

SUBJECT: THE PROBLEM WITH SPACES THAT HAVE NO SUSPENDED ACOUSTIC CEILINGS

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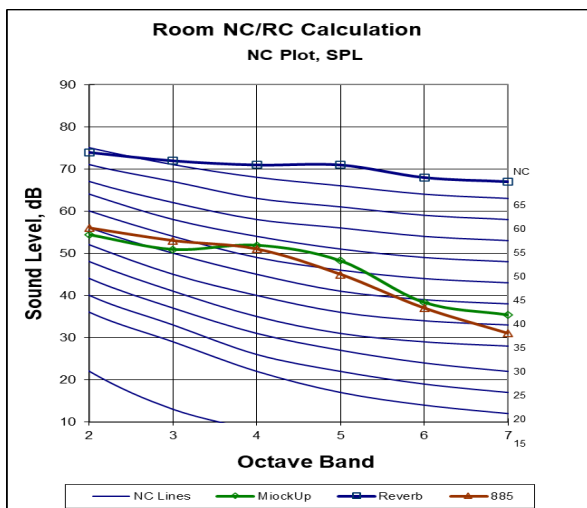
Recently, we have seen many commercial office buildings being designed without the traditional suspended acoustic tile ceilings. The resulting acoustics in these spaces have neither been officially evaluated or peer reviewed, and they are often found to be “noisy”. In performing evaluations in the mockup space at the Energetics Laboratories in Houston, we looked at the effect of removing the suspended ceiling. If a design engineer uses acoustical specifications based on spaces with suspended ceilings for spaces without those ceilings, the space is likely to be noisy. The following describes the issue and provides a recommended specification.

To understand what we found, one must understand what was known about the acoustics when there is a suspended acoustical tile ceiling. AHRI has an acoustical application standard, AHRI Standard 885. This standard includes Appendix E, which includes a table of deducts by octave band to apply to the Reverb Room sound data for calculating catalog Radiated NC data. AHRI requires that the Appendix E data be used for Manufacturer’s Catalog NC ratings for all AHRI Certified products.

The radiated sound deducts in Appendix E were generated through an AHRI/AHRAE Research Project, ASHRAE RP755, conducted at the Acoustical Laboratories in a Canadian facility in Ottawa. Three manufacturers and a renowned acoustician monitored the project. Several ceiling panel types were evaluated, and standard mineral tile panels were chosen as the basis of producing comparable data between manufacturers, beginning over 25 years ago.

A “standard” mock-up space, first specified by Cerami & Associates (now Trinity Consultants) for a project in NYC in the mid 1980’s, has become an often-specified situation for demonstration of a product’s applied acoustical performance. It specified a 2400 ft³ space, carpeted, and a 3ft deep plenum enclosed by a mineral tile suspended ceiling. Several manufacturer’s facilities, including the Energetics Laboratory in Houston, once owned by Cerami,

have created a space meeting these characteristics and this design and accepted it as a “defacto” standard. The Energetics mockup room has been utilized by several design engineers and is often referred to as the “Hines” mockup facility.



What is known, but not often commented on, is the fact that the measured sound in the Hines mockup does not yield the same data as the AHRI Appendix E deducts would predict. The AHRI data is typically conservative when compared to the observed results in the Hines space, likely due to the radiation from required inlet and discharge ductwork necessary to test for radiation and discharge sound data in the reverb room. If a series fan powered VAV terminal unit is installed in the space with no duct connections, there is

excellent agreement with the Appendix E table. One needs to realize the reverb room acoustic data is measured with all connecting ductwork carefully “lagged” so that the room is measuring only the sound emitted by the unit.

This indicates that the Appendix E radiated sound deducts are an excellent tool for comparisons between units and manufacturers, and it eliminates any variables that might be introduced by differences in inlet and discharge ductwork designs. In the field, these construction differences are likely impossible to be duplicated in a laboratory, and they are excluded by the test installation in the reverb room per ASHRAE Standard 130 and AHRI Standard 880 test Standards.

In AHRI 885, a discharge sound source is treated as a “point source” and the reduction in sound from the reverb room discharge measured sound uses a table. This table is known as the Shultz table, after the researcher who developed it in the early 70’s. The inputs are the volume of the room and the distance to the source. The Appendix E values are for a 2400 cubic foot room 5 ft from the source.

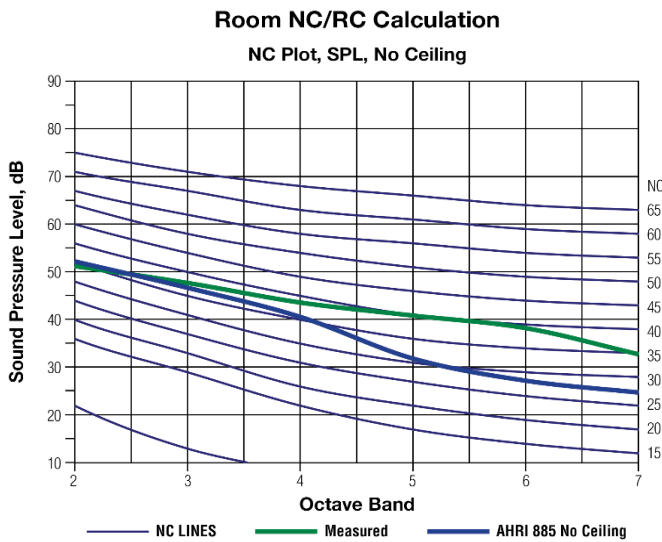
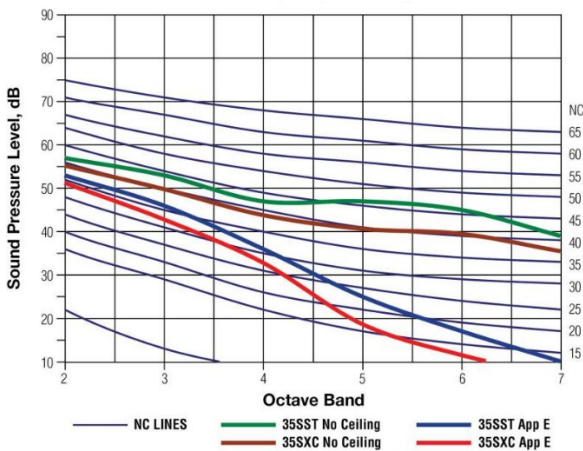


Figure 2. Measured vs estimated sound using AHRI 885 method for exposed plenums

The RP 755 study determined that a sound source above a suspended ceiling acts as an “Area Source” rather than a “Point Source”. A combined ceiling plenum and a space effect are defined as a “ceiling/space effect”, and a table is provided. Furthermore, In Standard 885, it is stated “For spaces with no ceiling, the sound attenuation of radiated sound should be calculated using the equation for Table D16 (the Shultz effect) employing room volume and distance to the sound source, as if the source were a point source. Be sure to include the total volume of the space including the region where the source is located.” This technique has been found to grossly underestimate the resultant space sound pressure, as shown in the following

graph, likely because it fails to account for the now significant effects of other sound sources in the upper part of the space. In this test, measured NC was found to be 5 NC higher than predicted, and set in the 4th to 6th octave bands, instead of the 2nd or 3rd.

Looking at data of this sort led Nailor to develop a Series Fan Powered VAV Terminal Unit that had significantly reduced radiated sound generation in the mid and upper frequencies. The 35 SXC has an NC rating using Appendix E that is very similar to the 35 SST. When installed in the Hines mockup, however, the SXC measured sound NC is



quite a bit lower than the SST, and in addition is a much more “neutral” sound, where the SST would likely be considered “hissy”.

Appendix E is designed primarily as a means for comparing different manufacturers’ sound data with a level playing field. It appears that to do so with the Exposed Ceiling design, this may lead to a serious understatement of the sound levels that will result in an exposed ceiling environment. As there is presently no industry agreed upon “Exposed Ceiling Transfer Function,” designs for spaces with exposed ceilings may well require mockup data. Issues such as duct supplying and leaving

terminals will have to be considered.

Removing acoustic ceilings results in derating terminal unit airflow by 15 to 25% to reach acoustic requirements resulting in smaller zones and more terminal units in the building. The cost to the building owner for a complete terminal unit in new construction varies by region from about \$10,000 to almost \$40,000. Using Nailor's 35SXC without acoustic tiles avoids the airflow reduction and avoids both derating the terminal unit airflow and the additional terminal units in the building to meet the acoustic specifications. It also provides a blended or neutral sound level in the space that is more pleasing to the human ear.

Suggested Add to Acoustic Specification

Acoustical Mock-up: An acoustical evaluation shall be conducted on every size terminal unit at flow range which covers the scheduled design air volumes in a custom independent or manufacturer's acoustical laboratory mock-up to evaluate both radiated and discharge noise levels. The acoustical laboratory shall be acceptable to the Acoustical Consultant, Engineer and Owner.

For radiated sound, the mock-up shall consist of one (1) 20' x 12' closed plan office. Office shall be constructed of 10 feet high sheet rock walls. The terminal unit shall be located 10 feet above the center of the office space and discharge ductwork shall be routed out of the space above the office walls. Office shall be constructed 13 feet high slab above a concrete floor. There shall be no suspended ceiling.

The unit shall be selected to be run at airflows determined by NC measurements of NC 30, 35, 40 and 45 as shown in the chart below. Unit selections shall be made according to the NC matrix.

NC MATRIX - 35SXC FAN POWERED VAV TERMINAL UNITS Exposed Ceiling Applications, 0.1 downstream 0.5 Upstream, prim = 80% fan

		Radiated Sound																		
		Size 1 35SXC						Size 3 35SXC						Size 5 35SXC						
		NC 45						NC 45						NC 45						
UNIT SIZE		1-4" Inlet		1-5" Inlet		1-6" Inlet		3-6" Inlet		3-8" Inlet		3-10" Inlet		5-10" Inlet		5-12" Inlet		5-14" Inlet		
		NO HEAT	HOT WATER	ELECTRIC	NO HEAT	HOT WATER	ELECTRIC	NO HEAT	HOT WATER	ELECTRIC	NO HEAT	HOT WATER	ELECTRIC	NO HEAT	HOT WATER	ELECTRIC	NO HEAT	HOT WATER	ELECTRIC	
CFM MIN		75	75	75	75	75	75	200	200	200	200	200	200	200	500	500	500	500	500	500
CFM MAX		225	225	225	400	400	400	550	475	550	700	610	700	1100	950	1100	1800	1600	1800	2000
		NC 40						NC 40						NC 40						
UNIT SIZE		1-4" Inlet		1-5" Inlet		1-6" Inlet		3-6" Inlet		3-8" Inlet		3-10" Inlet		5-10" Inlet		5-12" Inlet		5-14" Inlet		
CFM MIN		75	75	75	75	75	75	200	200	200	200	200	200	500	500	500	500	500	500	
CFM MAX		225	225	225	400	400	450	550	475	550	700	610	700	1100	975	1100	1450	1450	1600	1360
		NC 35						NC 35						NC 35						
UNIT SIZE		1-4" Inlet		1-5" Inlet		1-6" Inlet		3-6" Inlet		3-8" Inlet		3-10" Inlet		5-10" Inlet		5-12" Inlet		5-14" Inlet		
CFM MIN		75	75	75	75	75	75	200	200	200	200	200	200	500	500	500	500	500	500	
CFM MAX		190	180	190	250	220	250	300	260	300	500	430	500	650	600	700	600	800	700	
		NC 30						NC 30						NC 30						
UNIT SIZE		1-4" Inlet		1-5" Inlet		1-6" Inlet		3-6" Inlet		3-8" Inlet		3-10" Inlet		5-10" Inlet		5-12" Inlet		5-14" Inlet		
CFM MIN		75	75	75	75	75	75	200	200	200	200	200	200	500	500	500	500	500	500	
CFM MAX		85	80	85	130	118	130	n/a	n/a	n/a	300	290	300	350	300	350	550	500	550	

The restrictions of the attenuation inside the STEALTH boots on the SXC units should be minimized during operation of the terminal units. This is easy to do. You must modulate the fan to address only the instantaneous loads in each zone. The fan must track the primary air in the cooling mode, which reduces the plenum air entering the unit. Typical maximum set points would be same as primary air or up to 10% greater than primary air if the primary air is cooler than 55° F. The minimum set point is typically set by mixing plenum and primary air to achieve about 60° F. into the occupied space. This sequence improves comfort, reduces reheat, reduces fan energy and reduces sound levels. It is described in ASHRAE Guideline 36

END OF ARTICLE

SEO

Acoustic

Ceilings

Noise

35SXC

NC without ceilings

NC no ceiling

