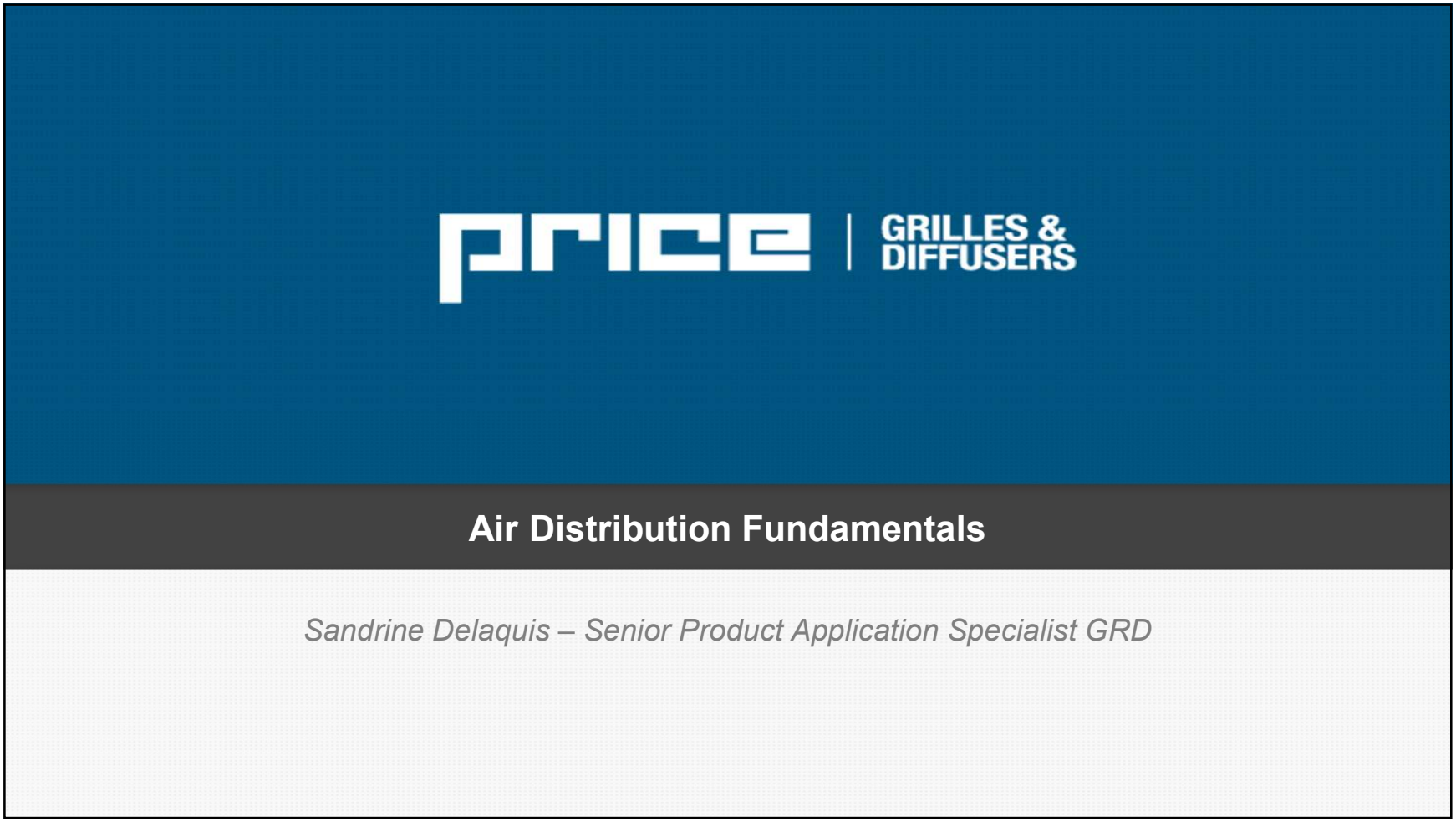

1

Overview

GRILLES & DIFFUSERS

Presenter

Sandrine Delaquis
Senior Product Application Specialist for GRD Products,
Price Industries

- Bachelor of Science in Mechanical Engineering from University of Manitoba
- Focus on Product Development and Product Support for Price Industries Grilles, Registers, and Diffuser product family
- ASHRAE – Manitoba Chapter Board member (2017-2020)

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Overview

GRILLES & DIFFUSERS

Course Summary

Mixed Air Distribution Systems using Grilles, Registers and Diffusers continue to be the most common air distribution system. In one form or another Mixed Air has been around for nearly 100 years.

This course will cover the basics of room air movement, the geometry of grilles and diffusers, and how to describe their performance.

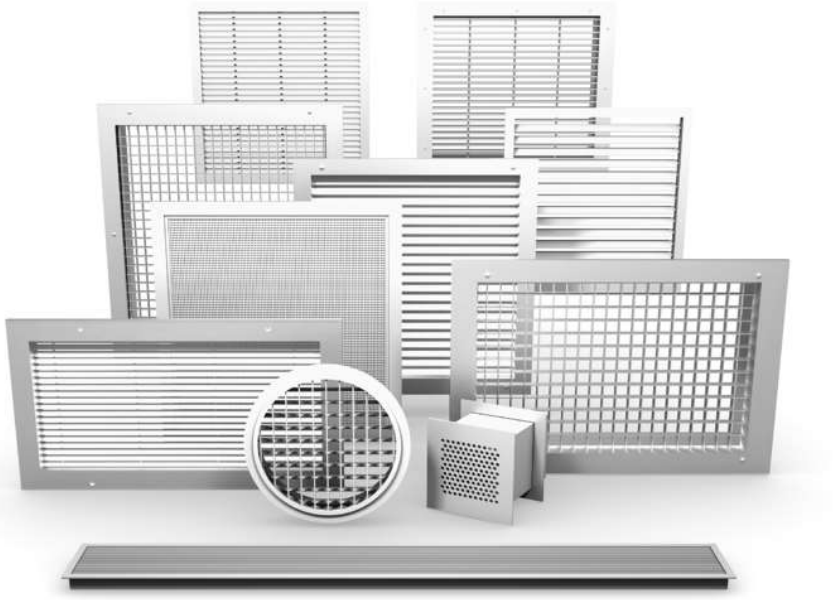
4

Overview

GRILLES & DIFFUSERS

Agenda

- Room Air Distribution
- Grilles, Registers, and Diffusers
- Sound
- Throw



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Air Distribution Fundamentals

Air Distribution Basics

6

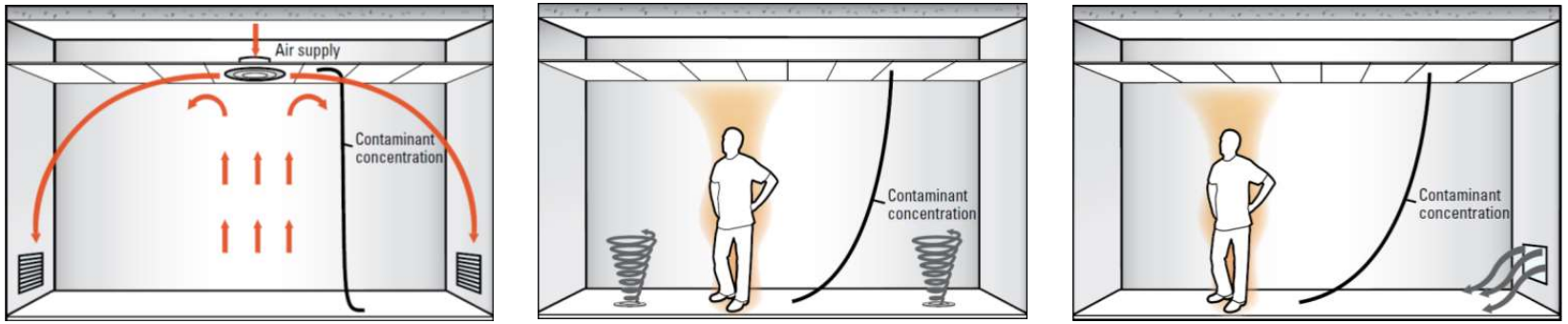
Air Distribution Basics

GRILLES & DIFFUSERS

Air Distribution Systems

- Fully Mixed / Partially Mixed / Fully Stratified
- What are we mixing/stratifying?
  - Contaminants / Heat / CO2 / Moisture / Particulates

Fully Mixed ⟷ **Fully Stratified**



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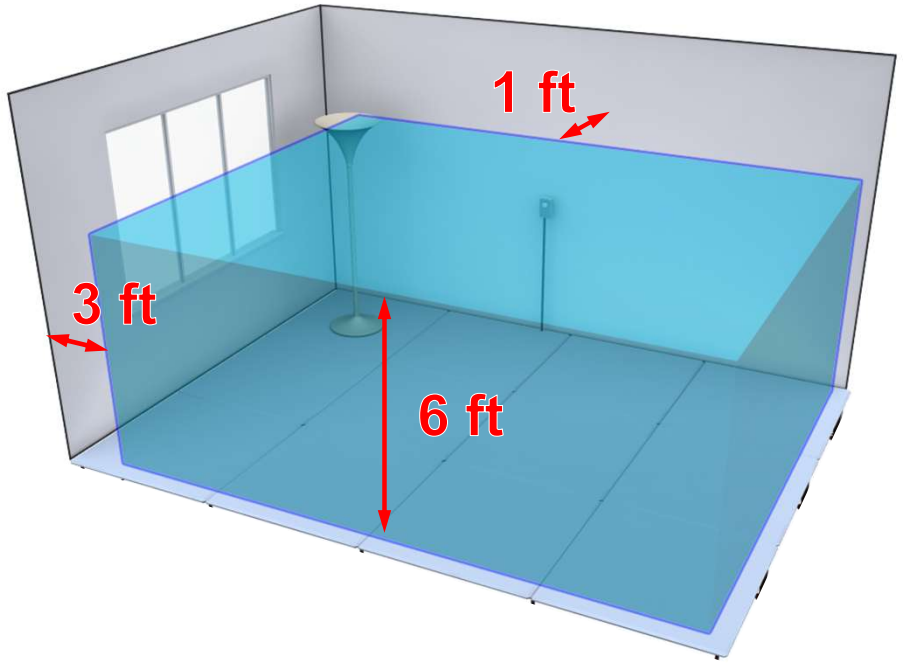
Air Distribution Basics

GRILLES & DIFFUSERS

Occupied Zone



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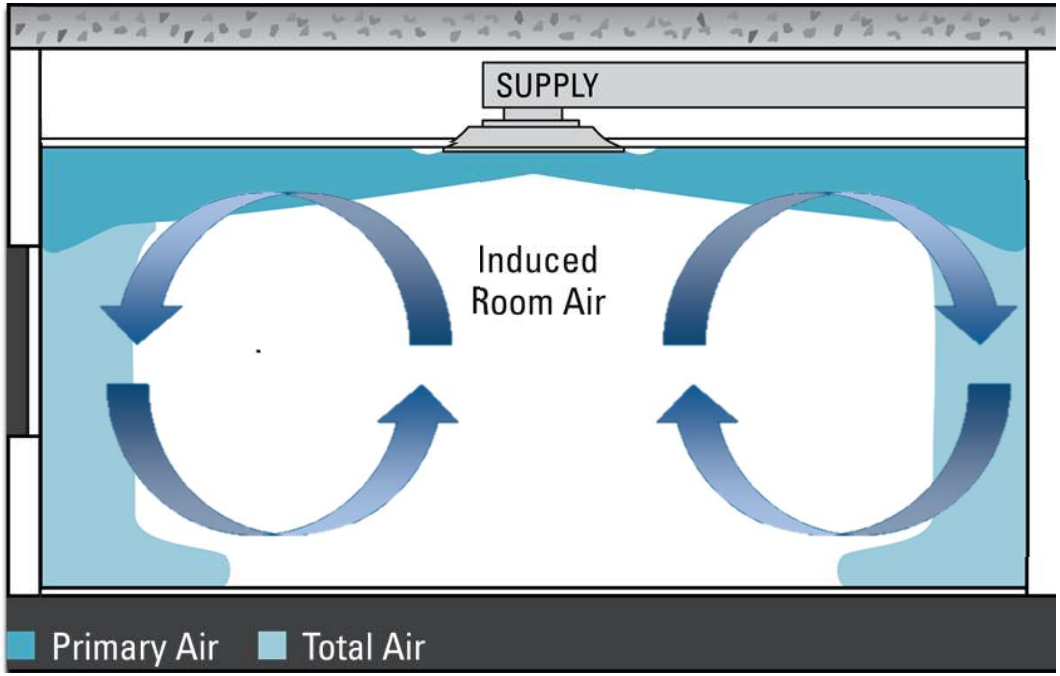
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes



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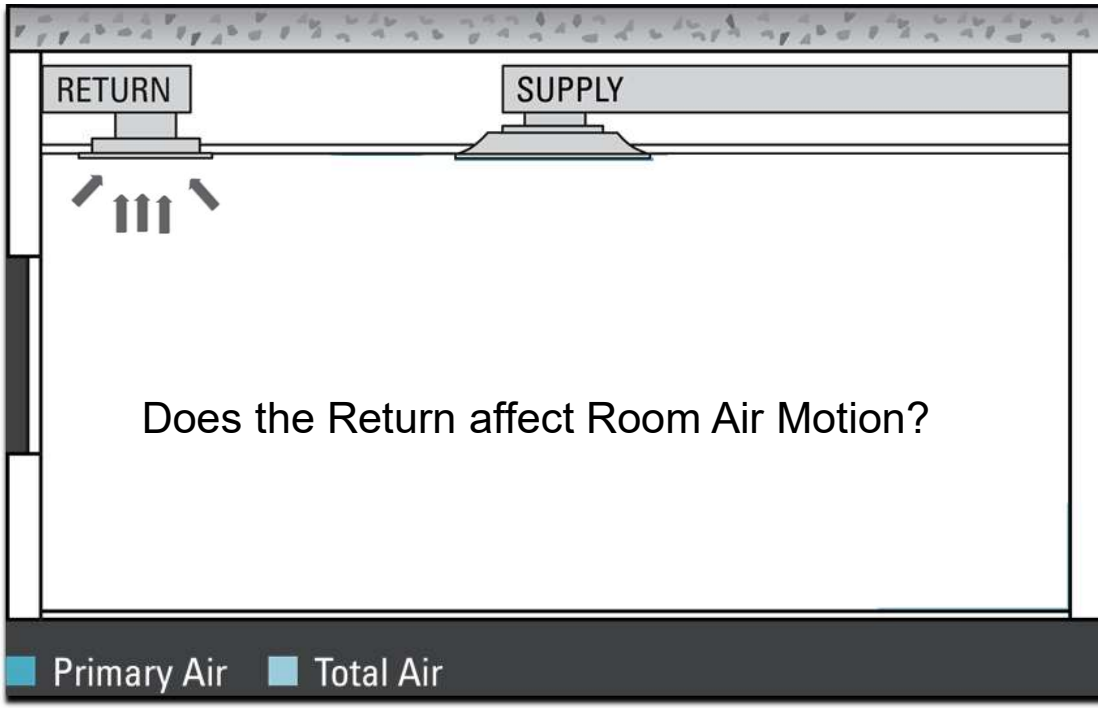
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes



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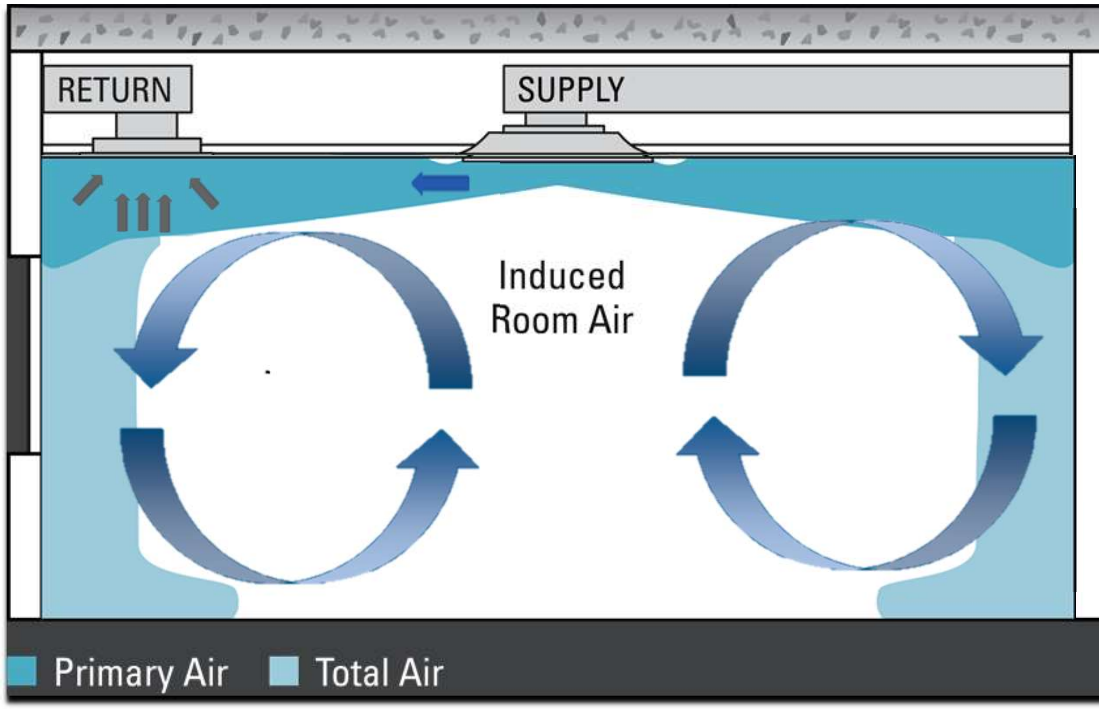
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes

Avoid supply air short-circuit



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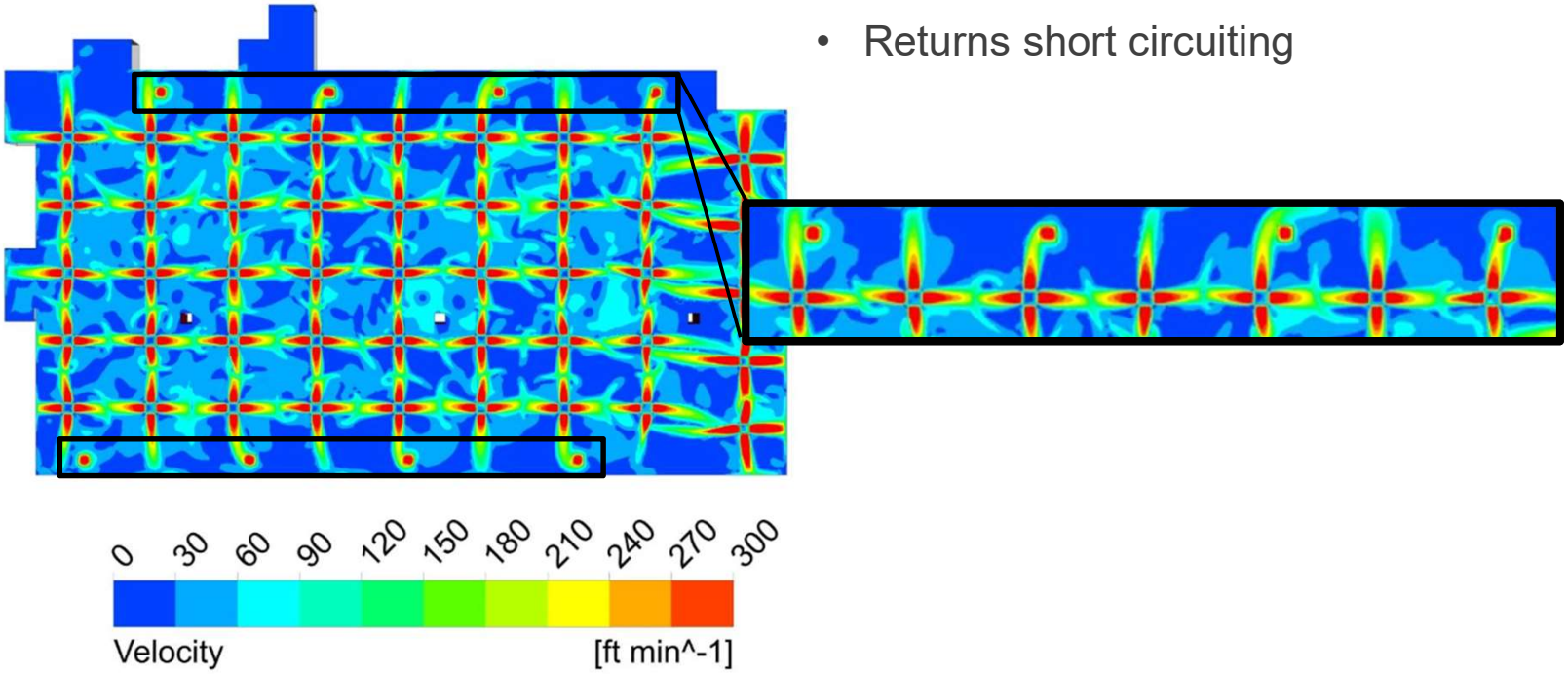
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes



- Returns short circuiting

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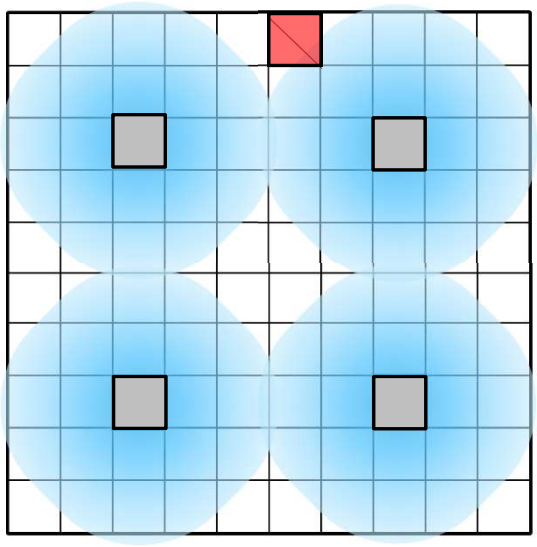
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes



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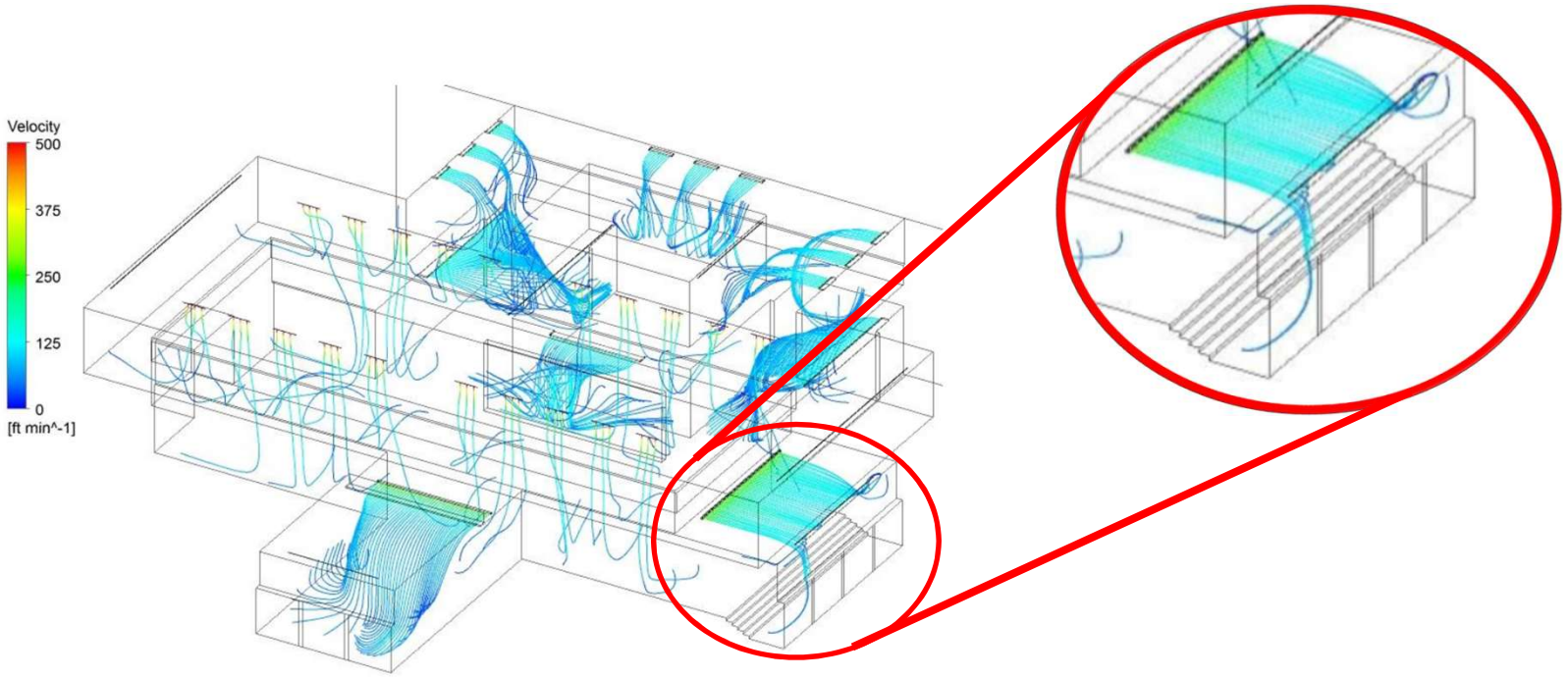
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes



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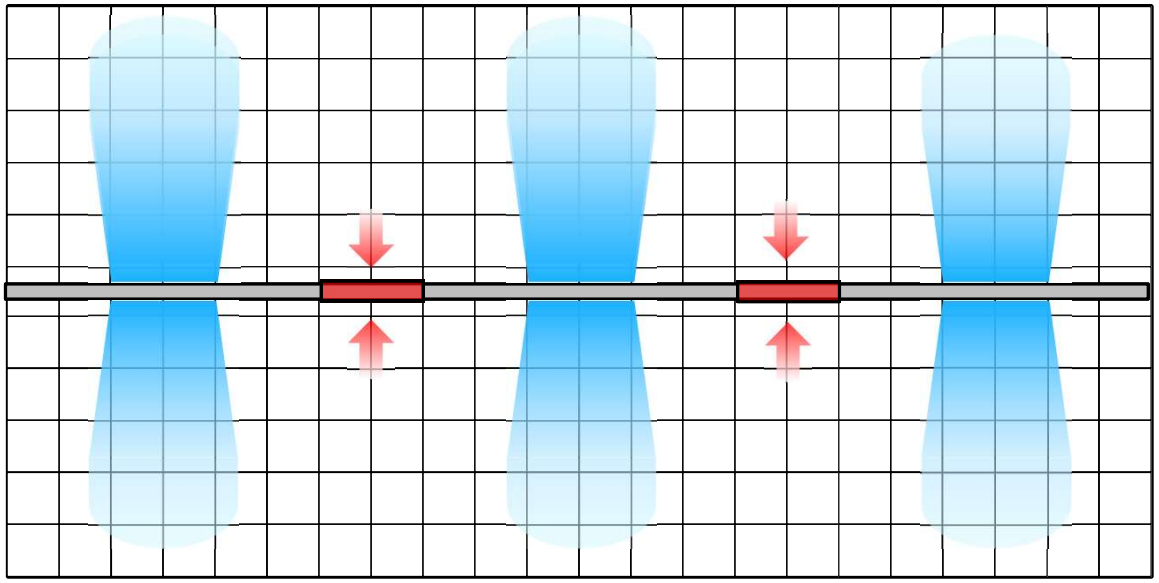
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes



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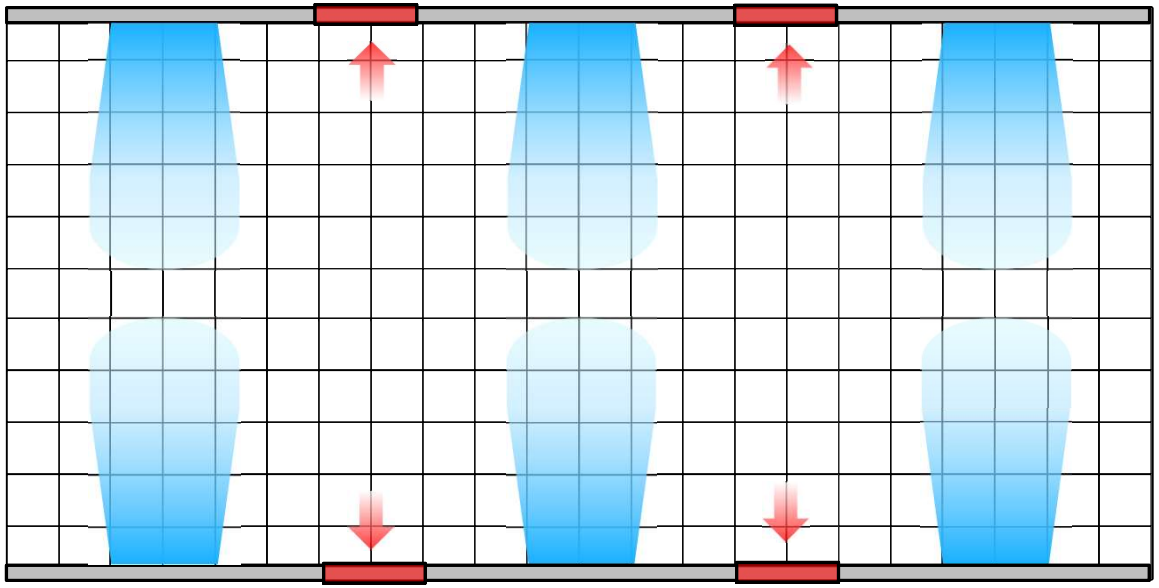
Air Distribution Basics

GRILLES & DIFFUSERS

How Air Mixes



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Air Distribution Fundamentals

Grilles, Registers & Diffusers

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Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Grille vs. Register

- What is the difference between a grille and a register?
  - A grille is a covering for any area through which air passes
  - A register also has a damper or control valve

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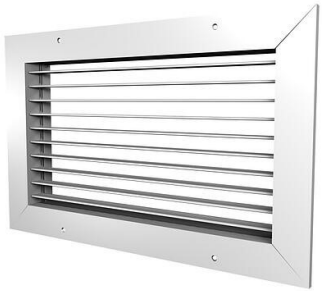
Grilles, Registers & Diffusers

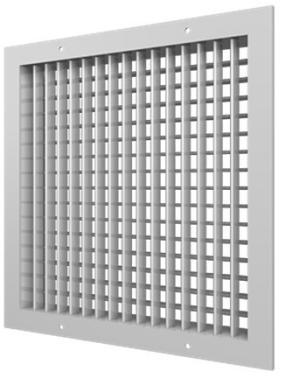
GRILLES & DIFFUSERS

Grille Type – Blade Type

Fixed Deflection
(Return)



Single Deflection
(Supply)



Double Deflection
(Supply)

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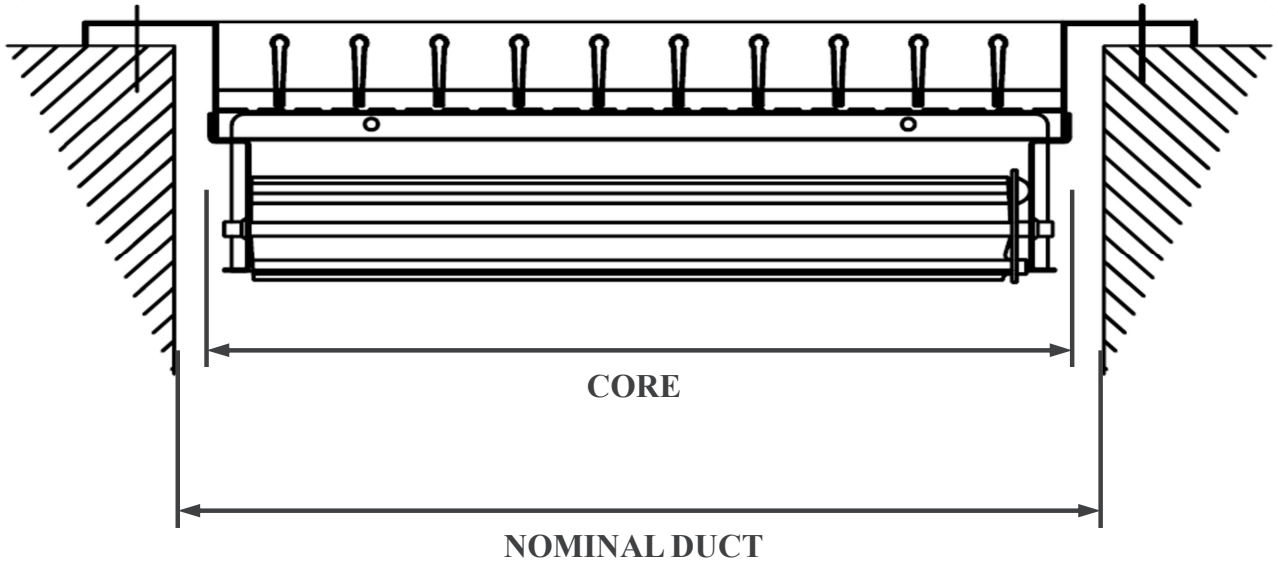
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Grille and Register Dimensions



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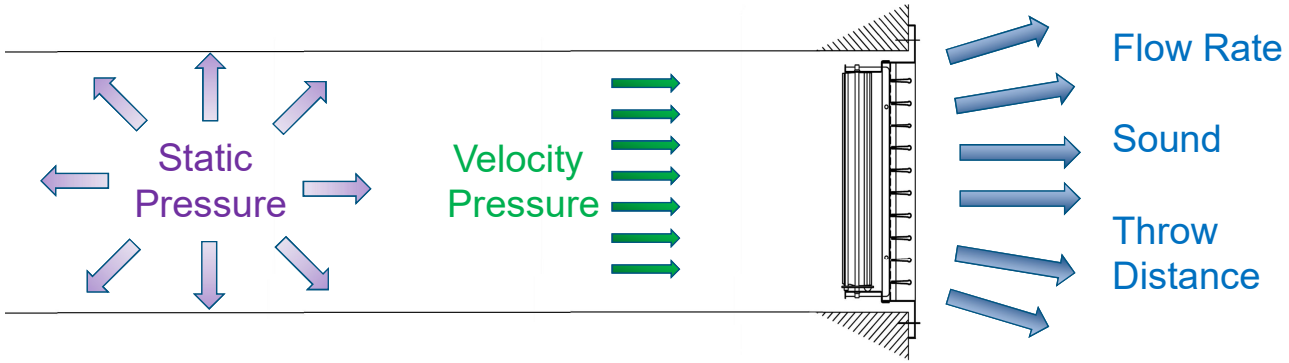
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Grille and Register Operation



Total Pressure = Static Pressure + Velocity Pressure

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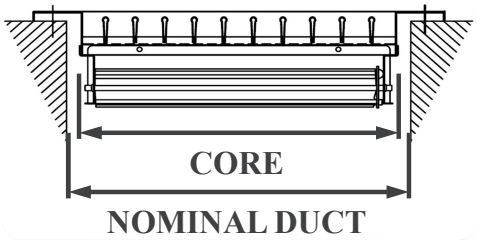
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Grille and Register Operation

Size	Core Velocity (fpm)		300	400	500	600
	Velocity Pressure (in. w.g.)		0.006	0.010	0.016	0.022
	Total Pressure (in. w.g.)	0°	0.014	0.024	0.038	0.052
		22.5°	0.017	0.028	0.045	0.063
		45°	0.025	0.042	0.067	0.093
Ac = 0.15 ft² 7 x 4 6 x 5	Flow Rate (cfm)		45	60	75	90
	Sound (NC)		-	-	-	-
	Throw (ft)	0°	4-6-12	5-8-14	7-10-16	8-12-17
		22.5°	3-5-10	4-6-11	6-8-13	6-10-14
		45°	2-3-6	3-4-7	3-5-8	4-6-9



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Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Grille and Register Operation

- Larger grilles allow more airflow with less noise

Core Area	Nominal Size			
		Core Velocity		1222
		Free Area Velocity		1722
		Velocity Pressure		0.093
		Total Pressure	0°	0.169
			22°	0.212
Sq. ft.			45°	0.322
		CFM		500
0.41	6" x 12"	NC	0°	26
			22°	30
			45°	37
		Throw (ft)	0°	23-28-40
			22°	18-23-32
			45°	12-14-20

Core Area	Nominal Size			
		Core Velocity		276
		Free Area Velocity		388
		Velocity Pressure		0.005
		Total Pressure	0°	0.009
			22°	0.011
Sq. ft.			45°	0.016
		CFM		500
1.81	12" x 24"	NC	0°	--
			22°	--
			45°	--
		Throw (ft)	0°	11-19-37
			22°	8-15-30
			45°	5-9-19

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Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Grille and Register Operation

- **Free Area** is the total non-obstructed cross-sectional area across the grille.

Eggcrate Face

Core Area	Nominal Size	Core Velocity	1010
		Velocity Pressure	0.064
Sq. ft.		Negative SP	0.136
0.40	12x6	CFM	400
		NC	26

Louvered Face

Core Area	Nominal Size	Core Velocity	975
		Velocity Pressure	0.059
Sq. ft.	L x W	Negative SP	0.239
		CFM	400
0.41	12" x 6"	NC	35

Perforated Face

Core Area	Nominal Size	Core Velocity	976
		Velocity Pressure	0.059
Sq. ft.		Negative SP	0.451
0.41	6x12	CFM	400
		NC	38

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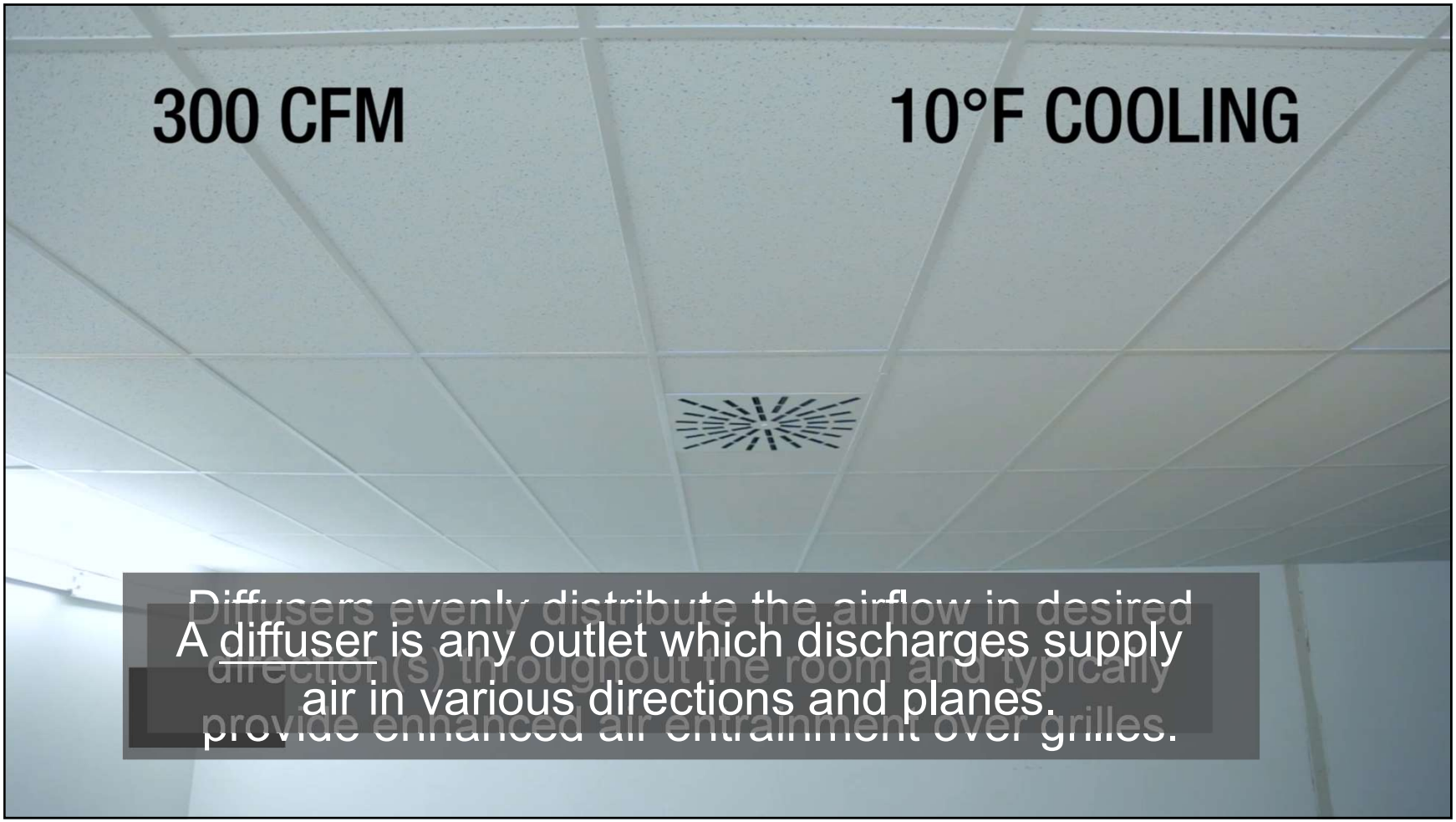

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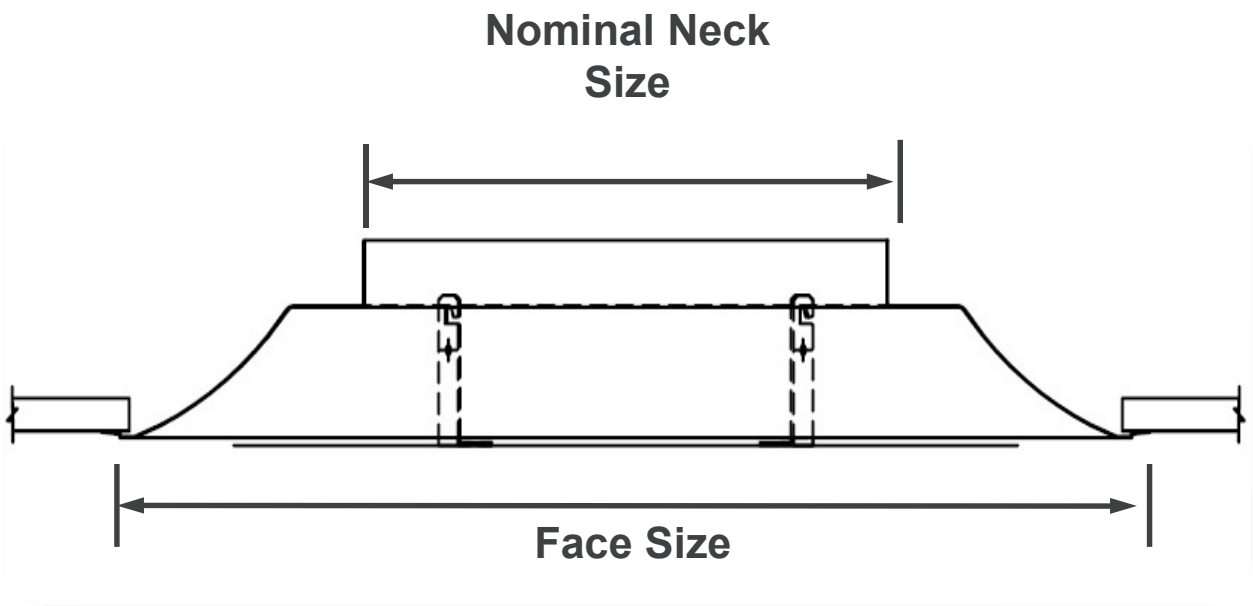
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Dimensions



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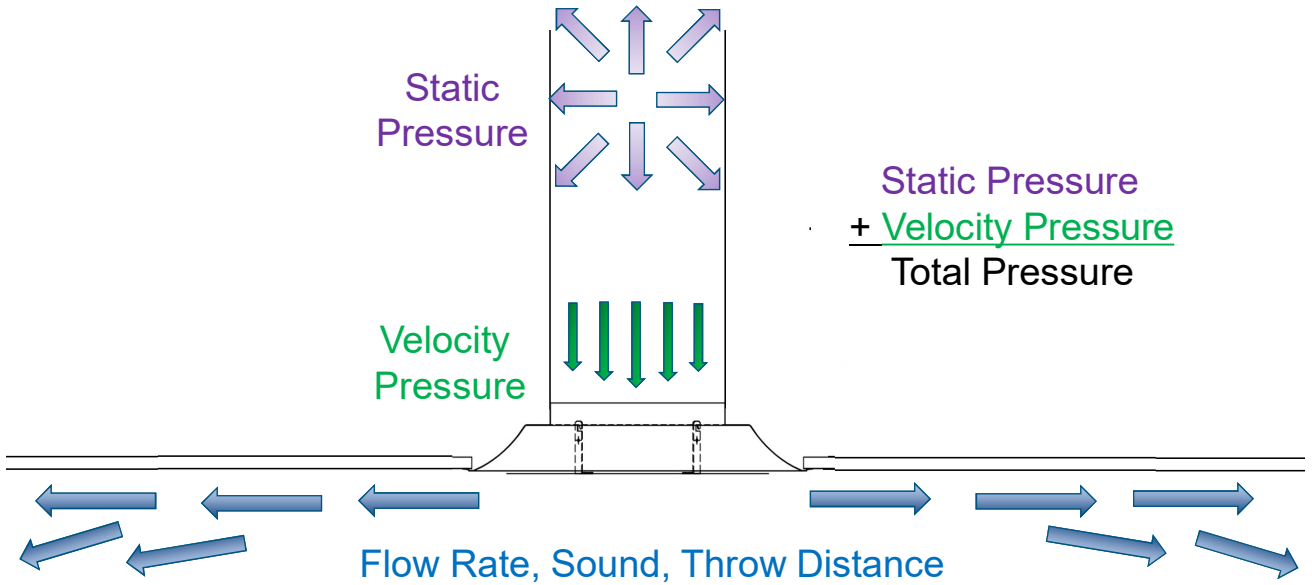
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation



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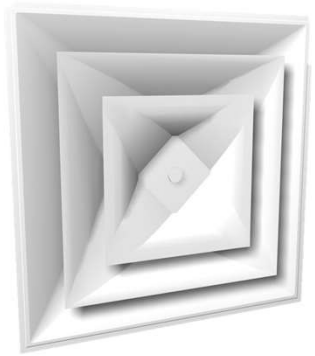
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation

Listed Size	Neck Velocity (fpm) / Velocity Pressure (in. w.g.)	400 .01	500 .016	600 .022	700 .031	800 .040	900 .050	1000 .062	1200 .090	1400 .122	1600 .160
6	Total Pressure (in. w.g.)	.015	.023	.034	.046	.060	.076	.094	.135	.183	.239
	Flow Rate (cfm)	78	98	118	137	157	176	196	235	274	314
	Sound (NC)	-	-	-	-	15	19	22	28	33	37
	Throw (ft.)	1-2-4	1-2-4	2-3-5	2-3-6	2-4-7	3-4-7	3-4-7	4-5-8	4-6-9	5-7-9
8	Total Pressure (in. w.g.)	.016	.025	.037	.050	.065	.082	.102	.146	.199	.260
	Flow Rate (cfm)	140	175	209	244	279	314	349	419	489	558
	Sound (NC)	-	-	-	-	19	22	26	31	36	40
	Throw (ft.)	2-2-5	2-3-6	2-4-7	3-4-8	3-5-9	4-6-9	4-6-10	5-7-11	6-8-12	7-9-12
10	Total Pressure (in. w.g.)	.019	.030	.044	.060	.078	.098	.122	.175	.238	.311
	Flow Rate (cfm)	218	273	327	382	436	491	545	654	763	872
	Sound (NC)	-	-	-	17	21	25	28	34	39	43
	Throw (ft.)	2-3-6	3-4-8	3-5-9	4-6-10	4-6-11	5-7-12	5-8-12	6-9-13	8-10-14	9-11-15
12	Total Pressure (in. w.g.)	.023	.036	.051	.070	.091	.115	.142	.205	.279	.364
	Flow Rate (cfm)	314	393	471	550	628	707	785	942	1099	1256
	Sound (NC)	-	-	-	19	24	27	30	36	41	45
	Throw (ft.)	3-4-8	3-5-10	4-6-11	5-7-12	5-8-13	6-9-14	7-10-15	8-11-16	9-12-17	11-13-19



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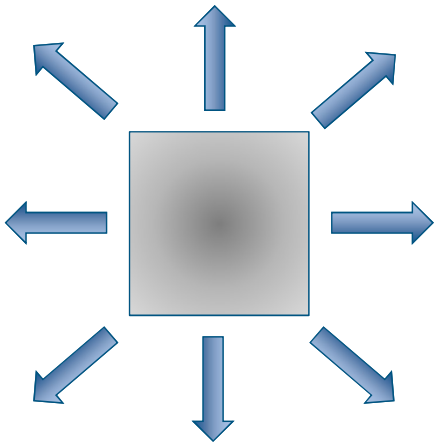
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation

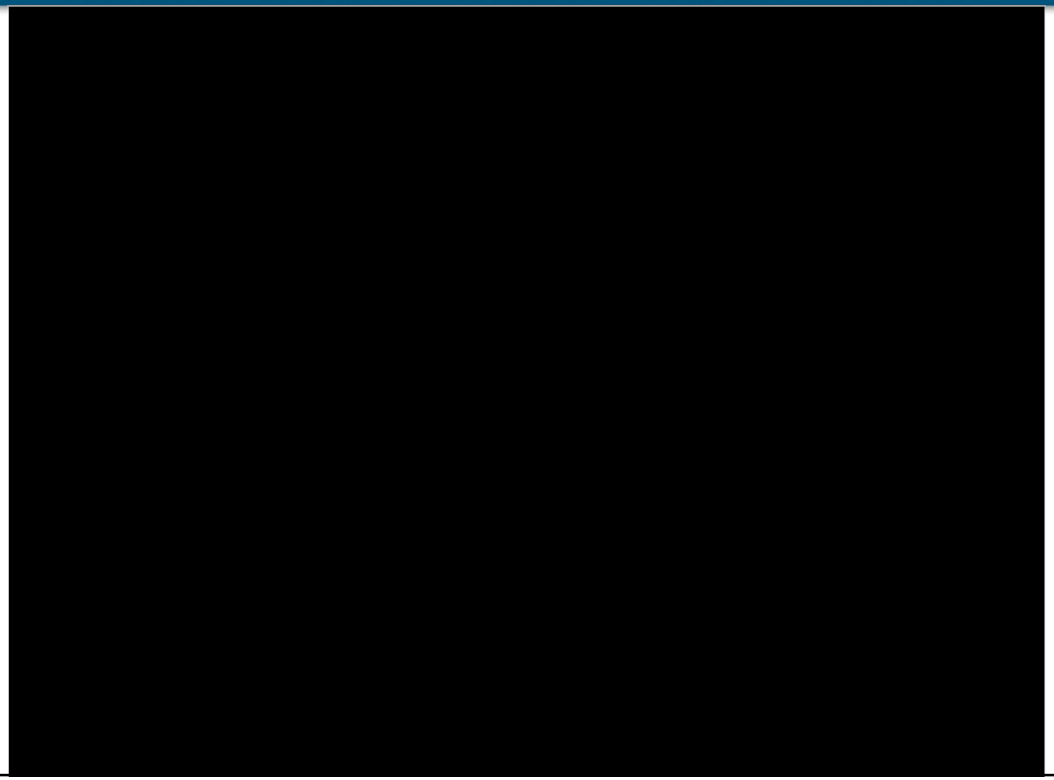


Square Cone Diffuser

Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation



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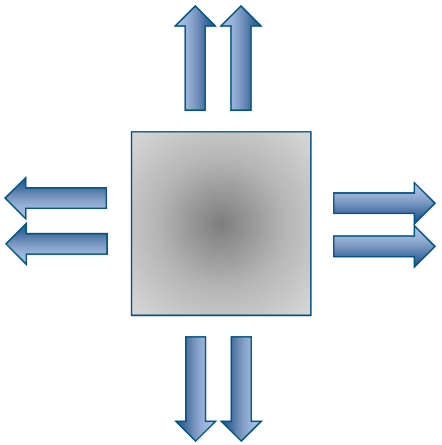
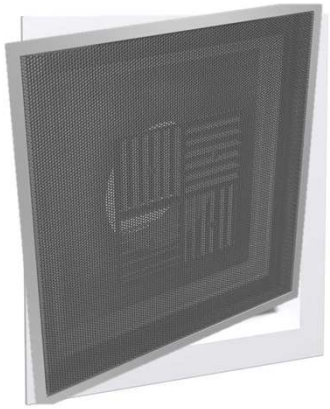
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation



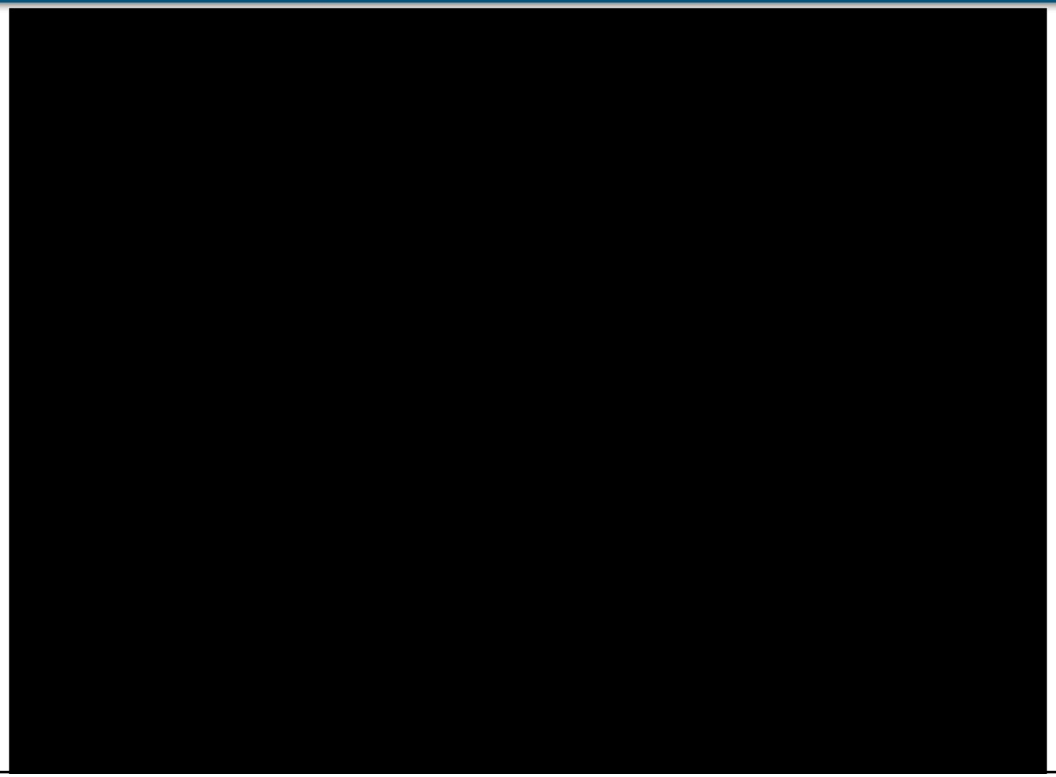


Perforated Face Diffuser

Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation



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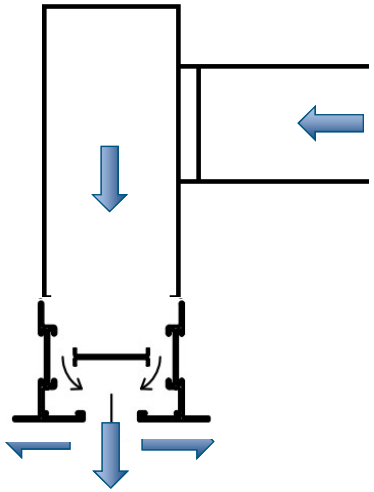
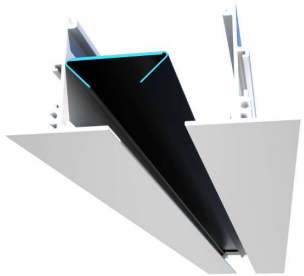
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation





Slot Diffuser

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Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation

Horizontal Throw

Vertical Throw

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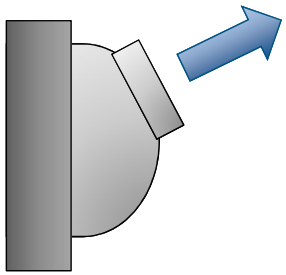
Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation



Nozzle Diffuser

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Grilles, Registers & Diffusers

GRILLES & DIFFUSERS

Diffuser Operation

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Air Distribution Fundamentals

Sound

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GRD Sound

GRILLES & DIFFUSERS

Testing

- Lab testing
  - ASHRAE Standard 70
    - Defines test procedures
    - Isothermal Testing
    - Non-turbulent, smooth inlet conditions
    - Note in all catalogue performance data

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GRD Sound

GRILLES & DIFFUSERS

Catalog Noise Data

- How do we measure “sound” from diffusers?

Neck Velocity (fpm)			300		400		500		600	
Velocity Pressure (in. w.g.)			0.006		0.01		0.016		0.022	
Total Pressure (in. w.g.)			0.036		0.065		0.099		0.144	
Duct Size 24 in. x 24 in.		Flow Rate (cfm)	1200		1600		2000		2400	
		Sound (NC)	15		24		31		37	
			A	B	A	B	A	B	A	B
Duct Area 4.00 ft²	4A	cfm/Side	300		400		500		600	
		Throw (ft)	16-20-28		19-23-32		21-26-36		23-28-40	
	3A	cfm/Side	300	450	400	600	500	750	600	900
		Throw (ft)	16-20-28	18-22-31	19-23-32	21-26-36	21-26-36	23-29-41	23-28-40	26-31-44
	2S, 2G	cfm/Side	600		800		1000		1200	
		Throw (ft)	20-24-34		23-28-39		25-31-44		28-34-48	
	1S	cfm/Side	1200		1600		2000		2400	
		Throw (ft)							34-41-59	

What does this NC value ACTUALLY mean?

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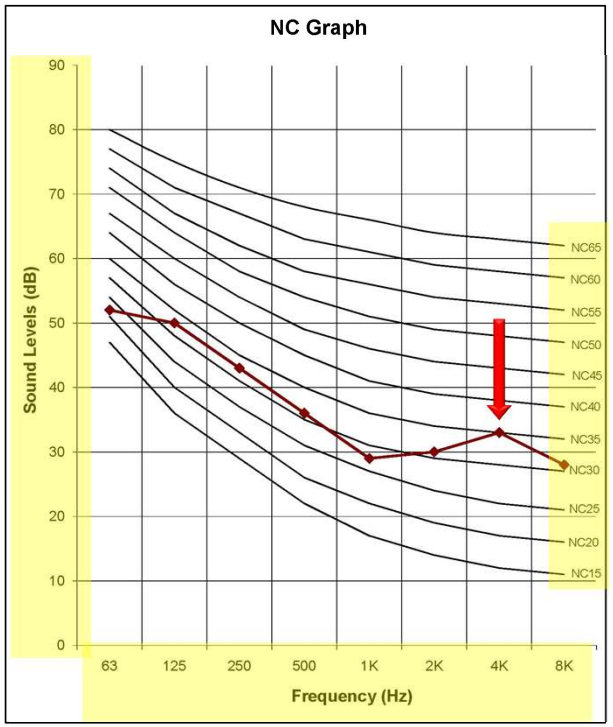
GRD Sound

GRILLES & DIFFUSERS

Noise Criterion (NC) Graph

- Plot sound levels at each of the 8 frequencies
- Frequency range is 63 Hz to 8000 Hz
- The high point on the NC curves sets the NC value



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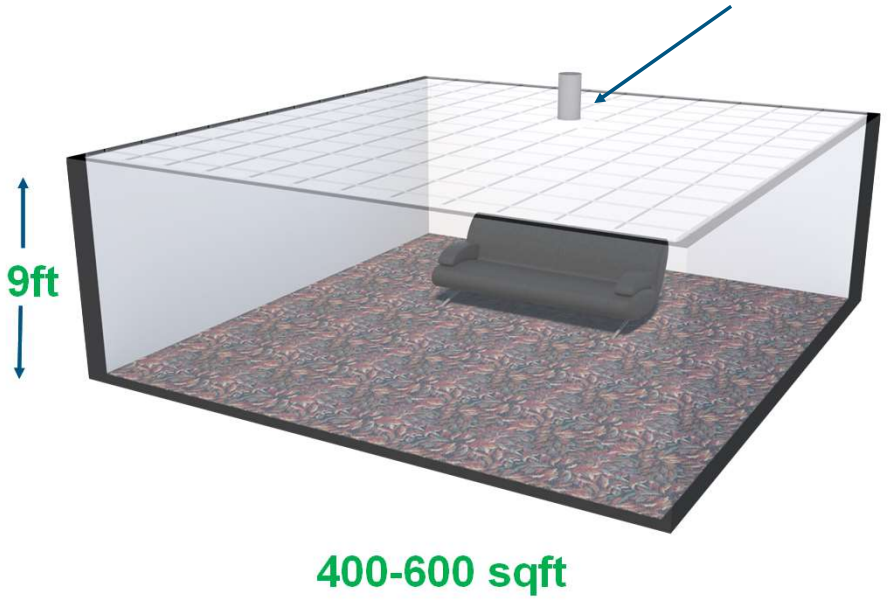
GRD Sound

GRILLES & DIFFUSERS

Catalog Noise Data

- Catalog sound data makes several assumptions in its measurement:
  - Average Room Size (400-600 sqft)
  - Distance from source (9 ft ceiling)
  - Assumes 10dB room absorption (carpet, drywall)
  - Single diffuser



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GRD Sound

GRILLES & DIFFUSERS

Catalog Noise Data

- So why use NC?
  - Been around 50 years
  - NC provides a means to quickly compare manufacturers.
    - (Comparing 1 number vs 8 numbers)
  - NC is weighted towards human perception
  - Easier to apply quick guidelines

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GRD Sound

GRILLES & DIFFUSERS

ASHRAE and Sound

- ASHRAE Publishes Guidelines
- Individual diffusers should be quieter than guidelines to account for multiple outlets in space

Room Types	Recommended NC or RC Criteria
Private residences	25-35
Hotels/Motels	
Individual rooms or suites	25-35
Meeting/banquet rooms	25-35
Corridors, lobbies	35-45
Service/support areas	35-45
Office Buildings	
Executive and private offices	25-35
Conference rooms	25-35
Teleconference rooms	< 25
Open-plan offices	< 40
- With sound masking	< 35
Corridors and lobbies	40-45
Hospitals and clinics	
Private rooms	25-35

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GRD Sound

GRILLES & DIFFUSERS

Performance Notes

Performance Data - Imperial Units - 12 x 12 Face Size

Listed Size	Neck Velocity, fpm / Velocity Pressure, in. w.g.	400 .010	500 .016	600 .022	700 .031	800 .040	900 .050	1000 .062	1200 .090	1400 .122	1600 .160
	Total Pressure	.017	.026	.038	.052	.068	.086	.106	.153	.208	.271
	Flow Rate, cfm	35	44	52	61	70	78	87	104	122	139
4	NC	—	—	—	—	—	15	19	25	30	34
	Throw 150, 100, 50	1-2-4	1-2-4	2-3-5	2-3-6	2-4-6	3-4-7	3-4-7	4-5-8	4-6-9	5-6-9
	Total Pressure, in. w.g.	.027	.042	.061	.082	.108	.136	.168	.242	.330	.431
	Flow Rate, cfm	54	68	82	95	109	122	136	163	190	218
5	NC	—	—	—	—	16	20	24	30	35	39
	Throw 150, 100, 50	2-2-5	2-3-6	2-4-7	3-4-8	3-5-8	4-5-9	4-6-9	5-7-10	5-8-11	6-8-11

Performance Notes:

1. Tested in accordance with ASHRAE Standard 70-2006 "Method of Testing for Rating the Performance of Air Outlets and Inlets."
2. Air flow is in cfm.
3. All pressures are in in. w.g.
4. Throw values are measured in feet for terminal velocities of 150 fpm (minimum), 100 fpm (middle) and 50 fpm (maximum).
5. Throw data is based on supply air and room air being atisothermal conditions.
6. If the diffuser is mounted on an exposed duct, multiply the radii of diffusion in the table by 0.70.
7. NC values are based on room absorption of 10 dB re 10^{-12} Watts and one diffuser.
8. Blanks (—) indicate an NC level below 15.
9. Does not include effects of ceiling radiation damper (SPD-FR)

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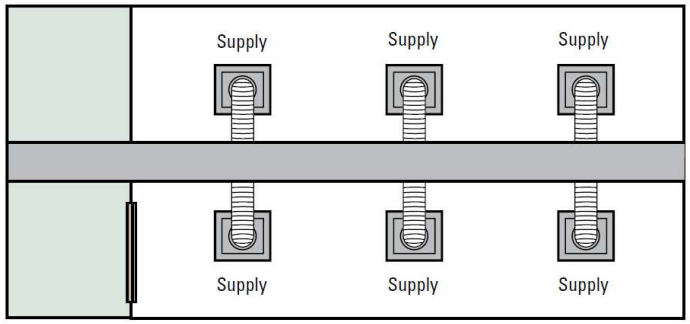
GRD Sound

GRILLES & DIFFUSERS

Multiple Outlets

- What to do with multiple outlets
  - Room size ~ 400-600 ft2



No. of Outlets	1	2	3	4	8	10	20	40
dB Boost	0	3	5	6	9	10	13	16

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GRD Sound

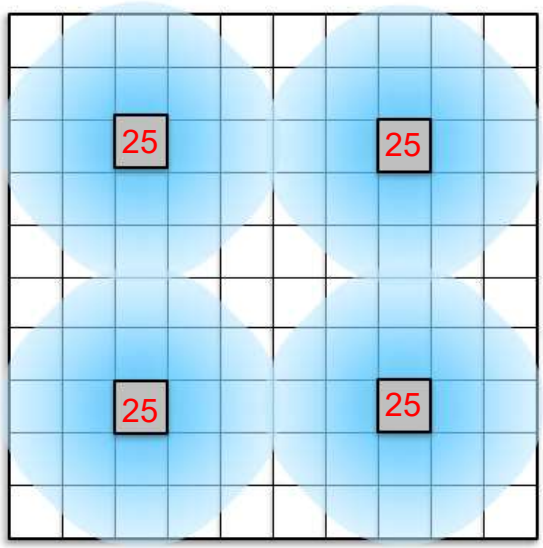
GRILLES & DIFFUSERS

Multiple Air Outlets

Select a diffuser for NC25

4 diffusers in the room

4 equal sound sources results in total sound level of NC31



No. of Outlets	1	2	3	4	8	10	20	40
dB Boost	0	3	5	6	9	10	13	16

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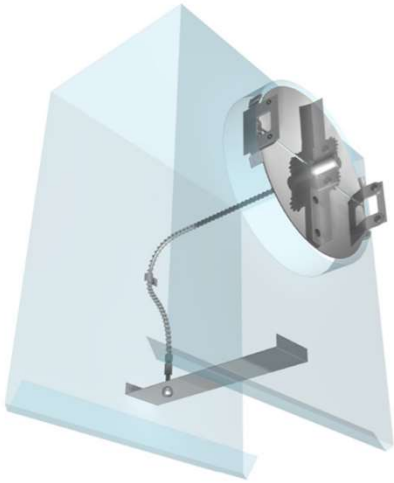
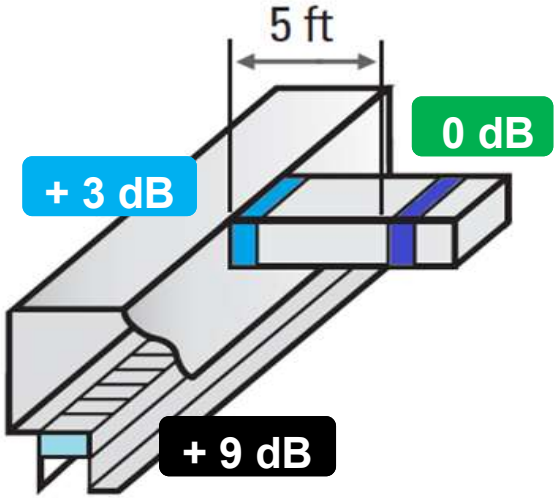
GRD Sound

GRILLES & DIFFUSERS

Accessories

- How does damper location effect sound?





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GRD Sound

GRILLES & DIFFUSERS

Sound Comparison

- Diffuser sound comparison – 24x24, 380cfm, 700fpm Neck Velocity
  - Square Cone ……NC 17
  - Square Plaque ……NC 18
  - Round Cone ……..NC 22
  - Modular Core ……..NC 26
  - Perforated Curved Vane ……...NC 28
  - Louvered Face ……NC 31
  - Perforated Face Deflector ……NC 33
  - Perforated Neck Deflector ……NC 37

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Air Distribution Fundamentals

Throw

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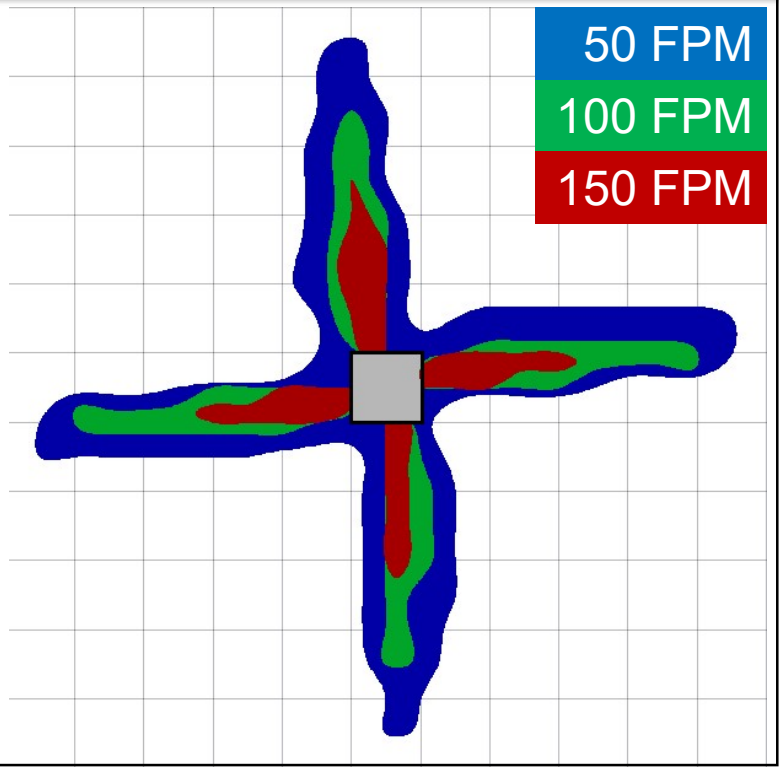
GRD Throw

GRILLES & DIFFUSERS

What is Throw?

- Throw is the **distance** air travels before it reduces to a terminal velocity
  - **150 fpm**
  - **100 fpm**
  - **50 fpm**
- The geometric boundary created by the terminal velocity is known as the **isovel**.



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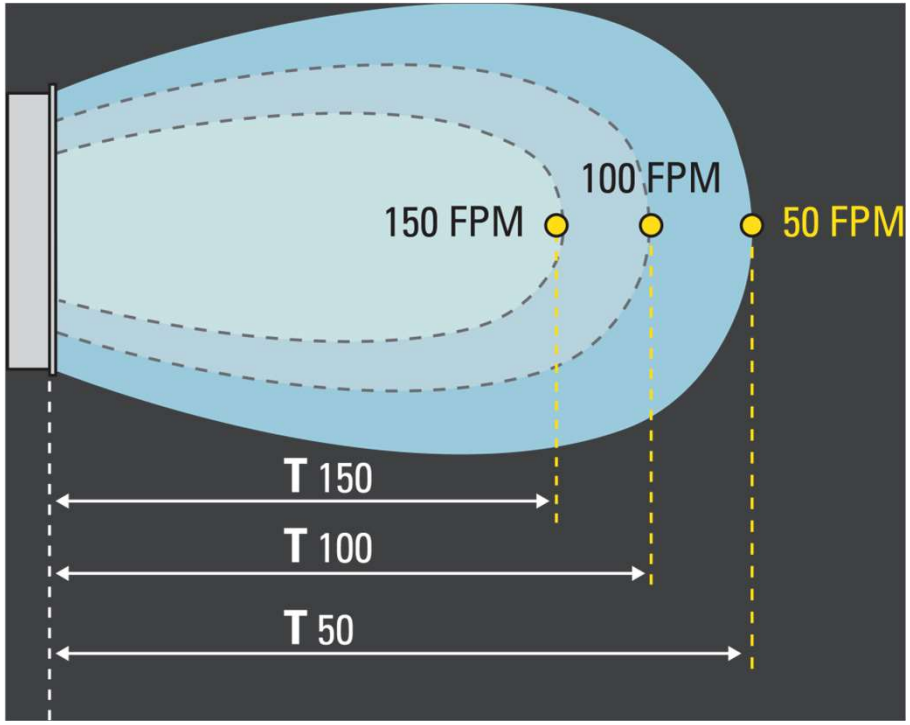
GRD Throw

GRILLES & DIFFUSERS

Grille Isovel



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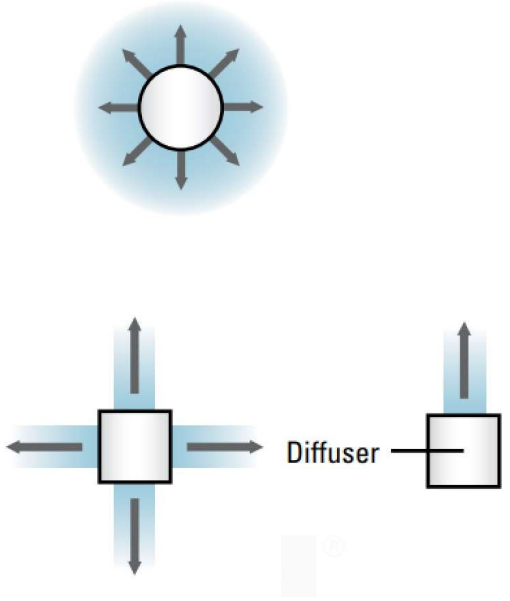
GRD Throw

GRILLES & DIFFUSERS

Throw Patterns

Diffuser Type	Flow	T_{50fpm}	Noise
Square Cone	450 CFM	11 ft	NC-21
Square Plaque	450 CFM	11 ft	NC-22
Round Cone	450 CFM	11 ft	NC-27
Perf Face 4-Way	450 CFM	16 ft	NC-37
Louvered Face 4-Way	450 CFM	26 ft	NC-35
Perf Face 1-Way	450 CFM	32 ft	NC-37
Louvered Face 1-Way	450 CFM	39 ft	NC-35

(All at identical inlet neck velocity, neck size, flow rate
10” or equiv. neck, 800 fpm neck velocity, 450 CFM, 24”x24” face)



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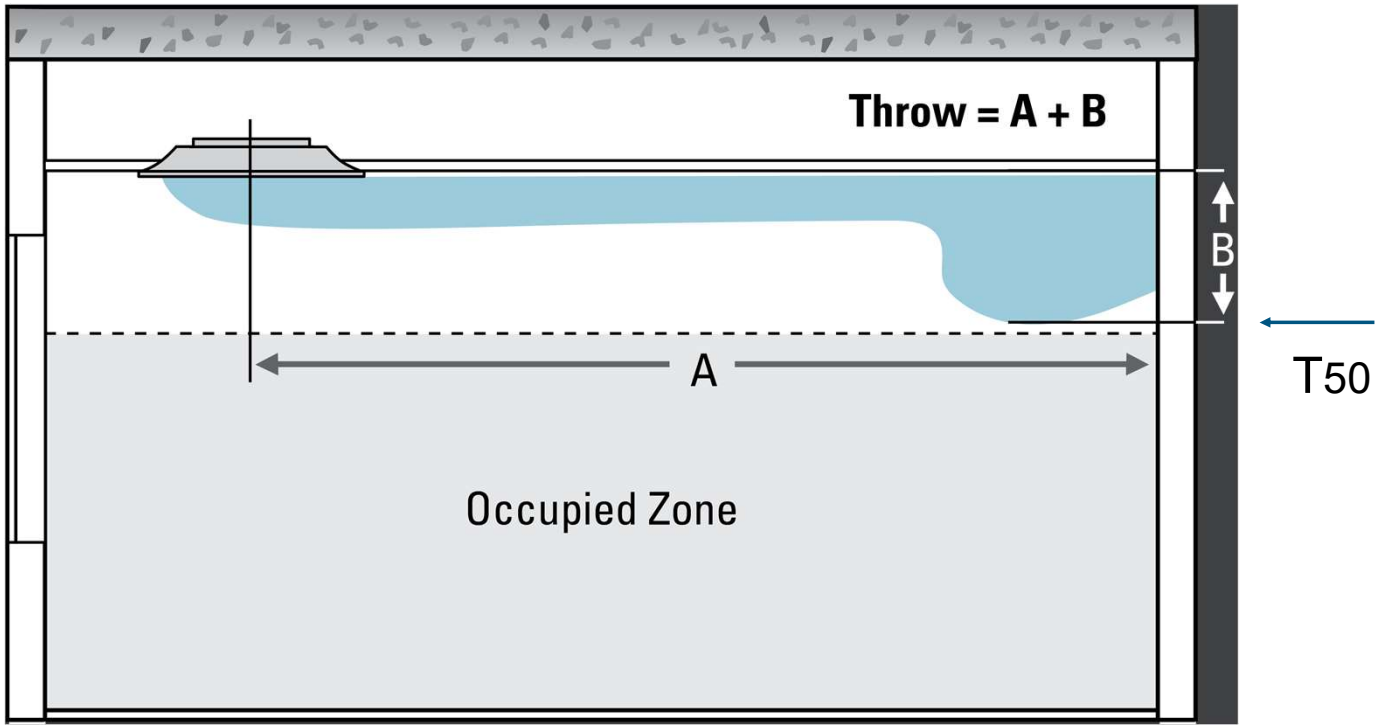
GRD Throw

GRILLES & DIFFUSERS

Throw Mapping



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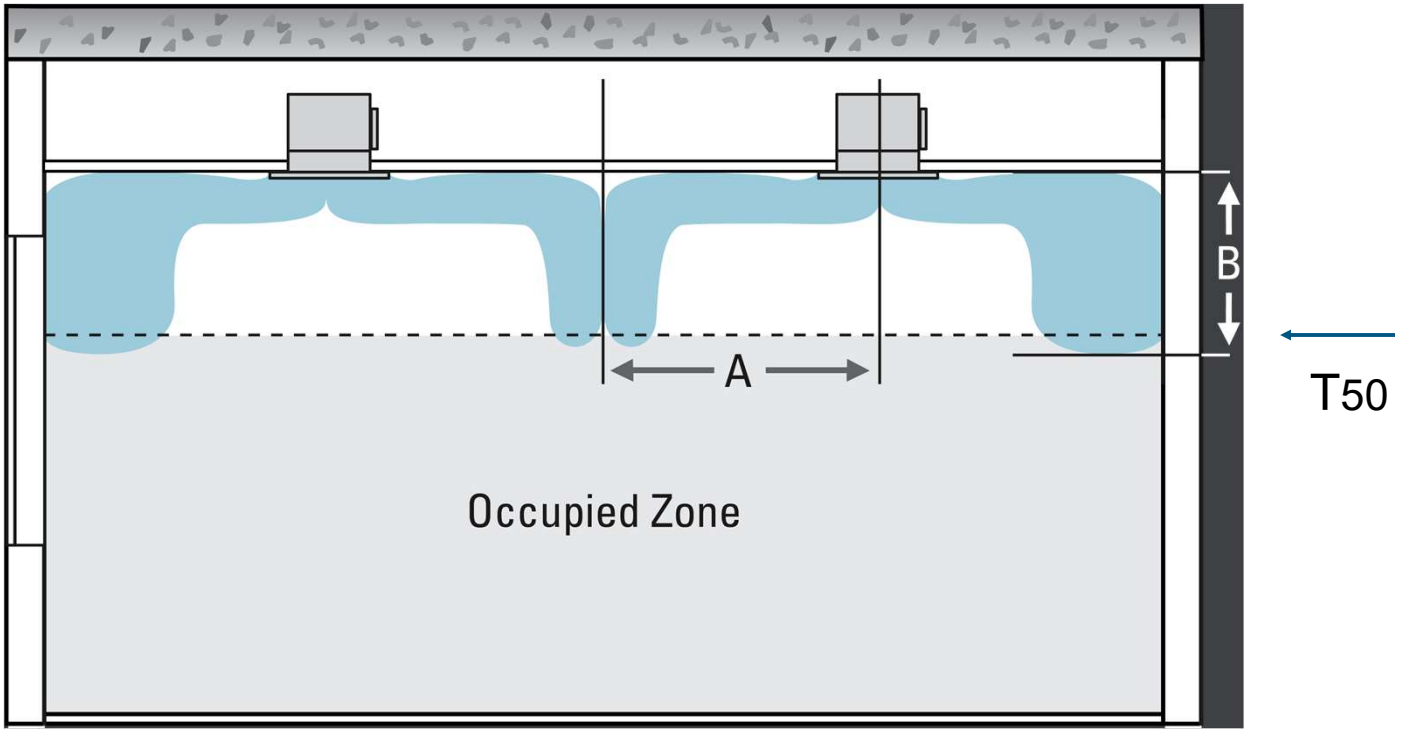
GRD Throw

GRILLES & DIFFUSERS

Throw Mapping



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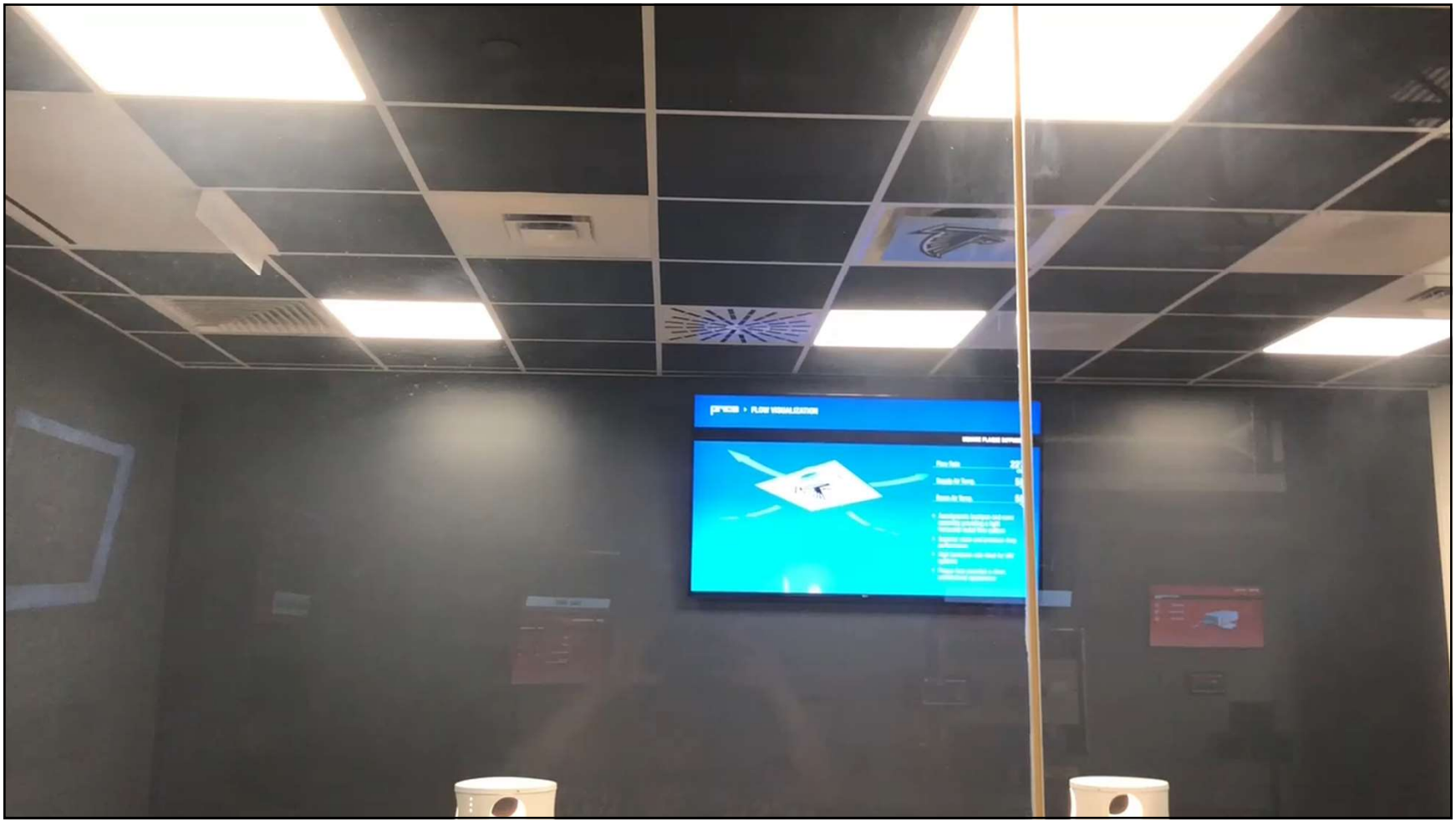

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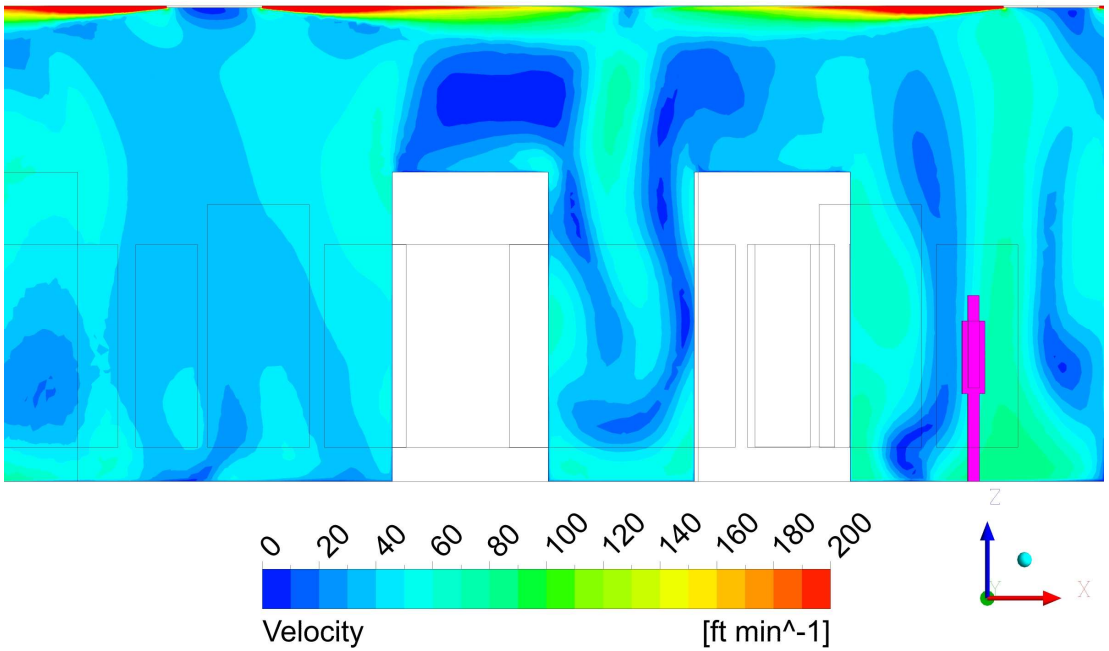
GRD Throw

GRILLES & DIFFUSERS

Throw Mapping



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GRD Throw

GRILLES & DIFFUSERS

Throw Mapping - Room Details

Room size = 20’ x 20’

Ceiling height = 10’

Air volume = 1000 cfm

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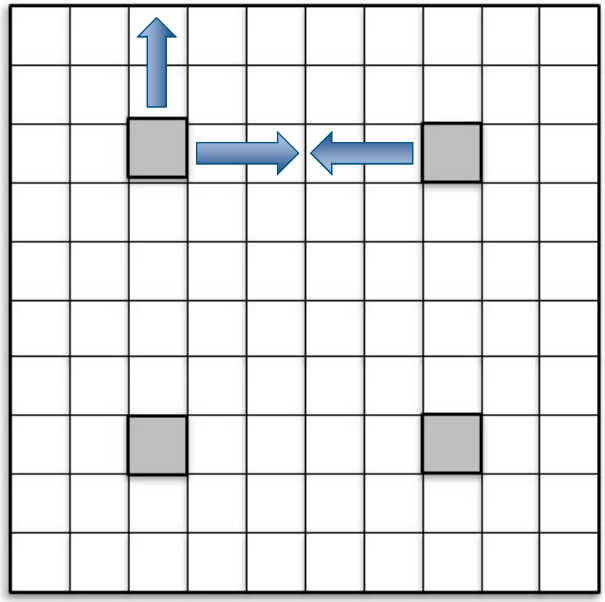
GRD Throw

GRILLES & DIFFUSERS

Throw Mapping - Horizontal Throw Distance

Assuming 24”x24” ceiling tile

- Diffusers are 8’ apparat
- Diffusers are 4’ from the wall



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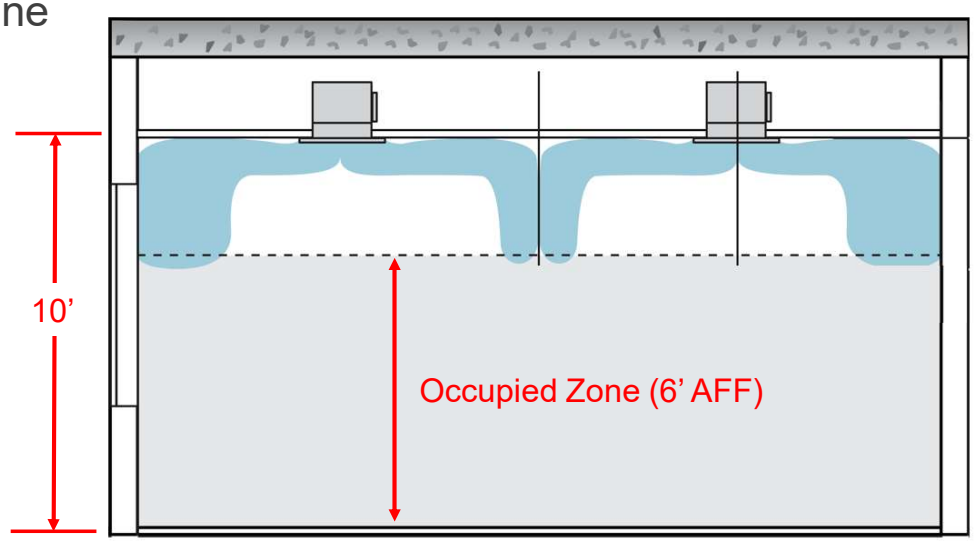
GRD Throw

GRILLES & DIFFUSERS

Throw Mapping - Vertical Throw Distance

Design for 50 fpm at occupied zone

- Space has a 10’ ceiling
- Occupied zone is 6’ AFF
- Vertical throw = 10’ – 6’ = 4’



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GRD Throw

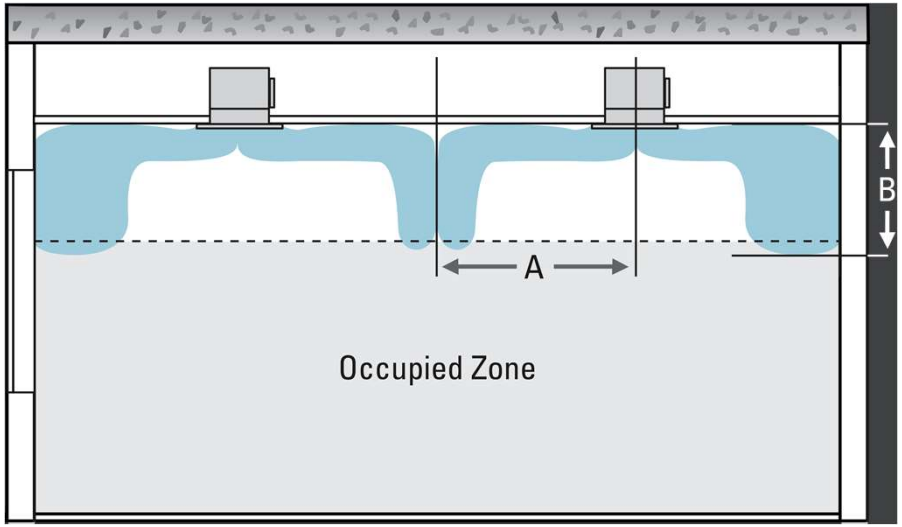
GRILLES & DIFFUSERS

Throw Mapping – Total Throw Distance

Ideal throw length = A+B
Horizontal throw (A) = 8’/2 = 4’
Vertical throw (B) = 4’

Ideal throw length = 4+4 = 8’

Select each diffuser for 8’@250cfm



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GRD Throw

GRILLES & DIFFUSERS

Directional Diffuser Selection

Neck Velocity (fpm)			300		400		500		600		700		800			
Velocity Pressure (in. w.g.)			0.006		0.01		0.016		0.022		0.031		0.04			
Total Pressure (in. w.g.)			0.036		0.065		0.099		0.144		0.196		0.256			
Duct Size 6 in. x 6 in.		Flow Rate (cfm)	75		100		125		150		175		200			
		Sound (NC)	-		-		17		23		27		31			
			A	B	A	B	A	B	A	B	A	B	A	B	A	B
Duct Area 0.25 ft²	4A	cfm/Side	19		25		31		38		44		50		56	
		Throw (ft)	4-6-12		5-8-15		7-10-16		8-12-18		9-14-19		11-15-21		12-16-22	
	3A	cfm/Side	19	28	25	38	31	47	38	56	44	66	50	75	56	84
		Throw (ft)	4-6-12	5-7-14	5-8-15	6-10-16	7-10-16	8-12-18	8-12-18	10-14-20	9-14-19	11-15-22	11-15-21	13-16-23	12-16-22	14-17-25
	2S, 2G	cfm/Side	38		50		63		75		88		100		113	
		Throw (ft)	6-8-15		7-11-18		9-14-20		11-15-22		13-17-24		15-18-25		15-19-27	
	1S	cfm/Side	75		100		125		150		175		200		225	
		Throw (ft)	8-12-19		11-15-22		13-17-24		15-19-27		17-20-29		18-22-31		19-23-33	
Duct Size 9 in. x 9 in.		Flow Rate (cfm)	169		225		282		338		394		450		507	
		Sound (NC)	-		-		21		27		31		35		39	
			A	B	A	B	A	B	A	B	A	B	A	B	A	B
Duct Area 0.56 ft²	4A	cfm/Side	42		56		71		85		99		113		127	
		Throw (ft)	6-9-16		8-12-18		10-15-21		12-16-23		14-17-24		15-18-26		16-20-28	
	3A	cfm/Side	42	63	56	84	71	106	85	127	99	148	113	169	127	190
		Throw (ft)	6-9-16	7-11-18	8-12-18	10-15-21	10-15-21	12-16-23	12-16-23	15-18-25	14-17-24	16-19-27	15-18-26	17-21-29	16-20-28	18-22-31
	2S, 2G	cfm/Side	85		113		141		169		197		225		254	
		Throw (ft)	8-13-19		11-16-22		14-18-25		16-19-28		17-21-30		18-22-32		19-24-34	
	1S	cfm/Side	169		225		282		338		394		450		507	
		Throw (ft)	12-17-24		16-19-27		18-22-31		19-24-34		21-26-36		22-27-39		21-29-41	

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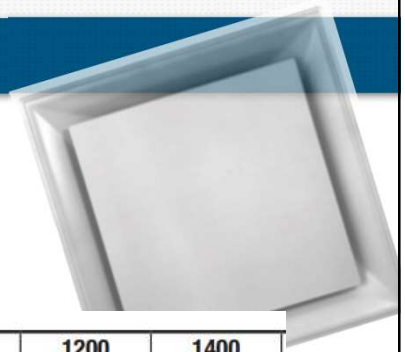
GRD Throw

GRILLES & DIFFUSERS

Radial Diffuser Selection



Listed Size	Neck Velocity (fpm)	400	500	600	700	800	900	1000	1200	1400
	Velocity Pressure (in. w.g.)	0.010	0.016	0.022	0.031	0.040	0.050	0.062	0.090	0.122
6	Total Pressure (in. w.g.)	0.010	0.016	0.023	0.032	0.041	0.053	0.065	0.093	0.127
	Flow Rate (cfm)	78	98	118	137	157	176	196	235	274
	Sound (NC)	-	-	-	-	-	19	22	29	34
	Throw (ft)	1-2-4	1-2-4	2-3-5	2-3-6	2-4-6	3-4-7	3-4-7	4-5-8	4-6-9
8	Total Pressure (in. w.g.)	0.018	0.029	0.042	0.057	0.074	0.093	0.115	0.166	0.226
	Flow Rate (cfm)	140	175	209	244	279	314	349	419	489
	Sound (NC)	-	-	-	-	19	23	27	33	38
	Throw (ft)	2-2-5	2-3-6	2-4-7	3-4-8	3-5-9	4-6-9	4-6-10	5-7-11	6-8-12
10	Total Pressure (in. w.g.)	0.029	0.045	0.065	0.088	0.115	0.146	0.180	0.259	0.353
	Flow Rate (cfm)	218	273	327	382	436	491	545	654	763
	Sound (NC)	-	-	-	18	22	26	30	36	41
	Throw (ft)	2-3-6	3-4-8	3-5-9	4-6-10	4-6-11	5-7-12	5-8-12	6-9-13	8-10-14

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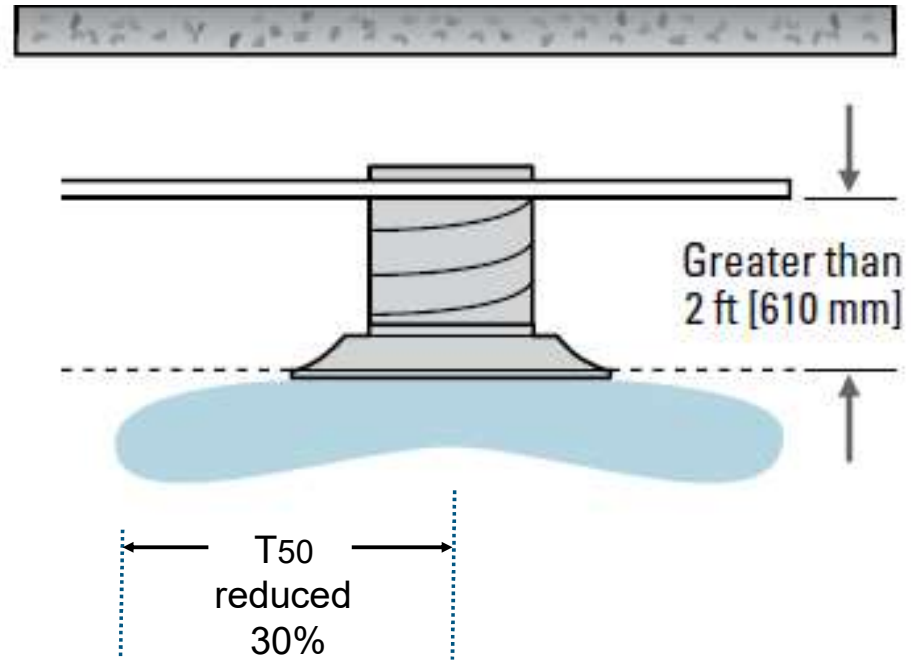
GRD Throw

GRILLES & DIFFUSERS

Coanda Effect

- The **Coanda Effect** is the tendency for high velocity air to cling to solid surfaces.
- An air jet without an adjacent surface will see a reduction in throw distance by roughly 30%.



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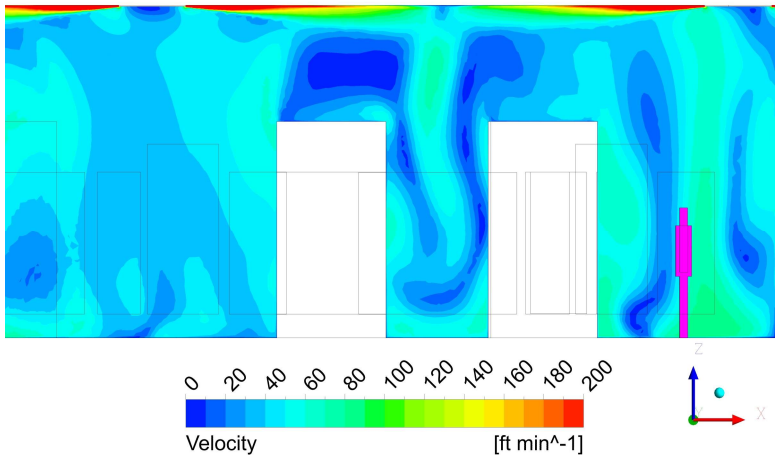
GRD Throw

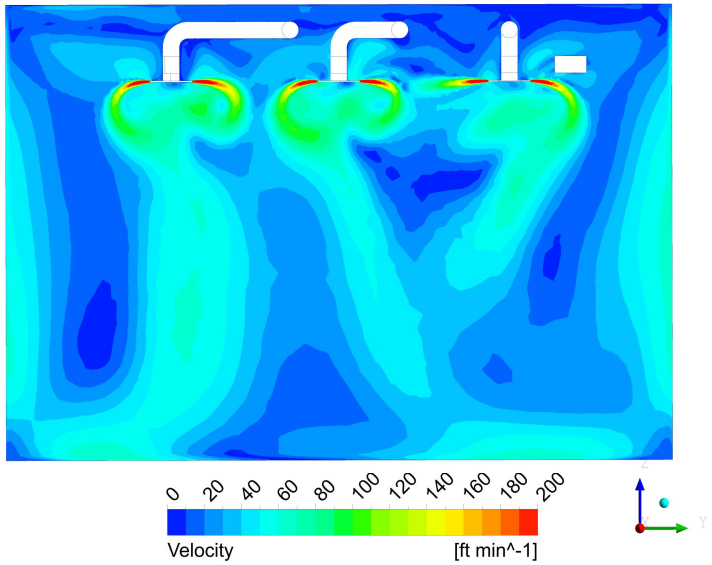
GRILLES & DIFFUSERS

Coanda Effect

- With a ceiling



- Without a ceiling



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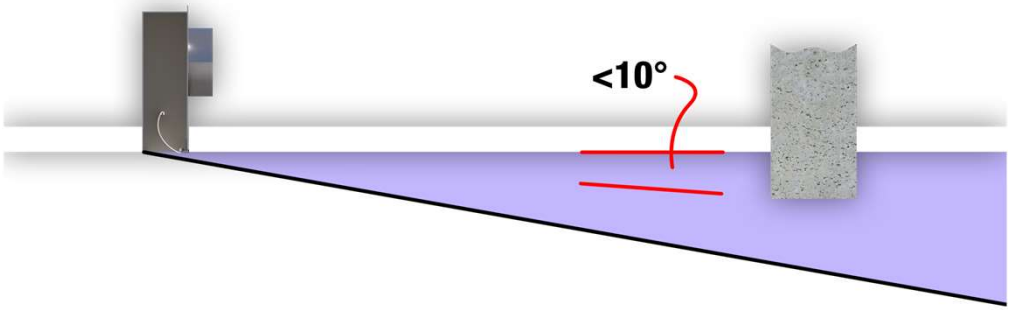
GRD Throw

GRILLES & DIFFUSERS

Throw Obstructions

- How do obstructions, like a coffered ceiling or bulkhead effect throw?
  - Coanda in effect if angle is <10°
  - Higher than this results in angular – vertical throw projection



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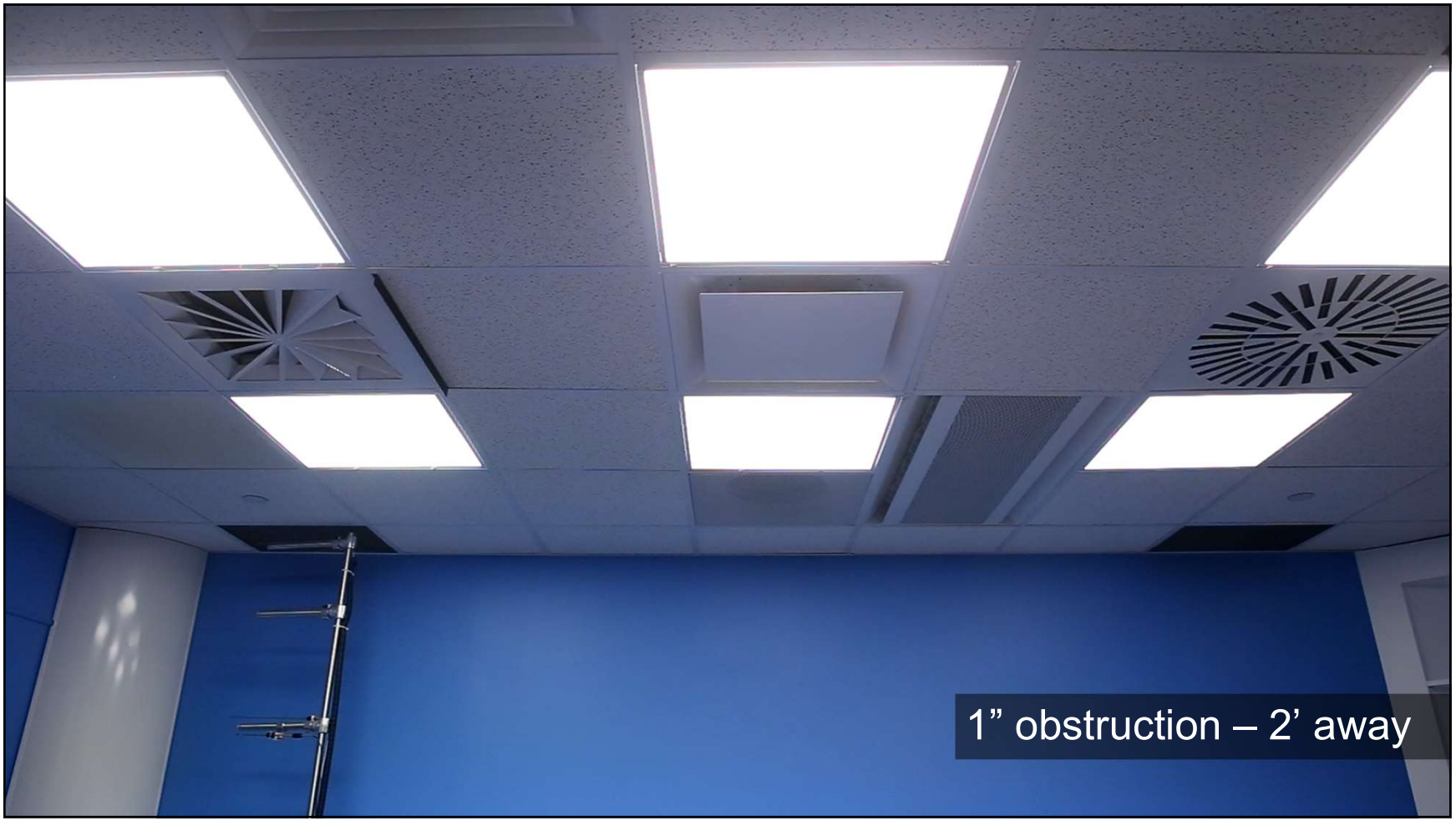

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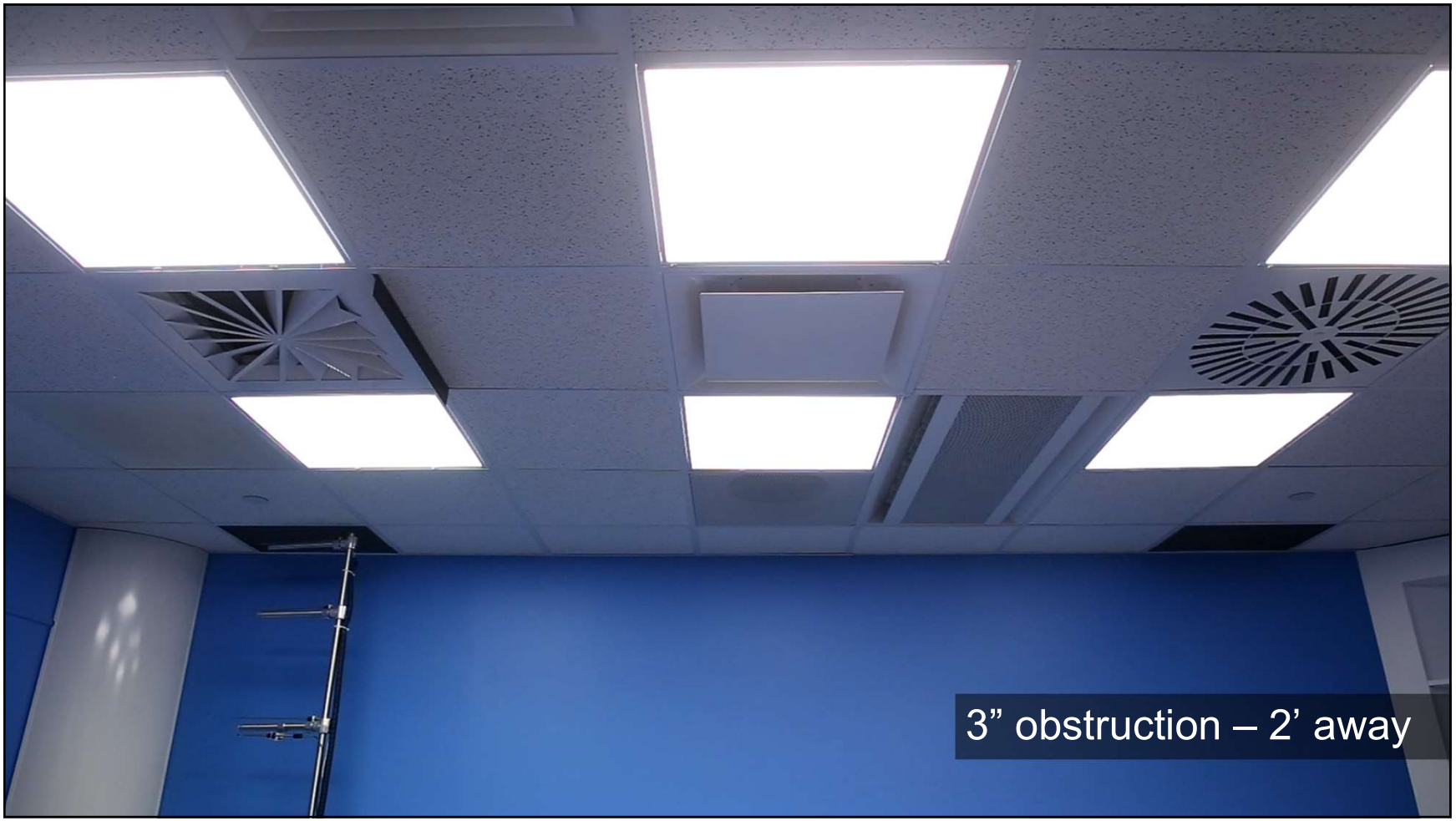

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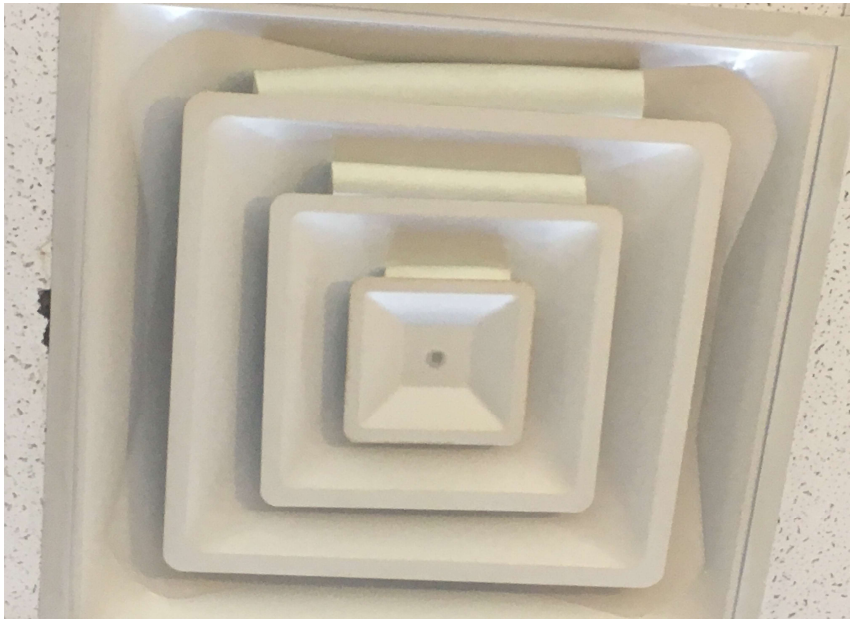
GRD Throw

GRILLES & DIFFUSERS

Throw Obstruction

- When things go wrong…



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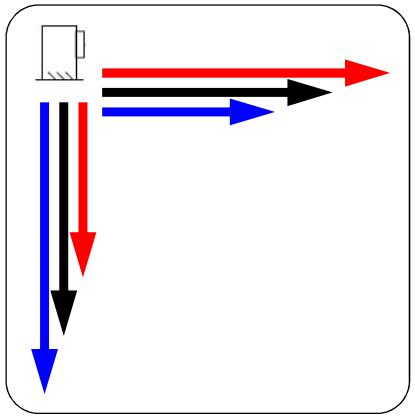
GRD Throw

GRILLES & DIFFUSERS

Non-Isothermal Throw

- Does heated and cooled air effect throw?
  - Non-Isothermal Effects
    - Adjust throw by 1% per F differential
    - Ex. 75F set point with 55F Air – Horizontal throw
      - Reduce throw by 20%

	Cooling	Heating
Horizontal	–	+
Vertical	+	–



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Air Distribution Fundamentals

GRILLES & DIFFUSERS

Summary

- How air moves through a room in a “Mixed Air” System
- Basics of a grille, register, diffuser, and how they function
- Applied Noise Criterion, how to calculate it and us it as a guide for acceptable sound levels
- Concept of “throw” patterns
- How to use throw mapping to select a product

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Questions?

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