Logistics Park of North Dakota Noise Analysis Report

AE Minot Intermodal Facility

Minot, ND

January 20, 2023

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Acronyms and Abbreviations

ANSI	American National Standards Institute
dB	Decibel
dBA	A-weighted decibel
FRA	Federal Rail Administration
FTA	Federal Transportation Administration
HVAC	Heating, ventilation, and air-conditioning
Hz	Hertz
ISO	International Standards Organization
L_{dn}	day-night sound level
L_{eq}	Equivalent sound level
L_{max}	Maximum Sound Level
L_{min}	Minimum Sound Level
L_{XX}	Sound Level Centile (XX percent exceeded)
mph	Miles per hour
N/A	Not Applicable
NIST	National Institute of Standards and Technology
OTR	Over-the-road
SEL	Sound Emission Level
SWL	Sound Power Level

1 Introduction

The Logistics Park of North Dakota (Project) is a proposed full-service logistics terminal to be located in Minot, North Dakota. The Project would co-locate intermodal, transload, bulk unit train shipping, and supporting infrastructure to support manifest shipper operations on a single site. Appendix A contains the proposed site plan.

This report discusses results from the pre-construction noise monitoring and noise modeling for the Project. Analysis results indicate that the Project is not anticipated to cause noise impacts at modeled receivers.

2 Fundamentals of Sound

Noise is typically defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, speech, or recreation. Sound is what we hear when fluctuations in air pressure occur above and below the standard atmospheric pressure. Three variables define characteristics of noise: level (or amplitude), frequency, and time pattern.

Sound pressure level is expressed in decibels (dB) on a logarithmic scale. Typical sound levels generally fall between 20 and 120 dB, similar to the range of human hearing. A 3 dB change in sound level is widely considered to be barely noticeable in outdoor environments, and a 10 dB change in sound level is perceived as a doubling (or halving) of the loudness.

The frequency of sound is the rate at which fluctuations in air pressure occur and is expressed in cycles per second, or hertz (Hz). Most sounds consist of a broad range of sound frequencies. The average human ear does not perceive all frequencies equally. Therefore, the A-weighted decibel (dBA) scale was developed to approximate the way the human ear responds to sound levels; it mathematically applies less “weight” to frequencies we do not hear well and applies more weight to frequencies we do hear well.

Analysts use two primary noise measurement descriptors to assess environmental noise. They are the equivalent sound level (L_{eq}) and the day-night sound level (L_{dn}). The L_{eq} is often used to describe sound levels that vary over time, typically for a 1-hour period. It describes the level of a constant sound that has the same acoustic energy as the time-varying sound over a given period. Using 24 consecutive 1-hour L_{eq} values, it is possible to calculate daily cumulative noise exposure. The L_{dn} is a 24-hour cumulative A-weighted noise level that includes all noise that occurs throughout a 24-hour period, with a 10 dBA penalty on noise that occurs during nighttime hours (between 10 PM and 7 AM) where sleep interference might be an issue. The 10 dBA penalty makes the L_{dn} useful when assessing noise in residential areas or other land uses where overnight sleep occurs.

Statistical descriptors, sometimes called centiles, are also used to describe outdoor noise levels. They represent the sound level exceeded XX percent of the time, where XX is a number. Therefore, the L_{50} represents the noise level exceeded 50 percent of the time and the L_{90} represents the noise level exceeded 90 percent of the time, etc.

3 Regulatory Environment

3.1 Local Regulations

The State of North Dakota and Ward County do not have quantitative noise ordinances that would apply to facilities such as the Project.

The City of Minot has quantitative noise limits based on the zoning district of the receiving property. Table 1 shows the permissible sound levels set forth by the City of Minot.

Table 1. City of Minot Noise Limits

Time of Day	Zoning District		
	Residential (R1, R2, R3, PD-MH)	Commercial (C1, C2, C3, C4)	Industrial (M1, M2)
7:00 AM – 11:00 PM	55	65	80
11:00 PM – 7:00 AM	50	60	75

Zoning districts surrounding the Project are mainly industrial and agricultural, with some residential.

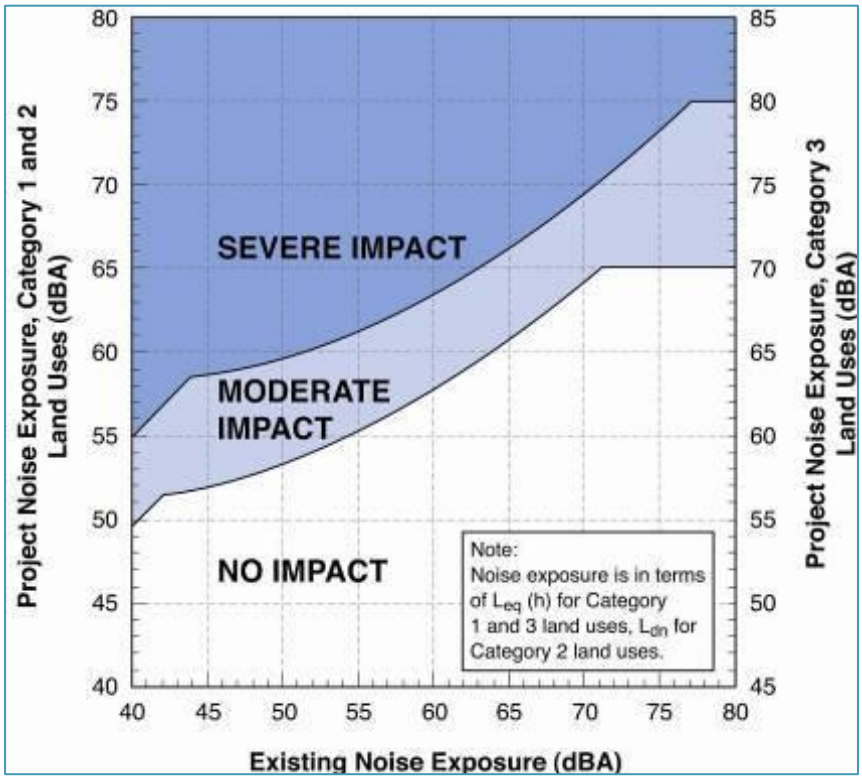
3.1.1 FRA/FTA Regulations

Noise emissions from the Project will also be evaluated against Federal Rail Administration (FRA) and Federal Transportation Administration (FTA) guidelines, which compare existing noise levels with future levels to determine impacts. FRA defers to FTA guidelines on noise and vibration assessment when train speeds are below 90 mph. FTA guidelines do not apply to freight rail traffic, and as such these guidelines are not regulatory limits applicable to the Project but rather a metric HDR used to evaluate the acceptability of Project-related noise levels. Figure 1 shows the allowable increases based on existing levels under the FTA/FTA guidelines. Below the lower curve, a project is considered to have no impact. The two degrees of noise impact defined by the FTA/FRA criteria are defined as follows:

Severe Impact: In the severe impact range, a significant percentage of people would be highly annoyed by the project noise. Noise mitigation will normally be specified for severe impact areas unless it is not feasible or reasonable (meaning there is no practical method of mitigating the impact or mitigation measures are cost-prohibitive).

Moderate Impact: In the moderate impact range, changes in the cumulative noise level are noticeable, but may not be sufficient to cause strong, adverse reactions from the community. In this range, other project-specific factors are considered to determine the magnitude of the impact and the need for mitigation. Other factors include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost-effectiveness of mitigating noise to more acceptable levels.

Figure 1. FTA/FRA Noise Impact Criteria



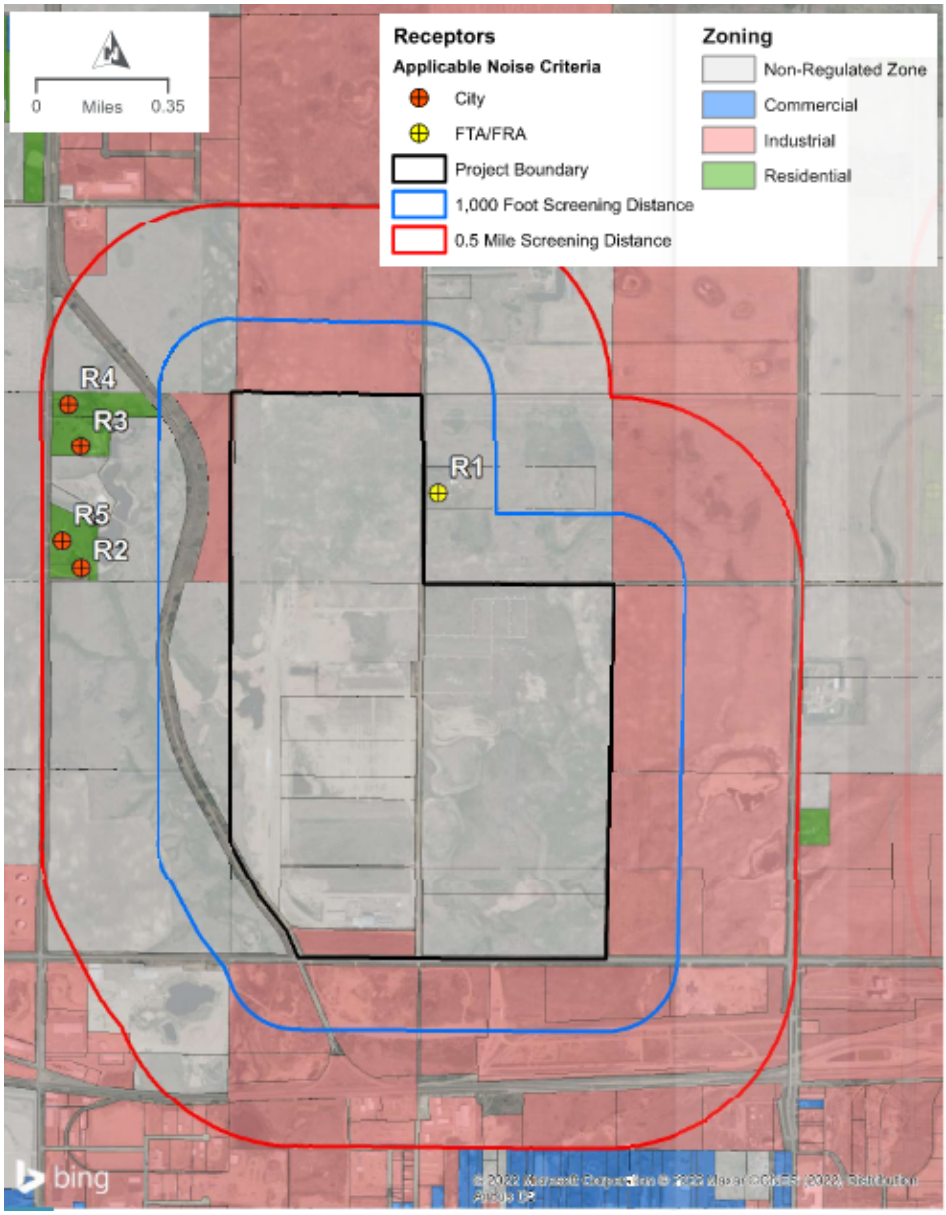
Source: FTA – Transit Noise and Vibration Impact Assessment (May 2006), Figure 3-2

3.2 Noise Screening

FTA/FRA's noise screening procedure is designed to determine if noise-sensitive land uses exist close enough to project features to merit a noise assessment. For rail yards and shops, the screening distance is 1000 feet from the Project boundary. HDR identified one location within 1000 feet of the Project boundary that would potentially be noise sensitive. This location, labeled as R1 in Figure 2, is zoned agricultural by the City and as such is not subject to the City's noise limits. However, since it appears there is a home at this property, HDR considered this receptor as a Category 2 (Residential) receptor for comparison to the FRA/FTA impact thresholds.

To evaluate Project noise levels against the City of Minot limits, HDR also identified properties in zones where noise is restricted within 0.5 mile from the Project boundary. HDR identified four properties in residential zoning within 0.5 mile of the Project, labeled as R2-R5 in Figure 2, as well as industrial zoned properties to the north, northwest, east, and south of the Project. Therefore, HDR evaluated project-related noise at these locations. The evaluation included measuring existing noise levels, calculating project-related noise levels and comparing them with relevant thresholds. Figure 2 shows the City of Minot zoning districts, generalized by noise limit.

Figure 2. Noise Receptors and Zoning



4 Existing Noise Measurements

HDR measured outdoor noise levels for a continuous 24-hour period at the two closest noise-sensitive locations identified in the noise screening assessment, labeled R1 and R2 on Figure 2. Noise levels at R2 were considered to be representative of those at locations R3 to R5. The measurements began in the morning on August 3, 2022 and ended around midday on August 4, 2022.

HDR used digital sound level meters with 1/3 octave band filters to perform the noise measurements. The sound level meters, and a handheld calibrator meet Class 1/Type 1 precision requirements of ANSI and International Electrotechnical Commission standards. All instrumentation used to measure noise levels on this project is calibrated on a regular basis by an independent accredited calibration laboratory using standards

traceable to the National Institute of Standards and Technology (NIST). The instrumentation was adjusted to a NIST-traceable reference level prior to transportation to the measurement site. Calibration checks were performed in the field prior to and upon completion of each series of measurements.

HDR deployed a mobile weather station with one of the sound level meters to measure wind speed and direction, temperature, and humidity during the measurement period. No precipitation events occurred during the measurements. Wind speeds during the measurement period were generally below 11 mph. Appendix B shows photographs of the noise measurement locations. Appendix C includes calibration certificates for equipment used to measure noise levels.

4.1 Measurement Results

Figure 3 shows a graph of measured hourly noise levels at R1. The measured noise levels are presented using the hourly equivalent sound level (L_{eq}), which represents a constant sound that, over the specified time-period, has the same acoustic energy as the time-varying signal.

Figure 3. Measured Hourly L_{eq} (dBA) at ML1 (August 3-4, 2022)

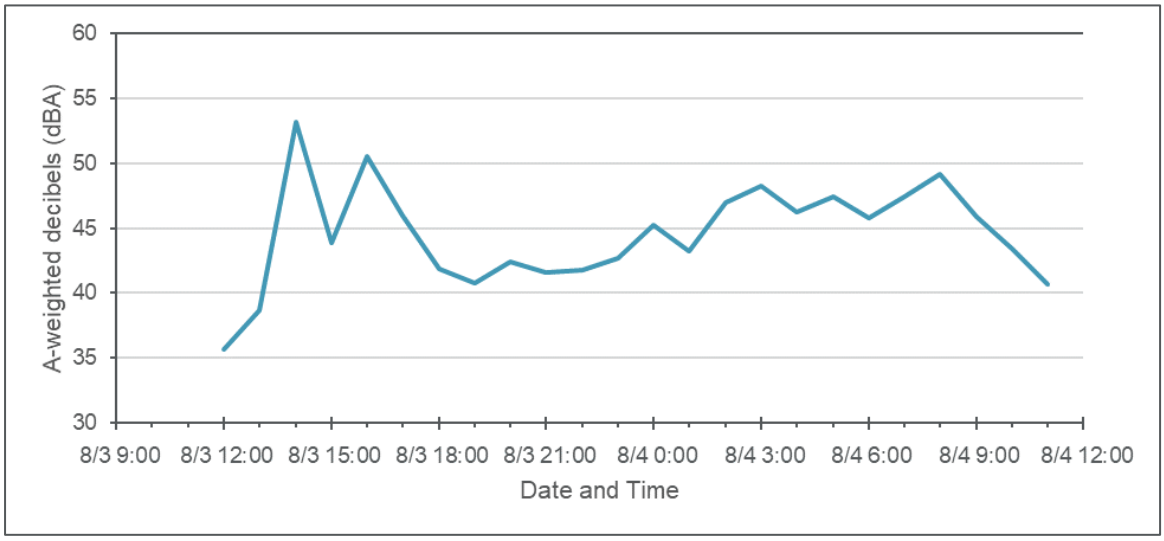
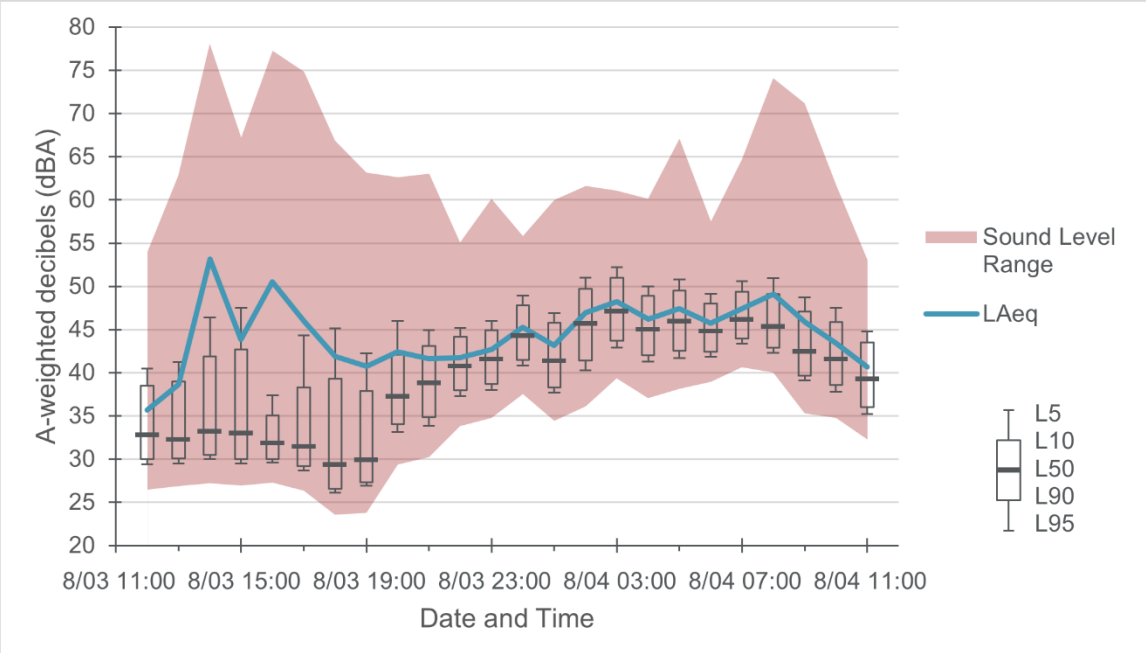


Figure 4 shows a graph of the statistical or centile noise levels and the overall range of sound pressure levels measured throughout the measurement duration.

Figure 4. Measured Centiles, and overall Range (dBA) at ML1 (August 3-4, 2022)



While deploying and retrieving the measurement equipment, HDR staff noted that the soundscape at this property was dominated by natural sounds such as insects and grass moving in the wind. Also audible was a hum from a facility to the south and occasional traffic along 42nd Street NE. Table 2 summarizes the noise measurement results at R1.

Table 2. Summary of Noise Measurements at R1

Date	Time	Duration	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L5 (dBA)	L10 (dBA)	L50 (dBA)	L90 (dBA)	L95 (dBA)
3-Aug-22	12:00	1:00:00	36	26	54	41	39	33	30	29
3-Aug-22	13:00	1:00:00	39	27	63	41	39	32	30	30
3-Aug-22	14:00	1:00:00	53	27	78	46	42	33	31	30
3-Aug-22	15:00	1:00:00	44	27	67	48	43	33	30	30
3-Aug-22	16:00	1:00:00	51	27	77	37	35	32	30	30
3-Aug-22	17:00	1:00:00	46	26	75	44	38	32	29	29
3-Aug-22	18:00	1:00:00	42	24	67	45	39	29	27	26
3-Aug-22	19:00	1:00:00	41	24	63	42	38	30	27	27
3-Aug-22	20:00	1:00:00	42	29	63	46	42	37	34	33
3-Aug-22	21:00	1:00:00	42	30	63	45	43	39	35	34
3-Aug-22	22:00	1:00:00	42	34	55	45	44	41	38	37
3-Aug-22	23:00	1:00:00	43	35	60	46	45	42	39	38
4-Aug-22	00:00	1:00:00	45	38	56	49	48	44	42	41
4-Aug-22	01:00	1:00:00	43	34	60	47	46	41	38	38
4-Aug-22	02:00	1:00:00	47	36	62	51	50	46	41	40
4-Aug-22	03:00	1:00:00	48	39	61	52	51	47	44	43
4-Aug-22	04:00	1:00:00	46	37	60	50	49	45	42	41

Date	Time	Duration	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L5 (dBA)	L10 (dBA)	L50 (dBA)	L90 (dBA)	L95 (dBA)
4-Aug-22	05:00	1:00:00	47	38	67	51	50	46	43	42
4-Aug-22	06:00	1:00:00	46	39	58	49	48	45	42	42
4-Aug-22	07:00	1:00:00	47	41	65	51	49	46	44	43
4-Aug-22	08:00	1:00:00	49	40	74	51	49	45	43	42
4-Aug-22	09:00	1:00:00	46	35	71	49	47	43	40	39
4-Aug-22	10:00	1:00:00	43	35	62	48	46	42	39	38
4-Aug-22	11:00	1:00:00	41	32	53	45	44	39	36	35

Figure 5 shows a graph of measured hourly Leq levels at R2.

Figure 5. Measured Hourly L_{eq} (dBA) at R2 (August 3-4, 2022)

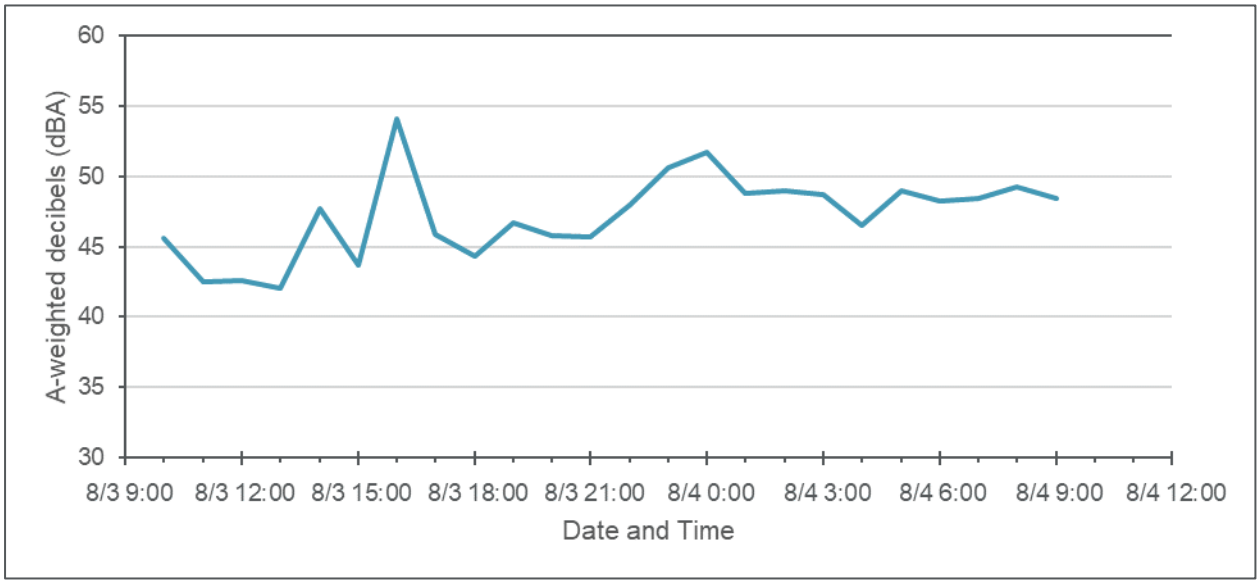


Figure 6 shows the measured centile levels, and overall range of minimum and maximum sound pressure levels measured at R2.

Figure 6. Measured Centiles, and overall Range (dBA) at R2 (August 3-4, 2022)

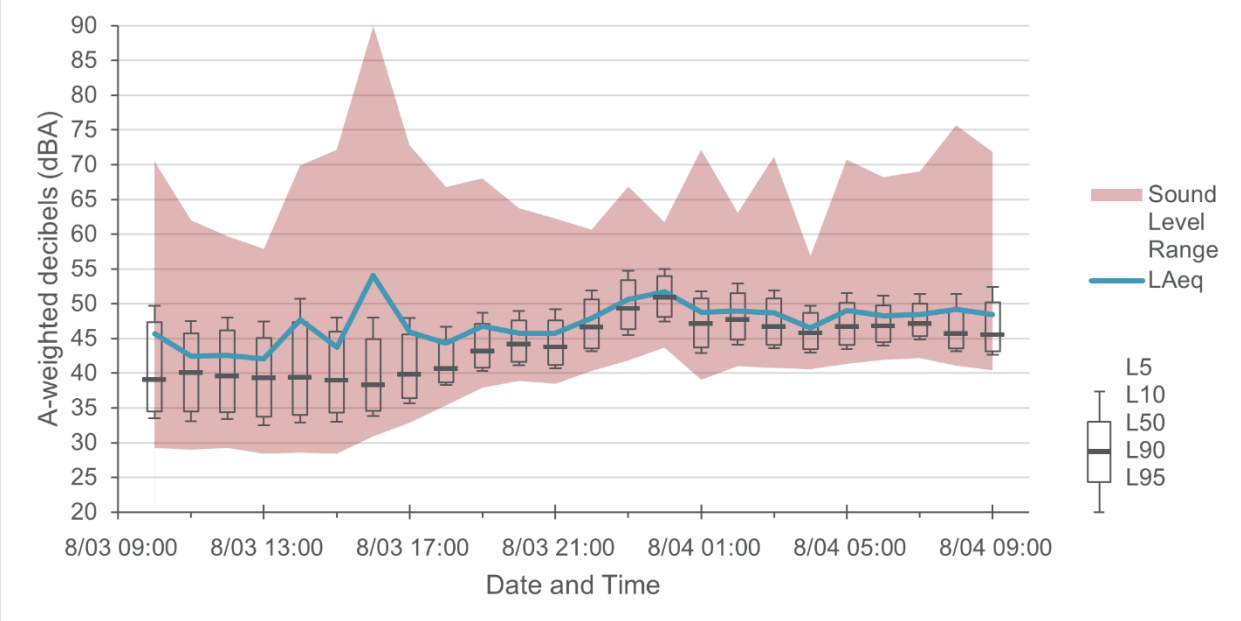


Table 3 summarizes the noise measurement results at R2.

Table 3. Summary of Noise Measurements at R2

Date	Time	Duration	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L5 (dBA)	L10 (dBA)	L50 (dBA)	L90 (dBA)	L95 (dBA)
3-Aug-22	10:00	1:00:00	46	29	70	50	47	39	35	34
3-Aug-22	11:00	1:00:00	43	29	62	48	46	40	35	33
3-Aug-22	12:00	1:00:00	43	29	60	48	46	40	34	33
3-Aug-22	13:00	1:00:00	42	28	58	47	45	39	34	33
3-Aug-22	14:00	1:00:00	48	29	70	51	47	39	34	33
3-Aug-22	15:00	1:00:00	44	28	72	48	46	39	34	33
3-Aug-22	16:00	1:00:00	54	31	90	48	45	38	35	34
3-Aug-22	17:00	1:00:00	46	33	73	48	46	40	36	36
3-Aug-22	18:00	1:00:00	44	35	67	47	45	41	39	38
3-Aug-22	19:00	1:00:00	47	38	68	49	47	43	41	40
3-Aug-22	20:00	1:00:00	46	39	64	49	48	44	42	41
3-Aug-22	21:00	1:00:00	46	38	62	49	48	44	41	41
3-Aug-22	22:00	1:00:00	48	40	61	52	51	47	44	43
3-Aug-22	23:00	1:00:00	51	42	67	55	53	49	46	46
4-Aug-22	00:00	1:00:00	52	44	62	55	54	51	48	47
4-Aug-22	01:00	1:00:00	49	39	72	52	51	47	44	43
4-Aug-22	02:00	1:00:00	49	41	63	53	52	48	45	44
4-Aug-22	03:00	1:00:00	49	41	71	52	51	47	44	44

Date	Time	Duration	Leq (dBA)	Lmin (dBA)	Lmax (dBA)	L5 (dBA)	L10 (dBA)	L50 (dBA)	L90 (dBA)	L95 (dBA)
4-Aug-22	04:00	1:00:00	47	41	57	50	49	46	44	43
4-Aug-22	05:00	1:00:00	49	41	71	52	50	47	44	44
4-Aug-22	06:00	1:00:00	48	42	68	51	50	47	45	44
4-Aug-22	07:00	0:59:59	48	42	69	51	50	47	45	45
4-Aug-22	08:00	1:00:00	49	41	76	51	49	46	44	43
4-Aug-22	09:00	1:00:00	48	40	72	52	50	46	43	43

Traffic noise was more frequently audible at R2 than at R1. Other audible sounds were birds and insects, as well as the occasional plane flying to or from the nearby Minot International Airport.

The two sound level meters also processed the 24-hour noise measurement results and determined the resulting L_{dn} values. The L_{dn} values were used to determine the corresponding FTA/FRA moderate and severe noise impact thresholds. Table 4 shows the measured L_{dn} values and corresponding FTA/FRA noise impact thresholds for parcels where overnight sleep occurs.

Table 4. Measured Ldn and FTA/FRA Noise Impact Thresholds

Site	Receptor Description	Minot Zoning Designation	FTA/FRA Land Use Category	Day-Night Noise Level (L_{dn})	FTA/FRA Moderate Noise Impact Threshold	FTA/FRA Severe Noise Impact Threshold
R1	2452 42nd Street NE	Agricultural	2[1]	52 dBA	55 dBA	>60 dBA
R2	1800 27th Street NE	Residential	2	55 dBA	55 dBA	>61 dBA

[1] While site R1 is zoned agricultural by the City and thus does not have a regulatory limit, there appears to be a home at the property where overnight sleep occurs. For this reason, HDR classified this receptor as residential use for comparison to the FRA/FTA guidelines.

5 Noise Modeling

HDR created two noise models using the acoustical analysis software Cadna-A, which is based on ISO 9613, “Attenuation of Sound during Propagation Outdoors.” The first model represented a peak hour of activity at the Project and was used to estimate the loudest hour of operational noise. The second model represented an average hour and was used to determine the Project-related day-night noise level.

5.1 Model Inputs

Activities at the Project can be generally divided into six categories: dry bulk train operations, liquid bulk train operations, renewables facility operations, intermodal operations, transload operations, and manifest train operations.

Dry bulk operations will involve the transportation and loading/unloading of food or feed grains or products such as fertilizer or other compounds that are usually transported in

covered hoppers. Modeled noise-generating activities for dry bulk operations include trains arriving to and departing from the facility, over-the-road (OTR) trucks traveling from the site entrance to the dry bulk facility and back, and train movements on the dry bulk tracks to move the rail cars through the loading or unloading pit.

Liquid bulk operation will include the transportation and loading/unloading of products such as petroleum or chemicals that would be handled in tank cars. Modeled noise-generating activities for petroleum operations include trains arriving to and departing from the facility, breaking of the train onto the processing tracks, and OTR trucks traveling from the site entrance to the petroleum facility.

Renewables facility operations will include the transportation and loading/unloading of ethanol or biodiesel. This facility could also house a different type of industry such as a cross-dock facility, food processing, or distribution. Modeled noise-generating activities for renewable facility operations include trains arriving to and departing from the facility and OTR trucks traveling from the site entrance to the renewable facility and back.

Intermodal operations will involve the transportation and loading/unloading of containers in well cars and trailers on flatcars. Modeled noise-generating activities for intermodal operations include trains arriving to and departing from the facility, OTR trucks traveling from the site entrance to the intermodal tracks and back; hostler trucks traveling in the intermodal area; sideloaders, reachstackers, and gantry trains lifting containers at the tracks; and locomotives idling on the intermodal tracks.

Transload operations will involve the transportation and loading/unloading of various products, including dry bulk, liquid bulk, manufactured goods, and machinery, in open hopper cars, covered hopper cars, tank cars, flat cars, or box cars. Modeled noise-generating activities for transload operations include trains arriving to and departing from the facility, and OTR trucks traveling from the site entrance to the transload unloading systems and back.

Manifest operations include the transportation and loading/unloading of similar products to the transload operations to the dedicated industry spurs including the existing AGT facility. Modeled noise-generating activities for manifest trains include OTR trucks traveling from the site entrance to the industrial facilities and back, and trains operating serving the manifest shippers.

Noise-generating activities not modeled include noise from HVAC or roof-top equipment, forklift use, maintenance activities, or employee vehicles.

Table 5 shows the noise-generating activities with the active time or number of activities for the peak modeled hour. Quantities, active times, and speeds were obtained from the project design criteria where possible, otherwise they were inferred from the available information or based on data from similar projects.

Table 5. Activity Assumptions for Peak Hour Noise Model

Activity	Location/Route	Quantity per hour	Active time (stationary sources only)
Dry Bulk Facility			
Moving OTR trucks	County Road 12 to & from Facility	4	N/A
Arriving train	Track 1 through 201 to 301	1	N/A
Loading/unloading moving train	Track 301	1	N/A
Loading/unloading idling locomotives	Track 301 at loading/unloading pit	4	27 min
Petroleum Facility			
Moving OTR trucks	County Road 12 to Facility	4	N/A
Arriving train	Track 1 to 701	1	N/A
Breaking train	Track 701 to 702-709	1	N/A
Renewables Facility			
Moving OTR trucks	County Road 12 to & from Facility	4	N/A
Intermodal			
Moving OTR trucks	County Road 12 to & from Facility	4	N/A
Moving Hostlers	Along intermodal tracks	2	N/A
Sideloader & reachstackers	Along intermodal tracks	4	N/A
Gantry cranes	Along intermodal tracks	12	N/A
Idling train	North end of Track 402	4	60 min
Transloading			
Moving OTR trucks	County Road 12 to & from Facility	3	N/A
Manifest			
Moving OTR trucks	County Road 12 to & from Facility	28: 4 AGT, 1 for each industry	N/A
Train operation	Along track 3	1	N/A

Table 6 show lists of noise-generating activities with the active time or number of activities for the average modeled hour. Quantities, active times, and speeds were obtained from the project design criteria where possible, otherwise they were inferred from the available information or based on data from similar projects.

Table 6. Activity Assumptions for Average Hour Noise Model

Activity	Location/Route	Quantity per hour (week)[1]	Active time (stationary sources only)
Dry Bulk Facility			
Moving OTR trucks	County Road 12 to & from Facility	4 (N/A)	N/A
Arriving train	Track 1 through 201 to 301	0.06 (10)	N/A
Loading/unloading moving train	Track 301	0.06 (10)	N/A
Departing train	Track 301 through 1 out Facility	0.06 (10)	N/A
Loading/unloading idling locomotives	Along Track 301	4 (N/A)	N/A
Petroleum Facility			
Moving OTR trucks	County Road 12 to Facility	4 (N/A)	N/A
Arriving train	Track 1 to 701	0.02 (3)	N/A
Breaking train	Track 701 to 702-709	0.02 (3)	N/A
Departing train	Track 701 through 1 out Facility	0.02 (3)	N/A
Loading/unloading idling locomotives	At loading/unloading tracks	4 (N/A)	60 min
Renewables Facility			
Moving OTR trucks	County Road 12 to & from Facility	4 (N/A)	N/A
Arriving train	Track 1 to 801	0.02 (3)	N/A
Breaking train	Track 801 to 802-805	0.02 (3)	N/A
Departing train	Track 801 through 1 out Facility	0.02 (3)	N/A
Intermodal			
Moving OTR trucks	County Road 12 to & from Facility	4 (N/A)	N/A
Arriving train	Track 2 to 401 and 402	0.07 (11)	N/A
Departing train	Tracks 401 and 402 out Facility	0.07 (11)	N/A
Moving Hostlers	Along intermodal tracks	2 (N/A)	N/A
Sideloaders & reachstackers	Along intermodal tracks	4 (N/A)	N/A
Gantry cranes	Along intermodal tracks	12 (N/A)	N/A
Idling train	North end of Track 402	4 (N/A)	60 min

Activity	Location/Route	Quantity per hour (week)[1]	Active time (stationary sources only)
Transloading			
Moving OTR trucks	County Road 12 to & from Facility	3 (N/A)	N/A
Arriving train	Track 1	0.02 (3)	N/A
Breaking train	Tracks 601-603	0.02 (3)	N/A
Departing train	Tracks 601-603 out Facility	0.02 (3)	N/A
Manifest			
Moving OTR trucks	County Road 12 to & from Facility	28: 4 AGT, 1 for each industry	N/A
Train operation	Along track 3	0.07 (12)	N/A

[1] Average hourly quantities for arriving and departing trains is based on expected weekly traffic volumes shown in parentheses. Average hourly quantities for other sources assumed to be same as peak hour quantities for conservative assessment of noise emissions.

All moving trains are assumed to be travelling at 10 mph, with the exception of the train moving the dry bulk train through the loading/unloading pit, and other moving vehicles which are assumed to be travelling at 15 mph.

Table 7 shows the spectral sound power levels (SWL) and overall A-weighted sound power level for each type of noise source in the model. These levels were obtained from HDR's library of similar projects.

Table 7. Octave Band Sound Power Level (dB re 10^{-12} W)

Source	Octave Band Center Frequency (Hz)									
	31.5	63	125	250	500	1000	2000	4000	8000	dBA
Moving hostler	101	105	113	107	108	102	100	95	87	109
Sideloader/ Reachstacker	110	111	107	103	105	101	97	96	87	106
Idling locomotive	103	107	104	101	98	93	89	88	90	100
Moving OTR truck	101	101	106	109	104	102	99	93	87	108

Sound levels for trains were calculated based on the size, speed, and type of train according to methods from the FTA "Transit Noise and Vibration Impact Assessment Manual." Table 8 shows the modeled train parameters and resulting hourly Leq as measured 50 feet from the train.

Table 8. Train Modeling Parameters

Source	$L_{eq,50\ ft}$ (dBA)	Vehicle	SEL (dBA)	Number of Vehicles	Speed (mph)	Track Correction (dB)
Dry Bulk, Liquid Bulk arriving trains	63.9	Locomotive	92	4	10	N/A
		Car	82	128	10	5
	62.4	Locomotive	92	4	1	N/A

Source	$L_{eq,50\ ft}$ (dBA)	Vehicle	SEL (dBA)	Number of Vehicles	Speed (mph)	Track Correction (dB)
Dry Bulk loading train		Car	82	128	1	5
Liquid Bulk processing train	49-50	Locomotive	N/A	N/A	N/A	N/A
		Car	82	13-19	10	5
Manifest train	62	Locomotive	92	3	10	N/A
		Car	82	60	10	5

Because the distance from sources to receivers was significantly greater than the largest dimension of the noise sources, all stationary noise sources were modeled as point sources. Moving sources within the facility were modeled as line sources using the "moving-point source" option in Cadna and the parameters shown in Table 5 through Table 7 above. Activities such as gantry and sideloader/reachstacker lifts and hostler movements at the intermodal facility that could take place over a large area were modeled as area sources, using the "moving-point source" option in Cadna.

Trains were modeled as railway sources using the FTA/FRA module included in Cadna. Cadna automatically calculates the information shown in Table 9 based on FTA/FRA methods from input train types and quantities. Large obstacles such as the buildings were also included in the models.

Cadna-A has the ability to account for the acoustical characteristics of the ground cover in the noise propagation path. The ground in the facility area was treated as 20% acoustically absorptive to represent a graded gravel surface, with the exception of paved areas, which were modeled as 0% acoustically absorptive, and planned green spaces and wetlands, which were modeled as 80% acoustically absorptive. The rest of the ground in the model extents was treated as 80% acoustically absorptive to account for the agricultural area between the facility and surrounding residences. Existing topography in the Project area and proposed Project site elevations were imported into the model to account for any terrain shielding between the noise sources and receivers in the noise propagation path.

5.2 Noise Modeling Results

Table 9 below shows results from the noise models at each modeled location. Cadna calculated an hourly L_{eq}, for the peak hour model, and an L_{dn} for the average hour model.

Table 9. Noise Modeling Results

Receiver	Modeled Facility-Related L_{eq} (dBA)	Modeled Facility-Related L_{dn} (dBA)	Noise Limit City of Minot L_{eq} (dBA)	FTA/FRA Moderate and Severe Noise Impact Thresholds L_{dn} (dBA)
R1	57	52	N/A	55/>60
R2	48	51	55 day, 50 night	55/>61
R3	46	51	55 day, 50 night	55/>61

Receiver	Modeled Facility-Related L_{eq} (dBA)	Modeled Facility-Related L_{dn} (dBA)	Noise Limit City of Minot L_{eq} (dBA)	FTA/FRA Moderate and Severe Noise Impact Thresholds L_{dn} (dBA)
R4	49	50	55 day, 50 night	55/>61
R5	49	49	55 day, 50 night	55/>61

5.2.1 Discussion

A noise impact is defined as an exceedance of a regulatory threshold. Analysis results indicate that loudest hour noise emissions from the Facility are expected to meet the City of Minot daytime and nighttime noise limits (on an L_{eq} basis) at all residential receivers where the City noise limits apply. Analysis results also indicate that project-related noise is expected to be below FTA/FRA moderate and severe noise impact thresholds at all modeled residential receivers. Therefore, analysis results indicate that the project is not anticipated to cause noise impacts.

While Cadna-A software incorporates equations for outdoor sound propagation that are based on the international acoustical standard ISO 9613, Cadna-A adds an additional element of conservatism by assuming “downwind propagation” in all directions simultaneously. Blowing winds can enhance sound propagation, and under those conditions noise levels at locations downwind of a noise source are higher than noise levels at locations upwind of the noise source. As a result, Cadna-A’s use of downwind propagation at all locations simultaneously produces modeling results that are somewhat conservative overestimates of likely noise levels.

Figure 7 shows the peak hour noise contours for the facility, as well as the locations of the receivers. Based on the noise contours, Project peak hour noise levels are also expected to be below 65 dBA at the Project boundary with adjacent industrial land uses, which is in compliance with the City noise limits.

Figure 7. Peak Hour Noise Modeling Contours (dBA)

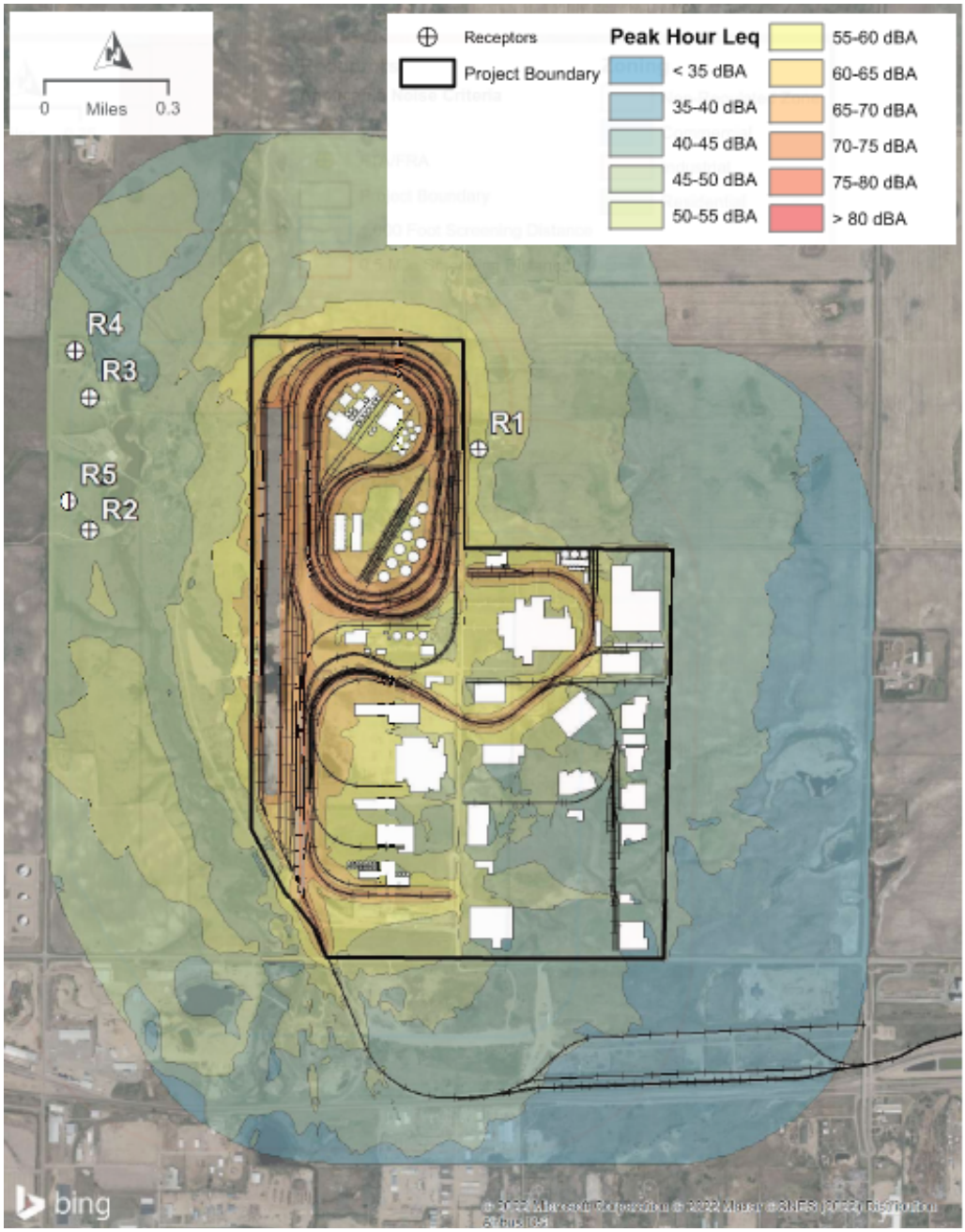
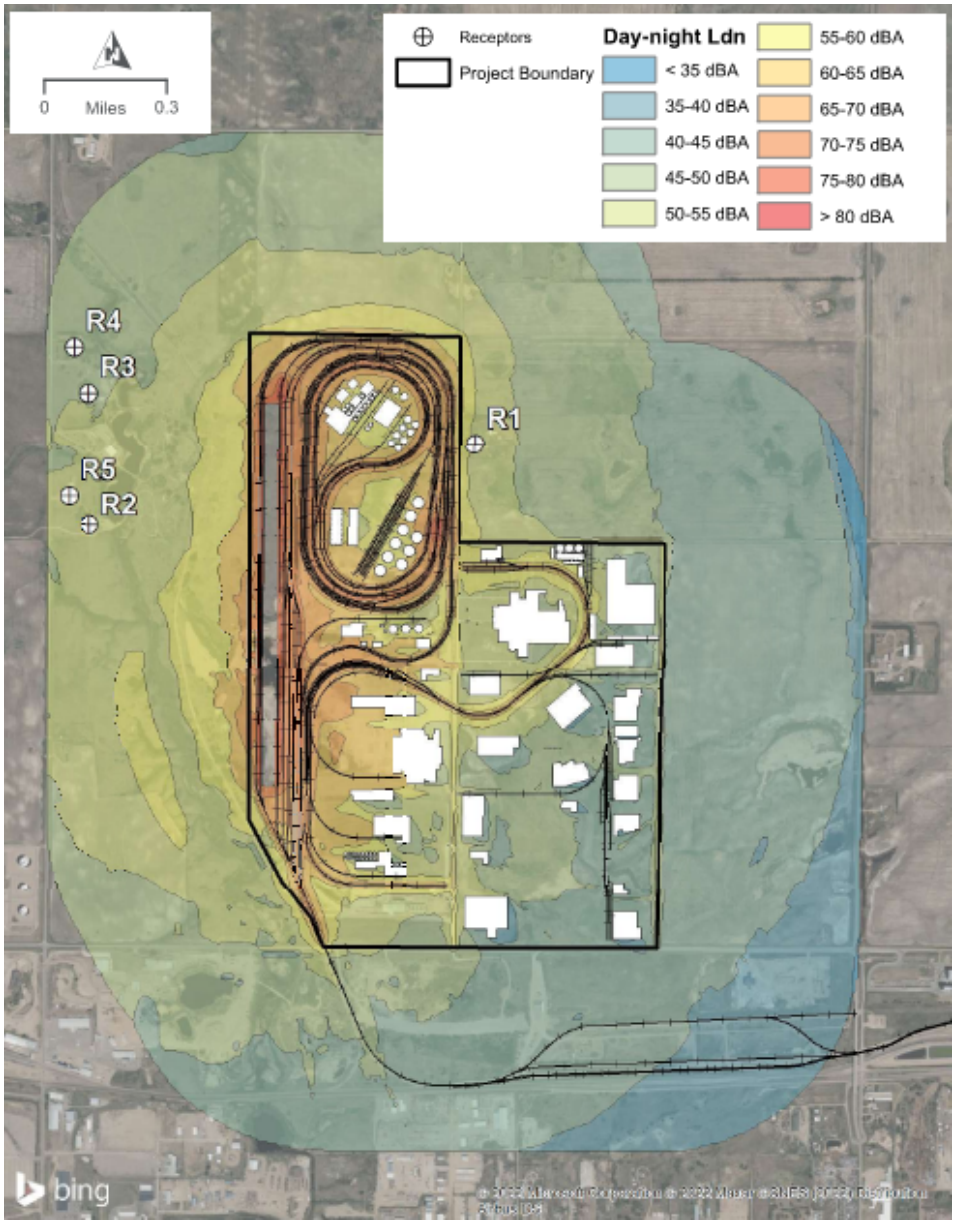


Figure 8 shows the peak hour noise contours for the facility, as well as the locations of the receivers. Based on the noise contours, Project peak hour noise levels are also expected to be below 65 dBA at the Project boundary with adjacent industrial land uses, which is in compliance with the City noise limits.

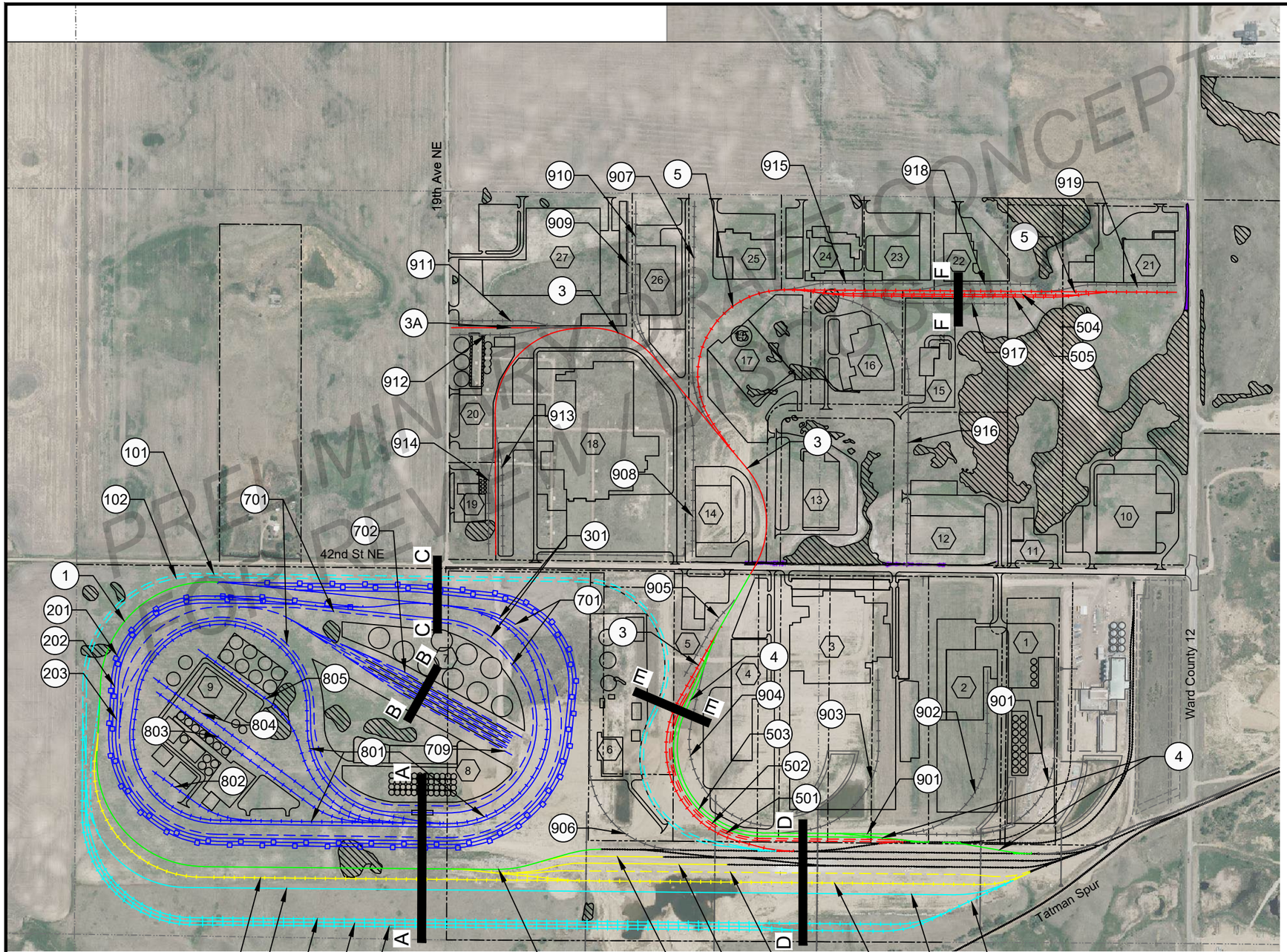
Figure 8. Average Hour Noise Modeling Contours (dBA)



6 Conclusion

Based on results from the operational noise models, HDR does not anticipate the Project will result in exceedances of noise limits or impact thresholds at nearby receptors.

Appendix A. Site Layout



LEGEND

INITIAL PHASE
- PHASE 1

INFINITY LOOP PHASES
- PHASE 2A
- PHASE 2B
- PHASE 2C
- PHASE 2D

MANIFEST SITE PHASES
- PHASE 3A
- PHASE 3B
- PHASE 3C

TRANSLOAD PHASES
- PHASE 4A
- PHASE 4B
- PHASE 4C

INTERMODAL PHASES
- PHASE 5A
- PHASE 5A TEMP. CONNECTION
- PHASE 5B
- PHASE 5C

- POTENTIAL INDUSTRY TRACKS
- EXISTING TRACKS
- WETLAND AREA
- (#) PARCEL IDENTIFICATION NUMBER
- (#) TRACK NUMBER

N

0' 400' 800'
GRAPHIC SCALE

THIS DESIGN INCLUDES USE OF THE HDR PATENTED RAILWAY FACILITY WITH HIGH THROUGHPUT LOOP TRACK (INFINITY LOOP) LAYOUT. PATENT NUMBER 11027752. USE OF THIS LAYOUT IS SUBJECT TO LICENSING REQUIREMENTS AND OR OTHER FORMS OF ACKNOWLEDGMENT FROM HDR.

NO.	REVISIONS	BY	DATE	APPR.

HDR

SCALE (H): 1"=800'
SCALE (V): 1"=800'
DRAWN BY: SK
DESIGNED BY: PW/SK
CHECKED BY: PW
DATE: 10/07/22

LOGISTICS PARK OF NORTH DAKOTA
CONCEPT 1 - RAIL PHASING -TRACK NUMBERING
MINOT, ND
EXHIBIT

Project NO.
10315558

Drawing Name
EXHB_MINOT 1

1 OF 1

DRAFT SET

Appendix B. Noise Monitoring Locations

Site R1

Site R2

Appendix C. Calibration Certificates

Calibration Certificate

Certificate Number 2021007965

Customer:

HDR Engineering Inc
1601 Utica Avenue South
St. Louis Park, MN 55416, United States

Model Number	831C	***Procedure Number***	D0001.8384		
Serial Number	11568	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	1 Jul 2021		
Initial Condition	As Manufactured	***Calibration Due***			
Description	Larson Davis Model 831C Class 1 Sound Level Meter Firmware Revision: 04.6.2R1	***Temperature***	23.62	°C	± 0.25 °C
		Humidity	51.7	%RH	± 2.0 %RH
		Static Pressure	86.32	kPa	± 0.13 kPa

Evaluation Method

Tested with:

Larson Davis PRM2103. S/N 001835
PCB 377B02. S/N 330804
Larson Davis CAL200. S/N 9079
Larson Davis CAL291. S/N 0108

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 61260:2014 Class 1	ANSI S1.11-2014 Class 1
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 17025:2017.
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 9001:2015.

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 SoundAdvisor Model 831C Reference Manual, I831C.01 Rev B, 2017-03-31

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.

No Pattern approval for IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 available.

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. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, 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 or correction data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3 cover only a limited subset of the specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
Larson Davis CAL291 Residual Intensity Calibrator	2020-09-18	2021-09-18	001250
Hart Scientific 2626-H Temperature Probe	2021-02-04	2022-08-04	006767
Larson Davis CAL200 Acoustic Calibrator	2020-07-21	2021-07-21	007027
Larson Davis Model 831	2021-03-02	2022-03-02	007182
PCB 377A13 1/2 inch Prepolarized Pressure Microphone	2021-03-03	2022-03-03	007185
SRS DS360 Ultra Low Distortion Generator	2021-04-13	2022-04-13	007635
Larson Davis 1/2" Preamplifier for Model 831 Type 1	2020-10-06	2021-10-06	PCB0004783

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

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	-0.06	-0.20	-1.20	0.80	0.23	Pass
1000	0.20	0.00	-0.70	0.70	0.23	Pass
8000	-2.54	-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	40.51

-- End of measurement results--

-- End of Report--

Signatory: Ron Harris

LARSON DAVIS - A PCB PIEZOTRONICS DIV.
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 2021007953

Customer:

HDR Engineering Inc
1601 Utica Avenue South
St. Louis Park, MN 55416, United States

Model Number	831C	***Procedure Number***	D0001.8378		
Serial Number	11568	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	1 Jul 2021		
Initial Condition	As Manufactured	***Calibration Due***			
Description	Larson Davis Model 831C Class 1 Sound Level Meter Firmware Revision: 04.6.2R1	***Temperature***	23.32	°C	± 0.25 °C
		Humidity	52.7	%RH	± 2.0 %RH
		Static Pressure	86.24	kPa	± 0.13 kPa

Evaluation Method Tested electrically using Larson Davis PRM2103 S/N 001835 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 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1
IEC 61260:2014 Class 1	ANSI S1.11-2014 Class 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 17025:2017. **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 9001:2015.

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.

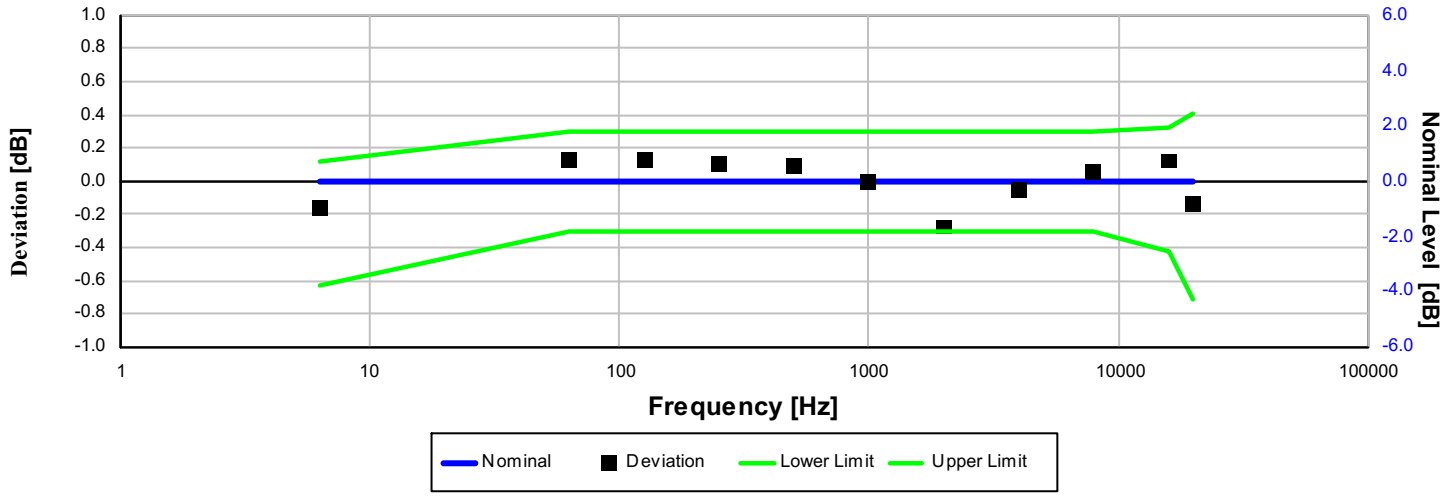
The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Correction data from Larson Davis SoundAdvisor Model 831C Reference Manual, I831C.01 Rev M, 2019-09-10

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

Standards Used			
Description	**Cal Date**	**Cal Due**	**Cal Standard**
Hart Scientific 2626-H Temperature Probe	2021-02-04	2022-08-04	006767
SRS DS360 Ultra Low Distortion Generator	2021-04-13	2022-04-13	007635

Z-weight Filter Response

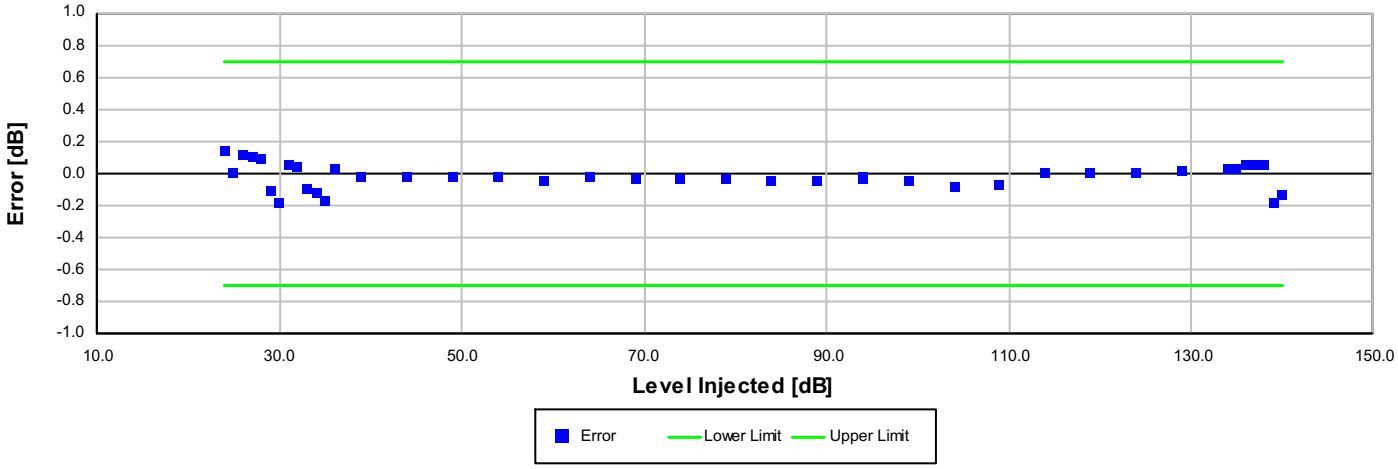


Electrical signal test of frequency weighting performed according to IEC 61672-3:2013 13 and ANSI S1.4-2014 Part 3: 13 for compliance to IEC 61672-1:2013 5.5; IEC 60651:2001 6.1 and 9.2.2; IEC 60804:2000 5; ANSI S1.4:1983 (R2006) 5.1 and 8.2.1; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Deviation [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
6.31	-0.16	-0.16	-0.63	0.12	0.15	Pass
63.10	0.14	0.14	-0.30	0.30	0.15	Pass
125.89	0.14	0.14	-0.30	0.30	0.15	Pass
251.19	0.11	0.11	-0.30	0.30	0.15	Pass
501.19	0.09	0.09	-0.30	0.30	0.15	Pass
1,000.00	0.00	0.00	-0.30	0.30	0.15	Pass
1,995.26	-0.27	-0.27	-0.30	0.30	0.15	Pass
3,981.07	-0.05	-0.05	-0.30	0.30	0.15	Pass
7,943.28	0.05	0.05	-0.30	0.30	0.15	Pass
15,848.93	0.12	0.12	-0.42	0.32	0.15	Pass
19,952.62	-0.13	-0.13	-0.71	0.41	0.15	Pass

-- End of measurement results--

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



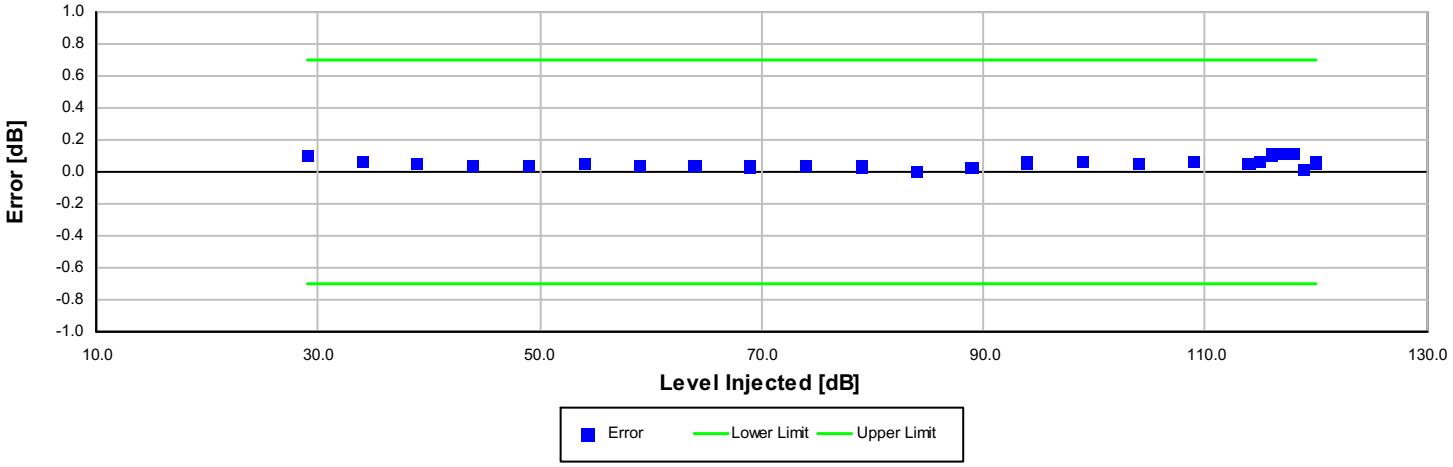
Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
24.00	0.14	-0.70	0.70	0.16	Pass
25.00	0.00	-0.70	0.70	0.16	Pass
26.00	0.12	-0.70	0.70	0.16	Pass
27.00	0.10	-0.70	0.70	0.16	Pass
28.00	0.10	-0.70	0.70	0.16	Pass
29.00	-0.11	-0.70	0.70	0.16	Pass
30.00	-0.18	-0.70	0.70	0.16	Pass
31.00	0.05	-0.70	0.70	0.16	Pass
32.00	0.04	-0.70	0.70	0.16	Pass
33.00	-0.10	-0.70	0.70	0.16	Pass
34.00	-0.11	-0.70	0.70	0.16	Pass
35.00	-0.17	-0.70	0.70	0.16	Pass
36.00	0.03	-0.70	0.70	0.16	Pass
39.00	-0.02	-0.70	0.70	0.16	Pass
44.00	-0.01	-0.70	0.70	0.16	Pass
49.00	-0.02	-0.70	0.70	0.16	Pass
54.00	-0.02	-0.70	0.70	0.16	Pass
59.00	-0.04	-0.70	0.70	0.16	Pass
64.00	-0.02	-0.70	0.70	0.16	Pass
69.00	-0.03	-0.70	0.70	0.16	Pass
74.00	-0.03	-0.70	0.70	0.16	Pass
79.00	-0.04	-0.70	0.70	0.16	Pass
84.00	-0.04	-0.70	0.70	0.16	Pass
89.00	-0.04	-0.70	0.70	0.16	Pass
94.00	-0.03	-0.70	0.70	0.16	Pass
99.00	-0.05	-0.70	0.70	0.16	Pass
104.00	-0.08	-0.70	0.70	0.15	Pass
109.00	-0.07	-0.70	0.70	0.15	Pass
114.00	0.00	-0.70	0.70	0.15	Pass
119.00	0.01	-0.70	0.70	0.15	Pass
124.00	0.00	-0.70	0.70	0.15	Pass
129.00	0.01	-0.70	0.70	0.15	Pass
134.00	0.03	-0.70	0.70	0.15	Pass
135.00	0.03	-0.70	0.70	0.15	Pass
136.00	0.05	-0.70	0.70	0.15	Pass
137.00	0.06	-0.70	0.70	0.15	Pass

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
138.00	0.06	-0.70	0.70	0.15	Pass
139.00	-0.18	-0.70	0.70	0.15	Pass
140.00	-0.14	-0.70	0.70	0.15	Pass

-- End of measurement results--

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

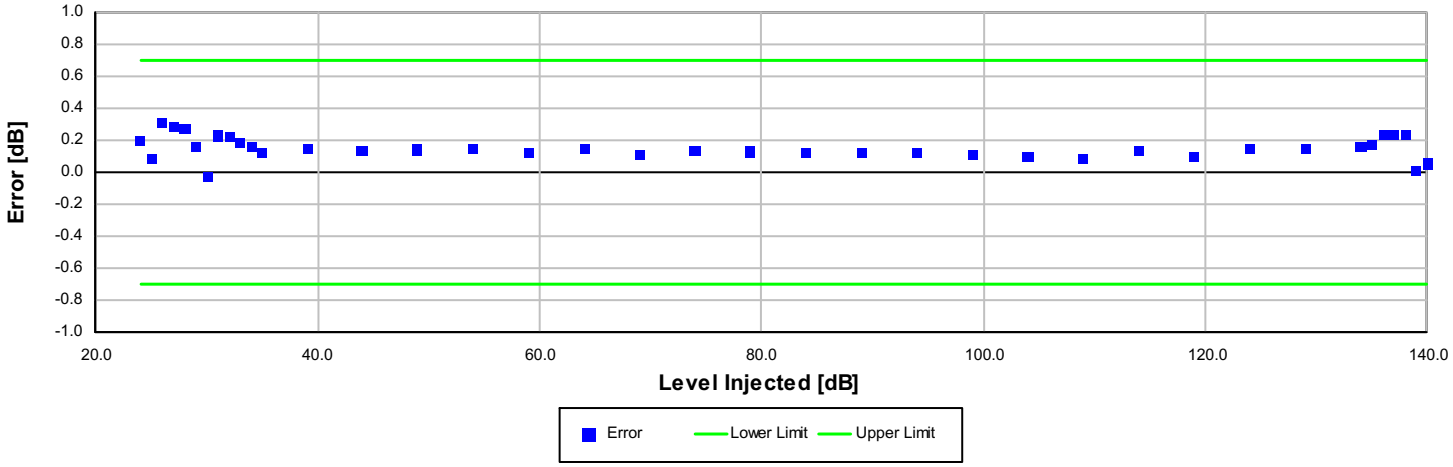


Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
29.00	0.09	-0.70	0.70	0.16	Pass
34.00	0.06	-0.70	0.70	0.16	Pass
39.00	0.05	-0.70	0.70	0.16	Pass
44.00	0.04	-0.70	0.70	0.16	Pass
49.00	0.03	-0.70	0.70	0.16	Pass
54.00	0.04	-0.70	0.70	0.16	Pass
59.00	0.03	-0.70	0.70	0.16	Pass
64.00	0.03	-0.70	0.70	0.16	Pass
69.00	0.03	-0.70	0.70	0.16	Pass
74.00	0.03	-0.70	0.70	0.16	Pass
79.00	0.03	-0.70	0.70	0.16	Pass
84.00	-0.01	-0.70	0.70	0.16	Pass
89.00	0.02	-0.70	0.70	0.16	Pass
94.00	0.05	-0.70	0.70	0.16	Pass
99.00	0.06	-0.70	0.70	0.16	Pass
104.00	0.05	-0.70	0.70	0.15	Pass
109.00	0.06	-0.70	0.70	0.15	Pass
114.00	0.05	-0.70	0.70	0.15	Pass
115.00	0.06	-0.70	0.70	0.15	Pass
116.00	0.10	-0.70	0.70	0.15	Pass
117.00	0.11	-0.70	0.70	0.15	Pass
118.00	0.11	-0.70	0.70	0.15	Pass
119.00	0.01	-0.70	0.70	0.15	Pass
120.00	0.05	-0.70	0.70	0.15	Pass

-- End of measurement results--

A-weighted 0 dB Gain Broadband Log Linearity: 1,000.00 Hz



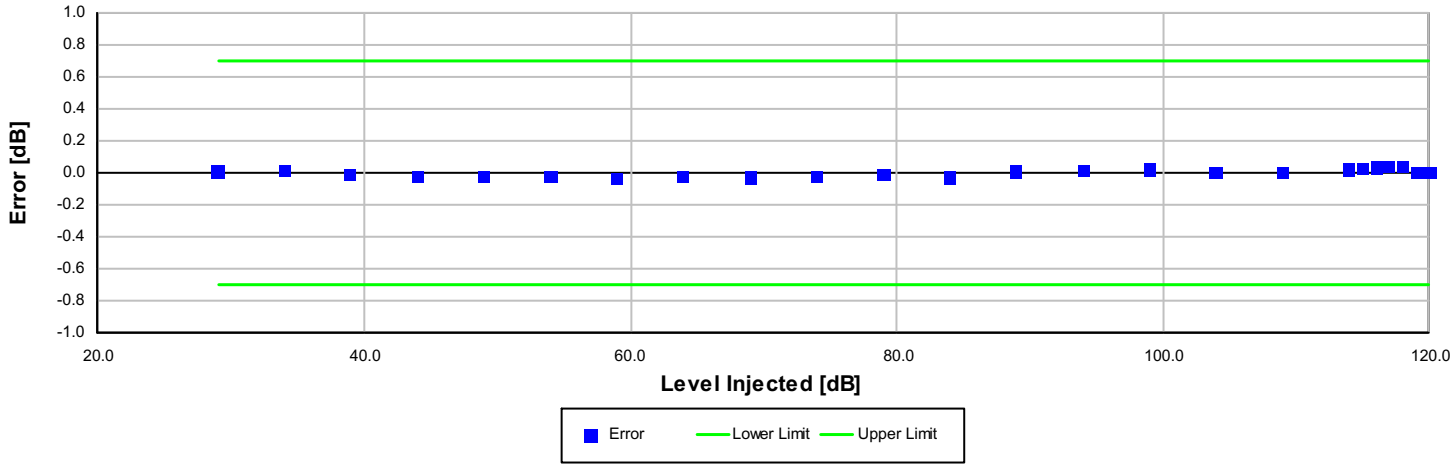
Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
24.00	0.19	-0.70	0.70	0.16	Pass
25.00	0.08	-0.70	0.70	0.16	Pass
26.00	0.30	-0.70	0.70	0.16	Pass
27.00	0.28	-0.70	0.70	0.16	Pass
28.00	0.27	-0.70	0.70	0.16	Pass
29.00	0.15	-0.70	0.70	0.16	Pass
30.00	-0.03	-0.70	0.70	0.16	Pass
31.00	0.22	-0.70	0.70	0.16	Pass
32.00	0.22	-0.70	0.70	0.16	Pass
33.00	0.18	-0.70	0.70	0.16	Pass
34.00	0.15	-0.70	0.70	0.16	Pass
35.00	0.12	-0.70	0.70	0.16	Pass
39.00	0.14	-0.70	0.70	0.16	Pass
44.00	0.13	-0.70	0.70	0.16	Pass
49.00	0.14	-0.70	0.70	0.16	Pass
54.00	0.14	-0.70	0.70	0.16	Pass
59.00	0.12	-0.70	0.70	0.16	Pass
64.00	0.14	-0.70	0.70	0.16	Pass
69.00	0.11	-0.70	0.70	0.16	Pass
74.00	0.13	-0.70	0.70	0.16	Pass
79.00	0.12	-0.70	0.70	0.16	Pass
84.00	0.12	-0.70	0.70	0.16	Pass
89.00	0.11	-0.70	0.70	0.16	Pass
94.00	0.12	-0.70	0.70	0.16	Pass
99.00	0.10	-0.70	0.70	0.16	Pass
104.00	0.09	-0.70	0.70	0.15	Pass
109.00	0.08	-0.70	0.70	0.15	Pass
114.00	0.13	-0.70	0.70	0.15	Pass
119.00	0.09	-0.70	0.70	0.15	Pass
124.00	0.14	-0.70	0.70	0.15	Pass
129.00	0.14	-0.70	0.70	0.15	Pass
134.00	0.15	-0.70	0.70	0.15	Pass
135.00	0.16	-0.70	0.70	0.15	Pass
136.00	0.22	-0.70	0.70	0.15	Pass
137.00	0.23	-0.70	0.70	0.15	Pass
138.00	0.23	-0.70	0.70	0.15	Pass
139.00	0.00	-0.70	0.70	0.15	Pass

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
140.00	0.05	-0.70	0.70	0.15	Pass

-- End of measurement results--

A-weighted 20 dB Gain Broadband Log Linearity: 1,000.00 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
29.00	0.00	-0.70	0.70	0.16	Pass
34.00	0.01	-0.70	0.70	0.16	Pass
39.00	-0.01	-0.70	0.70	0.16	Pass
44.00	-0.02	-0.70	0.70	0.16	Pass
49.00	-0.02	-0.70	0.70	0.16	Pass
54.00	-0.02	-0.70	0.70	0.16	Pass
59.00	-0.03	-0.70	0.70	0.16	Pass
64.00	-0.03	-0.70	0.70	0.16	Pass
69.00	-0.03	-0.70	0.70	0.16	Pass
74.00	-0.03	-0.70	0.70	0.16	Pass
79.00	-0.02	-0.70	0.70	0.16	Pass
84.00	-0.03	-0.70	0.70	0.16	Pass
89.00	0.01	-0.70	0.70	0.16	Pass
94.00	0.02	-0.70	0.70	0.16	Pass
99.00	0.02	-0.70	0.70	0.16	Pass
104.00	0.00	-0.70	0.70	0.15	Pass
109.00	0.00	-0.70	0.70	0.15	Pass
114.00	0.02	-0.70	0.70	0.15	Pass
115.00	0.02	-0.70	0.70	0.15	Pass
116.00	0.03	-0.70	0.70	0.15	Pass
117.00	0.04	-0.70	0.70	0.15	Pass
118.00	0.04	-0.70	0.70	0.15	Pass
119.00	0.00	-0.70	0.70	0.15	Pass
120.00	0.00	-0.70	0.70	0.15	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
139.00	40	Negative Pulse	135.74	134.40	136.40	0.15	Pass
		Positive Pulse	135.77	134.42	136.42	0.15	Pass
	30	Negative Pulse	134.73	134.40	136.40	0.15	Pass
		Positive Pulse	134.76	134.42	136.42	0.15	Pass

-- End of measurement results--

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	0.15 ‡	Pass
	5	OVLD	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
128.00	3	0.03	± 0.50	0.15 ‡	Pass
	5	0.08	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
118.00	3	0.03	± 0.50	0.15 ‡	Pass
	5	0.07	± 1.00	0.15 ‡	Pass
	10	-0.06	± 1.50	0.15 ‡	Pass
108.00	3	0.00	± 0.50	0.15 ‡	Pass
	5	0.06	± 1.00	0.15 ‡	Pass
	10	-0.04	± 1.50	0.15 ‡	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	0.15 ‡	Pass
	5	OVLD	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
128.00	3	0.03	± 0.50	0.15 ‡	Pass
	5	0.08	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
118.00	3	0.02	± 0.50	0.15 ‡	Pass
	5	0.06	± 1.00	0.15 ‡	Pass
	10	0.09	± 1.50	0.15 ‡	Pass
108.00	3	-0.02	± 0.50	0.15 ‡	Pass
	5	0.04	± 1.00	0.15 ‡	Pass
	10	0.19	± 1.50	0.16 ‡	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	94.00	93.91	94.11	0.15	Pass
0 dB Gain, Linearity	37.03	36.31	37.71	0.16	Pass
20 dB Gain	94.03	93.91	94.11	0.15	Pass
20 dB Gain, Linearity	37.00	36.31	37.71	0.16	Pass
OBA High Range	94.01	93.20	94.80	0.15	Pass
OBA Normal Range	94.01	93.91	94.11	0.15	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	7.32	16.00	Pass
C-weight Noise Floor	13.08	19.00	Pass
Z-weight Noise Floor	25.85	32.00	Pass

-- End of measurement results--

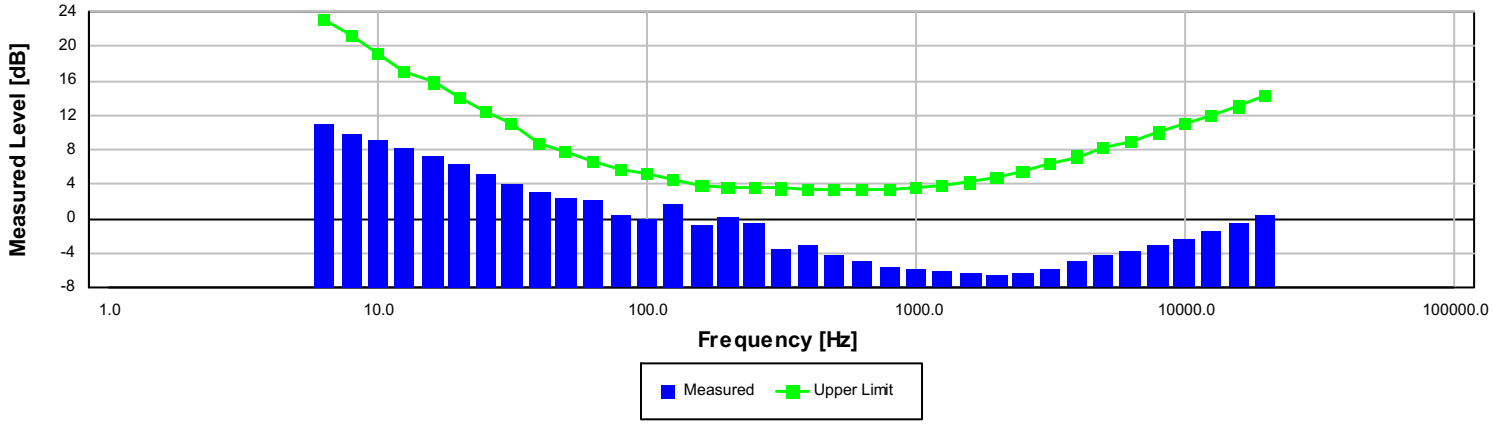
Total Harmonic Distortion

Measured using 1/3-Octave filters

Measurement	Test Result [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
10 Hz Signal	137.51	137.20	138.80	0.15	Pass
THD	-73.93		-60.00	1.30 ‡	Pass
THD+N	-73.18		-60.00	1.30 ‡	Pass

-- End of measurement results--

1/3-Octave Self-Generated Noise



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

Frequency [Hz]	Test Result [dB]	Upper limit [dB]	Result
6.30	10.92	23.10	Pass
8.00	9.88	21.30	Pass
10.00	9.22	19.10	Pass
12.50	8.31	17.10	Pass
16.00	7.41	15.80	Pass
20.00	6.36	14.10	Pass
25.00	5.22	12.40	Pass
31.50	4.18	11.10	Pass
40.00	3.12	8.80	Pass
50.00	2.43	7.70	Pass
63.00	2.17	6.60	Pass
80.00	0.32	5.70	Pass
100.00	-0.20	5.20	Pass
125.00	1.73	4.60	Pass
160.00	-0.75	3.90	Pass
200.00	0.18	3.70	Pass
250.00	-0.64	3.60	Pass
315.00	-3.48	3.50	Pass
400.00	-3.01	3.40	Pass
500.00	-4.26	3.30	Pass
630.00	-5.07	3.30	Pass
800.00	-5.66	3.40	Pass
1,000.00	-6.00	3.70	Pass
1,250.00	-6.19	3.90	Pass
1,600.00	-6.41	4.20	Pass
2,000.00	-6.51	4.70	Pass
2,500.00	-6.29	5.40	Pass
3,150.00	-5.92	6.30	Pass
4,000.00	-5.05	7.20	Pass
5,000.00	-4.37	8.20	Pass
6,300.00	-3.76	9.00	Pass
8,000.00	-3.16	10.00	Pass
10,000.00	-2.46	11.00	Pass
12,500.00	-1.40	12.00	Pass
16,000.00	-0.50	13.00	Pass
20,000.00	0.25	14.20	Pass

-- End of measurement results--

-- End of Report--

Signatory: Ron Harris

LARSON DAVIS - A PCB PIEZOTRONICS DIV.
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

Calibration Certificate

Certificate Number 2021009324

Customer:

HDR Engineering Inc
1601 Utica Avenue South
Suite 600
Minneapolis,MN 55416,United States

Model Number	831C	***Procedure Number***	D0001.8384		
Serial Number	11571	***Technician***	Eric Olson		
Test Results	**Pass**	***Calibration Date***	2 Aug 2021		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***			
		Temperature	24	°C	± 0.25 °C
Description	Larson Davis Model 831C Class 1 Sound Level Meter Firmware Revision: 04.6.2R1	***Humidity***	52.3	%RH	± 2.0 %RH
		Static Pressure	86.78	kPa	± 0.13 kPa

Evaluation Method ***Tested with:*** ***Data reported in dB re 20 µPa.***

Larson Davis PRM2103, S/N 001905
Larson Davis CAL291, S/N 0203
Larson Davis CAL200, S/N 6768
PCB 377B02, S/N 330809

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 61260:2014 Class 1	ANSI S1.11-2014 Class 1
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 17025:2017.
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 9001:2015.

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 SoundAdvisor Model 831C Reference Manual, I831C.01 Rev B, 2017-03-31

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.

No Pattern approval for IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 available.

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. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, 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 or correction data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3 cover only a limited subset of the specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
Larson Davis 1/2" Preamplifier for Model 831 Type 1	2021-05-24	2022-05-24	0000354
SRS DS360 Ultra Low Distortion Generator	2021-03-09	2022-03-09	006311
Hart Scientific 2626-H Temperature Probe	2021-02-04	2022-08-04	006767
1/2 inch Microphone - P - 0V	2021-03-12	2022-03-12	007081
Larson Davis CAL291 Residual Intensity Calibrator	2020-10-28	2021-10-28	007287
Larson Davis Model 831	2020-09-22	2021-09-22	007507
Larson Davis CAL200 Acoustic Calibrator	2021-04-12	2022-04-12	007784

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

Adjusted Level: 114.00
As Received Level: 114.13

-- 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	-0.19	-0.20	-1.20	0.80	0.23	Pass
1000	0.23	0.00	-0.70	0.70	0.23	Pass
8000	-2.06	-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	43.54

-- End of measurement results--

-- End of Report--

Signatory: *Eric Olson*

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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 2021009313

Customer:

HDR Engineering Inc
1601 Utica Avenue South
Suite 600
Minneapolis, MN 55416, United States

Model Number	831C	***Procedure Number***	D0001.8378		
Serial Number	11571	***Technician***	Eric Olson		
Test Results	**Pass**	***Calibration Date***	2 Aug 2021		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***			
		Temperature	23.76	°C	± 0.25 °C
Description	Larson Davis Model 831C Class 1 Sound Level Meter Firmware Revision: 04.6.2R1	***Humidity***	49.8	%RH	± 2.0 %RH
		Static Pressure	86.94	kPa	± 0.13 kPa

Evaluation Method Tested electrically using Larson Davis PRM2103 S/N 001905 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 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 17025:2017. **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 9001:2015.

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 SoundAdvisor Model 831C Reference Manual, I831C.01 Rev M, 2019-09-10

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.

No Pattern approval for IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 available.

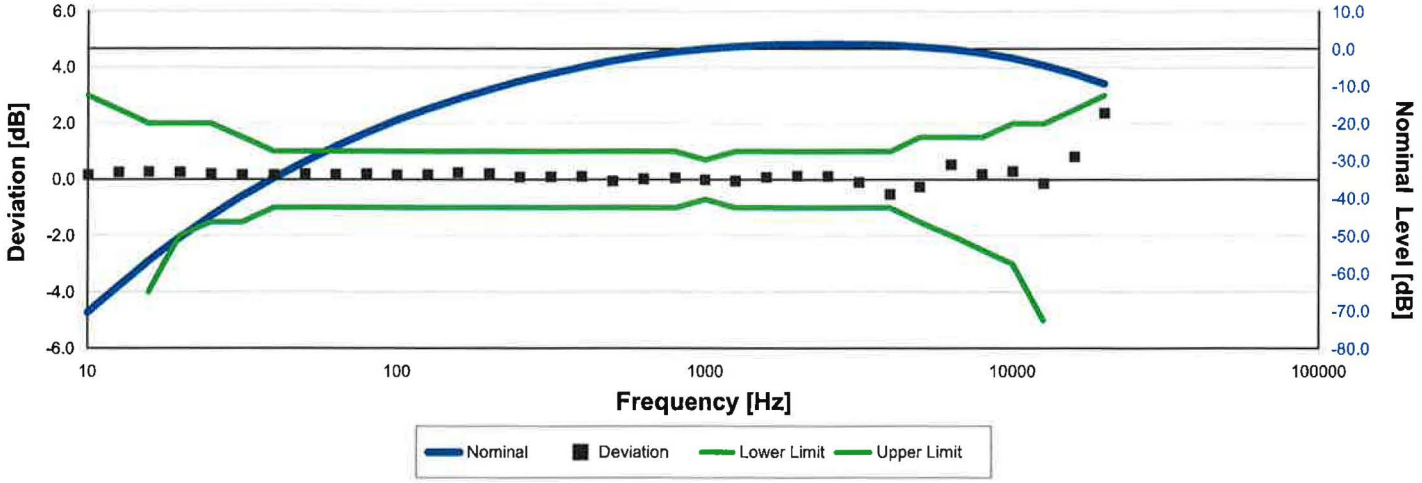
The sound level meter submitted for testing successfully completed the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3, for the environmental conditions under which the tests were performed. However, no general statement or conclusion can be made about

conformance of the sound level meter to the full specifications of IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, 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 or correction data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3 cover only a limited subset of the specifications 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	2021-03-09	2022-03-09	006311
Hart Scientific 2626-H Temperature Probe	2021-02-04	2022-08-04	006767

A-weight Filter Response



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	-70.23	0.17	-inf	3.00	0.25	Pass
12.59	-63.15	0.26	-inf	2.50	0.25	Pass
15.85	-56.43	0.27	-4.00	2.00	0.25	Pass
19.95	-50.24	0.26	-2.00	2.00	0.25	Pass
25.12	-44.50	0.20	-1.50	2.00	0.25	Pass
31.62	-39.23	0.17	-1.50	1.50	0.25	Pass
39.81	-34.44	0.17	-1.00	1.00	0.25	Pass
50.12	-30.00	0.20	-1.00	1.00	0.25	Pass
63.10	-26.02	0.18	-1.00	1.00	0.25	Pass
79.43	-22.30	0.20	-1.00	1.00	0.25	Pass
100.00	-18.93	0.17	-1.00	1.00	0.25	Pass
125.89	-15.93	0.17	-1.00	1.00	0.25	Pass
158.49	-13.15	0.25	-1.00	1.00	0.25	Pass
199.53	-10.69	0.21	-1.00	1.00	0.25	Pass
251.19	-8.52	0.08	-1.00	1.00	0.25	Pass
316.23	-6.50	0.10	-1.00	1.00	0.25	Pass
398.11	-4.70	0.11	-1.00	1.00	0.25	Pass
501.19	-3.25	-0.05	-1.00	1.00	0.25	Pass
630.96	-1.88	0.02	-1.00	1.00	0.25	Pass
794.33	-0.74	0.06	-1.00	1.00	0.25	Pass
1,000.00	0.00	0.00	-0.70	0.70	0.25	Pass
1,258.93	0.56	-0.04	-1.00	1.00	0.25	Pass
1,584.89	1.08	0.08	-1.00	1.00	0.25	Pass
1,995.26	1.33	0.13	-1.00	1.00	0.25	Pass
2,511.89	1.43	0.12	-1.00	1.00	0.25	Pass
3,162.28	1.10	-0.10	-1.00	1.00	0.25	Pass
3,981.07	0.48	-0.52	-1.00	1.00	0.25	Pass
5,011.87	0.25	-0.25	-1.50	1.50	0.25	Pass
6,309.57	0.44	0.54	-2.00	1.50	0.25	Pass
7,943.28	-0.91	0.19	-2.50	1.50	0.25	Pass
10,000.00	-2.21	0.29	-3.00	2.00	0.25	Pass
12,589.25	-4.43	-0.13	-5.00	2.00	0.25	Pass
15,848.93	-5.78	0.82	-16.00	2.50	0.25	Pass
19,952.62	-6.92	2.38	-inf	3.00	0.25	Pass

-- End of measurement results--

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1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ACCREDITED Cert. #3622.01

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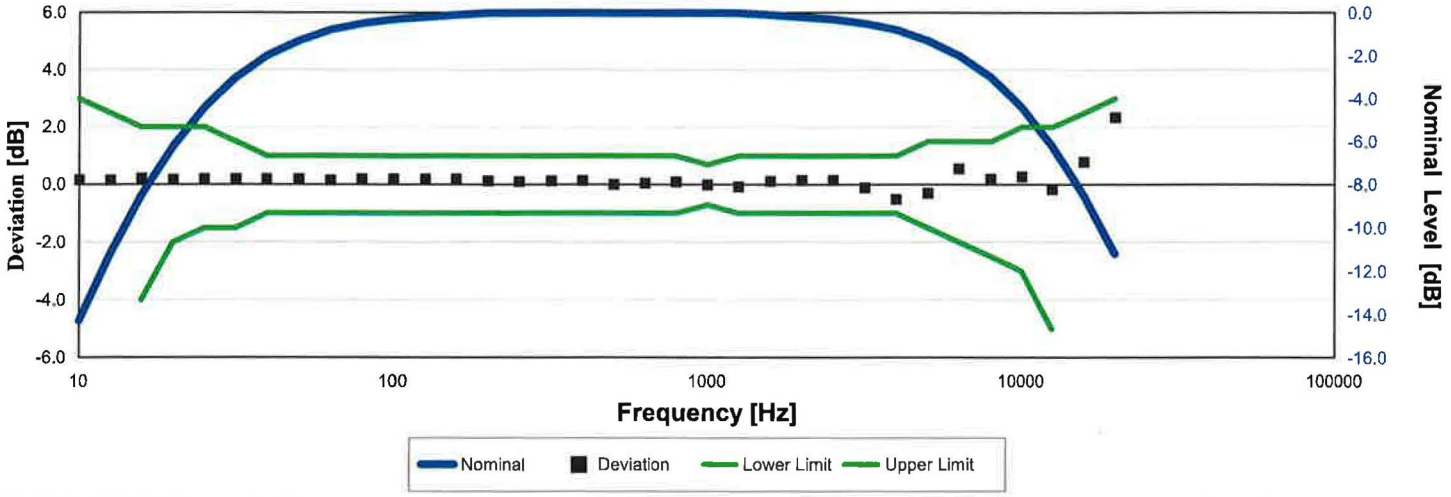
C-weight Filter Response

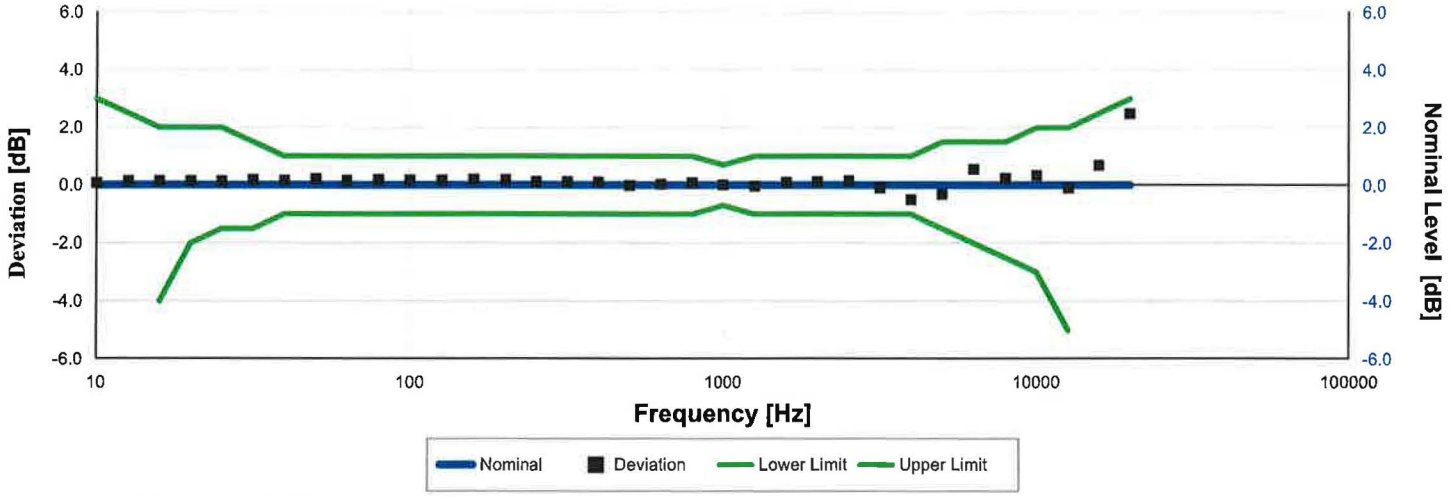


Electrical signal test of frequency weighting performed according to IEC 61672-3:2013 13 and ANSI S1.4-2014 Part 3: 13 for compliance to IEC 61672-1:2013 5.5; IEC 60651:2001 6.1 and 9.2.2; IEC 60804:2000 5; ANSI S1.4:1983 (R2006) 5.1 and 8.2.1; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Deviation [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
10.00	-14.14	0.17	-inf	3.00	0.25	Pass
12.59	-11.05	0.15	-inf	2.50	0.25	Pass
15.85	-8.27	0.23	-4.00	2.00	0.25	Pass
19.95	-6.03	0.18	-2.00	2.00	0.25	Pass
25.12	-4.21	0.20	-1.50	2.00	0.25	Pass
31.62	-2.80	0.20	-1.50	1.50	0.25	Pass
39.81	-1.80	0.20	-1.00	1.00	0.25	Pass
50.12	-1.10	0.20	-1.00	1.00	0.25	Pass
63.10	-0.64	0.16	-1.00	1.00	0.25	Pass
79.43	-0.30	0.20	-1.00	1.00	0.25	Pass
100.00	-0.10	0.20	-1.00	1.00	0.25	Pass
125.89	0.00	0.20	-1.00	1.00	0.25	Pass
158.49	0.11	0.20	-1.00	1.00	0.25	Pass
199.53	0.14	0.14	-1.00	1.00	0.25	Pass
251.19	0.11	0.11	-1.00	1.00	0.25	Pass
316.23	0.13	0.13	-1.00	1.00	0.25	Pass
398.11	0.14	0.14	-1.00	1.00	0.25	Pass
501.19	0.01	0.01	-1.00	1.00	0.25	Pass
630.96	0.05	0.05	-1.00	1.00	0.25	Pass
794.33	0.10	0.10	-1.00	1.00	0.25	Pass
1,000.00	0.00	0.00	-0.70	0.70	0.25	Pass
1,258.93	-0.07	-0.07	-1.00	1.00	0.25	Pass
1,584.89	0.02	0.12	-1.00	1.00	0.25	Pass
1,995.26	-0.04	0.16	-1.00	1.00	0.25	Pass
2,511.89	-0.15	0.15	-1.00	1.00	0.25	Pass
3,162.28	-0.60	-0.10	-1.00	1.00	0.25	Pass
3,981.07	-1.31	-0.50	-1.00	1.00	0.25	Pass
5,011.87	-1.60	-0.30	-1.50	1.50	0.25	Pass
6,309.57	-1.44	0.56	-2.00	1.50	0.25	Pass
7,943.28	-2.81	0.19	-2.50	1.50	0.25	Pass
10,000.00	-4.12	0.28	-3.00	2.00	0.25	Pass
12,589.25	-6.35	-0.15	-5.00	2.00	0.25	Pass
15,848.93	-7.71	0.79	-16.00	2.50	0.25	Pass
19,952.62	-8.85	2.35	-inf	3.00	0.25	Pass

-- End of measurement results--

Z-weight Filter Response



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	0.07	0.07	-inf	3.00	0.25	Pass
12.59	0.14	0.14	-inf	2.50	0.25	Pass
15.85	0.14	0.14	-4.00	2.00	0.25	Pass
19.95	0.14	0.14	-2.00	2.00	0.25	Pass
25.12	0.14	0.14	-1.50	2.00	0.25	Pass
31.62	0.18	0.18	-1.50	1.50	0.25	Pass
39.81	0.17	0.17	-1.00	1.00	0.25	Pass
50.12	0.22	0.22	-1.00	1.00	0.25	Pass
63.10	0.16	0.16	-1.00	1.00	0.25	Pass
79.43	0.20	0.20	-1.00	1.00	0.25	Pass
100.00	0.18	0.18	-1.00	1.00	0.25	Pass
125.89	0.17	0.17	-1.00	1.00	0.25	Pass
158.49	0.19	0.19	-1.00	1.00	0.25	Pass
199.53	0.18	0.18	-1.00	1.00	0.25	Pass
251.19	0.11	0.11	-1.00	1.00	0.25	Pass
316.23	0.11	0.11	-1.00	1.00	0.25	Pass
398.11	0.11	0.11	-1.00	1.00	0.25	Pass
501.19	-0.02	-0.02	-1.00	1.00	0.25	Pass
630.96	0.02	0.02	-1.00	1.00	0.25	Pass
794.33	0.09	0.09	-1.00	1.00	0.25	Pass
1,000.00	0.00	0.00	-0.70	0.70	0.25	Pass
1,258.93	-0.04	-0.04	-1.00	1.00	0.25	Pass
1,584.89	0.10	0.10	-1.00	1.00	0.25	Pass
1,995.26	0.12	0.12	-1.00	1.00	0.25	Pass
2,511.89	0.15	0.14	-1.00	1.00	0.25	Pass
3,162.28	-0.11	-0.11	-1.00	1.00	0.25	Pass
3,981.07	-0.50	-0.50	-1.00	1.00	0.25	Pass
5,011.87	-0.32	-0.32	-1.50	1.50	0.25	Pass
6,309.57	0.56	0.55	-2.00	1.50	0.25	Pass
7,943.28	0.23	0.23	-2.50	1.50	0.25	Pass
10,000.00	0.34	0.34	-3.00	2.00	0.25	Pass
12,589.25	-0.11	-0.11	-5.00	2.00	0.25	Pass
15,848.93	0.68	0.68	-16.00	2.50	0.25	Pass
19,952.62	2.49	2.49	-inf	3.00	0.25	Pass

-- End of measurement results--

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	0.02 ‡	Pass

-- End of measurement results--

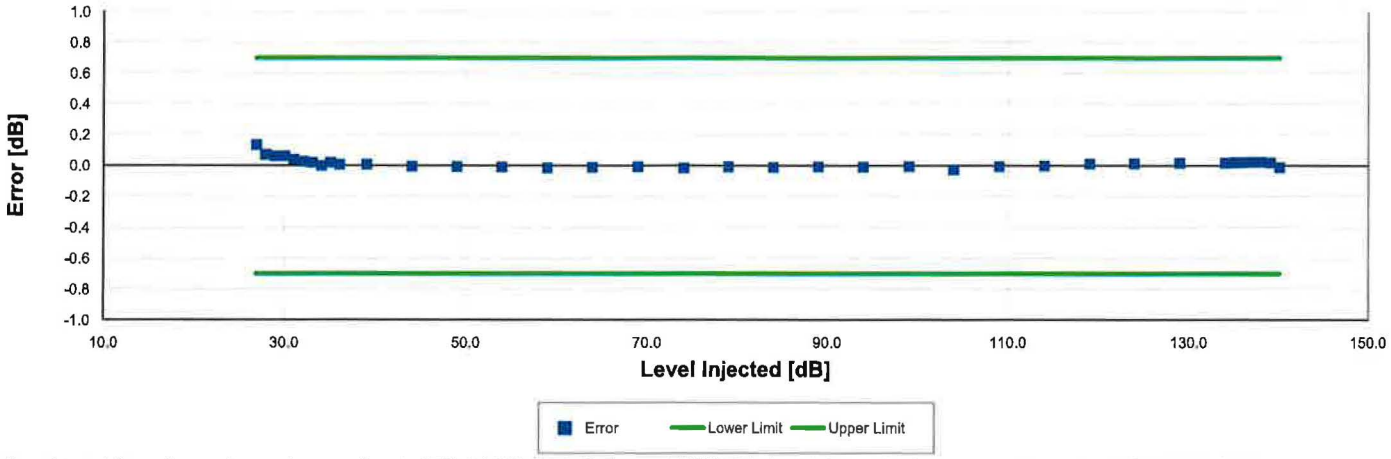
1 kHz Reference Levels

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	113.99	113.79	114.19	0.15	Pass
Z weight	113.99	113.79	114.19	0.15	Pass
Slow	113.99	113.89	114.09	0.15	Pass
Impulse	113.99	113.89	114.09	0.15	Pass

-- End of measurement results--

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

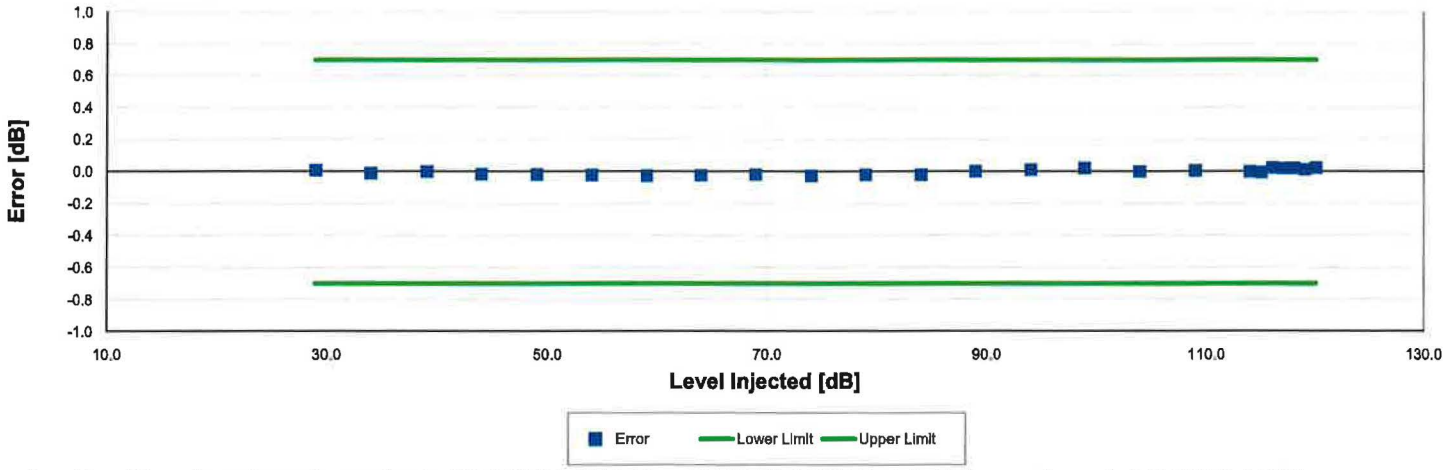


Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
27.00	0.14	-0.70	0.70	0.16	Pass
28.00	0.07	-0.70	0.70	0.16	Pass
29.00	0.06	-0.70	0.70	0.16	Pass
30.00	0.06	-0.70	0.70	0.16	Pass
31.00	0.04	-0.70	0.70	0.16	Pass
32.00	0.03	-0.70	0.70	0.16	Pass
33.00	0.02	-0.70	0.70	0.16	Pass
34.00	0.00	-0.70	0.70	0.16	Pass
35.00	0.02	-0.70	0.70	0.16	Pass
36.00	0.01	-0.70	0.70	0.16	Pass
39.00	0.01	-0.70	0.70	0.16	Pass
44.00	0.00	-0.70	0.70	0.16	Pass
49.00	0.00	-0.70	0.70	0.16	Pass
54.00	-0.01	-0.70	0.70	0.16	Pass
59.00	-0.01	-0.70	0.70	0.16	Pass
64.00	-0.01	-0.70	0.70	0.16	Pass
69.00	-0.01	-0.70	0.70	0.16	Pass
74.00	-0.01	-0.70	0.70	0.16	Pass
79.00	-0.01	-0.70	0.70	0.16	Pass
84.00	-0.01	-0.70	0.70	0.16	Pass
89.00	-0.01	-0.70	0.70	0.16	Pass
94.00	-0.01	-0.70	0.70	0.16	Pass
99.00	0.00	-0.70	0.70	0.16	Pass
104.00	-0.02	-0.70	0.70	0.15	Pass
109.00	0.00	-0.70	0.70	0.15	Pass
114.00	0.00	-0.70	0.70	0.15	Pass
119.00	0.01	-0.70	0.70	0.15	Pass
124.00	0.01	-0.70	0.70	0.15	Pass
129.00	0.02	-0.70	0.70	0.15	Pass
134.00	0.02	-0.70	0.70	0.15	Pass
135.00	0.02	-0.70	0.70	0.15	Pass
136.00	0.02	-0.70	0.70	0.15	Pass
137.00	0.03	-0.70	0.70	0.15	Pass
138.00	0.03	-0.70	0.70	0.15	Pass
139.00	0.02	-0.70	0.70	0.15	Pass
140.00	-0.01	-0.70	0.70	0.15	Pass

-- End of measurement results--

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

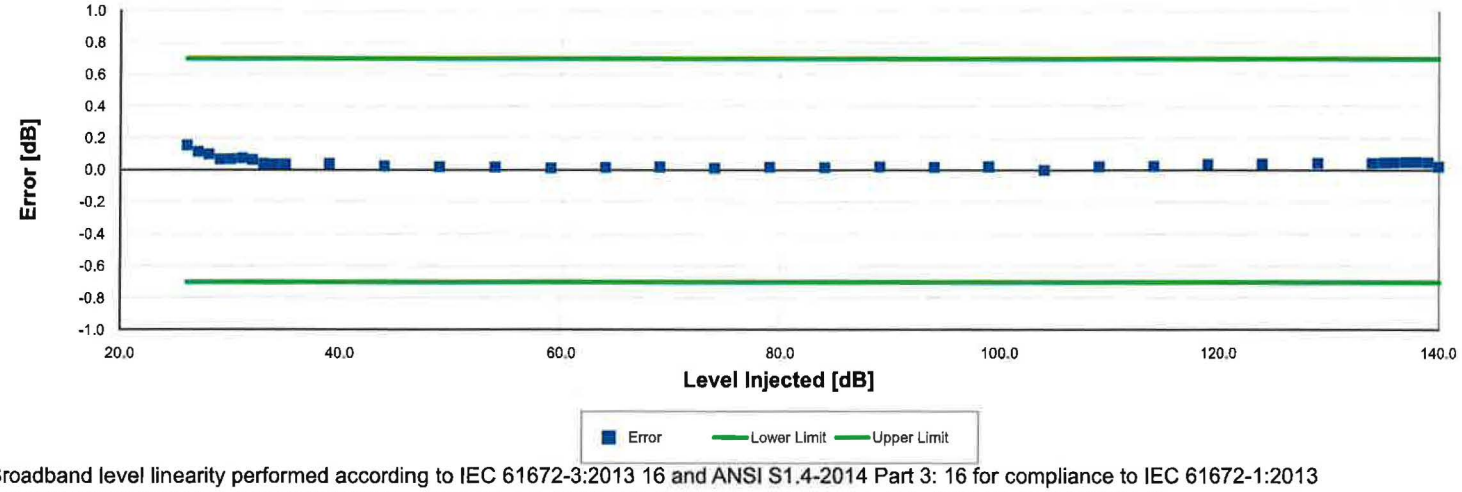


Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
29.00	0.01	-0.70	0.70	0.16	Pass
34.00	-0.01	-0.70	0.70	0.16	Pass
39.00	0.00	-0.70	0.70	0.16	Pass
44.00	-0.02	-0.70	0.70	0.16	Pass
49.00	-0.02	-0.70	0.70	0.16	Pass
54.00	-0.02	-0.70	0.70	0.16	Pass
59.00	-0.03	-0.70	0.70	0.16	Pass
64.00	-0.02	-0.70	0.70	0.16	Pass
69.00	-0.02	-0.70	0.70	0.16	Pass
74.00	-0.03	-0.70	0.70	0.16	Pass
79.00	-0.02	-0.70	0.70	0.16	Pass
84.00	-0.02	-0.70	0.70	0.16	Pass
89.00	0.00	-0.70	0.70	0.16	Pass
94.00	0.01	-0.70	0.70	0.16	Pass
99.00	0.02	-0.70	0.70	0.16	Pass
104.00	0.00	-0.70	0.70	0.15	Pass
109.00	0.01	-0.70	0.70	0.15	Pass
114.00	0.00	-0.70	0.70	0.15	Pass
115.00	0.00	-0.70	0.70	0.15	Pass
116.00	0.02	-0.70	0.70	0.15	Pass
117.00	0.02	-0.70	0.70	0.15	Pass
118.00	0.02	-0.70	0.70	0.15	Pass
119.00	0.01	-0.70	0.70	0.15	Pass
120.00	0.02	-0.70	0.70	0.15	Pass

-- End of measurement results--

A-weighted 0 dB Gain Broadband Log Linearity: 1,000.00 Hz

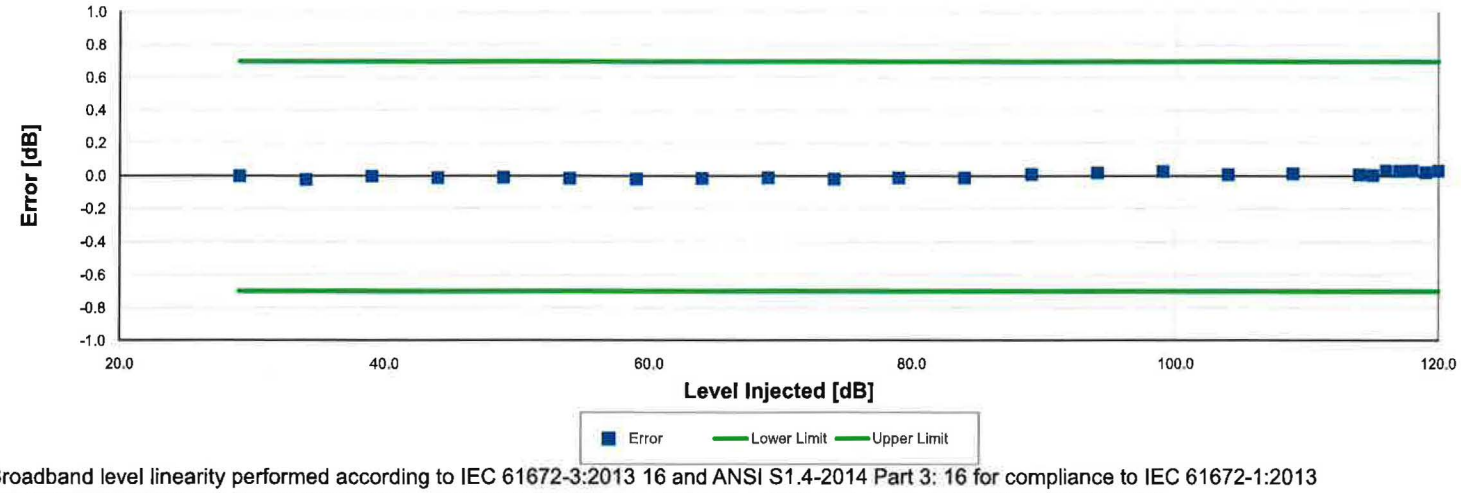


Broadband level linearity performed according to IEC 61672-3:2013 16 and ANSI S1.4-2014 Part 3: 16 for compliance to IEC 61672-1:2013 5.6, IEC 60804:2000 6.2, IEC 61252:2002 8, ANSI S1.4 (R2006) 6.9, ANSI S1.4-2014 Part 1: 5.6, ANSI S1.43 (R2007) 6.2

Level [dB]	Error [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
26.00	0.16	-0.70	0.70	0.16	Pass
27.00	0.12	-0.70	0.70	0.16	Pass
28.00	0.10	-0.70	0.70	0.16	Pass
29.00	0.07	-0.70	0.70	0.16	Pass
30.00	0.07	-0.70	0.70	0.16	Pass
31.00	0.08	-0.70	0.70	0.16	Pass
32.00	0.07	-0.70	0.70	0.16	Pass
33.00	0.04	-0.70	0.70	0.16	Pass
34.00	0.04	-0.70	0.70	0.16	Pass
35.00	0.04	-0.70	0.70	0.16	Pass
39.00	0.04	-0.70	0.70	0.16	Pass
44.00	0.03	-0.70	0.70	0.16	Pass
49.00	0.02	-0.70	0.70	0.16	Pass
54.00	0.02	-0.70	0.70	0.16	Pass
59.00	0.01	-0.70	0.70	0.16	Pass
64.00	0.02	-0.70	0.70	0.16	Pass
69.00	0.02	-0.70	0.70	0.16	Pass
74.00	0.01	-0.70	0.70	0.16	Pass
79.00	0.02	-0.70	0.70	0.16	Pass
84.00	0.02	-0.70	0.70	0.16	Pass
89.00	0.02	-0.70	0.70	0.16	Pass
94.00	0.02	-0.70	0.70	0.16	Pass
99.00	0.02	-0.70	0.70	0.16	Pass
104.00	0.00	-0.70	0.70	0.15	Pass
109.00	0.02	-0.70	0.70	0.15	Pass
114.00	0.03	-0.70	0.70	0.15	Pass
119.00	0.04	-0.70	0.70	0.15	Pass
124.00	0.04	-0.70	0.70	0.15	Pass
129.00	0.05	-0.70	0.70	0.15	Pass
134.00	0.05	-0.70	0.70	0.15	Pass
135.00	0.05	-0.70	0.70	0.15	Pass
136.00	0.05	-0.70	0.70	0.15	Pass
137.00	0.05	-0.70	0.70	0.15	Pass
138.00	0.05	-0.70	0.70	0.15	Pass
139.00	0.05	-0.70	0.70	0.15	Pass
140.00	0.02	-0.70	0.70	0.15	Pass

-- End of measurement results--

A-weighted 20 dB Gain Broadband Log Linearity: 1,000.00 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
29.00	0.00	-0.70	0.70	0.16	Pass
34.00	-0.02	-0.70	0.70	0.16	Pass
39.00	0.00	-0.70	0.70	0.16	Pass
44.00	-0.01	-0.70	0.70	0.16	Pass
49.00	-0.01	-0.70	0.70	0.16	Pass
54.00	-0.01	-0.70	0.70	0.16	Pass
59.00	-0.02	-0.70	0.70	0.16	Pass
64.00	-0.01	-0.70	0.70	0.16	Pass
69.00	-0.01	-0.70	0.70	0.16	Pass
74.00	-0.02	-0.70	0.70	0.16	Pass
79.00	-0.01	-0.70	0.70	0.16	Pass
84.00	-0.01	-0.70	0.70	0.16	Pass
89.00	0.01	-0.70	0.70	0.16	Pass
94.00	0.02	-0.70	0.70	0.16	Pass
99.00	0.03	-0.70	0.70	0.16	Pass
104.00	0.01	-0.70	0.70	0.15	Pass
109.00	0.02	-0.70	0.70	0.15	Pass
114.00	0.01	-0.70	0.70	0.15	Pass
115.00	0.01	-0.70	0.70	0.15	Pass
116.00	0.03	-0.70	0.70	0.15	Pass
117.00	0.03	-0.70	0.70	0.15	Pass
118.00	0.03	-0.70	0.70	0.15	Pass
119.00	0.02	-0.70	0.70	0.15	Pass
120.00	0.03	-0.70	0.70	0.15	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	-7.59	-7.92	-6.92	0.15	Pass
	2	-27.20	-29.99	-25.99	0.15	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	-1.07	-1.48	-0.48	0.15	Pass
	2.00	-18.30	-19.49	-16.99	0.16	Pass
	0.25	-27.27	-29.99	-25.99	0.15	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	-7.05	-7.49	-6.49	0.15	Pass
	2.00	-27.09	-28.49	-25.99	0.15	Pass
	0.25	-36.20	-39.02	-35.02	0.15	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	138.06	135.50	139.50	0.15	Pass
135.00	500.00	138.50	137.50	139.50	0.15	Pass
135.00	8,000.00	137.59	136.40	140.40	0.15	Pass
135.00, Negative	500.00	137.16	136.40	138.40	0.15	Pass
135.00, Positive	500.00	137.16	136.40	138.40	0.15	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	136.08	134.01	138.01	0.15	Pass
	100	Positive Pulse	136.08	134.00	138.00	0.15	Pass
126.00	100	Negative Pulse	126.09	124.01	128.01	0.15	Pass
	100	Positive Pulse	126.09	124.00	128.00	0.15	Pass
116.00	100	Negative Pulse	116.07	114.00	118.00	0.15	Pass
	100	Positive Pulse	116.08	113.98	117.98	0.15	Pass
106.00	100	Negative Pulse	106.08	104.00	108.00	0.15	Pass
	100	Positive Pulse	106.07	103.99	107.99	0.15	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	140.70	140.00	142.00	0.16	Pass
Negative	140.60	140.00	142.00	0.16	Pass
Difference	0.10	-1.50	1.50	0.15	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
139.00	40	Negative Pulse	136.03	134.71	136.71	0.15	Pass
		Positive Pulse	135.98	134.70	136.70	0.15	Pass
	30	Negative Pulse	135.19	134.71	136.71	0.15	Pass
		Positive Pulse	135.20	134.70	136.70	0.15	Pass

-- End of measurement results--

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	0.15 ‡	Pass
	5	OVLD	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
128.00	3	-0.11	± 0.50	0.15 ‡	Pass
	5	-0.12	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
118.00	3	-0.14	± 0.50	0.15 ‡	Pass
	5	-0.12	± 1.00	0.15 ‡	Pass
	10	-0.27	± 1.50	0.15 ‡	Pass
108.00	3	-0.11	± 0.50	0.15 ‡	Pass
	5	-0.10	± 1.00	0.15 ‡	Pass
	10	0.02	± 1.50	0.15 ‡	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	0.15 ‡	Pass
	5	OVLD	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
128.00	3	-0.11	± 0.50	0.15 ‡	Pass
	5	-0.09	± 1.00	0.15 ‡	Pass
	10	OVLD	± 1.50	0.15 ‡	Pass
118.00	3	-0.14	± 0.50	0.15 ‡	Pass
	5	-0.14	± 1.00	0.15 ‡	Pass
	10	-0.01	± 1.50	0.15 ‡	Pass
108.00	3	-0.11	± 0.50	0.15 ‡	Pass
	5	-0.11	± 1.00	0.15 ‡	Pass
	10	-0.06	± 1.50	0.16 ‡	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	0.15	Pass
	5	OVLD	± 1.00	0.15	Pass
128.00	3	-0.10	± 0.50	0.15	Pass
	5	-0.02	± 1.00	0.15	Pass
118.00	3	-0.11	± 0.50	0.15	Pass
	5	-0.10	± 1.00	0.15	Pass
108.00	3	-0.08	± 0.50	0.15	Pass
	5	0.01	± 1.00	0.15	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	0.15	Pass
	20.00	-7.81	-9.57	-5.57	0.20	Pass
	2.00	-8.96	-10.76	-6.76	0.16	Pass
Step	2.00	4.81	4.00	6.00	0.16	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	-3.72	-5.11	-2.11	0.15	Pass
	5.00	-8.76	-10.76	-6.76	0.15	Pass
	2.00	-12.71	-14.55	-10.55	0.16	Pass
Step	2.00	9.88	9.00	11.00	0.16	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	94.02	93.91	94.11	0.15	Pass
0 dB Gain, Linearity	37.04	36.31	37.71	0.16	Pass
20 dB Gain	94.03	93.91	94.11	0.15	Pass
20 dB Gain, Linearity	37.02	36.31	37.71	0.16	Pass
OBA High Range	94.01	93.20	94.80	0.15	Pass
OBA Normal Range	94.01	93.91	94.11	0.15	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	8.05	16.00	Pass
C-weight Noise Floor	13.18	19.00	Pass
Z-weight Noise Floor	24.63	32.00	Pass

-- End of measurement results--

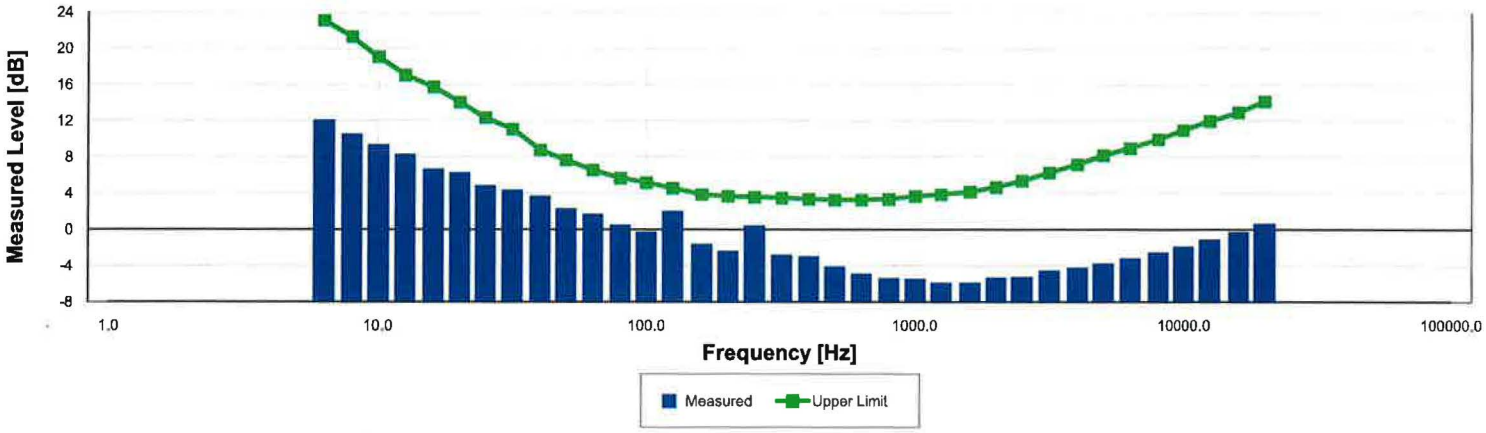
Total Harmonic Distortion

Measured using 1/3-Octave filters

Measurement	Test Result [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
10 Hz Signal	137.61	137.20	138.80	0.15	Pass
THD	-68.60		-60.00	1.30 ‡	Pass
THD+N	-68.18		-60.00	1.30 ‡	Pass

-- End of measurement results--

1/3-Octave Self-Generated Noise



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

Frequency [Hz]	Test Result [dB]	Upper limit [dB]	Result
6.30	12.14	23.10	Pass
8.00	10.62	21.30	Pass
10.00	9.45	19.10	Pass
12.50	8.37	17.10	Pass
16.00	6.75	15.80	Pass
20.00	6.34	14.10	Pass
25.00	4.92	12.40	Pass
31.50	4.43	11.10	Pass
40.00	3.75	8.80	Pass
50.00	2.38	7.70	Pass
63.00	1.76	6.60	Pass
80.00	0.56	5.70	Pass
100.00	-0.21	5.20	Pass
125.00	2.07	4.60	Pass
160.00	-1.57	3.90	Pass
200.00	-2.30	3.70	Pass
250.00	0.51	3.60	Pass
315.00	-2.74	3.50	Pass
400.00	-2.93	3.40	Pass
500.00	-4.06	3.30	Pass
630.00	-4.83	3.30	Pass
800.00	-5.35	3.40	Pass
1,000.00	-5.41	3.70	Pass
1,250.00	-5.81	3.90	Pass
1,600.00	-5.83	4.20	Pass
2,000.00	-5.26	4.70	Pass
2,500.00	-5.20	5.40	Pass
3,150.00	-4.49	6.30	Pass
4,000.00	-4.16	7.20	Pass
5,000.00	-3.70	8.20	Pass
6,300.00	-3.11	9.00	Pass
8,000.00	-2.47	10.00	Pass
10,000.00	-1.80	11.00	Pass
12,500.00	-1.04	12.00	Pass
16,000.00	-0.20	13.00	Pass
20,000.00	0.70	14.20	Pass

-- End of measurement results--

-- End of Report--

Signatory: *Eric Olson*

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716-684-0001

ACCREDITED Cert. #3622.01

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Calibration Certificate

Certificate Number 2022007293

Customer:
HDR Engineering Inc

,

Model Number	CAL200	***Procedure Number***	D0001.8386
Serial Number	2556	***Technician***	Scott Montgomery
Test Results	**Pass**	***Calibration Date***	8 Jun 2022
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	8 Jun 2023
Description	Larson Davis CAL200 Acoustic Calibrator	***Temperature***	24 °C ± 0.3 °C
		Humidity	31 %RH ± 3 %RH
		Static Pressure	101.2 kPa ± 1 kPa

Evaluation Method The data is aquired by the insert voltage calibration method using the reference microphone's open circuit sensitivity. Data reported in dB re 20 µPa.

Compliance Standards Compliant to Manufacturer Specifications per D0001.8190 and the following standards:
IEC 60942:2017 ANSI S1.40-2006

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 SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2017.
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 9001:2015.

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.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
Agilent 34401A DMM	08/06/2021	08/06/2022	001021
Larson Davis Model 2900 Real Time Analyzer	03/31/2022	03/31/2023	001051
Microphone Calibration System	02/23/2022	02/23/2023	005446
1/2" Preamplifier	08/26/2021	08/26/2022	006506
Larson Davis 1/2" Preamplifier 7-pin LEMO	08/09/2021	08/09/2022	006507
1/2 inch Microphone - RI - 200V	09/23/2021	09/23/2022	006511
Hart Scientific 2626-H Temperature Probe	02/04/2021	08/04/2022	006767
Pressure Sensor	03/15/2022	12/14/2022	PCB0087008

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Output Level

Nominal Level [dB]	Pressure [kPa]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
114	101.2	114.03	113.80	114.20	0.14	Pass
94	101.2	94.04	93.80	94.20	0.15	Pass

-- End of measurement results--

Frequency

Nominal Level [dB]	Pressure [kPa]	Test Result [Hz]	Lower limit [Hz]	Upper limit [Hz]	Expanded Uncertainty [Hz]	Result
114	101.2	999.96	993.00	1,007.00	0.20	Pass
94	101.2	999.98	993.00	1,007.00	0.20	Pass

-- End of measurement results--

Total Harmonic Distortion + Noise (THD+N)

Nominal Level [dB]	Pressure [kPa]	Test Result [%]	Lower limit [%]	Upper limit [%]	Expanded Uncertainty [%]	Result
114	101.2	0.33	0.00	2.00	0.25 ‡	Pass
94	101.2	0.36	0.00	2.00	0.25 ‡	Pass

-- End of measurement results--

Level Change Over Pressure

Tested at: 114 dB, 24 °C, 31 %RH

Nominal Pressure [kPa]	Pressure [kPa]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
108.0	108.0	-0.05	-0.25	0.25	0.04 ‡	Pass
101.3	100.9	0.00	-0.25	0.25	0.04 ‡	Pass
92.0	91.9	0.07	-0.25	0.25	0.04 ‡	Pass
83.0	83.0	0.10	-0.25	0.25	0.04 ‡	Pass
74.0	74.0	0.11	-0.25	0.25	0.04 ‡	Pass
65.0	65.0	0.09	-0.25	0.25	0.04 ‡	Pass

-- End of measurement results--

Frequency Change Over Pressure

Tested at: 114 dB, 24 °C, 31 %RH

Nominal Pressure [kPa]	Pressure [kPa]	Test Result [Hz]	Lower limit [Hz]	Upper limit [Hz]	Expanded Uncertainty [Hz]	Result
108.0	108.0	0.00	-7.00	7.00	0.20 ‡	Pass
101.3	100.9	0.00	-7.00	7.00	0.20 ‡	Pass
92.0	91.9	0.00	-7.00	7.00	0.20 ‡	Pass
83.0	83.0	0.00	-7.00	7.00	0.20 ‡	Pass
74.0	74.0	0.00	-7.00	7.00	0.20 ‡	Pass
65.0	65.0	0.00	-7.00	7.00	0.20 ‡	Pass

-- End of measurement results--

Total Harmonic Distortion + Noise (THD+N) Over Pressure

Tested at: 114 dB, 24 °C, 31 %RH

Nominal Pressure [kPa]	Pressure [kPa]	Test Result [%]	Lower limit [%]	Upper limit [%]	Expanded Uncertainty [%]	Result
108.0	108.0	0.33	0.00	2.00	0.25 ‡	Pass
101.3	100.9	0.32	0.00	2.00	0.25 ‡	Pass
92.0	91.9	0.32	0.00	2.00	0.25 ‡	Pass
83.0	83.0	0.32	0.00	2.00	0.25 ‡	Pass
74.0	74.0	0.33	0.00	2.00	0.25 ‡	Pass
65.0	65.0	0.35	0.00	2.00	0.25 ‡	Pass

-- End of measurement results--

Signatory: *Scott Montgomery*

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