Effective Room Air Distribution

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KRUEGER
Excellence in Air Distribution

Where We Are Today:

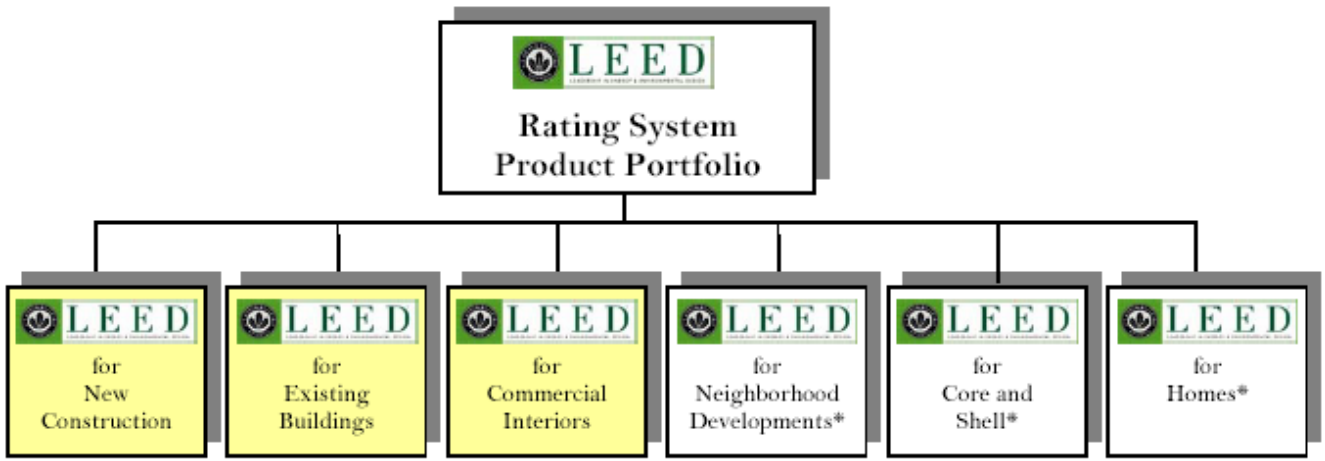
ERAD

Agenda

- Overview
- LEED issues and Update
- Diffuser Selection
- Perimeter
- Acoustics
- Thermal Comfort
- IAQ / Standard 62.1 Update
- Summary

LEED:

Leadership in Energy Efficient Design



*Under development as of November 2004

LEED:

- In V2.2, in order to get ANY LEED points, one must fully meet the VRP requirements of ASHRAE Standards 62.1 (Ventilation)
- Standard 55 (Comfort), is worth up to two points.
- Ventilation points are gained by increased ventilation

Environmental Acceptance Factors

Air Distribution

Comfort

Acoustics

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Air Distribution Device Selection Guidelines

Design Issues:

- •Diffuser Selection
- •Perimeter
- •Thermal Comfort
- •Acoustics
- •Ventilation & IAQ

- The ASHRAE fundamentals handbook, chapter 33, provides guidance on diffuser selection.
- Select a unit with throw at max, and minimum, flow that meets ADPI guidelines based on diffuser spacing and T_{50} (throw to 50 fpm).
- Additionally, select for maximum mixing:
  - Noise can be good.
  - Dirt on the ceiling is not bad.
- Air Distribution Effectiveness (ADE) is a new term describing room air mixing.

ADE (Ez)

- Air Distribution Effectiveness replaces “ventilation efficiency” and other terms.
- Older ASHRAE 62-99 minimum outside air quantities were based on an $E_z = 1$.
- Tests using ASHRAE 129 show that with ceiling cooling systems, E_z always = 1.
- Heating system performance, however, can reduce E_z to less than 70% (as low as 20%).
- Current Std 62.1 (2007) wording sets E_z = 0.8 when heating when ‘rules’ not followed.

Design Issues:

- •Diffuser Selection
- •Perimeter
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- •Acoustics
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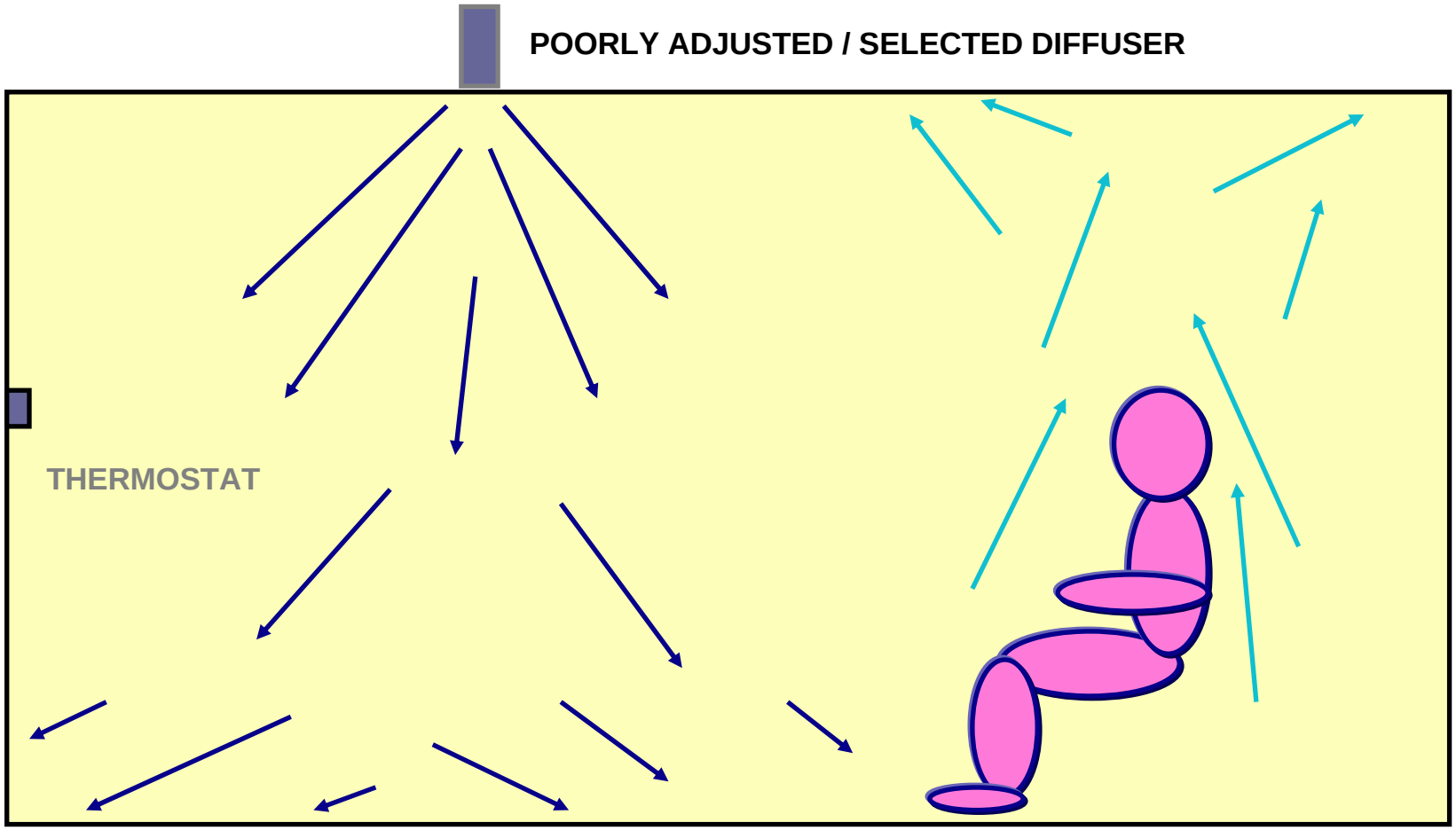
Air Distribution, Poor Pattern Example



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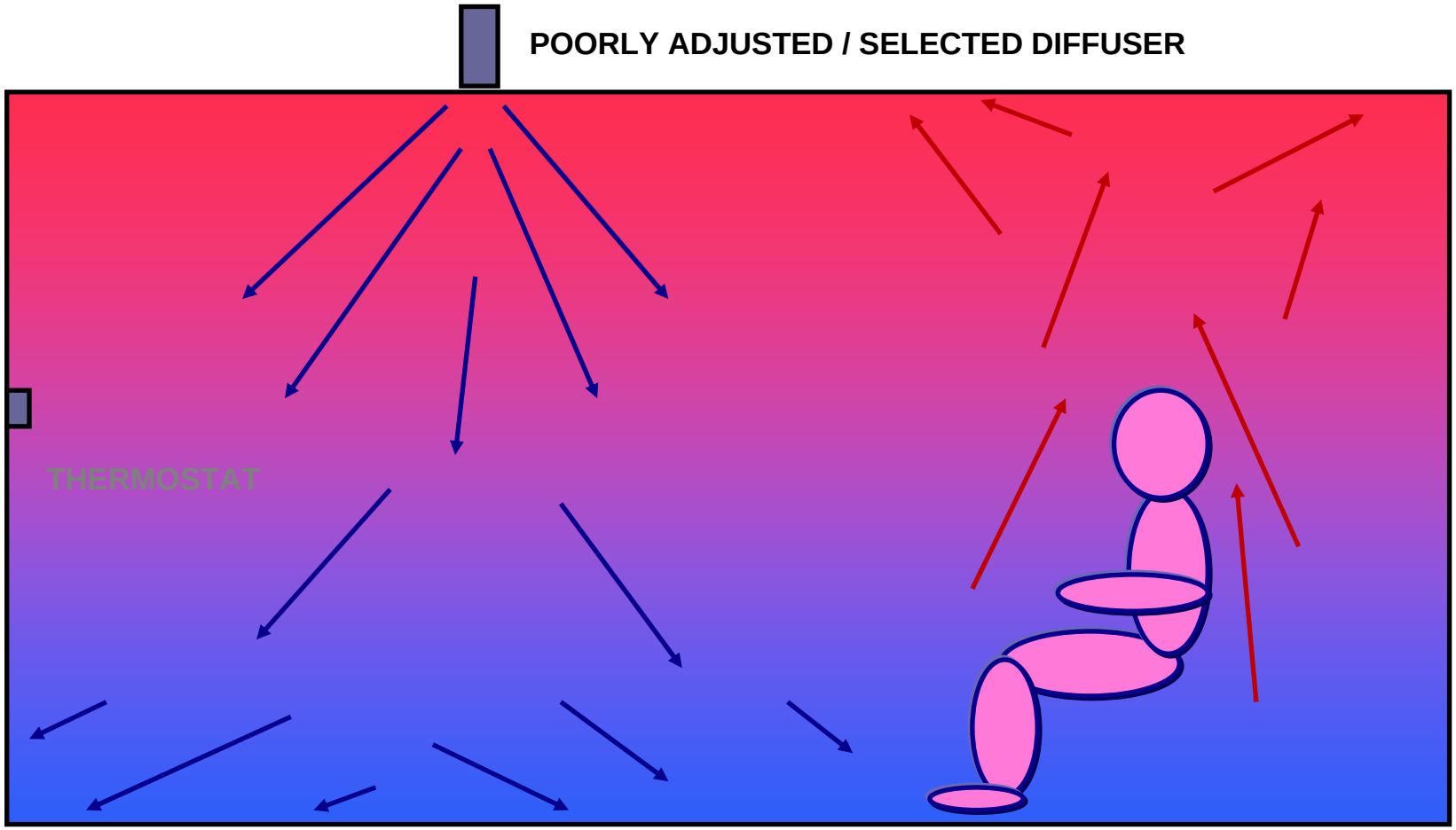
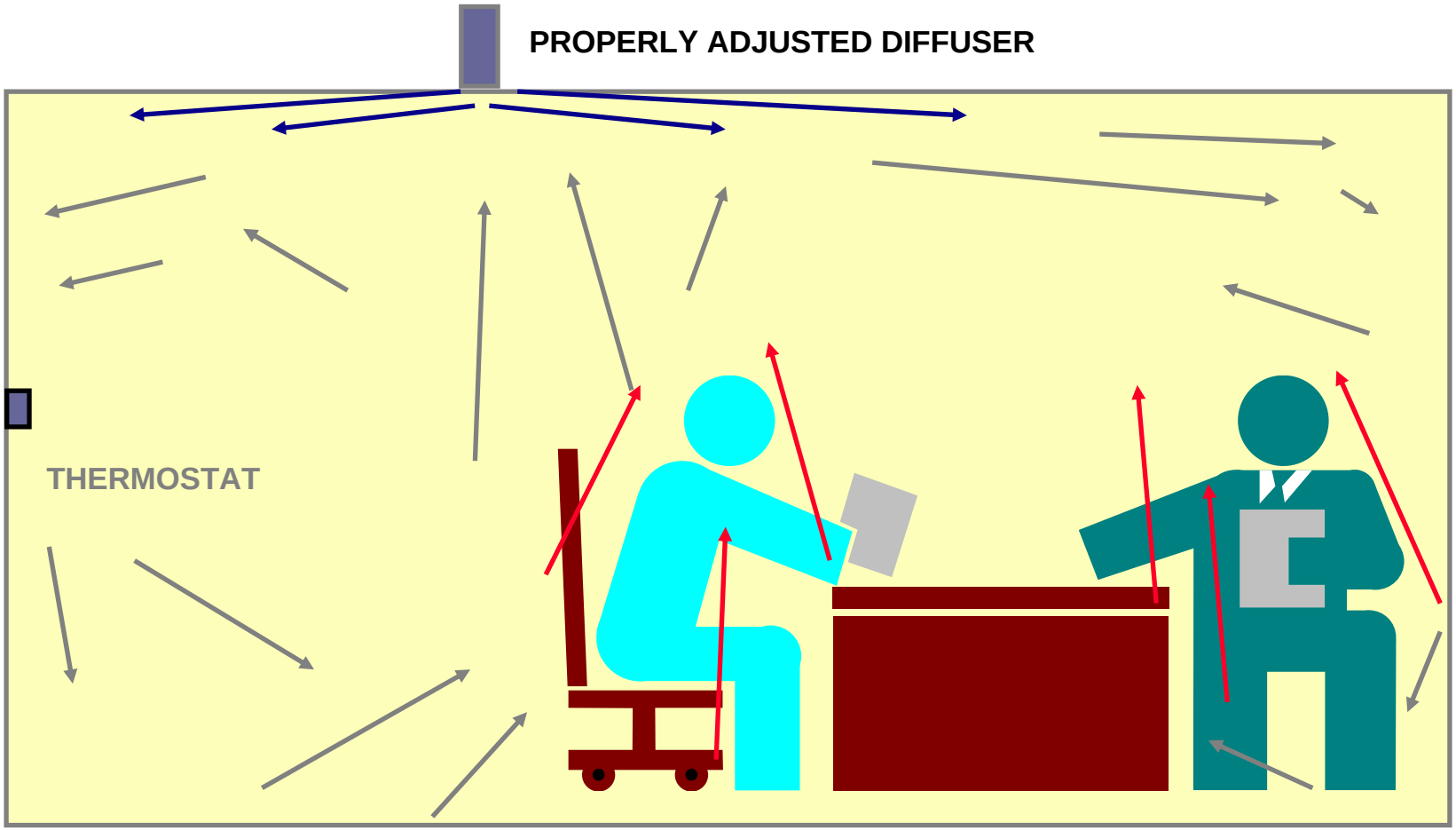


Good Pattern Example



ASHRAE Fundamentals, Chapter 33, Table 4

- ADPI selection using T_{50} / L was developed at KSU in the '60s.
- A relationship was found between isothermal throw and cooling throw, and built into the selection charts included in ASHRAE Fundamentals, Chapter 33, table 4.

Table 4 Air Diffusion Performance Index (ADPI) Selection Guide

Terminal Device	Room Load, Btu/h·ft²	T_{50}/L for Maximum ADPI	Maximum ADPI	For ADPI Greater than	Range of T_{50}/L
High sidewall grilles	80	1.8	68	—	—
	60	1.8	72	70	1.5–2.2
	40	1.6	78	70	1.2–2.3
	20	1.5	85	80	1.0–1.9
Circular ceiling diffusers	80	0.8	76	70	0.7–1.3
	60	0.8	83	80	0.7–1.2
	40	0.8	88	80	0.5–1.5
	20	0.8	93	90	0.7–1.3
Sill grille, straight vanes	80	1.7	61	60	1.5–1.7
	60	1.7	72	70	1.4–1.7
	40	1.3	86	80	1.2–1.8
	20	0.9	95	90	0.8–1.3
Sill grille, spread vanes	80	0.7	94	90	0.6–1.5
	60	0.7	94	80	0.6–1.7
	40	0.7	94	—	—
	20	0.7	94	—	—
Ceiling slot diffusers (for T_{100}/L)	80	0.3	85	80	0.3–0.7
	60	0.3	88	80	0.3–0.8
	40	0.3	91	80	0.3–1.1
	20	0.3	92	80	0.3–1.5
Light troffer diffusers	60	2.5	86	80	<3.8
	40	1.0	92	90	<3.0
	20	1.0	95	90	<4.5
Perforated, louvered ceiling diffusers	11–50	2.0	96	90	1.4–2.7
				80	1.0–3.4

ASHRAE Journal, 2004

Design Issues:

- **Diffuser Selection**
- **Perimeter**
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- **Ventilation & IAQ**

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Protection Against Liability For Poor Diffuser Selection

By Daniel Int-Hout III, Member ASHRAE

The manner of achieving an acceptable Air Diffusion Performance Index (ADPI) has been well understood for more than 20 years. Unfortunately, complaints of discomfort abound. It is not uncommon for building occupants who work in the same space to complain that they are "too hot" and "too cold."

Many unconventional designs and new technologies have been used to correct this apparent problem, including displacement ventilation, underfloor pressurized plenum air distribution, occupant task conditioning systems, etc. While all of these strategies assume that conventional overhead air distribution is unable to provide acceptable environments, this appears to be a false premise.

According to data and to technical papers as early as 1976, given a properly selected set of overhead ceiling diffusers, and an HVAC supply system capable of meeting the loads in the space, it is possible to devise a system of either VAV or constant volume air distribution than can respond to variations in localized loads from 20% to 100% of designed maximum loads at a variation in space temperature that most occupants will not notice.[1] This same system also will provide a ventilation effectiveness of 100% (all the ventilation air supplied at the ceiling will be delivered to the occupants). Heating performance with ceiling located diffusers also is well documented.

Int-Hout

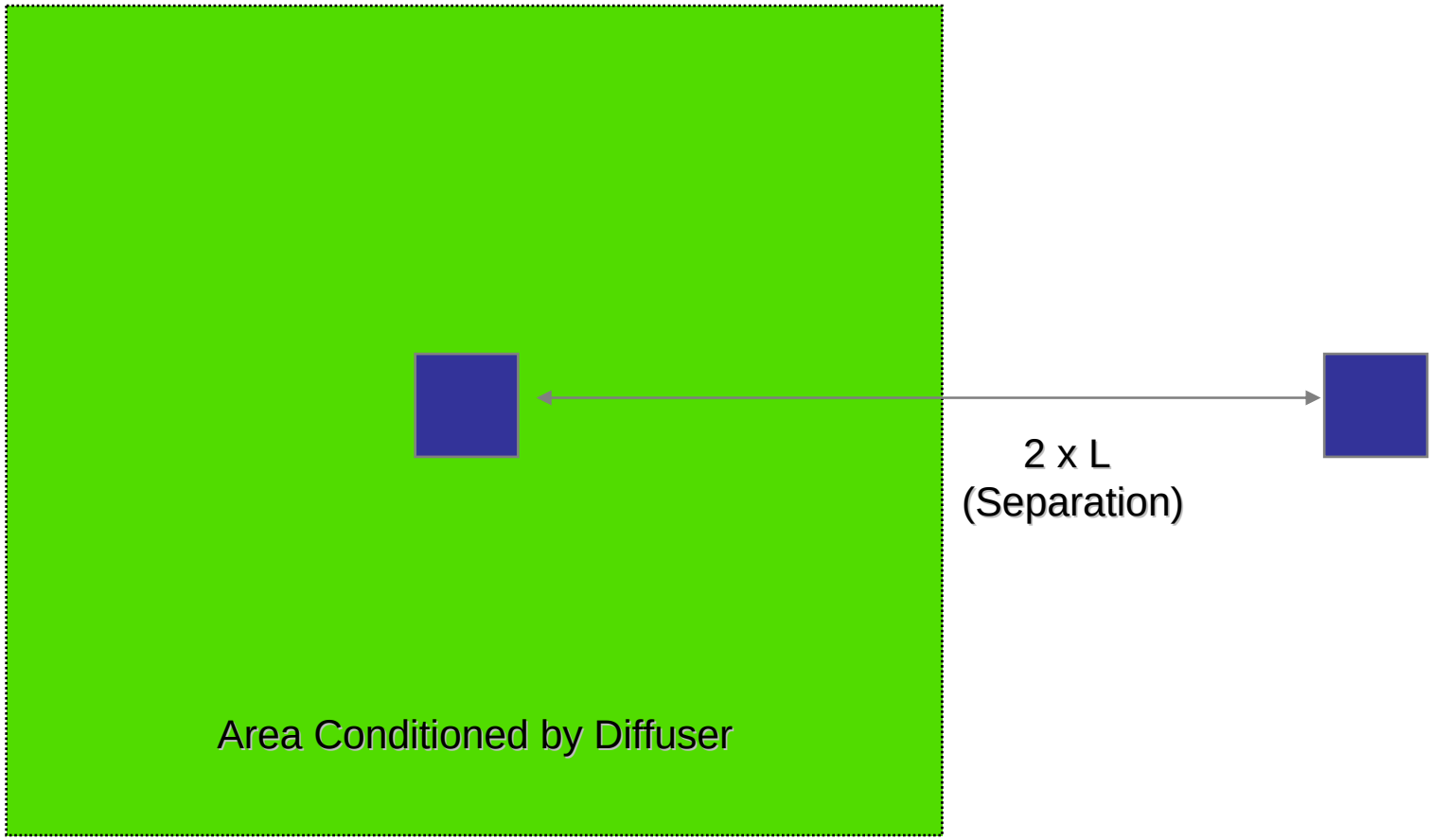
So why are building occupants complaining they're uncomfortable? The likely culprit is improper diffuser selection,[2] which can lead to a number of problems. The first is "dumping." At low airflows, diffuser velocities may not be high enough to create the "Coanda effect" necessary to overcome the negative buoyancy of the cold air being discharged. This causes cold air to drop into the space. As a result, it's cold under the diffuser, warm at the midpoint between diffusers, and cold air puddles at the floor creating a vertical stratification in the space. Another problem occurs at very high airflows. Jets collide at the midpoint between diffusers, causing cold airstreams to drop into the space (where it was hot earlier). The increased induction at the recently cold spot under the diffuser now creates an upflow, warming that location.[3]

At the perimeter (where closed executive offices often are located) even worse things can happen. In winter, air is being discharged at 15% of cooling velocities at discharge temperatures of 105°F (41°C).[4] Since the warm jet has too much buoyancy and too little projection to mix with cold air that will spill down the window, there will be an 8°F to 10°F (4.4°C to 5.6°C) temperature difference between 6 in. and 6 ft (0.1 m and 1.8 m) from the floor in the middle of the room (contrary to the minimum requirements of ASHRAE Standard 55, *Thermal Environmental Conditions for Human Occupancy*). In summer, heat rising from the window stratifies at the ceiling. Cold air from the diffuser, which is often set to blow down,[5] stratifies at the floor. In both cases, at 43 in. (1.1 m) above the floor, where the thermostat is located, it is 75°F (24°C).

Problems like these can lead to liability and exposure. Here are just a few examples. In a Baltimore condominium complex with two-story living rooms, the designer supplied air from the ceiling. Since the air was too hot in cold weather, it stratified at the ceiling, resulting in a temperature of 50°F (10°C) at the ankles and 80°F (27°C) at the head. The condominium owners sued the engineer. The case was eventually settled, but not until after the engineer incurred fees and costs for attorneys and experts. A similar problem occurred in a one-story bank in Pennsylvania. This time, the case went to trial and the jury returned a sizeable verdict against the engineer. The expert witness fees alone exceeded the amount in issue in the lawsuit.

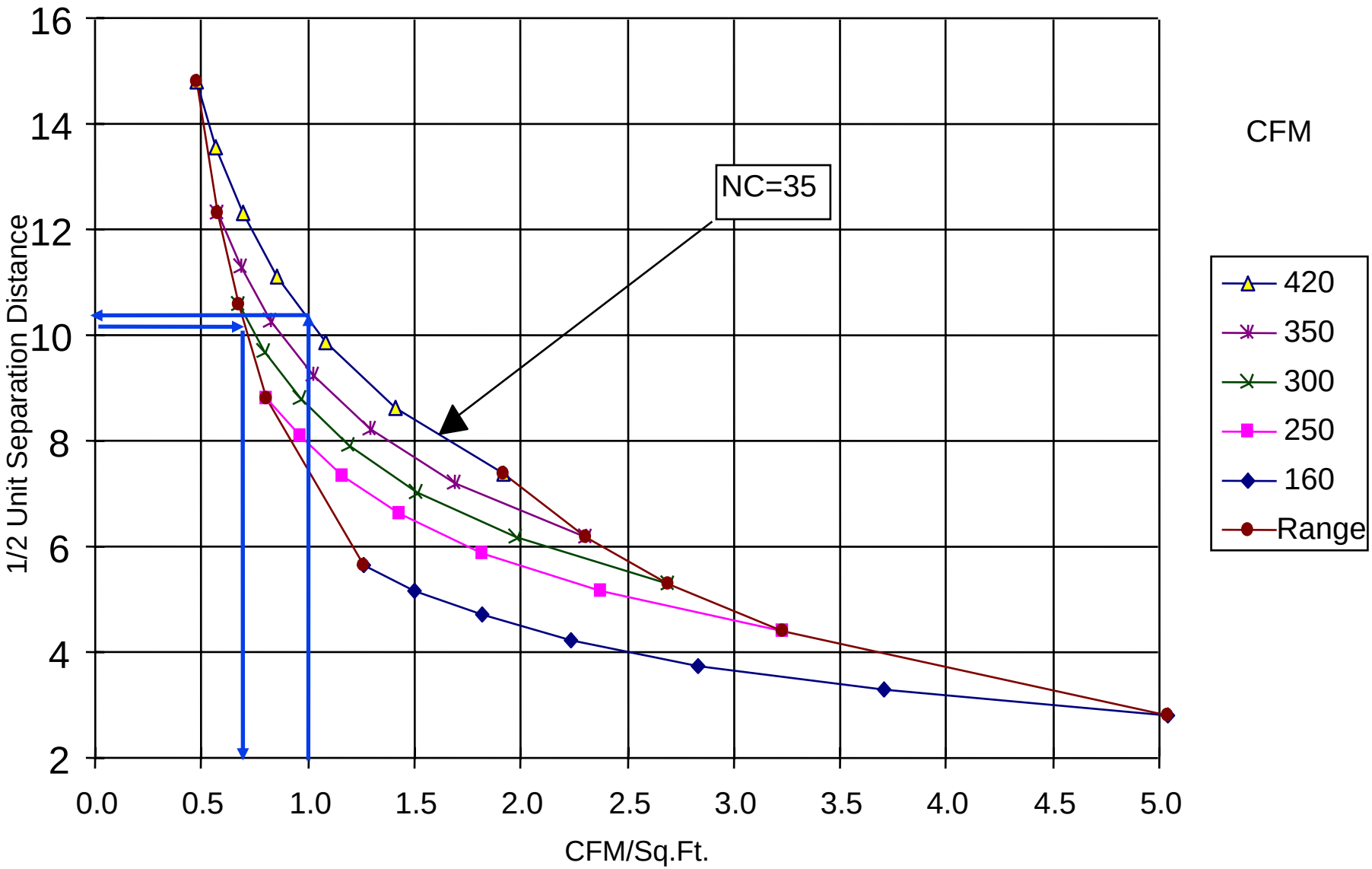
Improper diffuser selection can also lead to problems for owners. For example, in an office building in New Jersey, a tenant successfully broke its lease after complaining about comfort problems relating to ceiling diffusers. Indeed, according to the Building Owners and Managers Association, thermal comfort related issues (often misdiagnosed as IAQ problems) were the No. 1 reason for non-renewal of leases in 2002.

4-way Diffuser Selection

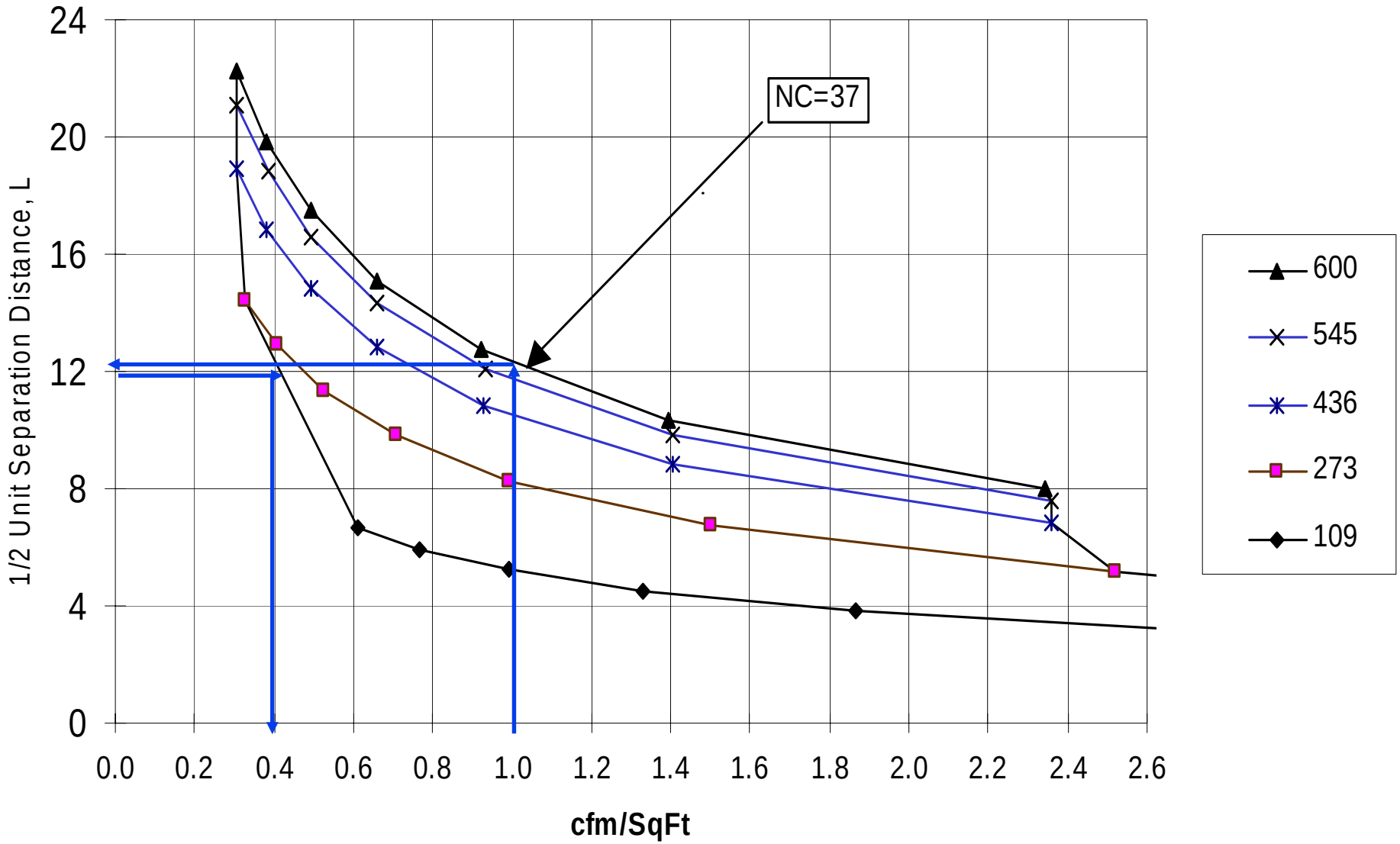


Perforated 24X24, 10” inlet, 4 way, 20° Delta-T

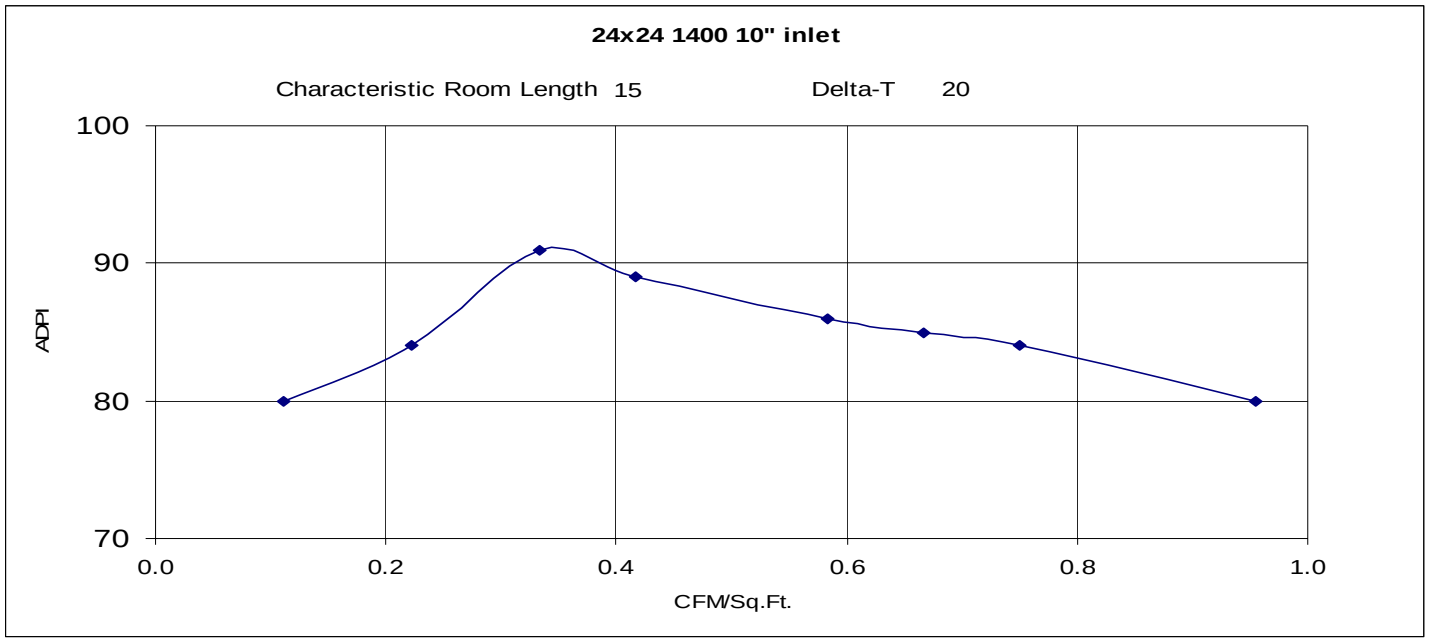
Spacing for 80% ADPI



Retrofit Diffuser, 24x24, 10” inlet, 4-way, 20º Delta-T
Spacing for 80% ADPI



ADPI and LEED



V 2.2 LEED-NC Credit 7.1 may be awarded for complying with ASHRAE Standard 55-2004. This Standard limits vertical temperature stratification, within the occupied zone, to be no greater than 5^{o} F. Assuring an ADPI no less than 80% will comply with this requirement.

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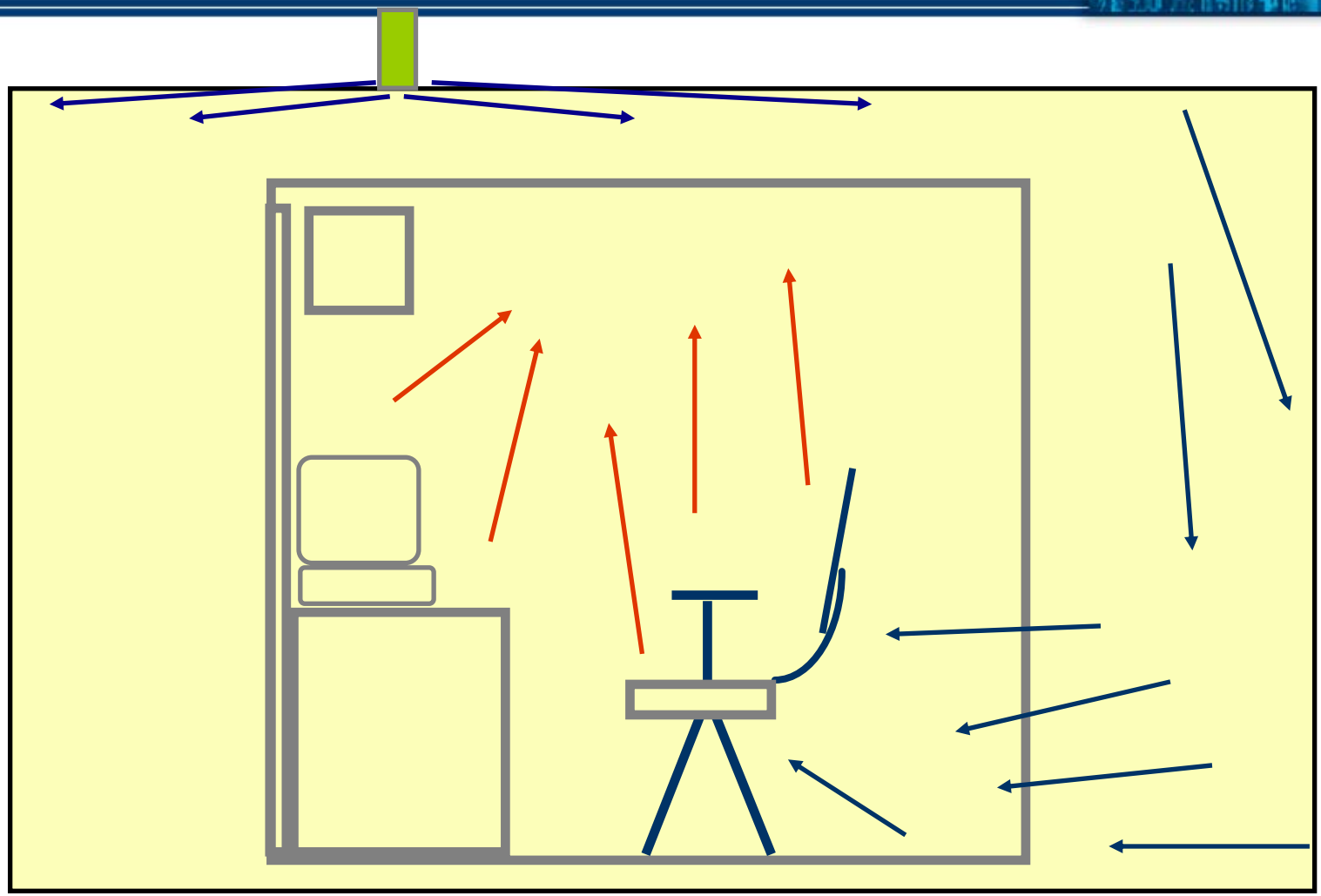
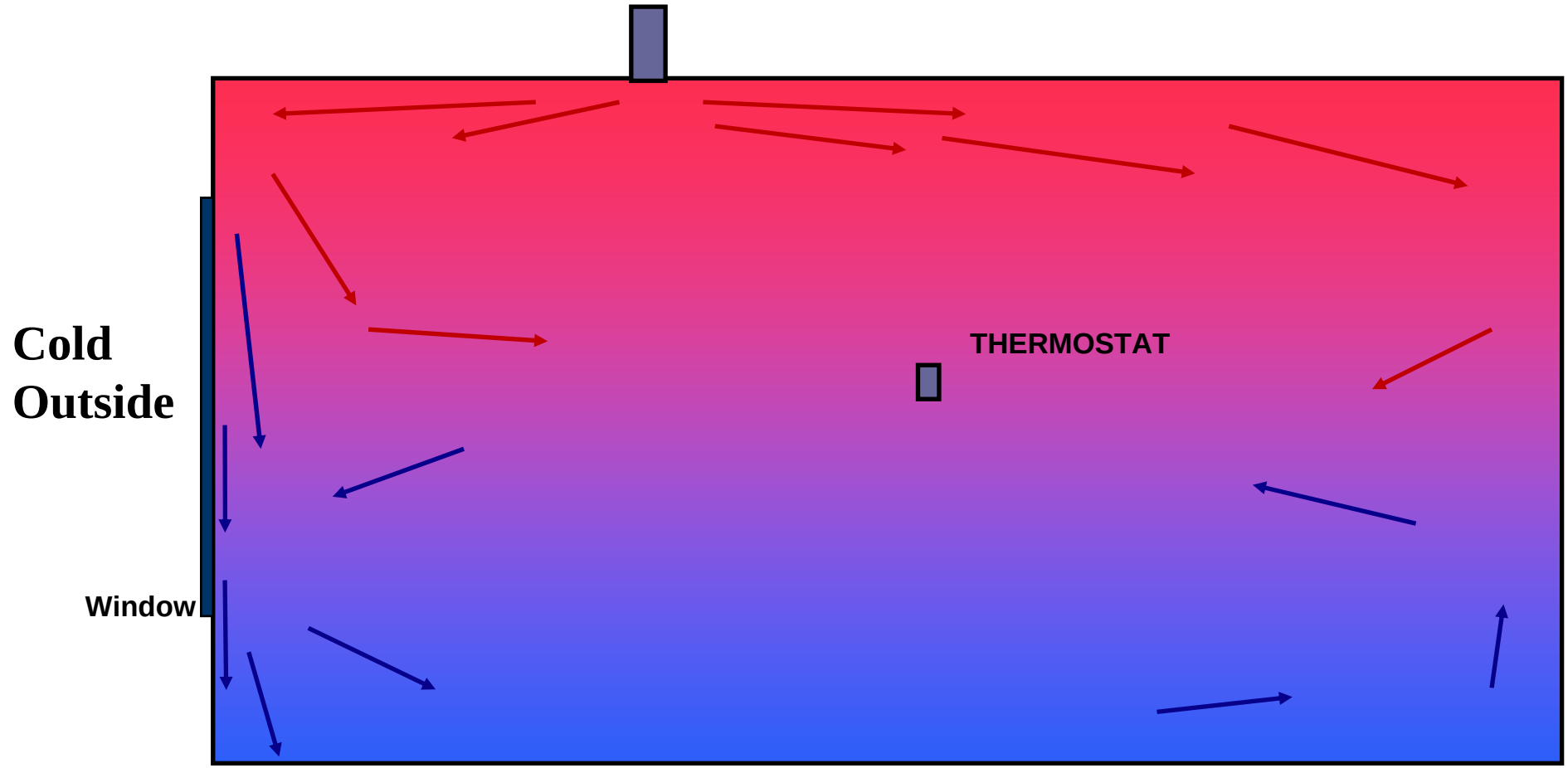
Air Distribution, Partition Effects



Poor Perimeter Example



Perimeter Considerations:

- Maximum delta-t for effective mixing when heating, per ASHRAE handbook = ?.
- = 15°F (90°F discharge), continuous operation.
- Throw toward and away from glass.
- 150 FPM should reach 4-5 feet from the floor.
- ASHRAE 62.1 requires that ventilation be increased by 25% when heating, if the above rules are not followed.
- Typical perimeters require only 8°F delta-t @ 1 cfm/sq.Ft.

Design Issues:

- Diffuser Selection
- Perimeter
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Perimeter Considerations:

From the December 2006 ASHRAE Journal:

Warm Supply Air

Although Table 6.2 shows lower zone air-distribution effectiveness with overhead heating, designers still have an opportunity to reduce outside air (ventilation air) when heating from the ceiling by meeting the discharge-to-room temperature difference and diffuser throw requirements outlined in the table. In other words, instead of concluding that discharge air temperature always exceeds zone temperature by 15°F when heating, designers can design for lower differential temperatures and comply with Table 6.2 requirements using $E_z = 1.0$.

In the *2005 ASHRAE Handbook—Fundamentals*, Chapter 33, indicates that differentials in excess of 15°F reduce the likelihood of achieving satisfactory occupant comfort, due to excessive stratification. ANSI/ASHRAE Standard 55-2004, *Thermal Environmental Conditions for Human Occupancy*, limits vertical stratification to 5°F in the occupied zone—a limit that may be violated when differential temperature exceeds 15°F. If too much stratification violates Standard 55-2004, it might also fail to comply with U.S. Green Building Council's LEED®-NC (New Construction) Indoor Environmental Quality (EQ) credit 7.1.

Suffice it to say that high differentials during overhead heating can lead to trouble while lower differentials can lead to many beneficial results.

ASHRAE Standard 62 Table 6.2

Table 6.2 Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air, at least 9 °C (15 °F) above space temperature, and ceiling return. **Note**: For cooler air, $E_z = 1.0$.	0.8
Ceiling supply of warm air, less than 9 °C (15 °F) above space temperature, and ceiling return ~~if~~ provided that the 0.8 m/s (150 fpm) supply air jet reaches to within 1.4 m (4.5 ft) of floor level. **Note**: For lower velocity supply air, $E_z = 0.8$.	1.0

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return.location.

Notes for Table 6.2

1. "Cool air" is air cooler than space temperature.
2. "Warm air" is air warmer than space temperature.
3. "Ceiling" includes any point above the *breathing zone*.
4. "Floor" includes any point below the *breathing zone*.
5. As an alternative to using the above values, E_z may be regarded as equal to Air Change Effectiveness determined in accordance with ASHRAE Standard 129 for all air distribution configurations except unidirectional flow.

Design Issues:

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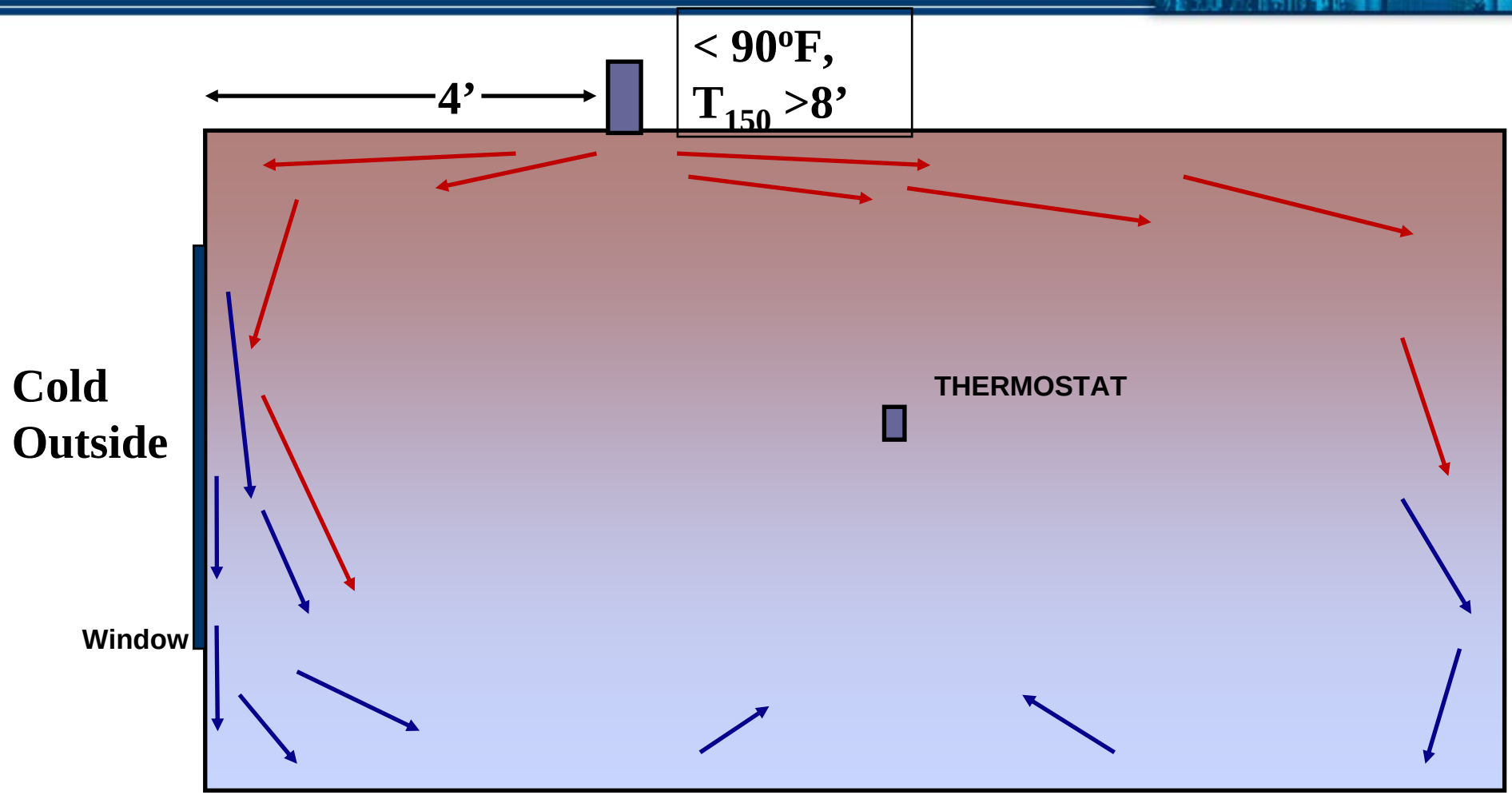
Proper Perimeter Example



Air Distribution and IAQ

- Previous ASHRAE standards assumed perfect mixing (E_{rm} = 1).
- There is no data that cooling air flows ever result in E_{rm} significantly less than 1 (not true with heating where E_{rm} has been observed at < 20%).
- ASHRAE standard 129-97 provides a standard method of test for measuring E_{rm} using tracer gas technology (in laboratories).
- Documented use of ADPI in the design phase can assist obtaining LEED certification.
- At least one manufacturer provides ADPI selection tables throughout their catalog

Design Issues:

- **Diffuser Selection**
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Air Distribution Summary

- Diffuser selection should be based on throw and room size.
- Select at both max and minimum occupied flow rates.
- Noisy diffusers are good.
- Dirt on the ceiling ain’t all bad.
- Use good design when heating.
- Poor air distribution yields poor comfort, poor air quality, slow system response.

Design Issues:

- **Diffuser Selection**
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Thermal Comfort:

- **Latest THERMAL COMFORT STANDARD: ASHRAE 55-2004**
- **ASHRAE Fundamentals, Chapter 8**
- **PMV - predicted mean vote - a single number rating.**
- **A program is available, based on the new ASHRAE 55-04, which allows plotting of the comfort envelope.**
- **Standard 55 mandates a maximum 5ºF vertical temperature stratification.**

Design Issues:

•Diffuser Selection

•Perimeter

•Thermal Comfort

•Acoustics

•Ventilation & IAQ

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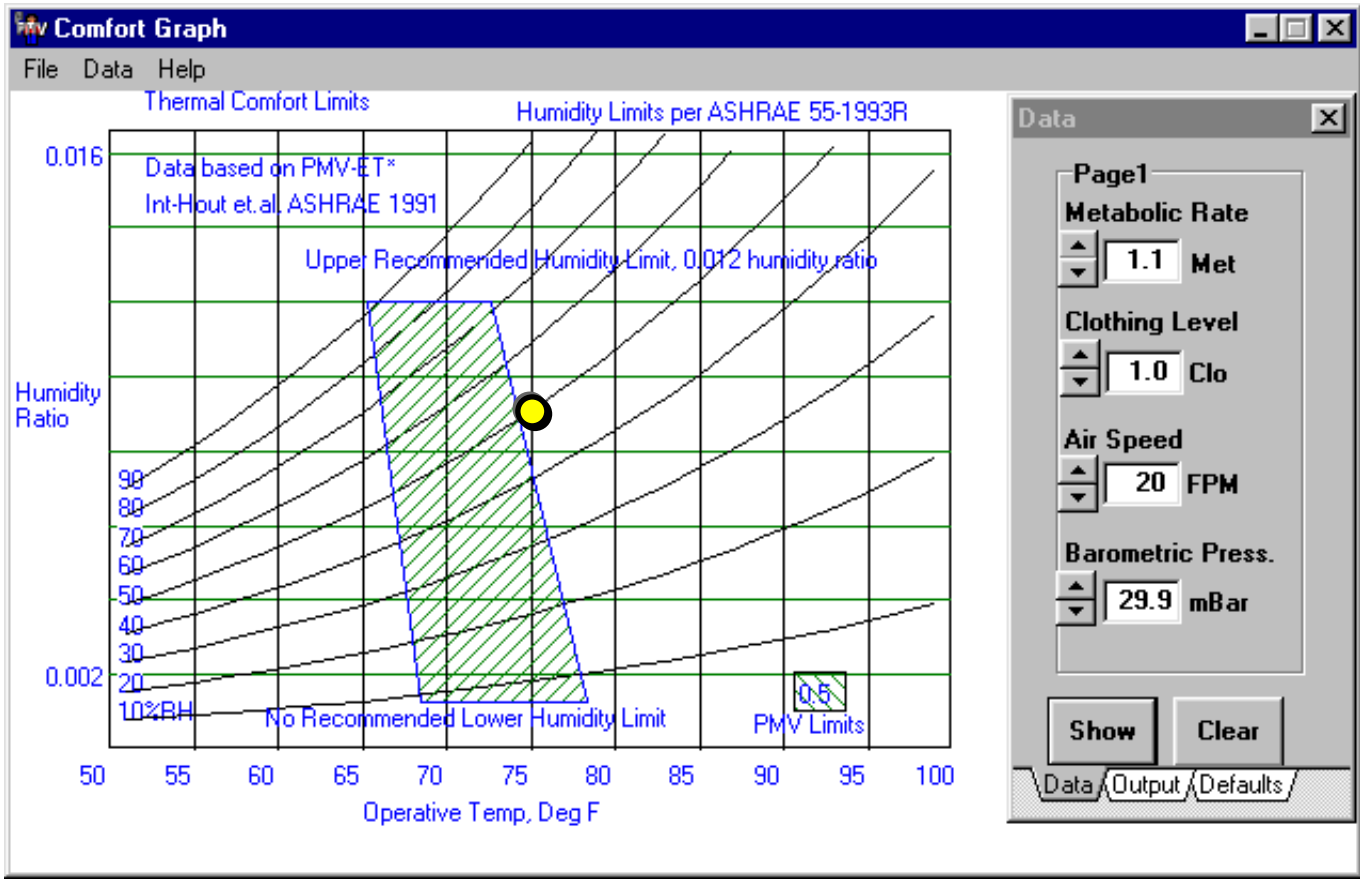
Typical “Executive Worker” Profile



Design Issues:

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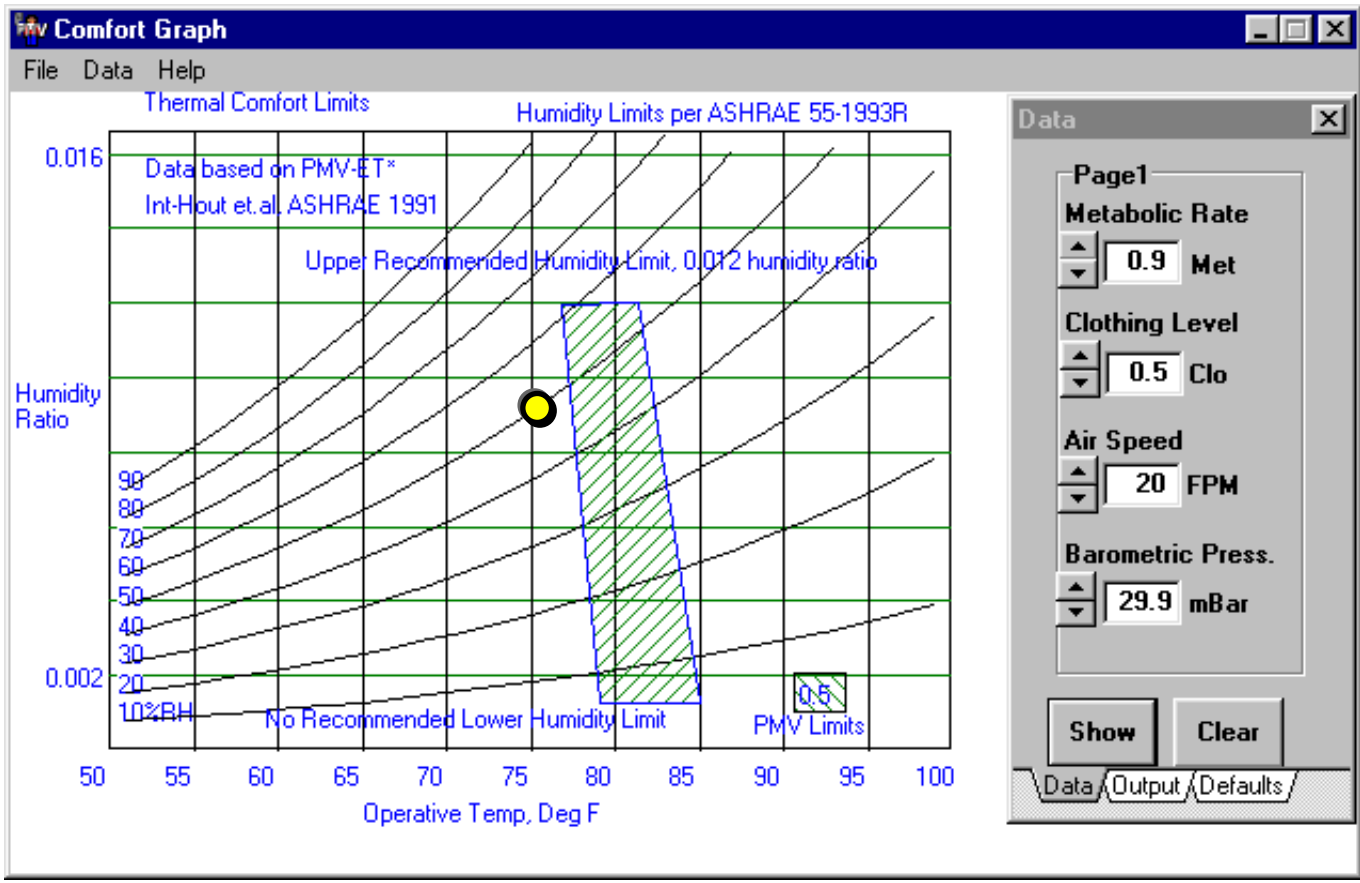
Typical “Clerical Worker” Profile



Design Issues:

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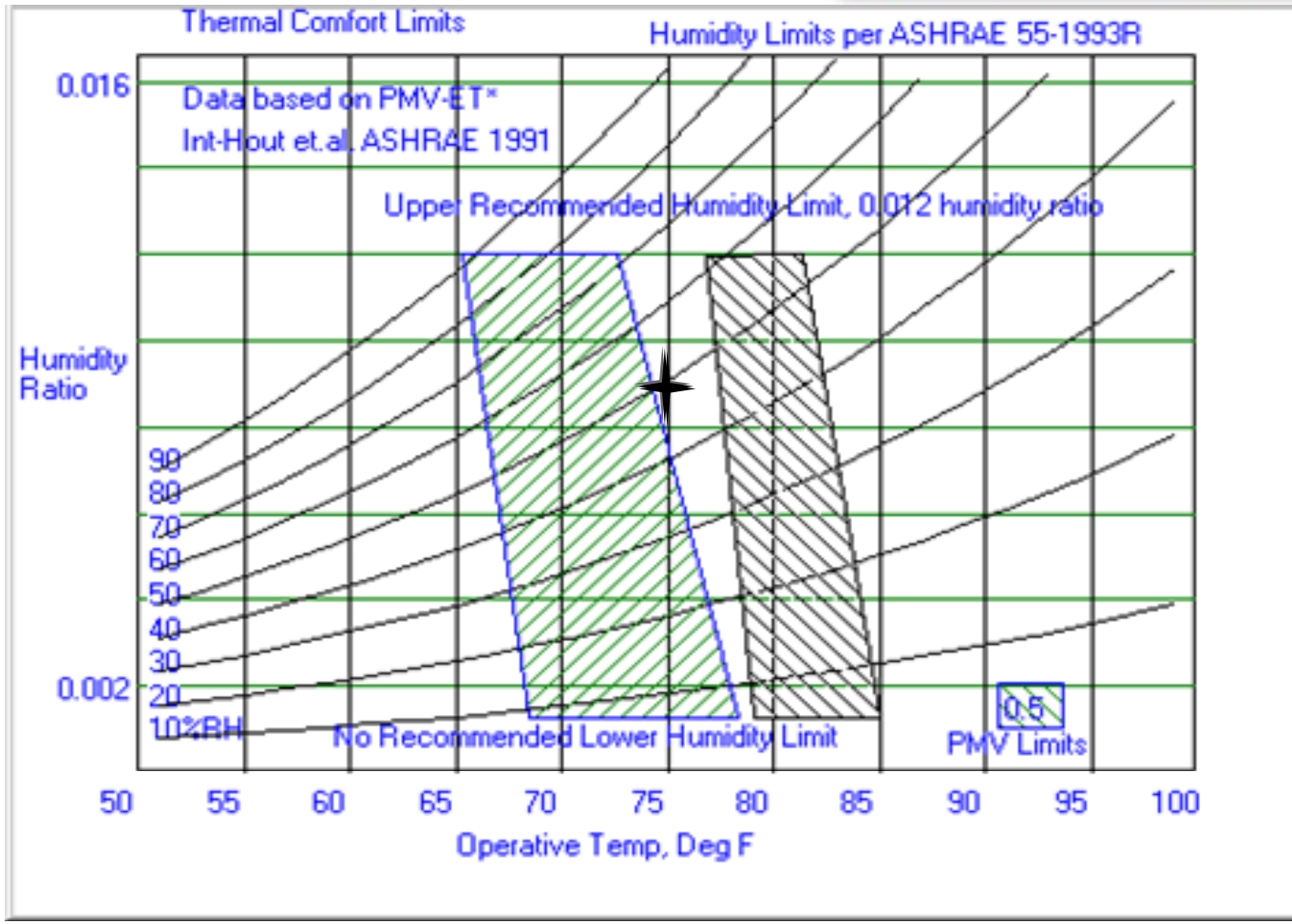
Plotting Both:



Design Issues:

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Comfort Economics

- Unlike in agricultural facilities, human productivity is hard to measure.
- Buildings cost $2.00/ sq. Ft./Yr. To heat and cool.
- Occupants get paid $200.00 / sq. Ft./Yr. ($375 in NYC!) - 1 sick day = $21B in US.
- Moving thermostats cannot cost (or save) more than 5% energy.
- The ratio of productivity to energy savings is 2000/1. A 10% reduction in productivity = rent cost!
- Buildings' HVAC first cost is $10-$20/sq. Ft.
- The EBTR was proven (in 1981) to increase HVAC energy consumption by as much as 20%.
- EBTR has been again imposed in federal buildings in California!

Design Issues:

- Diffuser Selection
- Perimeter
- Thermal Comfort
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Standard 55-2004

- Was being prepared in code language! But now is not.
- Now incorporates ISO 7730's PMV.
- Does not prescribe operating conditions.
- Eliminates the "summer/winter" chart labels, as they were misleading (is now 0.5 and 1.0 clo).
- Changing the upper humidity limits (again), back to 1981 limits.
- No lower humidity Limit.
- Approved by ANSI in March 2004, printed in June '04.
- Meeting Standard 55 is difficult at the design stage – ADPI can provide proof.

Design Issues:

- Diffuser Selection
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Comfort Summary

- Thermal comfort is #1 reason for not renewing the lease (don't fix the wrong thing).
- Many IAQ and air distribution complaints can be cured with temperature changes.
- The ratio of productivity to energy savings is 2000/1. First costs are minor compared to productivity.
- Internal heat loads cost 2X power consumption.
- Mandated designs and set points often waste energy. People will make themselves comfortable!
- Vertical Stratification requirement is often ignored
- Thermal comfort program available online!

Design Issues:

•Diffuser Selection

•Perimeter

•Thermal Comfort

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Acoustics:

- ARI 885-98 acoustical application standard.
- ARI 880-98 air terminal test standard.
- ARI 260-01 ducted equipment except air terminals.
- ARI 890 / ASHRAE 70-91 air diffuser performance.
- ADC 1062 test code was obsoleted in 1984!
- Acoustical quality suggests the use of RC (or newer measures) rather than NC.
- Goals:
  - Not too loud.
  - Not too quiet.
  - Not too annoying.
  - Not to be felt.

Design Issues:

•Diffuser Selection

•Perimeter

•Thermal Comfort

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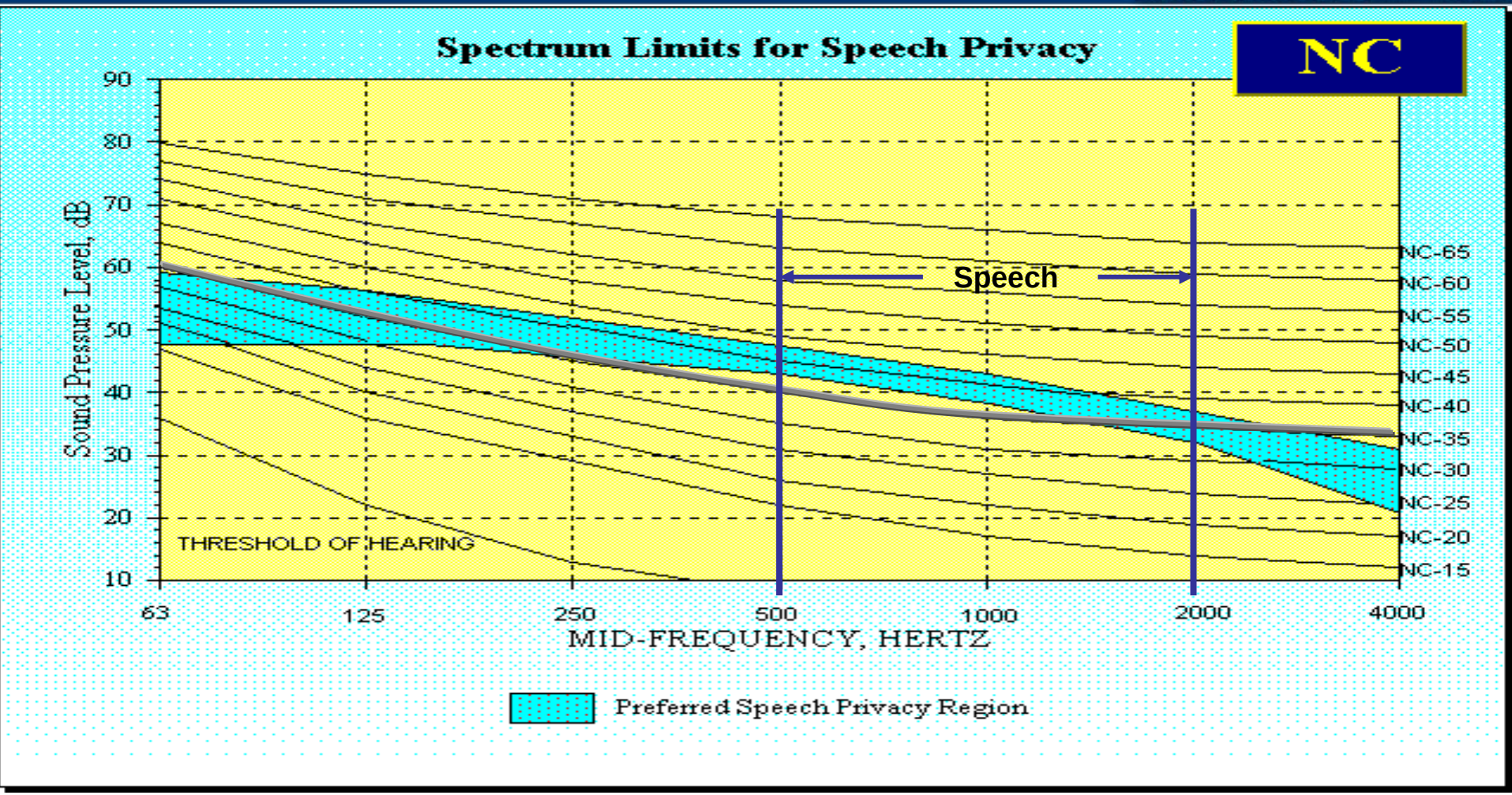
NC and Speech Privacy



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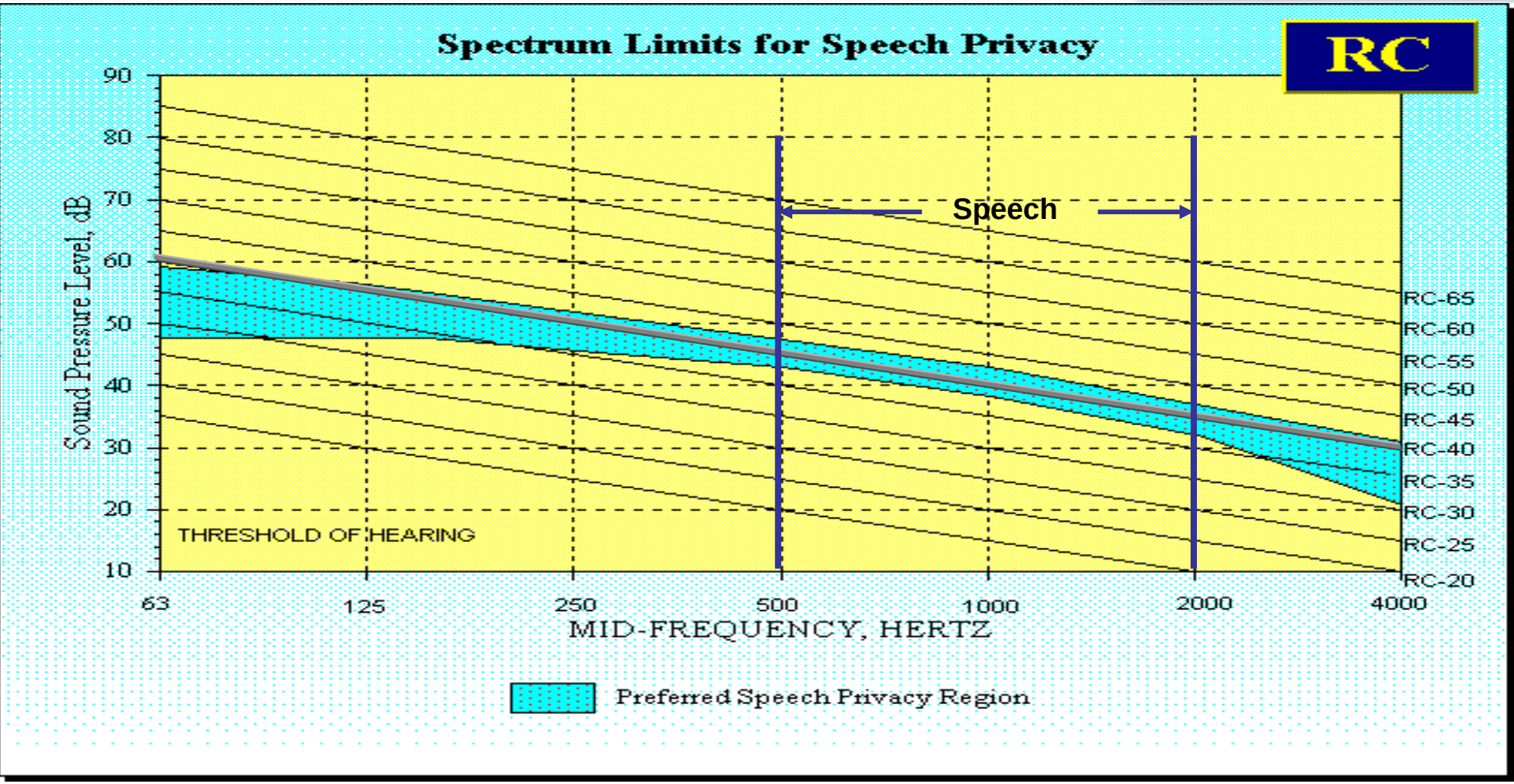
RC and Speech Privacy



Sound Specifications

- Should be based on clearly stated assumptions.
- Should reflect real project needs, not any manufacturer's data and use currently accepted application factors.
- If duct lining is used – require"NC shall be determined in accordance with ARI 885-98, Appendix E", otherwise specify octave band.
- Over-silencing increases both initial costs and operating costs, and may hinder proper IAQ performance.
- Manufacturer's air terminal selection software and generic specification makers such as (SounSpec.EXE) are available online!

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Schoolroom Acoustics - From the Federal Register:

Design Issues:

- **Diffuser Selection**
- **Perimeter**
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Published in the *Federal Register* June 1, 1998.

ARCHITECTURAL AND TRANSPORTATION BARRIERS COMPLIANCE BOARD

36 CFR Chapter XI

[Docket No. 98-4]

Petition for Rulemaking; Request for Information on Acoustics

AGENCY: Architectural and Transportation Barriers Compliance Board.

ACTION: Request for Information.

SUMMARY: The Architectural and Transportation Barriers Compliance Board has received a petition for rulemaking from a parent of a child with a hearing loss requesting that the ADA Accessibility Guidelines be amended to include new provisions for acoustical accessibility in schools for children who are hard of hearing. Several acoustics professionals, parents of children with hearing impairments, individuals who are hard of hearing, and a consortium of organizations representing them have also urged the Board to consider research and rulemaking on the acoustical performance of buildings and facilities, in particular school classrooms and related student facilities. The Board seeks comment on the issues outlined in this request for information. After evaluating responses to thisrequest for information, the Board will determine a course of action. Alternatives under consideration include research, rulemaking, and technical assistance on acoustical issues.

DATES: Comments should be received by July 31, 1998. Late comments will be considered to the extent practicable.

Classroom Acoustics:

Table 1 —Maximum A-weighted steady background noise levels and maximum reverberation times in unoccupied, furnished learning spaces

Learning space [a]	Maximum one-hour-average A-weighted steady background noise level [b, c] DB	Maximum reverberation time for sound pressure levels in octave bands with midband frequencies of 500, 1000 and 2000 Hz s
Core learning space with enclosed volume < 283 m^3 (< 10 000 ft^3)	35	0.6
Core learning space with enclosed volume > 283 m^3 and ≤ 566 m^3 (> 10 000 ft^3 and ≤ 20 000 ft^3)	35	0.7
Core learning spaces with enclosed volumes > 566 m^3 (20 000 ft^3) and all ancillary learning spaces	40 [d]	e)

a) See 3.1.1.1 and 3.1.1.2 for definitions of core and ancillary learning spaces.

b) See 4.3.1 for limits on unsteady (time varying) background noise levels.

c) See 4.3.2 for other limits on background noise from building services and utilities including C-weighted steady background noise levels.

d) When corridors are used solely for conveyance of occupants within the school building and structured learning activities do not occur, the A-weighted steady background noise level limit for such corridors may be increased to 45 dB. The use of corridors for formal learning purposes should be avoided.

e) See C3.3 in annex C for recommendations on control of reverberation in these spaces.

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Classroom Acoustics:

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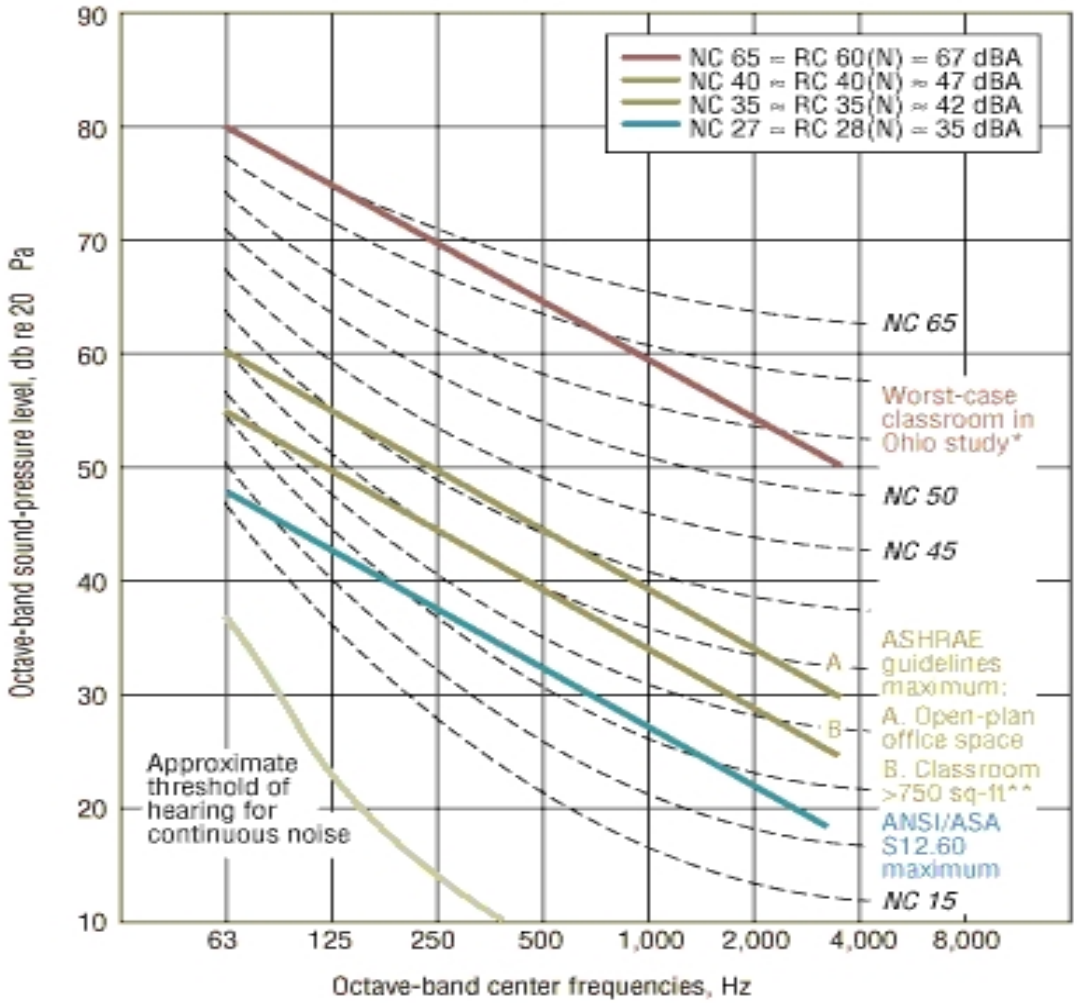
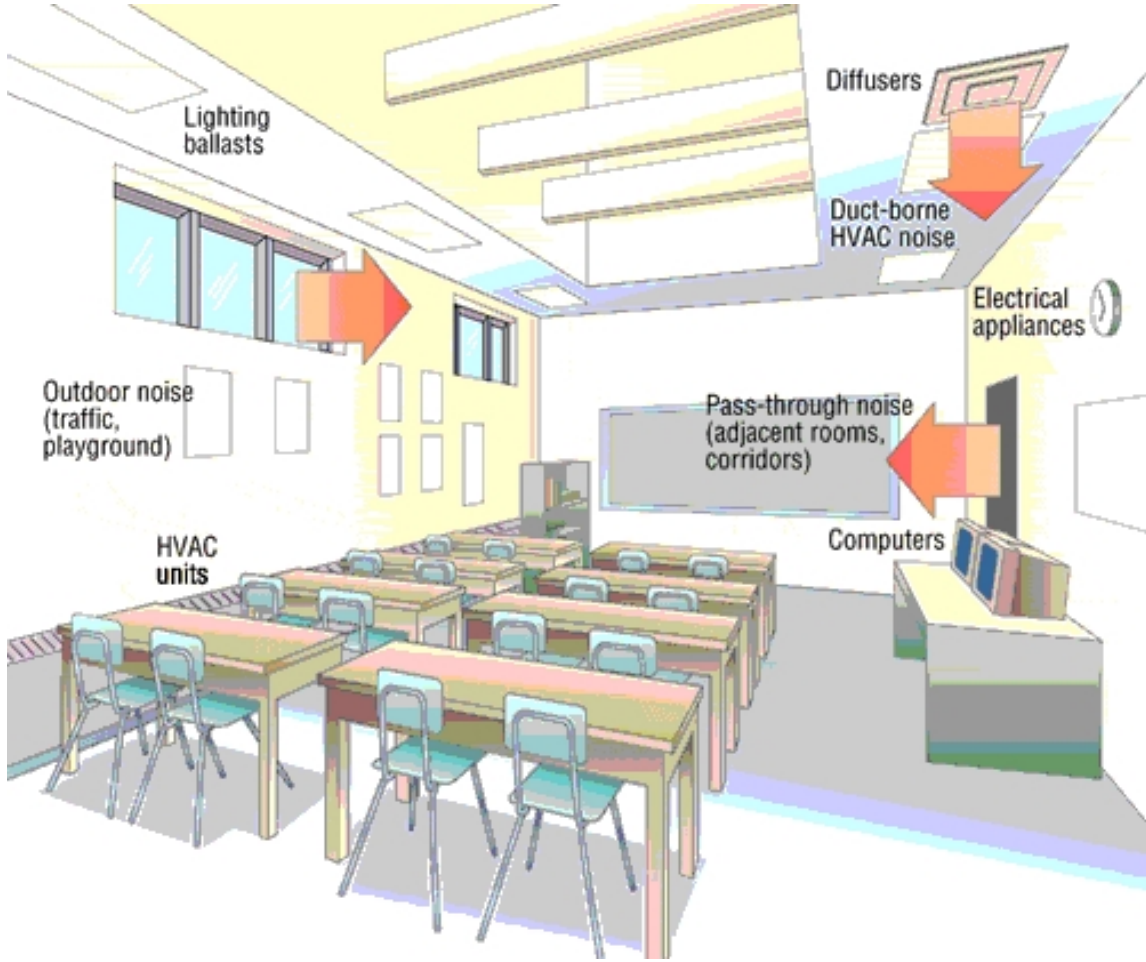


Classroom Acoustics:



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Classroom Acoustics:

- ADA ruling will either change rules, or awareness of options.
- ANSI has released a new standard on classroom acoustics (S12.60).
- See Feb 2000 and Feb 2003 ASHRAE journal for cover articles and HPAC article.
- Designs can reduce noise levels using current technology.
- ARI 260, in effect since 2001, defines method of test for sound power of ducted equipment.

Design Issues:

- **Diffuser Selection**
- **Perimeter**
- **Thermal Comfort**
- **Acoustics**
- **Ventilation & IAQ**

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New ASHRAE Book

Design Issues:

- **Diffuser Selection**
- **Perimeter**
- **Thermal Comfort**
- **Acoustics**
- **Ventilation & IAQ**

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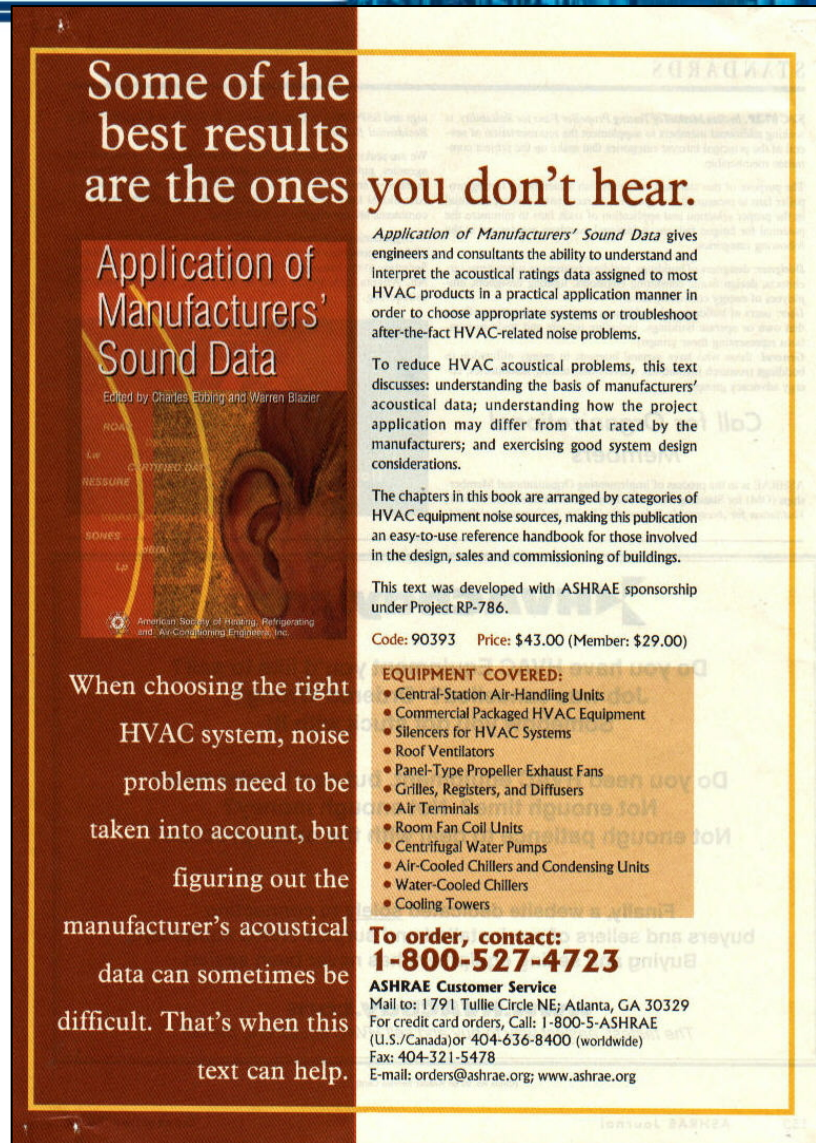

Acoustics/Summary

- NC levels don't tell it all, but are well suited for product ratings.
- RC levels are a better indication of quality, but don’t work well as product rating method.
- Specifying octave band assures you get what you want (and expect).
- It’s easier to design right than fix.
- Over-silencing is expensive and may cause poor indoor air quality.
- Programs and a new book are available to assist in the analysis.
- Download ARI 885-98 from www.ari.com.

Design Issues:

- Diffuser Selection
- Perimeter
- Thermal Comfort
- Acoustics
- Ventilation & IAQ

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Designing for IAQ: Three Strategies

- Filtration
- Source control
- Dilution

Design Issues:

- Diffuser Selection
- Perimeter
- Thermal Comfort
- Acoustics
- Ventilation & IAQ

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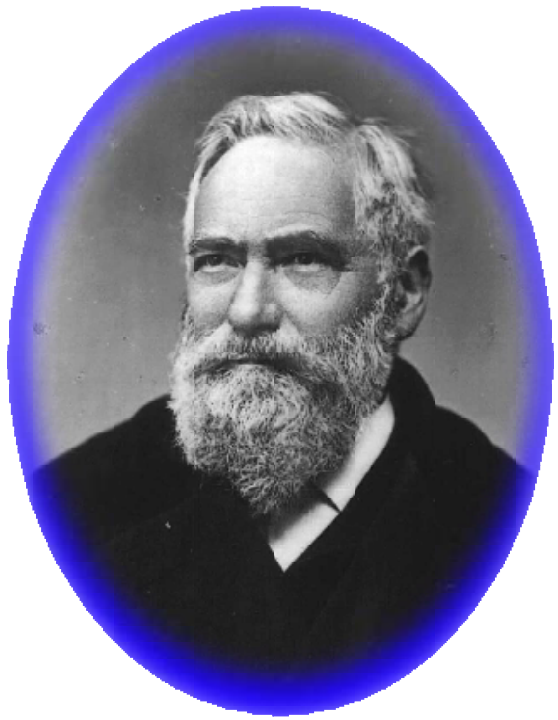
Pettenkofer (1858):

”If There Is a Pile of Manure in a Space, Do Not Try to Remove the Odor by Ventilation. Remove the Pile of Manure.”



Design Issues:

- **Diffuser Selection**
- **Perimeter**
- **Thermal Comfort**
- **Acoustics**
- **Ventilation & IAQ**

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Causes of Poor IAQ

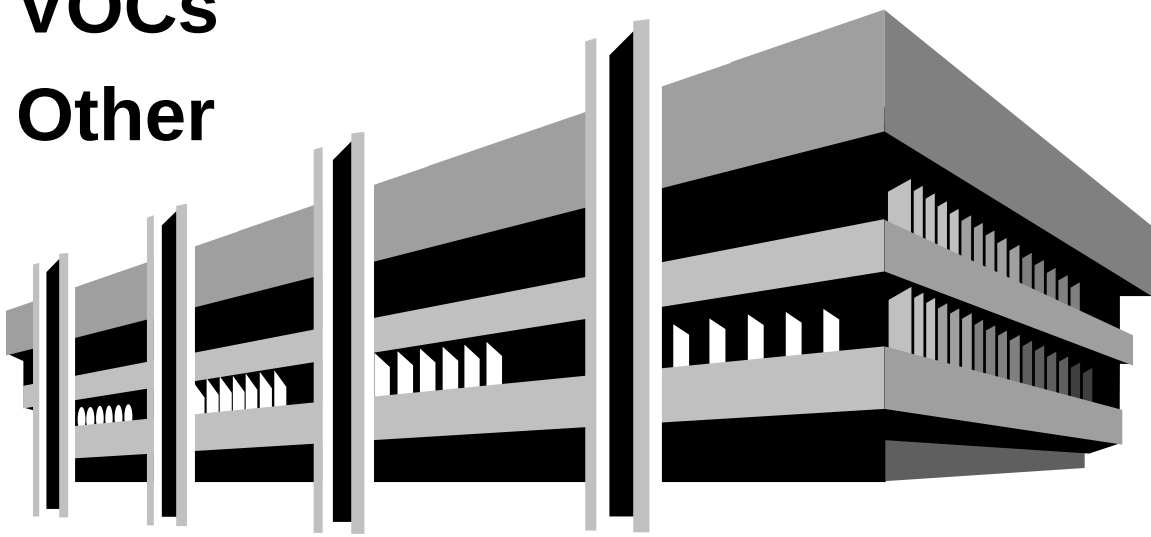
- Usually caused by system (not product) problems.
- Many times, no “contaminant” found.
- “A malignant conjunction of diabolical circumstances.”
- There are more bad consultants than good ones.
- The bad ones are cheaper.
- $8m in mold litigation in NYC alone. $32M in one case in Texas.
- Often the result of cost-saving issues.

Design Issues:

- Diffuser Selection
- Perimeter
- Thermal Comfort
- Acoustics
- Ventilation & IAQ

Pollutants

- Particulates
- Organics
- Gases
- VOCs
- Other

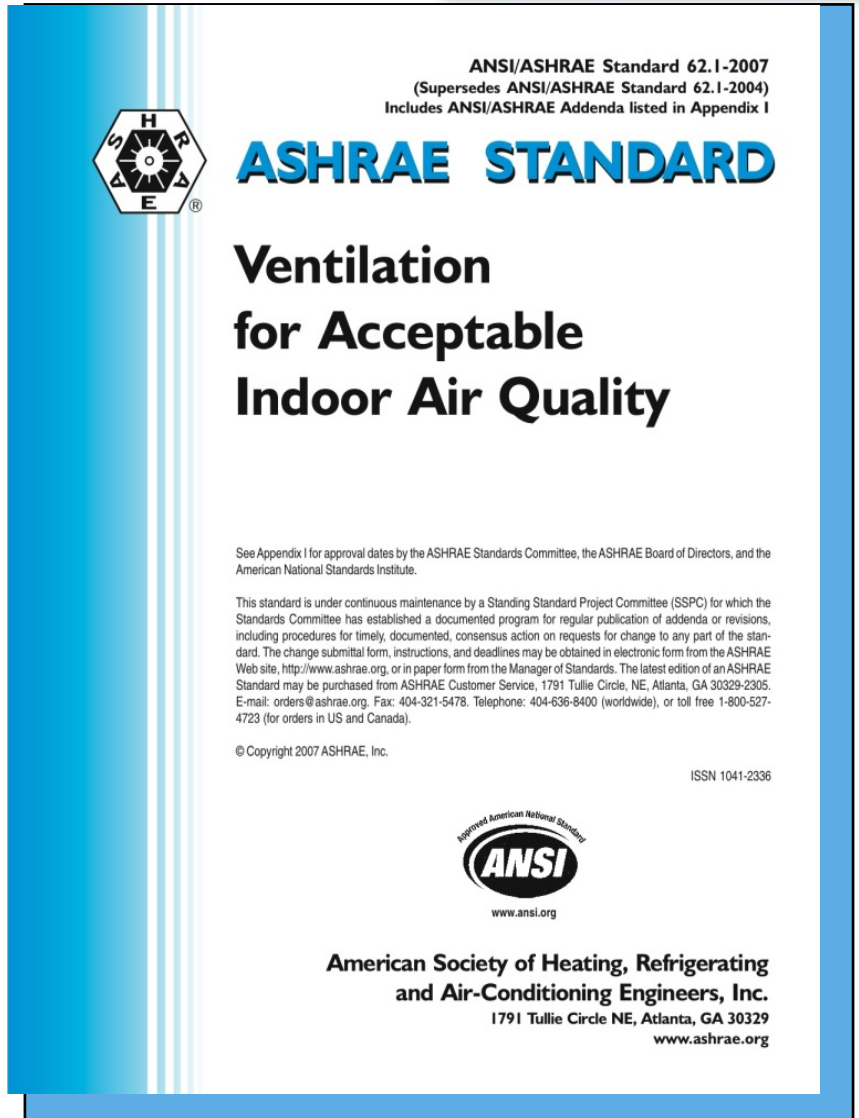


Design Issues:

- **Diffuser Selection**
- **Perimeter**
- **Thermal Comfort**
- **Acoustics**
- **Ventilation & IAQ**

Indoor Air Quality

- **Standing Standard Project Committee 62.1**
- **Residential Committee is 62.2**
- **Current Standard is 62.1-’07, and all addenda have been incorporated (and no longer available on the web).**



ANSI/ASHRAE Standard 62.1-2007
(Supersedes ANSI/ASHRAE Standard 62.1-2004)
Includes ANSI/ASHRAE Addenda listed in Appendix I

ASHRAE STANDARD

Ventilation for Acceptable Indoor Air Quality

See Appendix I for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

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IAQ Standard

- Standard 62 is on continuous maintenance.
- Continuous and incremental changes are in progress.
- It will attempt to be in coordination with building codes.
- A Guideline document for designing systems above minimum requirements is being created.
- Users Manual is available now.
- The IMC has indicated 62.1 will be referenced in the next release of the mechanical code.
- There seems to be minimal public awareness of the dynamic nature of the Standard.

Design Issues:

- **Acoustics**
- **Perimeter**
- **Diffuser Selection**
- **Thermal Comfort**
- **Ventilation**

IAQ Standard

Changes in place and coming:

- **A listserv application can be made online!**
- **Significant Modifications:**
  - **MERV 6 required upstream of wetted surfaces (= 2” pleat?).**
  - **Plenum located equipment must be directly connected to the ventilation supply.**
  - **Outside air particulate and ozone must be filtered.**
  - **Ventilation rate must be increased when in heating mode if ‘rules’ not followed.**
- **Standard 62.1 is a prerequisite to LEED 2.2**

Design Issues:

•Acoustics

•Perimeter

•Diffuser Selection

•Thermal Comfort

•Ventilation

ASHRAE Journal Forum, 8/01

Forgotten Past Lessons:

- **Acoustics**
- **Perimeter**
- **EBTR**
- **Open Plan Offices**

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Forum

Four Examples of 'Lost Science'

Those Who Forget the Past

Editor's Note: Forum columns are invited commentary. Letters with differing perspectives are welcome. To suggest a topic or submit a letter, contact Fred Turner at 404-636-8400 or fturner@ashrae.org.

By Dan Int-Hout and **Gus Faris**
Member ASHRAE Associate Member ASHRAE

As the engineering community designs building HVAC systems, it is assumed that we are employing the lessons of experience and good science. This knowledge mainly exists in codes and ASHRAE handbooks, standards and guidelines.

It has become apparent that much of the knowledge, which has been accumulated at great expense and often from painful experience, is not being used.

Keeping abreast of all the new ideas and codes is a full-time job for the designer. This becomes nearly impossible when regulations that were imposed to solve problems and were subsequently proven to be either ineffective or counterproductive are being reissued by a new generation of politicians who are apparently unaware of the failure of these past regulations.

As manufacturers of HVAC equipment, we often see specifications for products that we know cannot provide acceptable environments. We have three real-time choices when we are presented with these specifications:

1. We can provide products that we know, based on research and past history, will cause problems in the future.
2. We can contact the engineer and attempt to get the specifications revised. (It is tricky, of course, explaining to an engineer that his design is flawed.)
3. We can choose not to bid on these projects, knowing that someone else will most likely select Option 1.

A fourth option is to see as many design professionals as possible, explaining the current state-of-the-art, through lunch-and-learn sessions, technical development seminars, and one-on-one meetings with key engineering personnel to keep this from happening in the future.

The following are examples of apparent "lost science."

Overhead Heating

Issue: Heating perimeter zones from the ceiling became possible when perimeter glass became better, and in response to needs for better space utilization along the glass. A number of technical papers presented in the late 70s defined the parameters of this design, and established a repeatable method of test for evaluation of these spaces (ASHRAE Standard 113, *Method of Testing for Room Air Diffusion*). The *ASHRAE Handbook—Fundamentals*, Chapter 31 incorporated these results in the early 80s, and overhead heating became a "standard" method of heating perimeter zones.

Observation: Today we see a surprising number of designs that are obviously established in the absence of an understanding of these studies. This is evidenced by the cfm and kW settings specified on VAV terminals as well as discharge temperature requirements for small package units. Discharging low velocity, highly heated air at the ceiling may work in residential applications with low returns, but it will ensure highly stratified, poorly ventilated spaces with uncomfortable occupants in commercial applications with overhead returns. One of the authors has recently polled more than 2,000 consulting engineers regarding awareness of the overhead heating "rules." Almost none were aware of the ASHRAE design limitations.

Discussion: Since 1983, the *ASHRAE Handbook—Fundamentals* has provided specific guidance on the maximum room discharge temperature difference (not to exceed 15°F [8°C]) for effective control of the perimeter environment. In fact, the authors and others have conducted several hundred tests of perimeter designs in full-scale mock-ups, all confirming the ASHRAE guidelines.

Temperature Regulations

Issue: Imposed by President Carter in the late 70's, the Emergency Building Temperature Regulations (EBTR) established 68°F (20°C) heating and 78°F (26°C) cooling setpoint in federal buildings in response to the Arab oil embargo. These regulations found their way, in various forms, into other state, local, and corporate codes, regulations and guidelines.

Observation: Several studies and many observations have all confirmed that energy consumption often increases when these arbitrary setpoints are enforced. While the negative effect on productivity cannot be measured, it is obvious. It is rumored that the U.S. General Services Administration (GSA) actually had a study confirming this increase in energy use (one of the authors saw a draft of the study), but it was never made public. In response to the current energy crisis in California, the EBTR has again been imposed on federal buildings there.

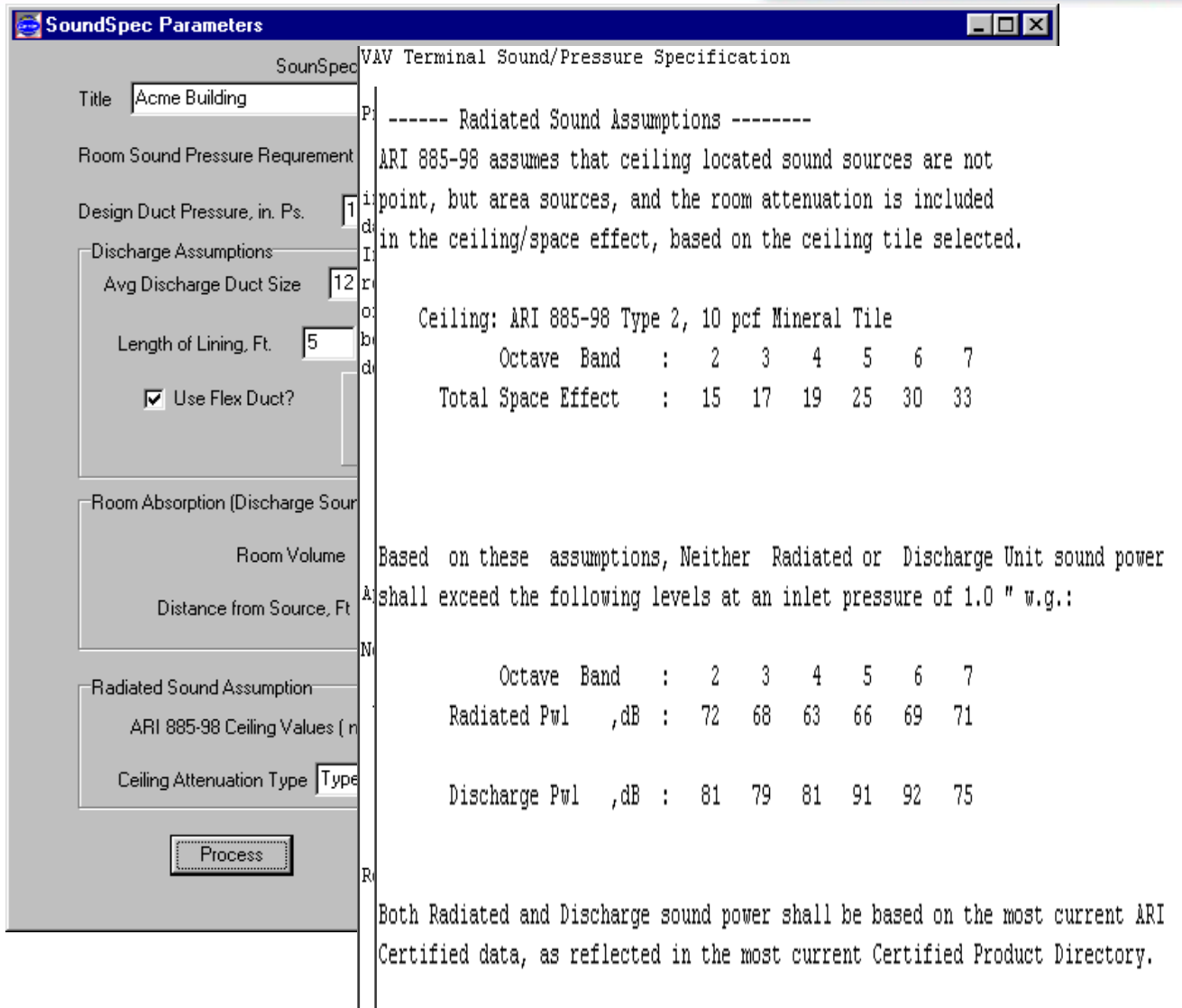
Discussion: Calculations show that with a few climatic exceptions, the maximum savings is on the order of 1% per 1°F (0.6°C) setpoint modification for the HVAC system. The discomfort created by this causes occupants to add their own

About the Authors
Dan Int-Hout is a senior marketing manager with Carrier's airside business, Carrollton, Texas.
Gus Faris is with Nailor Industries in Houston, Tx.

Several Engineer Tools Are Available
Get the right things specified!

Non-Product Software Tools

- **SounSpec Program**



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Several Engineer Tools Are Available
Get the right things specified!

Non-Product Software Tools

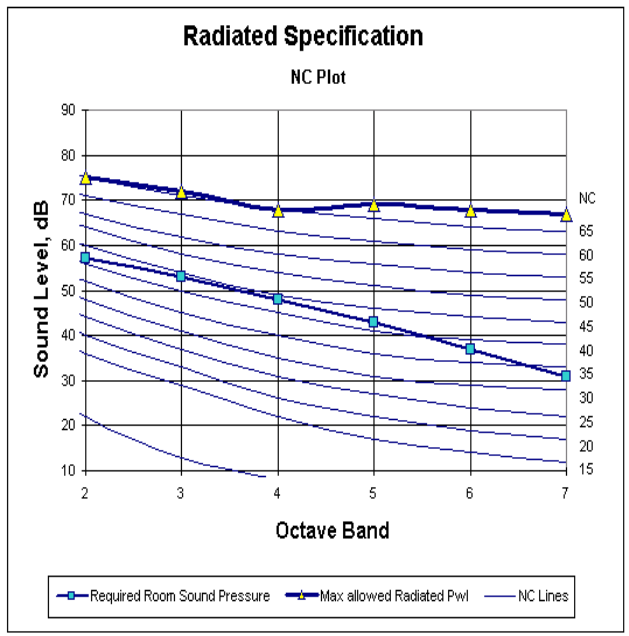
- **SounSpec Program**
- **885spec.xls**

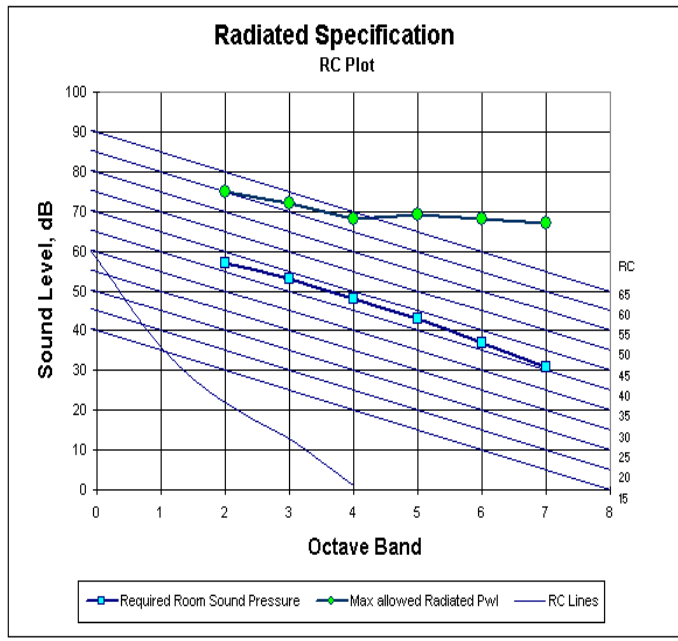
diated Specification

t Parameters:		
885-98		Type
ng Type	1	1, Mineral Fiber

ve Band	2	3	4	5	6	7
Frequency, Hz	125	250	500	1000	2000	4000
ired Room Sound Pressure	57	53	48	43	37	31
ng Plenum / Room Attenuation	16	18	20	26	31	36
onmental Adjustment Factor	2	1	0	0	0	0
Attenuation	18	19	20	26	31	36
allowed Radiated Pwl	75	72	68	69	68	67

From Discharge page
From selected method
From ARI 885-98





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Several Engineer Tools Are Available
Get the right things specified!

Non-Product Software Tools

- **SounSpec Program**
- **885spec.xls**
- **885Calc.xls**

All these tools are available on the internet

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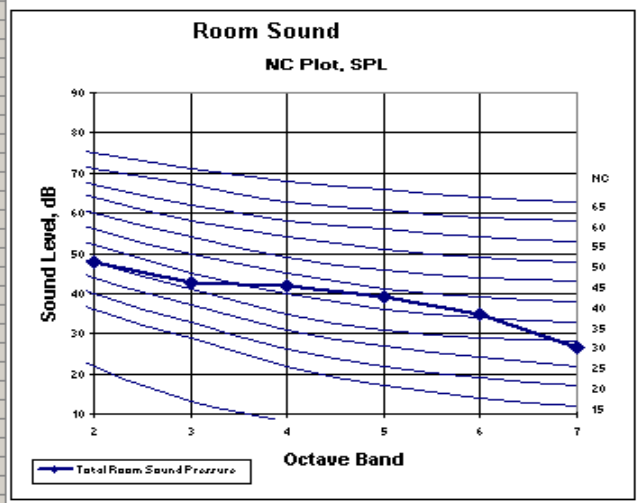
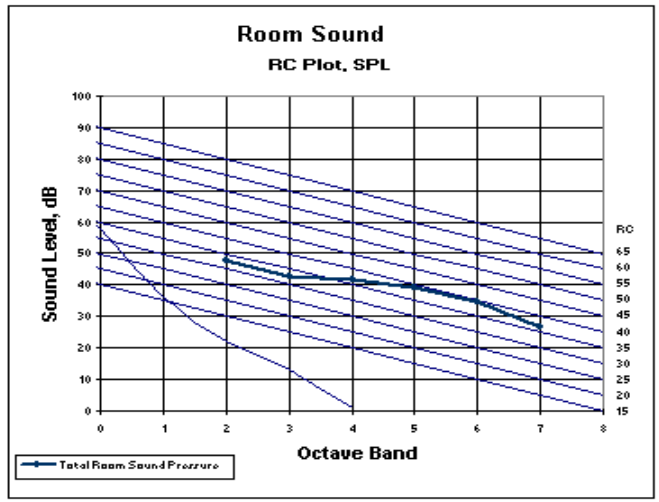
Room Sound Calculations

This page adds the sound from the VAV box in the previous examples to the sound from a selected diffuser

Project	0					
Octave Band	2	3	4	5	6	7
Mid Frequency, Hz	125	250	500	1000	2000	4000
VAV Box Discharge Sound Pressure	37	33	26	15	15	26
VAV Box Radiated Sound Pressure	47	40	40	31	19	9
Diffuser Sound Power	44	45	44	46	44	27
# of Diffusers	1					
Room Attenuation	5	6	7	8	9	10
Other (Custom)	0	0	0	0	0	0
Environmental Adjustment Factor	2	1	0	0	0	0
Diffuser Sound Pressure	37	38	37	38	35	17
Total Room Sound Pressure	48	43	42	39	35	26
Output NC	38					

		R?	H?
Output RC, Letters	39	N	N
DbA	44		





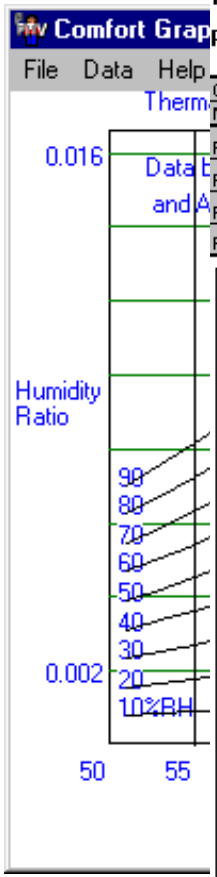
Discharge Calculator | Radiated Calculator | Room Sound Calculator

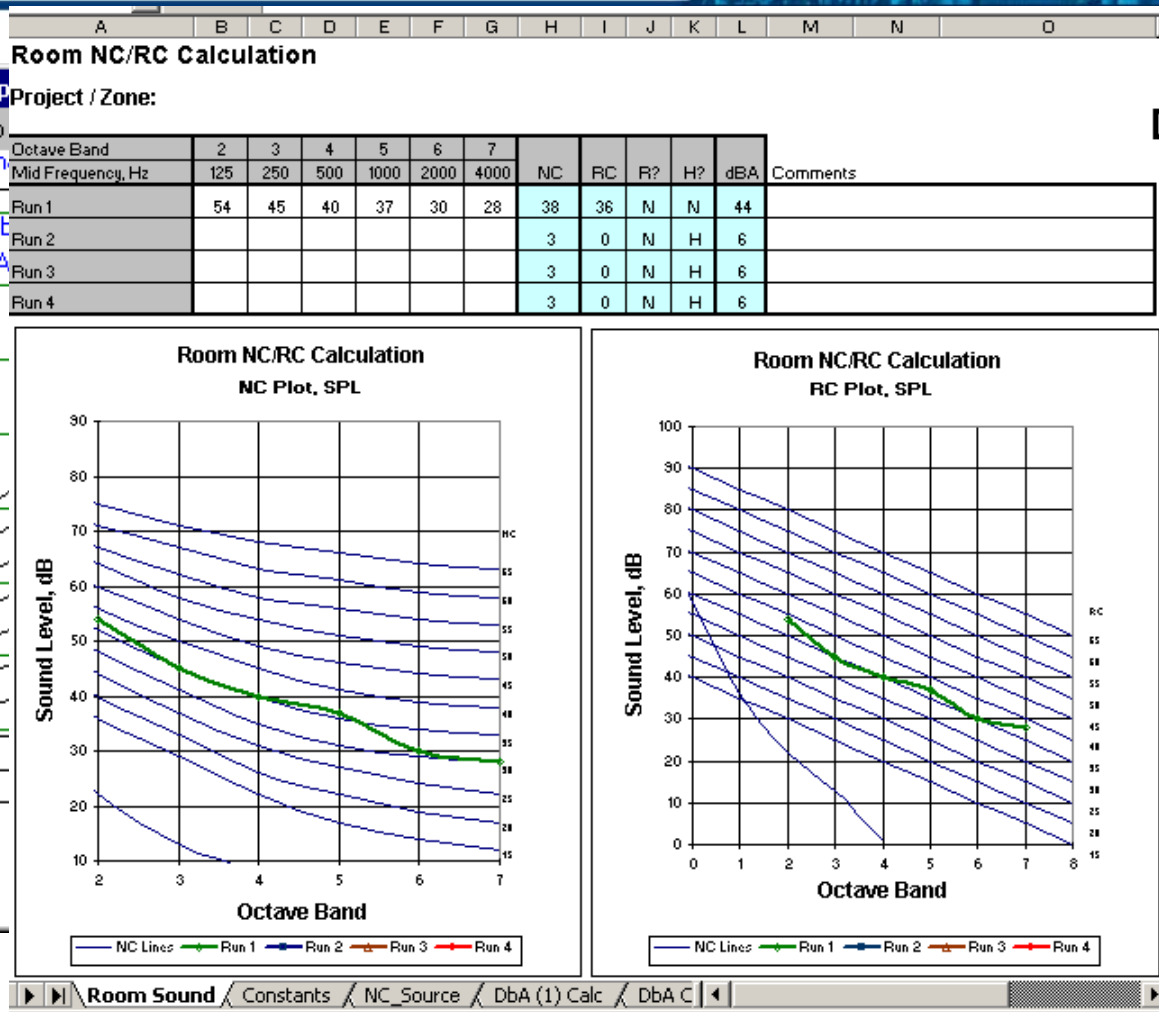
Several Engineer Tools Are Available
Get the right things specified!

Non-Product Software Tools

- **SounSpec Program**
- **885spec.xls**
- **885Calc.xls**
- **Room Sound Calc**
- **Thermal Comfort Pgm**
- **Web Site Files**

All these tools are available on the internet





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Summary

- LEED 2.2 requires meeting Standard 62.1
- Documented use of ADPI is the ONLY way to assure compliance to 55 in the design phase.
- Acoustics should be specified on the basis of need with clear assumptions.
- Reheat needs to be carefully considered in terms of discharge temperatures and velocities.
- Software is available to assist in selecting the best mix of products.
- The rules are dynamic - pay attention.

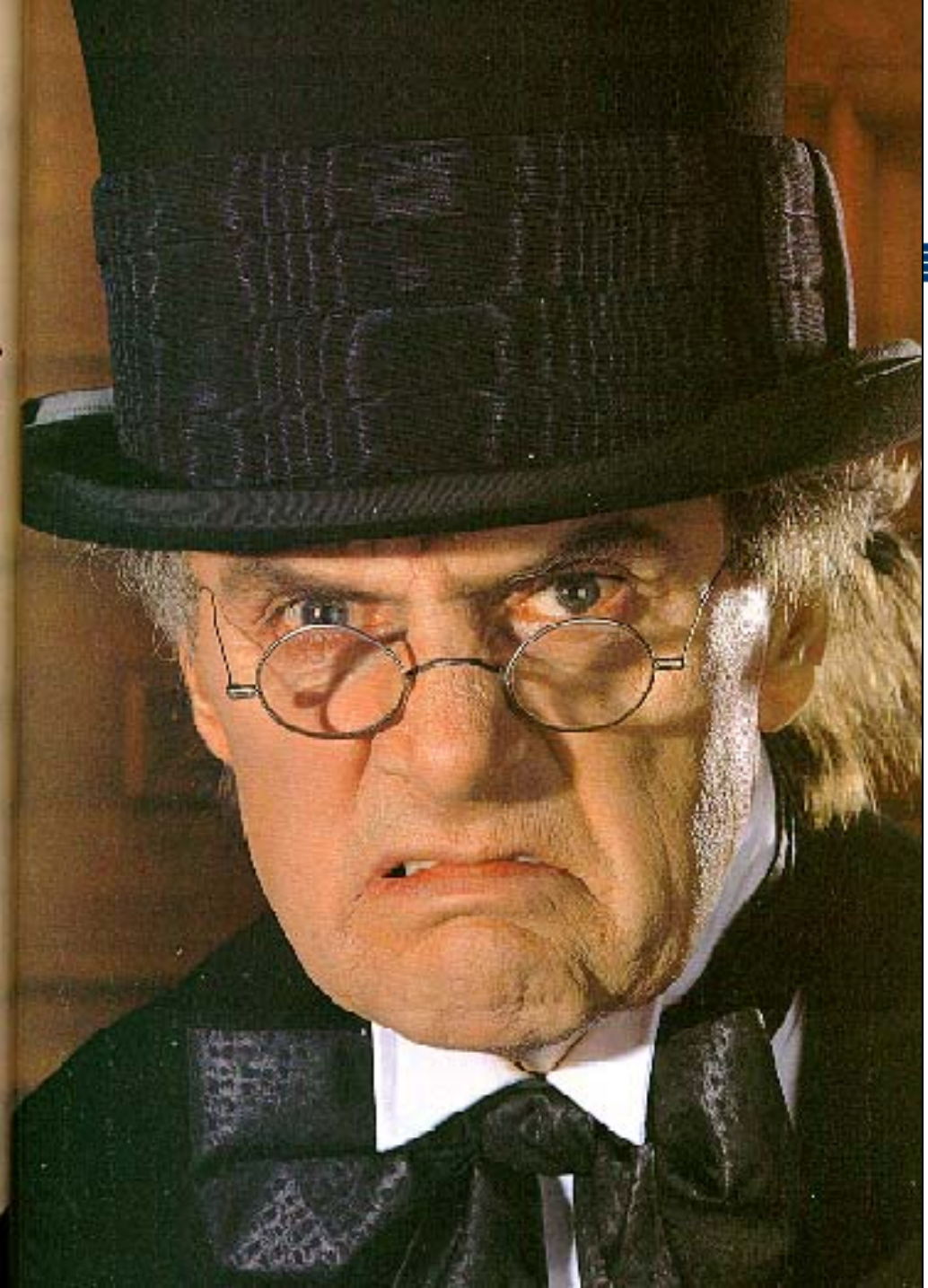
The Building's Challenge

Design Issues:

- Diffuser Selection
- Perimeter
- Thermal Comfort
- Acoustics
- Ventilation & IAQ

Recent court cases have suggested that the HVAC system in a building may be considered a product. This means:

- **Federal product liability laws apply**
- **We are expected to demonstrate an "acceptable standard of care"**
- **Everyone is liable**
- **Standards not in the code can be enforced**



ANY QUESTIONS?

Contact

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