APPENDIX F
NOISE AND VIBRATION REPORT

Sound Survey and Analysis Report

Long Ridge Terminal
Monroe County, Ohio

December 2019

Prepared for:

Prepared for:
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And

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ANSI	American National Standards Institute
°F	degrees Fahrenheit
μPa	microPascal
dB	Decibel
dBA	A-weighted decibel
dBL	linear decibel
Facility	Long Ridge Terminal Project
FHWA	Federal Highway Administration
FRA	Federal Rail Administration
FTA	Federal Transit Adminstration
Hp	Horsepower
Hz	Hertz
ISO	International Organization for Standardization
kHz	Kilohertz
L_{eq}	equivalent sound level
L_{W}	sound power level
L_{P}	sound pressure level
$L_{i(c)}$	interior sound pressure level
LT	Long-term
m	Meters
mi	Miles
ML	monitoring location
Mph	Miles per hour
NIST	National Institute of Standards and Technology
NGL	Natural Gas Liquids
OSHA	Occupational Safety and Health Administration
PPV	Peak-Particle-Velocity
pW	Picowatt
rms	Root Mean Square
ST	Short-term
Tetra Tech	Tetra Tech, Inc.

Acronyms/Abbreviations	Definition
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VdB	Vibration decibels

1.0 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has prepared this noise impact assessment for the proposed Long Ridge Terminal Project (the Facility) to support a grant application to the U.S. Department of Transportation's (USDOT) Better Utilizing Infrastructure Leverage Development (BUILD) program. The Facility is proposed to be located at the Long Ridge Energy Terminal in Hannibal, Ohio.

The Facility consists of a pipeline-to-rail transloading facility and a direct pipeline connection that allows Natural Gas Liquids (NGL) to move outbound from the Marcellus and Utica shale region to export terminals on the east coast. The transloading facility will connect to an existing short rail railroad which provides connectivity to the Norfolk Southern.

This report provides: a discussion of the Facility setting; descriptions of the noise and vibration metrics used throughout the report; applicable noise and vibration standards and regulations; the results of the ambient sound measurement program; predicted noise and vibration levels associated with the Facility construction; and predicted noise and vibration levels from the worst-case operations of the Facility equipment and railway.

1.1 FACILITY DESCRIPTION AND SETTING

The Long Ridge Terminal Project is being developed into a multi-use industrial port with capabilities to handle breakbulk materials and liquid products. The Facility consists of a pipeline-rail transloading facility capable of handling 40 railcars at one time. The facility will receive a single train from Northfolk Southern once a week consisting of a maximum 110 rail cars. Six 200 horsepower (HP) pumps will be used for loading NGL onto rail transportation.

The Long Ridge Terminal Site is located on the northwestern bank of the Ohio River in the City of Hannibal, in Monroe County Ohio on property zoned for industrial use. The Facility Site is bounded by industrial facilities to the east and west, the Ohio River to the south, and the Ohio River Scenic Byway located to the north. Existing noise sources in the area include traffic along the Ohio River Scenic Byway and West Virginia Route 2, industrial uses located directly west and east of the Facility site, and waterway activities associated with the Ohio River.

The closest residence from the Facility Site is located approximately 0.72 miles southeast from the Facility Site boundary across the Ohio River. The next nearest residence from the Facility Site is located approximately 0.92 miles east of the Facility Site boundary across the Ohio River. A residential neighborhood is located approximately 1.1 miles west from the Facility Site boundary. This residential neighborhood is separated from the Facility site by existing industrial land use and the Ohio River Scenic Byway. Several residences are located along Long Ridge Road located approximately 0.97 miles north of the Facility Site boundary. These residences are located at an elevation 580 feet above the Facility Site elevation. Residential homes located within the City of Martinsville are located as close as approximately 1.16 miles southwest of the Facility Site boundary. Figure 1 provides an overview of the Facility Site as well as the surrounding area.

LEGEND

MONITORING LOCATION

NOTE:
AERIAL PHOTO OBTAINED FROM ARCGIS SOFTWARE

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LONG RIDGE TRANSLOADING
MONROE COUNTY, OHIO

FACILITY SITE AND
MEASUREMENT LOCATIONS

DATE:	12/12/19
PROJECT NO.:	212C–CF–00264
DESIGNED BY:	KF
DRAWN BY:	JK
CHECKED BY:	KF
SHEET:	1 OF 3

FIGURE 1

X:\CADD\Long Ridge Transloading\212c–cf–00264\FIGURES\Noise Monitoring Figures\FIGURE 1.dwg PIT JIM.KUSIOWSKI 12/13/2019 12:57:21 PM

1.2 ACOUSTIC METRICS AND TERMINOLOGY

All sounds originate with a source, whether it is a human voice, motor vehicles on a roadway, or a combustion turbine. Energy is required to produce sound and this sound energy is transmitted through the air in the form of sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear. A sound source is defined by a sound power level (abbreviated "L_W"), which is independent of any external factors. By definition, sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts.

A source sound power level cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source outside the acoustic and geometric near-field. A sound pressure level (abbreviated "L_P") is a measure of the sound wave fluctuation at a given receiver location, and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. The sound pressure level in decibels (dB) is the logarithm of the ratio of the sound pressure of the source to the reference sound pressure of 20 microPascals (μPa), multiplied by 20.[1] The range of sound pressures that can be detected by a person with normal hearing is very wide, ranging from about 20 μPa for very faint sounds at the threshold of hearing, to nearly 10 million μPa for extremely loud sounds such as a jet during take-off at a distance of 300 feet.

Broadband sound includes sound energy summed across the entire audible frequency spectrum. In addition to broadband sound pressure levels, analysis of the various frequency components of the sound spectrum can be completed to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves. Typically, the frequency analysis examines 11 octave bands ranging from 16 Hz (low) to 16,000 Hz (high). Since the human ear does not perceive every frequency with equal loudness, spectrally-varying sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system, and is represented in dBA.

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level (L_{eq}). The equivalent sound level has been shown to provide both an effective and uniform method for comparing time-varying sound levels and is widely used in acoustic assessments in the State of Ohio. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in **Table 1**. Additional reference information on terminology used in the report is presented in **Table 2**.

Table 1. Sound Pressure Levels (L_P) and Relative Loudness of Typical Noise Sources and Acoustic Environments

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Vacuum cleaner (10 feet)	70	Moderate
Passenger car at 65 miles per hour (25 feet)	65	
Large store air-conditioning unit (20 feet)	60	
Light auto traffic (100 feet)	50	Quiet
Quiet rural residential area with no activity	45	
Bedroom or quiet living room; Bird calls	40	Faint

[1] The sound pressure level (L_p) in dB corresponding to a sound pressure (p) is given by the following equation:

$$Lp = 20 \log10 (p / pref);$$

Where:

p = the sound pressure in μPa; and

pref = the reference sound pressure of 20 μPa.

Table 1. Sound Pressure Levels (L_P) and Relative Loudness of Typical Noise Sources and Acoustic Environments

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Typical wilderness area	35	
Quiet library, soft whisper (15 feet)	30	Very quiet
Wilderness with no wind or animal activity	25	Extremely quiet
High-quality recording studio	20	
Acoustic test chamber	10	Just audible
	0	Threshold of hearing

Adapted from: Kurze and Beranek (1988) and United States Environmental Protection Agency (USEPA) (1971)

Table 2. Acoustic Terms and Definitions

Term	Definition
Noise	Typically defined as unwanted sound. This word adds the subjective response of humans to the physical phenomenon of sound. It is commonly used when negative effects on people are known to occur.
Sound Pressure Level (L_P)	Pressure fluctuations in a medium. Sound pressure is measured in dB referenced to 20 microPascals, the approximate threshold of human perception to sound at 1,000 Hz.
Sound Power Level (L_W)	The total acoustic power of a noise source measured in dB referenced to picowatts (one trillionth of a watt). Noise specifications are provided by equipment manufacturers as sound power as it is independent of the environment in which it is located. A sound level meter does not directly measure sound power.
Equivalent Sound Level (L_{eq})	The L_{eq} is the continuous equivalent sound level, defined as the single sound pressure level that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period.
A-Weighted Decibel (dBA)	Environmental sound is typically composed of acoustic energy across all frequencies. To compensate for the auditory frequency response of the human ear, an A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report.
Unweighted Decibels (dBL)	Unweighted sound levels are referred to as linear. Linear decibels are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Sound levels that are linear are presented as dBL in this report.
Propagation and Attenuation	Propagation is the decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Additional sound attenuation factors include air absorption, terrain effects, sound interaction with the ground, diffraction of sound around objects and topographical features, foliage, and meteorological conditions including wind velocity, temperature, humidity, and atmospheric conditions.
Octave Bands	The audible range of humans spans from 20 to 20,000 Hz and is typically divided into center frequencies ranging from 31 to 8,000 Hz.
Broadband Noise	Noise which covers a wide range of frequencies within the audible spectrum, i.e., 200 to 2,000 Hz.

Table 2. Acoustic Terms and Definitions

Term	Definition
Frequency (Hz)	The rate of oscillation of a sound, measured in units of Hz or kilohertz (kHz). One hundred Hz is a rate of one hundred times (or cycles) per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz.

1.3 VIBRATION METRICS AND TERMINOLOGY

Vibration is an oscillatory motion that is described in terms of the displacement, velocity, or acceleration. Velocity is the most common descriptor used when evaluating human perception or structural damage. Velocity represents the instantaneous speed of movement and more accurately describes the response of humans, buildings, and equipment to vibrations.

Peak-Particle-Velocity (PPV) and root mean square (rms) velocity are typical metrics used to describe vibration levels in units of inches per second in the USA and meters per second in the rest of the world. PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal. PPV is commonly used in evaluating the potential of building damage and is used to measuring blasting events.

However, to evaluate and describe vibration levels from transit operations, the vibration decibel (VdB) notation is commonly used. The decibel notation acts to compress the range of numbers required to describe vibration. In the USA, the accepted velocity reference for converting to decibels is 1×10^{-6} inches per second.

In contrast to airborne noise, ground-borne vibration is not an everyday occurrence for humans. The background vibration velocity levels within residential areas are usually 0.0013 PPV in/sec (50 VdB) or lower, which is well below the human perception threshold of approximately 0.007 PPV in/sec (65 VdB). However, human response to vibration is not usually significant unless the vibration exceeds 0.013 PPV in/sec (70 VdB). Outdoor sources that generate perceptible ground-borne vibrations are typically construction equipment, steel-wheeled trains, and traffic on uneven roadways. Table 3 provides common vibration sources as well as human and structural response to ground borne vibrations.

Table3. Typical Levels of Ground-Borne Vibration

Human/Structural Response	PPV (In/sec)	Velocity Level (VdB)*	Typical sources 50 feet from source)
Threshold, Minor Cosmetic Damage, Fragile Buildings	0.4	100	Blasting from Construction Projects
	0.15-0.2	92-94	Heavy Tracked Construction Equipment
Difficulty with Tasks Such as Reading a VDT Screen	0.13	90	

Table3. Typical Levels of Ground-Borne Vibration

Human/Structural Response	PPV (In/sec)	Velocity Level (VdB)*	Typical sources 50 feet from source)
	0.07	85	Commuter Rail, Upper Range
Residential Annoyance, Infrequent Events	0.04	80	Rapid Transit, Upper Range
	0.022	75	Commuter Rail, Typical
Residential Annoyance, Frequent Events	0.016	72	Bus or Truck Bump Over
	0.013	70	Rapid Transit, Typical
Approximate Threshold of Human Perception	0.007	65	
	0.005	62	Bus or Truck, Typical
	0.0013	50	Typical Background Vibration Levels
*RMS Vibration Velocity in VdB reference to 10-6 inches/second. Source: FTA Transit Noise and Vibration Impact Assessment Manual, 2018			

Vibration from construction and traffic do not typically result in damage to buildings, with the occasional exception of blasting and pile-driving during construction operations. The U.S. Bureau of Mines and Office of Surface Mining Reclamation and Enforcement have developed a blast vibration criterion for the protection of buildings with various structure types and conditions.

The degree of annoyance cannot always be explained by the magnitude of the vibrations alone. Ground-borne noise, rattling, visual effects such as movement of hanging objects, and time of day all influence the response of individuals. The American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) have developed criteria for evaluation of human exposure to vibrations. The recommendations of these standards and other studies evaluating human response to vibrations have been incorporated into the Federal Transit Authority's published "Transit Noise and Vibration Impact Assessment Manual", May 2016. The criteria within this manual is used to assess noise and vibration impacts from transit operations.

1.4 NOISE AND VIBRATION REQUIREMENTS AND GUIDELINES

The Federal Rail Adminstration (FRA) had established guidelines for the assessment of noise and vibration impacts as defined in the FRA Office of Railroad Policy and development, High-Speed Ground Transportation Noise and Vibration Assessment Impact document (FDR 2012). The FRA guidelines are identified for projects with train speeds of 90 to 250 miles per hour (mph). The Federal Transit Administration's Transit Noise and Vibration Impact Assessment Manual (FTA 2018) provides guidance with conventional train speeds below 90 mph. The FTA noise and vibration criteria will be used to evaluate the impacts from the construction and operation of the proposed

Facility. Also, there are no local guidelines or regulations. However, the Ohio Power Sitting Board has established noise criteria for power generating facilities that has been applied to projects adjacent to the proposed Facility site. The FTA criteria are further discussed below.

1.4.1 Federal Transit Administration

1.4.1.1 Noise Criteria

The FTA defines distinct applicable noise metrics for three land-use categories. These land use categories, along with defined noise metrics, are summarized in **Table 4** below. Categories 1 and 3 land-use noise exposure metrics are defined as the maximum 1-hour L_{eq}, while for Category 2 the noise exposure criteria is defined by the 24 hour day-night sound level (L_{dn})[2] metric. Category 2 includes places where people normally sleep, such as residences, motels, and hotels. Category 3 includes institutional land uses with primarily daytime and evening uses such places of worship and libraries.

Table 4. Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor L_{eq}(h)*	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor L_{eq}(h)*	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

* Leq for the noisiest hour of transit-related activity during hours of noise sensitivity

The FTA noise impact criterion is based on comparing the existing ambient outdoor noise levels to the Project related outdoor noise levels. Based on the magnitude of the numerical comparative difference, the FTA further defines 3 levels of impacts: none, moderate and severe. **Table 5** below provides a summary of the FTA noise impact criteria, where the moderate and severe impacts are based on the existing ambient noise exposure. For example, based on the FTA criteria if the measured existing noise exposure level is 60 dBA L_{eq}, then the moderate impact threshold for land use classification 3 would be within a range of 63 to 68 dBA and the severe impact threshold would be 68 dBA or greater.

[2] The L_{dn} is the A-weighted L_{eq} over a 24 hour period with a penalty of 10 dB(A) for noise during the hours of 22:00-07:00

Table 5. Noise Levels Defining Impact for Transit Projects

Existing Noise Exposure* $L_{eq(h)}$ or L_{dn} (dBA)	Project Noise Impact Exposure, * $L_{eq(h)}$ or L_{dn} (dBA)					
	Category 1 or 2 Sites			Category 3 Sites		
	No Impact	Moderate Impact	Severe Impact	No Impact	Moderate Impact	Severe Impact
<43	**<Ambient + 10**	**Ambient + 10 to 15**	**>Ambient + 15**	**<Ambient +15**	**Ambient + 15 to 20**	**>Ambient + 20**
43	<52	52-58	>58	<57	57-63	>63
44	<52	52-58	>58	<57	57-63	>63
45	<52	52-58	>58	<57	57-63	>63
46	<53	53-59	>59	<58	58-64	>64
47	<53	53-59	>59	<58	58-64	>64
48	<53	53-59	>59	<58	58-64	>64
49	<54	54-59	>59	<59	59-64	>64
50	<54	54-59	>59	<59	59-64	>64
51	<54	54-60	>60	<59	59-65	>65
52	<55	55-60	>60	<60	60-65	>65
53	<55	55-60	>60	<60	60-65	>65
54	<55	55-61	>61	<60	60-66	>66
55	<56	56-61	>61	<61	61-66	>66
56	<56	56-62	>62	<61	61-67	>67
57	<57	57-62	>62	<62	62-67	>67
58	<57	57-62	>62	<62	62-67	>67
59	<58	58-63	>63	<63	63-68	>68
60	<58	58-63	>63	<63	63-68	>68
61	<59	59-64	>64	<64	64-69	>69
62	<59	59-64	>64	<64	64-69	>69
63	<60	60-65	>65	<65	65-70	>70
64	<61	61-65	>65	<66	66-70	>70
65	<61	61-66	>66	<66	66-71	>71
66	<62	62-67	>67	<67	67-72	>72
67	<63	63-67	>67	<68	68-72	>72
68	<63	63-68	>68	<68	68-73	>73
69	<64	64-69	>69	<69	69-74	>74
70	<65	65-69	>69	<70	70-74	>74
71	<66	66-70	>70	<71	71-75	>75
72	<66	66-71	>71	<71	71-76	>76
73	<66	66-71	>71	<71	71-76	>76
74	<66	66-72	>72	<71	71-77	>77
75	<66	66-73	>73	<71	71-78	>78
76	<66	66-74	>74	<71	71-79	>79
77	<66	66-74	>74	<71	71-79	>79
>77	<66	66-75	>65	<71	71-80	>80

* Ldn is used for land use where nighttime sensitivity is a factor.
* Leq is measured during the hour of maximum transit noise exposure and is used for land use involving only daytime activities.

The FTA defines noise impacts as moderate and severe. For these two levels of impacts, noise mitigation measures must be investigated. Furthermore, severe impact mitigation measures must be incorporated into the Project unless extenuating circumstances are discovered that prevent it. The overall analysis goal when evaluating mitigation for severe impacts is to describe and recommend measures to reduce the noise levels to below the moderate impact threshold limits.

More discretion is allowed for moderate impacts based on the consideration of factors including cost, number of sensitive receptors affected, community views, the absolute level of noise exceedance, and the sensitivity of the affected receptors.

For land uses that do not have an exterior use area the FTA has an established criterion for interior noise levels. The criterion establishes an interior noise threshold limit of 65 dBA or less from transit sources and 70 dBA or less for homes impacted by train horns. Interior noise level impacts exceeding these established interior noise thresholds would require the consideration of cost-effective sound insulation treatment. The cost-effective treatment must provide a minimum of 5 dBA or less to be feasible.

1.4.1.2 Vibration Criteria

The FTA general assessment vibration impact criteria for acceptable ground-borne vibration impacts are specified for three land use categories. **Table 6** below lists the three land-use categories that are defined by the FTA and the applicable vibration impact threshold for each land-use category.

Table 6. Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch /sec)			GBN Impact Levels (dB re 20 micro Pascals)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[4]	N/A[4]	N/A[4m]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Notes:
1. "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have these many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

The FTA has developed a guideline for defining a vibration damage criterion involving considerable operations. The purpose of this criterion is to identify the potential problem areas so that they can be addressed during the project's final design stage and avoid any potential for damage. **Table 7** summarizes the vibration damage criteria.

Table 7. FTA Operational Damage Criteria

Building Category	PPV (in/sec)	Approximate L_v*
I. Reinforced-concrete, steel or timber (no plaster)	0.5	102
II. Engineered Concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

*RMS velocity in decibels (VdB) re 1 micro-inch/second

2.0 EXISTING SOUND ENVIRONMENT

Tetra Tech conducted a series of ambient sound level measurements to characterize the existing acoustic environment in the vicinity of the Facility during both daytime and nighttime periods. This section summarizes the methodology used by Tetra Tech to conduct the sound survey and describes the measurement locations.

2.1 FIELD METHODOLOGY

To document the existing conditions, baseline sound level measurements were performed on October 2-4, 2019. Weather conditions were conducive for the collection of accurate sound data. The measurement locations were selected to be representative of the surroundings of potential receptors nearest to the proposed Facility Site in the principal geographical directions. The ambient sound survey included both automated, an unattended long-term (LT) measurement that extended over a 24-hour period, as well as short-term (ST) measurements in the presence of an acoustics expert for a minimum duration of 30 minutes. The ST measurements were made during both daytime (10:00 a.m. to 4:00 p.m.) and nighttime (10:30 p.m. to 2:00 a.m.) periods at noise sensitive areas. The long-term measurement was conduct on the Facility site collecting data from 10:00 am on October 2nd to 10:00 am on October 3rd, 2019.

All of the measurements were conducted using a Larson Davis Model 831 precision integrating sound-level meter that meets the requirements of ANSI Standards for Type 1 precision instrumentation. This sound analyzer has an operating range of 5 dB to 140 dB, and an overall frequency range of 8 to 20,000 Hz. During the measurement program, microphones were fitted with a windscreen, set upon a tripod at a height of approximately 1.5 meters (5 feet) above the ground and located out of the influence of any vertical reflecting surfaces. The sound analyzer was calibrated at the beginning and end of the measurement period using a Larson Davis Model CAL200 acoustic calibrator following procedures that are traceable to the National Institute of Standards and Technology (NIST). **Table 8** lists the measurement equipment employed during the survey. The sound level meters were programmed to sample and store A-weighted and octave band sound level data, including L_{eq} and the percentile sound levels.

Table 8. Measurement Equipment

Description	Manufacturer	Type
Signal Analyzer	Larson Davis	831
Preamplifier	Larson Davis	PRM902
Microphone	PCB	377B02
Windscreen	ACO Pacific	7-inch
Calibrator	Larson Davis	CAL200

During the survey weather conditions were conducive to accurate data collection. Weather conditions were mainly overcast with no precipitation occurring during the measurement period. Temperatures ranged from 80 to 95 degrees Fahrenheit (°F) during the day, and 65 to 75°F during the nighttime. Wind speeds were variable, averaging from 10 to 20 miles per hour (mph) during the daytime, and 0 to 8 mph during the nighttime.

2.2 FIELD METHODOLOGY

Five short-term, attended sound measurements were performed at public locations near residential properties proximate to the Facility Site. The monitoring locations (ML-1 through ML-5) were selected to represent ambient conditions at land uses in the vicinity of the Facility Site.

The short-term monitoring locations are described in **Table 9** and mapped on Figure 1. Additional descriptions of the monitoring locations and field observations are provided below.

Table 9. Sound Level Monitoring Locations

Monitoring Location	Coordinates (Universal Transverse Mercator Zone 19N)		Distance and Direction from Facility Site Boundary
	Easting (m)	Northing (m)	
ML-1	512263	4396171	0.97 mile N
ML-2	512116	4394488	1.11 mile W
ML-3	512656	4393916	1.16 mile SW
ML-4	514345	4394497	0.72 mile SE
ML-5	514876	4395322	0.75 mile E
LT	513839	4395356	Northeast corner of Facility Site

2.2.1 Location ML-1

This monitoring location is located along Long Ridge Road approximately 0.97 miles north of the Facility Site boundary line. This location was selected to represent the residences located along Long Ridge Road. Long Ridge Road is a windy single-lane paved road bordered mostly by steeply sloped forested areas and is at an elevation 580 feet above the Facility Site grade.

During the daytime measurements, ML-1 was generally fairly quiet with some contribution from distance traffic along the Ohio River Scenic Byway as well as noise from wildlife. There was little to no traffic along Long Ridge Road, nor any other noticeable sound sources. Nighttime measurements were fairly consistent with the daytime measurements; however, traffic along the Ohio River Scenic Byway appeared to be decreased.

2.2.2 Location ML-2

This monitoring location is located across the Ohio River Scenic Byway approximately miles west of the Facility Site boundary line, along Fisher Hill Road in the City of Hannibal. This location represents a residential neighborhood located along Fisher Hill Road.

During the daytime measurement period, noise generated by traffic on the Ohio River Scenic Byway was dominant; however, there was also noise generated by the nearby industrial uses. During the nighttime measurement period, which occurred approximately between 1:00 am to 1:30 am, traffic was not as frequent from the Ohio River Scenic

Byway. There was also noise audible from the Hannibal Industrial site. There was little to no local traffic along Fisher Hill Road during the nighttime measurement period.

2.2.3 Location ML-3

This monitoring location is in the City of New Martinsville, West Virginia approximately 1.16 mile southwest of the Facility Site boundary line. This location represents the residences along Route 2 within the City of New Martinsville.

During the daytime measurement period, noise generated by traffic on the Route 2 was dominant; however, there was also noise generated by the nearby railway operations. During the nighttime measurement period, which occurred approximately between 2:00 am to 2:30 am, traffic was still frequent and generated elevated noise levels along Route 2.

2.2.4 Location ML-4

This monitoring location is located along Route 2 approximately 0.72 miles southeast of the Facility Site property boundary. This location was representative the nearest residence to the Facility Site.

During the daytime measurement period, noise generated by traffic on the Route 2 was dominant. During the nighttime measurement period, which occurred approximately between 1:30 am to 2:00 am, traffic was still frequent and audible from the Route 2. There was also noise audible from the distant industrial uses.

2.2.5 Location ML-5

This monitoring location is located within a community baseball field on Route 2 in Proctor and is located approximately 0.75 miles east from the Facility Site boundary line.

During the daytime measurements, traffic along Route 2 was frequent and the primary source of noise. During the nighttime period there was still some traffic along Route 2; however, noise from railway and barge operations were also audible.

2.2.6 Long-Term Monitoring Location

The LT monitor is located on the northern portion of the Facility Site located approximately 900 feet southwest from Ohio River Scenic Byway. The long-term measurements provide insight into variability of ambient sound levels over time, within the vicinity of the Generating Facility Site.

Sound level measurements at LT were collected from 10:00 am. on October 2nd, 2019 through 10:00 a.m. on October 3rd, 2019. No rail operations were documented from the railway adjacent to the Ohio River Scenic Byway during the monitoring period.

2.3 MEASUREMENT RESULTS

Table 10 provides a summary of the measured ambient sound levels observed at each of the monitoring locations for both the daytime and nighttime L_{eq}.

Table 10. Sound Measurement Results – L_{eq} Sound Levels

Monitoring Location	Time Period	Leq (dBA)
ML-1	Day	50
	Night	42
ML-2	Day	54
	Night	49
ML-3	Day	56
	Night	55
ML-4	Day	56
	Night	54
ML-5	Day	53
	Night	48
Long-Term Monitor	Day	49
	Night	46

Ambient sound levels did exhibit typical diurnal patterns. Daytime L_{eq} sound levels at the measurement locations ranged from a low of 50 dBA at ML-1 to a high of 56 dBA at ML-3 and ML-4. Nighttime sound levels ranged from a low of 42 dBA at ML-1 to 55 dBA at ML-3. The noise levels at ML-2 were heavily influenced by vehicle traffic along Highway 7. Noise levels at ML-3, ML-4 and ML-5 were influenced by vehicle traffic along Highway 2 as well as train operations associated with the nearby railway.

The daytime L_{eq} sound level at the long-term monitor was 49 dBA and the nighttime L_{eq} sound level was 46 dBA. The data collected during the 24-hour sound monitoring study showed relative consistency with the short-term measurements; however, since the Facility site is further setback from the roadway, it was not as influenced by traffic-related noise. Also, no rail operations were documented from the railway adjacent to the Ohio River Scenic Byway during the monitoring period.

3.0 FACILITY CONSTRUCTION

Construction of the Facility is expected to be typical of other terminal facilities in terms of schedule, equipment, and activities. Construction is anticipated to require approximately 12 months. Nighttime construction will be limited; however, activities may occur 6 days per week, 10 hours per day. Certain activities, such as foundation pours, cannot be stopped until the task is completed, which may continue into the nighttime period. As required, a night shift may be implemented to maintain schedule or complete a continuous task.

3.1 NOISE CALCULATION METHODOLOGY

Acoustic emission levels for activities associated with Facility construction were based upon typical ranges of energy equivalent noise levels at construction sites, as documented by the U.S. Environmental Protection Agency (USEPA) (USEPA 1971) and the USEPA's "Construction Noise Control Technology Initiatives" (USEPA 1980). The USEPA methodology distinguishes between type of construction and construction phase.

Using those energy equivalent noise levels as input to a basic propagation model, construction noise levels were calculated at the nearest Facility Site boundary and the five MLs.

The basic model assumed spherical wave divergence from a point source located at the acoustic center of the Facility Site. Furthermore, the model conservatively assumed that all pieces of construction equipment associated with an activity would operate simultaneously for the duration of that activity. An additional level of conservatism was built into the construction noise model by excluding potential shielding effects due to intervening structures and buildings along the propagation path from the site to receiver locations.

3.2 PROJECTED NOISE LEVELS DURING CONSTRUCTION

Table 11 summarizes the projected noise levels due to Facility construction, organized into the following five broad work activities:

1. Site clearing and grading;
2. Placement of major structural concrete foundations;
3. Erection of structures;
4. Installation of mechanical and electrical equipment; and
5. Commissioning and testing of equipment.

Based on sound propagation calculations, construction sound levels are predicted to range from 45 to 53 dBA at the MLs. Periodically, sound levels may be higher or lower than those presented in **Table 11**; however, the overall sound levels should generally be lower due to excess attenuation and the trend toward quieter construction equipment in the intervening decades since these data were developed. As shown in **Table 11**, the highest projected sound level from construction-related activity is expected to occur at ML-4 and ML-5, during activities associated with excavation and commissioning.

Table 11. Projected Construction Noise Levels by Phase (dBA)

Construction Phase	USEPA Construction Noise Level 50 feet	ML-1	ML-2	ML-3	ML-4	ML-5
Phase 1: Site clearing and grading	86	45	44	44	48	48
Phase 2: Excavation and placement of major structural concrete foundations	89	49	48	47	51	51
Phase 3: Erection of building structural steel	85	45	43	43	47	47
Phase 4: Installation of mechanical and electrical equipment	83	43	42	42	46	45
Phase 5: Equipment installation, commissioning and testing	89	49	48	48	52	51

3.3 PROJECTED VIBRATION LEVELS DURING CONSTRUCTION

Each project component will incorporate mechanical equipment that will generate vibration levels. Significant vibration producing source will be earth moving equipment such as bull dozers. Blasting it not expected to be required during construction. This study evaluates the worst-case non-blasting source, which will be earth moving equipment

Vibration levels for activities associated with the project components are based on average of source levels in PPV published with the FTA Noise and Vibration Manual (FTA 2018), which documents several types of heavy equipment measured under a wide variety of activities. Using the documented vibration levels as input into a basic propagation model, non-blasting project vibration levels were calculated at various distances from the source. These vibration levels are evaluated based on the worst-case vibration source, which will be bull dozers. Based on vibration propagation calculations, the vibration levels from the earth moving operations will be 0.089 PPV in/sec (87 VdB) at 25 feet from the source and will be 0.001 PPV in/sec (48 VdB) at 500 feet from the source. The vibration levels past 500 feet would not be distinguishable from ambient vibration levels. Based vibration criteria established by the FTA safe level of vibrations for residential type structures is 0.5 PPV in/sec. Annoyance to humans is typically occurs at vibration levels above 80 VdB. **Table 12** provides the vibration levels in 25 foot increments from the source. Based on the calculated vibration levels damage to structures could occur within 25 feet from the source and human annoyance could occur within 50 feet from the source. There are no sensitive receptors that will be located 50 feet or less from the earth moving equipment. There impacts from non-blasting vibrations sources are unlikely to occur.

Table 12. Worst-Case Calculated Non-Blasting Vibration Levels

Feet from Source	Calculated Non-Blasting Vibration Levels	
	PPV In/sec	VdB
25	0.0890	87
50	0.0315	78
75	0.0171	73
100	0.0111	69
125	0.0080	66
150	0.0061	64
175	0.0048	62
200	0.0039	60
225	0.0033	58
250	0.0028	57
275	0.0024	56
300	0.0021	55
325	0.0019	54
350	0.0017	53
375	0.0015	52
400	0.0014	51
425	0.0013	50
450	0.0012	49
475	0.0011	49
500	0.0010	48

3.4 CONSTRUCTION NOISE AND VIBRATION MITIGATION

Since construction machines operate intermittently, and the types of machines in use at the Facility Site change with the phase of construction, noise emitted during construction will be mobile and highly variable, making it challenging to control. The construction management protocols will include the following noise mitigation measures to minimize noise impacts:

- Maintain all construction tools and equipment in good operating order according to manufacturers' specifications;
- Limit use of major excavating and earth moving machinery to daytime hours;
- To the extent practicable, schedule construction activity during normal working hours on weekdays when higher sound levels are typically present, and are found acceptable. Some limited activities, such as concrete pours, will be required to occur continuously until completion;
- Equip any internal combustion engine used for any purpose on the job or related to the job with a properly operating muffler that is free from rust, holes, and leaks;
- For construction devices that utilize internal combustion engines, ensure the engine's housing doors are kept closed, and install noise-insulating material mounted on the engine housing consistent with manufacturers' guidelines, if possible;
- Limit possible evening shift work to low noise activities such as welding, wire pulling and other similar activities, together with appropriate material handling equipment;
- Utilize a Complaint Resolution Procedure to address any noise complaints received from residents; and
- Communicate with neighbors prior to conducting specific loud noise activities such as steam blows.

Reasonable efforts will be made to minimize the impact of noise resulting from construction activities at proximate noise sensitive areas through the use of noise mitigation. Because of the temporary nature of the construction noise, no adverse or long-term effects are expected.

4.0 OPERATIONAL ANALYSIS

This section describes the model utilized for the assessment; input assumptions used to calculate noise levels due to the Facility's normal operation; a conceptual noise mitigation strategy, and the results of the noise impact analysis.

4.1 NOISE PREDICTION MODEL

The Cadna-A® computer noise model was used to calculate sound pressure levels from the operation of the Facility equipment and the rail activities in the vicinity of the Facility Site. An industry standard, Cadna-A® was developed by DataKustik GmbH to provide an estimate of sound levels at distances from sources of known emission. It is used by acousticians and acoustic engineers due to the capability to accurately describe noise emission and propagation from complex facilities consisting of various equipment types like the Facility and in most cases yields conservative results of operational noise levels in the surrounding community.

The current ISO standard for outdoor sound propagation, ISO 9613 Part 2 – "Attenuation of Sound during Propagation Outdoors," was used within Cadna-A® (ISO 1996). The method described in this standard calculates sound attenuation under weather conditions that are favorable for sound propagation, such as for downwind propagation or atmospheric inversion, conditions which are typically considered worst-case. The calculation of sound propagation from source to receiver locations consists of full octave band sound frequency algorithms, which incorporate the following physical effects:

- Geometric spreading wave divergence;
- Reflection from surfaces;
- Atmospheric absorption at 10 degrees Celsius and 70 percent relative humidity;
- Screening by topography and obstacles;
- The effects of terrain features including relative elevations of noise sources;
- Sound power levels from stationary and mobile sources;
- The locations of noise-sensitive land use types;
- Intervening objects including buildings and barrier walls, to the extent included in the design;
- Ground effects due to areas of pavement and unpaved ground;
- Sound power at multiple frequencies;
- Source directivity factors;
- Multiple noise sources and source type (point, area, and/or line); and
- Averaging predicted sound levels over a given time period.

Cadna-A® allows for three basic types of sound sources to be introduced into the model: point, line, and area sources. Each noise-radiating element was modeled based on its noise emission pattern. Point sources were programmed for operational pumps that radiate sound hemispherically. Line sources are used for linear-shaped sources such as rail operations. The interaction between sound sources and structures was taken into account with reflection loss.

Offsite topography was obtained using the publicly available United States Geological Survey digital elevation data. A default ground attenuation factor of 0.5 was assumed for offsite sound propagation over acoustically "mixed" ground. A ground attenuation factor of 0.0 for a reflective surface was assumed for paved onsite areas.

The output from Cadna-A® includes tabular sound level results at selected receiver locations and colored noise contour maps (isopleths) that show areas of equal and similar sound levels.

4.2 INPUT TO THE NOISE PREDICTION MODEL

The Facility general arrangement was reviewed and directly imported into the acoustic model so that on-site equipment could be easily identified; buildings and structures could be added; and sound emission data could be assigned to sources as appropriate. Figure 2 shows the Facility equipment layout.

The primary noise sources during operations include six (6) 200 HP pumps associated with loading NGLs onto rail transportation. Reference sound power levels input to Cadna-A® were based on information contained in reference documents, or developed using empirical methods. The source levels used in the predictive modeling are based on estimated sound power levels that are generally deemed to be conservative. The projected operational noise levels are based on sound power levels published by the Federal Highway Administration (FHWA). **Table 13** summarizes the equipment sound power level data used as inputs to the initial modeling analysis that includes only mitigation inherent in the design.

Table 13. Modeled Octave Band Sound Power Level (L_P) for Major Pieces of Facility Equipment

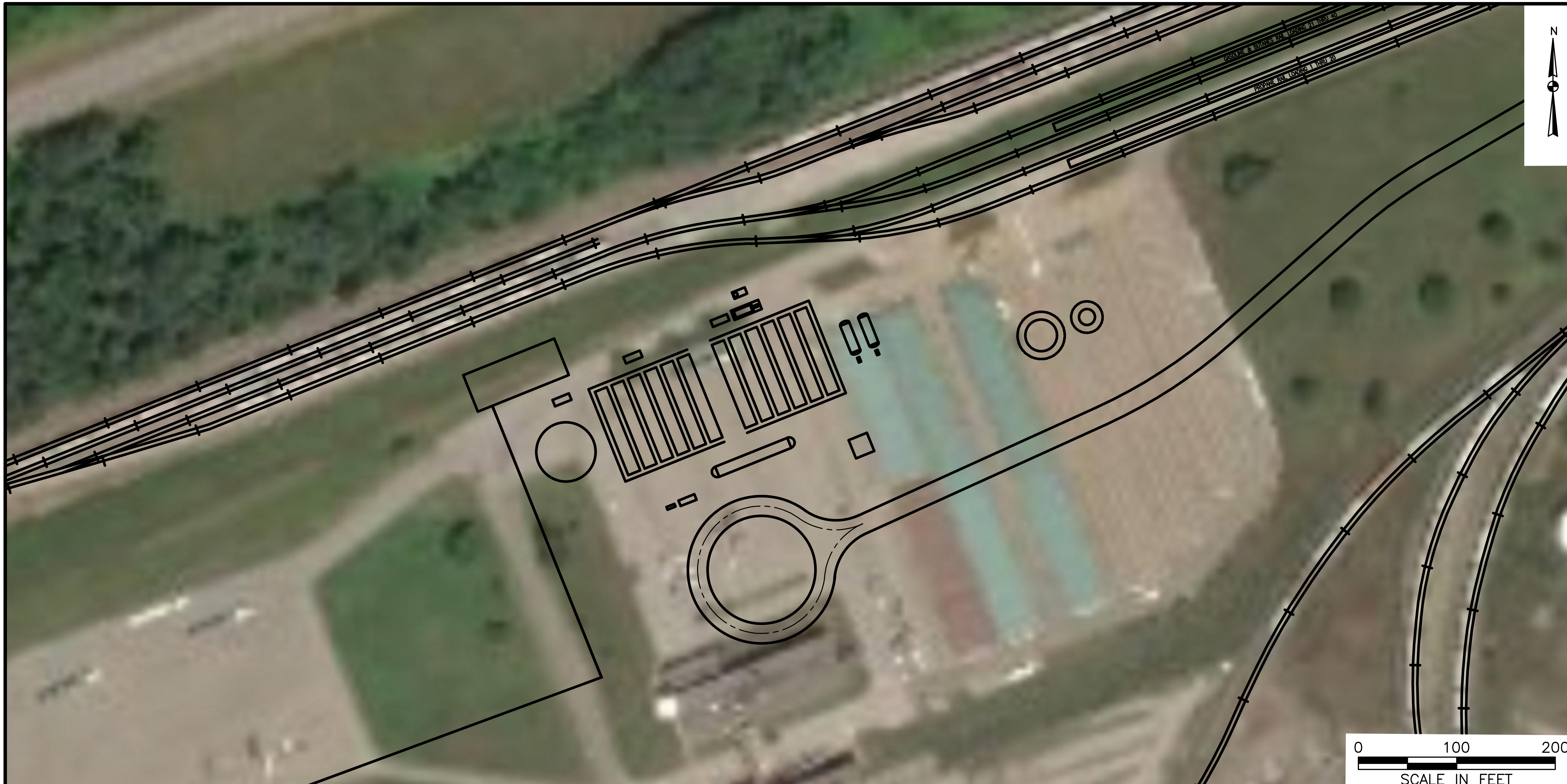
Sound Source	Sound Power Level (L_P) by Octave Band Frequency dBL at 50 feet									Broadband Level
	31.5	63	125	250	500	1k	2k	4k	8k	dBA
200 Hp Pump	96	95	97	97	94	91	87	88	85	97

The noise model also incorporates the arrival and leaving of a single train with 110 cars. The offloading loop incorporates the movement of 40 cars. These inputs are considered to be worst-case assumptions.

4.3 NOISE PREDICTION MODEL RESULTS

Broadband (dBA) sound pressure levels were calculated for expected normal Facility operation assuming that all components identified previously are operating continuously and concurrently at the representative manufacturer-rated sound. The sound energy was then summed to determine the equivalent continuous A-weighted downwind sound pressure level at a point of reception. Sound contour plots displaying broadband (dBA) sound levels presented as color-coded isopleths are provided in Figure 3. The sound contours are graphical representations of the cumulative noise associated with full operation of the equipment and show how operational noise would be distributed over the surrounding area within a 1-mile radius of the Facility Site. The contour lines shown are analogous to elevation contours on a topographic map, i.e., the noise contours are continuous lines of equal noise level around some source, or sources, of noise. Figure 3 also shows the ambient sound monitoring locations, representative of proximate noise sensitive land uses, that were used to assess potential noise impacts on a cumulative basis. The nearest residences are also specifically shown on this figure for land use context.

Table 14 shows the projected exterior sound levels resulting from worst-case operation of the Facility at the MLs. The table also provides the total predicted net increase in sound energy at each of the five MLs, which are representative of proximate noise sensitive areas in each of the principal geographical directions relative to the Facility Site.



NOTE:
AERIAL PHOTO OBTAINED FROM ARCGIS SOFTWARE

TETRA TECH
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T: (330) 286-3683 | F: (330) 286-3573

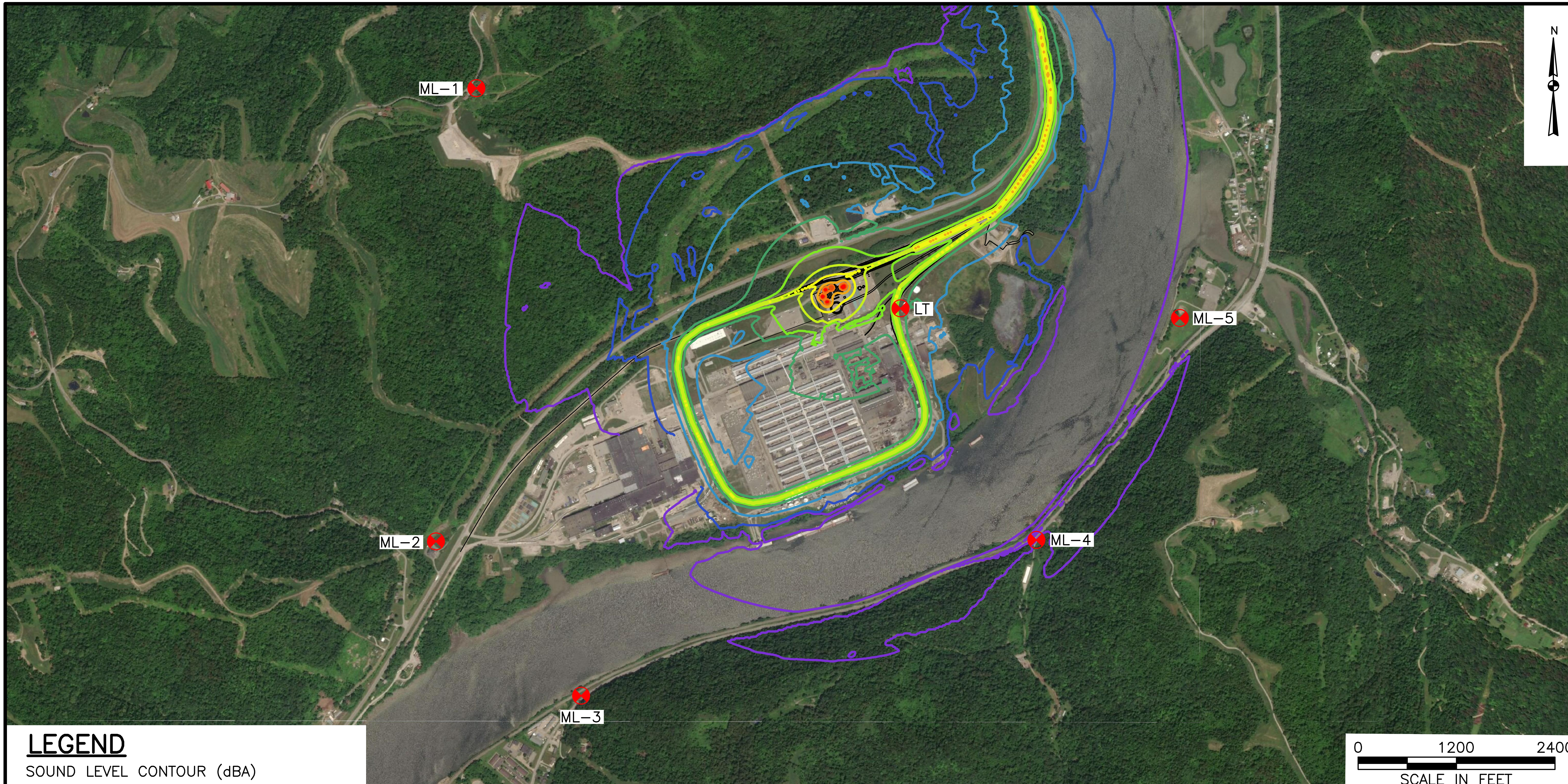
LONG RIDGE TRANSLOADING
MONROE COUNTY, OHIO

FACILITY EQUIPMENT LAYOUT

DATE:	12/12/19
PROJECT NO.:	212C-CF-00264
DESIGNED BY:	KF
DRAWN BY:	JK
CHECKED BY:	KF
SHEET:	2 OF 3

FIGURE 2

X:\CADD\Long Ridge Transloading\212c-cf-00264\FIGURES\Noise Monitoring Figures\FIGURE 2.dwg PIT JIM.KUSIOWSKI 12/13/2019 12:57:14 PM



LEGEND

SOUND LEVEL CONTOUR (dBA)

	30		60
	35		65
	40		70
	45		75
	50		80
	55		MONITORING LOCATION

NOTE:
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LONG RIDGE TRANSLOADING
MONROE COUNTY, OHIO

RECEIVED SOUND LEVELS
PROJECT OPERATION

DATE:	12/12/19
PROJECT NO.:	212C–CF–00264
DESIGNED BY:	KF
DRAWN BY:	JK
CHECKED BY:	KF
SHEET:	3 OF 3

FIGURE 3

X:\CADD\Long Ridge Transloading\212c–cf–00264\FIGURES\Noise Monitoring Figures\FIGURE 3.dwg PIT JIM.KUSIOWSKI 12/13/2019 1:01:24 PM

Table 14. Acoustic Modeling Results Summary

Monitoring Location	Nighttime Ambient L_{eq}, dBA	Facility Sound Level, dBA	Total Sound Level (Ambient + Facility), dBA	Net Increase in Sound Level, dBA
ML-1	42	20	42	<1
ML-2	49	23	49	<1
ML-3	55	25	55	<1
ML-4	54	30	54	<1
ML-5	48	29	48	<1
Long-Term Monitor	46	49	51	5

As shown in Figure 3, the majority of surrounding residences will experience Facility sound levels less than 40 dBA and will result in overall increases of less than 1 dBA or less to the existing nighttime ambient levels. Based on the FTA guidelines the noise levels resulting from the Facility will be consider no impact.

4.4 VIBRATION EVALUATION

The vibration impacts from the Facility and rail operations were evaluated based on the FTA guidelines. The vibration levels from the single train from the Facility would result in levels ranging from 80 to 90 VdB and would be considered an infrequent event. The rail line that services the Facility runs along the Ohio River Scenic Byway. Residents are located on the other side of the roadway approximately over 150 feet from the rail line. The vibration impacts from the single train would be less than 80 VdB at distance of 150 feet or greater. The FTA guidelines establish a vibration impact criteria of 80 VdB from infrequent events at residences. The Facility vibration levels would result in levels less than 80 VdB at the nearest residences and would therefore have no impact.

5.0 CONCLUSIONS

The noise and vibration levels from the Facility have been evaluated for both construction and operation scenarios. At the nearest receptors the Facility would increase the existing ambient noise level by less than 1 dB, which results in no impact based on the FTA criteria. The vibration levels from the Facility construction and railway operations would be less than 80 VdB at the nearest sensitive receptors. These vibration levels would be less than the FTA criteria and result in no impact.

6.0 REFERENCES

ANSI S1.4-1983 American National Standard Specification for Sound Level Meters, (R2006), 1819 L Street, N.W., Sixth Floor, Washington D.C. 20036.

Federal Railroad Administration. 2012. High-Speed Ground Transportation Nosie and Vibration Impact Assessment.

Federal Transit Administration. 2018. Transit Noise and Vibration Impact Assessment Manual. FTA Report No. 0123.

Harris, C. M. 1998. Handbook of Acoustical Measurements and Noise Control, 3rd Edition. Acoustical Society of America.

ISO. 1996. Acoustics – Attenuation of Sound during Propagation Outdoors. Part 2: General Method of Calculation. ISO Standard 9613-2. Geneva, Switzerland.

Kurze, U. and L. Beranek. 1988. Noise and Vibration Control. Institute of Noise Control Engineering, Washington, DC.

USEPA. 1971. Technical Document NTID300.1, Noise from Construction Equipment and Operations, US Building Equipment, and Home Appliances. Prepared by Bolt Beranek and Newman for USEPA Office of Noise Abatement and Control, Washington, DC. December 1971.

USEPA 1980. *Construction Noise Control Technology Initiatives*. Technical Report No. 1789. Prepared by ORI, Inc. Prepared for USEPA, Office of Noise Abatement and Control. September 1980. Available at: http://www.nonoise.org/epa/Roll5/roll5doc22.pdf.

APPENDIX A: EQUIPMENT CALIBRATION CERTIFICATES

Calibration Certificate

Certificate Number 2017004944

Customer:

Tetra Tech Inc
3rd Floor
160 Federal Street
Boston, MA 02110, United States

Model Number	831	***Procedure Number***	D0001.8384		
Serial Number	0004001	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	11 May 2017		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	11 May 2019		
		Temperature	23.71	°C	± 0.25 °C
Description	Larson Davis Model 831 Class 1 Sound Level Meter Firmware Revision: 2.313	***Humidity***	49.5	%RH	± 2.0 %RH
		Static Pressure	86.48	kPa	± 0.13 kPa

Evaluation Method ***Tested with:***

Larson Davis PRM831. S/N 036849
PCB 377B02. S/N 156091
Larson Davis CAL200. S/N 9079
Larson Davis CAL291. S/N 0203

Data reported in dB re 20 μPa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.
Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Correction data from Larson Davis Model 831 Sound Level Meter Manual, I831.01 Rev O, 2016-09-19

For 1/4" microphones, the Larson Davis ADP024 1/4" to 1/2" adaptor is used with the calibrators and the Larson Davis ADP043 1/4" to

1/2" adaptor is used with the preamplifier.

Calibration Check Frequency: 1000 Hz; Reference Sound Pressure Level: 114 dB re 20 μPa; Reference Range: 0 dB gain

Periodic tests were performed in accordance with precedures from IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part3.

Pattern approval for IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 successfully completed by Physikalisch-Technische Bundesanstalt (PTB) on 2016-02-24 certificate number DE-15-M-PTB-0056.

The sound level meter submitted for testing successfully completed the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3, for the environmental conditions under which the tests were performed. As evidence was publicly available, from an independent testing organization responsible for approving the results of pattern-evaluation tests performed in accordance with IEC 61672-2:2013 / ANSI/ASA S1.4-2014/Part 2, to demonstrate that the model of sound level meter fully conformed to the class 1 specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1; the sound level meter submitted for testing conforms to the class 1specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
SRS DS360 Ultra Low Distortion Generator	2016-06-21	2017-06-21	006311
Hart Scientific 2626-S Humidity/Temperature Sensor	2016-06-17	2017-06-17	006946
Larson Davis CAL200 Acoustic Calibrator	2016-07-26	2017-07-26	007027
Larson Davis Model 831	2017-03-01	2018-03-01	007182
PCB 377A13 1/2 inch Prepolarized Pressure Microphone	2017-03-08	2018-03-08	007185
Larson Davis CAL291 Residual Intensity Calibrator	2016-09-22	2017-09-22	007287

Acoustic Calibration

Measured according to IEC 61672-3:2013 10 and ANSI S1.4-2014 Part 3: 10

Measurement	Test Result [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
1000 Hz	114.01	113.80	114.20	0.14	Pass

As Received Level: 114.33
Adjusted Level: 114.01

-- End of measurement results--

Acoustic Signal Tests, C-weighting

Measured according to IEC 61672-3:2013 12 and ANSI S1.4-2014 Part 3: 12 using a comparison coupler with Unit Under Test (UUT) and reference SLM using slow time-weighted sound level for compliance to IEC 61672-1:2013 5.5; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Expected [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
125	-0.20	-0.20	-1.20	0.80	0.23	Pass
1000	0.19	0.00	-0.70	0.70	0.23	Pass
8000	-2.58	-3.00	-5.50	-1.50	0.32	Pass

-- End of measurement results--

Self-generated Noise

Measured according to IEC 61672-3:2013 11.1 and ANSI S1.4-2014 Part 3: 11.1

Measurement	Test Result [dB]
A-weighted, 20 dB gain	37.91

-- End of measurement results--

-- End of Report--

Signatory: Ron Harris

Larson Davis, a division of PCB Piezotronics, Inc
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ACCREDITED
Cert. #3622.01

LARSON DAVIS
A PCB PIEZOTRONICS DIV.

Calibration Certificate

Certificate Number 2017003261

Customer:

Tetra Tech Inc
3rd Floor
160 Federal Street
Boston, MA 02110, United States

Model Number	831	***Procedure Number***	D0001.8378		
Serial Number	0003847	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	30 Mar 2017		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	30 Mar 2018		
Description	Larson Davis Model 831 Class 1 Sound Level Meter Firmware Revision: 2.311	***Temperature*** ***Humidity*** ***Static Pressure***	23.3 50 85.65	°C %RH kPa	± 0.25 °C ± 2.0 %RH ± 0.13 kPa

Evaluation Method Tested electrically using Larson Davis PRM831 S/N 036754 and a 12.0 pF capacitor to simulate microphone capacitance. Data reported in dB re 20 μPa assuming a microphone sensitivity of 50.0 mV/Pa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8384:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005. **Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.**

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis Model 831 Sound Level Meter Manual, I831.01 Rev O, 2016-09-19

Calibration Check Frequency: 1000 Hz; Reference Sound Pressure Level: 114 dB re 20 μPa; Reference Range: 0 dB gain

Periodic tests were performed in accordance with precedures from IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part3.

Pattern approval for IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 successfully completed by Physikalisch-Technische Bundesanstalt (PTB) on 2016-02-24 certificate number DE-15-M-PTB-0056.

The sound level meter submitted for testing successfully completed the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3, for the environmental conditions under which the tests were performed. As evidence was publicly available, from an independent testing organization responsible for approving the results of pattern-evaluation tests performed in accordance with IEC 61672-2:2013 / ANSI/ASA S1.4-2014/Part 2, to demonstrate that the model of sound level meter fully conformed to the class 1 specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1; the sound level meter submitted for testing conforms to the class 1specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
Hart Scientific 2626-S Humidity/Temperature Sensor	2016-06-17	2017-06-17	006946
SRS DS360 Ultra Low Distortion Generator	2017-03-16	2018-03-16	007174

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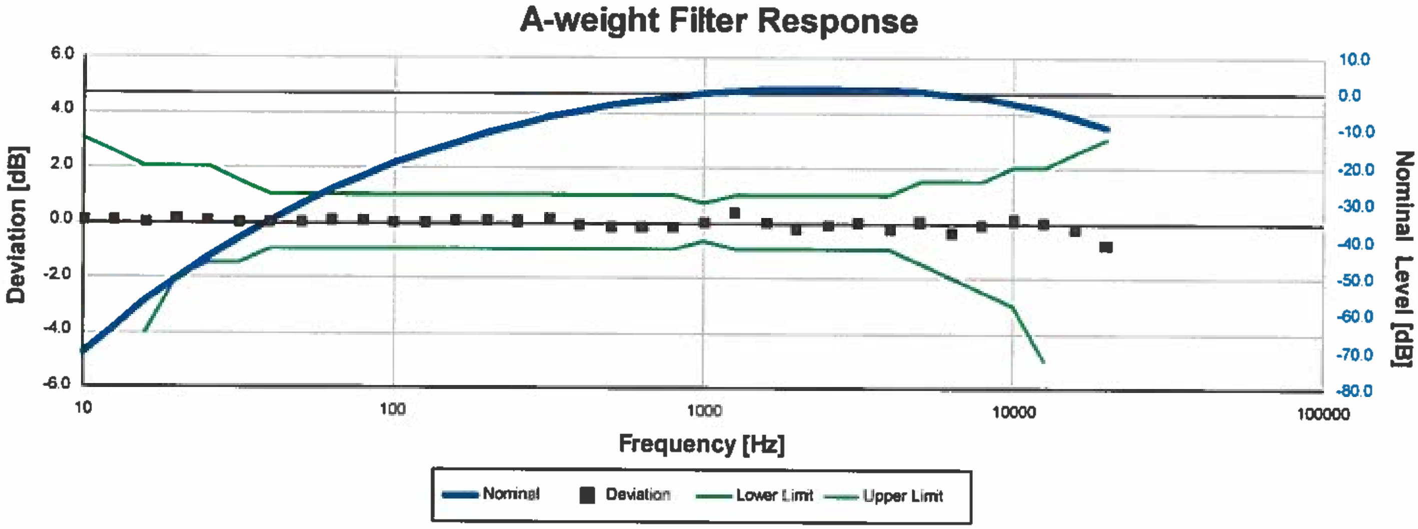

Electrical signal test of frequency weighting performed according to IEC 61672-3:2013 13 and ANSI S1.4-2014 Part 3: 13 for compliance to IEC 61672-1:2013 5.5; IEC 60651:2001 6.1 and 9.2.2; IEC 60804:2000 5; ANSI S1.4:1983 (R2006) 5.1 and 8.2.1; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Deviation [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
10.00	-70.30	0.10	-inf	3.00	0.22	Pass
12.59	-63.34	0.06	-inf	2.50	0.22	Pass
15.85	-56.68	0.02	-4.00	2.00	0.22	Pass
19.95	-50.35	0.15	-2.00	2.00	0.22	Pass
25.12	-44.62	0.08	-1.50	2.00	0.22	Pass
31.62	-39.37	0.03	-1.50	1.50	0.22	Pass
39.81	-34.57	0.03	-1.00	1.00	0.22	Pass
50.12	-30.21	-0.01	-1.00	1.00	0.22	Pass
63.10	-26.14	0.06	-1.00	1.00	0.22	Pass
79.43	-22.45	0.05	-1.00	1.00	0.22	Pass
100.00	-19.11	-0.01	-1.00	1.00	0.22	Pass
125.89	-16.12	-0.02	-1.00	1.00	0.22	Pass
158.49	-13.32	0.08	-1.00	1.00	0.22	Pass
199.53	-10.82	0.08	-1.00	1.00	0.22	Pass
251.19	-8.56	0.04	-1.00	1.00	0.22	Pass
316.23	-6.47	0.13	-1.00	1.00	0.22	Pass
398.11	-4.89	-0.09	-1.00	1.00	0.22	Pass
501.19	-3.33	-0.13	-1.00	1.00	0.22	Pass
630.96	-2.04	-0.14	-1.00	1.00	0.22	Pass
794.33	-0.96	-0.16	-1.00	1.00	0.22	Pass
1,000.00	0.00	0.00	-0.70	0.70	0.22	Pass
1,258.93	0.98	0.38	-1.00	1.00	0.22	Pass
1,584.89	1.02	0.02	-1.00	1.00	0.22	Pass
1,995.26	0.99	-0.21	-1.00	1.00	0.22	Pass
2,511.89	1.26	-0.04	-1.00	1.00	0.22	Pass
3,162.28	1.19	-0.01	-1.00	1.00	0.22	Pass
3,981.07	0.82	-0.18	-1.00	1.00	0.22	Pass
5,011.87	0.54	0.04	-1.50	1.50	0.22	Pass
6,309.57	-0.44	-0.34	-2.00	1.50	0.22	Pass
7,943.28	-1.19	-0.09	-2.50	1.50	0.22	Pass
10,000.00	-2.39	0.11	-3.00	2.00	0.22	Pass
12,589.25	-4.31	-0.01	-5.00	2.00	0.22	Pass
15,848.93	-6.82	-0.22	-16.00	2.50	0.22	Pass
19,952.62	-10.07	-0.77	-inf	3.00	0.22	Pass

-- End of measurement results--

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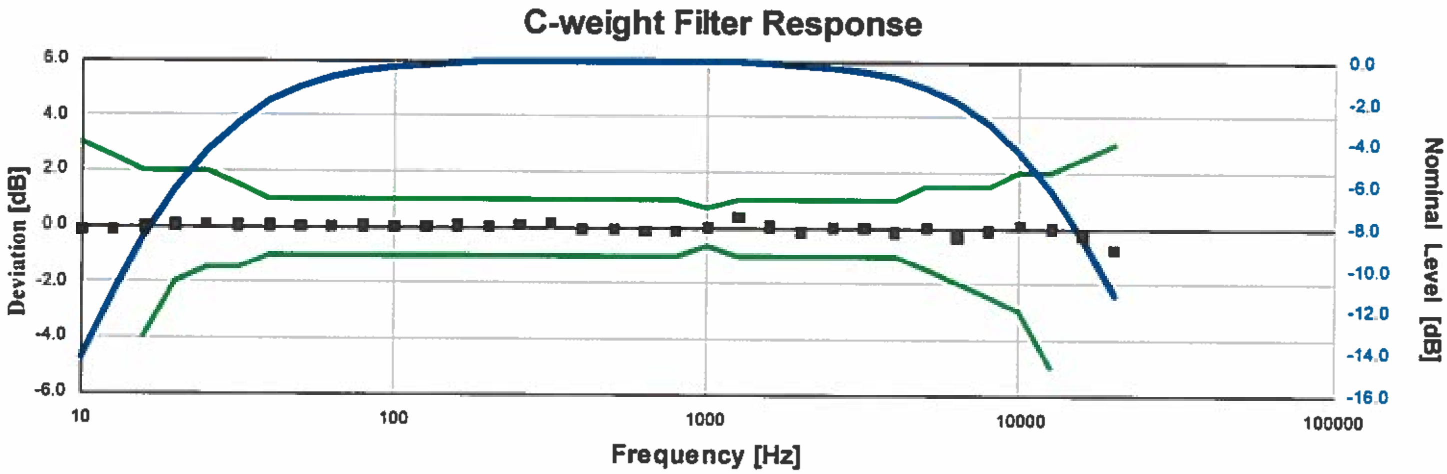

Electrical signal test of frequency weighting performed according to IEC 61672-3:2013 13 and ANSI S1.4-2014 Part 3: 13 for compliance to IEC 61672-1:2013 5.5; IEC 60651:2001 6.1 and 9.2.2; IEC 60804:2000 5; ANSI S1.4:1983 (R2006) 5.1 and 8.2.1; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Deviation [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
10.00	-14.42	-0.12	-inf	3.00	0.22	Pass
12.59	-11.31	-0.11	-inf	2.50	0.22	Pass
15.85	-8.53	-0.03	-4.00	2.00	0.22	Pass
19.95	-6.15	0.05	-2.00	2.00	0.22	Pass
25.12	-4.33	0.07	-1.50	2.00	0.22	Pass
31.62	-2.94	0.06	-1.50	1.50	0.22	Pass
39.81	-1.94	0.06	-1.00	1.00	0.22	Pass
50.12	-1.27	0.03	-1.00	1.00	0.22	Pass
63.10	-0.76	0.04	-1.00	1.00	0.22	Pass
79.43	-0.45	0.05	-1.00	1.00	0.22	Pass
100.00	-0.26	0.04	-1.00	1.00	0.22	Pass
125.89	-0.19	0.01	-1.00	1.00	0.22	Pass
158.49	-0.05	0.05	-1.00	1.00	0.22	Pass
199.53	0.00	0.00	-1.00	1.00	0.22	Pass
251.19	0.06	0.06	-1.00	1.00	0.22	Pass
316.23	0.16	0.16	-1.00	1.00	0.22	Pass
398.11	-0.05	-0.05	-1.00	1.00	0.22	Pass
501.19	-0.06	-0.06	-1.00	1.00	0.22	Pass
630.96	-0.11	-0.11	-1.00	1.00	0.22	Pass
794.33	-0.12	-0.12	-1.00	1.00	0.22	Pass
1,000.00	0.00	0.00	-0.70	0.70	0.22	Pass
1,258.93	0.35	0.35	-1.00	1.00	0.22	Pass
1,584.89	-0.04	0.06	-1.00	1.00	0.22	Pass
1,995.26	-0.38	-0.18	-1.00	1.00	0.22	Pass
2,511.89	-0.31	-0.01	-1.00	1.00	0.22	Pass
3,162.28	-0.51	-0.01	-1.00	1.00	0.22	Pass
3,981.07	-0.97	-0.17	-1.00	1.00	0.22	Pass
5,011.87	-1.29	0.01	-1.50	1.50	0.22	Pass
6,309.57	-2.32	-0.32	-2.00	1.50	0.22	Pass
7,943.28	-3.09	-0.09	-2.50	1.50	0.22	Pass
10,000.00	-4.30	0.10	-3.00	2.00	0.22	Pass
12,589.25	-6.23	-0.03	-5.00	2.00	0.22	Pass
15,848.93	-8.74	-0.24	-16.00	2.50	0.22	Pass
19,952.62	-12.00	-0.80	-inf	3.00	0.22	Pass

-- End of measurement results--

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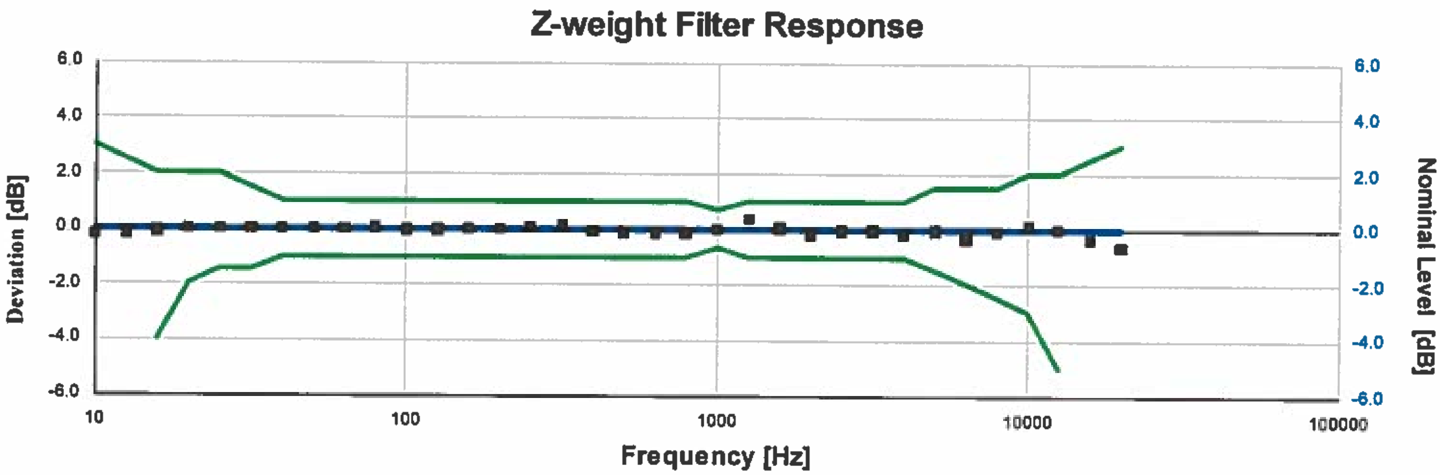

Electrical signal test of frequency weighting performed according to IEC 61672-3:2013 13 and ANSI S1.4-2014 Part 3: 13 for compliance to IEC 61672-1:2013 5.5; IEC 60651:2001 6.1 and 9.2.2; IEC 60804:2000 5; ANSI S1.4:1983 (R2006) 5.1 and 8.2.1; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Deviation [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
10.00	-0.21	-0.21	-inf	3.00	0.22	Pass
12.59	-0.17	-0.17	-inf	2.50	0.22	Pass
15.85	-0.10	-0.10	-4.00	2.00	0.22	Pass
19.95	0.02	0.02	-2.00	2.00	0.22	Pass
25.12	0.02	0.02	-1.50	2.00	0.22	Pass
31.62	0.04	0.04	-1.50	1.50	0.22	Pass
39.81	0.03	0.03	-1.00	1.00	0.22	Pass
50.12	0.01	0.01	-1.00	1.00	0.22	Pass
63.10	0.03	0.03	-1.00	1.00	0.22	Pass
79.43	0.05	0.05	-1.00	1.00	0.22	Pass
100.00	-0.02	-0.02	-1.00	1.00	0.22	Pass
125.89	-0.03	-0.03	-1.00	1.00	0.22	Pass
158.49	0.04	0.04	-1.00	1.00	0.22	Pass
199.53	0.04	0.04	-1.00	1.00	0.22	Pass
251.19	0.07	0.07	-1.00	1.00	0.22	Pass
316.23	0.14	0.14	-1.00	1.00	0.22	Pass
398.11	-0.07	-0.07	-1.00	1.00	0.22	Pass
501.19	-0.10	-0.10	-1.00	1.00	0.22	Pass
630.96	-0.13	-0.13	-1.00	1.00	0.22	Pass
794.33	-0.13	-0.13	-1.00	1.00	0.22	Pass
1,000.00	0.00	0.00	-0.70	0.70	0.22	Pass
1,258.93	0.39	0.39	-1.00	1.00	0.22	Pass
1,584.89	0.04	0.04	-1.00	1.00	0.22	Pass
1,995.26	-0.21	-0.21	-1.00	1.00	0.22	Pass
2,511.89	-0.02	-0.02	-1.00	1.00	0.22	Pass
3,162.28	-0.02	-0.02	-1.00	1.00	0.22	Pass
3,981.07	-0.16	-0.16	-1.00	1.00	0.22	Pass
5,011.87	-0.01	-0.01	-1.50	1.50	0.22	Pass
6,309.57	-0.32	-0.32	-2.00	1.50	0.22	Pass
7,943.28	-0.04	-0.04	-2.50	1.50	0.22	Pass
10,000.00	0.16	0.17	-3.00	2.00	0.22	Pass
12,589.25	0.02	0.02	-5.00	2.00	0.22	Pass
15,848.93	-0.35	-0.35	-16.00	2.50	0.22	Pass
19,952.62	-0.66	-0.66	-inf	3.00	0.22	Pass

-- End of measurement results--

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High Level Stability

Electrical signal test of high level stability performed according to IEC 61672-3:2013 21 and ANSI S1.4-2014 Part 3: 21 for compliance to IEC 61672-1:2013 5.15 and ANSI S1.4-2014 Part 1: 5.15

Measurement	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
High Level Stability	0.00	-0.10	0.10	0.01	Pass

-- End of measurement results--

Long-Term Stability

Electrical signal test of long term stability performed according to IEC 61672-3:2013 15 and ANSI S1.4-2014 Part 3: 15 for compliance to ISC 61672-1:2013 5.14 and ANSI S1.4-2014 Part 1: 5.14

Test Duration [min]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
33	0.00	-0.10	0.10	0.01	Pass

-- End of measurement results--

1 kHz Reference Levels

Frequency weightings and time weightings at 1 kHz (reference is A weighted Fast) performed according to IEC 61672-3:2013 14 and ANSI S1.4-2014 Part 3: 14 for compliance to IEC 61672-1:2013 5.5.9 and 5.8.3 and ANSI S1.4-2014 Part 1: 5.5.9 and 5.8.3

Measurement	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
C weight	114.00	113.80	114.20	0.09	Pass
Z weight	114.00	113.80	114.20	0.09	Pass
Slow	114.00	113.90	114.10	0.09	Pass
Impulse	114.00	113.90	114.10	0.09	Pass

-- End of measurement results--

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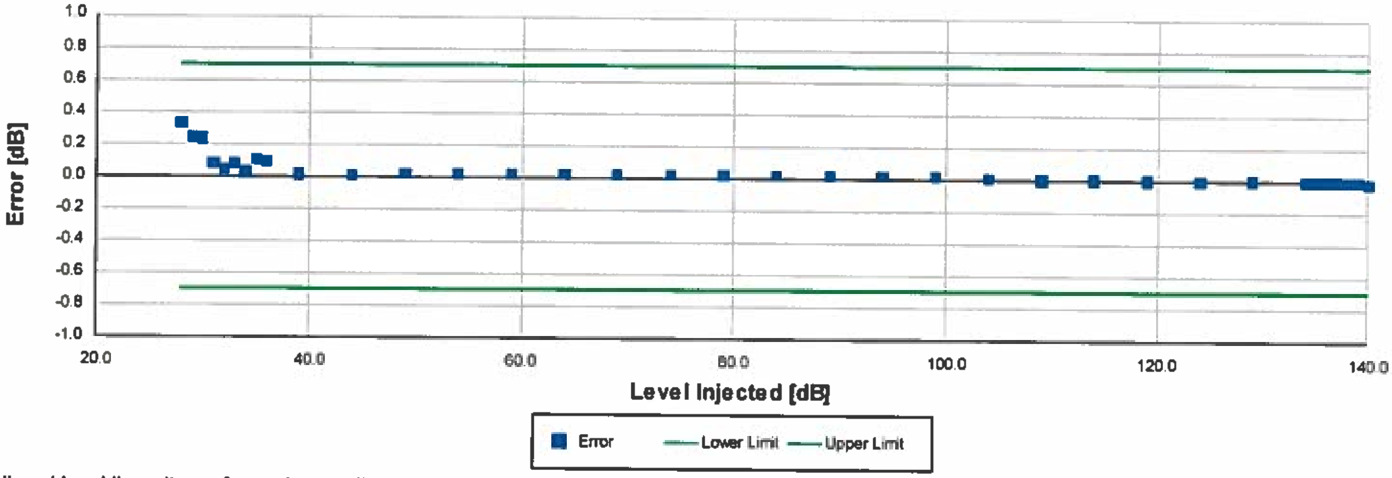
A-weighted 0 dB Broadband Log Linearity: 8,000.00 Hz



Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
28.00	0.33	-0.70	0.70	0.09	Pass
29.00	0.24	-0.70	0.70	0.09	Pass
30.00	0.23	-0.70	0.70	0.09	Pass
31.00	0.08	-0.70	0.70	0.09	Pass
32.00	0.04	-0.70	0.70	0.09	Pass
33.00	0.08	-0.70	0.70	0.09	Pass
34.00	0.02	-0.70	0.70	0.09	Pass
35.00	0.11	-0.70	0.70	0.09	Pass
36.00	0.09	-0.70	0.70	0.09	Pass
39.00	0.01	-0.70	0.70	0.09	Pass
44.00	0.00	-0.70	0.70	0.09	Pass
49.00	0.02	-0.70	0.70	0.09	Pass
54.00	0.02	-0.70	0.70	0.09	Pass
59.00	0.02	-0.70	0.70	0.09	Pass
64.00	0.02	-0.70	0.70	0.09	Pass
69.00	0.02	-0.70	0.70	0.09	Pass
74.00	0.02	-0.70	0.70	0.09	Pass
79.00	0.02	-0.70	0.70	0.09	Pass
84.00	0.02	-0.70	0.70	0.09	Pass
89.00	0.02	-0.70	0.70	0.09	Pass
94.00	0.02	-0.70	0.70	0.09	Pass
99.00	0.01	-0.70	0.70	0.09	Pass
104.00	0.00	-0.70	0.70	0.09	Pass
109.00	0.00	-0.70	0.70	0.09	Pass
114.00	0.00	-0.70	0.70	0.09	Pass
119.00	0.00	-0.70	0.70	0.09	Pass
124.00	0.00	-0.70	0.70	0.09	Pass
129.00	0.00	-0.70	0.70	0.09	Pass
134.00	0.00	-0.70	0.70	0.09	Pass
135.00	-0.01	-0.70	0.70	0.09	Pass
136.00	-0.01	-0.70	0.70	0.09	Pass
137.00	-0.01	-0.70	0.70	0.09	Pass
138.00	-0.01	-0.70	0.70	0.09	Pass
139.00	-0.01	-0.70	0.70	0.09	Pass
140.00	-0.02	-0.70	0.70	0.09	Pass

-- End of measurement results--

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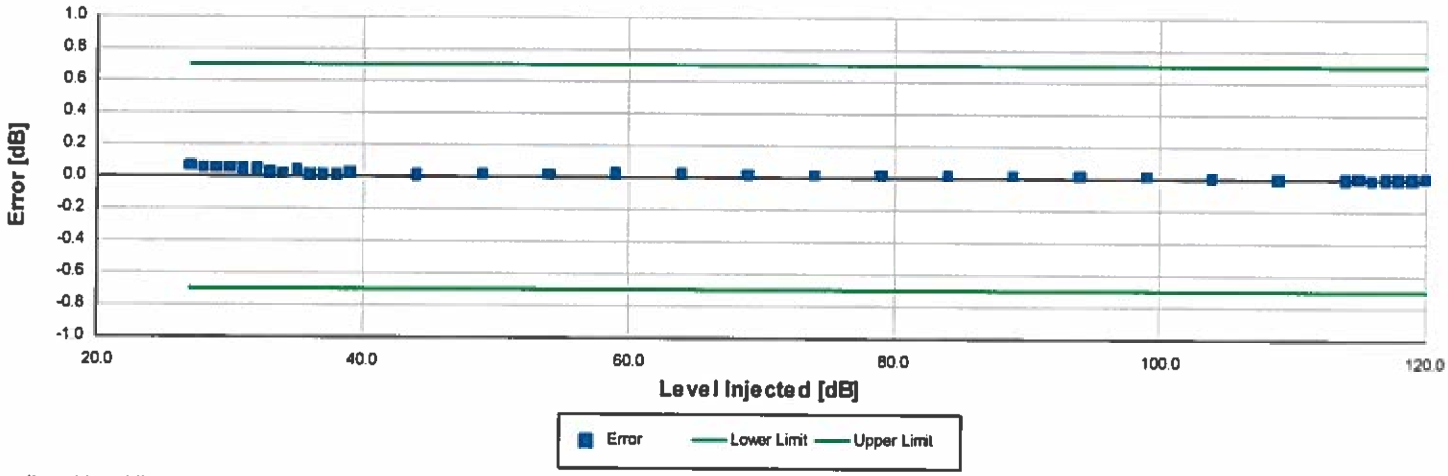
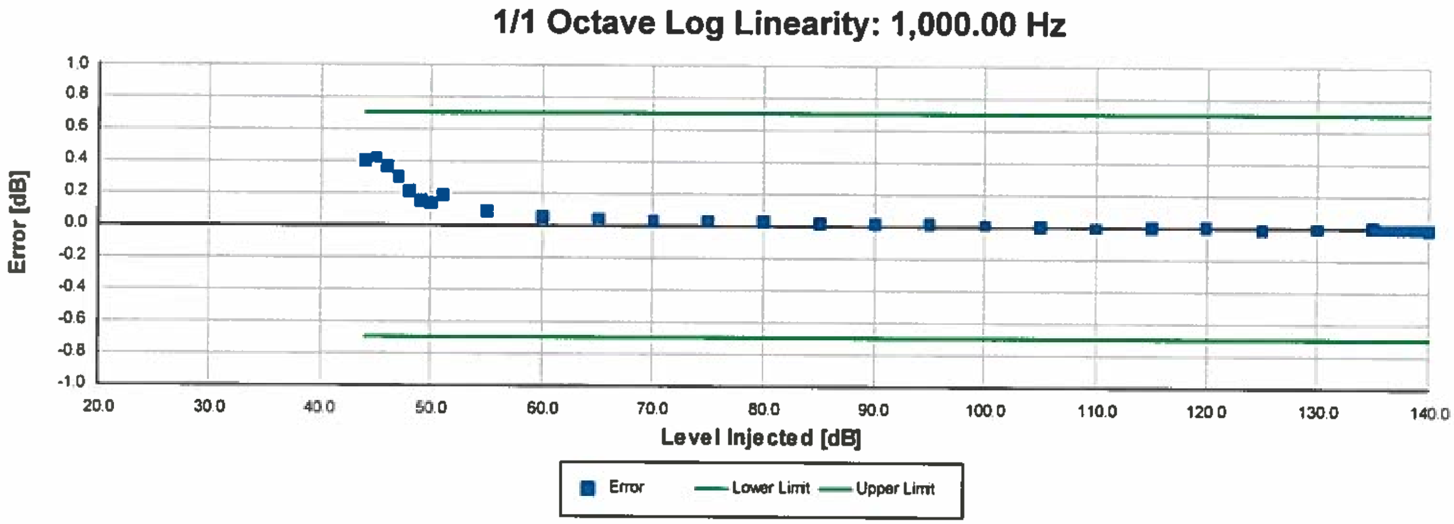
A-weighted 20 dB Broadband Log Linearity: 8,000.00 Hz



Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
27.00	0.07	-0.70	0.70	0.09	Pass
28.00	0.05	-0.70	0.70	0.09	Pass
29.00	0.05	-0.70	0.70	0.09	Pass
30.00	0.05	-0.70	0.70	0.09	Pass
31.00	0.05	-0.70	0.70	0.09	Pass
32.00	0.05	-0.70	0.70	0.09	Pass
33.00	0.02	-0.70	0.70	0.09	Pass
34.00	0.02	-0.70	0.70	0.09	Pass
35.00	0.04	-0.70	0.70	0.09	Pass
36.00	0.01	-0.70	0.70	0.09	Pass
37.00	0.01	-0.70	0.70	0.09	Pass
38.00	0.01	-0.70	0.70	0.09	Pass
39.00	0.02	-0.70	0.70	0.09	Pass
44.00	0.01	-0.70	0.70	0.09	Pass
49.00	0.02	-0.70	0.70	0.09	Pass
54.00	0.01	-0.70	0.70	0.09	Pass
59.00	0.02	-0.70	0.70	0.09	Pass
64.00	0.02	-0.70	0.70	0.09	Pass
69.00	0.02	-0.70	0.70	0.09	Pass
74.00	0.02	-0.70	0.70	0.09	Pass
79.00	0.02	-0.70	0.70	0.09	Pass
84.00	0.02	-0.70	0.70	0.09	Pass
89.00	0.02	-0.70	0.70	0.09	Pass
94.00	0.01	-0.70	0.70	0.09	Pass
99.00	0.01	-0.70	0.70	0.09	Pass
104.00	0.00	-0.70	0.70	0.09	Pass
109.00	0.00	-0.70	0.70	0.09	Pass
114.00	0.00	-0.70	0.70	0.09	Pass
115.00	0.00	-0.70	0.70	0.09	Pass
116.00	-0.01	-0.70	0.70	0.09	Pass
117.00	0.00	-0.70	0.70	0.09	Pass
118.00	0.00	-0.70	0.70	0.09	Pass
119.00	-0.01	-0.70	0.70	0.09	Pass
120.00	0.00	-0.70	0.70	0.09	Pass

-- End of measurement results--



1/1 octave level linearity at normal range with 0 dB gain performed according to IEC 61260:2001 4.6, ANSI S.11 (R2009) 4.6

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
44.00	0.40	-0.70	0.70	0.09	Pass
45.00	0.42	-0.70	0.70	0.09	Pass
46.00	0.37	-0.70	0.70	0.09	Pass
47.00	0.30	-0.70	0.70	0.10	Pass
48.00	0.21	-0.70	0.70	0.10	Pass
49.00	0.15	-0.70	0.70	0.10	Pass
50.00	0.14	-0.70	0.70	0.09	Pass
51.00	0.19	-0.70	0.70	0.09	Pass
55.00	0.08	-0.70	0.70	0.09	Pass
60.00	0.05	-0.70	0.70	0.09	Pass
65.00	0.04	-0.70	0.70	0.09	Pass
70.00	0.02	-0.70	0.70	0.09	Pass
75.00	0.03	-0.70	0.70	0.09	Pass
80.00	0.02	-0.70	0.70	0.09	Pass
85.00	0.01	-0.70	0.70	0.09	Pass
90.00	0.01	-0.70	0.70	0.09	Pass
95.00	0.01	-0.70	0.70	0.09	Pass
100.00	0.01	-0.70	0.70	0.09	Pass
105.00	0.00	-0.70	0.70	0.09	Pass
110.00	-0.01	-0.70	0.70	0.09	Pass
115.00	0.00	-0.70	0.70	0.09	Pass
120.00	0.00	-0.70	0.70	0.09	Pass
125.00	-0.01	-0.70	0.70	0.09	Pass
130.00	-0.01	-0.70	0.70	0.09	Pass
135.00	0.00	-0.70	0.70	0.09	Pass
136.00	-0.01	-0.70	0.70	0.09	Pass
137.00	-0.01	-0.70	0.70	0.09	Pass
138.00	-0.01	-0.70	0.70	0.09	Pass
139.00	-0.01	-0.70	0.70	0.09	Pass
140.00	-0.02	-0.70	0.70	0.09	Pass

– End of measurement results–

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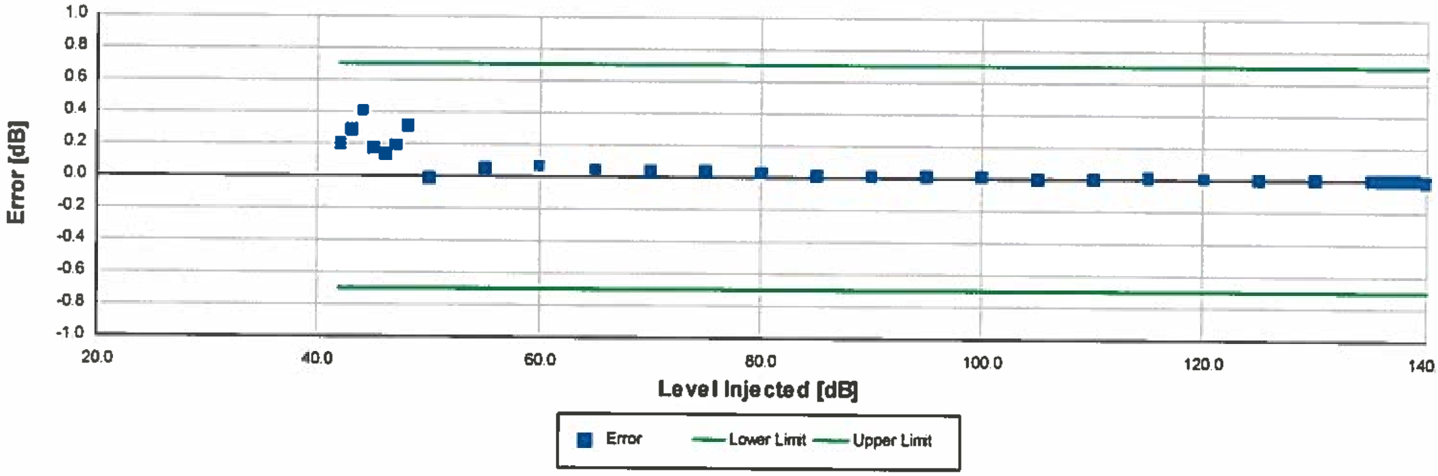
1/3 Octave Log Linearity: 1,000.00 Hz



1/3 octave level linearity at normal range with 0 dB gain performed according to IEC 61260:2001 4.6, ANSI S.11 (R2009) 4.6

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
42.00	0.20	-0.70	0.70	0.09	Pass
43.00	0.29	-0.70	0.70	0.10	Pass
44.00	0.40	-0.70	0.70	0.10	Pass
45.00	0.17	-0.70	0.70	0.10	Pass
46.00	0.14	-0.70	0.70	0.09	Pass
47.00	0.19	-0.70	0.70	0.09	Pass
48.00	0.31	-0.70	0.70	0.09	Pass
50.00	-0.02	-0.70	0.70	0.09	Pass
55.00	0.05	-0.70	0.70	0.09	Pass
60.00	0.07	-0.70	0.70	0.09	Pass
65.00	0.04	-0.70	0.70	0.09	Pass
70.00	0.03	-0.70	0.70	0.09	Pass
75.00	0.04	-0.70	0.70	0.09	Pass
80.00	0.03	-0.70	0.70	0.09	Pass
85.00	0.01	-0.70	0.70	0.09	Pass
90.00	0.01	-0.70	0.70	0.09	Pass
95.00	0.01	-0.70	0.70	0.09	Pass
100.00	0.01	-0.70	0.70	0.09	Pass
105.00	0.00	-0.70	0.70	0.09	Pass
110.00	0.00	-0.70	0.70	0.09	Pass
115.00	0.01	-0.70	0.70	0.09	Pass
120.00	0.01	-0.70	0.70	0.09	Pass
125.00	-0.01	-0.70	0.70	0.09	Pass
130.00	0.00	-0.70	0.70	0.09	Pass
135.00	0.00	-0.70	0.70	0.09	Pass
136.00	0.00	-0.70	0.70	0.09	Pass
137.00	0.00	-0.70	0.70	0.09	Pass
138.00	0.00	-0.70	0.70	0.09	Pass
139.00	0.00	-0.70	0.70	0.09	Pass
140.00	-0.01	-0.70	0.70	0.09	Pass

-- End of measurement results--

Slow Detector

Toneburst response performed according to IEC 61672-3:2013 18 and ANSI S1.4-2014 Part 3: 18 for compliance to IEC 61672-1:2013 5.9, IEC 60651:2001 9.4.2, ANSI S1.4:1983 (R2006) 8.4.2 and ANSI S1.4-2014 Part 1: 5.9

Amplitude [dB]	Duration [ms]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
137.00	200	-7.55	-7.92	-6.92	0.09	Pass
	2	-27.19	-29.99	-25.99	0.09	Pass

-- End of measurement results--

Fast Detector

Toneburst response performed according to IEC 61672-3:2013 18 and ANSI S1.4-2014 Part 3: 18 for compliance to IEC 61672-1:2013 5.9, IEC 60651:2001 9.4.2, ANSI S1.4:1983 (R2006) 8.4.2 and ANSI S1.4-2014 Part 1: 5.9

Amplitude [dB]	Duration [ms]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
137.00	200.00	-1.04	-1.48	-0.48	0.09	Pass
	2.00	-18.12	-19.49	-16.99	0.09	Pass
	0.25	-27.49	-29.99	-25.99	0.09	Pass

-- End of measurement results--

Sound Exposure Level

Toneburst response performed according to IEC 61672-3:2013 18 and ANSI S1.4-2014 Part 3: 18 for compliance to IEC 61672-1:2013 5.9, IEC 60651:2001 9.4.2, ANSI S1.4:1983 (R2006) 8.4.2 and ANSI S1.4-2014 Part 1: 5.9

Amplitude [dB]	Duration [ms]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
137.00	200.00	-7.02	-7.49	-6.49	0.09	Pass
	2.00	-27.05	-28.49	-25.99	0.09	Pass
	0.25	-36.16	-39.02	-35.02	0.09	Pass

-- End of measurement results--

Peak C-weight

C-weighted peak sound level performed according to IEC 61672-3:2013 19 and ANSI S1.4-2014 Part 3: 19 for compliance to IEC 61672-1:2013 5.13 and ANSI S1.4-2014 Part 1: 5.13

Level [dB]	Frequency [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
135.00	31.50	138.21	135.50	139.50	0.09	Pass
135.00	500.00	138.55	137.50	139.50	0.09	Pass
135.00	8,000.00	137.72	136.40	140.40	0.10	Pass
135.00, Negative	500.00	137.15	136.40	138.40	0.09	Pass
135.00, Positive	500.00	137.15	136.40	138.40	0.09	Pass

-- End of measurement results--

Peak Z-weight

Z-weighted peak sound level performed according to IEC 60651:2001 9.4.4 and ANSI S1.4:1983 (R2006) 8.4.4

Amplitude [dB]	Duration[µs]		Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
136.00	100	Negative Pulse	136.35	134.00	138.00	0.09	Pass
	100	Positive Pulse	136.24	134.01	138.01	0.09	Pass
126.00	100	Negative Pulse	126.12	124.00	128.00	0.09	Pass
	100	Positive Pulse	126.29	124.00	128.00	0.09	Pass
116.00	100	Negative Pulse	116.09	114.00	118.00	0.09	Pass
	100	Positive Pulse	116.21	114.00	118.00	0.09	Pass
106.00	100	Negative Pulse	106.29	103.95	107.95	0.09	Pass
	100	Positive Pulse	106.31	103.99	107.99	0.09	Pass

-- End of measurement results--

Overload Detector

Overload indication performed according to IEC 61672-3:2013 20 and ANSI S1.4-2014 Part 3: 20 for compliance to IEC 61672-1:2013 5.11, IEC 60804:2000 9.3.5, IEC 61252:2002 11, ANSI S1.4 (R2006) 5.8, and ANSI S1.4-2014 Part 1: 5.11, ANSI S1.25 (R2007) 7.6, ANSI S1.43 (R2007) 7

Measurement	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
Positive	141.10	140.00	142.00	0.09	Pass
Negative	140.90	140.00	142.00	0.09	Pass
Difference	0.20	-1.50	1.50	0.10	Pass

-- End of measurement results--

Peak Rise Time

Peak rise time performed according to IEC 60651:2001 9.4.4 and ANSI S1.4:1983 (R2006) 8.4.4

Amplitude [dB]	Duration [µs]		Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
137.00	40	Negative Pulse	136.48	134.99	136.99	0.09	Pass
		Positive Pulse	136.50	135.00	137.00	0.09	Pass
	30	Negative Pulse	135.56	134.99	136.99	0.09	Pass
		Positive Pulse	135.43	135.00	137.00	0.09	Pass

-- End of measurement results--

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Positive Pulse Crest Factor

200 µs pulse tests at 2.0, 12.0, 22.0, 32.0 dB below Overload Limit

Crest Factor measured according to IEC 60651:2001 9.4.2 and ANSI S1.4:1983 (R2006) 8.4.2

Amplitude [dB]	Crest Factor	Test Result [dB]	Limits [dB]	Expanded Uncertainty [dB]	Result
138.00	3	OVLD	± 0.50	0.09	Pass
	5	OVLD	± 1.00	0.09	Pass
	10	OVLD	± 1.50	0.09	Pass
128.00	3	-0.14	± 0.50	0.10	Pass
	5	-0.14	± 1.00	0.09	Pass
	10	OVLD	± 1.50	0.09	Pass
118.00	3	-0.15	± 0.50	0.10	Pass
	5	-0.15	± 1.00	0.09	Pass
	10	-0.10	± 1.50	0.09	Pass
108.00	3	-0.12	± 0.50	0.13	Pass
	5	-0.12	± 1.00	0.09	Pass
	10	-0.18	± 1.50	0.09	Pass

-- End of measurement results--

Negative Pulse Crest Factor

200 µs pulse tests at 2.0, 12.0, 22.0, 32.0 dB below Overload Limit

Crest Factor measured according to IEC 60651:2001 9.4.2 and ANSI S1.4:1983 (R2006) 8.4.2

Amplitude [dB]	Crest Factor	Test Result [dB]	Limits [dB]	Expanded Uncertainty [dB]	Result
138.00	3	OVLD	± 0.50	0.09	Pass
	5	OVLD	± 1.00	0.09	Pass
	10	OVLD	± 1.50	0.09	Pass
128.00	3	-0.14	± 0.50	0.09	Pass
	5	-0.15	± 1.00	0.09	Pass
	10	OVLD	± 1.50	0.09	Pass
118.00	3	-0.16	± 0.50	0.09	Pass
	5	-0.14	± 1.00	0.09	Pass
	10	-0.11	± 1.50	0.09	Pass
108.00	3	-0.12	± 0.50	0.09	Pass
	5	-0.13	± 1.00	0.09	Pass
	10	-0.18	± 1.50	0.09	Pass

-- End of measurement results--

Tone Burst

2kHz tone burst tests at 2.0, 12.0, 22.0, 32.0 dB below Overload Limit

Tone burst response measured according to IEC 60651:2001 9.4.2 and ANSI S1.4:1983 (R2006) 8.4.2

Amplitude [dB]	Crest Factor	Test Result [dB]	Limits [dB]	Expanded Uncertainty [dB]	Result
138.00	3	OVLD	± 0.50	0.09	Pass
	5	OVLD	± 1.00	0.09	Pass
128.00	3	-0.07	± 0.50	0.12	Pass
	5	-0.02	± 1.00	0.09	Pass
118.00	3	-0.08	± 0.50	0.09	Pass
	5	-0.02	± 1.00	0.09	Pass
108.00	3	-0.07	± 0.50	0.09	Pass
	5	-0.03	± 1.00	0.09	Pass

-- End of measurement results--

Impulse Detector - Repeat

Impulse Detector measured according to IEC 60651:2001 9.4.3 and ANSI S1.4:1983 (R2006) 8.4.3

Amplitude [dB]	Repitition Rate [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
140	100.00	-2.78	-3.71	-1.71	0.09	Pass
	20.00	-7.76	-9.57	-5.57	0.09	Pass
	2.00	-8.85	-10.76	-6.76	0.09	Pass
Step	2.00	4.95	4.00	6.00	0.11	Pass

-- End of measurement results--

Impulse Detector - Single

Impulse Detector measured according to IEC 60651:2001 9.4.3 and ANSI S1.4:1983 (R2006) 8.4.3

Amplitude [dB]	Duration [ms]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
140	20.00	-3.65	-5.11	-2.11	0.09	Pass
	5.00	-8.96	-10.76	-6.76	0.10	Pass
	2.00	-12.77	-14.55	-10.55	0.11	Pass
Step	2.00	10.00	9.00	11.00	0.11	Pass

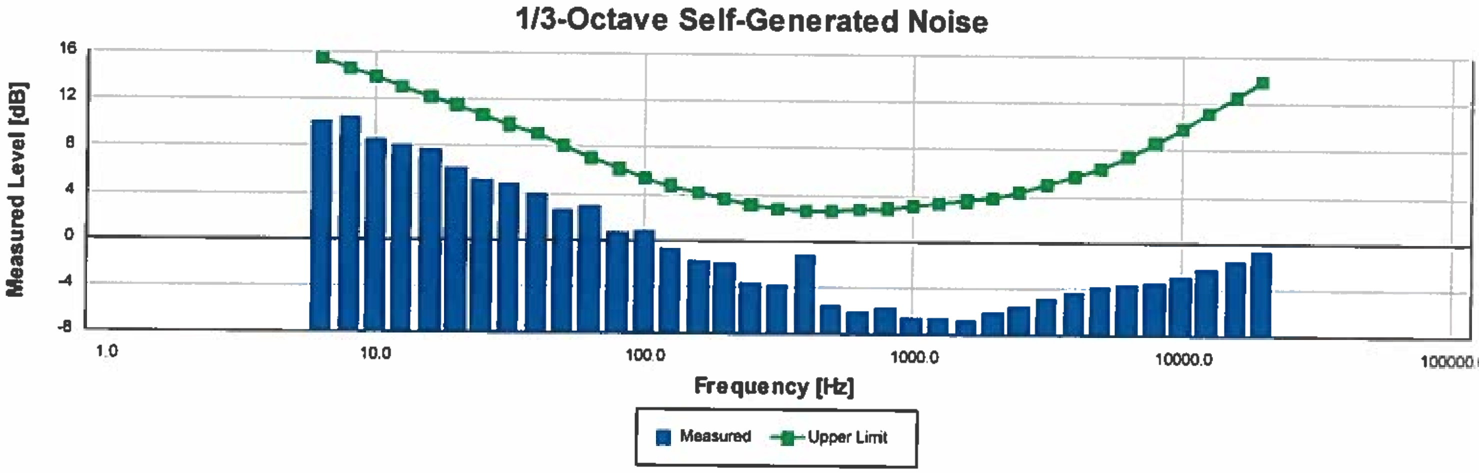
-- End of measurement results--

Gain

Gain measured according to IEC 61672-3:2013 17.3 and 17.4 and ANSI S1.4-2014 Part 3: 17.3 and 17.4

Measurement	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
0 dB Gain	94.03	93.91	94.11	0.09	Pass
0 dB Gain, Linearity	28.84	28.31	29.71	0.10	Pass
20 dB Gain	94.02	93.91	94.11	0.09	Pass
20 dB Gain, Linearity	23.71	23.31	24.71	0.12	Pass
OBA Low Range	94.02	93.91	94.11	0.09	Pass
OBA Normal Range	94.01	93.20	94.80	0.09	Pass

-- End of measurement results--



The SLM is set to low range and 20 dB gain.

Frequency [Hz]	Test Result [dB]	Upper limit [dB]	Result
6.30	10.16	15.50	Pass
8.00	10.50	14.70	Pass
10.00	8.67	13.90	Pass
12.50	8.04	13.10	Pass
16.00	7.68	12.30	Pass
20.00	6.16	11.50	Pass
25.00	5.18	10.70	Pass
31.50	4.75	9.90	Pass
40.00	3.90	9.10	Pass
50.00	2.63	8.10	Pass
63.00	2.88	7.10	Pass
80.00	0.66	6.10	Pass
100.00	0.83	5.30	Pass
125.00	-0.75	4.70	Pass
160.00	-1.75	4.10	Pass
200.00	-2.01	3.60	Pass
250.00	-3.69	3.10	Pass
315.00	-3.82	2.70	Pass
400.00	-1.32	2.60	Pass
500.00	-5.52	2.60	Pass
630.00	-6.16	2.70	Pass
800.00	-5.76	2.80	Pass
1,000.00	-6.67	3.00	Pass
1,250.00	-6.71	3.20	Pass
1,600.00	-6.73	3.50	Pass
2,000.00	-6.14	3.80	Pass
2,500.00	-5.52	4.30	Pass
3,150.00	-4.87	4.90	Pass
4,000.00	-4.36	5.70	Pass
5,000.00	-3.86	6.40	Pass
6,300.00	-3.64	7.40	Pass
8,000.00	-3.51	8.60	Pass
10,000.00	-3.06	9.80	Pass
12,500.00	-2.39	11.20	Pass
16,000.00	-1.58	12.60	Pass
20,000.00	-0.66	14.00	Pass

– End of measurement results–

Broadband Noise Floor

Self-generated noise measured according to IEC 61672-3:2013 11.2 and ANSI S1.4-2014 Part 3: 11.2

Measurement	Test Result [dB]	Upper limit [dB]	Result
A-weight Noise Floor	7.07	15.00	Pass
C-weight Noise Floor	12.91	17.30	Pass
Z-weight Noise Floor	21.88	24.50	Pass

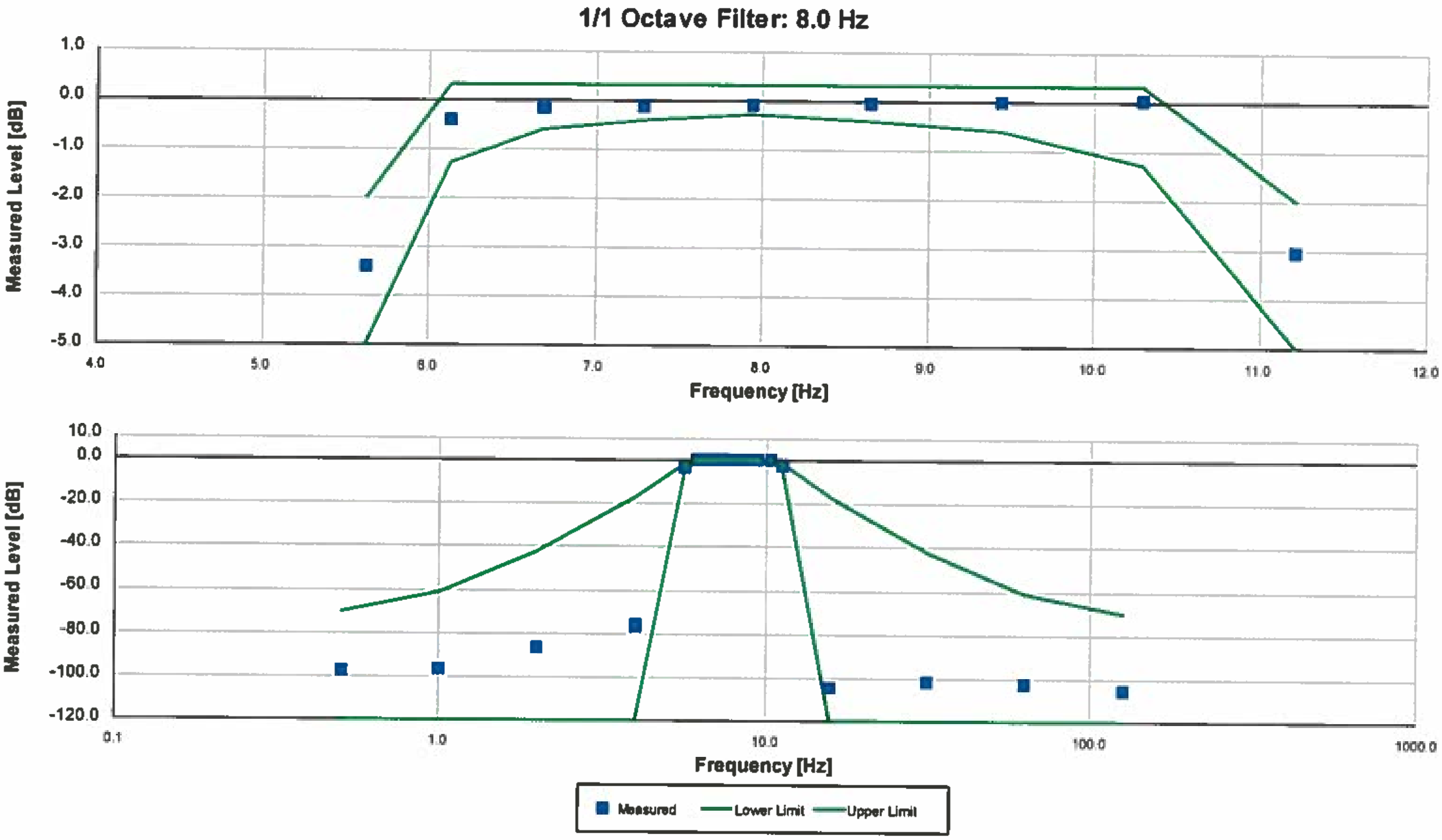
-- End of measurement results--

Total Harmonic Distortion

Measured using 1/3-Octave filters

Measurement	Test Result [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
10 Hz Signal	137.50	137.20	138.80	0.09	Pass
THD	-72.11		-60.00	0.01	Pass
THD+N	-65.84		-60.00	0.01	Pass

-- End of measurement results--

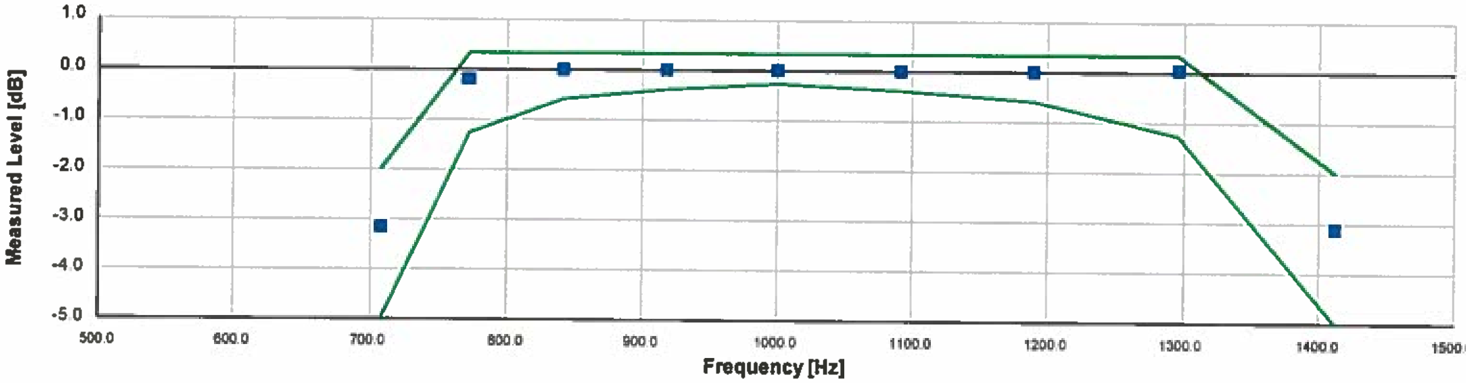


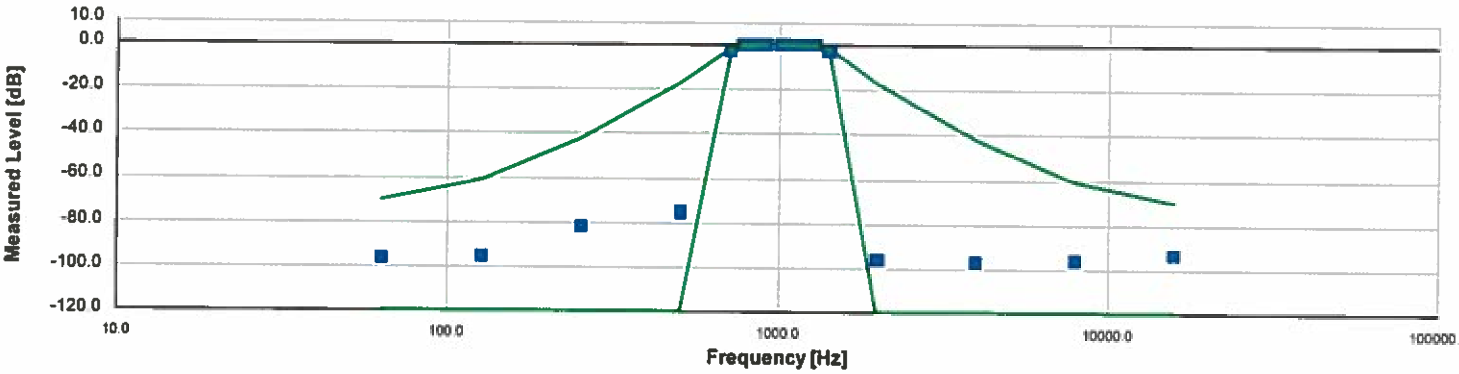
The SLM is set to normal range and 0 dB gain. Filter shape measured according to IEC 61260:2001 and ANSI S1.11:2004

Frequency [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
0.50	-96.87	-inf	-70.00	2.40	Pass
1.00	-96.58	-inf	-61.00	2.20	Pass
2.00	-86.18	-inf	-42.00	0.24	Pass
3.98	-76.04	-inf	-17.50	0.23	Pass
5.62	-3.39	-5.00	-2.00	0.09	Pass
6.13	-0.41	-1.30	0.30	0.09	Pass
6.68	-0.16	-0.60	0.30	0.09	Pass
7.29	-0.12	-0.40	0.30	0.09	Pass
7.94	-0.09	-0.30	0.30	0.09	Pass
8.66	-0.06	-0.40	0.30	0.09	Pass
9.44	-0.01	-0.60	0.30	0.09	Pass
10.29	0.03	-1.30	0.30	0.09	Pass
11.22	-3.05	-5.00	-2.00	0.09	Pass
15.85	-104.41	-inf	-17.50	1.30	Pass
31.62	-101.99	-inf	-42.00	1.70	Pass
63.10	-102.25	-inf	-61.00	1.10	Pass
125.89	-104.92	-inf	-70.00	1.80	Pass

-- End of measurement results--

1/1 Octave Filter: 1 kHz





The SLM is set to normal range and 0 dB gain. Filter shape measured according to IEC 61260:2001 and ANSI S1.11:2004

Frequency [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
63.10	-96.37	-inf	-70.00	0.28	Pass
125.89	-95.34	-inf	-61.00	0.32	Pass
251.19	-81.90	-inf	-42.00	0.18	Pass
501.19	-75.14	-inf	-17.50	0.09	Pass
707.95	-3.15	-5.00	-2.00	0.09	Pass
771.79	-0.23	-1.30	0.30	0.09	Pass
841.40	-0.02	-0.60	0.30	0.09	Pass
917.28	-0.01	-0.40	0.30	0.09	Pass
1,000.00	0.00	-0.30	0.30	0.09	Pass
1,090.18	-0.02	-0.40	0.30	0.09	Pass
1,188.50	-0.01	-0.60	0.30	0.09	Pass
1,295.69	0.01	-1.30	0.30	0.09	Pass
1,412.54	-3.13	-5.00	-2.00	0.09	Pass
1,995.26	-96.23	-inf	-17.50	0.26	Pass
3,981.07	-96.82	-inf	-42.00	0.26	Pass
7,943.28	-96.39	-inf	-61.00	0.31	Pass
15,848.93	-93.90	-inf	-70.00	0.24	Pass

-- End of measurement results--

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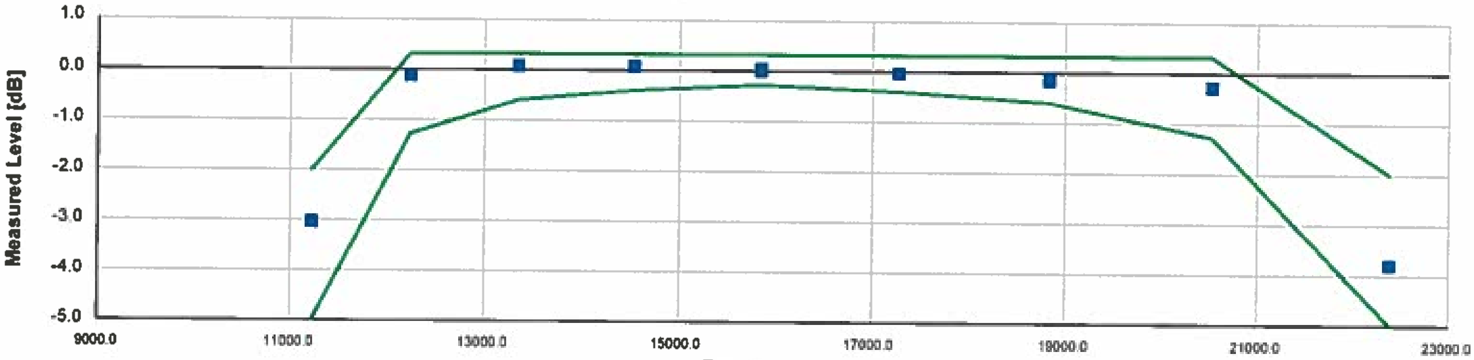
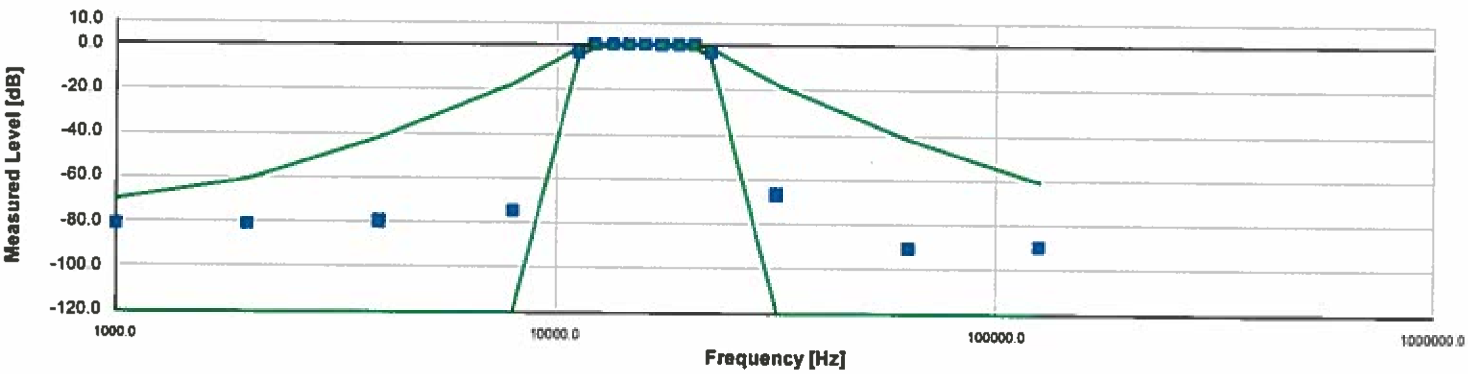
1/1 Octave Filter: 16 kHz





The SLM is set to normal range and 0 dB gain. Filter shape measured according to IEC 61260:2001 and ANSI S1.11:2004

Frequency [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
1,000.00	-81.08	-inf	-70.00	0.11	Pass
1,995.26	-80.80	-inf	-61.00	0.09	Pass
3,981.07	-79.55	-inf	-42.00	0.10	Pass
7,943.28	-74.36	-inf	-17.50	0.10	Pass
11,220.18	-3.04	-5.00	-2.00	0.09	Pass
12,232.07	-0.13	-1.30	0.30	0.09	Pass
13,335.21	0.08	-0.60	0.30	0.09	Pass
14,537.84	0.05	-0.40	0.30	0.09	Pass
15,848.93	0.01	-0.30	0.30	0.09	Pass
17,278.26	-0.06	-0.40	0.30	0.09	Pass
18,836.49	-0.16	-0.60	0.30	0.09	Pass
20,535.25	-0.28	-1.30	0.30	0.09	Pass
22,387.21	-3.79	-5.00	-2.00	0.09	Pass
31,622.78	-66.86	-inf	-17.50	0.09	Pass
63,095.73	-90.41	-inf	-42.00	0.10	Pass
125,892.54	-89.76	-inf	-61.00	0.09	Pass

-- End of measurement results--

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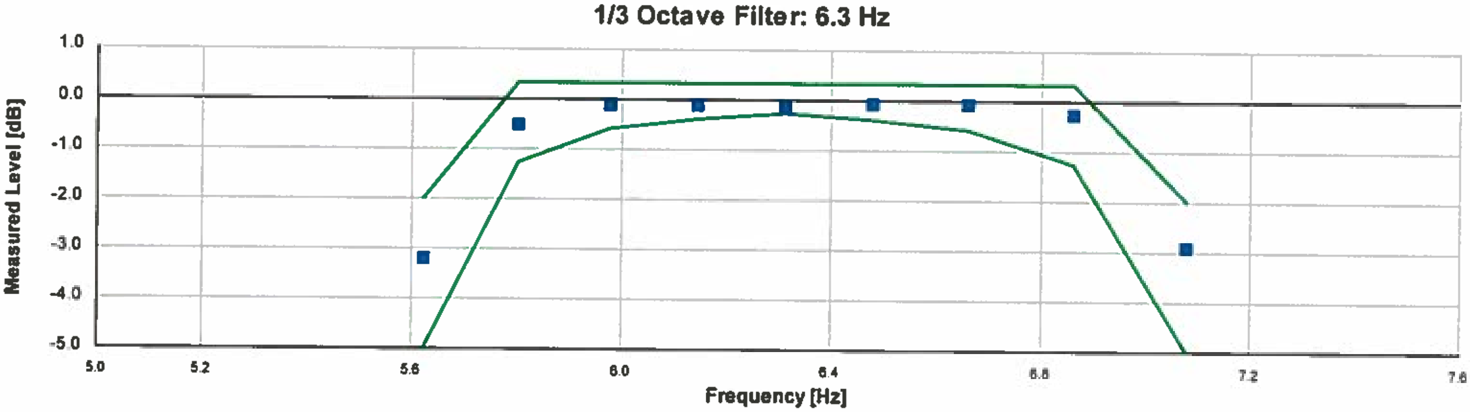
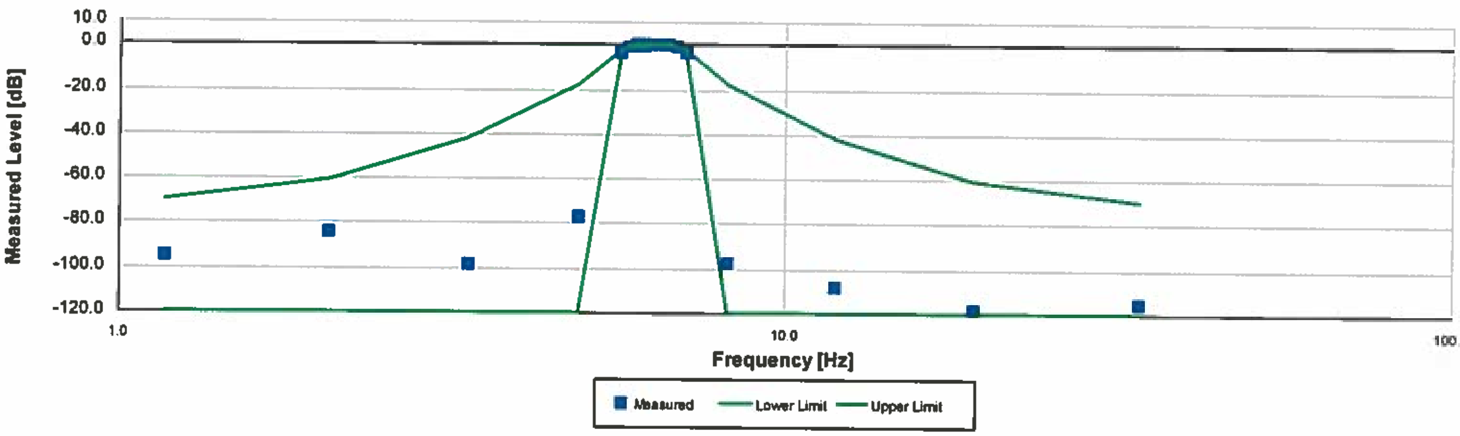
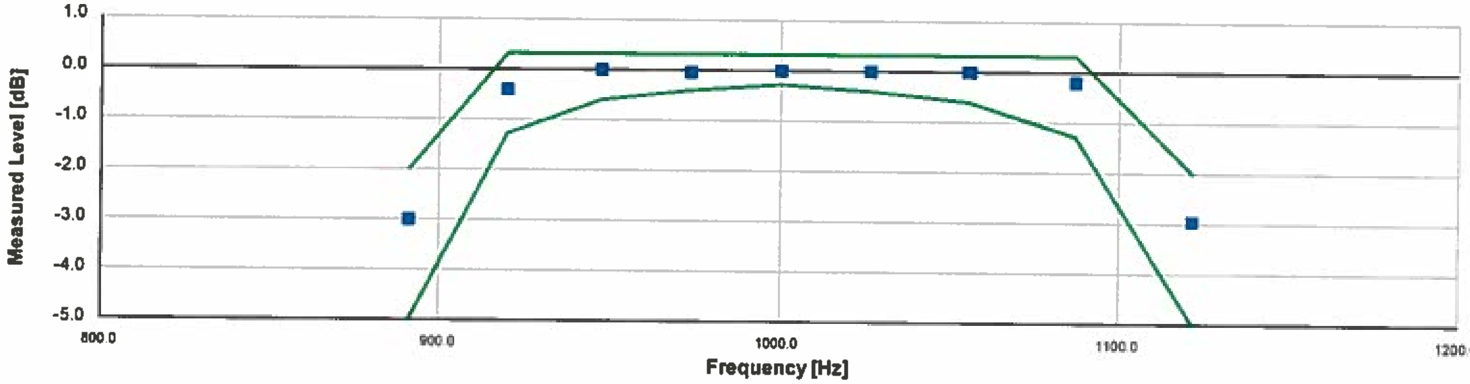


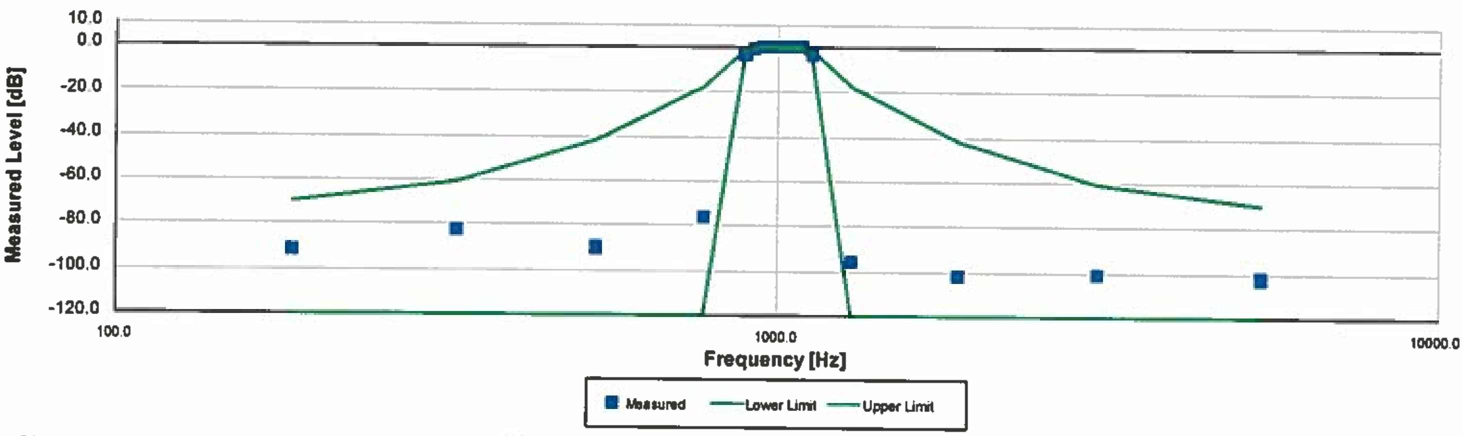


The SLM is set to normal range and 0 dB gain. Filter shape measured according to IEC 61260:2001 and ANSI S1.11:2004

Frequency [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
1.17	-94.53	-inf	-70.00	0.36	Pass
2.07	-84.37	-inf	-61.00	0.11	Pass
3.35	-98.26	-inf	-42.00	0.09	Pass
4.87	-76.82	-inf	-17.50	0.10	Pass
5.62	-3.20	-5.00	-2.00	0.09	Pass
5.80	-0.55	-1.30	0.30	0.09	Pass
5.98	-0.14	-0.60	0.30	0.09	Pass
6.15	-0.13	-0.40	0.30	0.09	Pass
6.31	-0.12	-0.30	0.30	0.09	Pass
6.48	-0.11	-0.40	0.30	0.09	Pass
6.66	-0.10	-0.60	0.30	0.09	Pass
6.86	-0.28	-1.30	0.30	0.09	Pass
7.08	-2.93	-5.00	-2.00	0.09	Pass
8.17	-97.59	-inf	-17.50	0.34	Pass
11.87	-108.40	-inf	-42.00	1.70	Pass
19.27	-118.58	-inf	-61.00	2.50	Pass
34.02	-115.57	-inf	-70.00	2.10	Pass

-- End of measurement results--

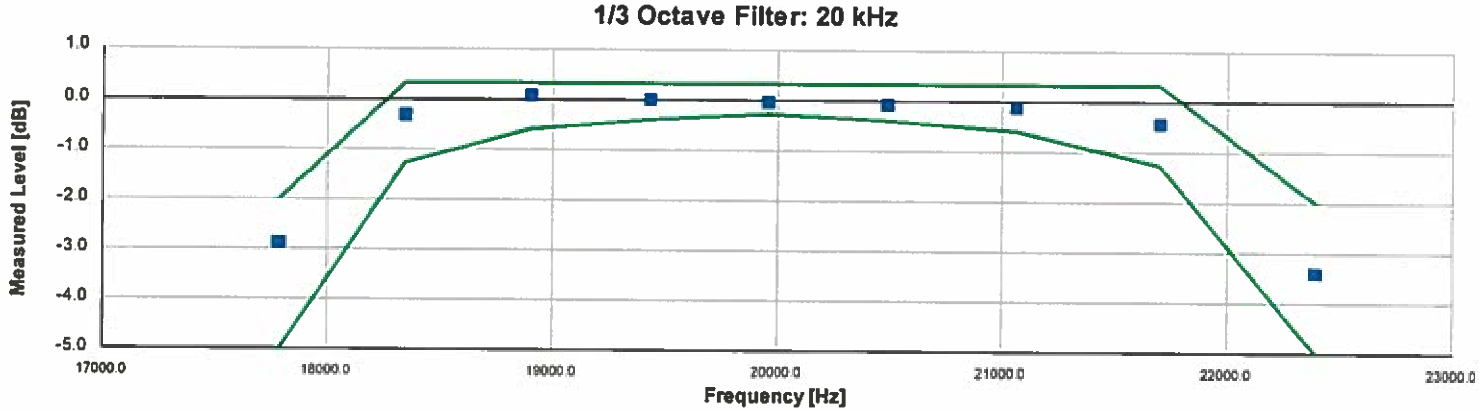


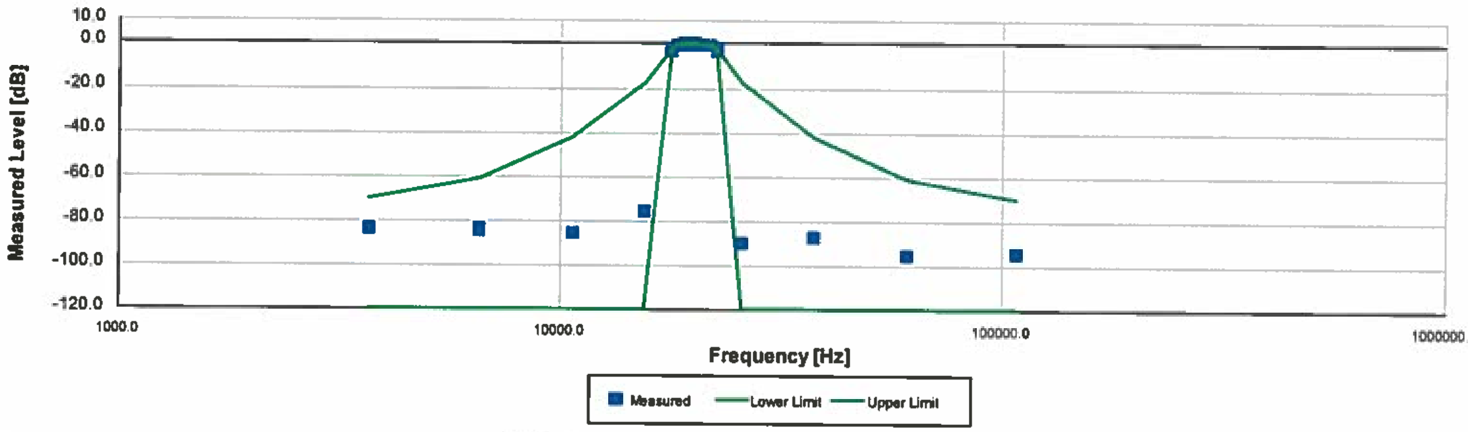


The SLM is set to normal range and 0 dB gain. Filter shape measured according to IEC 61260:2001 and ANSI S1.11:2004

Frequency [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
185.46	-91.74	-inf	-70.00	0.17	Pass
327.48	-82.23	-inf	-61.00	0.12	Pass
531.43	-90.06	-inf	-42.00	0.25	Pass
772.57	-76.26	-inf	-17.50	0.09	Pass
891.25	-3.00	-5.00	-2.00	0.09	Pass
919.58	-0.40	-1.30	0.30	0.09	Pass
947.19	0.00	-0.60	0.30	0.09	Pass
974.02	-0.04	-0.40	0.30	0.09	Pass
1,000.00	0.00	-0.30	0.30	0.09	Pass
1,026.67	0.00	-0.40	0.30	0.09	Pass
1,055.75	-0.02	-0.60	0.30	0.09	Pass
1,087.46	-0.22	-1.30	0.30	0.09	Pass
1,122.02	-2.95	-5.00	-2.00	0.09	Pass
1,294.37	-96.08	-inf	-17.50	0.25	Pass
1,881.73	-101.82	-inf	-42.00	0.40	Pass
3,053.65	-101.61	-inf	-61.00	0.44	Pass
5,391.95	-102.63	-inf	-70.00	0.40	Pass

– End of measurement results–





The SLM is set to normal range and 0 dB gain. Filter shape measured according to IEC 61260:2001 and ANSI S1.11:2004

Frequency [Hz]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
3,700.45	-83.29	-inf	-70.00	0.11	Pass
6,534.02	-83.97	-inf	-61.00	0.11	Pass
10,603.35	-85.44	-inf	-42.00	0.13	Pass
15,414.88	-75.68	-inf	-17.50	0.09	Pass
17,782.79	-2.87	-5.00	-2.00	0.09	Pass
18,347.97	-0.33	-1.30	0.30	0.09	Pass
18,898.93	0.05	-0.60	0.30	0.09	Pass
19,434.23	-0.01	-0.40	0.30	0.09	Pass
19,952.62	-0.06	-0.30	0.30	0.09	Pass
20,484.85	-0.08	-0.40	0.30	0.09	Pass
21,065.07	-0.14	-0.60	0.30	0.09	Pass
21,697.62	-0.44	-1.30	0.30	0.09	Pass
22,387.21	-3.40	-5.00	-2.00	0.09	Pass
25,826.16	-89.59	-inf	-17.50	0.12	Pass
37,545.40	-87.51	-inf	-42.00	0.11	Pass
60,928.37	-95.12	-inf	-61.00	0.12	Pass
107,583.52	-94.40	-inf	-70.00	0.11	Pass

-- End of measurement results--

-- End of Report--

Signatory: Ron Harris

Larson Davis, a division of PCB Piezotronics, Inc
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ACCREDITED Cert. #3622.01

LARSON DAVIS A PCB PIEZOTRONICS DIV.

Calibration Certificate

Certificate Number 2017003285

Customer:

Tetra Tech Inc
3rd Floor
160 Federal Street
Boston, MA 02110, United States

Model Number	831	***Procedure Number***	D0001.8384		
Serial Number	0003848	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	30 Mar 2017		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	30 Mar 2018		
Description	Larson Davis Model 831 Class 1 Sound Level Meter Firmware Revision: 2.311	***Temperature***	23.36	°C	± 0.25 °C
		Humidity	51.2	%RH	± 2.0 %RH
		Static Pressure	85.31	kPa	± 0.13 kPa

Evaluation Method ***Tested with:***

Larson Davis PRM831. S/N 036755
PCB 377B02. S/N 150728
Larson Davis CAL200. S/N 9079
Larson Davis CAL291. S/N 0203

Data reported in dB re 20 μPa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.

Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Correction data from Larson Davis Model 831 Sound Level Meter Manual, I831.01 Rev O, 2016-09-19

For 1/4" microphones, the Larson Davis ADP024 1/4" to 1/2" adaptor is used with the calibrators and the Larson Davis ADP043 1/4" to

1/2" adaptor is used with the preamplifier.

Calibration Check Frequency: 1000 Hz; Reference Sound Pressure Level: 114 dB re 20 μPa; Reference Range: 0 dB gain

Periodic tests were performed in accordance with precedures from IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part3.

Pattern approval for IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 successfully completed by Physikalisch-Technische Bundesanstalt (PTB) on 2016-02-24 certificate number DE-15-M-PTB-0056.

The sound level meter submitted for testing successfully completed the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3, for the environmental conditions under which the tests were performed. As evidence was publicly available, from an independent testing organization responsible for approving the results of pattern-evaluation tests performed in accordance with IEC 61672-2:2013 / ANSI/ASA S1.4-2014/Part 2, to demonstrate that the model of sound level meter fully conformed to the class 1 specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1; the sound level meter submitted for testing conforms to the class 1specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
SRS DS360 Ultra Low Distortion Generator	2016-06-21	2017-06-21	006311
Hart Scientific 2626-S Humidity/Temperature Sensor	2016-06-17	2017-06-17	006946
Larson Davis CAL200 Acoustic Calibrator	2016-07-26	2017-07-26	007027
Larson Davis Model 831	2017-03-01	2018-03-01	007182
PCB 377A13 1/2 inch Prepolarized Pressure Microphone	2017-03-08	2018-03-08	007185
Larson Davis CAL291 Residual Intensity Calibrator	2016-09-22	2017-09-22	007287

Acoustic Calibration

Measured according to IEC 61672-3:2013 10 and ANSI S1.4-2014 Part 3: 10

Measurement	Test Result [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
1000 Hz	114.00	113.80	114.20	0.14	Pass

As Received Level: 113.14
Adjusted Level: 114.00

-- End of measurement results--

Acoustic Signal Tests, C-weighting

Measured according to IEC 61672-3:2013 12 and ANSI S1.4-2014 Part 3: 12 using a comparison coupler with Unit Under Test (UUT) and reference SLM using slow time-weighted sound level for compliance to IEC 61672-1:2013 5.5; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Expected [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
125	-0.21	-0.20	-1.20	0.80	0.23	Pass
1000	0.11	0.00	-0.70	0.70	0.23	Pass
8000	-2.37	-3.00	-5.50	-1.50	0.32	Pass

-- End of measurement results--

Self-generated Noise

Measured according to IEC 61672-3:2013 11.1 and ANSI S1.4-2014 Part 3: 11.1

Measurement	Test Result [dB]
A-weighted, 20 dB gain	37.84

-- End of measurement results--

-- End of Report--

Signatory: Ron Harris

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716-684-0001

ilac-MRA A2LA ACCREDITED Cert. #3622.01

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A PCB PIEZOTRONICS DIV.