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## Acoustic Measurement for Effective Room Design

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### James Maltese – CTS-D, CTS-I, CQD, CQT

- VP of Quality Standards, Level 3 AV
- Avixa Educator of the Year 2017
- Board Member, AQAV
- Quality Committee Chairman, PSNI
- Avid scouter, ham radio



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## Rebecca Sullins – CTS-D, CTS-I, ANP

- Senior Design Engineer; AmpThink
- BFA in Sound Design and Engineering from the North Carolina School of the Arts.
- Former Chair, Certification Steering Committee, Women's Council Local Leader
- Avid pool player and hobby collector.



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## Acoustics – the man, the myth, the legend.

- What are acoustics?
- What measurements should we be taking?
- How do these measurements affect the way we design rooms and systems?

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# ACOUSTICS:

a science that deals with the production, control, transmission, reception, and effects of sound



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The ic26 logo, a stylized 'i' in a triangle.

## Key 3 Measurements

For Successful Conference Rooms:

- RT60
- NC
  - Ambient Noise
- SNR at Mic

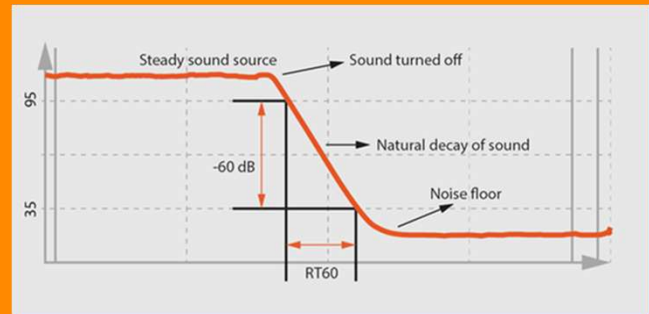


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## Reverberation Time (RT60)

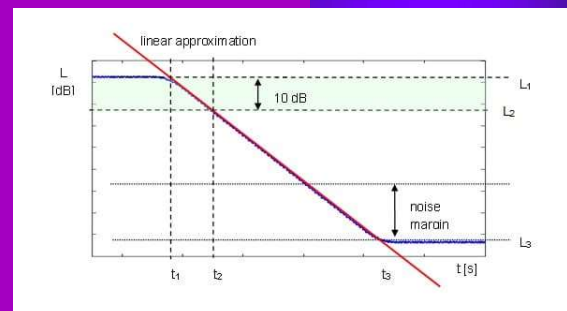
- How long sound bounces around a space
- Poor RT60 =
  - Poor intelligibility
  - Poor AEC



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## Reverb and Early Decay Time [EDT]

- EDT is the time it takes the initial sound to decay from 0 > -10dB.
- Much more location dependent than full RT60.



Courtesy of Svantek Academy

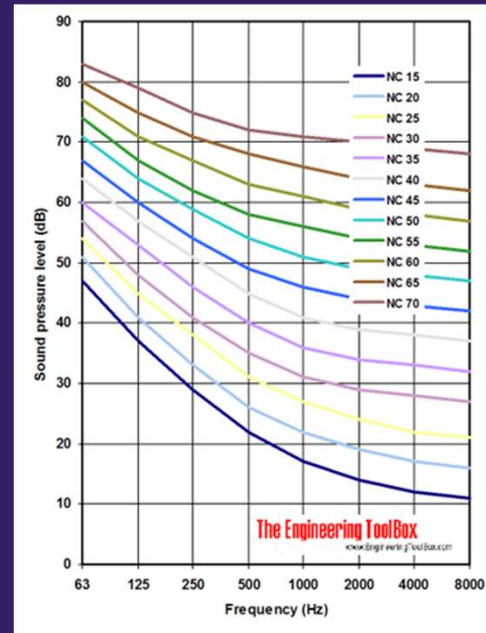


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## Noise Criteria (NC)

- Full-spectrum measurements taken in a room to establish the noise floor.
- Poor NC = Poor AEC

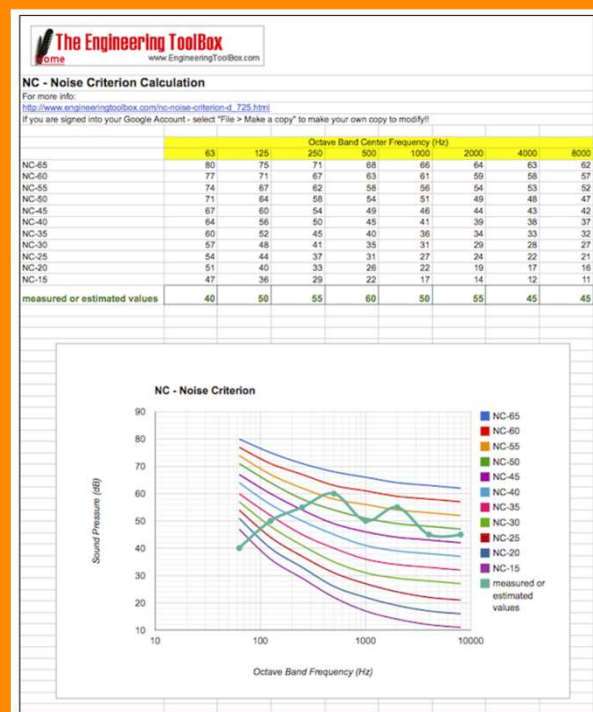


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## Noise Criteria (NC)

Use the lowest curve that is not exceeded by any measurement.



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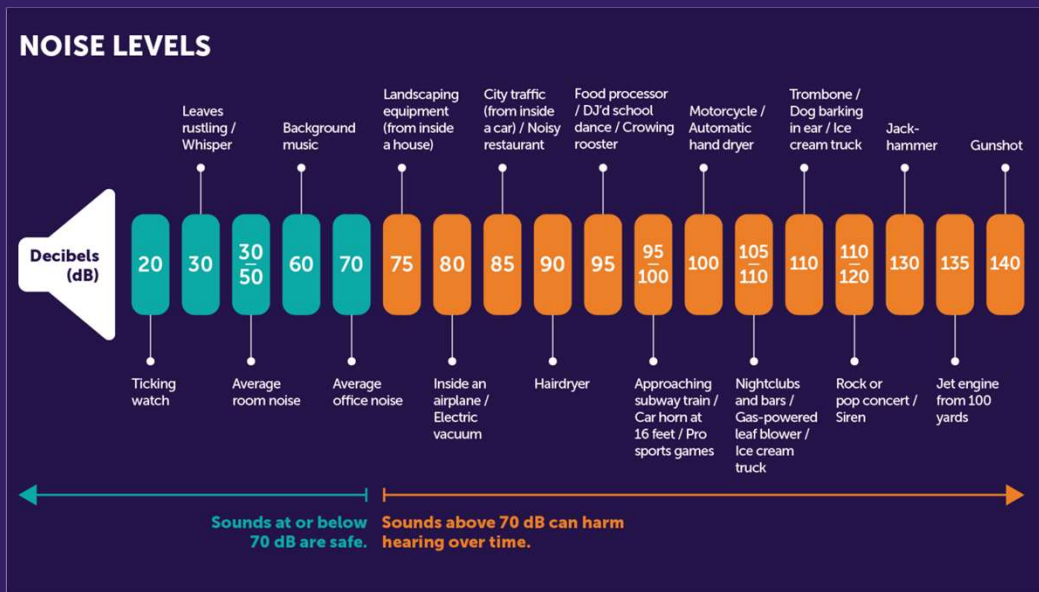
# Noise Criteria (NC) Standards

TYPE OF ROOM	RECOMMENDED NC LEVEL	EQUIVALENT SOUND LEVEL
		DbA
Conference Rooms	25-30	35-40
Open-Plan Offices	35-40	45-50
Lecture and Classrooms	25-30	35-40
Movie Theater	30-35	40-45
Libraries	35-40	40-50
Broadcast Studio	15-25	25-35
Concert and Recital Halls	15-20	25-30

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# Ambient Noise

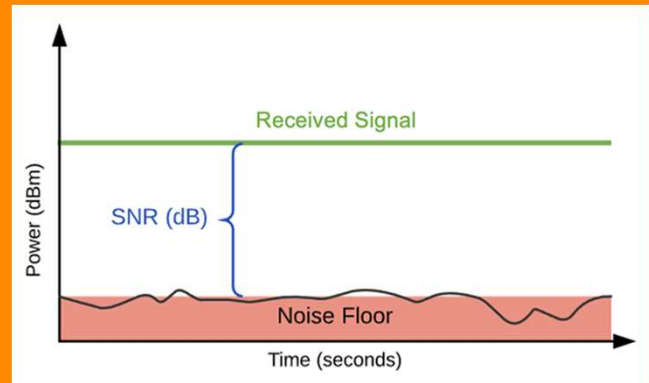


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## Signal to Noise Ratio [SNR]

- Difference in level between signal and noise (dB)
- More dB = More Better
- Don't forget there are two different SNR ratings in any system
  - Acoustic SNR
  - System SNR



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## 3 Key Values

For Successful DSP performance:

- $RT60 < 0.5s$
- $NC < NC30$ 
  - Ambient  $< 35$  dBA
- $SNR @ Mic > 25$  dB

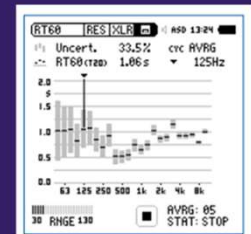
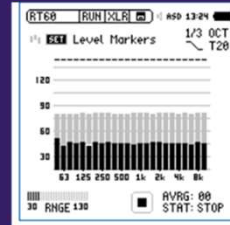


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## How to Measure RT60

- Audio Analyzer
- Need to excite the room and measure decay at all octaves
- Look for worst case, not “averages”



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## How to Measure RT60

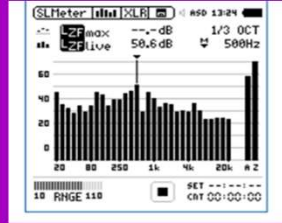
- ISO 3382 and ASTM E2235 define measurement standards
- Use an omnidirectional source
  - Minimum of two sources should be used.
  - Sources should be 1.5 M above floor.
- Measure from multiple locations
  - Take into account walls, overhangs, balconies, and other architectural anomalies.



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# How to Measure NC

- RTA or Audio Analyzer
- Fit to curve (\$0)
- Software (\$\$\$)



Noise Criteria Mapping Spreadsheet

NC #	63	125	250	500	1000	2000	4000	8000
NC10	63	70	75	77	77	75	70	65
NC15	66	73	77	79	79	77	71	66
NC20	69	76	80	82	82	80	73	68
NC25	71	78	82	84	84	82	75	70
NC30	74	81	85	87	87	85	78	73
NC35	76	83	87	89	89	87	80	75
NC40	78	85	89	91	91	89	82	77
NC45	80	87	91	93	93	91	84	79
NC50	82	89	93	95	95	93	86	81
NC55	84	91	95	97	97	95	88	83
NC60	86	93	97	99	99	97	90	85
NC65	88	95	99	101	101	99	92	87
NC70	90	97	101	103	103	101	94	89
NC75	92	99	103	105	105	103	96	91
NC80	94	101	105	107	107	105	98	93
NC85	96	103	107	109	109	107	100	95
NC90	98	105	109	111	111	109	102	97
NC95	100	107	111	113	113	111	104	99
NC100	102	109	113	115	115	113	106	101
NC105	104	111	115	117	117	115	108	103
NC110	106	113	117	119	119	117	110	105
NC115	108	115	119	121	121	119	112	107
NC120	110	117	121	123	123	121	114	109
NC125	112	119	123	125	125	123	116	111
NC130	114	121	125	127	127	125	118	113
NC135	116	123	127	129	129	127	120	115
NC140	118	125	129	131	131	129	122	117
NC145	120	127	131	133	133	131	124	119
NC150	122	129	133	135	135	133	126	121
NC155	124	131	135	137	137	135	128	123
NC160	126	133	137	139	139	137	130	125
NC165	128	135	139	141	141	139	132	127
NC170	130	137	141	143	143	141	134	129
NC175	132	139	143	145	145	143	136	131
NC180	134	141	145	147	147	145	138	133
NC185	136	143	147	149	149	147	140	135
NC190	138	145	149	151	151	149	142	137
NC195	140	147	151	153	153	151	144	139
NC200	142	149	153	155	155	153	146	141
NC205	144	151	155	157	157	155	148	143
NC210	146	153	157	159	159	157	150	145
NC215	148	155	159	161	161	159	152	147
NC220	150	157	161	163	163	161	154	149
NC225	152	159	163	165	165	163	156	151
NC230	154	161	165	167	167	165	158	153
NC235	156	163	167	169	169	167	160	155
NC240	158	165	169	171	171	169	162	157
NC245	160	167	171	173	173	171	164	159
NC250	162	169	173	175	175	173	166	161
NC255	164	171	175	177	177	175	168	163
NC260	166	173	177	179	179	177	170	165
NC265	168	175	179	181	181	179	172	167
NC270	170	177	181	183	183	181	174	169
NC275	172	179	183	185	185	183	176	171
NC280	174	181	185	187	187	185	178	173
NC285	176	183	187	189	189	187	180	175
NC290	178	185	189	191	191	189	182	177
NC295	180	187	191	193	193	191	184	179
NC300	182	189	193	195	195	193	186	181
NC305	184	191	195	197	197	195	188	183
NC310	186	193	197	199	199	197	190	185
NC315	188	195	199	201	201	199	192	187
NC320	190	197	201	203	203	201	194	189
NC325	192	199	203	205	205	203	196	191
NC330	194	201	205	207	207	205	198	193
NC335	196	203	207	209	209	207	200	195
NC340	198	205	209	211	211	209	202	197
NC345	200	207	211	213	213	211	204	199
NC350	202	209	213	215	215	213	206	201
NC355	204	211	215	217	217	215	208	203
NC360	206	213	217	219	219	217	210	205
NC365	208	215	219	221	221	219	212	207
NC370	210	217	221	223	223	221	214	209
NC375	212	219	223	225	225	223	216	211
NC380	214	221	225	227	227	225	218	213
NC385	216	223	227	229	229	227	220	215
NC390	218	225	229	231	231	229	222	217
NC395	220	227	231	233	233	231	224	219
NC400	222	229	233	235	235	233	226	221
NC405	224	231	235	237	237	235	228	223
NC410	226	233	237	239	239	237	230	225
NC415	228	235	239	241	241	239	232	227
NC420	230	237	241	243	243	241	234	229
NC425	232	239	243	245	245	243	236	231
NC430	234	241	245	247	247	245	238	233
NC435	236	243	247	249	249	247	240	235
NC440	238	245	249	251	251	249	242	237
NC445	240	247	251	253	253	251	244	239
NC450	242	249	253	255	255	253	246	241
NC455	244	251	255	257	257	255	248	243
NC460	246	253	257	259	259	257	250	245
NC465	248	255	259	261	261	259	252	247
NC470	250	257	261	263	263	261	254	249
NC475	252	259	263	265	265	263	256	251
NC480	254	261	265	267	267	265	258	253
NC485	256	263	267	269	269	267	260	255
NC490	258	265	269	271	271	269	262	257
NC495	260	267	271	273	273	271	264	259
NC500	262	269	273	275	275	273	266	261
NC505	264	271	275	277	277	275	268	263
NC510	266	273	277	279	279	277	270	265
NC515	268	275	279	281	281	279	272	267
NC520	270	277	281	283	283	281	274	269
NC525	272	279	283	285	285	283	276	271
NC530	274	281	285	287	287	285	278	273
NC535	276	283	287	289	289	287	280	275
NC540	278	285	289	291	291	289	282	277
NC545	280	287	291	293	293	291	284	279
NC550	282	289	293	295	295	293	286	281
NC555	284	291	295	297	297	295	288	283
NC560	286	293	297	299	299	297	290	285
NC565	288	295	299	301	301	299	292	287
NC570	290	297	301	303	303	301	294	289
NC575	292	299	303	305	305	303	296	291
NC580	294	301	305	307	307	305	298	293
NC585	296	303	307	309	309	307	300	295
NC590	298	305	309	311	311	309	302	297
NC595	300	307	311	313	313	311	304	299
NC600	302	309	313	315	315	313	306	301
NC605	304	311	315	317	317	315	308	303
NC610	306	313	317	319	319	317	310	305
NC615	308	315	319	321	321	319	312	307
NC620	310	317	321	323	323	321	314	309
NC625	312	319	323	325	325	323	316	311
NC630	314	321	325	327	327	325	318	313
NC635	316	323	327	329	329	327	320	315
NC640	318	325	329	331	331	329	322	317
NC645	320	327	331	333	333	331	324	319
NC650	322	329	333	335	335	333	326	321
NC655	324	331	335	337	337	335	328	323
NC660	326	333	337	339	339	337	330	325
NC665	328	335	339	341	341	339	332	327
NC670	330	337	341	343	343	341	334	329
NC675	332	339	343	345	345	343	336	331
NC680	334	341	345	347	347	345	338	333
NC685	336	343	347	349	349	347	340	335
NC690	338	345	349	351	351	349	342	337
NC695	340	347	351	353	353	351	344	339
NC700	342	349	353	355	355	353	346	341
NC705	344	351	355	357	357	355	348	343
NC710	346	353	357	359	359	357	350	345
NC715	348	355	359	361	361	359	352	347
NC720	350	357	361	363	363	361	354	349
NC725	352	359	363	365	365	363	356	351
NC730	354	361	365	367	367	365	358	353
NC735	356	363	367	369	369	367	360	355
NC740	358	365	369	371	371	369	362	357
NC745	360	367	371	373	373	371	364	359
NC750	362	369	373	375	375	373	366	361
NC755	364	371	375	377	377	375	368	363
NC760	366	373	377	379	379	377	370	365
NC765	368	375	379	381	381	379	372	367
NC770	370	377	381	383	383	381	374	369
NC775	372	379	383	385	385	383	376	371
NC780								



## How to Measure Ambient Noise [AN]

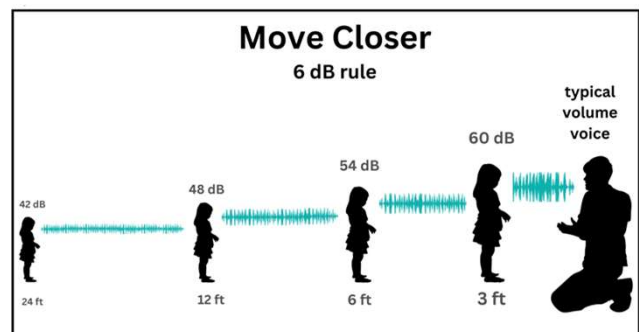
- Verify measurements at multiple times/locations in room.
  - Traffic noises, HVAC, etc. can all vary widely at different times of day.
- Human response is more subjective to frequent noise intrusions than a higher, steady level.
  - Remember this when documenting measurements.

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## How to Measure SNR @ Mic

- Subtract ambient noise from “talker level”
- Standard Talker is 60 dB @ 1m [3ft]
- Drops 6 dB every doubling of distance



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## How to Measure SNR @ Mic

- Subtract ambient noise from “talker level”
- Standard Talker is 60 dB @ 1m [3ft]
- Drops 6 dB every doubling of distance

Mic	Distance	Level
Gooseneck	.3m	70 dB
Table	1m	60 dB
Ceiling	3m	50 dB

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## How to Measure SNR @ Mic

Mic	Distance	Level @ Mic	SNR @ Mic
Gooseneck	.3m	70 dB	30 dB
Table	1m	60 dB	20 dB
Ceiling	3m	50 dB	10 dB

Target SNR @ Mic: 25 dB  
 Standard Talker is 60 dB @ 1m  
 Ambient Noise is 40 dBA-slow

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## How to Measure SNR @ Mic

Mic	Distance	Level @ Mic	SNR @ Mic
Gooseneck	.3m	70 dB	18 dB
Table	1m	60 dB	8 dB
Ceiling	3m	50 dB	-2 dB

Target SNR @ Mic: 25 dB  
 Standard Talker is 60 dB @ 1m  
 Ambient Noise is 52 dBA-slow

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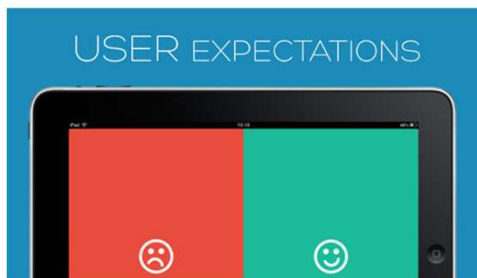
## How to Balance Your Budget

RT60 > 0.5s

NC35+

SNR @ Mic > 25 dB

- Set user expectations
- Hire an acoustician
- Change the design



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## New Construction

- Meet early with the programming team
- Confirm architect appreciates the effect acoustics has on AV
- Measure ASAP



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## Existing Spaces

- Get in early. Early in both the overall project timeline and your own.
- The more input you have on materials, architecture, and infrastructure, the fewer problems you'll have later.
- Have your measurements lead your design choices.
- The measurement survey is incredibly valuable! \$\$\$
- Manage end-user expectations.
- Use benchmarking tools to help the client understand the benefits of good acoustic design.



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## What is Your Call to Action?

- Pick one
- Apply it
- Observe how it affects your projects



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## Keep in Touch!

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LinkedIn: Rebecca Sullins



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Thank you!

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