Cullum-USA

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Date: 9th November 2023

Attn: Joseph Niemann
jnieman@acousticalsolutions.com

Ref: **Acoustical Solutions Wall Assembly In-field Testing**

Cullum: **PA1109C**

Dear Sir,

Further to our conversations and emails, we are pleased to supply our summary report for acoustical testing of the wall assemblies implemented at your Vernon Road facility.

Measurements were conducted using ISO 15186-2, as such the single number transmission loss of each wall assembly has been measured using the ISO Rw designation, however the gathered transmission loss data at each frequency can be used to assess single number transmission loss as NIC (as per ASTM standard E336).

Please do not hesitate to contact me at any time should you require additional information.

Yours Sincerely,

Jordan Moran

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1. Introduction

The goal of this report, and its associated measurements, is to establish the in-field performance of common “enhanced” wall constructions which include acoustical materials to improve the overall performance of the assembly.

The acoustic performance of a wall assembly is called “transmission loss”. It is measured across several frequency bands, and then converted to a single number value to allow easy comparison.

Typically tests to establish in-field transmission loss are conducted using ASTM E336. This used a sound source in one room, and several sound pressure level measurements in the receiver room to establish the transmission loss of the separating partition. These frequency dependant transmission losses are converted to a single number value called “NIC”.

The drawback to ASTM E336 is that it measures the performance of not only the wall assembly but the whole “partition”. The partition includes the sound which “flanks” over the wall via the ceiling cavity, around the wall through the adjacent walls, and under the wall via the floor.

If the sound “flanking” the wall under test is small, relative to the sound coming through the wall, then ASTM E336 is suitable to assess a wall’s performance. However, it is known that the ceiling cavity is a significant weak point for all wall assemblies under test. As such, ASTM E336 yields inconclusive results for the wall assemblies that are desired to be tested in this report.

Hence, an alternative international standard ISO15186-2 *“Measurement of sound insulation in buildings and of building elements using sound intensity”* has been used for all tests of the wall assemblies of interest.

The international standard refers to “transmission loss” as “sound insulation”, and “NIC” is equivalent to “Rw” (however it is calculated using a slightly different reference curve). The “sound insulation” data gathered can be used to calculate “NIC” since it is an equivalent to the transmission loss data used in NIC calculations.

These measurements will be used to compare various wall construction detail for their relative acoustic performance. The expected performance of each wall assembly will be predicted so that measured data can be compared to the expected result.

There is no specific “output”/”conclusion” from this report as the goal is to measure the in-field performance and compare the relative performance. What value this data yields or the acceptance criteria of the performance of each wall is not within the purview of this report.

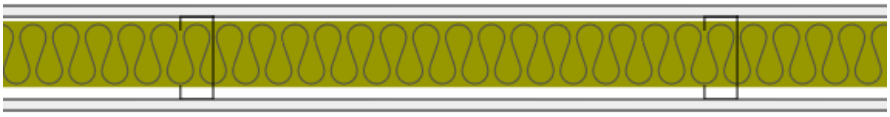
2. Pre-Study Predictions

Prior to undertaking the field survey, each wall assembly's performance. This was conducted using the commercially available INSUL v9.0. There are limitations regarding certain elements of the wall construction (i.e. green glue layers), but these predictions are only intended as indicative guides.

2.1 Standard Non-Acoustical Wall Construction [1x Drywall – Studs – 1x Drywall]

63	125	250	500	1k	2k	4k
14	18	35	46	54	54	45

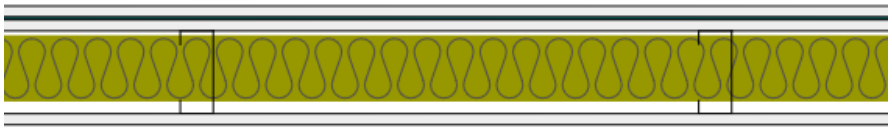
Rw 44 dB



2.2 2x Drywall – Green Glue – Studs – 1x Drywall

63	125	250	500	1k	2k	4k
16	25	41	51	58	59	49

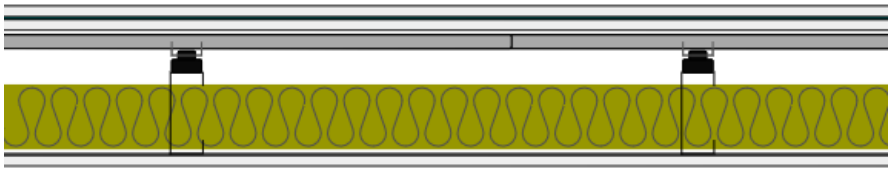
Rw 50 dB



2.3 2x Drywall – Green Glue – RSIC – Studs – MLV – 1x Drywall [with insulation]

63	125	250	500	1k	2k	4k
16	34	49	60	67	70	66

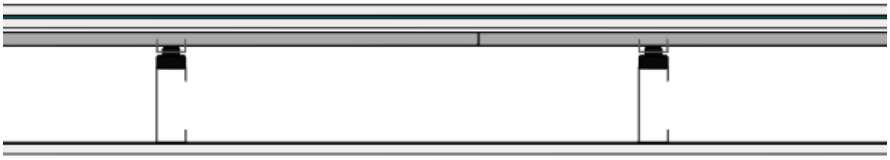
Rw 59 dB



2.4 2x Drywall – Green Glue – RSIC – Studs – MLV – 1x Drywall [w/o insulation]

63	125	250	500	1k	2k	4k
14	30	43	52	58	61	55

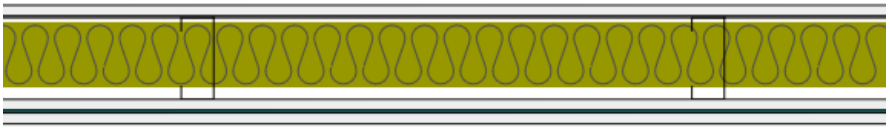
Rw 52 dB



2.5 1x Drywall – MLV – Studs – 2x Drywall – Green Glue

63	125	250	500	1k	2k	4k
16	32	46	54	61	64	60

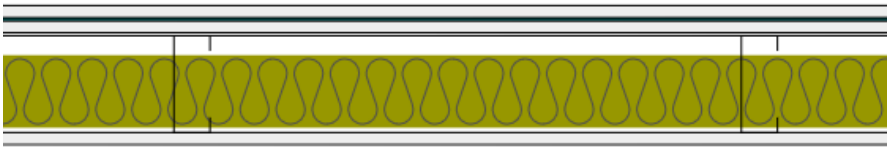
Rw 56 dB



2.6 2x Drywall – Green Glue – MLV – Studs – 1x Drywall

63	125	250	500	1k	2k	4k
17	29	44	53	60	62	56

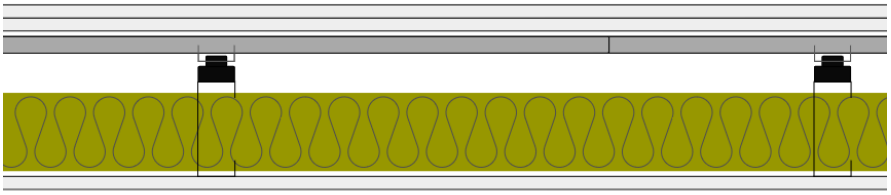
Rw 54 dB



2.7 2x Drywall – RSIC Clips – Studs – 1x Drywall

63	125	250	500	1k	2k	4k
15	30	45	57	65	65	58

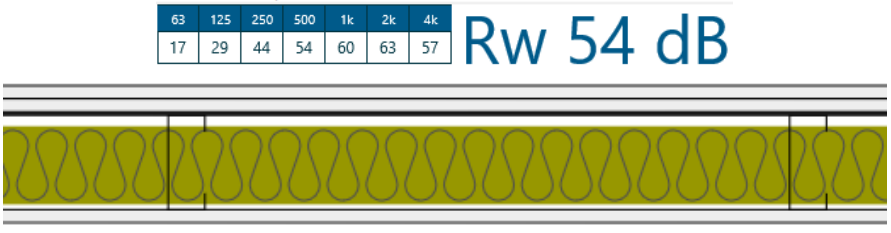
Rw 55 dB



2.8 2x Drywall – MLV – Studs – 1x Drywall

63	125	250	500	1k	2k	4k
17	29	44	54	60	63	57

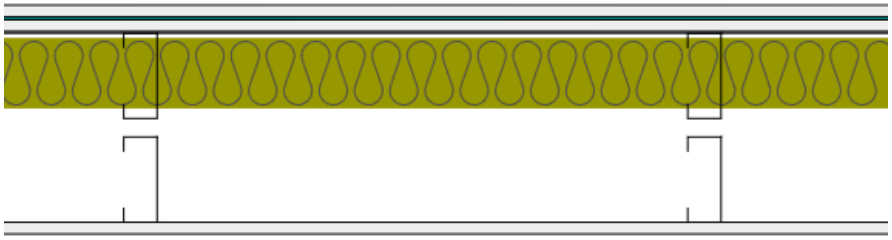
Rw 54 dB



2.9 2x Drywall – Green Glue – MLV – Double Studs – 1x Drywall

63	125	250	500	1k	2k	4k
17	36	50	61	71	73	65

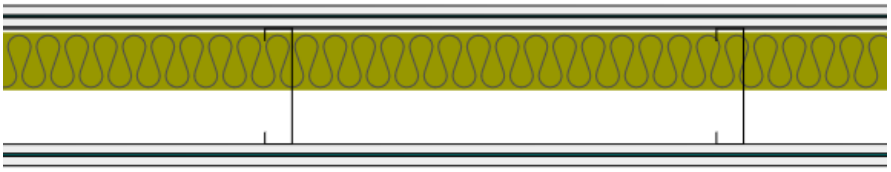
Rw 60 dB



2.10 2x Drywall – Green Glue – MLV – Studs – 2x Drywall – Green Glue

63	125	250	500	1k	2k	4k
17	38	51	59	65	68	60

Rw 61 dB

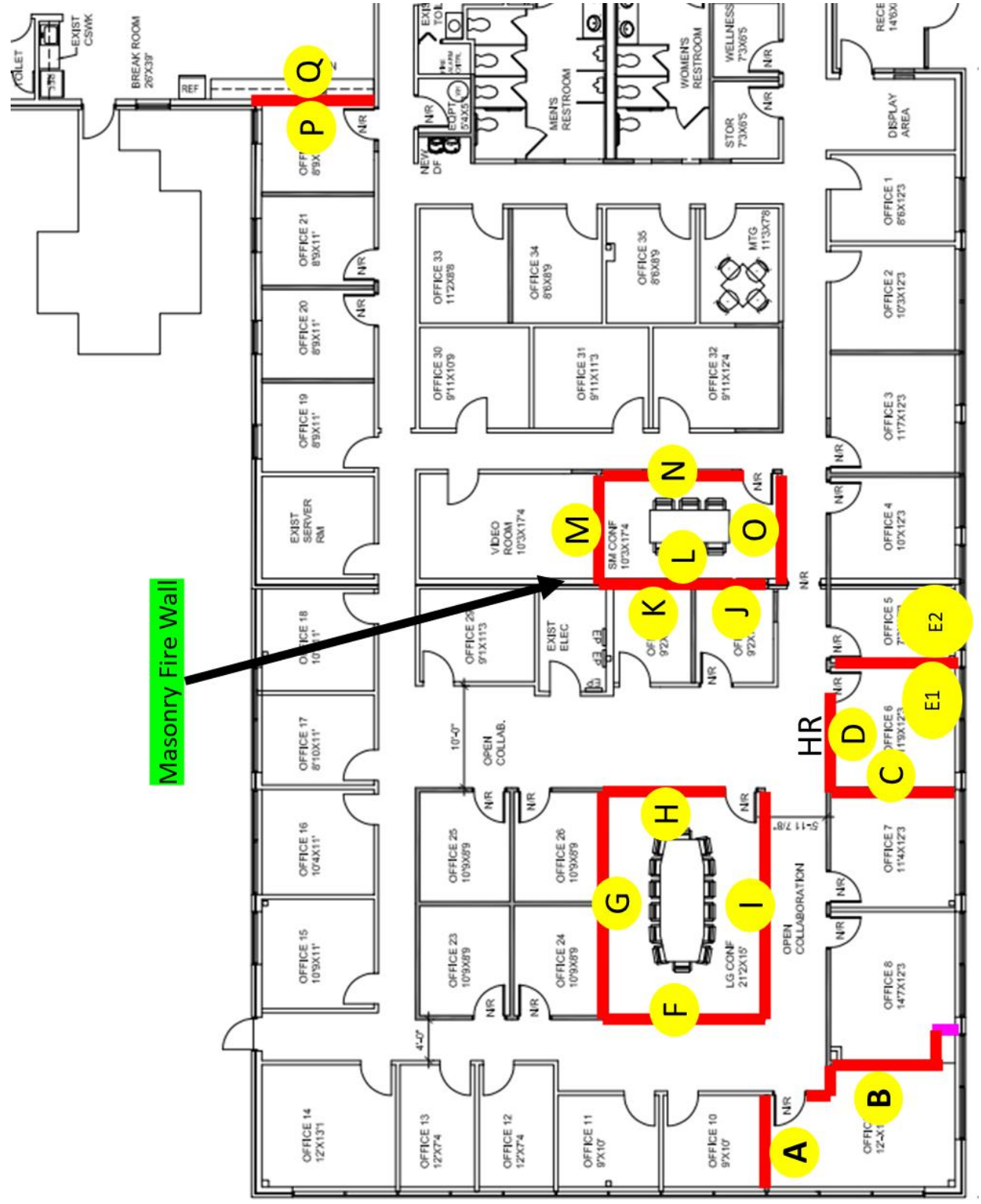


2.11 1x Drywall – Masonry – 2x Drywall – Green Glue

63	125	250	500	1k	2k	4k
28	37	49	60	68	73	78

Rw 61 dB

3. Wall Locations



4. Summary of Results

4.1 All Test Results

Location	Construction	Rw	NIC
Wall A	2x Drywall – RSIC Clips – Studs – 1x Drywall	**54**	**56**
Wall B	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**56**
Wall C	2x Drywall – MLV – Studs – 1x Drywall	**55**	**56**
Wall D	2x Drywall – Green Glue – Studs – 1x Drywall	**50**	**48**
Wall E	1x Drywall – MLV – Studs – 2x Drywall – Green Glue	**53**	**55**
Wall F	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**55**
Wall G	2x Drywall – Green Glue – MLV – Double Studs – 1x Drywall	**57**	**58**
Wall H	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**52**	**53**
Wall I	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**54**
Wall J	2x Drywall – Green Glue – MLV – Studs – 2x Drywall – Green Glue	**61**	**61**
Wall K	1x Drywall – Masonry – 2x Drywall – Green Glue	**71**	**71**
Wall M	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**56**	**58**
Wall N	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**52**	**53**
Wall O	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**55**
Wall P	2x Drywall – Green Glue – RSIC – Studs – MLV – 1x Drywall	**53**	**51**

4.2 Test Results Ordered by Rw Performance and Wall Assembly

The following table ranks each wall construction based on overall performance. “Affected” is to gauge whether the overall NIC/Rw measured were affected by measurement uncertainty i.e. frequencies that govern the single number NIC/Rw is dependent on a frequency band measurement which had repeatability/dynamic range/under range issues.

Location	Construction	Rw	NIC	Affected?
Wall D	2x Drywall – Green Glue – Studs – 1x Drywall	**50**	**48**	
Wall P	2x Drywall – Green Glue – RSIC – Studs – MLV – 1x Drywall	**53**	**51**	
Wall E	1x Drywall – MLV – Studs – 2x Drywall – Green Glue	**53**	**55**	
Wall A	2x Drywall – RSIC Clips – Studs – 1x Drywall	**54**	**56**	
Wall B	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**56**	
Wall F	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**55**	
Wall H	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**52**	**53**	Definitely
Wall I	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**54**	Maybe
Wall M	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**56**	**58**	Maybe
Wall N	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**52**	**53**	
Wall O	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**55**	
Wall C	2x Drywall – MLV – Studs – 1x Drywall	**55**	**56**	Maybe
Wall G	2x Drywall – Green Glue – MLV – Double Studs – 1x Drywall	**57**	**58**	
Wall J	2x Drywall – Green Glue – MLV – Studs – 2x Drywall – Green Glue	**61**	**61**	
Wall K	1x Drywall – Masonry – 2x Drywall – Green Glue	**71**	**71**	

4.3 Test Results Ranked by NIC Performance

All measurements have been ranked relative to each other using NIC as the basis. Where measurements were taken of the same construction detail in multiple locations, these were averaged (excluding “affected” measurements).

The ranked data is also compared to the previously predicted Rw of each wall construction.

Rank	Construction	Rw	NIC	Predicted Rw
9	2x Drywall – Green Glue – Studs – 1x Drywall	**50**	**48**	**50**
8	2x Drywall – Green Glue – RSIC – Studs – MLV – 1x Drywall	**53**	**51**	**59 (52)**
7	1x Drywall – MLV – Studs – 2x Drywall – Green Glue	**53**	**55**	**56**
6	2x Drywall – Green Glue – MLV – Studs – 1x Drywall	**54**	**55**	**54**
5	2x Drywall – RSIC Clips – Studs – 1x Drywall	**54**	**56**	**55**
4	2x Drywall – MLV – Studs – 1x Drywall	**55**	**56**	**54**
3	2x Drywall – Green Glue – MLV – Double Studs – 1x Drywall	**57**	**58**	**60**
2	2x Drywall – Green Glue – MLV – Studs – 2x Drywall – Green Glue	**61**	**61**	**61**
1	1x Drywall – Masonry – 2x Drywall – Green Glue	**71**	**71**	**61**

5. Discussion

5.1 Expected Results

As there is a lot of data to compare, it is best to start with tests which yield results that were expected.

The ranking of the top three constructions are in the order that is expected:
Masonry walls have a high density (mass) and as such yield far superior performance than several layers of drywall (regardless of stud construction), hence the #1 ranking.
Based on the predictions, the #2 ranked construction should have just higher performance than that of #3. It appears the extra mass of the additional layer of drywall and the extra vibration isolation from the green glue outperforms the isolations gained by double studs.

#9 performs exactly in line with what was predicted, and that prediction would put it low down on the table of relative performance.

#4 and #5 where predicted to have very similar levels of acoustic performance. As such, their closeness in the table is expected. However, #4 position relative to other constructions is not (this will be discussed in the next section).

#6 and #7 have identical performance which is as expected. The construction details are identical except for which side of the studs the MLV is placed. Based on the way in which MLV adds acoustic performance (mass and limply supported layer) it makes sense that which side it is applied has a negligible impact the acoustic performance it provides to the assembly.

5.2 Un-Expected Results

There are several unexpected placements in the rankings of performance.

#4 outperforms more complicated constructions with a similar number of layers of drywall but extra acoustical materials. Based on prediction (and logic it) should be below #7.

This implies either the green glue layer has no effect on performance OR the measurement had some error associated with it. As per section 4.2, it has been noted that this result “maybe” affected. As such, it is recommended that this is treated as an anomalous result.

#8 is out of position based on the prediction of expected construction. This construction should performance closer to rank #3 (Rw 59) but was measured at Rw 53. A secondary prediction was created, which omits the insulation of the wall (the construction should have included insulation). This yielded a prediction of Rw 52 – much closer to the as-measured performance and may explain the difference relative to expectation.

After on-site inspection of the wall construction, it was found that the construction is correct, but inside this wall (and the surveyed area) was a wastewater pipe. This would be equivalent to “no insulation” and/or sound from the ceiling plenum could enter the pipe and reduce acoustic performance. This explains the lack of performance of this assembly.

5.3 Measurement Limitations/Errors

As mentioned in previous sections, several measurements had difficulties with site limitations. The entire test had to be conducted inside an enclosure to isolate the measurement surface/intensity probe from the background noise due to flanking (mainly due to the joined plenum ceiling).

The use of the enclosure overcame most of the flanking issues (which created “dynamic capability too low” errors in the data), however it can be seen that some tests at certain frequencies were still affected by flanking noise.

Another issue seen in the measurement data was “repeatability failed”. Each measurement requires two “scans”. One scan sweeps the surface left to right; the second scan sweeps the surface up to down. To achieve “repeatability” the two scans must be within 1dB of each other.

The difference in scans usually indicates that the partition is not uniform in construction – in ideal situations one would increase the survey area. Due to the necessity of the enclosure and space limitations, scanning larger areas was not possible. However, repeatability is a factor in conformance with the ISO standard but does not inherently invalidate the measurements taken.

The other issue seen with the data taken is that certain tests at certain frequencies have “under-range” errors. This means that the level of noise measured at that frequency is below the background noise level i.e. the noise from the partition cannot be accurately measured. This is not a big hinderance to the measurement since this will lead to a reported transmission loss which is less than the actual value.

Even though many measurements were affected at certain frequencies by one or several of these limitation/errors, only 4 measurements were actually “affected” i.e. the overall NIC/Rw was dictated by measurements at frequencies that had these errors (excluding repeatability).
As such, the overall validity of the measurements appears to be acceptable.

6. Summary Conclusions

Acceptable data was gathered for most wall assemblies built at the project location. Based upon these measurements the NIC and Rw of each wall assembly was calculated.

This measured data was compared to predictive analysis of each wall construction. Good correlation was found, with a few notable exceptions.
After accounting for any deviations from these predictions which may have arisen from measurement errors, it has been concluded that only minor deviations have arisen due to the measurement errors.

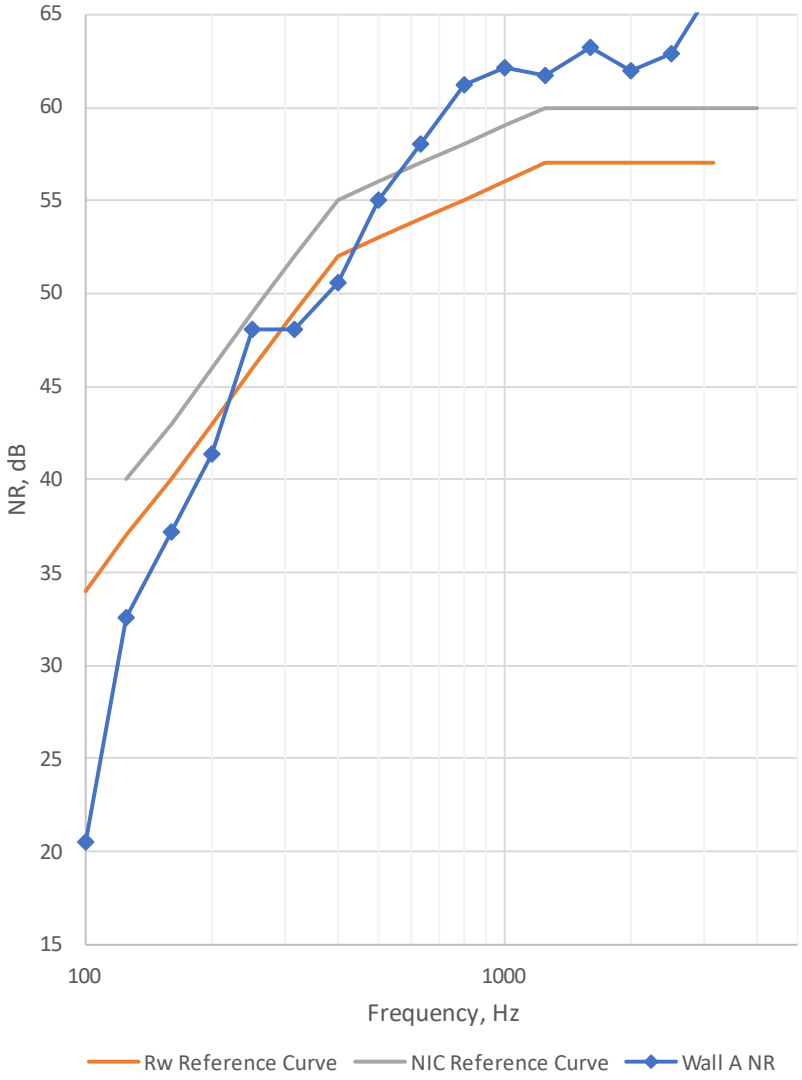
It appears more likely that large deviation from the predicted performance are due to the as-built construction details deviating from the expected construction (which was used to generate the predictive analysis).

7. APPENDIX A - Wall Assembly In-Field Test Results

7.1 Wall A

	NR	Issues
100	20.5	
125	32.6	
160	37.2	
200	41.3	*+
250	48.1	*
315	48.1	*
400	50.6	*
500	55.0	*
630	58.0	*
800	61.2	
1000	62.2	*
1250	61.7	*
1600	63.3	*
2000	61.9	*
2500	62.9	^
3150	66.5	^
4000	65.9	*^

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



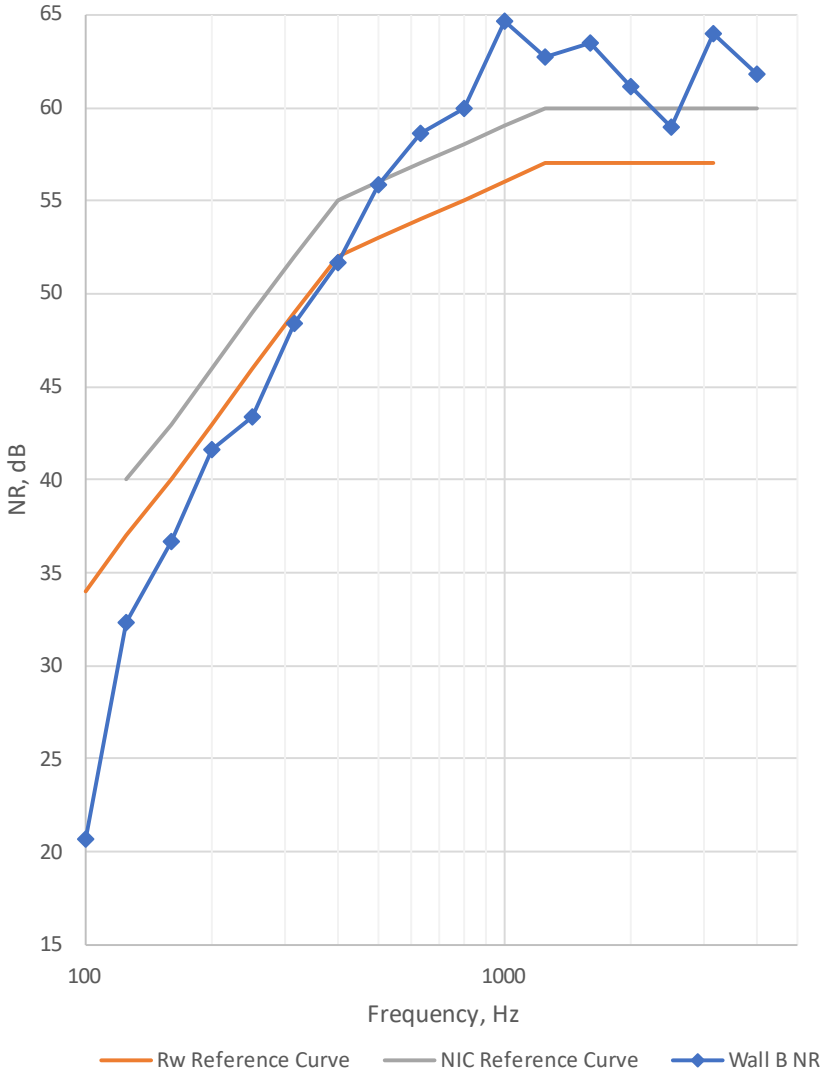
7.1.1 Rw = 54

7.1.2 NIC = 56

7.2 Wall B

	NR	Issues
100	20.7	
125	32.3	
160	36.6	
200	41.6	*
250	43.4	*
315	48.4	*
400	51.7	*
500	55.9	*
630	58.7	
800	60.0	
1000	64.6	*
1250	62.7	
1600	63.5	
2000	61.1	*
2500	58.9	*
3150	64.0	*
4000	61.8	*

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



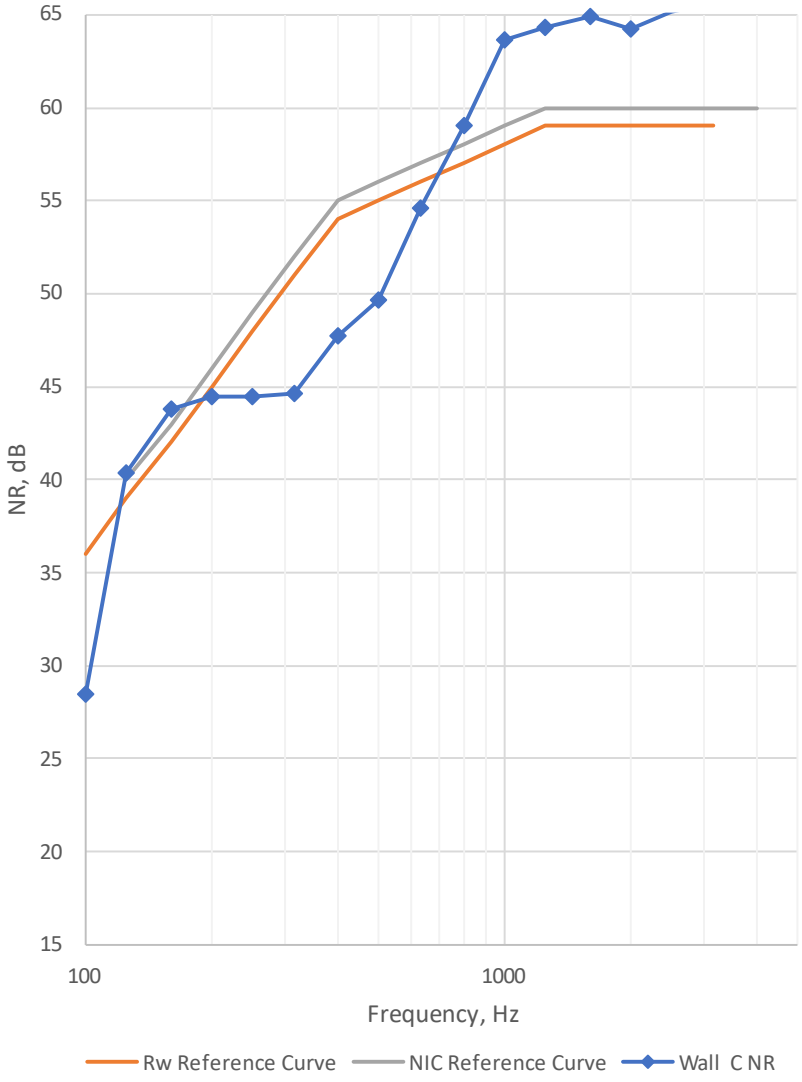
7.2.1 Rw = 53

7.2.2 NIC = 56

7.3 Wall C

	NR	Issues
100	28.5	*
125	40.4	+
160	43.8	*+
200	44.5	*
250	44.5	*
315	44.7	*
400	47.7	*
500	49.7	*
630	54.6	*
800	59.0	*
1000	63.6	*
1250	64.3	*
1600	64.9	*
2000	64.2	*
2500	65.2	
3150	65.7	
4000	68.9	*

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



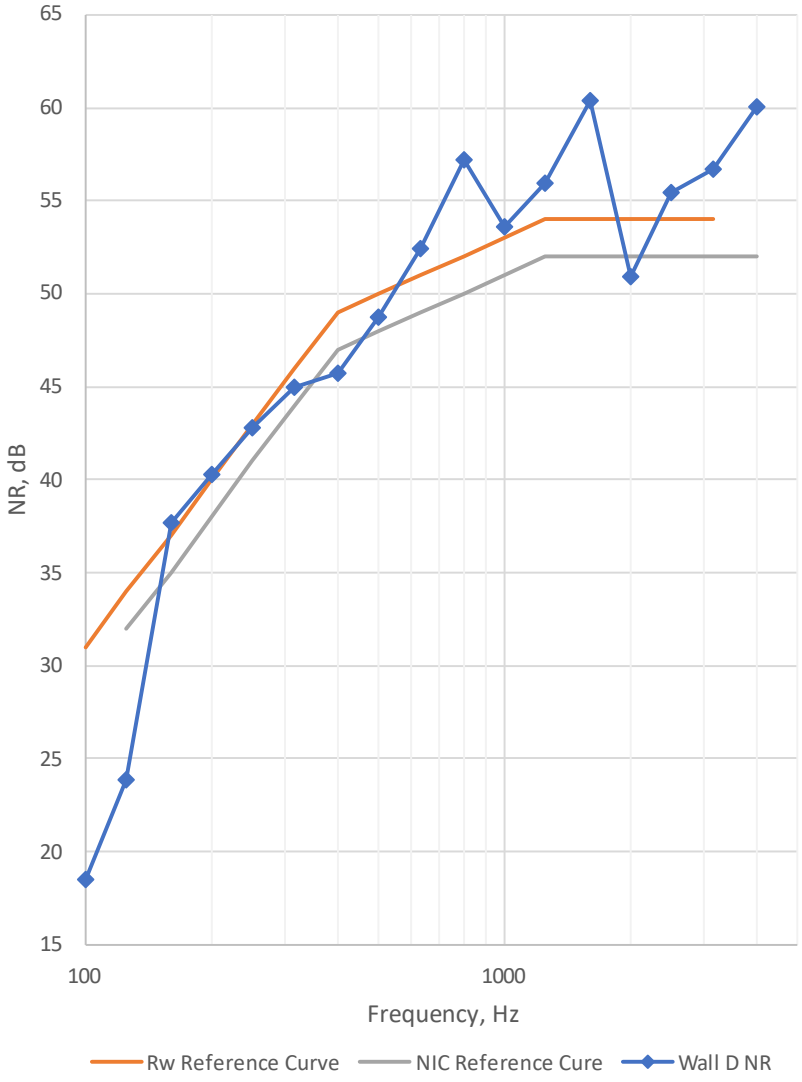
7.3.1 Rw = 55

7.3.2 NIC = 56

7.4 Wall D

	NR	Issues
100	18.5	
125	23.8	
160	37.7	
200	40.3	*
250	42.8	*
315	45.0	*
400	45.7	*
500	48.8	*
630	52.4	*
800	57.2	*
1000	53.6	*
1250	55.9	*
1600	60.4	*
2000	50.9	*
2500	55.4	*
3150	56.7	*
4000	60.0	*

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



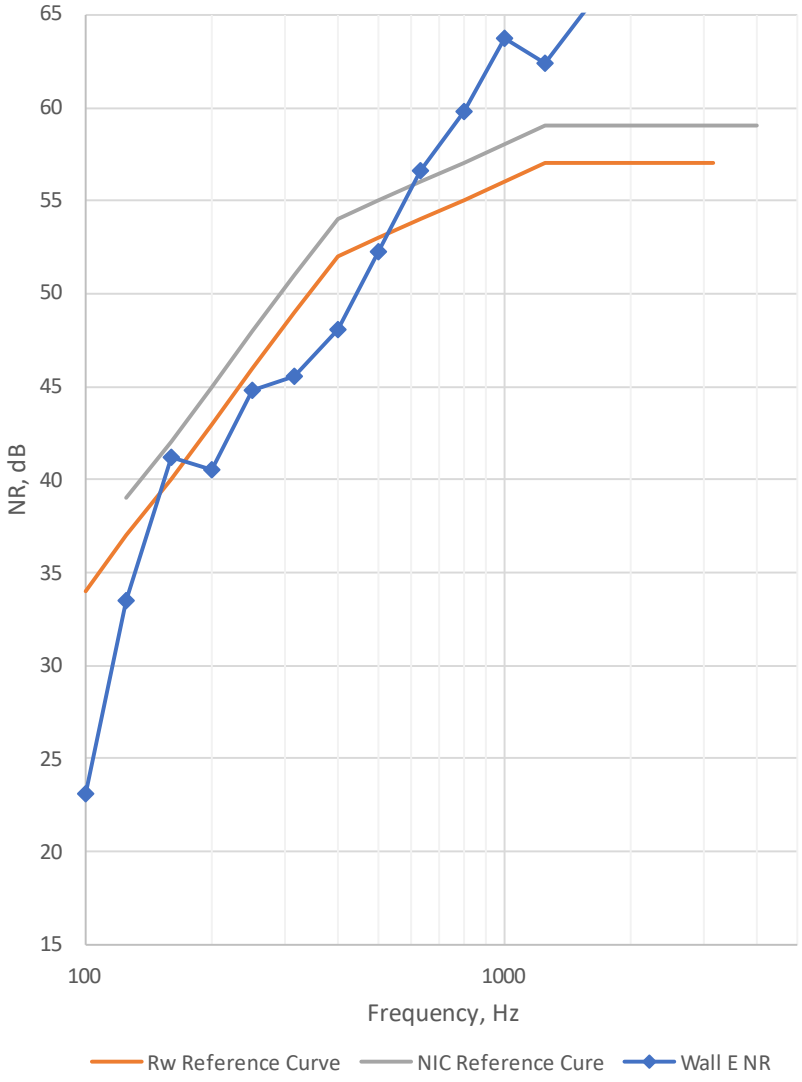
7.4.1 Rw = 50

7.4.2 NIC = 48

7.5 Wall E

	NR	Issues
100	23.1	
125	33.5	
160	41.2	
200	40.5	
250	44.8	*
315	45.6	
400	48.0	
500	52.3	
630	56.6	
800	59.8	*
1000	63.7	*
1250	62.4	*
1600	65.6	*^
2000	67.8	*^
2500	69.8	^
3150	68.5	*^
4000	72.0	*^

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



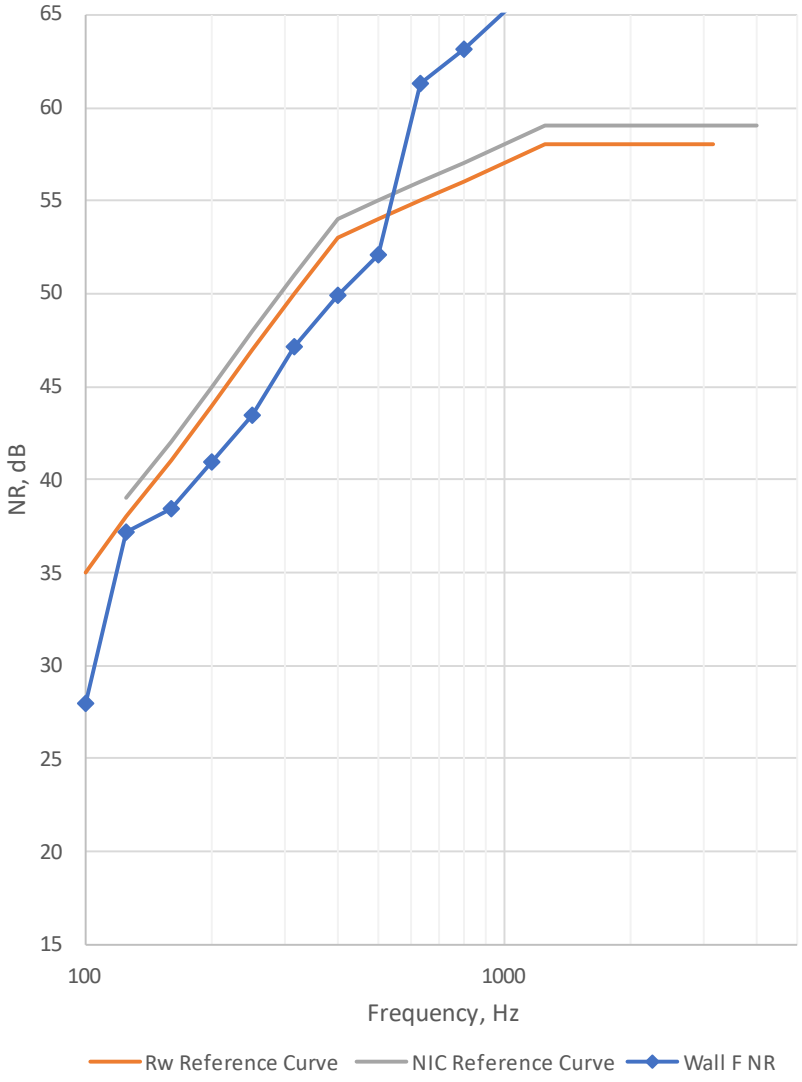
7.5.1 Rw = 53

7.5.2 NIC = 55

7.6 Wall F

	NR	Issues
100	28.0	
125	37.2	
160	38.4	
200	41.0	
250	43.5	
315	47.2	
400	49.9	
500	52.1	
630	61.3	
800	63.1	
1000	65.2	
1250	67.0	
1600	70.2	*
2000	71.0	
2500	73.8	
3150	74.2	
4000	77.6	

* - Failed Repeatability
\+ - Dynamic Capability too low
^ - Under-range



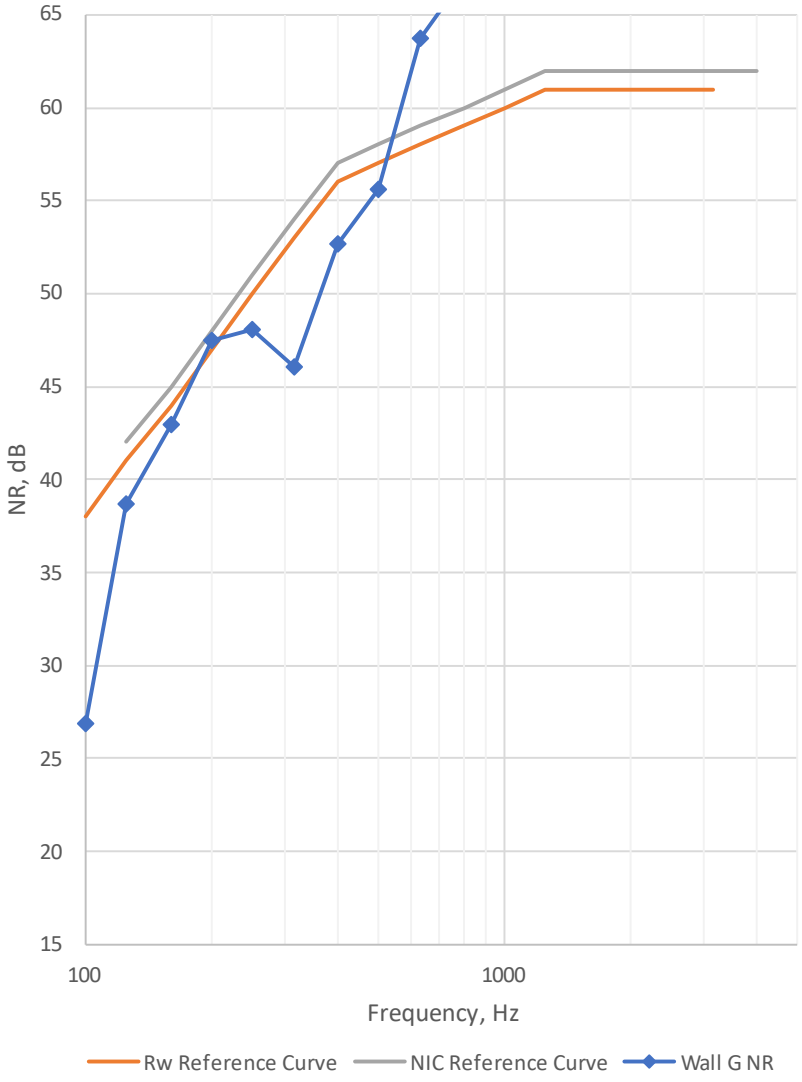
7.6.1 Rw = 54

7.6.2 NIC = 55

7.7 Wall G

	NR	Issues
100	26.9	
125	38.7	
160	43.0	
200	47.4	
250	48.0	
315	46.1	
400	52.6	
500	55.6	
630	63.7	*
800	67.0	
1000	67.9	
1250	67.7	
1600	70.3	
2000	74.6	
2500	76.9	
3150	75.9	
4000	77.3	

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



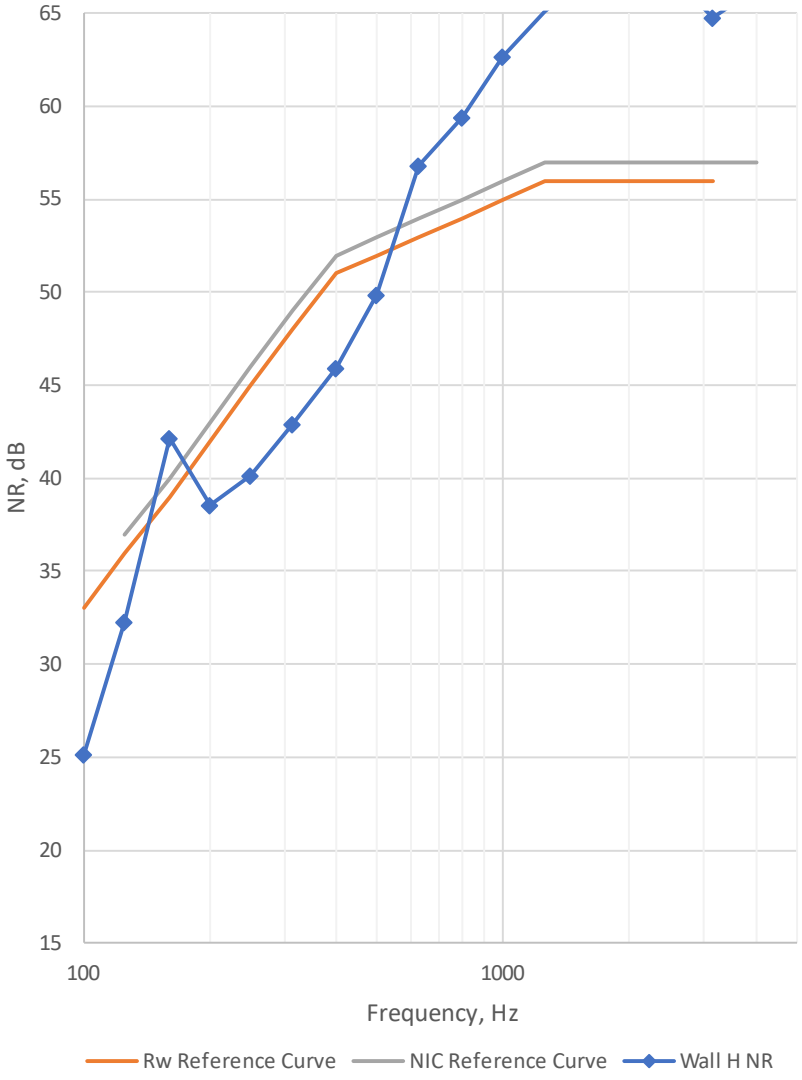
7.7.1 Rw = 57

7.7.2 NIC = 58

7.8 Wall H

	NR	Issues
100	25.2	+
125	32.3	+
160	42.2	*
200	38.6	+
250	40.1	*+
315	42.9	*+
400	46.0	*+
500	49.9	*
630	56.8	*
800	59.4	
1000	62.7	
1250	65.1	*
1600	67.0	
2000	65.8	*
2500	67.0	*
3150	64.8	*
4000	66.4	*

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



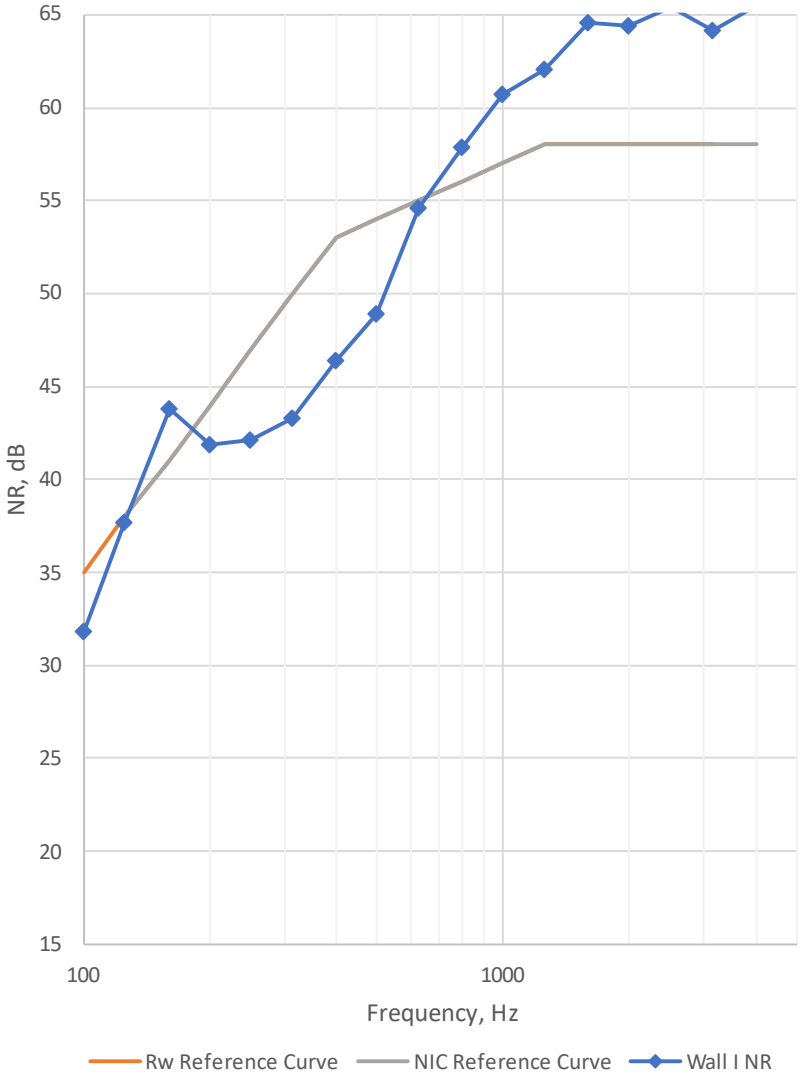
7.8.1 Rw = 52

7.8.2 NIC = 53

7.9 Wall I

	NR	Issues
100	31.8	*
125	37.7	*
160	43.8	*
200	41.8	*
250	42.1	*
315	43.3	*
400	46.4	*
500	48.9	*
630	54.6	*
800	57.9	
1000	60.7	*
1250	62.0	*
1600	64.6	*
2000	64.4	*
2500	65.4	*
3150	64.2	*
4000	65.5	*

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



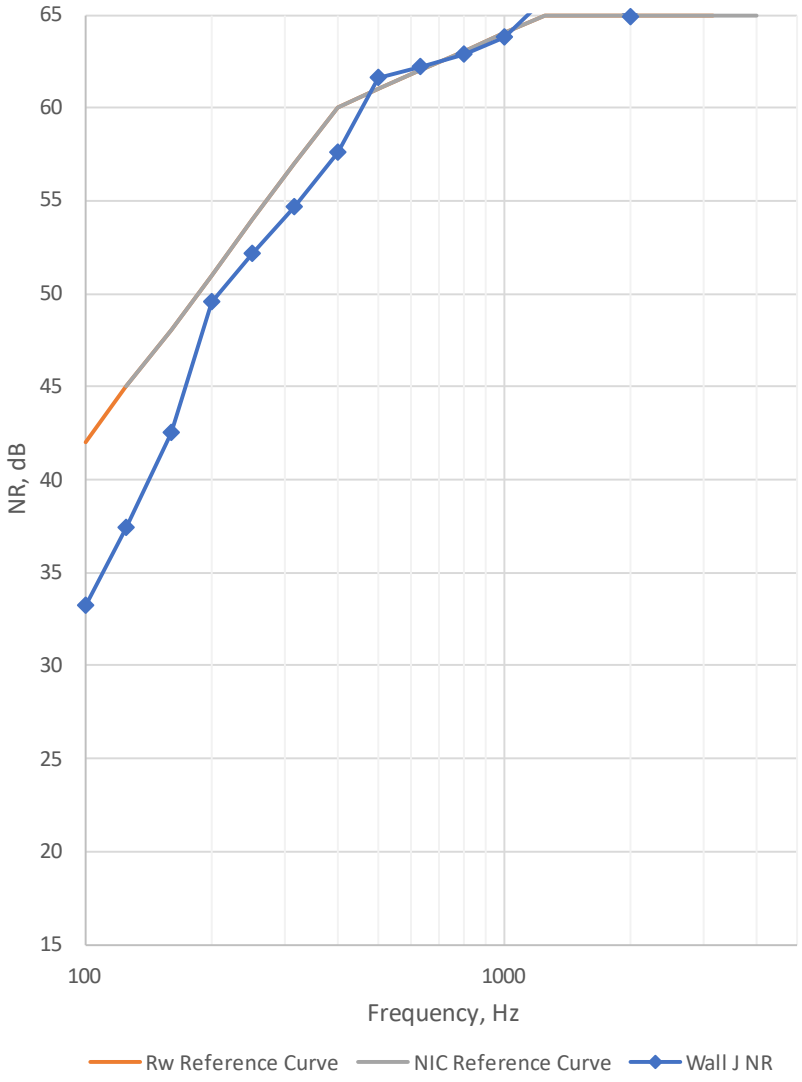
7.9.1 Rw = 54

7.9.2 NIC = 54

7.10 Wall J

	NR	Issues
100	33.2	
125	37.4	
160	42.5	
200	49.5	
250	52.1	*
315	54.7	
400	57.6	*
500	61.6	
630	62.2	
800	62.8	*
1000	63.8	
1250	65.9	
1600	66.5	
2000	64.9	
2500	66.8	
3150	68.3	
4000	70.7	

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



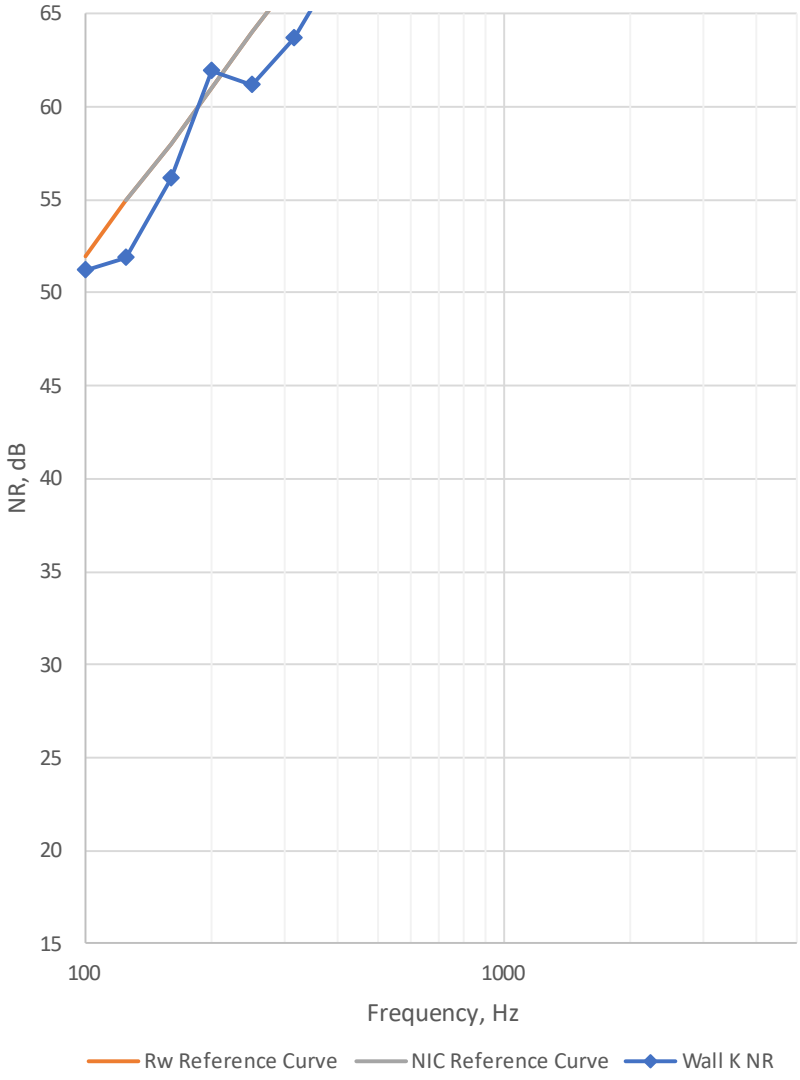
7.10.1 Rw = 61

7.10.2 NIC = 61

7.11 Wall K

	NR	Issues
100	51.2	
125	51.9	
160	56.2	
200	61.9	
250	61.2	
315	63.7	
400	67.6	
500	71.5	*
630	70.4	
800	71.9	
1000	71.4	
1250	73.2	
1600	74.1	
2000	74.9	
2500	69.3	
3150	75.1	
4000	76.4	^

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



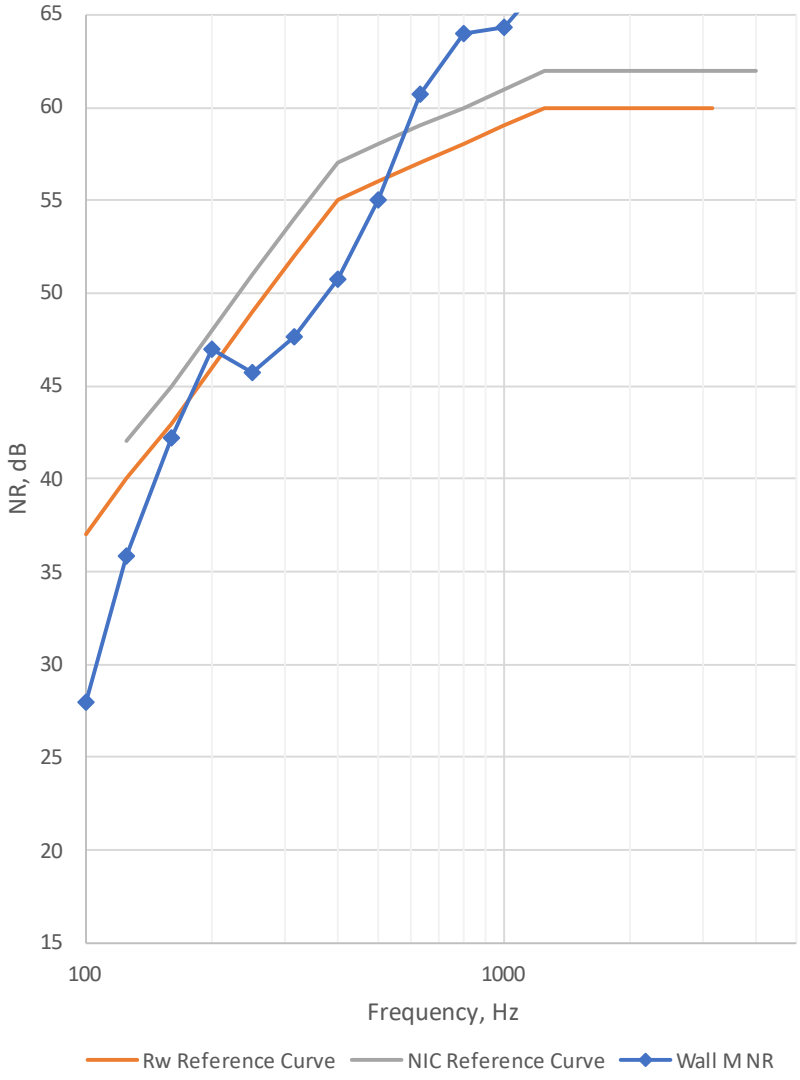
7.11.1 Rw = 71

7.11.2 NIC = 71

7.12 Wall M

	NR	Issues
100	28.0	*
125	35.8	*
160	42.2	
200	47.0	*
250	45.7	
315	47.6	*
400	50.8	*
500	55.0	*
630	60.7	*
800	64.0	*
1000	64.3	*
1250	66.9	*
1600	70.9	*
2000	70.8	*
2500	67.3	
3150	72.9	
4000	73.7	

* - Failed Repeatability
\+ - Dynamic Capability too low
^ - Under-range



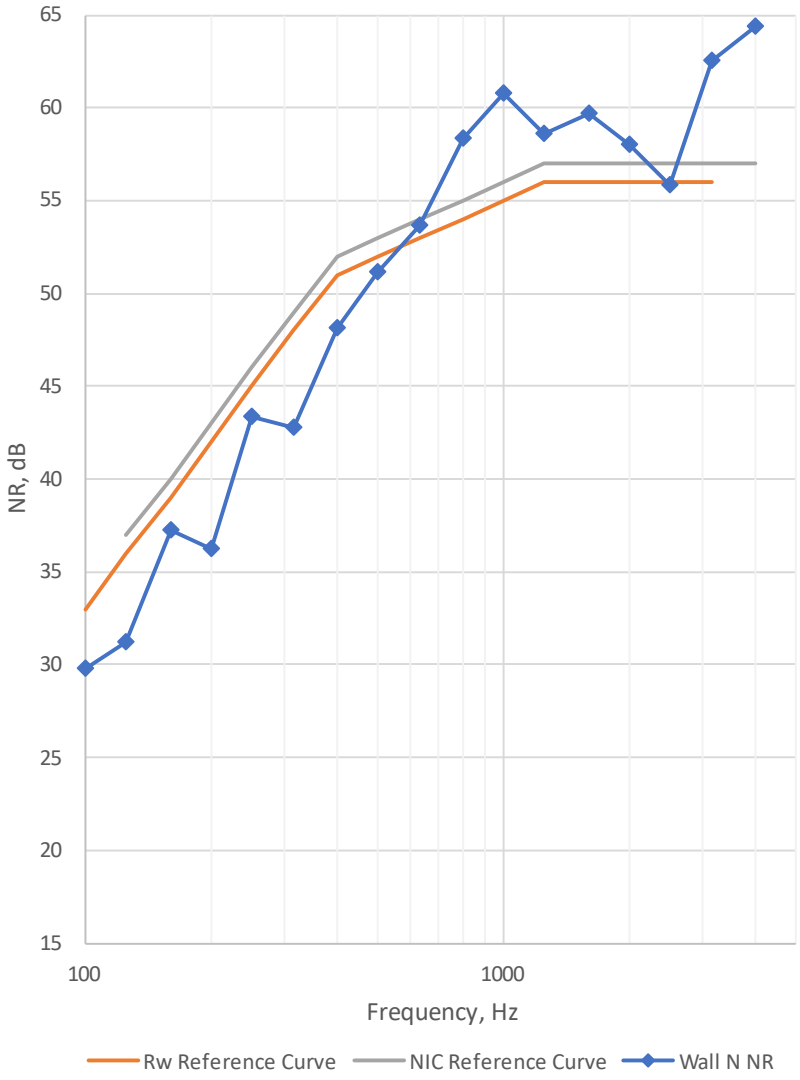
7.12.1 Rw = 56

7.12.2 NIC = 58

7.13 Wall N

	NR	Issues
100	29.8	
125	31.2	
160	37.3	
200	36.2	
250	43.4	
315	42.7	
400	48.2	
500	51.2	
630	53.6	
800	58.3	
1000	60.8	
1250	58.6	
1600	59.7	
2000	58.0	
2500	55.8	
3150	62.5	
4000	64.4	

* - Failed Repeatability
\+ - Dynamic Capability too low
^ - Under-range



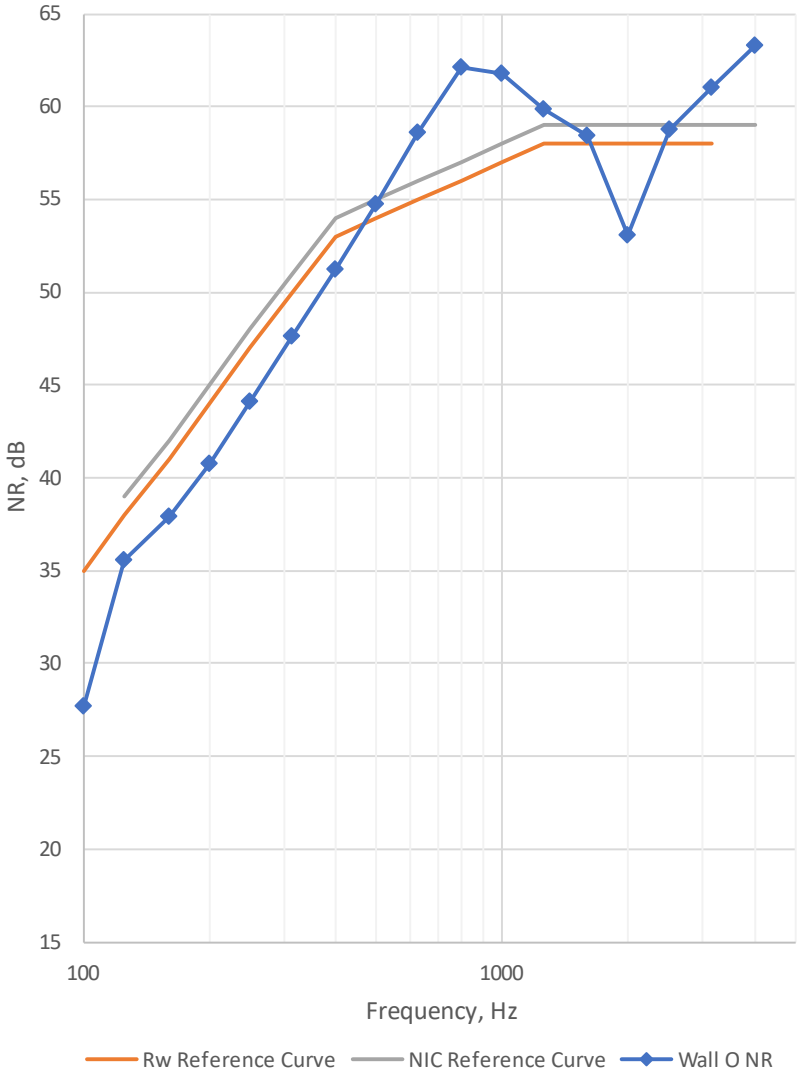
7.13.1 Rw = 52

7.13.2 NIC = 53

7.14 Wall O

	NR	Issues
100	27.7	
125	35.6	
160	37.9	
200	40.7	
250	44.1	
315	47.6	
400	51.2	
500	54.8	*
630	58.6	
800	62.1	
1000	61.8	*
1250	59.8	
1600	58.4	
2000	53.1	
2500	58.8	
3150	61.0	
4000	63.3	

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



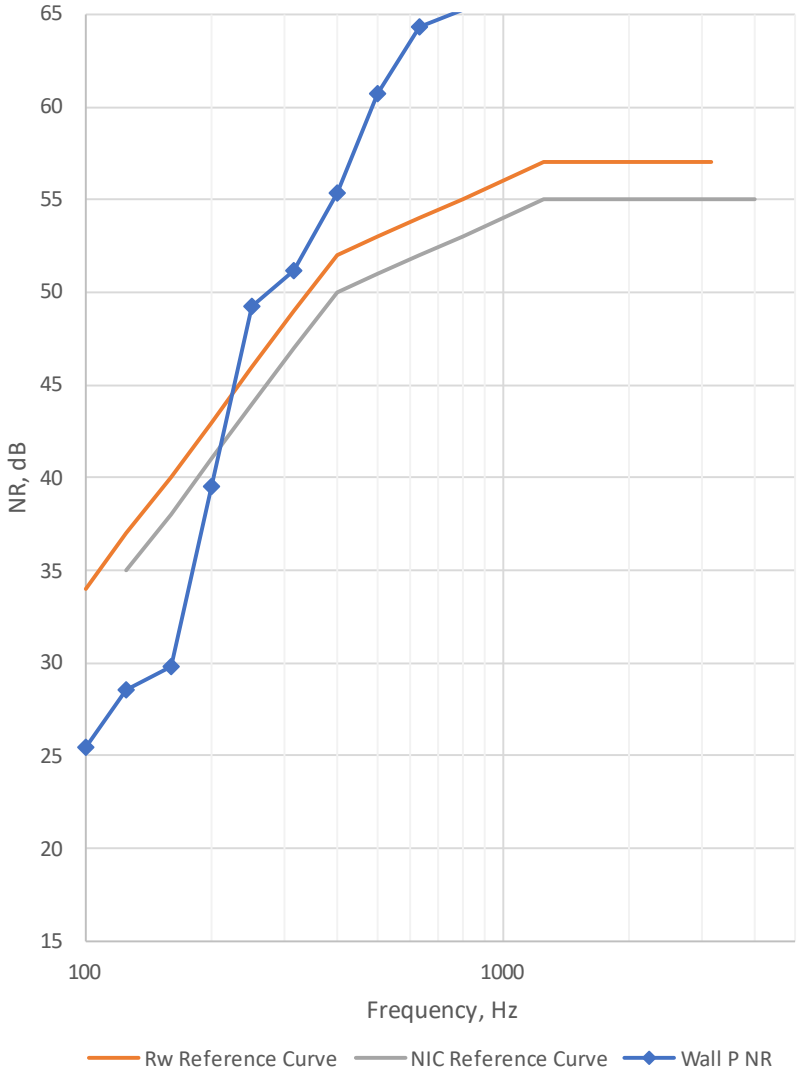
7.14.1 Rw = 54

7.14.2 NIC = 55

7.15 Wall P

	NR	Issues
100	25.5	
125	28.5	
160	29.8	
200	39.5	
250	49.2	*
315	51.2	*
400	55.4	*
500	60.7	*
630	64.3	*^
800	65.2	*
1000	67.9	^
1250	67.3	*
1600	78.4	*+^
2000	76.4	*+
2500	70.4	
3150	65.6	*
4000	66.1	*

* - Failed Repeatability
+ - Dynamic Capability too low
^ - Under-range



7.15.1 Rw = 53

7.15.2 NIC = 51