2LA       Nov 11         34401A-Agilent Technologies       Digital Multimeter       MY41022043       Nov 13, 2008       Transcat / NVLAP       Nov 21         DPI 141-Druck       Pressure Indicator       790/00-04       Nov 21, 2008       Transcat / NVLAP       Nov 2         8903A-HP       Audio Analyzer       2514A05691       Jan 2, 2008       Transcat / NVLAP       Jan 2,         HMR233-Vaisala Ovi       Humidity & Temp.       V3820001       May 7, 2008       Vaisala / A21 A       Nov 7
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, DS-360-SRS       Function       61646       Nov 19, 2007       Davis Inotek / A2LA       Nov 19         2011 141-Druck       Pressure Indicator       790/00-04       Nov 21, 2008       Transcat / NVLAP       Nov 2         8903A-HP       Audio Analyzer       2514A05691       Jan 2, 2008       Transcat/ NVLAP       Jan 2, Jan 2, 2008         HMP233-Vaisala Oyj       Humidity & Temp. Transmitter       V3820001       May 7, 2008       Vaisala / A2LA       Nov 7, Vaildated
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, Nov 19, 2007       Davis Inotek / A2LA       Nov 19         9S-360-SRS       Function       61646       Nov 19, 2007       Davis Inotek / A2LA       Nov 13         2401A-Agilent Technologies       Digital Multimeter       MY41022043       Nov 13, 2008       Transcat / NVLAP       Nov 2         2903A-HP       Audio Analyzer       2514A05691       Jan 2, 2008       Transcat / NVLAP       Jan 2, 1008         HMP233-Vaisala Oyj       Humidity & Temp. Transmitter       V3820001       May 7, 2008       Vaisala / A2LA       Nov 7, 2008
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./INVLAP       Jan 2, Ds-360-SRS       Function       61646       Nov 19, 2007       Davis Inotek / A2LA       Nov 13         2401A-Agilent Technologies       Digital Multimeter       MY41022043       Nov 13, 2008       Transcat / NVLAP       Nov 22         2903A-HP       Audio Analyzer       2514A05691       Jan 2, 2008       Transcat/ NVLAP       Jan 2, Nov 7,         HMP233-Vaisala Oyj       Humidity & Temp. Transmitter       V3820001       May 7, 2008       Vaisala / A2LA       Nov 7,         PC Program 1018 Norsonic       Calibration software       v.44       Validated May 2006       -       -
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, Ds-360-SRS       Function       61646       Nov 19, 2007       Davis Inotek / A2LA       Nov 19         34401A-Agilent Technologies       Digital Multimeter       MY41022043       Nov 13, 2008       Transcat / NVLAP       Nov 2         DPI 141-Druck       Pressure Indicator       790/00-04       Nov 21, 2008       Transcat / NVLAP       Nov 2         8903A-HP       Audio Analyzer       2514A05691       Jan 2, 2008       Transcat / NVLAP       Jan 2,         HMP233-Vaisala Oyj       Humidity & Temp. Transmitter       V3820001       May 7, 2008       Vaisala / A2LA       Nov 7,         PC Program 1018 Norsonic       Calibration software       v.44       Validated May 2006       -       -       -         1253-Norsonic       Calibrator       28326       Feb 16, 2009       Scantek, Inc. / NVLAP       Feb 16
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005         Instrumentation used for calibration: Nor-1504 Norsonic Test System:         Instrument - Manufacturer       Description       S/N       Cal. Date Cal. Lab / Accreditation       Traceability evidence Cal. Lab / Accreditation       Cal         483B-Norsonic       SME Cal Unit       25747       Jan 2, 2009       Scantek, Inc./NVLAP       Jan 2, Ds-360-SRS       Function       61646       Nov 19, 2007       Davis Inotek / A2LA       Nov 19         201141-Druck       Pressure Indicator       790/00-04       Nov 13, 2008       Transcat / NVLAP       Nov 2         8903A-HP       Audio Analyzer       2514A05691       Jan 2, 2008       Transcat / NVLAP       Jan 2, Jan 2, 2008         HMP233-Vaisala Oyj       Humidity & Temp. Transmitter       V3820001       May 7, 2008       Vaisala / A2LA       Nov 7, May 2006         PC Program 1018 Norsonic       Calibration software       v.44       Validated May 2006       -       -         1253-Norsonic       Calibrator       28326       Feb 16, 2009       Scantek, Inc. / NVLAP       Feb 16         1203-Norsonic       Preamplifier       14051       Jan 2, 2009       Scantek, Inc. / NVLAP       Jan 2,





#### B&K 2250/2270 Unit #4 Calibration Certificate(s)





	N LABORATOR	Y		R	v/l/	$\Delta \square^{\mathbb{R}}$
and relevant require ACCREDIT (an ILAC and			P Lab Code: 2	200625-0		
Calibr	ation C	Certifi	cate I	No.2	20672	
Model: 42 Manufacturer: Br	coustical Calibrat 31 rüel and Kjær 42956	or	Date Calibr Status: In tolerance Out of toler See commen Contains no	ance:	11/2/       Received       X       index       index       index       index       index	Sent X
Customer: Ad	coustical Consulta 0-414-6373/ -6376		Address:	Edmon	07, 9920-63 ton, Alberta DA T6E 0G9	
Tested in accordance Calibration of Acoustic				andards:		
	al Calibrators, So	antek Inc., (	06/06/2005	t System: Traceabi	ility evidence	Cal. Due
Calibration of Acoustic	al Calibrators, So	Nor-1504 N	06/06/2005 Iorsonic Test	t System: Traceabi	ility evidence Accreditation	Cal. Due
Calibration of Acoustic Instrumentation used Instrument - Manufacturer	al Calibrators, So for calibration: Description	Nor-1504 N	06/06/2005 Iorsonic Tesi Cal. Date	t System: Traceabi Cal. Lab /	ility evidence Accreditation nc./NVLAP	
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies	al Calibrators, So for calibration: Description SME Cal Unit Function Digital Multimeter	cantek Inc., ( Nor-1504 N <u>S/N</u> 25747 61646 MY41022043	06/06/2005 Iorsonic Test Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008	t System: Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I	ility evidence Accreditation hc./NVLAP ek / A2LA NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck	al Calibrators, Sc for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator	eantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04	06/06/2005 Iorsonic Test Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008	Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / I	ility evidence / Accreditation nc./NVLAP ek / A2LA NVLAP NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck 8903A-HP	al Calibrators, So for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator Audio Analyzer	cantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04 2514A05691	06/06/2005 Iorsonic Test Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 Jan 2, 2008	Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / N Transcat / N	ility evidence / Accreditation nc./NVLAP ek / A2LA NVLAP NVLAP NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Jan 2, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck	al Calibrators, Sc for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator	eantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04	06/06/2005 Iorsonic Test Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008	Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / I	ility evidence / Accreditation nc./NVLAP ek / A2LA NVLAP NVLAP NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck 8903A-HP	al Calibrators, So for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator Audio Analyzer Humidity & Temp.	cantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04 2514A05691	06/06/2005 Iorsonic Test Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 Jan 2, 2008 May 7, 2008 Validated	Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / N Transcat / N	ility evidence / Accreditation nc./NVLAP ek / A2LA NVLAP NVLAP NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Jan 2, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck 8903A-HP HMP233-Vaisala Oyj	al Calibrators, So for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator Audio Analyzer Humidity & Temp. Transmitter Calibration	cantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04 2514A05691 V3820001	06/06/2005 Iorsonic Test Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 Jan 2, 2008 May 7, 2008	Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / I Vaisala / A -	ility evidence / Accreditation nc./NVLAP ek / A2LA NVLAP NVLAP NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Jan 2, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck 8903A-HP HMP233-Vaisala Oyj PC Program 1018 Norsonic	al Calibrators, So for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator Audio Analyzer Humidity & Temp. Transmitter Calibration software	cantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04 2514A05691 V3820001 v.44	06/06/2005 Iorsonic Test Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 Jan 2, 2008 May 7, 2008 Validated May 2006 Feb 16, 2009	t System: Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / N Vaisala / A - Scantek, In	ility evidence / Accreditation hc./NVLAP k/ A2LA NVLAP NVLAP VVLAP 2LA	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Jan 2, 2010 Nov 7, 2009
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck 8903A-HP HMP233-Vaisala Oyj PC Program 1018 Norsonic 1253-Norsonic	al Calibrators, So for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator Audio Analyzer Humidity & Temp. Transmitter Calibration software Calibrator	cantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04 2514A05691 V3820001 v.44 28326	06/06/2005 Iorsonic Test Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 Jan 2, 2008 May 7, 2008 Validated May 2006	t System: Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / N Vaisala / A - Scantek, In	ility evidence / Accreditation nc./NVLAP ek / A2LA NVLAP NVLAP 2LA nc. / NVLAP nc. / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Jan 2, 2010 Nov 7, 2009 Feb 16, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck 8903A-HP HMP233-Vaisala Oyj PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic	al Calibrators, So for calibration: Description SME Cal Unit Function Digital Multimeter Pressure Indicator Audio Analyzer Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone	cantek Inc., ( Nor-1504 N 25747 61646 MY41022043 790/00-04 2514A05691 V3820001 v.44 28326 14051 2246115 traceable to and NPL (U	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 Jan 2, 2008 May 7, 2008 Validated May 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008	t System: Traceabi Cal. Lab / Scantek, In Davis Inote Transcat / I Transcat / I Transcat / N Vaisala / A Scantek, In NPL (UK) / tional System ure	ility evidence Accreditation ic./NVLAP sk / A2LA NVLAP NVLAP 2LA nc. / NVLAP ic./ NVLAP iut./ NVLAP iut./ NVLAP iut./ NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Jan 2, 2010 Nov 7, 2009 Feb 16, 2010 Jan 2, 2010 Mar 7, 2010

#### B&K 2250/2270 Unit #4 Calibrator Calibration Certificate

#### B&K 2250/2270 Unit #5 Calibration Certificate(s)







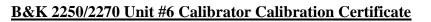


#### <u>B&K 2250/2270 Unit #6 Calibration Certificate(s)</u>





CALIBRATIO ISO 17025: 2005, ANS and relevant requirer ACCREDIT		Y 94 Part 1 2: 1994		NVLAF	Y Lab Code: 2	200625-0 ®
Calibr	ation C	Certifi	cate I	No.2	0674	
Model: 42. Manufacturer: Br	oustical Calibrat 31 üel and Kjær 56414	or	Date Calibr Status: In tolerance Out of toler See commer Contains no	2:	11/2/ Received X ed tests:Y	Sent X
				CANAD	OA T6E 0G9	
Tested in accordance Calibration of Acoustica Instrumentation used	al Calibrators, So	cantek Inc., 0	06/06/2005	andards: t System:		
Calibration of Acoustica	al Calibrators, So	cantek Inc., 0	06/06/2005	andards: t System: Traceabili	ity evidence	Cal. Due
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Calibration of Acoustica Instrumentation used	al Calibrators, So for calibration: Description	s/N	06/06/2005 lorsonic Tes Cal. Date	andards: t System: Traceabili Cal. Lab / /	ity evidence Accreditation c./NVLAP	Cal. Due
Calibration of Acoustica Instrumentation used Instrument - Manufacturer 483B-Norsonic	al Calibrators, So for calibration: Description SME Cal Unit Function	cantek Inc., 0 Nor-1504 N <u>S/N</u> 25747 61646	06/06/2005 lorsonic Tes Cal. Date Jan 2, 2009	andards: t System: Traceabili Cal. Lab / / Scantek, Inc Davis Inotek	ity evidence Accreditation c./NVLAP < / A2LA	Cal. Due Jan 2, 2010
Calibration of Acoustica Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS	al Calibrators, So for calibration: Description SME Cal Unit Function	cantek Inc., 0 Nor-1504 N <u>S/N</u> 25747 61646	06/06/2005 lorsonic Tes Cal. Date Jan 2, 2009 Nov 19, 2007	andards: t System: Traceabili Cal. Lab // Scantek, Inc Davis Inotek Transcat / N	ity evidence Accreditation c./NVLAP A2LA<br IVLAP	Cal. Due Jan 2, 2010 Nov 19, 2009
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#### B&K 2250/2270 Unit #7 Calibrator Calibration Certificate

# MANUFACTURER'S CERTIFICATE OF CONFORMANCE

We certify that Brüel & Kjær -2250--- Serial No. 2722859 has been tested and passed all production tests, confirming compliance with the manufacturer's published specification at the date of the test.

The final test has been performed using calibrated equipment, traceable to National or International Standards or by ratio measurements.

Brüel & Kjær is certified under ISO 9001:2008 assuring that all test data is retained on file and is available for inspection upon request.

Nærum 29-jun-2010

Vice President, Operations

Torben Bjørn

arly

Please note that this document is not a calibration certificate. For information on our calibration services please contact your nearest Brüel & Kjær office.

HEADQUARTERS: Brüel & Kjær Sound & Vibration Measurement A/S - DK-2850 Nærum - Denmark Telephone: +45 77412000 - Fax: +45 45801405 - www.bksv.com - info@bksv.com Local representatives and service organisations worldwide



Bruel & Kjær Serial No:	Prepolarized 1/2" Microphe Calibration Chart 2710791	Free- one T	field ype 4189
Open-circuit Sensitiv	vity*, So:	-26.1	dB re 1V/Pa
Equivalent to:			mV/Pa
Uncertainty, 95 %	confidence level	0.2	dB
Capacitance:		12.8	pF
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Environmental Calibr 101.5 kPa			
Procedure: 704215	Date: 29. Jun. 2010	Signa	ture: S.L.
*K <sub>0</sub> = - 26 - S <sub>0</sub> Exam	ple: K <sub>0</sub> = - 26 - (- 26.2)		



#### B&K 2260 SLM Calibration Certificate









## Appendix II. THE ASSESSMENT OF ENVIRONMENTAL NOISE (GENERAL)

#### Sound Pressure Level

Sound pressure is initially measured in Pascal's (Pa). Humans can hear several orders of magnitude in sound pressure levels, so a more convenient scale is used. This scale is known as the decibel (dB) scale, named after Alexander Graham Bell (telephone guy). It is a base 10 logarithmic scale. When we measure pressure we typically measure the RMS sound pressure.

$$SPL = 10\log_{10}\left[\frac{P_{RMS}^{2}}{P_{ref}^{2}}\right] = 20\log_{10}\left[\frac{P_{RMS}}{P_{ref}}\right]$$

Where:

SPL = Sound Pressure Level in dB

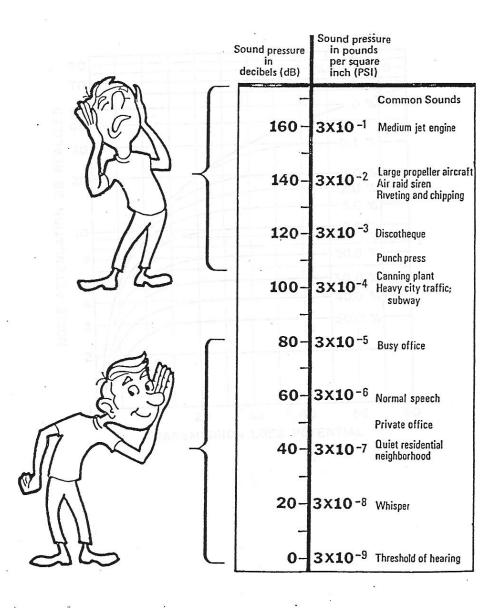
 $P_{RMS}$  = Root Mean Square measured pressure (Pa)

 $P_{ref}$  = Reference sound pressure level ( $P_{ref} = 2 \times 10^{-5} \text{ Pa} = 20 \text{ }\mu\text{Pa}$ )

This reference sound pressure level is an internationally agreed upon value. It represents the threshold of human hearing for "typical" people based on numerous testing. It is possible to have a threshold which is lower than 20  $\mu$ Pa which will result in negative dB levels. As such, zero dB does not mean there is no sound!

In general, a difference of  $1 - 2 \, dB$  is the threshold for humans to notice that there has been a change in sound level. A difference of 3 dB (factor of 2 in acoustical energy) is perceptible and a change of 5 dB is strongly perceptible. A change of 10 dB is typically considered a factor of 2. This is quite remarkable when considering that 10 dB is 10-times the acoustical energy!







#### **Frequency**

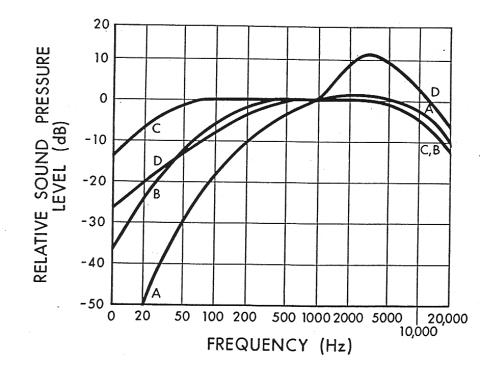
The range of frequencies audible to the human ear ranges from approximately 20 Hz to 20 kHz. Within this range, the human ear does not hear equally at all frequencies. It is not very sensitive to low frequency sounds, is very sensitive to mid frequency sounds and is slightly less sensitive to high frequency sounds. Due to the large frequency range of human hearing, the entire spectrum is often divided into 31 bands, each known as a 1/3 octave band.

The internationally agreed upon center frequencies and upper and lower band limits for the 1/1 (whole octave) and 1/3 octave bands are as follows:

	Whole Octave			1/3 Octave	
Lower Band	Center	Upper Band	Lower Band	Center	Upper Band
Limit	Frequency	Limit	Limit	Frequency	Limit
11	16	22	14.1	16	17.8
			17.8	20	22.4
			22.4	25	28.2
22	31.5	44	28.2	31.5	35.5
			35.5	40	44.7
			44.7	50	56.2
44	63	88	56.2	63	70.8
			70.8	80	89.1
			89.1	100	112
88	125	177	112	125	141
			141	160	178
			178	200	224
177	250	355	224	250	282
			282	315	355
			355	400	447
355	500	710	447	500	562
			562	630	708
			708	800	891
710	1000	1420	891	1000	1122
			1122	1250	1413
			1413	1600	1778
1420	2000	2840	1778	2000	2239
			2239	2500	2818
			2818	3150	3548
2840	4000	5680	3548	4000	4467
			4467	5000	5623
			5623	6300	7079
5680	8000	11360	7079	8000	8913
			8913	10000	11220
			11220	12500	14130
11360	16000	22720	14130	16000	17780
			17780	20000	22390



Human hearing is most sensitive at approximately 3500 Hz which corresponds to the <sup>1</sup>/<sub>4</sub> wavelength of the ear canal (approximately 2.5 cm). Because of this range of sensitivity to various frequencies, we typically apply various weighting networks to the broadband measured sound to more appropriately account for the way humans hear. By default, the most common weighting network used is the so-called "A-weighting". It can be seen in the figure that the low frequency sounds are reduced significantly with the A-weighting.



## **Combination of Sounds**

When combining multiple sound sources the general equation is:

$$\Sigma SPL_n = 10\log_{10} \left[ \sum_{i=1}^n 10^{\frac{SPL_i}{10}} \right]$$

#### Examples:

- Two sources of 50 dB each add together to result in 53 dB.
- Three sources of 50 dB each add together to result in 55 dB.
- Ten sources of 50 dB each add together to result in 60 dB.
- One source of 50 dB added to another source of 40 dB results in 50.4 dB

It can be seen that, if multiple similar sources exist, removing or reducing only one source will have little effect.



#### Sound Level Measurements

Over the years a number of methods for measuring and describing environmental noise have been developed. The most widely used and accepted is the concept of the Energy Equivalent Sound Level  $(L_{eq})$  which was developed in the US (1970's) to characterize noise levels near US Air-force bases. This is the level of a steady state sound which, for a given period of time, would contain the same energy as the time varying sound. The concept is that the same amount of annoyance occurs from a sound having a high level for a short period of time as from a sound at a lower level for a longer period of time. The  $L_{eq}$  is defined as:

$$L_{eq} = 10\log_{10}\left[\frac{1}{T}\int_{0}^{T}10^{\frac{dB}{10}}dT\right] = 10\log_{10}\left[\frac{1}{T}\int_{0}^{T}\frac{P^{2}}{P_{ref}^{2}}dT\right]$$

We must specify the time period over which to measure the sound. i.e. 1-second, 10-seconds, 15-seconds, 1-minute, 1-day, etc. An  $L_{eq}$  is meaningless if there is no time period associated.

In general there a few very common  $L_{eq}$  sample durations which are used in describing environmental noise measurements. These include:

- L<sub>eq</sub>24 Measured over a 24-hour period
- $L_{eq}$ Night Measured over the night-time (typically 22:00 07:00)
  - $L_{eq}Day$  Measured over the day-time (typically 07:00 22:00)
- $L_{DN}$  Same as  $L_{eq}24$  with a 10 dB penalty added to the night-time



#### **Statistical Descriptor**

Another method of conveying long term noise levels utilizes statistical descriptors. These are calculated from a cumulative distribution of the sound levels over the entire measurement duration and then determining the sound level at xx % of the time.

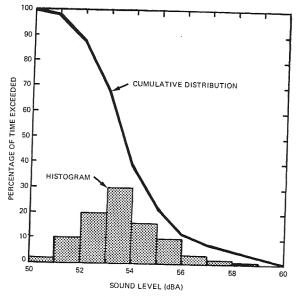


Figure 16.6 Statistically processed community noise showing histogram and cumulative distribution of A weighted sound levels.

Industrial Noise Control, Lewis Bell, Marcel Dekker, Inc. 1994

The most common statistical descriptors are:

L <sub>min</sub>	- minimum sound level measured
L <sub>01</sub>	- sound level that was exceeded only 1% of the time
L <sub>10</sub>	- sound level that was exceeded only 10% of the time.
	- Good measure of intermittent or intrusive noise
	- Good measure of Traffic Noise
L <sub>50</sub>	- sound level that was exceeded 50% of the time (arithmetic average)
	- Good to compare to $L_{eq}$ to determine steadiness of noise
L <sub>90</sub>	- sound level that was exceeded 90% of the time
	- Good indicator of typical "ambient" noise levels
L99	- sound level that was exceeded 99% of the time
L <sub>max</sub>	- maximum sound level measured

These descriptors can be used to provide a more detailed analysis of the varying noise climate:

- If there is a large difference between the  $L_{eq}$  and the  $L_{50}$  ( $L_{eq}$  can never be any lower than the  $L_{50}$ ) then it can be surmised that one or more short duration, high level sound(s) occurred during the time period.
- If the gap between the  $L_{10}$  and  $L_{90}$  is relatively small (less than 15 20 dBA) then it can be surmised that the noise climate was relatively steady.



#### **Sound Propagation**

In order to understand sound propagation, the nature of the source must first be discussed. In general, there are three types of sources. These are known as 'point', 'line', and 'area'. This discussion will concentrate on point and line sources since area sources are much more complex and can usually be approximated by point sources at large distances.

#### Point Source

As sound radiates from a point source, it dissipates through geometric spreading. The basic relationship between the sound levels at two distances from a point source is:

$$\therefore SPL_1 - SPL_2 = 20\log_{10}\left(\frac{r_2}{r_1}\right)$$

Where:

 $SPL_1$  = sound pressure level at location 1,  $SPL_2$  = sound pressure level at location 2  $r_1$  = distance from source to location 1,  $r_2$  = distance from source to location 2

Thus, the reduction in sound pressure level for a point source radiating in a free field is 6 dB per doubling of distance. This relationship is independent of reflectivity factors provided they are always present. Note that this only considers geometric spreading and does not take into account atmospheric effects. Point sources still have some physical dimension associated with them, and typically do not radiate sound equally in all directions in all frequencies. The directionality of a source is also highly dependent on frequency. As frequency increases, directionality increases.

Examples (note no atmospheric absorption):

- A point source measuring 50 dB at 100m will be 44 dB at 200m.
- A point source measuring 50 dB at 100m will be 40.5 dB at 300m.
- A point source measuring 50 dB at 100m will be 38 dB at 400m.
- A point source measuring 50 dB at 100m will be 30 dB at 1000m.

#### Line Source

A line source is similar to a point source in that it dissipates through geometric spreading. The difference is that a line source is equivalent to a long line of many point sources. The basic relationship between the sound levels at two distances from a line source is:

$$SPL_1 - SPL_2 = 10 \log_{10} \left( \frac{r_2}{r_1} \right)$$

The difference from the point source is that the '20' term in front of the 'log' is now only 10. Thus, the reduction in sound pressure level for a line source radiating in a free field is 3 dB per doubling of distance.

Examples (note no atmospheric absorption):

- A line source measuring 50 dB at 100m will be 47 dB at 200m.
- A line source measuring 50 dB at 100m will be 45 dB at 300m. -
- A line source measuring 50 dB at 100m will be 34 dB at 400m.
- A line source measuring 50 dB at 100m will be 40 dB at 1000m.



#### **Atmospheric Absorption**

As sound transmits through a medium, there is an attenuation (or dissipation of acoustic energy) which can be attributed to three mechanisms:

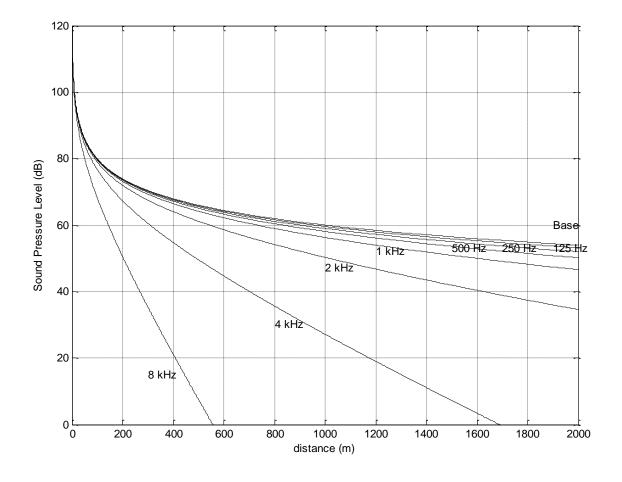
- 1) **Viscous Effects** Dissipation of acoustic energy due to fluid friction which results in thermodynamically irreversible propagation of sound.
- 2) **Heat Conduction Effects** Heat transfer between high and low temperature regions in the wave which result in non-adiabatic propagation of the sound.
- 3) **Inter Molecular Energy Interchanges** Molecular energy relaxation effects which result in a time lag between changes in translational kinetic energy and the energy associated with rotation and vibration of the molecules.

The following table illustrates the attenuation coefficient of sound at standard pressure (101.325 kPa) in units of dB/100m.

Temperature	Relative Humidity		I	Frequen	cy (Hz)	I	
°C	(%)	125	250	500	1000	2000	4000
	20	0.06	0.18	0.37	0.64	1.40	4.40
30	50	0.03	0.10	0.33	0.75	1.30	2.50
	90	0.02	0.06	0.24	0.70	1.50	2.60
	20	0.07	0.15	0.27	0.62	1.90	6.70
20	50	0.04	0.12	0.28	0.50	1.00	2.80
	90	0.02	0.08	0.26	0.56	0.99	2.10
	20	0.06	0.11	0.29	0.94	3.20	9.00
10	50	0.04	0.11	0.20	0.41	1.20	4.20
	90	0.03	0.10	0.21	0.38	0.81	2.50
	20	0.05	0.15	0.50	1.60	3.70	5.70
0	50	0.04	0.08	0.19	0.60	2.10	6.70
	90	0.03	0.08	0.15	0.36	1.10	4.10

- As frequency increases, absorption increases
- As Relative Humidity increases, absorption decreases
- There is no direct relationship between absorption and temperature
- The net result of atmospheric absorption is to modify the sound propagation of a point source from 6 dB/doubling-of-distance to approximately 7 – 8 dB/doubling-of-distance (based on anecdotal experience)





Atmospheric Absorption at 10°C and 70% RH



#### **Meteorological Effects**

There are many meteorological factors which can affect how sound propagates over large distances. These various phenomena must be considered when trying to determine the relative impact of a noise source either after installation or during the design stage.

#### Wind

- Can greatly alter the noise climate away from a source depending on direction
- Sound levels downwind from a source can be increased due to refraction of sound back down towards the surface. This is due to the generally higher velocities as altitude increases.
- Sound levels upwind from a source can be decreased due to a "bending" of the sound away from the earth's surface.
- Sound level differences of  $\pm 10$ dB are possible depending on severity of wind and distance from source.
- Sound levels crosswind are generally not disturbed by an appreciable amount
- Wind tends to generate its own noise, however, and can provide a high degree of masking relative to a noise source of particular interest.

#### <u>Temperature</u>

- Temperature effects can be similar to wind effects
- Typically, the temperature is warmer at ground level than it is at higher elevations.
- If there is a very large difference between the ground temperature (very warm) and the air aloft (only a few hundred meters) then the transmitted sound refracts upward due to the changing speed of sound.
- If the air aloft is warmer than the ground temperature (known as an *inversion*) the resulting higher speed of sound aloft tends to refract the transmitted sound back down towards the ground. This essentially works on Snell's law of reflection and refraction.
- Temperature inversions typically happen early in the morning and are most common over large bodies of water or across river valleys.
- Sound level differences of  $\pm 10$ dB are possible depending on gradient of temperature and distance from source.

#### <u>Rain</u>

- Rain does not affect sound propagation by an appreciable amount unless it is very heavy
- The larger concern is the noise generated by the rain itself. A heavy rain striking the ground can cause a significant amount of highly broadband noise. The amount of noise generated is difficult to predict.
- Rain can also affect the output of various noise sources such as vehicle traffic.

#### Summary

- In general, these wind and temperature effects are difficult to predict
- Empirical models (based on measured data) have been generated to attempt to account for these effects.
- Environmental noise measurements must be conducted with these effects in mind. Sometimes it is desired to have completely calm conditions, other times a "worst case" of downwind noise levels are desired.



## **Topographical Effects**

Similar to the various atmospheric effects outlined in the previous section, the effect of various geographical and vegetative factors must also be considered when examining the propagation of noise over large distances.

## Topography

- One of the most important factors in sound propagation.
- Can provide a natural barrier between source and receiver (i.e. if berm or hill in between).
- Can provide a natural amplifier between source and receiver (i.e. large valley in between or hard reflective surface in between).
- Must look at location of topographical features relative to source and receiver to determine importance (i.e. small berm 1km away from source and 1km away from receiver will make negligible impact).

## Grass

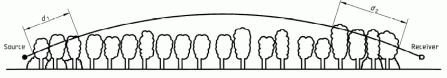
- Can be an effective absorber due to large area covered
- Only effective at low height above ground. Does not affect sound transmitted direct from source to receiver if there is line of sight.
- Typically less absorption than atmospheric absorption when there is line of sight.
- Approximate rule of thumb based on empirical data is:

$$A_g = 18\log_{10}(f) - 31$$
 (*dB*/100*m*)

Where:  $A_g$  is the absorption amount

## Trees

- Provide absorption due to foliage
- Deciduous trees are essentially ineffective in the winter
- Absorption depends heavily on density and height of trees
- No data found on absorption of various kinds of trees
- Large spans of trees are required to obtain even minor amounts of sound reduction
- In many cases, trees can provide an effective visual barrier, even if the noise attenuation is negligible.



NOTE —  $d_f = d_1 + d_2$ 

Table A.1 — Attenuation of an octave band of noise due to propagation a distance  $d_{\rm f}$  through dense foliage

Propagation distance $d_{\rm f}$	Nominal midband frequency							
				. ⊢	z			
m	63	125	250	500	1 000	2 000	4 000	8 000
	Attenuatio	on, dB:						
$10 \le d_{\rm f} \le 20$	0	0	1	1	1	1	2	3
	Attenuatio	on, dB/m:						
$20 \le d_{\rm f} \le 200$	0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

Tree/Foliage attenuation from ISO 9613-2:1996



For calculating  $d_1$  and  $d_2$ , the curved path radius may be assumed to be 5 km.

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance  $d_{\rm l}$  through the foliage

Bodies of Water

- Large bodies of water can provide the opposite effect to grass and trees.
- Reflections caused by small incidence angles (grazing) can result in larger sound levels at great distances (increased reflectivity, Q).
- Typically air temperatures are warmer high aloft since air temperatures near water surface tend to be more constant. Result is a high probability of temperature inversion.
- Sound levels can "carry" much further.

Snow

- Covers the ground for approximately 1/2 of the year in northern climates.
- Can act as an absorber or reflector (and varying degrees in between).
- Freshly fallen snow can be quite absorptive.
- Snow which has been sitting for a while and hard packed due to wind can be quite reflective.
- Falling snow can be more absorptive than rain, but does not tend to produce its own noise.
- Snow can cover grass which might have provided some means of absorption.
- Typically sound propagates with less impedance in winter due to hard snow on ground and no foliage on trees/shrubs.



## Appendix III. SOUND LEVELS OF FAMILIAR NOISE SOURCES

Used with Permission Obtained from EUB Guide 38: Noise Control Directive User Guide (November 1999)

Source <sup>1</sup>	Sound Level ( dBA)
Bedroom of a country home	30
Soft whisper at 1.5 m	30
Quiet office or living room	40
Moderate rainfall	50
Inside average urban home	50
Quiet street	50
Normal conversation at 1 m	60
Noisy office	60
Noisy restaurant	70
Highway traffic at 15 m	75
Loud singing at 1 m	75
Tractor at 15 m	78-95
Busy traffic intersection	80
Electric typewriter	80
Bus or heavy truck at 15 m	88-94
Jackhammer	88-98
Loud shout	90
Freight train at 15 m	95
Modified motorcycle	95
Jet taking off at 600 m	100
Amplified rock music	110
Jet taking off at 60 m	120
Air-raid siren	130

<sup>&</sup>lt;sup>1</sup> Cottrell, Tom, 1980, *Noise in Alberta*, Table 1, p.8, ECA80 - 16/1B4 (Edmonton: Environment Council of Alberta).



# SOUND LEVELS GENERATED BY COMMON APPLIANCES

Used with Permission Obtained from EUB Guide 38: Noise Control Directive User Guide (November 1999)

Source <sup>1</sup>	Sound level at 3 feet (dBA)	
Freezer	38-45	
Refrigerator	34-53	
Electric heater	47	
Hair clipper	50	
Electric toothbrush	48-57	
Humidifier	41-54	
Clothes dryer	51-65	
Air conditioner	50-67	
Electric shaver	47-68	
Water faucet	62	
Hair dryer	58-64	
Clothes washer	48-73	
Dishwasher	59-71	
Electric can opener	60-70	
Food mixer	59-75	
Electric knife	65-75	
Electric knife sharpener	72	
Sewing machine	70-74	
Vacuum cleaner	65-80	
Food blender	65-85	
Coffee mill	75-79	
Food waste disposer	69-90	
Edger and trimmer	81	
Home shop tools	64-95	
Hedge clippers	85	
Electric lawn mower	80-90	

<sup>&</sup>lt;sup>1</sup> Reif, Z. F., and Vermeulen, P. J., 1979, "Noise from domestic appliances, construction, and industry," Table 1, p.166, in Jones, H. W., ed., *Noise in the Human Environment*, vol. 2, ECA79-SP/1 (Edmonton: Environment Council of Alberta).



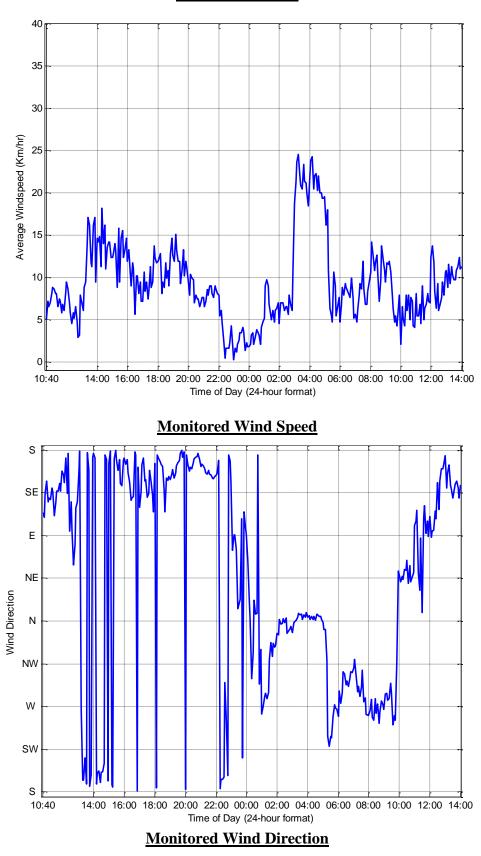
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June 23, 2010 <sup>1</sup>						
Time	Temperature (°C)	Relative Humidity (%)	Wind Direction	Wind Speed (km/hr)	Weather	
00:00	12.8	88	South-West	9	Mainly Clear	
01:00	12.5	88	South-West	11	Clear	
02:00	11.8	85	South-West	6	Clear	
03:00	10.7	89	North	0	Mainly Clear	
04:00	10.4	92	North-West	4	Clear	
05:00	9.8	90	North-West	7	Mainly Clear	
06:00	12.0	86	North	0	Mainly Clear	
07:00	13.4	83	South	7	Mainly Clear	
08:00	15.3	75	South	4	Mostly Cloudy	
09:00	17.5	64	South	7	Mostly Cloudy	
10:00	18.8	58	South-East	11	Mostly Cloudy	
11:00	19.6	55	South-East	7	Mostly Cloudy	
12:00	20.6	54	East	11	Mostly Cloudy	
13:00	20.7	54	South	4	Mostly Cloudy	
14:00	21.3	53	East	7	Cloudy	
15:00	20.7	54	South-East	17	Rain Showers	
16:00	20.8	58	East	11	Mostly Cloudy	
17:00	21.8	58	East	22	Mostly Cloudy	
18:00	20.9	48	South-East	15	Mostly Cloudy	
19:00	16.8	68	South-West	22	Thunderstorms, Heavy Rain Showers	
20:00	16.4	58	North-East	13	Thunderstorms, Rain Showers	
21:00	15.4	65	North	11	Mostly Cloudy	
22:00	13.8	73	North	17	Mostly Cloudy	
23:00	12.9	75	North-West	15	Mainly Clear	

## Appendix IV. WEATHER DATA

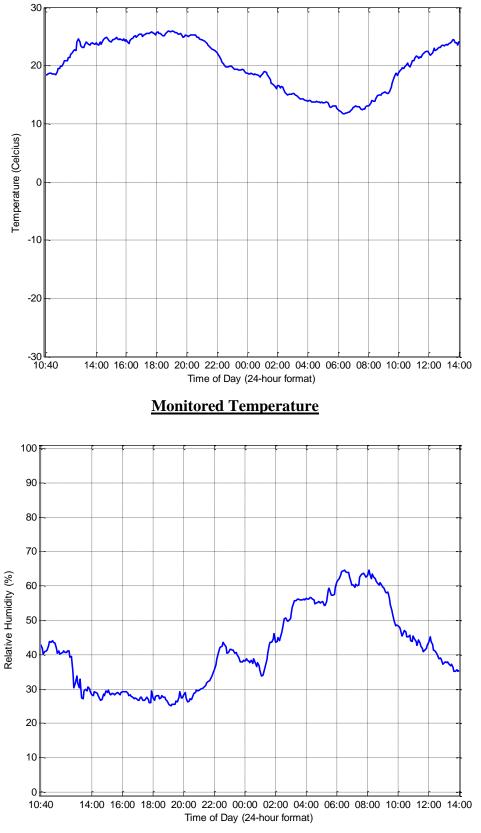
<sup>&</sup>lt;sup>1</sup> Data was obtained from Environment Canada at the Calgary International Airport. This was the only monitoring period that weather was taken from Environment Canada as the monitoring locations where in close proximity of the airport.





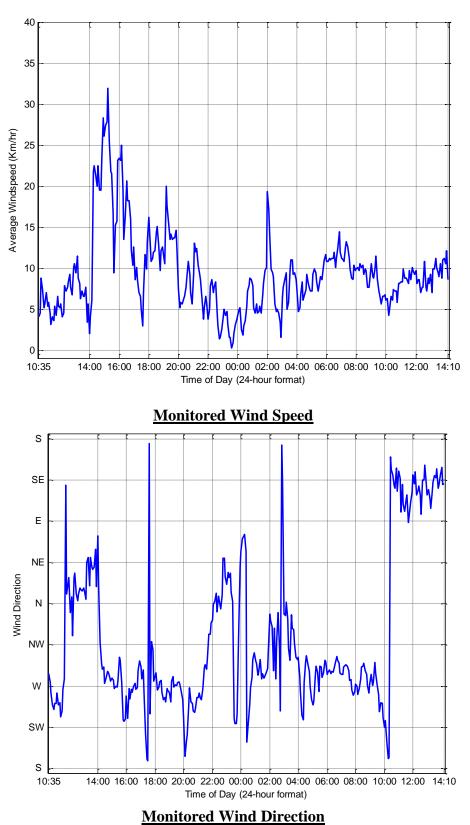
June 28 - 29, 2010





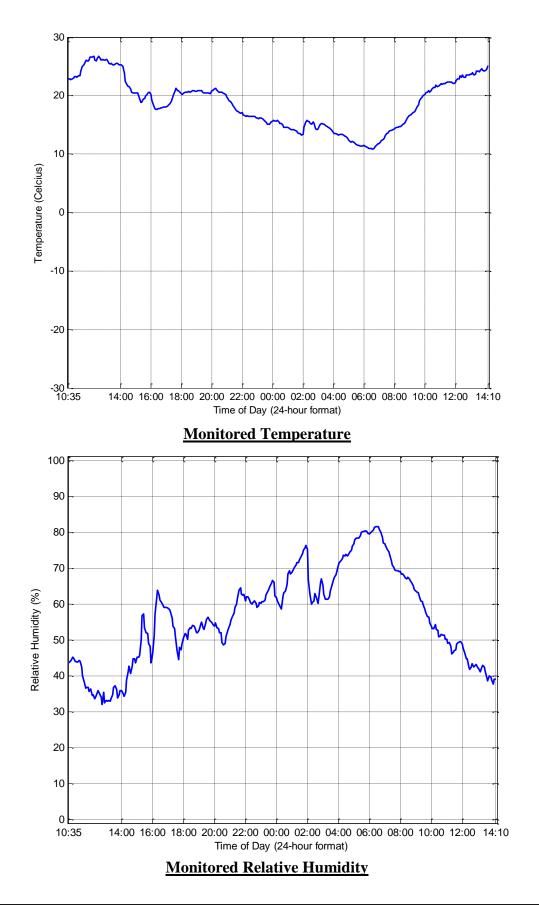




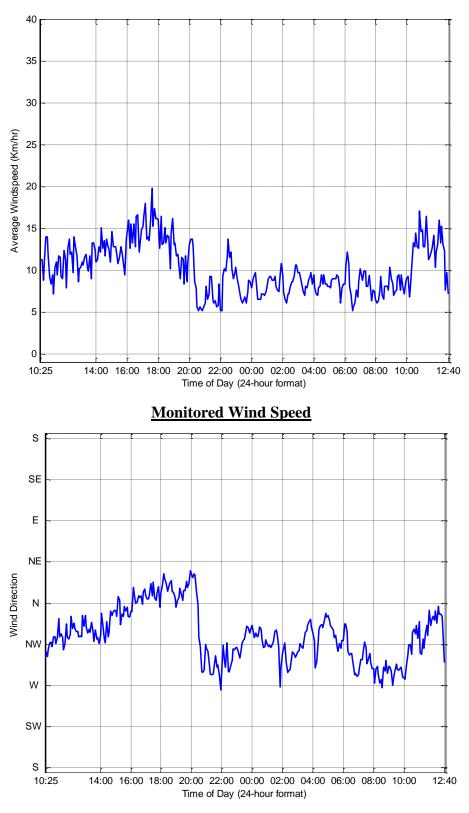


July 29 - 30, 2010





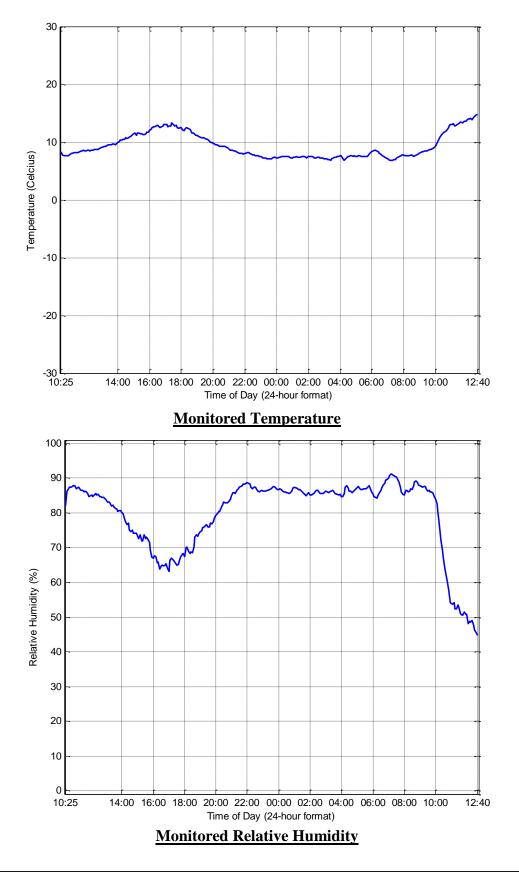




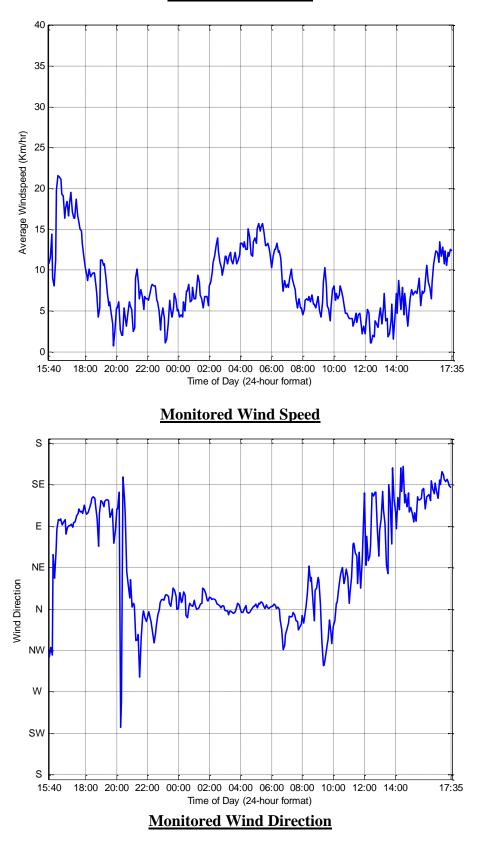
September 9 - 10, 2010











October 21 - 22, 2010



