



Appendix E
Acoustic Analysis

Room Constant Calculation for Hearing Science Lab (3122).

Room Constant Calculation for:
HSLS Audiology Hearing Science Lab (3122)

Surface	Material	Area [m ²]	Material Absorption Coefficient (α)						
			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Walls	Gypsum Board (2)	97.54883	0.28	0.12	0.10	0.07	0.13	0.09	
Floor	Carpet	75.8064	0.08	0.27	0.39	0.34	0.48	0.63	
Ceiling ¹	Acoustical Board	75.8064	0.76	0.93	0.83	0.99	0.99	0.94	
Doors	Wood	19.509	0.19	0.14	0.09	0.06	0.06	0.05	
Total: 268.6706									
			α_{SAB} :	0.35247	0.39232	0.38707	0.40504	0.46632	0.47929
			Room Constant (R_T) :	146.24	173.45	169.67	182.90	234.76	247.30

Transmission Losses for Hearing Science Lab (3122).

Transmission Losses Through Building Construction (TL) [dB]
Calculation for Room: HSLS Audiology Hearing Science Lab (3122)

Building Construction	Transmission Loss [dB]						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Walls	38	52	59	60	56	62	
Doors	29	31	31	31	39	43	
Partitions ¹	35	39	39	39	46	51	
Floor	38	44	52	55	60	65	
Roof	original	17	22	26	30	35	41
	green	27	32	36	40	45	61

¹ Composite of doors and walls.

Noise Reductions for Hearing Science Lab (3122).

Noise Reduction Through Building Construction (L_p) [dB]
Calculation for Room: HSLS Audiology Hearing Science Lab (3122)

Building Construction	Noise Reduction ¹ [dB]						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Partitions ²	36	40	40	41	49	54	
Floor	41	48	55	59	65	70	
Roof	original	20	26	29	34	40	46
	green	29	35	39	43	50	66

¹ Noise reduction of average sound pressure levels through building construction.
² Composite of walls and doors.

Room Noise from each source for Hearing Science Lab (3122), original VAV system.

Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Audiology Hearing Science Lab (3122)

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Original Roof	Case 1	37	24	21	11	0	0
	Case 2	49	37	27	24	15	1
	Case 3	43	40	27	24	19	4
Green Roof	Case 1	28	14	11	2	0	0
	Case 2	39	27	17	14	5	0
	Case 3	33	30	17	14	9	0
Partitions ¹		16	5	0	0	0	0
Floor ¹		11	0	0	0	0	0
Mechanical Noise		34	31	26	20	11	5

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for Hearing Science Lab (3122), original VAV system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Audiology Hearing Science Lab (3122)

Case		Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Original Roof	Case 1	39	32	27	21	11	5	21
	Case 2	49	38	29	25	16	6	31
	Case 3	43	40	29	25	20	7	30
Green Roof	Case 1	35	31	26	20	11	5	20
	Case 2	40	33	27	21	12	5	20
	Case 3	37	34	27	21	13	5	20

Case 1: Typical ambient conditions
 Case 2: Car driving by site
 Case 3: Diesel truck driving by site

Room Noise from each source for Hearing Science Lab (3122), proposed DOAS system.

Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Audiology Hearing Science Lab (3122)

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Original Roof	Case 1	37	24	21	11	0	0
	Case 2	49	37	27	24	15	1
	Case 3	43	40	27	24	19	4
Green Roof	Case 1	28	14	11	2	0	0
	Case 2	39	27	17	14	5	0
	Case 3	33	30	17	14	9	0
Partitions ¹		16	5	0	0	0	0
Floor ¹		11	-3	0	0	0	0
Mechanical Noise		34	27	20	11	5	5

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for Hearing Science Lab (3122), proposed DOAS system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Audiology Hearing Science Lab (3122)

Case		Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Original Roof	Case 1	39	29	24	14	6	5	20
	Case 2	49	37	28	24	15	6	31
	Case 3	43	40	28	24	19	7	30
Green Roof	Case 1	35	27	21	12	5	5	20
	Case 2	40	30	22	16	8	5	20
	Case 3	37	32	22	16	11	5	20

Case 1: Typical ambient conditions
 Case 2: Car driving by site
 Case 3: Diesel truck driving by site

Output from Trane Acoustical Program (TAP) for HSLs Audiology and Hearing Science Lab (3122), original VAV system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	98	98	97	95	88	81	77	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	98	97	91	84	78	71	67	
	62	57	49	42	34	25	14	Regenerated
sound from elbow.								
SubSum	98	97	91	84	78	71	67	
Straight Duct(RL)	-10	-13	-36	-40	-40	-40	-40	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	88	83	51	37	31	24	20	
	64	65	63	58	50	39	24	Regenerated
sound from elbow.								
SubSum	88	83	63	58	50	39	25	
Straight Duct(RL)	-1	-1	-3	-11	-9	-7	-7	
Straight Duct(RL)	-2	-3	-7	-23	-20	-16	-16	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	84	76	47	20	17	12	5	
	64	63	60	54	45	33	16	Regenerated
sound from elbow.								
SubSum	84	76	60	54	45	33	16	
Straight Duct(RU1)	-8	-5	-3	-1	-1	-1	-1	
Straight Duct(RU1)	-1	-1	0	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	75	69	54	47	40	28	11	
	59	56	51	42	30	14	0	Regenerated
sound from elbow.								
SubSum	75	69	56	48	40	28	11	
Straight Duct(RU1)	-1	-1	-1	0	0	0	0	
Junction (T,atten.)	-7	-7	-7	-7	-7	-7	-7	
SubSum	67	61	48	41	33	21	5	
	43	39	34	28	22	15	7	Regenerated
sound from junction.								
SubSum	67	61	48	41	33	22	9	
Straight Duct(RU1)	-3	-2	-1	0	0	0	0	
Elbow (ul.rad.rct)	-1	-2	-3	-3	-3	-3	-3	
SubSum	63	57	44	38	30	19	6	
	0	0	0	0	0	0	0	Regenerated
sound from elbow.								
SubSum	63	57	44	38	30	19	7	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	62	56	43	37	29	18	6	
	7	5	1	0	0	0	0	Regenerated
sound from junction.								
SubSum	62	56	43	37	29	18	7	
Straight Duct(RU1)	-2	-1	0	0	0	0	0	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	59	54	42	36	28	17	6	
	5	1	0	0	0	0	0	Regenerated
sound from junction.								
SubSum	59	54	42	36	28	17	7	
Junction (90,atten.)AB	-5	-5	-5	-5	-5	-5	-5	
SubSum	54	49	37	31	23	12	5	
	14	9	4	0	0	0	0	Regenerated
sound from junction.								

SubSum	54	49	37	31	23	12	6	
Straight Duct(RU1)	-2	-1	-1	0	0	0	0	
SubSum	52	48	36	31	23	12	6	
Custom Element	0	70	64	60	62	65	69	VAV-125
SubSum	52	70	64	60	62	65	69	
Custom Element	-18	-42	-40	-48	-52	-50	-39	SA-3
Junction (90,atten.)	-2	-2	-2	-2	-2	-2	-2	
SubSum	32	26	22	10	8	13	28	
	38	33	25	16	7	0	0	Regenerated
sound from junction.								
SubSum	39	34	27	17	11	13	28	
Straight Duct(RU1)	-5	-3	-1	-1	-1	-1	-1	
SubSum	34	31	26	16	10	12	27	
Diffuser	42	40	37	31	23	13	1	
SubSum	43	41	37	31	23	16	27	
Indoor (Regression)	-9	-10	-11	-11	-12	-13	-14	
SUM	34	31	26	20	11	5	13	
RATING	NC 16			RC 12(H)		23 dBA		

Output from Trane Acoustical Program (TAP) for HSLS Audiology and Hearing Science Lab (3122), proposed DOAS system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	88	88	90	82	78	71	67	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	88	87	84	71	68	61	57	
SubSum	49	42	36	28	20	11	0	Regenerated
sound from elbow.								
SubSum	88	87	84	71	68	61	57	
Straight Duct(RL)	-14	-19	-40	-40	-40	-40	-40	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	74	67	40	24	21	14	10	
SubSum	53	53	50	45	37	25	10	Regenerated
sound from elbow.								
SubSum	74	67	50	45	37	25	13	
Straight Duct(RL)	-1	-2	-4	-13	-12	-10	-8	
Straight Duct(RL)	-3	-4	-10	-28	-26	-22	-19	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	70	60	33	5	5	5	5	
SubSum	53	53	50	45	37	25	10	Regenerated
sound from elbow.								
SubSum	70	61	50	45	37	25	11	
Straight Duct(RU1)	-10	-7	-4	-1	-1	-1	-1	
Straight Duct(RU1)	-1	-1	0	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	59	52	43	38	32	20	6	
SubSum	53	53	50	45	37	25	10	Regenerated
sound from elbow.								
SubSum	60	56	51	46	38	26	11	
Straight Duct(RU1)	-2	-1	-1	0	0	0	0	
Junction (T,atten.)	-7	-7	-7	-7	-7	-7	-7	
SubSum	51	48	43	39	31	19	5	
SubSum	37	34	28	22	16	8	0	Regenerated
sound from junction.								
SubSum	51	48	43	39	31	19	6	
Straight Duct(RU1)	-3	-2	-1	-1	-1	-1	-1	
Elbow (ul.rad.rct)	0	0	-1	-2	-3	-3	-3	
SubSum	48	46	41	36	27	15	5	
SubSum	0	0	0	0	0	0	0	Regenerated
sound from elbow.								
SubSum	48	46	41	36	27	15	6	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	47	45	40	35	26	14	5	
SubSum	0	0	0	0	0	0	0	Regenerated
sound from junction.								
SubSum	47	45	40	35	26	14	6	
Straight Duct(RU1)	-1	-1	0	0	0	0	0	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	45	43	39	34	25	13	5	
SubSum	0	0	0	0	0	0	0	Regenerated
sound from junction.								
SubSum	45	43	39	34	25	13	6	
Junction (90,atten.)	-3	-3	-3	-3	-2	-2	-2	
SubSum	42	40	36	31	23	11	5	
SubSum	0	0	0	0	0	0	0	Regenerated
sound from junction.								

SubSum	42	40	36	31	23	11	6	
Straight Duct(RL)	-7	-8	-12	-25	-40	-40	-33	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	34	31	23	5	5	5	5	
	56	53	48	42	34	24	14	Regenerated
sound from junction.								
SubSum	56	53	48	42	34	24	15	
Straight Duct(RL)	-10	-11	-17	-34	-40	-40	-40	
SubSum	46	42	31	8	5	5	5	
Diffuser	42	40	37	31	23	13	1	
SubSum	47	44	38	31	23	14	6	
Indoor (Regression)	-9	-10	-11	-11	-12	-13	-14	
SUM	38	34	27	20	11	5	5	
RATING	NC < 15			RC 12(R)		23 dBA		

Room Constant Calculation for HSLs Fac. Lab (3122H).

Room Constant Calculation for:
HSLs Fac. Lab (3122H)

Surface	Material	Area [m ²]	Material Absorption Coefficient (α)					
			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Walls	Gypsum Board (2)	21.36834	0.28	0.12	0.10	0.07	0.13	0.09
Floor	Carpet	11.148	0.08	0.27	0.39	0.34	0.48	0.63
Ceiling ¹	Acoustical Board	5.574	0.76	0.93	0.83	0.99	0.99	0.94
	Spray fib. insul.	11.148	0.08	0.29	0.75	0.98	0.93	0.76
Doors	Wood	19.509	0.19	0.14	0.09	0.06	0.06	0.05

Total: 68.74734

α_{SAB} :	0.21554	0.19621	0.18716	0.17419	0.21554	0.22054
Room Constant (R_T) :	18.89	16.78	15.83	14.50	18.89	19.45

¹ The ceiling must be a blend of acoustic board and perforated ceiling panels in a passive chilled beam application.

Transmission Losses for HSLs Fac. Lab (3122H).

Transmission Losses Through Building Construction (L_p) [dB]

Calculation for Room: HSLs Fac. Lab (3122H)

Building Construction	Transmission Loss [dB]						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Walls	38	52	59	60	56	62	
Doors	29	31	31	31	39	43	
Partitions ¹	32	34	34	34	42	46	
Floor	38	44	52	55	60	65	
Roof	original	17	22	26	30	35	41
	green	27	32	36	40	45	61

¹ Composite of doors and walls.

Noise Reductions for HSLs Fac. Lab (3122H).

Noise Reduction Through Building Construction (L_p) [dB]

Calculation for Room: HSLs Fac. Lab (3122H)

Building Construction	Noise Reduction ¹ [dB]						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Partitions ²	28	30	30	30	39	43	
Floor	40	46	54	56	62	67	
Roof	original	19	24	28	31	37	43
	green	29	34	38	41	47	63

¹ Noise reduction of average sound pressure levels through building construction.

² Composite of walls and doors.

Room Noise from each source for HSLs Fac. Lab (3122H), original VAV system.

Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Fac. Lab (3122H)

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Original Roof	Case 1	38	26	23	14	3	0
	Case 2	49	39	29	26	18	4
	Case 3	43	42	29	26	22	6
Green Roof	Case 1	28	16	13	4	0	0
	Case 2	39	29	19	16	8	0
	Case 3	33	32	19	16	12	0
Partitions ¹		24	15	10	6	0	0
Floor ¹		12	0	0	0	0	0
Mechanical Noise		35	30	23	15	5	5

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for HSLs Fac. Lab (3122H), original VAV system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Fac. Lab (3122H)

Case		Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Original Roof	Case 1	40	31	26	18	7	5	20
	Case 2	50	39	30	27	18	8	32
	Case 3	44	42	30	27	22	9	32
Green Roof	Case 1	36	30	24	16	6	5	17
	Case 2	41	32	25	19	10	5	20
	Case 3	37	34	25	19	13	5	21

Case 1: Typical ambient conditions
 Case 2: Car driving by site
 Case 3: Diesel truck driving by site

Room Noise from each source for HSLs Fac. Lab (3122H), proposed DOAS system.

Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Fac. Lab (3122H)

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Original Roof	Case 1	38	26	23	14	3	0
	Case 2	49	39	29	26	18	4
	Case 3	43	42	29	26	22	6
Green Roof	Case 1	28	16	13	4	0	0
	Case 2	39	29	19	16	8	0
	Case 3	33	32	19	16	12	0
Partitions ¹		24	15	10	6	0	0
Floor ¹		12	0	0	0	0	0
Mechanical Noise		39	32	24	13	5	5

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for HSLs Fac. Lab (3122H), proposed DOAS system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: HSLs Fac. Lab (3122H)

Case		Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Original Roof	Case 1	42	33	27	17	7	5	23
	Case 2	50	40	30	27	18	8	33
	Case 3	45	42	30	27	22	9	31
Green Roof	Case 1	39	32	24	14	6	5	20
	Case 2	42	34	25	18	10	5	23
	Case 3	40	35	25	18	13	5	23

Case 1: Typical ambient conditions
 Case 2: Car driving by site
 Case 3: Diesel truck driving by site

Output from Trane Acoustical Program (TAP) for HSLs Fac. Lab (3122H), original VAV system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	98	98	97	95	88	81	77	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	98	97	91	84	78	71	67	
	62	57	49	42	34	25	14	Regenerated
sound from elbow.								
SubSum	98	97	91	84	78	71	67	
Straight Duct(RL)	-10	-13	-36	-40	-40	-40	-40	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	88	83	51	37	31	24	20	
	64	65	63	58	50	39	24	Regenerated
sound from elbow.								
SubSum	88	83	63	58	50	39	25	
Straight Duct(RL)	-1	-1	-3	-11	-9	-7	-7	
Straight Duct(RL)	-2	-3	-7	-23	-20	-16	-16	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	84	76	47	20	17	12	5	
	64	63	60	54	45	33	16	Regenerated
sound from elbow.								
SubSum	84	76	60	54	45	33	16	
Straight Duct(RU1)	-8	-5	-3	-1	-1	-1	-1	
Straight Duct(RU1)	-1	-1	0	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	75	69	54	47	40	28	11	
	59	56	51	42	30	14	0	Regenerated
sound from elbow.								
SubSum	75	69	56	48	40	28	11	
Straight Duct(RU1)	-1	-1	-1	0	0	0	0	
Junction (T,atten.)	-7	-7	-7	-7	-7	-7	-7	
SubSum	67	61	48	41	33	21	5	
	43	39	34	28	22	15	7	Regenerated
sound from junction.								
SubSum	67	61	48	41	33	22	9	
Straight Duct(RU1)	-3	-2	-1	0	0	0	0	
Elbow (ul.rad.rct)	-1	-2	-3	-3	-3	-3	-3	
SubSum	63	57	44	38	30	19	6	
	0	0	0	0	0	0	0	Regenerated
sound from elbow.								
SubSum	63	57	44	38	30	19	7	
Junction (90,atten.)AB	-10	-10	-10	-10	-10	-10	-10	
SubSum	53	47	34	28	20	9	5	
	0	0	0	0	0	0	0	Regenerated
sound from junction.								
SubSum	53	47	34	28	20	10	6	
Straight Duct(RU1)	-1	-1	0	0	0	0	0	
SubSum	52	46	34	28	20	10	6	
Custom Element	0	70	64	60	62	65	69	VAV-125
SubSum	52	70	64	60	62	65	69	
Custom Element	-18	-42	-40	-48	-52	-50	-39	SA-3
Junction (90,atten.)AB	-2	-2	-2	-2	-2	-2	-2	
SubSum	32	26	22	10	8	13	28	
	0	0	0	0	0	0	0	Regenerated
sound from junction.								
SubSum	32	26	22	10	9	13	28	
Straight Duct(RL)	-11	-12	-16	-30	-40	-40	-40	

Elbow (ln.sq.rct)	0	0	0	-1	-6	-11	-10	
SubSum	21	14	6	5	5	5	5	
	0	0	0	0	0	0	0	Regenerated
sound from elbow.								
Diffuser	44	42	39	33	25	15	3	
SubSum	44	42	39	33	25	16	8	
Indoor (Regression)	-8	-9	-9	-10	-10	-11	-12	
SUM	36	33	30	23	15	5	5	
RATING	NC 16			RC 14(R)		25 dBA		

Output from Trane Acoustical Program (TAP) for HSLs Fac. Lab (3122H), proposed DOAS system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	88	88	90	82	78	71	67	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	88	87	84	71	68	61	57	
sound from elbow.	49	42	36	28	20	11	0	Regenerated
SubSum	88	87	84	71	68	61	57	
Straight Duct(RL)	-14	-19	-40	-40	-40	-40	-40	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	74	67	40	24	21	14	10	
sound from elbow.	53	53	50	45	37	25	10	Regenerated
SubSum	74	67	50	45	37	25	13	
Straight Duct(RL)	-1	-2	-4	-13	-12	-10	-8	
Straight Duct(RL)	-3	-4	-10	-28	-26	-22	-19	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	70	60	33	5	5	5	5	
sound from elbow.	53	53	50	45	37	25	10	Regenerated
SubSum	70	61	50	45	37	25	11	
Straight Duct(RU1)	-10	-7	-4	-1	-1	-1	-1	
Straight Duct(RU1)	-1	-1	0	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	59	52	43	38	32	20	6	
sound from elbow.	53	53	50	45	37	25	10	Regenerated
SubSum	60	56	51	46	38	26	11	
Straight Duct(RU1)	-2	-1	-1	0	0	0	0	
Junction (T,atten.)	-7	-7	-7	-7	-7	-7	-7	
SubSum	51	48	43	39	31	19	5	
sound from junction.	37	34	28	22	16	8	0	Regenerated
SubSum	51	48	43	39	31	19	6	
Straight Duct(RU1)	-3	-2	-1	-1	-1	-1	-1	
Elbow (ul.rad.rct)	0	0	-1	-2	-3	-3	-3	
SubSum	48	46	41	36	27	15	5	
sound from elbow.	0	0	0	0	0	0	0	Regenerated
SubSum	48	46	41	36	27	15	6	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	47	45	40	35	26	14	5	
sound from junction.	0	0	0	0	0	0	0	Regenerated
SubSum	47	45	40	35	26	14	6	
Straight Duct(RU1)	-1	-1	0	0	0	0	0	
Junction (90,atten.)	-7	-7	-7	-7	-7	-7	-7	
SubSum	39	37	33	28	19	7	5	
sound from junction.	0	0	0	0	0	0	0	Regenerated
SubSum	39	37	33	28	19	8	6	
Straight Duct(RL)	-40	-40	-40	-40	-40	-40	-40	
Junction (90,atten.)	-3	-3	-3	-3	-3	-3	-3	
SubSum	5	5	5	5	5	5	5	
sound from junction.	0	0	0	0	0	0	0	Regenerated

SubSum	6	6	6	6	6	6	6	
Elbow (ul.sq.rct)	0	0	0	-1	-5	-8	-4	
SubSum	6	6	6	5	5	5	5	
	17	12	8	1	0	0	0	Regenerated
sound from elbow.								
SubSum	17	13	10	6	6	6	6	
Straight Duct(RL)	-28	-29	-31	-40	-40	-40	-40	
Diffuser	47	44	38	30	20	8	-7	
Indoor (Regression)	-9	-10	-11	-11	-12	-13	-14	
SUM	43	39	32	24	13	5	5	
RATING	NC 19			RC 14(R)		28 dBA		

Room Constant Calculation for Hearing Aid Fitting Room (2207).

Room Constant Calculation for:
Hearing Aid Fitting Room (2207)

Surface	Material	Area [m ²]	Material Absorption Coefficient (α)					
			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Int. Walls	Gypsum Board (2)	29.73	0.28	0.12	0.10	0.07	0.13	0.09
Ext. Walls	Gypsum Board (1)	5.39	0.55	0.14	0.08	0.04	0.12	0.11
Floor	Carpet	10.22	0.08	0.27	0.39	0.34	0.48	0.63
Ceiling ¹	Acoustical Board	5.11	0.76	0.93	0.83	0.99	0.99	0.94
	Spray fib. insul.	10.22	0.08	0.29	0.75	0.98	0.93	0.76
Doors	Wood	1.95	0.19	0.14	0.09	0.06	0.06	0.05
Windows	Glass	1.95	0.18	0.06	0.04	0.03	0.02	0.02
Total: 62.61581								
α _{SAB} :			0.21954	0.18316	0.18291	0.17231	0.22334	0.22443
Room Constant (R _T) :			17.61	14.04	14.02	13.04	18.01	18.12

¹ The ceiling must be a blend of acoustic board and perforated ceiling panels in a passive chilled beam application.

Transmission Losses for Hearing Aid Fitting Room (2207) Exterior Wall.

Calculated Transmission Loss Through Exterior Wall (TL) [dB]
Calculation for Room: Hearing Aid Fitting Room (2207)

Building Construction	Transmission Loss [dB]					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Int. Wall Surface	28	45	54	55	47	54
Ext. Wall Surface	32	34	40	47	55	61
Total Ext. Wall	60	79	94	102	102	115

Transmission Losses for Hearing Aid Fitting Room (2207).

Transmission Losses Through Building Construction (TL) [dB]
Calculation for Room: Hearing Aid Fitting Room (2207)

Building Construction	Transmission Loss [dB]					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Int. Walls	38	52	59	60	56	62
Ext. Walls	60	79	94	102	102	115
Glass	21	30	40	44	46	57
Doors	29	31	31	31	39	43
Partitions ¹	36	43	43	43	50	54
Exterior Wall ²	27	36	46	50	52	63
Floor	38	44	52	55	60	65

¹ Composite of doors and walls.
² Composite of glass and wall.

Noise Reductions for Hearing Aid Fitting Room (2207).

Noise Reduction Through Building Construction (L_p) [dB]
Calculation for Room: Hearing Aid Fitting Room (2207)

Building Construction	Noise Reduction ¹ [dB]					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Partitions ²	34	39	39	39	47	52
Exterior Wall ³	31	39	49	52	56	67
Floor	40	45	53	56	62	67

¹ Noise reduction of average sound pressure levels through building construction.
² Composite of walls and doors.
³ Composite of glass and doors.

Room Noise from each source for Hearing Aid Fitting Room (2207), original VAV system.

Noise in Receiver Room (L_p)_{rec} [dB]
Calculation for Room: Hearing Aid Fitting Room (2207)

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Exterior Wall	Case 1	27	11	2	-7	0	0
	Case 2	38	24	8	5	0	0
	Case 3	32	27	8	5	3	0
Partitions ¹		18	6	1	-3	0	0
Floor ¹		12	0	0	0	0	0
Mechanical Noise		36.0	29.0	22.0	17.0	14.0	12.0

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for Hearing Aid Fitting Room (2207), original VAV system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
Calculation for Room: Hearing Aid Fitting Room (2207)

	Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Case 1	37	29	22	17	14	12	16
Case 2	40	30	22	17	14	12	20
Case 3	38	31	22	17	14	12	19

Case 1: Typical ambient conditions
Case 2: Car driving by site
Case 3: Diesel truck driving by site

Room Noise from each source for Hearing Aid Fitting Room (2207), proposed DOAS system.

Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: Hearing Aid Fitting Room (2207)

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Exterior Wall	Case 1	27	11	2	0	0	0
	Case 2	38	24	8	5	0	0
	Case 3	32	27	8	5	3	0
Partitions ¹		18	6	1	0	0	0
Floor ¹		12	0	0	0	0	0
Mechanical Noise		21.0	14.0	7.0	5.0	5.0	5.0

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for Hearing Aid Fitting Room (2207), proposed DOAS system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
 Calculation for Room: Hearing Aid Fitting Room (2207)

	Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Case 1	28	16	9	6	5	5	<15
Case 2	38	24	11	8	6	5	18
Case 3	33	27	11	8	7	5	<15

Case 1: Typical ambient conditions
 Case 2: Car driving by site
 Case 3: Diesel truck driving by site

Output from Trane Acoustical Program (TAP) for Hearing Aid Fitting Room (2207), original VAV system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	101	101	100	98	91	84	80	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	101	100	94	87	81	74	70	
57	51	45	37	29	19	9		Regenerated
sound from elbow.								
SubSum	101	100	94	87	81	74	70	
Straight Duct(RL)	-4	-5	-14	-40	-38	-31	-29	
Elbow (In.sq.rct)	-1	-4	-7	-7	-7	-7	-7	
SubSum	96	91	73	40	36	36	34	
62	63	61	56	48	37	22		Regenerated
sound from elbow.								
SubSum	96	91	73	56	48	40	34	
Straight Duct(RL)	-1	-1	-4	-11	-9	-8	-7	
Elbow (In.sq.rct)	-1	-4	-7	-7	-7	-7	-7	
SubSum	94	86	62	38	32	25	20	
62	63	61	56	48	37	22		Regenerated
sound from elbow.								
SubSum	94	86	65	56	48	37	24	
Straight Duct(RL)	-1	-1	-2	-5	-5	-4	-4	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	93	84	59	44	36	26	13	
65	65	63	59	52	41	27		Regenerated
sound from elbow.								
SubSum	93	84	64	59	52	41	27	
Straight Duct(RL)	-4	-5	-12	-38	-33	-27	-26	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	89	78	48	14	12	7	5	
62	63	61	56	48	37	22		Regenerated
sound from elbow.								
SubSum	89	78	61	56	48	37	22	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	89	77	57	49	41	30	15	
62	63	61	56	48	37	22		Regenerated
sound from elbow.								
SubSum	89	77	62	57	49	38	23	
Straight Duct(RL)	-3	-4	-11	-33	-28	-23	-22	
Elbow (ul.sq.rct)	0	-1	-5	-8	-4	-3	-3	
SubSum	86	72	46	16	17	12	5	
57	51	45	37	29	19	9		Regenerated
sound from elbow.								
SubSum	86	72	49	37	29	20	10	
Junction (T,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	85	71	48	36	28	19	9	
55	49	42	33	24	14	3		Regenerated
sound from junction.								
SubSum	85	71	49	38	29	20	10	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	84	70	48	37	28	19	9	
43	39	35	31	26	20	12		Regenerated
sound from junction.								
SubSum	84	70	48	38	30	23	14	
Straight Duct(RU1)	-3	-2	-1	0	0	0	0	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	80	67	46	37	29	22	13	

	51	46	40	34	27	20	11	Regenerated
sound from junction.								
Junction (T,atten.)	0	0	0	0	0	0	0	
	29	25	20	15	9	2	0	Regenerated
sound from junction.								
SubSum	80	67	47	39	31	24	15	
Straight Duct(RU1)	-4	-2	-2	0	0	0	0	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	75	64	44	38	30	23	14	
	36	32	26	21	14	7	0	Regenerated
sound from junction.								
SubSum	75	64	44	38	30	23	14	
Straight Duct(RU1)	-3	-2	-1	0	0	0	0	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	71	61	42	37	29	22	13	
	33	29	24	19	12	4	0	Regenerated
sound from junction.								
SubSum	71	61	42	37	29	22	13	
Straight Duct(RU1)	-3	-2	-1	0	0	0	0	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	67	58	40	36	28	21	12	
	32	27	22	16	9	2	0	Regenerated
sound from junction.								
SubSum	67	58	40	36	28	21	12	
Straight Duct(RU1)	-6	-4	-3	-1	-1	-1	-1	
Junction (90,atten.)AB	0	-4	0	0	0	0	0	
SubSum	61	50	37	35	27	20	11	
	34	29	24	18	12	4	0	Regenerated
sound from junction.								
SubSum	61	50	37	35	27	20	11	
Straight Duct(RU1)	-1	-1	-1	0	0	0	0	
Junction (T,atten.)	-2	-4	-2	-2	-2	-2	-2	
SubSum	58	45	34	33	25	18	9	
	16	6	0	0	0	0	0	Regenerated
sound from junction.								
SubSum	58	45	34	33	25	18	10	
Straight Duct(RU1)	-1	-1	-1	0	0	0	0	
Junction (90,atten.)AB	-6	-6	-6	-6	-6	-6	-6	
SubSum	51	38	27	27	19	12	5	
	24	19	13	6	0	0	0	Regenerated
sound from junction.								
SubSum	51	38	27	27	19	12	6	
Elbow (ul.rad.rct)	0	0	-1	-2	-3	-3	-3	
SubSum	51	38	26	25	16	9	5	
	4	0	0	0	0	0	0	Regenerated
sound from elbow.								
SubSum	51	38	26	25	16	10	6	
Straight Duct(RU1)	-3	-1	-1	0	0	0	0	
Junction (T,atten.)	-2	-2	-2	-2	-2	-2	-2	
SubSum	46	35	23	23	14	8	5	
	19	13	8	0	0	0	0	Regenerated
sound from junction.								
Custom Element	0	70	64	60	62	65	69	VAV-064
SubSum	46	70	64	60	62	65	69	
Custom Element	-12	-40	-35	-31	-27	-28	-42	SA-2
Straight Duct(RL)	-2	-2	-3	-7	-15	-14	-9	
Junction (T,atten.)	-3	-3	-3	-3	-3	-3	-3	
SubSum	29	25	23	19	17	20	15	
	0	0	0	0	0	0	0	Regenerated
sound from junction.								
SubSum	29	25	23	19	17	20	15	

Straight Duct(RL)	-2	-3	-4	-8	-19	-18	-10	
SubSum	27	22	19	11	5	5	5	
Custom Element	34	29	22	15	11	9	6	Diffuser
SubSum	35	30	24	16	12	10	9	
Indoor (Regression)	-9	-9	-10	-10	-11	-11	-12	
SUM	26	21	14	6	5	5	5	
RATING	NC < 15			RC 5(H)		13 dBA		

Output from Trane Acoustical Program (TAP) for Hearing Aid Fitting Room (2207), proposed DOAS system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	85	85	87	79	75	68	64	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	85	84	81	68	65	58	54	
	50	45	39	31	23	13	4	Regenerated
sound from elbow.								
SubSum	85	84	81	68	65	58	54	
Straight Duct(RL)	-6	-8	-19	-40	-40	-40	-35	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	79	75	58	21	18	11	12	
	53	53	51	46	37	26	11	Regenerated
sound from elbow.								
SubSum	79	75	59	46	37	26	15	
Straight Duct(RL)	-2	-2	-5	-13	-12	-11	-9	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	77	72	50	26	18	8	5	
	53	53	51	46	37	26	11	Regenerated
sound from elbow.								
SubSum	77	72	54	46	37	26	12	
Straight Duct(RL)	-1	-1	-2	-7	-6	-5	-4	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	76	70	48	32	24	14	5	
	53	53	51	46	37	26	11	Regenerated
sound from elbow.								
SubSum	76	70	53	46	37	26	12	
Straight Duct(RL)	-5	-7	-17	-40	-40	-37	-31	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	71	62	32	5	5	5	5	
	53	53	51	46	37	26	11	Regenerated
sound from elbow.								
SubSum	71	63	51	46	37	26	12	
Elbow (In.sq.rct)	0	-1	-4	-7	-7	-7	-7	
SubSum	71	62	47	39	30	19	5	
	53	53	51	46	37	26	11	Regenerated
sound from elbow.								
SubSum	71	63	52	47	38	27	12	
Straight Duct(RL)	-5	-6	-15	-40	-37	-32	-26	
Elbow (ul.sq.rct)	0	-1	-5	-8	-4	-3	-3	
SubSum	66	56	32	5	5	5	5	
	25	19	11	1	0	0	0	Regenerated
sound from elbow.								
SubSum	66	56	32	6	6	6	6	
Junction (T,atten.)	-6	-6	-6	-6	-6	-6	-6	
SubSum	60	50	26	5	5	5	5	
	74	69	62	55	45	35	23	Regenerated
sound from junction.								
Junction (90,atten.)	0	0	0	0	0	0	0	
	32	29	27	23	19	15	9	Regenerated
sound from junction.								
SubSum	74	69	62	55	45	35	23	
Straight Duct(RU1)	-4	-3	-2	-1	-1	-1	-1	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	69	65	59	53	43	33	21	

	38	35	30	25	18	11	4	Regenerated
sound from junction.								
Junction (T,atten.)	0	0	0	0	0	0	0	
	29	26	22	18	13	7	1	Regenerated
sound from junction.								
SubSum	69	65	59	53	43	33	21	
Straight Duct(RU1)	-5	-3	-2	-1	-1	-1	-1	
SubSum	64	62	57	52	42	32	20	
Junction (90,atten.)	0	0	0	0	0	0	0	
	38	36	31	27	22	16	9	Regenerated
sound from junction.								
SubSum	64	62	57	52	42	32	20	
Straight Duct(RU1)	-5	-3	-2	-1	-1	-1	-1	
SubSum	59	59	55	51	41	31	19	
Junction (90,atten.)	0	0	0	0	0	0	0	
	24	24	21	18	15	10	5	Regenerated
sound from junction.								
SubSum	59	59	55	51	41	31	19	
Straight Duct(RU1)	-4	-3	-2	-1	-1	-1	-1	
SubSum	55	56	53	50	40	30	18	
Junction (90,atten.)	0	0	0	0	0	0	0	
	36	33	29	24	19	12	6	Regenerated
sound from junction.								
SubSum	55	56	53	50	40	30	18	
Straight Duct(RU1)	-8	-5	-4	-1	-1	-1	-1	
SubSum	47	51	49	49	39	29	17	
Junction (90,atten.)	0	0	0	0	0	0	0	
	42	37	34	28	22	15	8	Regenerated
sound from junction.								
SubSum	48	51	49	49	39	29	18	
Straight Duct(RU1)	-2	-1	-1	0	0	0	0	
Junction (T,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	45	49	47	48	38	28	17	
	43	38	32	25	17	9	0	Regenerated
sound from junction.								
SubSum	47	49	47	48	38	28	17	
Straight Duct(RU1)	-2	-1	-1	0	0	0	0	
Junction (90,atten.)	-10	-10	-10	-10	-10	-10	-10	
SubSum	35	38	36	38	28	18	7	
	35	31	26	21	15	8	0	Regenerated
sound from junction.								
SubSum	38	39	36	38	28	18	8	
Elbow (ul.rad.rct)	0	0	0	-1	-2	-3	-3	
SubSum	38	39	36	37	26	15	5	
	0	0	0	0	0	0	0	Regenerated
sound from elbow.								
SubSum	38	39	36	37	26	15	6	
Straight Duct(RU1)	-2	-1	-1	-1	-1	-1	-1	
Junction (T,atten.)	-2	-2	-2	-2	-2	-2	-2	
SubSum	34	36	33	34	23	12	5	
	21	16	12	7	1	0	0	Regenerated
sound from junction.								
SubSum	34	36	33	34	23	12	6	
Straight Duct(RL)	-3	-4	-5	-9	-23	-22	-12	
Junction (T,atten.)	-3	-3	-3	-3	-3	-3	-3	
SubSum	28	29	25	22	5	5	5	
	15	10	5	0	0	0	0	Regenerated
sound from junction.								
SubSum	28	29	25	22	6	6	6	
Straight Duct(RL)	-4	-5	-6	-10	-27	-27	-13	
SubSum	24	24	19	12	5	5	5	

Custom Element	34	29	22	15	11	9	6	Diffuser
SubSum	34	30	24	17	12	10	9	
Indoor (Regression)	-9	-9	-10	-10	-11	-11	-12	
SUM	25	21	14	7	5	5	5	
RATING	NC < 15			RC 6(H)		13 dBA		

Room Constant Calculation for Classroom (2302).

Room Constant Calculation for:
Classroom (2302)

Surface	Material	Area [m ²]	Material Absorption Coefficient (α)						
			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Int. Walls	Gypsum Board (2)	29.73	0.28	0.12	0.10	0.07	0.13	0.09	
Ext. Walls	Gypsum Board (1)	5.39	0.55	0.14	0.08	0.04	0.12	0.11	
Floor	Carpet	10.22	0.08	0.27	0.39	0.34	0.48	0.63	
Ceiling ¹	Acoustical Board	5.11	0.76	0.93	0.83	0.99	0.99	0.94	
	Spray fib. insul.	10.22	0.08	0.29	0.75	0.98	0.93	0.76	
Doors	Wood	1.95	0.19	0.14	0.09	0.06	0.06	0.05	
Windows	Glass	1.95	0.18	0.06	0.04	0.03	0.02	0.02	
Total: 62.61581									
			α_{SAB} :	0.21954	0.18316	0.18291	0.17231	0.22334	0.22443
			Room Constant (R_T):	17.61	14.04	14.02	13.04	18.01	18.12

¹ The ceiling must be a blend of acoustic board and perforated ceiling panels in a passive chilled beam application.

Transmission Losses for Classroom (2302).

Transmission Losses Through Building Construction (TL) [dB]
Calculation for Room: Classroom (2302)

Building Construction	Transmission Loss [dB]						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Int. Walls	38	52	59	60	56	62	
Ext. Walls	60	79	94	102	102	115	
Glass	21	30	40	44	46	57	
Doors	29	31	31	31	39	43	
Partitions ¹	36	43	43	43	50	54	
Exterior Wall ²	27	36	46	50	52	63	
Floor	38	44	52	55	60	65	
Roof	original	17	22	26	30	35	41
	green	27	32	36	40	45	61

¹ Composite of doors and walls.
² Composite of glass and wall.

Noise Reductions for Classroom (2302).

Noise Reduction Through Building Construction (L_p) [dB]
Calculation for Room: Classroom (2302)

Building Construction	Noise Reduction ¹ [dB]						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Walls w/ insul.	38	52	59	60	56	62	
Doors	29	31	31	31	39	43	
Partitions ²	34	39	39	39	47	52	
Exterior Wall ³	31	39	49	52	56	67	
Floor	40	45	53	56	62	67	
Roof	original	19	23	27	31	37	43
	green	29	33	37	41	47	63

¹ Noise reduction of average sound pressure levels through building construction.
² Composite of walls and doors.
³ Composite of glass and doors.

Room Noise from each source for Classroom (2302), original VAV system.

Noise in Receiver Room (L_p)_{rec} [dB]
Calculation for Room: Classroom (2302)

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Original Roof	Case 1	38	26	23	14	3	0
	Case 2	49	39	29	26	17	4
	Case 3	43	42	29	26	22	6
Green Roof	Case 1	28	16	13	4	0	0
	Case 2	39	29	19	16	7	0
	Case 3	33	32	19	16	12	0
Exterior Wall	Case 1	27	11	2	0	0	0
	Case 2	38	24	8	5	0	0
	Case 3	32	27	8	5	3	0
Partitions ¹		18	6	1	0	0	0
Floor ¹		12	0	0	0	0	0
Mechanical Noise		36	32	23	14	5	5

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for Classroom (2302), original VAV system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
Calculation for Room: Classroom (2302)

Case		Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Original Roof	Case 1	40	33	26	17	7	5	20
	Case 2	50	40	30	27	18	7	33
	Case 3	44	43	30	27	22	9	33
Green Roof	Case 1	37	32	23	15	5	5	20
	Case 2	41	34	24	18	9	5	21
	Case 3	38	35	24	18	12	5	23

Case 1: Typical ambient conditions
Case 2: Car driving by site
Case 3: Diesel truck driving by site

Room Noise from each source for Classroom (2302), proposed DOAS system.

Source		Average Ambient Sound Pressure Level (L_p) [dB]					
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Original Roof	Case 1	38	26	23	14	3	0
	Case 2	49	39	29	26	17	4
	Case 3	43	42	29	26	22	6
Green Roof	Case 1	28	16	13	4	0	0
	Case 2	39	29	19	16	7	0
	Case 3	33	32	19	16	12	0
Exterior Wall	Case 1	27	11	2	0	0	0
	Case 2	38	24	8	5	0	0
	Case 3	32	27	8	5	3	0
Partitions ¹		18	6	1	-3	0	0
Floor ¹		12	0	0	0	0	0
Mechanical Noise		30	27	20	11	5	5

¹ Worst case for Design NC Level of surrounding spaces.

Combined Room Noise for Classroom (2302), proposed DOAS system.

Combined Noise in Receiver Room (L_p)_{rec} [dB]
Calculation for Room: Classroom (2302)

Case		Average Ambient Sound Pressure Level (L_p) [dB]						NC Level
		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Original Roof	Case 1	39	30	25	16	7	5	20
	Case 2	50	40	29	27	18	7	33
	Case 3	44	42	29	27	22	9	32
Green Roof	Case 1	32	27	21	12	5	5	20
	Case 2	40	31	23	17	9	5	20
	Case 3	35	33	22	17	12	5	20

Case 1: Typical ambient conditions
Case 2: Car driving by site
Case 3: Diesel truck driving by site

Output from Trane Acoustical Program (TAP) for Classroom (2302), original VAV system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	106	106	105	103	96	89	85	
Elbow (In.sq.rct)	-1	-6	-11	-10	-10	-10	-10	
SubSum	105	100	94	93	86	79	75	
	64	58	51	43	34	25	14	Regenerated
sound from elbow.								
SubSum	105	100	94	93	86	79	75	
Straight Duct(RL)	-6	-8	-22	-40	-40	-40	-40	
Elbow (In.sq.rct)	-1	-6	-11	-10	-10	-10	-10	
SubSum	98	86	61	43	36	29	25	
	64	58	51	43	34	25	14	Regenerated
sound from elbow.								
SubSum	98	86	61	46	38	30	25	
Straight Duct(RL)	-2	-3	-7	-25	-20	-16	-17	
Straight Duct(RU2)	-5	-3	-2	0	0	0	0	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	90	77	46	17	14	10	5	
	64	64	61	54	45	32	17	Regenerated
sound from elbow.								
SubSum	90	77	61	54	45	32	17	
Straight Duct(RU2)	-4	-3	-2	0	0	0	0	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	85	71	53	50	41	28	13	
	64	64	61	54	45	32	17	Regenerated
sound from elbow.								
SubSum	85	72	62	55	46	33	18	
Straight Duct(RU2)	-3	-2	-2	0	0	0	0	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	81	67	54	51	42	29	14	
	64	64	61	54	45	32	17	Regenerated
sound from elbow.								
SubSum	81	69	62	56	47	34	19	
Straight Duct(RU2)	-22	-15	-10	-2	-2	-2	-2	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	58	51	46	50	41	28	13	
	64	64	61	54	45	32	17	Regenerated
sound from elbow.								
SubSum	65	64	61	55	46	33	18	
Straight Duct(RU2)	-1	-1	-1	0	0	0	0	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	63	60	54	51	42	29	14	
	64	64	60	54	45	32	15	Regenerated
sound from elbow.								
SubSum	67	65	61	56	47	34	18	
Straight Duct(RU2)	-5	-3	-2	0	0	0	0	
Junction (90,atten.)AB	-3	-3	-3	-3	-3	-3	-3	
SubSum	59	59	56	53	44	31	15	
	63	57	51	43	36	26	17	Regenerated
sound from junction.								
SubSum	64	61	57	53	45	32	19	
Straight Duct(RU2)	-6	-4	-3	0	0	0	0	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	57	56	53	52	44	31	18	
	58	55	49	44	36	29	20	Regenerated
sound from junction.								

SubSum	61	59	54	53	45	33	22	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	61	58	51	47	41	29	18	
	63	63	62	58	51	40	26	Regenerated
sound from elbow.								
SubSum	65	64	62	58	51	40	27	
Straight Duct(RU1)	-2	-1	-1	0	0	0	0	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	62	62	60	57	50	39	26	
	49	44	40	34	29	22	15	Regenerated
sound from junction.								
SubSum	62	62	60	57	50	39	26	
Straight Duct(RU1)	-1	-1	-1	0	0	0	0	
Elbow (ul.sq.rct)	-1	-3	-6	-4	-4	-4	-4	
SubSum	60	58	53	53	46	35	22	
	64	65	64	61	55	45	32	Regenerated
sound from elbow.								
SubSum	65	66	64	62	56	45	32	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	64	65	63	61	55	44	31	
	51	48	45	41	36	31	25	Regenerated
sound from junction.								
SubSum	64	65	63	61	55	44	32	
Junction (90,atten.)AB	-1	-1	-1	-1	-1	-1	-1	
SubSum	63	64	62	60	54	43	31	
	52	49	44	39	34	27	18	Regenerated
sound from junction.								
SubSum	63	64	62	60	54	43	31	
Straight Duct(RU1)	-6	-4	-3	-1	-1	-1	-1	
Junction (T,atten.)	-6	-6	-6	-6	-6	-6	-6	
SubSum	51	54	53	53	47	36	24	
	41	36	32	27	21	14	7	Regenerated
sound from junction.								
SubSum	51	54	53	53	47	36	24	
Straight Duct(RU1)	-5	-3	-2	-1	-1	-1	-1	
Junction (90,atten.)AB	-5	-5	-5	-4	-4	-4	-4	
SubSum	41	46	46	48	42	31	19	
	44	40	36	32	27	21	15	Regenerated
sound from junction.								
SubSum	46	47	46	48	42	31	20	
Straight Duct(RL)	-3	-3	-5	-11	-22	-19	-15	
SubSum	43	44	41	37	20	12	5	
Custom Element	0	74	70	79	87	86	68	VAV-196
SubSum	43	74	70	79	87	86	68	
Custom Element	-9	-44	-41	-40	-52	-49	-41	
Straight Duct(RL)	-5	-5	-9	-22	-40	-39	-30	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	29	24	17	11	5	5	5	
	45	45	43	39	32	21	7	Regenerated
sound from elbow.								
SubSum	45	45	43	39	32	21	9	
Straight Duct(RL)	-5	-5	-9	-22	-40	-39	-30	
SubSum	40	40	34	17	5	5	5	
Diffuser	42	40	37	31	23	13	1	
SubSum	44	43	39	31	23	14	6	
Indoor (Regression)	-5	-7	-7	-8	-9	-10	-13	
SUM	39	36	32	23	14	5	5	
RATING	NC 19			RC 14(R)		27 dBA		

Output from Trane Acoustical Program (TAP) for Classroom (2302), proposed DOAS system.

Path Table View -- Path1:

LINE ELEMENT	Octave Band Data							COMMENTS
	63	125	250	500	1k	2k	4k	
ASHRAE Fan	85	85	87	79	75	68	64	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	85	84	81	68	65	58	54	
	45	40	33	26	17	8	0	Regenerated
sound from elbow.								
SubSum	85	84	81	68	65	58	54	
Straight Duct(RL)	-13	-17	-39	-40	-40	-40	-40	
Elbow (In.sq.rct)	0	-1	-6	-11	-10	-10	-10	
SubSum	72	66	36	17	15	8	5	
	45	40	33	26	17	8	0	Regenerated
sound from elbow.								
SubSum	72	66	38	27	19	11	6	
Straight Duct(RL)	-4	-6	-13	-35	-33	-28	-23	
Straight Duct(RU2)	-8	-5	-4	-1	-1	-1	-1	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	60	54	18	5	5	5	5	
	52	53	51	46	38	27	13	Regenerated
sound from elbow.								
SubSum	61	57	51	46	38	27	14	
Straight Duct(RU2)	-7	-5	-3	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	54	51	45	40	34	23	10	
	51	52	50	45	37	26	12	Regenerated
sound from elbow.								
SubSum	56	55	51	46	39	28	14	
Straight Duct(RU2)	-6	-4	-3	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	50	50	45	40	35	24	10	
	51	52	50	45	37	26	12	Regenerated
sound from elbow.								
SubSum	54	54	51	46	39	28	14	
Straight Duct(RU2)	-37	-25	-16	-3	-3	-3	-3	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	17	28	32	37	32	21	7	
	51	52	50	45	37	26	12	Regenerated
sound from elbow.								
SubSum	51	52	50	46	38	27	13	
Straight Duct(RU2)	-2	-2	-1	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	49	49	46	40	34	23	9	
	51	52	50	45	37	26	12	Regenerated
sound from elbow.								
SubSum	53	54	51	46	39	28	14	
Straight Duct(RU2)	-8	-5	-4	-1	-1	-1	-1	
Junction (90,atten.)	-2	-2	-2	-2	-2	-2	-2	
SubSum	43	47	45	43	36	25	11	
	42	38	32	26	18	9	0	Regenerated
sound from junction.								
SubSum	46	48	45	43	36	25	11	
Straight Duct(RU2)	-9	-6	-4	-1	-1	-1	-1	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	36	41	40	41	34	23	9	
	37	34	28	23	16	9	0	Regenerated
sound from junction.								

SubSum	40	42	40	41	34	23	10	
Elbow (ul.sq.rct)	0	0	-1	-3	-6	-4	-4	
SubSum	40	42	39	38	28	19	6	
	48	48	46	41	34	22	7	Regenerated
sound from elbow.								
SubSum	49	49	47	43	35	24	10	
Straight Duct(RU1)	-3	-2	-1	0	0	0	0	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	45	46	45	42	34	23	9	
	34	29	25	18	12	4	0	Regenerated
sound from junction.								
SubSum	45	46	45	42	34	23	10	
Straight Duct(RU1)	-2	-1	-1	0	0	0	0	
Elbow (ul.sq.rct)	0	-1	-3	-6	-4	-4	-4	
SubSum	43	44	41	36	30	19	6	
	48	49	48	45	38	29	15	Regenerated
sound from elbow.								
SubSum	49	50	49	46	39	29	16	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	48	49	48	45	38	28	15	
	26	23	19	15	9	4	0	Regenerated
sound from junction.								
SubSum	48	49	48	45	38	28	15	
Junction (90,atten.)	-1	-1	-1	-1	-1	-1	-1	
SubSum	47	48	47	44	37	27	14	
	16	14	11	7	2	0	0	Regenerated
sound from junction.								
SubSum	47	48	47	44	37	27	14	
Straight Duct(RU1)	-10	-5	-3	-1	-1	-1	-1	
Junction (T,atten.)	-10	-10	-10	-10	-10	-10	-10	
SubSum	27	33	34	33	26	16	5	
	19	16	12	8	2	0	0	Regenerated
sound from junction.								
SubSum	28	33	34	33	26	16	6	
Straight Duct(RU1)	-7	-4	-2	-1	-1	-1	-1	
Junction (90,atten.)	-5	-5	-5	-5	-5	-5	-5	
SubSum	16	24	27	27	20	10	5	
	22	18	14	9	2	0	0	Regenerated
sound from junction.								
SubSum	23	25	27	27	20	10	6	
Straight Duct(RL)	-5	-6	-8	-16	-39	-38	-22	
Straight Duct(RL)	-10	-12	-16	-32	-40	-40	-40	
Elbow (ul.sq.rct)	0	0	-1	-3	-6	-4	-4	
SubSum	8	7	5	5	5	5	5	
	37	39	39	36	30	22	10	Regenerated
sound from elbow.								
SubSum	37	39	39	36	30	22	11	
Straight Duct(RL)	-10	-12	-16	-32	-40	-40	-40	
SubSum	27	27	23	5	5	5	5	
Diffuser	42	40	37	31	23	13	1	
SubSum	42	40	37	31	23	14	6	
Indoor (Regression)	-8	-10	-10	-11	-12	-13	-16	
SUM	34	30	27	20	11	5	5	
RATING	NC < 15			RC 12(N)		22 dBA		