

Spectral Balance Data Collection Form and Procedure

8: 201x Audio System Spectral Balance
Standard Task Group

August 2, 2012



Sound System Measurement Procedure

This procedure defines a methodology that is not dependent on a particular measurement technology or product line. The intention is to measure the frequency response of the direct sound at the equivalent of ear height at each location. The response at each location must be measured in a way that allows the relative level at each location to be compared. In other words do not change the gain of the sound system or the measurement system between measurements at the different locations.

General Considerations

- If the sound system is multi-channel (stereo, LCR, surround, etc.), measure the sound from each **reproduction channel** in isolation from the other channels. (Note: This is **not** saying that each **loudspeaker** needs to be measured independently since a single sound system reproduction channel might drive multiple loudspeakers.)
- If the room is so dead acoustically and/ or the sound system is so directional that energy arriving after the direct sound is no more than -10 dB relative to the direct sound level, then a time blind measurement system such as a RTA may be used.
- In more common situations, a test method that is able to separate the direct sound from the energy that follows shall be used.
- The injection into the sound system may be analog or digital.
- No input signal processing (EQ, dynamic processing, reverb, etc.) shall be applied to the test signal as the intent is to measure the sound delivered by the sound system to the listener's ears.
- System processing (EQ, crossovers, delay, protection limiting) that is always a part of the sound system is considered a part of the sound system for the purposes of these measurements, and shall be in use.
- For consistency of data, follow the ACU® method for selecting the measurement locations. See the "Measurement Locations per ANSI/INFOCOMM 1M-2009" document. For smaller rooms this method should be followed unless there are compelling reasons to do otherwise. In larger rooms approaching the limit of 5,000 seats, strict adherence to the ACU method will involve hundreds of test locations, which is probably a bigger measurement project than anyone would like to tackle. In this case, choose 50 locations selected from the ACU defined locations. In all cases, the measurement locations used should be marked on the floor plan.
- Since the intent is to (primarily) measure the direct sound, assuming a free field measurement microphone is used, it should be pointed in the direction of the source of the direct sound.

Procedure

- **Measure direct sound with a window of at least 10 ms, but no more than 30 ms.**
 - **Submit measurement results as *a raw data file* and as *a report showing 1/12 octave (or higher resolution) averaged data.***
- 1) Complete ALL information on the Measurement Submission form. Please DO NOT leave any fields blank.
For SYSTEM TYPE, please describe as: mono, stereo, LCR, multi-channel, or ceiling distributed
 - 2) Mark where the measurements will be made on a floor plan of the room that shows the listening areas.
 - 3) Take the measurements over the working frequency range of the sound system, with a resolution of 1/12 octave or at higher resolution.
 - 4) For each measurement location, record the arrival time of the direct sound relative to the point at which the test signal is injected into the sound system.
 - 5) Send to Aron Abrams at InfoComm (aabrams@infocomm.org):
 - 4 Completed Measurement Submission Form
 - 4 Marked floor plan
 - 4 Raw data files with requested information

Thank You Kindly!

Questions about this test procedure should be addressed to Ray A. Rayburn (Ray@SoundFirst.com)

Sound System Spectral Balance Measurement Submission

SUBMITTER'S INFORMATION

Name _____

Phone # _____

Email _____

SITE AND SYSTEM INFORMATION

Name _____

Address _____

Altitude _____

Temperature _____

Humidity _____

System Type _____

Notes _____

INSTRUMENTATION AND TEST INFORMATION

Make/Model
of Hardware _____

Software _____

Microphone Type _____

Microphone
Measurement
Height _____

Measurement Locations per ANSI/INFOCOMM 1M-2009

Audio Coverage Uniformity in Enclosed Listener Areas

Also known as ACU

This method of choosing measurement locations is intended for indoor spaces of under 5000 seats.

Definitions:

- a. Audio Coverage Uniformity Measurement Locations (ACUML) – the test points within a venue that have been determined to carry out the measurements for the Audio Coverage Uniformity test.
- b. Audio Coverage Uniformity Plan (ACUP) – a stand-alone document that identifies the Audio Coverage Uniformity measurement locations for a particular venue, using the InfoComm indication symbol.

Criteria:

- a. The system shall be able to develop an acoustic output of 15 dB above the ambient noise level in each octave band to be tested. This is not intended to be the nominal operating level of the system; rather, it is the minimum level required to perform the Audio Coverage Uniformity tests. The ACU should be measured at either 15 dB above ambient or at the nominal operating level, whichever is higher.
- b. If multi-channel sound systems are tested in accordance with this standard, each channel shall be measured independently of the other channel(s).
- c. Location and quantity of measurement locations will vary according to the type and deployment of audio system and the specific venue. An Audio Coverage Uniformity Plan is a stand-alone document that identifies the measurement locations for a particular venue, using the InfoComm indication symbol. This plan shall be included as part of a design package for the venue. In addition to the measurement locations, this plan shall indicate areas of noncompliance either as part of the design, after the system has been measured, or both. This ACUP serves as direction from the system designer to the test engineer or technician, and becomes a part of the project documentation delivered to the system owner for test verification. Further documentation enumerating reasons for non-compliance shall be attached. Data indicating ambient noise reference levels and the measured system levels shall be provided; either displayed on the plan itself as a table or as a spreadsheet included with the system testing and commissioning information. See Appendices 1 and 5 for examples.
- d. Identification of time-windowed or time-blind testing shall be noted. Instrumentation used, calibration dates, manufacturer and software version (if applicable) shall be included.

Audio Coverage Uniformity Plan (ACUP) Guidelines

The application of this standard requires a determination of where the measurement locations are to be made in the venue, as represented on the ACUP:

- a) Draw the required coverage area on a plan layout of the room and determine the total coverage area in square meters (square feet). The minimum number of permissible measurements is then defined as follows:
 - i) Areas less than 10m² (108 ft²) shall have at least three (3) measurements

- ii) Areas between 10m² (108 ft²) and 50m² (538 ft²) shall have at least one (1) measurement per 5m² (54 ft²)
- iii) Areas between 50m² (538 ft²) and 150m² (1615 ft²) shall have at least one (1) measurement per 7m² (75 ft²)
- iv) Areas greater than 150m² (1615 ft²) shall have at least one (1) measurement per 10m² (108 ft²)
- b) Establish the shortest of the following two distances, which shall be used as the basis of the grid of measurement points:
 - i) For Point Source Systems – Distance from closest loudspeaker to closest listener
 - ii) For Distributed Systems – Distance between closest two loudspeakers (excluding loudspeakers that are arrayed or in a cluster)
- c) Define the measurement grid, using a plan layout of the coverage area, the grid dimensions determined by Clause b and following the criteria below:
 - i) Measurement points shall first be placed on all sides of the perimeter of the coverage area, ensuring that a measurement is taken at each corner of the perimeter.
 - ii) Measurement points shall be placed throughout the area within the perimeter, using a grid with centers as determined by Clause b, between all perimeter points. Where the distance between perimeter points is insufficient to place grid points within the listener coverage area, evenly spaced central point(s) shall be taken based on the minimum per square meter measurements defined in Clause a. Refer to Figures 4, 7 and 9 for examples of implementing this requirement.

Tolerance of +/-5% (percent) on measurement grid dimensions shall be permissible in order to fit the nominated grid evenly within the total area. Once the best-fit grid dimension for the coverage area has been selected, this shall be used for the entire grid (i.e., it is not acceptable to manipulate the grid +/-5% (percent) for individual points).

If the grid calculation based on Clause b.i or b.ii and application of Clause c.ii does not achieve the minimum per square meter requirement, additional points shall be nominated, evenly spread throughout the area, in order to achieve the minimum number of measurements stipulated in points a, b, c and d of Clause a.

- d) Distributed loudspeaker systems with multiple, non-arrayed loudspeakers serving a single coverage area shall have at least one measurement taken at each of the following positions:
 - i) Within the coverage area directly on axis to a loudspeaker
 - ii) At a point off-axis equidistant from two loudspeakers, or at an equivalent distance from the nearest loudspeaker at the edge of the coverage area

If either of these requirements cannot be accommodated within the standard measurement grid, additional point(s) shall be included for this purpose.

- e) When there are multiple listener areas in the venue, repeat steps a-d above for each additional area. For example, “head tables,” “stages,” “jury boxes,” “presentation areas,” etc., may be considered as “listener areas” when audio reinforcement is included for these areas. For small areas (less than 5m² (54 ft²)), a minimum of three (3) measurements shall be taken – one (1) at the center of the area and one (1) at each diagonal extreme of the coverage area.
- f) For rooms featuring operable walls, measurements shall be taken and reported separately for the “wall open” and “wall closed” states.
- g) The positioning of the grid within the room shall be measured to a tolerance of +/-50mm (2 inches) or the stated construction tolerance value for the building, whichever is lower. The method of measuring to determine grid locations shall be stated in the ACU report for the room.
- h) The measurement microphone shall be positioned at the height nominated as the Listener Ear Height for the coverage area. Care shall be taken to ensure that all measurements are taken at the nominated height to a tolerance of +/-25mm (1 inch).

Figures 1 through 9 indicate examples of measurement point determinations. Each figure lists the following criteria:

- i) Total coverage area
- ii) Minimum number of permissible measurements
- iii) Ceiling Height

- iv) Loudspeaker system type (point source or distributed)
- v) Loudspeaker height above floor
- vi) Listener Ear Height (1.2m (4 ft.) for seated, 1.6m (5.25 ft.) for standing) – This is the required height for the measurement microphone at each point on the grid
- vii) Distance (D_{LL}) from Closest Loudspeaker to Closest Listener (Point Source) or between Loudspeakers (Distributed)

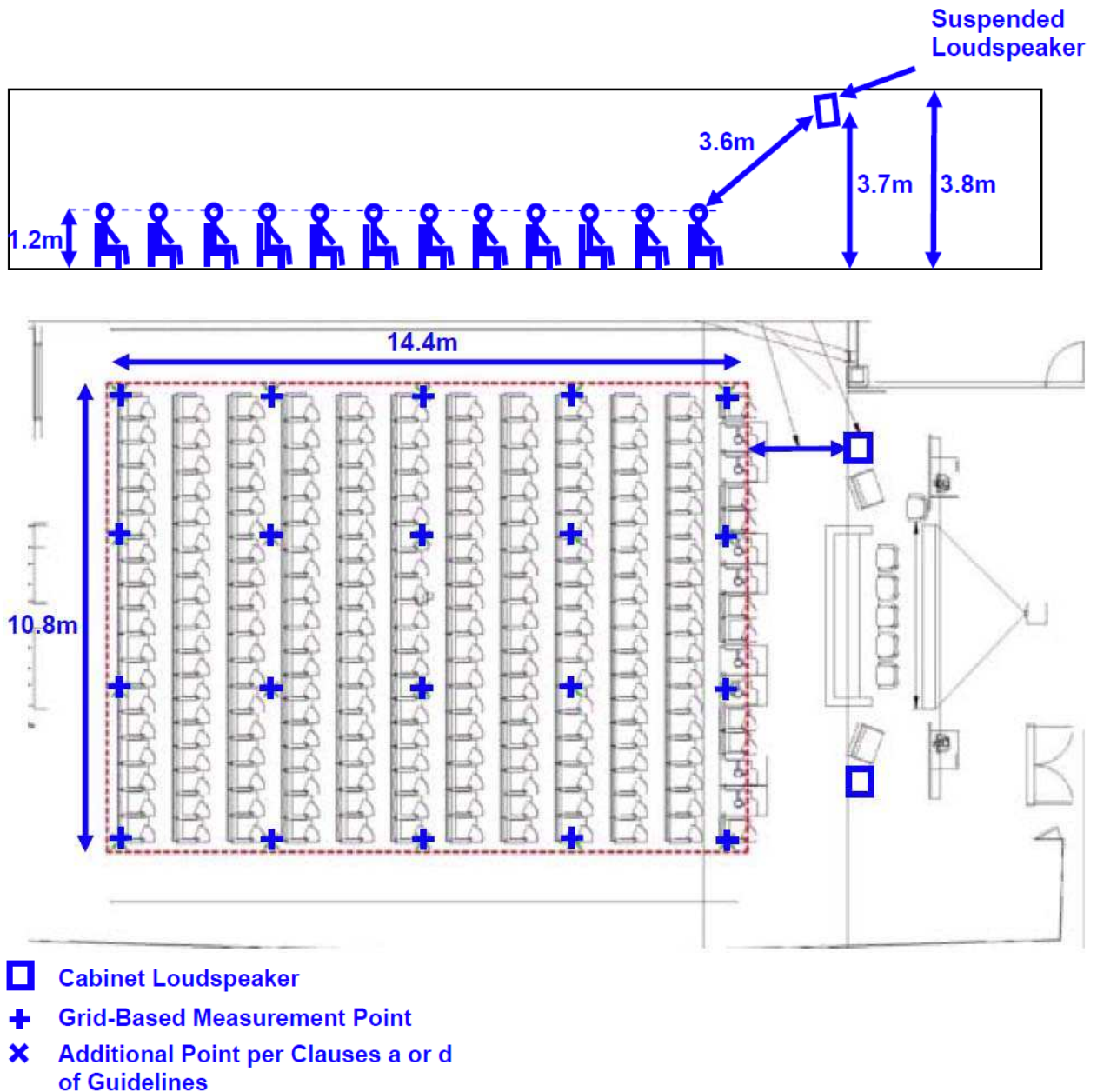


Figure 1. ACUP Example: Auditorium (Audience Space Only)

Criteria:

1. Total coverage area – 155m² (1668 ft²)
2. Minimum number of permissible measurements – 16
3. Ceiling Height – 3.8m (12.5 ft.)
4. Loudspeaker System Type – Point Source

5. Loudspeaker Height above floor – 3.7m (12.1 ft.)
6. Listener Ear Height – 1.2m (4 ft.)
7. DLL – 3.6m (11.8 ft.)

Commentary:

The grid fits within the perimeter, points within the listener area are achieved using the grid, and the number of points required by the grid exceeds the minimum permissible so no additional points are required.

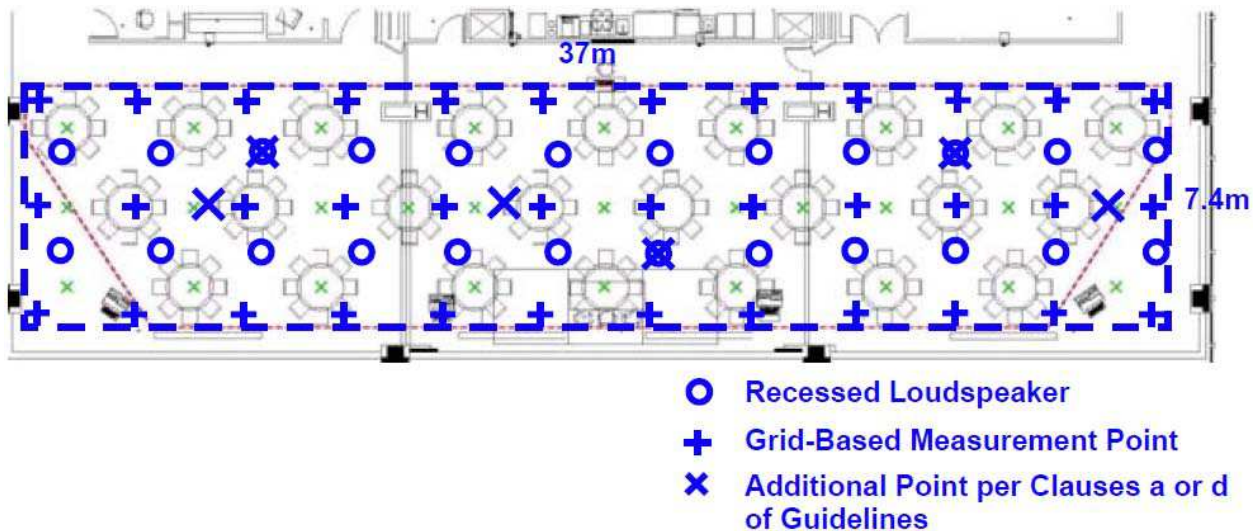


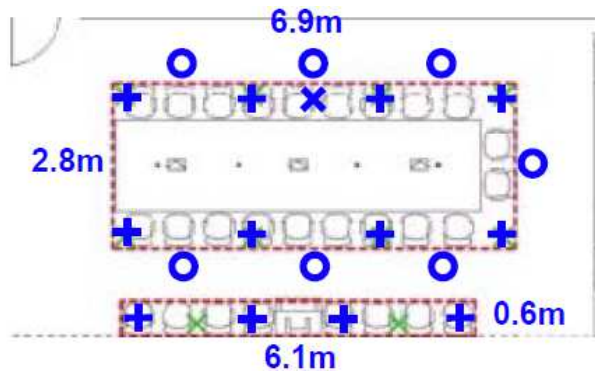
Figure 2. ACUP Example: Multi-Purpose Room

Criteria:

1. Total coverage area when open – 288m² (3100 ft²)
2. Total coverage area when closed (per room) – 96m² (1033 ft²)
3. Minimum number of permissible measurements (open) – 29, (closed) –14
4. Ceiling Height – 3.0m (9.8 ft.)
5. Loudspeaker System Type – Distributed on 3.5m (11.5 ft.) square layout (ceiling recessed)
6. Loudspeaker Height above floor – 3.0m (9.8 ft.)
7. Listener Ear Height – 1.2m (4 ft.)
8. DLL – 3.5m (11.5 ft.)

Commentary:

Figure 2 includes additional points due to the Clause a. rule regarding points per square meter and Clause d. regarding on-axis and equidistant measurements for distributed sound systems. Where both Clauses a. and d. require additional points, points added for Clause d. are counted as part of the Clause a. requirement.



- Recessed Loudspeaker
- + Grid-Based Measurement Point
- × Additional Point per Clauses a or d of Guidelines

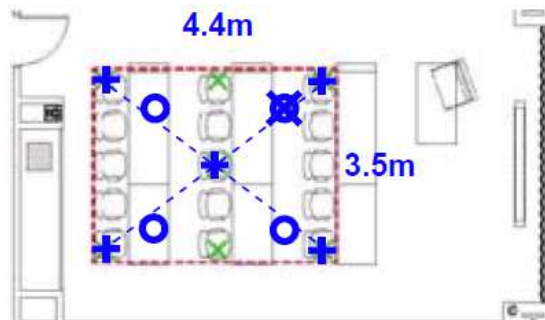
Figure 3. ACUP Example: 20-Person Conference Room

1. Total coverage area – 19.0m² (205 ft²) and 3.6m² (38.8 ft²)
2. Minimum number of permissible measurements – 4 and 3
3. Ceiling Height – 2.7m (8.9 ft.)
4. Loudspeaker System Type – Distributed on 2.4m (7.9 ft.) square layout (ceiling recessed)
5. Loudspeaker Height above floor – 2.7m (8.9 ft.)
6. Listener Ear Height – 1.2m (4 ft.)
7. DLL – 2.4m (7.9 ft.)

Commentary:

Figure 3 includes one additional point to achieve compliance with Clause d. regarding the need to measure a point on axis to a loudspeaker. An additional point to achieve the off-axis requirement is not needed as this is already achieved with the planned grid.

No central points are required as there are no listeners in these locations.



- Recessed Loudspeaker
- + Grid-Based Measurement Point
- × Additional Point per Clauses a or d of Guidelines
- Measurement lines to determine Central Point per Clause c.ii

Figure 4. ACUP Example: Classroom (Student Area Only)

Criteria:

1. Total coverage area – 15.4m² (165.8 ft²)
2. Minimum number of permissible measurements – 4
3. Ceiling Height – 2.7m (8.9 ft.)
4. Loudspeaker System Type – Distributed on 2.4m (7.9 ft.) square layout (ceiling recessed)
5. Loudspeaker Height above floor – 2.7m (8.9 ft.)
6. Listener Ear Height – 1.2m (4 ft.)
7. DLL – 2.4m (7.9 ft.)

Commentary:

Figure 4 indicates a situation where the 2.4m (7.9 ft.) grid cannot be made to fit multiple points once perimeter measurements are made, even when a tolerance of +/-5% (percent) is applied. In this situation, a single measurement is made in the center of the area as stipulated in Clause c.ii. The diagonal lines indicate the method for establishing the central measurement position.



Figure 5. ACUP Example: 8-Person Conference Room

Criteria:

1. Total coverage area – 7.84m² (84.4 ft²)
2. Minimum number of permissible measurements – 3
3. Ceiling Height – 2.8m (9.2 ft.)
4. Loudspeaker System Type – Distributed on 2.9m (9.5 ft.) triangular layout (ceiling recessed)
5. Loudspeaker Height above floor – 2.7m (8.9 ft.)
6. Listener Ear Height – 1.2m (4 ft.)
7. DLL – 2.9m (9.5 ft.)

Commentary:

Figure 5 presents an example where the measurement points are defined by the number of perimeter corners rather than by the grid or the minimum area quantity. No center measurement is required as there is no listener in this position.

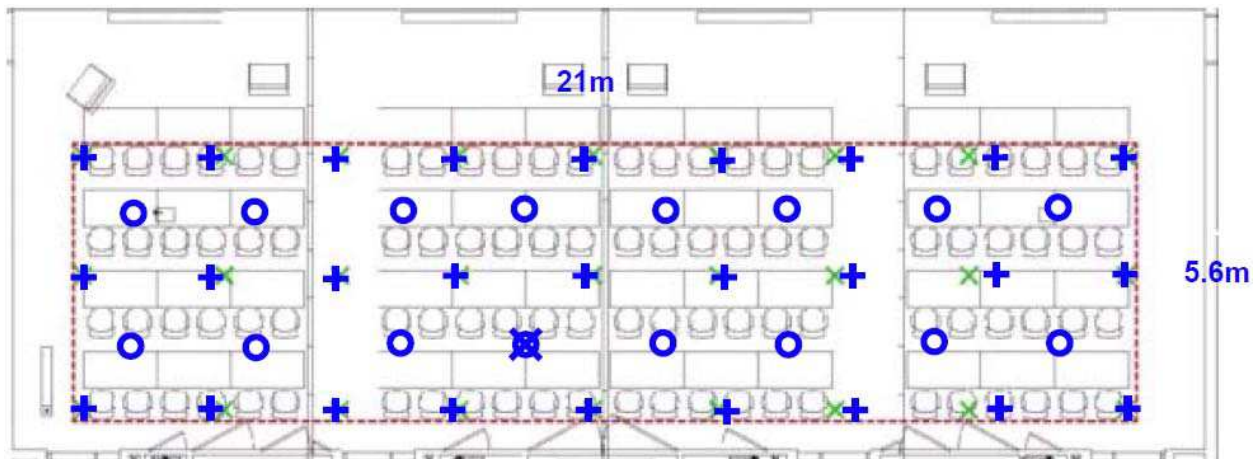


Figure 6. ACUP Example – Divisible Training Room – Open

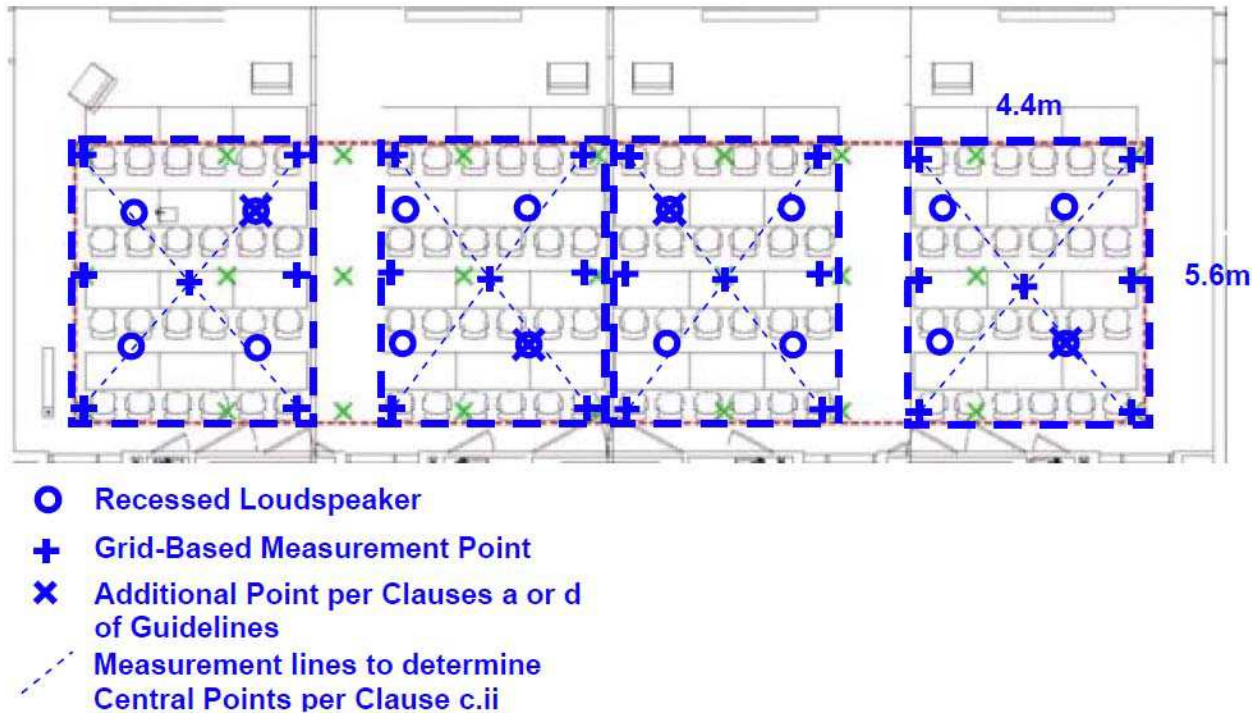


Figure 7. Divisible Training Room – Closed

Criteria:

1. Total coverage area – 115m² (1238 ft²) and 24m² (258.3 ft²) per room
2. Minimum number of permissible measurements – 16 and 5 per room
3. Ceiling Height – 2.7m (8.9 ft.)
4. Loudspeaker System Type – Distributed on 2.8m (9.2 ft.) square layout (ceiling recessed)
5. Loudspeaker Height above floor – 2.7m (8.9 ft.)
6. Listener Ear Height – 1.2m (4 ft.)
7. DLL – 2.8m (9.2 ft.)

Commentary:

As the required coverage area of the rooms changes between the open and closed states as shown in Figures 6 and 7, separate measurement points are used for the two states. In the open state, the grid can be accommodated and there is no need for additional points to satisfy Clauses a. or c.ii.

Additional central points and the measurement lines required to determine them for compliance with Clause c.ii. are shown for the closed state.

For both states, additional points are required to achieve compliance with Clause d.

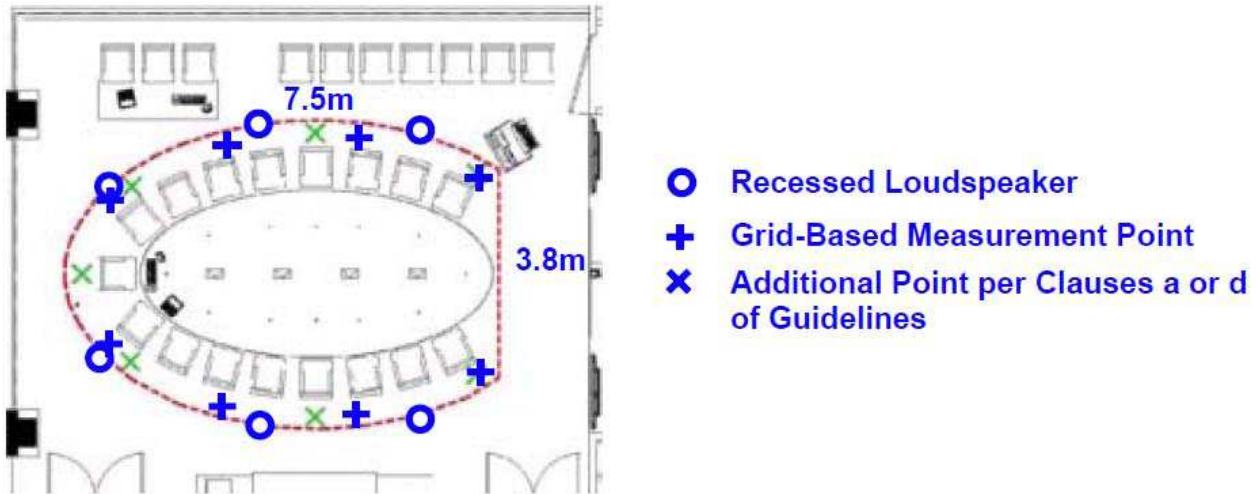


Figure 8. ACUP Example: Boardroom

Criteria:

1. Total coverage area – 28m² (301 ft²)
2. Minimum number of permissible measurements – 6
3. Ceiling Height – 2.7m (8.9 ft.)
4. Loudspeaker System Type – Distributed on 2.4m (7.9 ft.) curved layout to suit table shape (ceiling recessed)
5. Loudspeaker Height above floor – 2.7m (8.9 ft.)
6. Listener Ear Height – 1.2m (4 ft.)
7. DLL – 2.4m (7.9 ft.)

Commentary:

The boardroom in Figure 8 shows an example of designing the coverage area based on the client's expectations. The seating at the side and the assistants' table have been deemed unnecessary to achieve ACU standard performance in this example. The boardroom table has been nominated as requiring ACU standard performance up to 0.5m (1.6 ft.) beyond standard seating positions.

The layout for this grid of measurement points meets the requirement for on-axis and off-axis measurements and therefore requires no additional points to satisfy Clause d.

No central points are required as there are no listeners at these positions.



- Recessed Loudspeaker
- + Grid-Based Measurement Point
- × Additional Point per Clauses a or d of Guidelines
- Measurement lines to determine Central Points per Clause c.ii

Figure 9. ACUP Example: Morning Meeting Room

Criteria:

1. Total coverage area – 72m² (775 ft²) and 2m² (21.5 ft²)
2. Minimum number of permissible measurements – 14 and 3
3. Ceiling Height – 3.0m (9.8 ft.)
4. Loudspeaker System Type – Distributed on 2.8m (9.2 ft.) square layout (recessed ceiling)
5. Loudspeaker Height above floor – 3.0 m (9.8 ft.)
6. Listener Ear Height – 1.2m (4 ft.)
7. DLL – 2.8m (9.2 ft.)

Commentary:

The example morning meeting room in Figure 9 demonstrates the correct approach to resolving a situation where the perimeter points and the grid dimensions do not permit a complete row in the middle of the main coverage area. Clause c.ii. indicates that additional points are required, evenly spaced through the central area, determined by drawing measurement lines between diagonal points as indicated above.