CLASSROOM ACOUSTICAL SCREENING SURVEY WORKSHEET[1]

Date ______________________ Audiologist/Surveyor ____

School ____________________ Room _____________ Teacher _________________

Student Name (if applicable) ____ Grade _______

This worksheet is intended to be used to screen for acoustical problems in classrooms. When noise and/or reverberation levels are suspected of exceeding those recommended by ANSI/ASA S12.60-2009/2010, the screening survey data is an indicator for further assessment. This assessment may include a referral to an acoustical specialist who can perform a comprehensive acoustical analysis and suggest solutions.

1. OBSERVATION INFORMATION

A classroom observation is a preparatory step for making classroom acoustical measurements. The observation provides information about acoustical parameters of the classroom as well as the style of instruction, seating arrangement and communication access.

Background Noise

Listen in the classroom and check for the following; a "yes" is an indicator of potentially excessive levels of noise.

Classroom Features	Yes	No
Heating and ventilation system is audible		
Mechanical equipment must be turned off during important lessons		
Noise from playground is audible		
Noise from automobile traffic is audible		
Noise from air traffic is audible		
With heating and ventilation system turned off, sounds from other classrooms, learning spaces or hallway are audible		

Reverberation

Overall reverberation is determined by the volume of the room and the absorptive characteristics of the materials making up the classroom walls, floors and ceilings. Check the classroom for the following surfaces; a "yes" is an indicator of potential long reverberation times.

Classroom Features	Yes	No
A hard surface, flat ceiling without acoustical ceiling tiles		
Ceiling height is over 11 feet		
Acoustical ceiling tiles have been painted		
Walls are constructed of sound reflective materials (e.g., plasterboard, concrete, wood paneling)		
Floors are constructed of sound reflective materials (e.g. concrete, tiles, wood)		

Current Technology in the Classroom (if used)

- ☐ Personal FM [Number of students ___] Type____________________________________
- ☐ ADS: Whole Classroom Type____________________________________
- ☐ ADS: Targeted Area Type____________________________________

Teacher to Listener Distance: Nearest ____ Ft Farthest ____ Ft

Classroom Style: ☐ Traditional ☐ Open ☐ Portable/Relocatable

Primary Instruction Style: ☐ Lecture ☐ Large Group ☐ Small Group ☐ Individual Other_____

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[1] *Source:* Adapted by C. D. Johnson & J. Smaldino (2010) from Acoustic measurements in classrooms by J. Smaldino, C. Crandell, & B. Kreisman, 2005. In *Sound Field Amplification*, Crandell, Smaldino, & Flexer (Eds.) p. 131. Thomson Delmar Learning. Reprinted by permission.

Seating Arrangement: ☐ Clusters ☐ Rows ☐ U-shape or Circle Other____________________

2. NOISE MEASUREMENTS

Classroom Schematic Diagram: see attached

Sound Level Meter: Make/Model# ____

Method Used: ☐ One Hour Average ☐ Short-Term: ___ second average; # of time samples ___

		Ambient Noise Levels (dBA, dBC) Unoccupied and Occupied Classroom								**Teacher Voice Levels (dBA): Occupied Classroom**			
Condition (circle number for condition):		**1**=unoccupied, HVAC off; **2**=unoccupied, HVAC on; **3**=occupied, HVAC off **4**=occupied, HVAC on								Without Classroom ADS ☐ **Hon** ☐ **Hoff**		With Classroom ADS ☐ **Hon** ☐ **Hoff**	
		1 2 3 4		1 2 3 4		1 2 3 4		1 2 3 4		Level	SNR	Level	SNR
Weighting:		A	C	A	C	A	C	A	C	A	A	A	A
Measurement Locations	A*												
	B												
	C												
	D												
	E												
	F												
Ave dB Level													

* Target Student

Comments:

3. REVERBERATION TIME

Measured: Sound stimulus used: ____

Frequency:		500 Hz	1000 Hz	2000 Hz
Measurement Locations	A			
	B			
	C			
	D			
	Middle			
RT-60 Ave Seconds:				

RT-60 Classroom Average: ______ seconds

Estimated:

Note: On-line RT-60 calculation programs may also be used for this calculation (e.g., www.sengpielaudio.com/calculator-RT-60.htm, www.mcsquared.com/homerteng.htm).

Room Volume (V) = _______________________ cubic feet

Area Floor _______ x ABS. Coef. ________ = A Floor _____________

Area Ceiling _______ xABS. Coef. _________ = A Ceiling _____________

Area Side Wall 1 _______ x ABS. Coef. ________ = A Wall 1 _____________

Area Side Wall 2 _______ x ABS. Coef. ________ = A Wall 2 _____________

Area End Wall 1 _______ x ABS. Coef. ________ = A End 1 _____________

Area End Wall 2 _______ x ABS. Coef. ________ = A End 2 _____________

Total A _____________

Estimated Average RT of Classroom = .049 x _______ (V) / ________ (A) = _______ seconds

Comments:

4. ESTIMATED CRITICAL DISTANCE:

_____ **Ft**

Recommended Classroom Acoustical Standards for Core Learning Spaces
<10,000 ft^3 volume (ANSI/ASA S12.60-2009, 2010):

Permanent Classrooms: Ambient Noise Level: 35dBA/55dBC; Reverberation Time: .6 seconds*

Relocatable Classrooms: Ambient Noise Level: 41dBA, [38 dBA by 2013, 35 dBA by 2017]
Reverberation Time: .5 seconds*

*Note: Core learning spaces in permanent classrooms shall be readily adaptable to allow reduction in reverberation time to .3 seconds to accommodate children with special listening needs. Relocatable classrooms are generally not suitable for any child with special listening requirements due to higher noise levels.

CLASSROOM ACOUSTICAL SCREENING SURVEY WORKSHEET[2]

Directions

This worksheet contains a tiered approach to surveying classroom noise levels and reverberation times that can be used by professionals with varying degrees of training and equipment. The purpose of the worksheet is to help identify classrooms that may have acoustical problems that interfere with communication and instruction. These problems affect a student's ability to attend, hear, listen, understand and participate in educational programs. They will also detract from the performance of a classroom audio distribution system (ADS) that might be in use. Section 1 (Tier 1) is a cursory listening assessment using a checklist to note obvious problems that might negatively impact the performance of a classroom ADS. Sections 2-4 require more knowledge and training to take measurements or estimate levels. When noise and/or reverberation levels are suspected as exceeding those recommended by ANSI/ASA S12.60-2009/2010, the screening survey data is an indicator for further assessment. This assessment may include a referral to an acoustical specialist who can perform a comprehensive acoustical analysis and suggest solutions.

Directions for Classroom Observations (Section 1 of the worksheet)

Complete the checklists for background noise levels and reverberation times. Any "yes" responses are indicators of possible problems and a referral to Tier 2 measurements that are contained in Sections 2-4 of this worksheet. Provide information regarding current technology used in the classroom, teacher to listener distance, classroom and instructional style, and seating arrangements.

Directions for Classroom Sound Level Measurements (Section 2 of the worksheet)

Equipment needed: Type II sound level meter (SLM), 20 ft measuring tape or laser tape, standard reading material (e.g., rainbow passage or similar sustained reading material).

1. Draw a schematic of the classroom on the back of the form or a separate piece of paper marking the locations of the measurements (A-F). Generally measurements should be taken from student desks at the four corners of the instructional area, the middle and the middle back of the room. If there is a target student, use location A to mark that student's position and eliminate middle back of room. Additional positions can be added if necessary.
2. Identify the make and model of the SLM used as well as the averaging timeframe. The ANSI/ASA standard requires a one hour average of the noisiest time period during learning instruction to capture maximum internal (inside the classroom) as well as external (outside the classroom and building) noise. When it is not possible to perform a one hour average, indicate, under the short term option, the number of seconds or minutes and the number of time samples that were made to determine the average for each measurement (e.g., 5 time samples, 1 min each). Type II SLMs may contain an averaging function to determine this value and often recommend a timeframe.
3. Weighting: Ideally, sound level measurements should be taken in both A- and C- weighted conditions for the classroom ambient noise levels. A-weighting will capture a better estimate of speech information as received by the listener while the C- weighting will address HVAC and other low frequency noise in the classroom. If only one weighting is performed, select A- weighted. Only A- weighted levels are used to measure the teacher's voice levels to determine the speech-to-noise ratio (SNR) level.
4. Ambient Noise Levels:
   a. Turn on the SLM; set to the A- or C-weighted scale and slow response. If you can set the range of the meter, set it to accommodate 40-60 dB SPL to begin.
   b. Ambient noise levels should be measured for the unoccupied and occupied conditions at several locations in the classroom as levels may vary according to distance from noise sources. Indicate which condition you are using by circling the corresponding number (1=unoccupied, HVAC off; 2=unoccupied, HVAC on; 3=occupied, HVAC off; 4=occupied, HVAC on); use the column that corresponds to the weighting used for each of the measurements taken. Measure as many conditions as possible. When making short-term measurements, it is recommended that 3 to 5 one-minute time samples are averaged to determine the level. <u>The ANSI/ASA standard is based on a one hour average unoccupied classroom with the HVAC on; therefore a measurement in this condition is necessary when making a comparison to the standard.</u>
   c. If the room is occupied, have the students remain quiet. Measure the ambient noise level at the selected student locations and record it on the worksheet. These measurements will provide an estimate of the ambient noise level during an instructional period. If measurements can only be taken in an empty classroom you may estimate occupied classroom levels by converting the unoccupied noise levels to occupied by adding 10 dB to each unoccupied measurement. This conversion is comparable to reported differences in noise levels between *average* unoccupied and occupied classrooms (Bess et al., 1984; Bradley & Sato, 2008; Sanders, 1965).

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[2] *Source:* Adapted by C. D. Johnson & J. Smaldino (2010) from Acoustic measurements in classrooms by J. Smaldino, C. Crandell, & B. Kreisman, 2005. In *Sound Field Amplification,* Crandell, Smaldino, & Flexer (Eds.) p. 131. Thomson Delmar Learning. Reprinted by permission.

   d. Calculate and record the average ambient noise level for each condition measured. Compare to the ANSI/ASA standards for the weighting used and the size and type of room (permanent or portable).
5. Teacher Voice Levels:
   a. Position the teacher in the typical instructional position in the classroom. The students should be seated in their normal locations for instruction. It is important that the measurements are made at a time that represents the noisiest time of instruction, especially if there is significant external noise. This procedure will help capture the acoustical conditions that represent the average maximum noise periods of the day.
   b. Set the SLM for A-weighted measurements. Orient the SLM to approximate the center of each selected student's positions while he/she is seated at his/her desks. Point the SLM toward the teacher, taking care to avoid placing your body in the sound path between teacher and student, which can produce inaccurate measurements.
   c. Ask the teacher to begin reading a standard passage; record the teacher voice levels on the form at the various locations using the same procedures outlined in 4b. These measurements provide an estimate of the average signal level during an instructional period.
   d. Determine the SNR of the classroom by subtracting the A-weighted ambient noise level from the teacher voice level at the selected student locations. For example, a student location with a teacher voice level of 60dBA and an A-weighted ambient noise level of 50dBA would have a SNR of +10dB. One with a teacher level of 60dBA and a noise level of 70dBA would have a SNR of -10dB.
   e. Averaging all teacher voice levels and subtracting from the average A-weighted ambient level for the various conditions will calculate an average SNR level.
6. Teacher Voice Levels with Classroom Audio Distribution System (ADS):
   a. Repeat the steps 5a-e above.
   b. Compare results to the condition without the system to determine the benefits of the ADS The goal is even distribution of the teacher's voice throughout the classroom . For children with special listening needs, an average of at least +15 dB SNR is recommended; this improvement is best attained *not* by increasing the loudness of the ADS beyond that recommended earlier in Sec 4.2 Intensity Levels, but by reducing background noise levels.

Directions for Classroom Reverberation Measurements (Section 3 of the worksheet)

Reverberation time (RT-60) is the amount of time in seconds that it takes a sound to decay by 60 dB in a room. RT-60 can be measured with special instrumentation or estimated based on absorption co-efficients of surface materials in a classroom. Each method is outlined below.

Directions for RT-60 measurements:
Equipment needed: Reverberation instrument or sound level meter with reverberation measurement capability, noise generation source such as a balloon or two boards that can be clapped together. Note: These measurements should be made in empty classrooms for accuracy as well as to avoid exposure of occupants to loud noise.
1. Make separate RT-60 measurements at 500 Hz, 1000 Hz and 2000 Hz.
2. These measurements require an impulse sound to be generated that is at least 25 dB louder than the background noise in the room. The impulse sound can be produced by dedicated sound generators, or, more commonly, breaking balloons or slapping boards together.
3. Measurements at each frequency should be made in the four corners and the middle of the room. The five measurements at each frequency should be averaged to obtain the best estimate of the RT-60 for that frequency in the room. Record this average on the form for each frequency. These locations can also be indicated on the classroom schematic.
4. An overall RT-60 estimate in the classroom for the speech frequencies is obtained by averaging the RT-60 estimates obtained for 500 Hz, 1000 Hz and 2000 Hz. Record this as the room average RT-60.

Directions for calculating estimated RT-60 using the Sabine formula:
The most common formula for estimating reverberation time is the familiar Sabine equation (RT-60=.049 x Volume/Surface Area x Average Absorption). This equation can be used to make paper and pencil estimates of RT-60.
Equipment needed: 20 ft measuring tape or laser tape and calculator.
Formula to estimate classroom reverberation time: RT=.049 x V/A where RT=reverberation time in seconds, V=volume room, and A=total absorption of the room surfaces in Sabins.
1. All of the reverberation estimates can be conducted in an unoccupied classroom. Because a formula is used, no improvement in accuracy is obtained with students and teacher present.
2. Calculate the volume of the classroom by measuring the length, width, and height of the classroom in feet and multiplying them together (volume=length of room x width of room x height of room).
3. Record the resulting room volume in cubic feet on the classroom documentation form.
4. Multiply the volume of the room by the constant .049 to obtain the numerator for the RT=.049 V/A equation. Record the results on the form.
5. To obtain the denominator of the equation, the area of the walls, floor, and ceiling of the room must first be calculated in square feet. If the walls, ceiling, or floor are irregularly shaped, each section must be measured separately. The area of the floor and ceiling is determined by multiplying the length of the floor or ceiling times its width. The area of

the walls can be obtained by multiplying the length of each wall by its height. Enter the values for the area of each on the classroom documentation form.

6. The absorption coefficient (Abs. Coef.) is a measure of the sound reflectiveness of different construction materials. The coefficient, expressed in Sabins, must be determined for the material composing the walls, ceiling, and floor. Average absorption coefficients are given in the table below for the most common construction materials. If a different construction material is encountered and you use another absorption coefficient table, average the coefficients given in the other table for 500, 1000, and 2000 Hz for the purpose of these calculations. Enter the average absorption coefficient in the appropriate place on the documentation form.
7. Multiply the area of each floor, ceiling, and wall times the absorptive coefficient of the material composing the surface. Add up all of the resultants of the multiplications to obtain the A (total absorption of the room in Sabins) in the RT=.049 V/A formula for the room and record it on the form.
8. Take the numerator from Step 3 (.049 x V) and the denominator from Step 6 (A=total absorption in Sabins for the room) and divide them in order to determine the estimated reverberation time of the room in seconds (RT=.049 V/A). Enter the estimate on the documentation form. It Compare the results to the ANSI/ASA standards for the type of room (permanent or portable).

Sound Absorption Co-Efficients for Common Classroom Materials[a]

Material	Ave Absorp Coefficient	Material	Ave. Absorp Coefficient	Material	Ave. Absorp Coefficient
WALLS:		FLOORS:		CEILINGS:	
Brick	0.04	Wood parquet on concrete	0.06	Plaster, gypsum, or lime on lath	0.05
Painted concrete	0.07	Linoleum	0.03	Acoustical tiles (5/8")- suspended	0.68
Window glass	0.12	Carpet on concrete	0.37	Acoustical tiles (1/2")- suspended	0.66
Plaster on concrete	0.06	Carpet on foam padding	0.63	Acoustical tiles (1/2")- not suspended	0.67
Plywood	0.12			High absorptive panels- suspended	0.91
Concrete block	0.33				

[a]Adapted from Berg, F. (1993) by J Smaldino and C. Crandell (1995). In *Sound-field FM Amplification,* Crandell, Smaldino, & Flexer (Eds.) p. 78. Singular Publishing Group, Inc. Reprinted by permission. See RT-60 websites for a more comprehensive list of materials.

Directions to Determine Approximate Critical Distance (Section 4 of worksheet)

Using the table below, match the volume and estimated reverberation time of the room being analyzed. The resulting value is the critical distance. Up to and including this distance from the talker, reflections from the sound reverberating in the room will enhance the speech signal; beyond this distance the speech signal will be degraded by the later reflections of the sound reverberations. For example for a room of 10,000 cubic feet and a reverberation time of .4 seconds, the critical distance is 10 feet. It is important that students with special listening requirements are not positioned any further than 10 feet from the talker in this situation to receive the most intelligible signal from the talker.

Estimated Critical Distance Table[b]

Room Volume (Cubic Ft)	Reverberation Time (seconds)							
	.3	.4	.5	.6	.7	.8	.9	1.0
2000	**5.2**	**4.5**	**4.0**	**3.7**	**3.4**	**3.2**	**3.0**	**2.8**
4000	**7.3**	**6.3**	**5.7**	**5.2**	**4.8**	**4.5**	**4.2**	**4.0**
6000	**8.9**	**7.7**	**6.9**	**6.3**	**5.9**	**5.5**	**5.2**	**4.9**
8000	**10.3**	**8.9**	**8.0**	**7.3**	**6.8**	**6.3**	**6.0**	**5.7**
10,000	**11.5**	**10.0**	**8.9**	**8.2**	**7.6**	**7.1**	**6.7**	**6.3**
12,000	**12.6**	**11.0**	**9.8**	**8.9**	**8.3**	**7.7**	**7.3**	**6.9**
14,000	**13.7**	**11.8**	**10.6**	**9.7**	**8.9**	**8.4**	**7.9**	**7.5**
16,000	**14.6**	**12.6**	**11.3**	**10.3**	**9.6**	**8.9**	**8.4**	**8.0**
18,000	**15.5**	**13.4**	**12.0**	**11.0**	**10.1**	**9.5**	**8.9**	**8.5**
20,000	**16.3**	**14.1**	**12.6**	**11.5**	**10.7**	**10.0**	**9.4**	**8.9**
	Critical Distance (feet)							

[b]© Arthur Boothroyd, used with permission