Course 140 - Speech Intelligibility for Public Addressed Systems
Detailed Outline

Introduction

My first exposure to the consideration speech intelligibility when designing sound systems came in the early 1980's. I had just botched a system design for reverberant Methodist church. The system was aesthetically pleasing but unintelligible. It was while reeling from this sonic disaster that I found a textbook that changed my career - Sound System Engineering by Don and Carolyn Davis (SSE). I soon realized that the mistakes I made with this sound system were both predictable and preventable, and I made it my life's goal to understand all of the principles presented in SSE. Fast-forward nearly half a century and SSE is now in its 4th edition and I am a co-author. Go figure.

This course will shorten your learning curve to becoming a speech intelligibility professional. The principles presented in SSE will come to life with structured training videos, demonstrations, and a software calculator - all designed to help you avoid mistakes similar to the one that began my career. *Pat Brown*

Two instructional videos on the below topics.

1. Overview
2. The 2nd Law of Thermodynamics
3. Entropy
4. Communication

Sound Pressure Level (SPL) Measurements

The most fundamental acoustic measurement is that of SPL (or L_P). This measurement is how we assign an objective value to the sound level. It is easy to stick a meter up in the air and get a number, but this seldom produces a meaningful value. Humans are quite complex and even non-linear with regard to sound perception. This lesson will present the requirements for making meaningful L_P measurements.

Three instructional videos on the below topics.

1. Sound Pressure from Sound Power
2. Sound Pressure Level
3. Loudness Time-Dependence
4. Loudness Frequency/Level-Dependence
5. Weighting Scales
6. Peak SPL
7. Loudness
8. SPL Measurements
9. Equivalent Level - L_{EQ}
10. Calibration
11. In Conclusion

Room Acoustics

The study of architectural acoustics is a vocation in and of itself. Careers are spent attempting to understand and quantify the behavior of sound in enclosed spaces. In this lesson, I will present room acoustics with a broad brush stroke. The depth will be sufficient for assessing the influence of room acoustics on speech intelligibility. While the speech intelligibility professional need not be an acoustician, they need sufficient knowledge to identify and quantify a system's acoustic limitations. They must also understand when the solution to a speech intelligibility problem must go beyond the design of the sound system.

Seven instructional videos on the below topics.

1. Introduction
2. Sound Power
3. The Room Impulse Response - RIR
   A. The Direct Field
   B. Reflections
      1. Room Surface Behavior
      2. Ear-Brain Integration Time
      3. Sound Absorption
      4. Sound Scattering
   C. Late Reflections
   D. Reverberation
4. The Reverberation Time - T_{60}
   A. The Schroeder Integration
   B. T_{60} Calculation
5. The Reverberation Level - L_R
6. Source Directivity
7. N-Factor
8. The Architectural Modifier - M_A
9. Hopkins-Stryker Relationships
10. Room Acoustics and PA
11. Manipulating the DRR
12. Conclusion

Environmental Noise

We live in a world fraught with noise pollution. Many of the inventions that enhance our lives also produce noise. Environmental noise always degrades the speech intelligibility. This makes the signal-to-noise ratio (SNR) of primary interest when designing a public address system. This lesson looks at how to identify noise sources and quantify their effect on speech intelligibility.

Two instructional videos and a Demo on the below topics.

1. Introduction
2. Noise Defined
3. Spectrum Shape
4. Noise Measurements
5. Noise Analysis Curves
6. Time Record of Noise
7. Conclusion

Speech Intelligibility

The best speech intelligibility analyzer is the human ear-brain system. Since human hearing and perception are neither calibrated nor consistent, it is often necessary to augment them with instrumentation. A half-century of research and development has produced some useful algorithms for measuring (and predicting) the ability of a system to retain the information that passes through it. This lesson will summarize that work.

As with room acoustics, the study of speech intelligibility is a vocation in and of itself. This lesson will present and demonstrate the tools that are available for speech intelligibility prediction and measurement.

Four instructional videos on the below topics.

1. Introduction
2. The Signal Chain
3. The Talkbox
4. Speech System Requirements
5. Level-Dependent Masking
6. Speech Intelligibility Measures
7. Speech Signal Characteristics
8. A Modulation Example
9. Speech Transmission Index
10. STI for PA Systems
11. Full STI or STIPA
12. Measurement Conditions
13. Direct vs. Indirect Method
14. Conclusion

System Design Overview

No where is speech intelligibility more important than when making life-safety announcements to the public. The voice evacuation system (VES) requires consideration of every principle presented thus far in this course. It should not be surprising that the fire alarm industry have established by code the requirements for a successful VES.

Annex D of NFPA 72 provides a framework for the deployment and testing of VES. I will present some of the key concepts in this lesson. Whether or not your system will be used for emergency announcements, you will benefit from this presentation of the performance requirements for such systems.

Six instructional videos on the below topics.

1. Introduction
2. A Code-Driven Process
3. A Acoustically Distinguishable Space - ADS
4. Test the Variables
5. IntelliKwik - The Room
6. Calculation - The Direct Field L_D

7. Calculation - The Reverberant Field Level L_R
8. Calculation - Speech Intelligibility SI
9. Design Phase 1 - Divide the Space
10. Design Phase 2 - Audience Zones
11. Design Phase 3 - Loudspeaker Selection and Placement
12. NFPA 72 Details
13. Loudspeaker Technologies
14. Loudspeaker Data
15. Design Software Hierarchy

Five instructional videos on Design Calculations

We have looked at the major influences on speech intelligibility using a statistical acoustical approach. The variables have been identified and their mathematical relationships have been established. Early in my career we performed our predictive calculations using HP calculators. It was a laborious, manual process and each time a variable was changed we had to start over. We got answers, but we did not develop an intuition for improving speech intelligibility.

In this lesson I will use IntelliKwik to walk through some common design calculations. This interactive calculator not only speeds the process, it trains the intuition.

Case Study - Elementary School

It's time to connect the dots. In this case study I will perform a site survey on the gymnasium of a local elementary school. I will then use the site survey data, along with IntelliKwik™ to perform some initial design investigations. The objective is to develop a data-driven thought process with regard to achieving high speech intelligibility.

The final section contains a comparison of a line-up of loudspeakers of various types, performed in the same gymnasium. The devices include low, medium, and high directivity units that are general purpose in their design. Each test position includes a data matrix that compares the STIPA (made with a hand-held meter) and the full STI (derived from the room impulse response). I have also included listening examples produced from the RIRs.

This case study is designed to reinforce the principles taught in the course. Nothing new is added and there are no questions on the final exam from this lesson. *pb*

Case Study - Passive Line Arrays

This study compares the performance of a lineup of passive line arrays in a reverberant space.

Site: Techny Towers Chapel

Room Dimensions: 177 ft (54 m) x 67 ft (22.3) x 43 ft (14.3 m)

Room Volume: 509,937 ft^3 (14,440 m^3)