

# Speech privacy in healthcare buildings: review of early studies and current procedures for analysis

---

*Privacy Symposium*

*August 20, 2008*

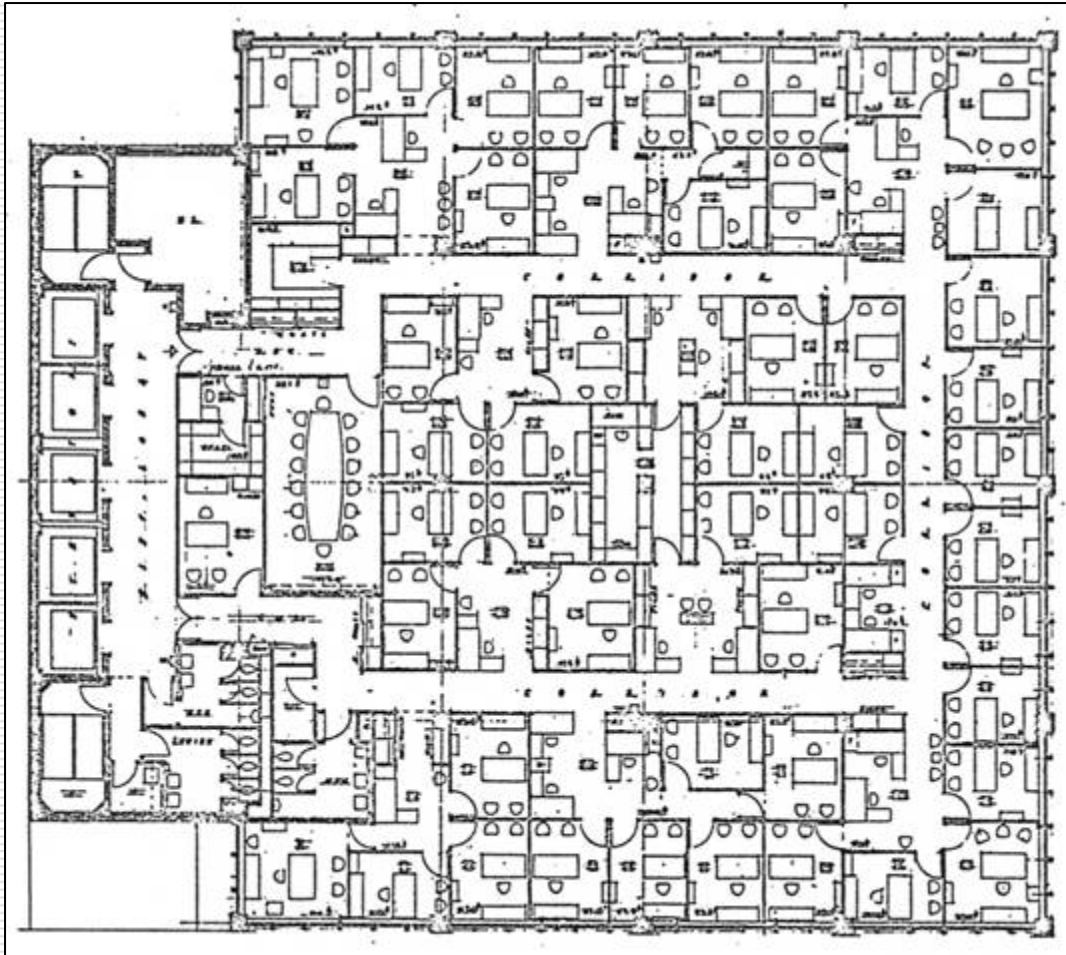
*Harvard University, Cambridge, MA*

*William J. Cavanaugh – Cavanaugh Tocci Associates, Inc.*

*wcavanaugh@cavtocci.com*

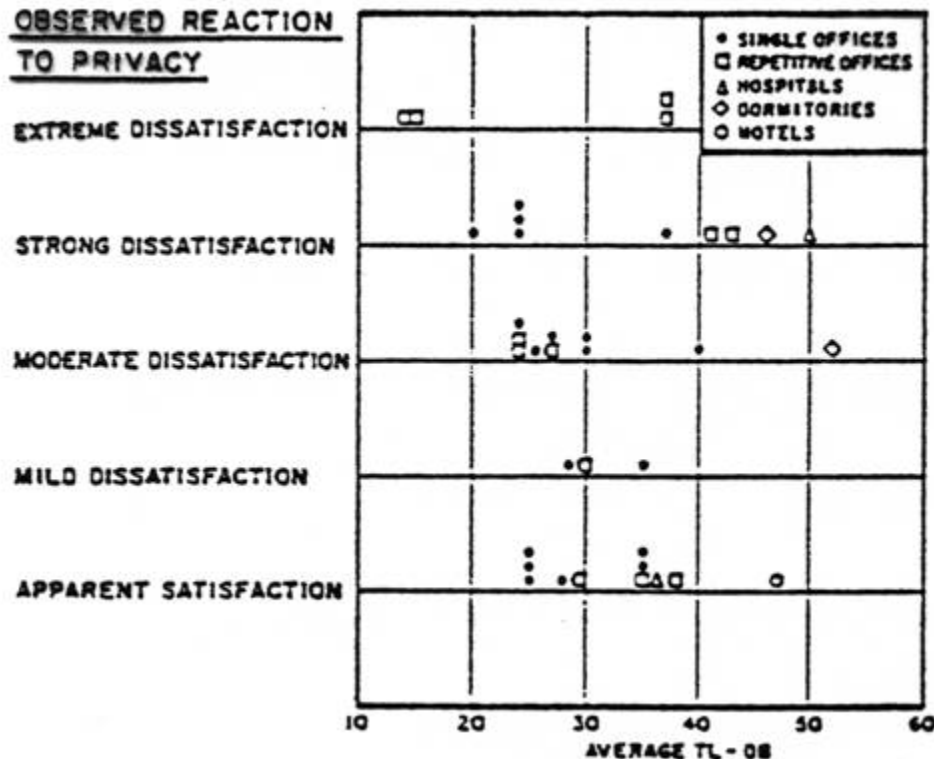
# 1950's background...the post WWII building boom

---



Enclosed offices, conventional partitioned scheme

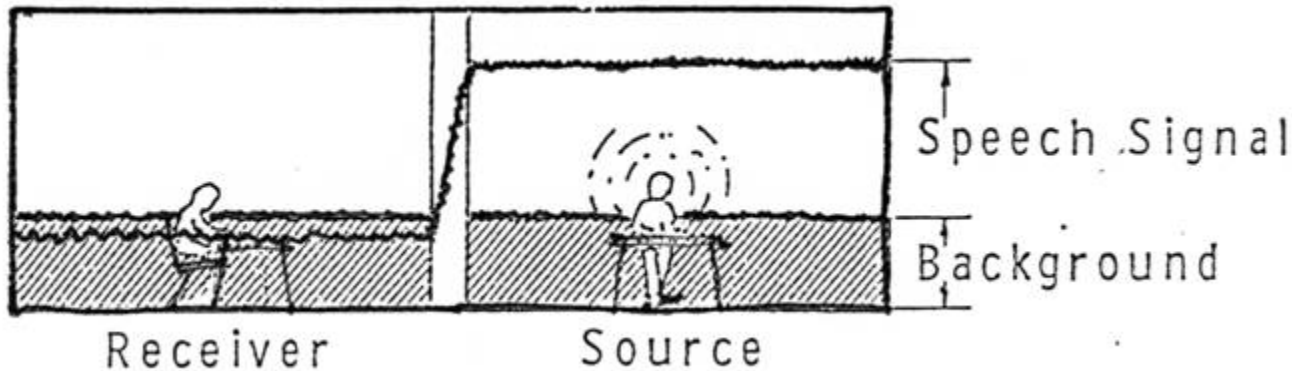
# Beginning a search for criteria for speech privacy in buildings



**Reference:** "Speech Privacy in Buildings". Cavanaugh, W.J.; Farrell, W.R.; Hirtle, P.W.; Waters, B.G. J. Acoust. Soc. Am., 1962 (CFHW-1962)

Plot of subjective reactions observed in 37 case histories of speech privacy versus the average TL rating of the isolating wall. For the most part, published average TL values were used; where the wall was flanked by other sound-transmission paths, measured values were used (CFHW-1962-Figure 1).

# The essential elements in speech privacy analysis between enclosed rooms

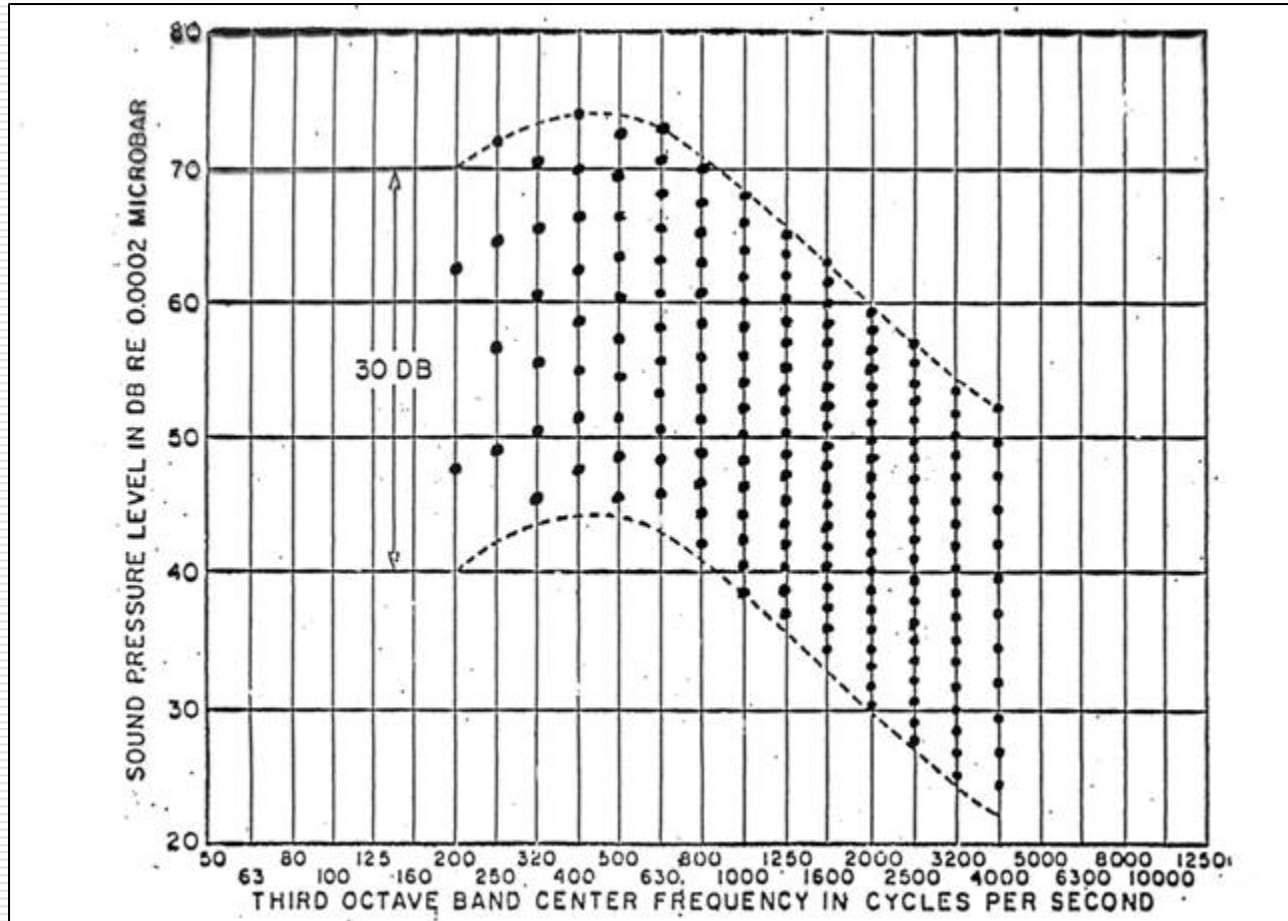


|                        | Approx. range (dB)         |
|------------------------|----------------------------|
| Speech effort          | 12 (Conv. → Raised → Loud) |
| Source room absorption | 10-15                      |
| Partition NR           | 20-50                      |
| Background ambient     | 30                         |
| Privacy requirement    | 6 (Normal → Confidential)  |

## Variables in the speech privacy between rooms

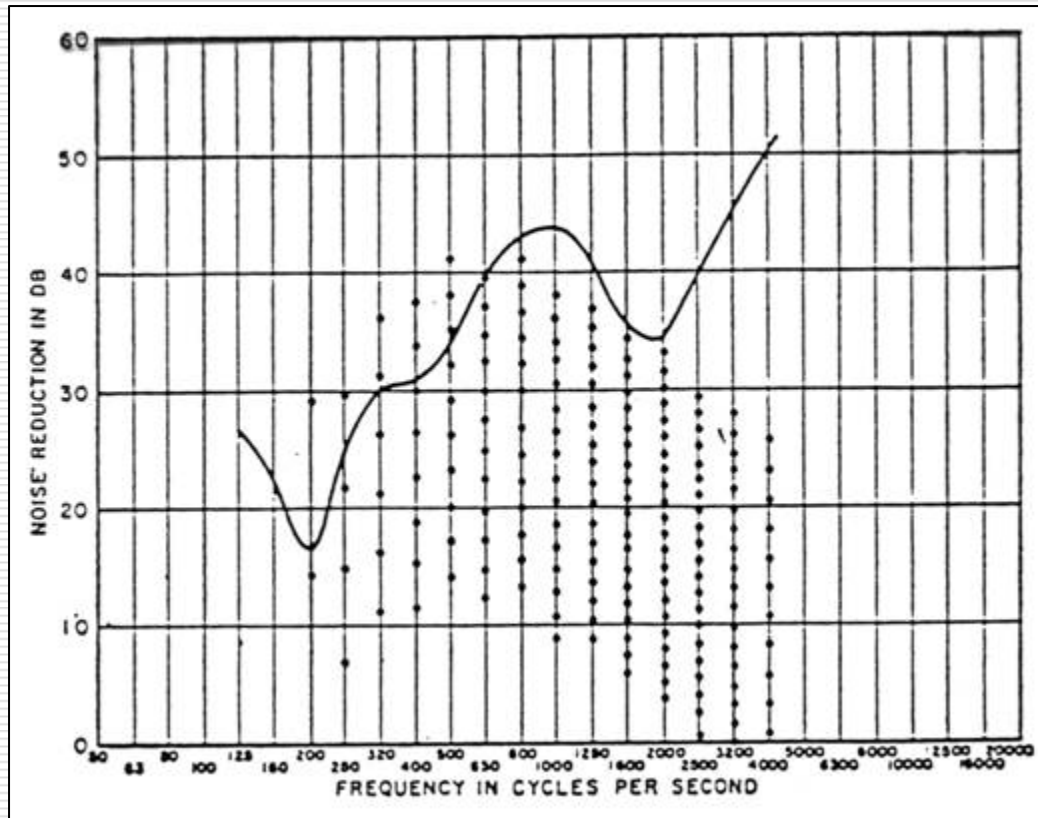
# The basic research on speech was already there....Bell Labs, Beranek & others

---



Visualizing the intelligibility of speech...normal speech in a 100 sabine room (CFHW-1962-Figure 5).

# A rating scheme for room-to-room partition NR

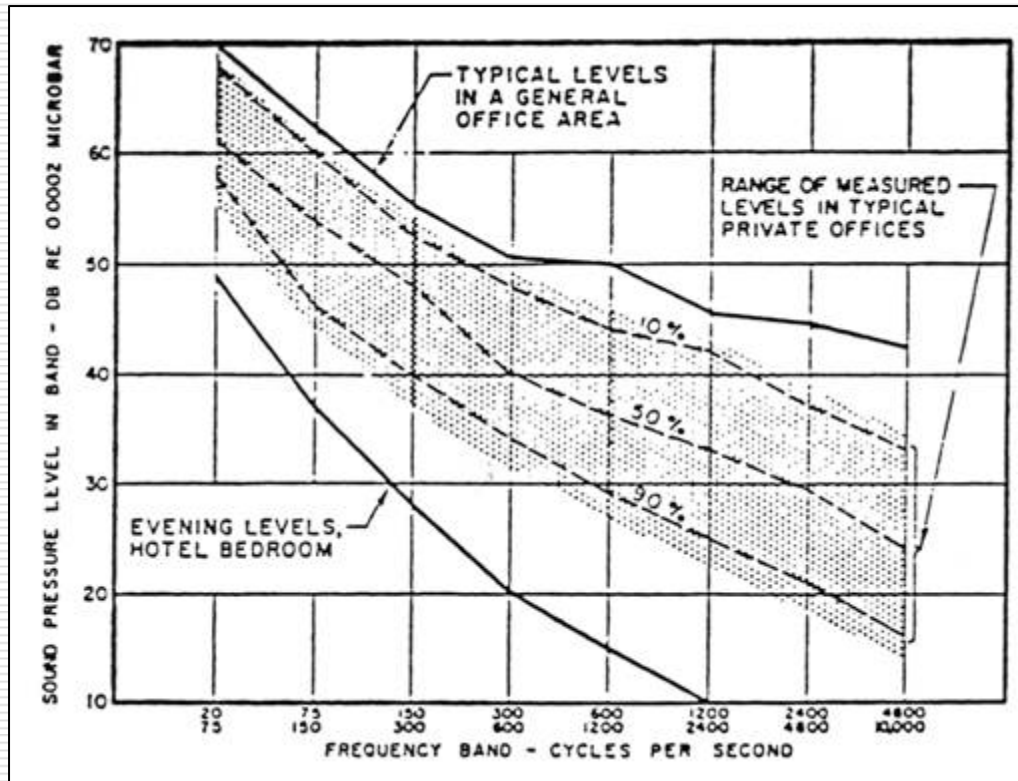


Measured NR of wall, 2 x 4 wood studs, gypsum lath, and ½-in. sand plaster. Superimposed dot field is for "N" background noise spectrum shape and has been adjusted so that 5% of dots lie above NR curve (CFHW-1962-Figure 16).



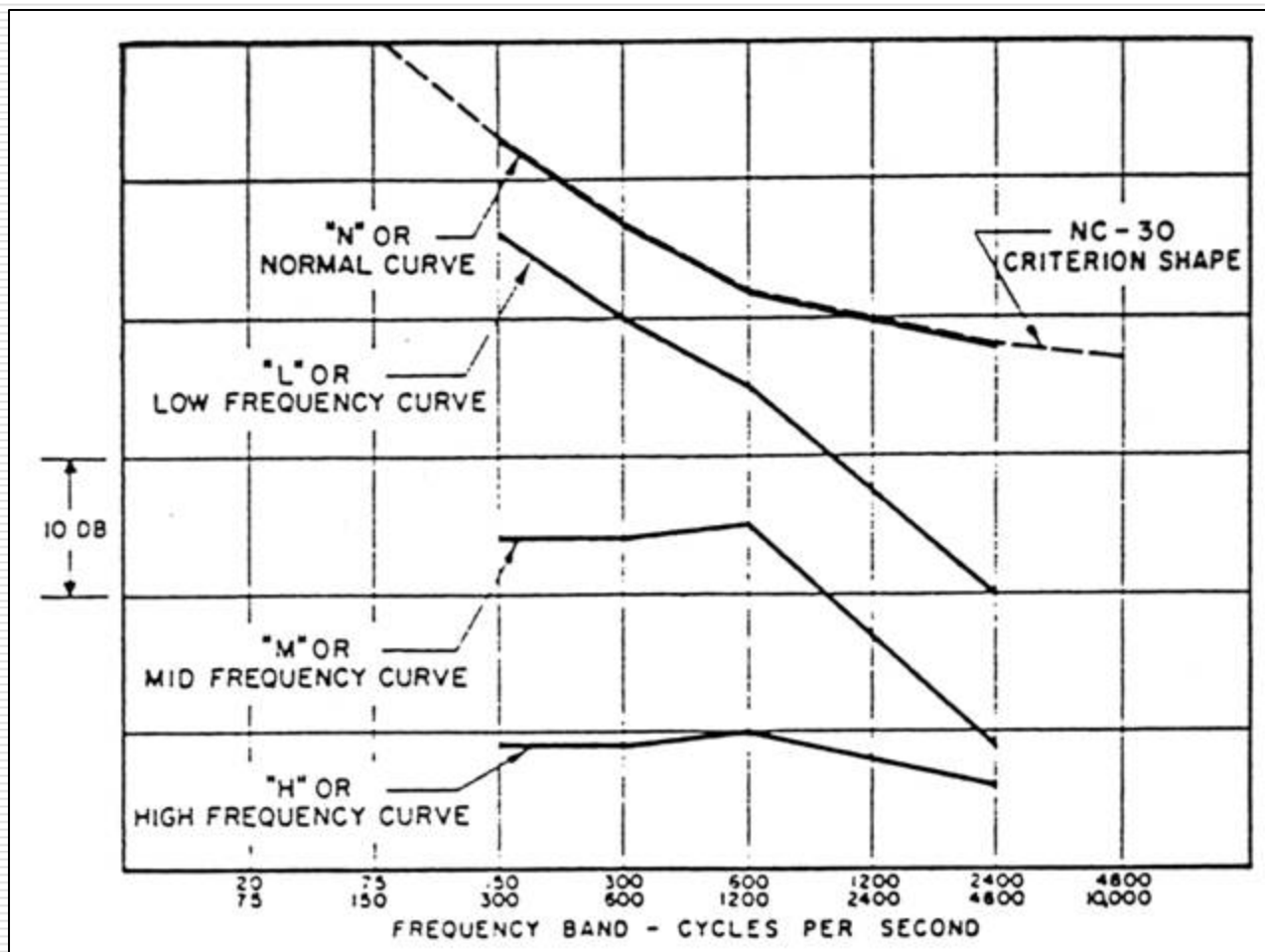
# Wide range of background levels in buildings

---



Steady background noise levels measured in spaces where speech privacy is important. The dashed lines represent measurements in 62 private offices in which there was no complaint about the noise. Octave band levels in the given percent of offices exceed the dashed contours shown (CFHW-1962-Figure 2).

# A rating scheme for background noise



Characteristic noise curves (CFHW-1962-Figure 14).

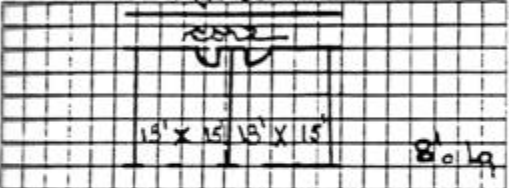


# The analysis scheme accounting for five significant variables

**SPEECH PRIVACY - CASE HISTORY WORKSHEET**

**DESCRIPTION OF SPACES**  
Professional Bldg -  
Lawyers Office  
Partition: wire studs, metal lath & plaster to ceiling  
Ceiling: AC tile on plaster on metal lath, continuous air diffuser slots 4' oc running @ 90° to partition

**PLAN**

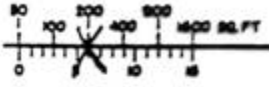
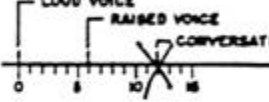
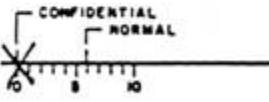


**OBSERVED REACTION TO BACKGROUND NOISE**

☐ DISSATISFACTION  
☒ APPARENT SATISFACTION

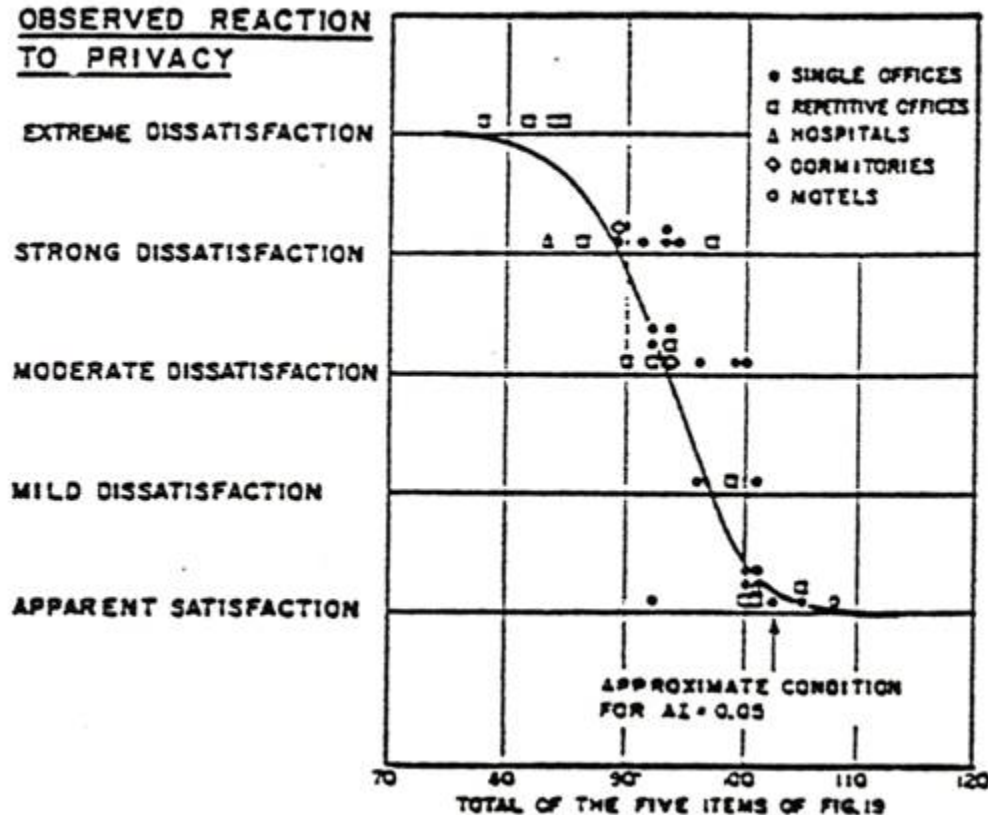
**OBSERVED REACTION TO PRIVACY**

☒ EXTREME DISSATISFACTION  
☐ STRONG DISSATISFACTION  
☐ MODERATE DISSATISFACTION  
☐ MILD DISSATISFACTION  
☐ APPARENT SATISFACTION

|   |   |   |
|---|---|---|
| <div style="border: 1px solid black; padding: 2px; display: inline-block;">1</div> SOURCE ROOM FLOOR AREA                         |     | <div style="border: 1px solid black; padding: 2px; display: inline-block;">6</div>    |
| <div style="border: 1px solid black; padding: 2px; display: inline-block;">2</div> SOURCE ROOM SPEECH USE                         |     | <div style="border: 1px solid black; padding: 2px; display: inline-block;">12</div>   |
| +   |   |   |
| <div style="border: 1px solid black; padding: 2px; display: inline-block;">3</div> MEASURED ADJACENT ROOM BACKGROUND NOISE RATING | <div style="border: 1px solid black; padding: 2px; display: inline-block;">N 25</div> |   |
| +   |   |   |
| <div style="border: 1px solid black; padding: 2px; display: inline-block;">4</div> MEASURED NOISE REDUCTION RATING                | <div style="border: 1px solid black; padding: 2px; display: inline-block;">N 38</div> |   |
| +   |   |   |
| <div style="border: 1px solid black; padding: 2px; display: inline-block;">5</div> PRIVACY REQUIREMENT                            |    | <div style="border: 1px solid black; padding: 2px; display: inline-block;">0</div>    |
| =   |   |   |
| TOTAL   |   | <div style="border: 1px solid black; padding: 2px; display: inline-block;">N 81</div> |

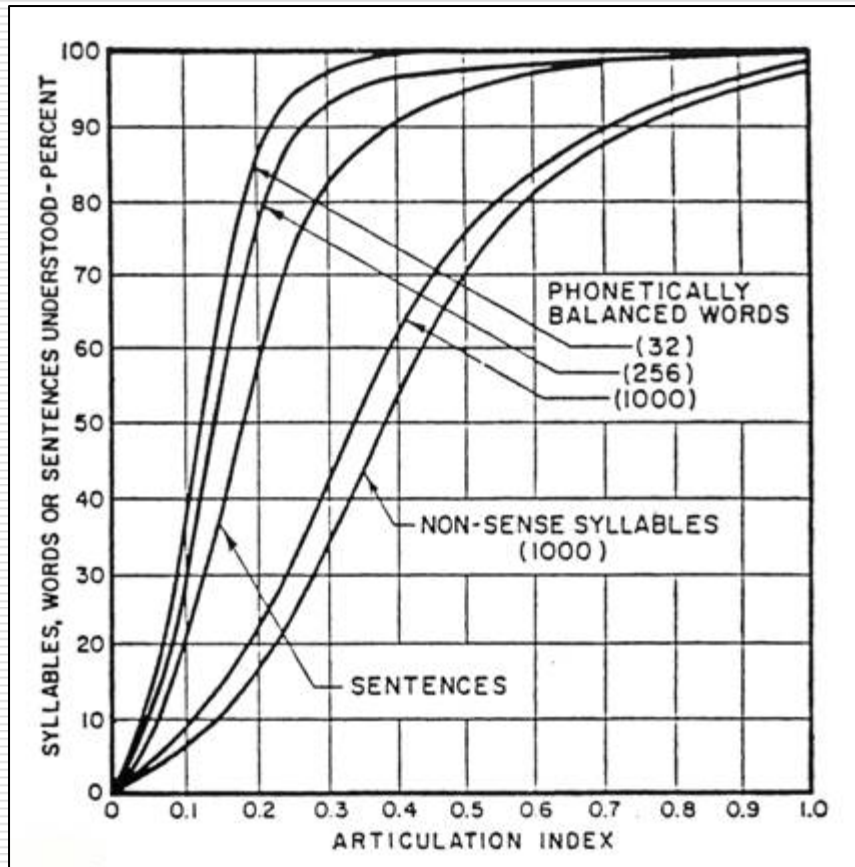
Worksheet for compiling case history data (CFHW-1962-Figure 19).

# Voilà! Correlation!



Plot of subjective reactions observed in 37 case histories versus the total rating computed from proposed rating scheme (CFHW-1962-Figure 20).

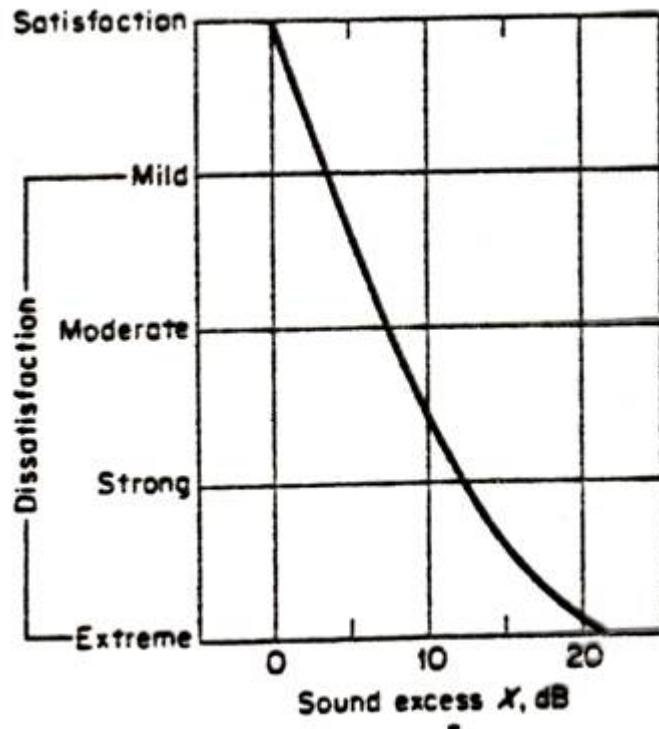
# Key finding: Relationship between articulation index and speech privacy



Approximate relationship between articulation index and intelligibility for skilled talkers and listeners. The numbers in parentheses give the size of the test vocabulary (CFHW-1962-Figure 6).

# Young's re-analysis of CFHW data

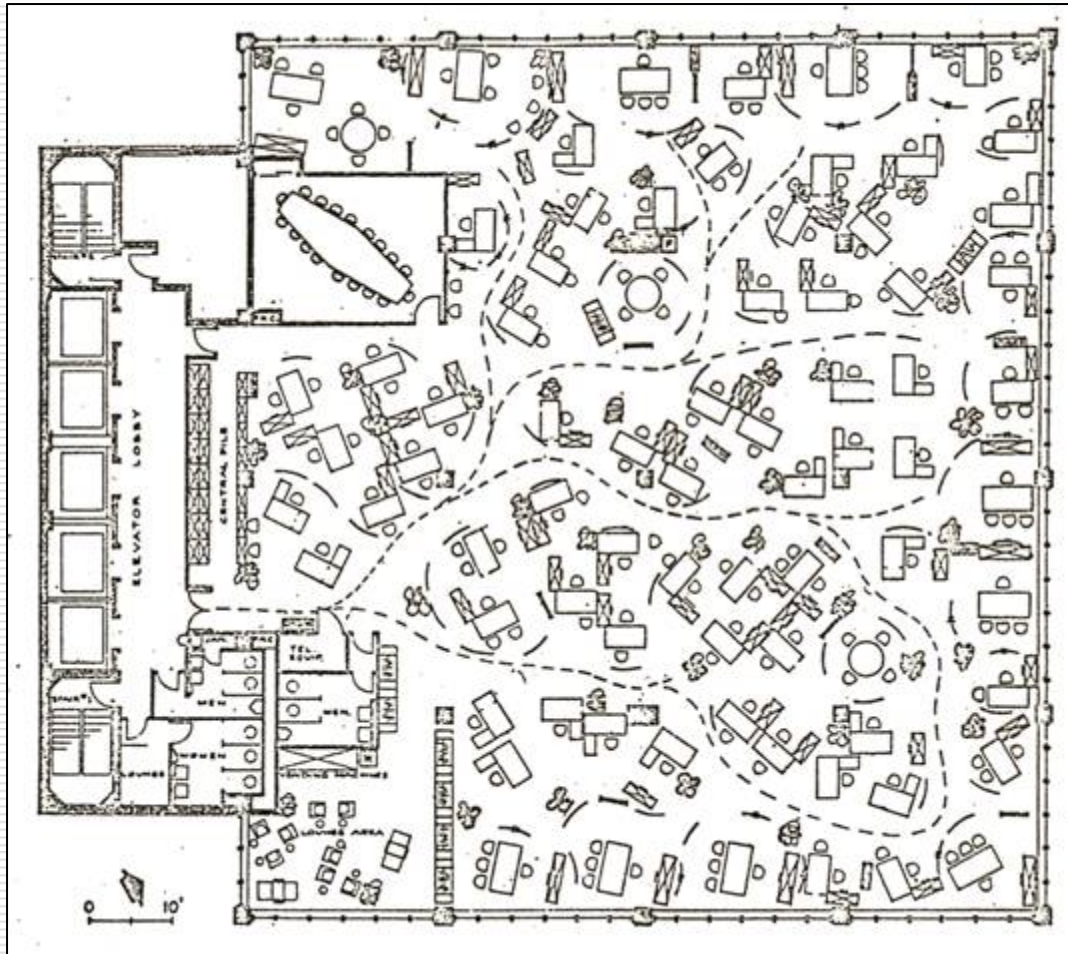
---



Simplified rating procedure using STC and A-weighted sound levels yields good correlation with CFHW results (R.W. Young. "Re-Vision of the Speech Privacy Calculation". J. Acoust. Soc. Am., Vol. 38, pp. 524-533. October, 1965).

# Here comes open plan!

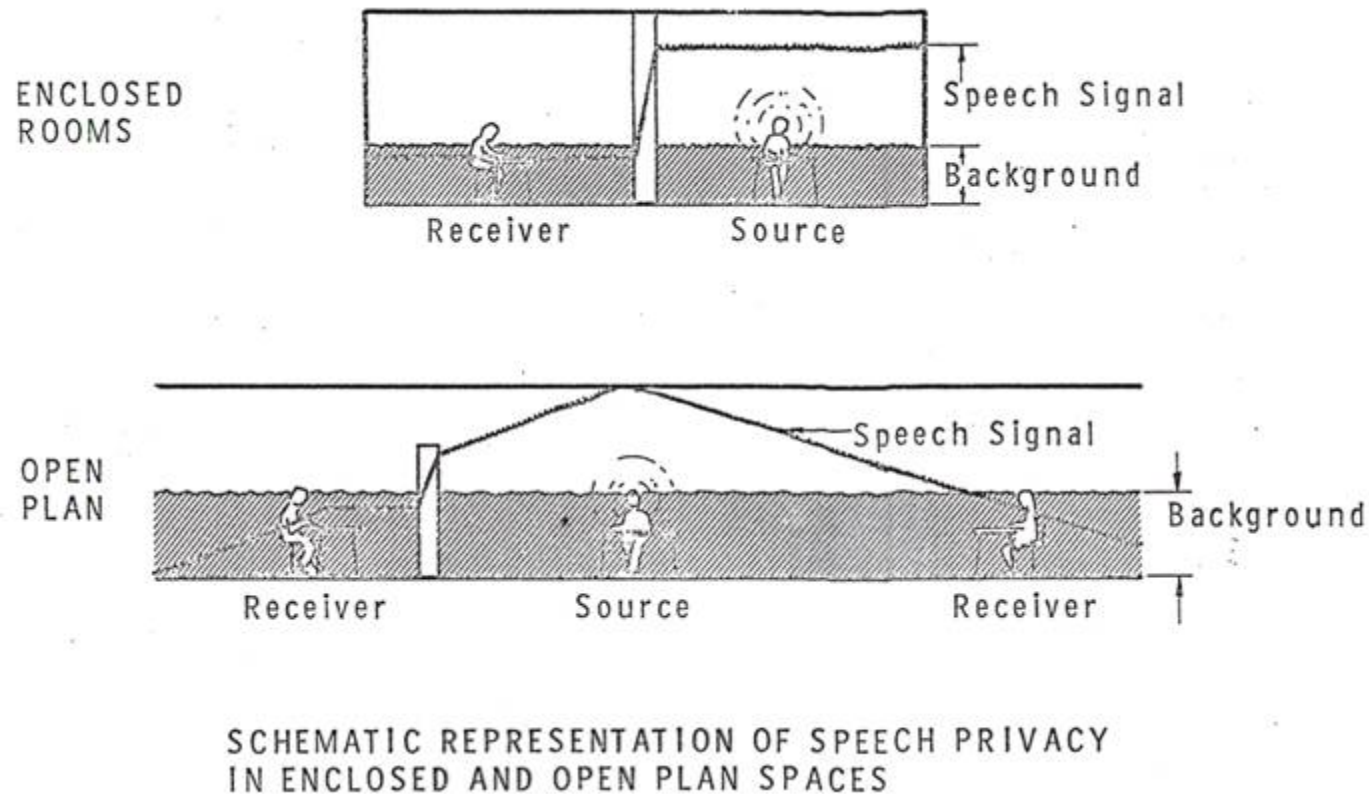
---



Burolandschaft (Office Landscape) layout, circa 1960



# Schematic comparison of open vs. enclosed planning



Schematic representation of speech privacy in enclosed and open plan spaces (HWC-1969-Figure 5).

(Reference: P.W. Hirtle, B.G. Waters and W.J. Cavanaugh, 77<sup>th</sup> ASA, April 1969 (unpublished))



# Open plan speech privacy analysis

① SPEECH EFFORT

Loud                      Raised                      Normal                      Low

0                      6                      12                      18

---

② DISTANCE - SOURCE TO LISTENER

3'    6'    12'    25'    50'    100'    200'

|                    |    |    |    |    |    |    |    |
|--------------------|----|----|----|----|----|----|----|
| Hard Flr. and Clg. | 25 | 28 | 31 | 34 | 37 | 40 | 43 |
| Carpet Only        | 25 | 29 | 33 | 37 | 41 | 45 | 49 |
| AC. Tile Only      | 25 | 30 | 35 | 40 | 45 | 50 | 55 |
| Carpet and Tile    | 25 | 31 | 37 | 43 | 49 | 55 | 61 |

---

③ BARRIER

Barrier Height  
(Assumes  $\alpha_{Clg.} = 0.75$ )

|    |    |    |   |   |   |   |   |
|----|----|----|---|---|---|---|---|
| 0' | 0  | 0  | 0 | 0 | 0 | 0 | 0 |
| 1' | 11 | 7  | 4 | 2 | 0 | 0 | 0 |
| 2' | 14 | 10 | 7 | 4 | 3 | 2 | 1 |
| 3' | 15 | 11 | 8 | 5 | 4 | 3 | 2 |
| 4' | 16 | 12 | 9 | 6 | 5 | 4 | 3 |

---

④ BACKGROUND NOISE RATING

If L or M use rating  
If N or H use rating +5

---

⑤ PRIVACY AND/OR COMMUNICATION REQUIREMENT

Confidential                      Normal

0                      6                      12                      18

Privacy ←                      → Communication

---

TOTAL

---

Worksheet for open plan case histories (HWC-1969-Figure 7).

# Summary of open plan case history data

| Type of Space and Use                     | Speech Effort | Distance and Room Treatment | Barrier | Bkgd. Noise Rating | Privacy or Communication Requirement | TOTAL RATING | Observed Reaction and Comments |
|---|---------------|-----------------------------|---------|--------------------|--------------------------------------|--------------|--------------------------------|
| 1. Bank Loan Dep't - New Bldg.            | 12            | 37                          | -       | 40                 | 6                                    | 95           | Unsatisfactory                 |
| 2. Bank Loan Dep't - Old Bldg.            | 12            | 37                          | -       | 46                 | 6                                    | 101          | Satisfactory                   |
| 3. Industrial Office                      | 12            | 35                          | -       | 37                 | 6                                    | 90           | Unsatisfactory                 |
| 4. Industrial Design and Drafting Dep't   | 12            | 35                          | -       | 50                 | 6                                    | 103          | Satisfactory                   |
| 5. Bank Trust Office Area                 | 12            | 47                          | -       | 28                 | 0                                    | 87           | Unsatisfactory                 |
| 6. Bank Trust Office Area w/ Elect. Bkgd. | 12            | 47                          | -       | 42                 | 0                                    | 101          | Satisfactory                   |
| 7. Industrial Office Area                 | 12            | 32                          | -       | 53                 | 6                                    | 103          | Satisfactory                   |
| 8. Office Landscape                       | (18)          | 37                          | -       | 38                 | 6                                    | 99           | Marginal                       |
| 9. Open Plan Elementary School            |               |                             |         |                    |                                      |              |                                |
| a. Privacy                                | 12            | 38                          | -       | 40                 | 6                                    | 96           | Unsatisfactory                 |
| b. Communication                          | 12            | 36                          | -       | 40                 | (15)                                 | 103          | Satisfactory                   |

Summary of 9 open plan case histories, including schools (HWC-1969-Figure 8).

# Some limitations of simplified rating analysis techniques & need for further research

---

- Insensitivity of simplified ratings to large dips in TL or background spectra.
- Source spectral variations from idealized.
- Component performance below 125 Hz.
- Field vs. lab performance, flanking, etc.
- Variations in occupant expectations
- Cultural and language differences

# Speech Privacy Goals & Metrics

| Privacy Goal       | AI<br>Articulation<br>Index    | PI<br>Privacy<br>Index | STI<br>Sound<br>Transmission<br>Index | SII<br>Speech<br>Intelligibility<br>Index |
|--------------------|--------------------------------|------------------------|---------------------------------------|---|
| <b>Closed Plan</b> |                                |                        |                                       |   |
| Normal             | $\leq 0.15$                    | $\geq 85\%$            | $\leq 0.19$                           | $\leq 0.20$                               |
| Confidential       | $\leq 0.05$                    | $\geq 95\%$            | $\leq 0.12$                           | $\leq 0.10$                               |
| Secure             | Special consideration required |                        |                                       | →   |
| <b>Open Plan</b>   |                                |                        |                                       |   |
| Normal             | $\leq 0.20$                    | $\geq 80\%$            | $\leq 0.23$                           | $\leq 0.25$                               |
| Confidential       | Special consideration required |                        |                                       | →   |

**Reference:** "Interim Sound and Vibration Design Guidelines for Hospital and Healthcare Facilities (Public Draft 1.1, November 28, 2007)".  
Facilities Guidelines Institute.

# Typical speech privacy worksheet: enclosed spaces

**Anticipated response to privacy situation**

Apparent satisfaction

Mild dissatisfaction

Moderate dissatisfaction

Strong dissatisfaction

Serious dissatisfaction

Speech privacy rating number

NOTE: Curve shows average response of people to intruding speech based on rating number figured below.

Speech rating

- Speech effort – how people talk in source room
- Source room floor area ( $A_1$ ) – approximates effect of source room absorption
- Privacy allowance – degree of privacy desired

Loud      Raised      Conversational

72      65      60

125    250    500    1000 (sq ft)

10      6      3      0

Confidential      Normal

15      9

Examples

A.      B.      C.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Isolation rating

- Sound transmission class (STC) – accounts for transmission loss of common barrier
- Noise reduction factor ( $A_2/S$ ) – approximates effect of receiving room sound absorption and common barrier size
- Adjacent room background noise level (dBA) – masking sound available

1      5      10 (unitless)

0    2    3    4    5    6    7    8

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Speech privacy rating number

Find speech privacy rating number by subtracting isolation rating total from speech rating total. Then use graph at top of sheet to predict degree of satisfaction.

● Speech rating total

\_\_\_\_\_

● Isolation rating total

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

A. \_\_\_\_\_

B. \_\_\_\_\_

C. \_\_\_\_\_

# Typical speech privacy worksheet: open plan spaces

**Anticipated response to privacy situation**

Apparent satisfaction

Mild dissatisfaction

Moderate dissatisfaction

Strong dissatisfaction

Serious dissatisfaction

Speech privacy rating number

0 5 10 15 20

Source or listener

Barrier

Height

Acoustical "line of sight"

Source or listener

Distance D (ft.)

**Speech rating**

1. **Speech effort** – how people talk in room.

2. **Privacy allowance** – degree of privacy desired.

**Isolation rating**

3. **Distance from source to listener** – Table approximates effect of room sound absorption and sound level falloff with distance (D) from source to listener.

Room finishes

Ceiling

Floor

Reflecting

Reflecting

Reflecting

Absorbing

Absorbing

Absorbing

Absorbing

Distance D, ft.

3 6 12 25 50 100

0 3 6 9 12 15

0 4 8 12 16 20

0 5 10 15 20 25

0 6 12 18 24 30

4. **Partial** – height barrier – Table accounts for attenuation from barrier with ceiling absorption based on NRC of 0.75. Barrier width should be at least twice its total height.

Barrier height H – Portion above acoustical "line-of-sight" in feet.

Distance D, ft.

3 6 12 25 50 100

11 7 4 2 0 0

14 10 7 4 3 2

15 11 8 5 4 3

16 12 9 6 5 4

5. **Room background noise level** (dBA) – Masking sound available.

**Speech privacy rating number**

Find speech privacy rating number by subtracting isolation rating total from speech rating total. Satisfactory conditions are anticipated when speech privacy rating number is 0 or less. (Use graph on p. 108 to assess approx. degrees of satisfaction.)

A.

B.

C.