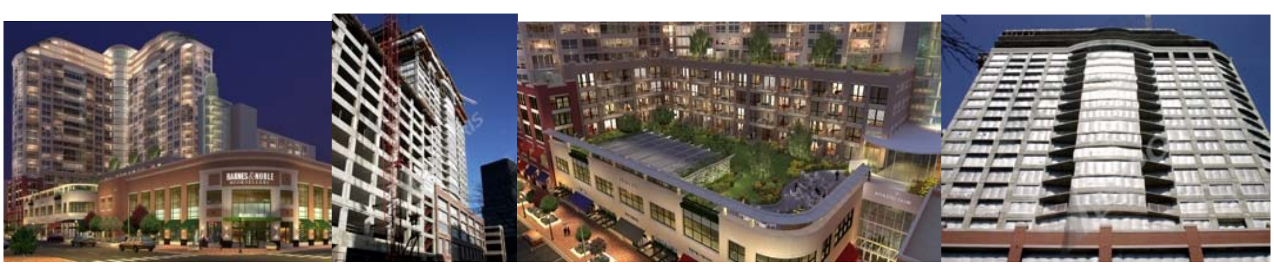
ACOUSTICS BREADTH STUDY



Acoustics Breadth Study

Introduction:

By changing the primary structural system of Sherman Plaza from reinforced concrete to structural steel, other building systems were also impacted. The building's acoustics were affected, because the new structural materials have a different Sound Transmission Class than the existing materials. The new system should provide the same, if not better, sound isolation as the existing system. In cases when the sound transmission value was too high, other alternatives were considered to bring the sound pressure levels to acceptable values.

The sound transmission was considered in locations that were directly affected by the change of structural materials. The first case to be considered was the sound transmission through the floor, because the new floor system is considerably thinner than the original floor. The second case considered an area that contained a concrete shear wall in the original structural design. The new design, therefore, would need to provide a new wall design that would provide comparable transmission loss.

Floor System Transmission Loss:

The transmission loss of the floor system was analyzed between the residential and retail portions of the building. The transition between the retail and residential was a critical area, because the retail area, which contains a health club, had a higher sound level and required a greater sound barrier to isolate sound from the residential dwellings.

First, the transmission loss (TL) of the floor systems was determined from tables of TL data for common building elements. The source room sound pressure level (L1) was also determined from a table of noise level data for common building activity noise sources. The Noise Reduction value of the floor system was found using the following equation:

$$NR = TL + 10 \log(a/S)$$

The value of the variable "a" was found by multiplying the surface area of the receiving room's materials by their sound absorption coefficient. The noise reduction is then used to find the receiving room's sound pressure level (L2) using the following equation:

$$L2 = L1 - NR$$

The acceptable range of noise criteria for a residential space is from NC-25 to NC-35. To be conservative, the sound pressure levels will be compared with NC-25. These decibel values can be found from Figure 22.

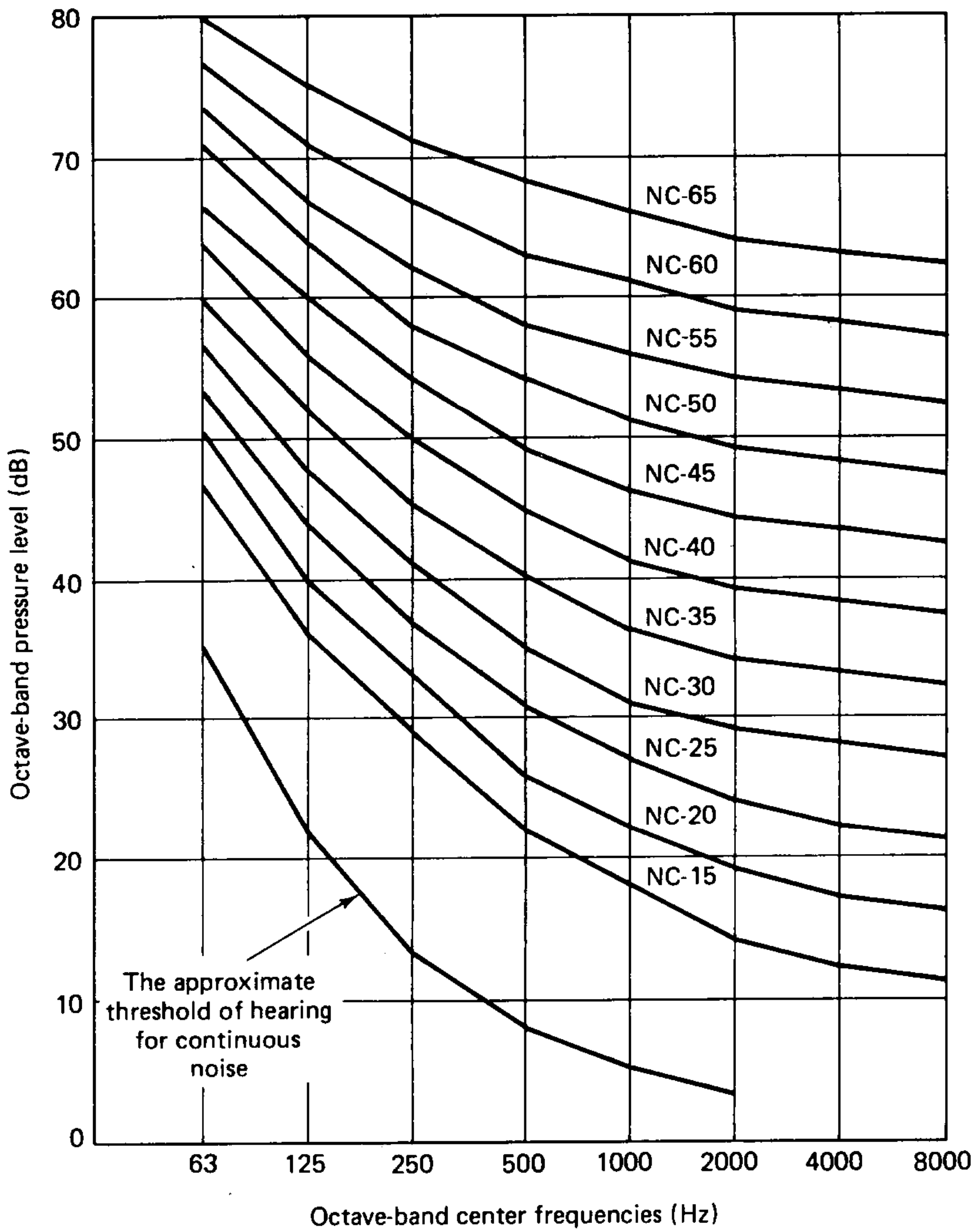


Figure 22: Noise Criteria Curve

The original floor system is composed of an eight inch thick concrete slab. The original floor system was found to have acceptable transmission loss, but the new floor system did not. The new floor system is made up of a three inch concrete slab on composite metal deck. The calculations can be found in Tables 10-11. Figures 23-24 show the residential sound pressure level versus the NC-25 noise criteria curve.

Original Floor System: 8" Reinforced Concrete Floor

Source Room: Health Club
Receiving Room: Residential Area

	Surface Area:		Sound Absorption Coefficients				
Concrete Walls	490	0.1	0.05	0.06	0.07	0.09	0.08
Partition Walls	2170	0.55	0.14	0.08	0.04	0.12	0.11
Floor	1344	0.04	0.04	0.07	0.06	0.06	0.07
Ceiling	1344	0.01	0.01	0.02	0.02	0.02	0.02
Windows	0	0.35	0.25	0.18	0.12	0.07	0.04
a = S*alpha		1309.7	395.5	323.96	228.62	412.02	398.86
TL of Floor		38	48	56	60	67	72
10 log(a/S)		6	1	0	0	1	1
NR = TL + 10 log(a/S)		44	49	56	60	68	73
Sound Pressure Level		78	84	89	86	80	72
L2 = L1 - NR		34	35	33	26	12	0
NC-25		44	37	33	27	25	23

Table 10: Noise Reduction Original Floor System

New Floor System: 3" Concrete Slab on Composite Metal Deck

Source Room: Health Club
Receiving Room: Residential Area

	Surface Area:		Sound Absorption Coefficients				
Concrete Walls	490	0.1	0.05	0.06	0.07	0.09	0.08
Partition Walls	2170	0.55	0.14	0.08	0.04	0.12	0.11
Floor	1344	0.04	0.04	0.07	0.06	0.06	0.07
Ceiling	1344	0.01	0.01	0.02	0.02	0.02	0.02
Windows	0	0.35	0.25	0.18	0.12	0.07	0.04
a = S*alpha		1309.7	395.5	323.96	228.62	412.02	398.86
TL of Floor		48	42	45	56	57	66
10 log(a/S)		6	1	0	0	1	1
NR = TL + 10 log(a/S)		54	43	45	56	58	67
Sound Pressure Level		78	84	89	86	80	72
L2 = L1 - NR		24	41	44	30	22	5
NC-25		44	37	33	27	25	23

Table 11: Noise Reduction New Floor System

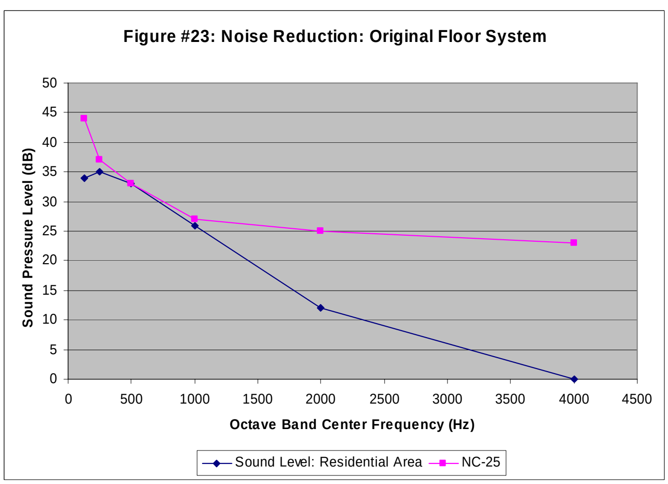


Figure #23: Noise Reduction: Original Floor System

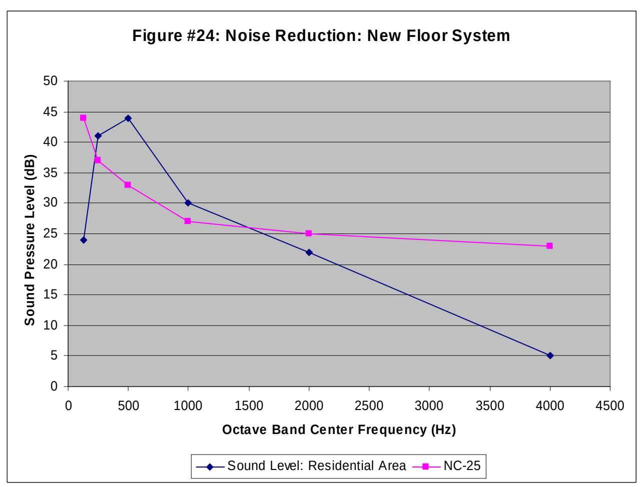


Figure #24: Noise Reduction: New Floor System

In order to improve the transmission loss of the floor system, several alternative systems were analyzed. First, suspended acoustical ceiling tiles were added to the floor system. The tiles improved the sound absorption of the room, but still did not result in acceptable sound pressure levels. Second, carpeting with a foam underlayment was added, but this system also did not have acceptable values. Next, the entire system was considered with both acoustical ceiling tiles and a carpeted floor. This system had values that were almost acceptable for NC-25 and were acceptable for NC-30, which is still in the preferred range for residential spaces. Tables 12-14 show the calculations for these floor systems, and Graphs 25-27 show the residential area sound pressure level versus the noise criteria curves.

New Floor System: Including Acoustical Ceiling Tiles

Source Room: Health Club
Receiving Room: Residential Area

	Surface Area:			Sound Absorption Coefficients			
Concrete Walls	490	0.1	0.05	0.06	0.07	0.09	0.08
Partition Walls	2170	0.55	0.14	0.08	0.04	0.12	0.11
Floor	1344	0.04	0.04	0.07	0.06	0.06	0.07
Ceiling	1344	0.76	0.93	0.83	0.99	0.99	0.94
Windows	0	0.35	0.25	0.18	0.12	0.07	0.04
a = S*alpha		2317.7	1631.98	1412.6	1532.3	1715.7	1635.34
TL of Floor		48	42	45	56	57	66
10 log(a/S)		8	7	6	6	7	7
NR = TL + 10 log(a/S)		56	49	51	62	64	73
Sound Pressure Level		78	84	89	86	80	72
L2 = L1 - NR		22	35	38	24	16	0
NC-25		44	37	33	27	25	23

Table 12: Noise Reduction Floor System with Ceiling Tiles

New Floor System: Including Sound Absorbing Floor Material

Source Room: Health Club
Receiving Room: Residential Area

	Surface Area:			Sound Absorption Coefficients			
Concrete Walls	490	0.1	0.05	0.06	0.07	0.09	0.08
Partition Walls	2170	0.55	0.14	0.08	0.04	0.12	0.11
Floor	1344	0.08	0.24	0.57	0.69	0.71	0.73
Ceiling	1344	0.01	0.01	0.02	0.02	0.02	0.02
Windows	0	0.35	0.25	0.18	0.12	0.07	0.04
a = S*alpha		1363.46	664.3	995.96	1075.34	1285.62	1285.9
TL of Floor		48	42	45	56	57	66
10 log(a/S)		6	3	5	5	6	6
NR = TL + 10 log(a/S)		54	45	50	61	63	72
Sound Pressure Level		78	84	89	86	80	72
L2 = L1 - NR		24	39	39	25	17	0
NC-25		44	37	33	27	25	23

Table 13: Noise Reduction Floor System with Sound Absorbing Floor

New Floor System: Including Sound Absorbing Floor and Ceiling Materials

Source Room: Health Club
Receiving Room: Residential Area

	Surface Area:	Sound Absorption Coefficients					
Concrete Walls	490	0.1	0.05	0.06	0.07	0.09	0.08
Partition Walls	2170	0.55	0.14	0.08	0.04	0.12	0.11
Floor	1344	0.08	0.24	0.57	0.69	0.71	0.73
Ceiling	1344	0.76	0.93	0.83	0.99	0.99	0.94
Windows	0	0.35	0.25	0.18	0.12	0.07	0.04
a = S*alpha		2371.46	1900.78	2084.6	2379.02	2589.3	2522.38
TL of Floor		48	42	45	56	57	66
10 log(a/S)		8	7	8	8	9	9
NR = TL + 10 log(a/S)		56	49	53	64	66	75
Sound Pressure Level		78	84	89	86	80	72
L2 = L1 - NR		22	35	36	22	14	0
NC-25		44	37	33	27	25	23

Table 14: Noise Reduction Floor with Sound Absorbing Floor and Ceiling

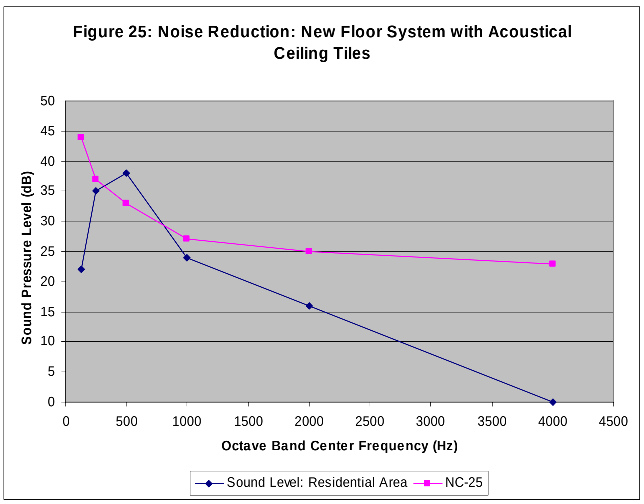


Figure 25: Noise Reduction: New Floor System with Acoustical Ceiling Tiles

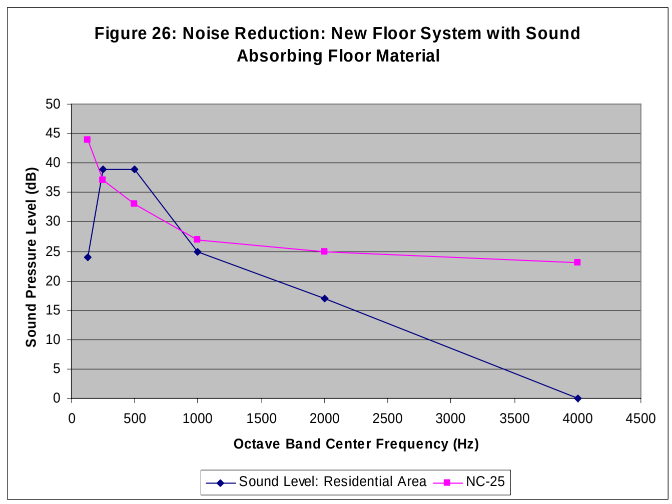


Figure 26: Noise Reduction: New Floor System with Sound Absorbing Floor Material

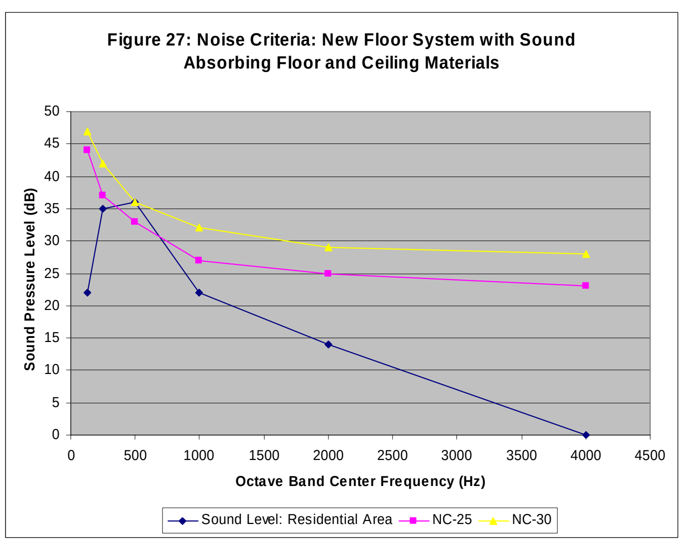


Figure 27: Noise Criteria: New Floor System with Sound Absorbing Floor and Ceiling Materials

Shear Wall Transmission Loss:

The transmission loss of the wall systems was analyzed in a location where there was a concrete shear wall in the original structural design. The area providing the source sound pressure level is a mechanical room, and the receiving room is a residential unit. The existing concrete wall was analyzed to determine if it provided adequate transmission loss. Next several alternative walls were analyzed, and the one with the best sound transmission loss was chosen to replace the existing wall.

This analysis uses the same procedure as the floor transmission loss calculations. The original shear wall is a 12 inch reinforced concrete wall and has an adequate transmission loss to produce sound pressure levels that are below the noise criteria curve, NC-25.

Original Wall System: 12" Reinforced Concrete Shear Wall

Source Room: Mechanical Room
Receiving Room: Residential Area

	Surface Area:		Sound Absorption Coefficients				
Concrete Walls	972	0.1	0.05	0.06	0.07	0.09	0.08
Floor	702	0.02	0.03	0.03	0.03	0.03	0.02
Ceiling	702	0.01	0.01	0.02	0.02	0.02	0.02
a = S*alpha		118.26	76.68	93.42	103.14	122.58	105.84
TL of Wall		44	48	56	58	64	67
10 log(a/S)		0	0	0	0	0	0
NR = TL + 10 log(a/S)		44	48	56	58	64	67
Sound Pressure Level		86	85	84	83	82	80
L2 = L1 - NR		42	37	28	25	18	13
NC-25		44	37	33	27	25	23

Table 15: Noise Reduction Original Wall System

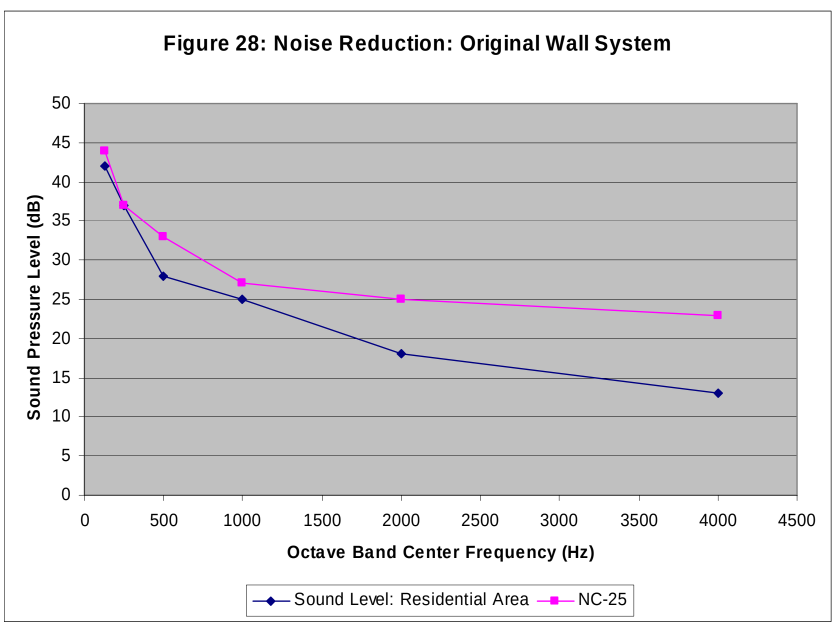


Figure 28: Noise Reduction: Original Wall System

Next, these calculations were performed on several wall assemblies until one was found that had acceptable transmission loss values. The walls that were considered were:

1. 2 ½" steel channel studs 24 in. o.c. with 5/8" gypsum board both sides, with 2" glass-fiber insulation in cavity
2. 2 ½" steel channel studs 24 in. o.c. with two layers 5/8" gypsum board one side, one layer other side, with 2" glass-fiber insulation in cavity
3. 3 5/8" steel channel studs 24 in. o.c. with two layers 5/8" gypsum board both sides, with 3" mineral-fiber insulation in cavity

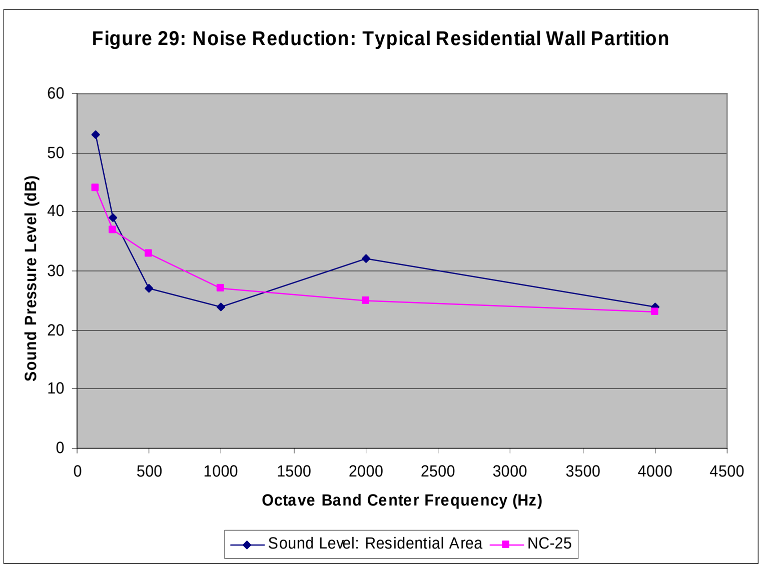
The calculations can be found in Tables 16-18, and Figures 29-31 show the sound pressure levels versus NC-25. The calculations show that the first two alternative walls were inadequate, but the third wall produced acceptable values.

New Wall System: Typical Residential Wall Partition

Source Room: Mechanical Room
Receiving Room: Residential Area

	Surface Area:			Sound Absorption Coefficients			
Partition Walls	972	0.55	0.14	0.08	0.04	0.12	0.11
Floor	702	0.02	0.03	0.03	0.03	0.03	0.02
Ceiling	702	0.76	0.93	0.83	0.99	0.99	0.94
a = S*alpha		1082.16	810	681.48	754.92	832.68	780.84
TL of Wall		26	41	52	54	45	51
10 log(a/S)		7	5	5	5	5	5
NR = TL + 10 log(a/S)		33	46	57	59	50	56
Sound Pressure Level		86	85	84	83	82	80
L2 = L1 - NR		53	39	27	24	32	24
NC-25		44	37	33	27	25	23

Table 16: Noise Reduction Wall Alternative 1



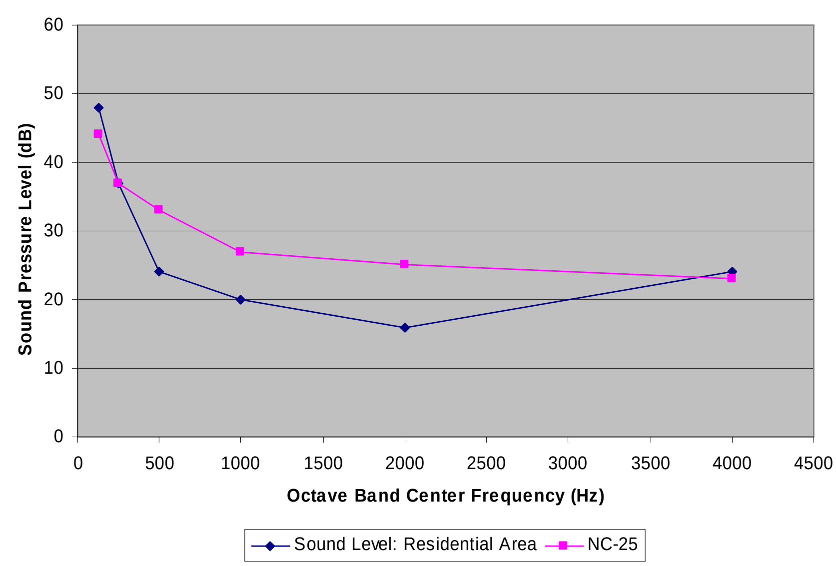
New Wall System: Residential Partition Wall with Extra Layer Gypsum Board

Source Room: Mechanical Room
Receiving Room: Residential Area

	Surface Area:	Sound Absorption Coefficients					
Partition Walls	972	0.55	0.14	0.08	0.04	0.12	0.11
Floor	702	0.02	0.03	0.03	0.03	0.03	0.02
Ceiling	702	0.76	0.93	0.83	0.99	0.99	0.94
a = S*alpha		1082.16	810	681.48	754.92	832.68	780.84
TL of Wall		31	43	55	58	61	51
10 log(a/S)		7	5	5	5	5	5
NR = TL + 10 log(a/S)		38	48	60	63	66	56
Sound Pressure Level		86	85	84	83	82	80
L2 = L1 - NR		48	37	24	20	16	24
NC-25		44	37	33	27	25	23

Table 17: Noise Reduction Wall Alternative 2

Figure 30: Noise Reduction: Residential Wall Alternative 2

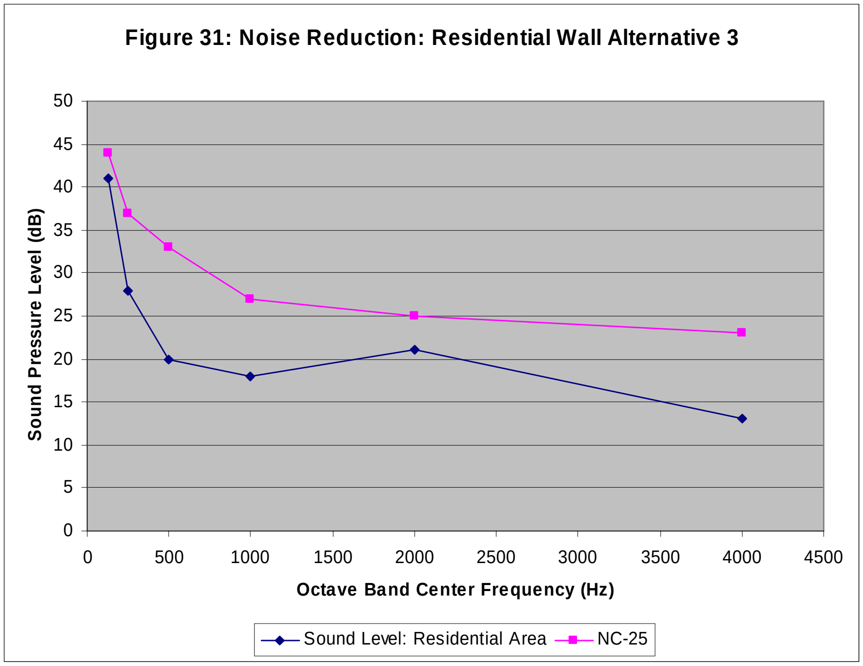


New Wall System: Residential Partition Wall with Two Extra Layers Gypsum Board

Source Room: Mechanical Room
Receiving Room: Residential Area

	Surface Area:			Sound Absorption Coefficients			
Partition Walls	972	0.55	0.14	0.08	0.04	0.12	0.11
Floor	702	0.02	0.03	0.03	0.03	0.03	0.02
Ceiling	702	0.76	0.93	0.83	0.99	0.99	0.94
a = S*alpha		1082.16	810	681.48	754.92	832.68	780.84
TL of Wall		38	52	59	60	56	62
10 log(a/S)		7	5	5	5	5	5
NR = TL + 10 log(a/S)		45	57	64	65	61	67
Sound Pressure Level		86	85	84	83	82	80
L2 = L1 - NR		41	28	20	18	21	13
NC-25		44	37	33	27	25	23

Table 18: Noise Reduction Wall Alternative 3



Conclusion:

The first acoustical analysis was between the existing 8 inch concrete floor system and the new floor system of a 3 inch slab on metal deck. The existing floor system was found to have an adequate transmission loss. The new system, however, was not acceptable according to the NC-25 noise criteria curve. The first two alternatives were also not acceptable. The final alternative combined both acoustical ceiling tiles and a sound absorbing floor material. This system was close to being adequate for NC-25, but was below the values of NC-30, which is in the preferred range for a residential area.

The second analysis investigated the transmission loss of one of the concrete shear walls from the original structural system. The shear wall was found to have an acceptable transmission loss to reduce the mechanical room noise. Based on the acceptable sound pressure levels, a new wall system was chosen to replace this wall. Three alternatives were analyzed. The chosen wall system was made up of 3 5/8" steel channel studs with two layers 5/8" gypsum board on both sides and 3" mineral-fiber insulation in the cavity.