▼ Metric Conversion Equations

Converting from Imperial to Metric values . . .

Measurement	Multiply	By	To Obtain	Example
Length	Feet (Ft.)	.3048	meters (m)	15 feet multiplied by .3048 equals 4.572 m.
Length	Inches (In.)	2.54	centimeters (cm)	12 inches multiplied by 2.54 equals 30.48 cm.
Flow	Cubic Feet/Minute (cfm)	.4720	Liters/second (L/s)	500 cfm multiplied by .4720 equals 236 L/s.
Air Pressure	Inches of Water (w.g.)	249	Pascals (Pa)	.134 w.g. multiplied by 249 equals 33.366 Pa.
Air Pressure	Inches of Water (w.g.)	.249	KiloPascals(kPa)	.134 w.g. multiplied by .249 equals .033 kPa.
Area	Square Feet (Ft^2)	.0929	Square Meters(m^2)	1.36 Ft^2 multiplied by .0929 equals .126m^2.

Measurement	Divide	By	To Obtain	Example
Speed	Feet Per Minute (FPM)	196.8	meters/second (m/s)	500 FPM divided by 196.8 equals 2.54 m/s.

Converting from Metric to Imperial values . . .

Measurement	Multiply	By	To Obtain	Example
Speed	Meters/seconds (m/s)	196.8	Feet Per Minute (FPM)	3.0 m/s multiplied by 196.8 equals 590 FPM.

Measurement	Divide	By	To Obtain	Example
Length	meters (m)	.0348	Feet (Ft.)	5 m divided by .3048 equals 16.4 feet.
Length	centimeters (cm)	2.54	Inches (In.)	10.5 cm divided by 2.54 equals 4.13 inches.
Flow	Liters/second (L/s)	.4720	Cubic feet/min (cfm)	200 L/s divided by .4720 equals 424 cfm.
Air Pressure	Pascals (Pa)	249	Inches of water (w.g.)	30 Pa divided by 249 equals .120 w.g.
Air Pressure	KiloPascals (kPa)	.249	Inches of water (w.g.)	.1 kPa divided by .249 equals .402 w.g.
Area	Square meters (m^2)	.0929	Square Feet (Ft^2)	.7 m^2 divided by .0929 equals 7.535 Ft^2.

▼ Terminology

Blade Deflection- The number of degrees a single blade is rotated from its basic position. i.e., minimum blade profile facing the air stream.

Coanda Effect- Named for a German airline pilot who first noticed the tendency of an air stream to hug a flat surface as it passes by.

Decibel (db)- The standard unit of sound level measurement.

Drop- The vertical distance that the lower edge of a horizontally projected air stream falls.

Dump- A colloquial term referring to an air stream in a room that fails to hug the ceiling and distribute properly into the room, instead losing its horizontal speed and entering the occupied zone at a higher than acceptable vertical speed.

Free Area- The effective total area of the opening in supply or return units through which air can pass.

Induction- Mixing of an air stream with another body of air that it is passing through.

NC (Noise Criteria)- A method of showing the loudest sound level generated by a unit, or a method of setting the loudest acceptable sound level in a room.

Nominal CFM- The flow (in CFM) at which the NC or RC level is 35.

Occupied Zone- The area of conditioned space in a room which extends to within 6" of all room surfaces, and up to a height of 6'.

Primary Air- The air delivered to the outlet by the supply duct.

RC (Room Criteria)- A method of summarizing and characterizing the sound level generated by a unit and a method of setting acceptable sound levels in a room.

Secondary Air- The air already present in the space to be conditioned.

Spread- The measurement in degrees of horizontal divergence of an air stream after leaving the duct. OR..

The measurement (in feet) of the maximum width of the air pattern at the point of terminal velocity.

Static Pressure- The outward force of air within a duct. Measured in inches of water (in. w.g.) or pascals (pa). The static pressure in a duct is comparable to the air pressure in an automobile tire.

Throw- The distance an airstream travels before the air stream velocity is reduced to a specific terminal velocity.

Terminal Velocity- The maximum air stream velocity at the specified throw distance.

Total Pressure - The sum of Static and Velocity pressures. This pressure is measured in inches of water (w.g.) or pascals (pa). Changes in total pressure are directly associated with changes in sound level. Anything that increases Total Pressure, such as undersizing outlets or increasing the air velocity, also increases sound level.

Velocity Pressure- The force of forward moving air in a duct. This pressure is measured in inches of water (w.g.) or pascals (pa). Velocity Pressure is comparable to the rush of air from a punctured tire.

▼ Sound Level Corrections for Multiple Outlets in One-Room

If several outlets are operating in the same area, the total sound level contribution from them can be obtained as follows. Remember, decibels cannot be added directly.

1. Take the NC level (from the performance data) for the loudest unit, and add the correction from the chart below for the difference between that and the next loudest unit.
2. For each successive outlet in the room, repeat the procedure.

For a difference of this much ---->	0	1	2	3	4	5	6	7	8	9	10
Add this number ---->	3	3	2	2	2	1	1	1	1	1	0

Example: Given three units with the following NC levels - X(35), Y(35) and Z(30).
1st - Add 35 + 3 = 38 (for difference of 0, add 3)
2nd - Add 38 + 1 = 39 (for difference of 8, add 1)
Total NC levels for all three units combined is 39.

Selection of Air Outlets (Grilles, Registers and Diffusers) Using NC & RC Sound Data.

RC sound data provides not only a summary of the overall sound level, but indicates if the sound might be objectionable. If the selected outlet has objectionable sound, and the application is critical enough to do something about it, follow these 2 rules of thumb:

- If the sound has a Hiss quality (H), increase the size of the selected unit.
- If the sound has a Rumble quality (R), decrease the size of the selected unit.

Figure 4 below is Carnes' recommended sound level for different applications. Note that this chart is intended only as a guide for design purposes. For situations where sound levels are critical Carnes recommends consulting an acoustical engineer. For more information on RC Sound, contact Carnes and request the Tech Talk *Room Criteria (RC)*, published June 1998.

Recommended Noise Criteria (NC) and Room Criteria (RC) design levels.

Type of Room	NC	RC
Performance Arts Spaces		
Concert and Recital Halls	20-25	25 max.
Drama Theaters	25-30	25 max.
Movie Theaters	30-35	25-30
Music Teaching Studios	25-30	25 max.
Schools		
Classrooms up to 750 ft² (70m²)	35-45	40 max.
Class rooms over 750 ft² (70m²)	30-40	35 max.
Lecture Halls for over 50 students	30-35	35 max.
Libraries	30-40	30-40
Corridors	40-50	35-45
Hospitals and Clinics		
Private Rooms	25-35	25-35
Wards	30-40	30-40
Operating Rooms	30-40	25-35
Corridors	35-45	35-45
Indoor Stadiums and Gymnasiums		
Gymnasiums and Swimming Pools	45-55	40-50
Large Capacity Spaces with Amplified Speech	45-55	40-50
Hotels/Motels		
Individual Rooms or Suites	30-40	25-35
Meeting/Banquet Rooms	30-40	25-35
Halls and Corridors, Lobbies	35-40	35-45
Service/Support Areas	40-50	35-45

Type of Room	NC	RC
Offices		
Executive and Private Offices	30-40	25-35
Conference Rooms	25-35	25-35
Teleconference Rooms	25-30	25-30
Open Plan Offices	35-50	30-40
Halls and Lobbies	35-55	40-45
Laboratories with Fume Hoods		
Minimal Speech Communication	50-55	45-50
Extensive Speech Communication	40-45	35-40
Retail Stores, Restaurants		
Clothing Stores (Upper Floors)	35-45	30-40
Department Stores (Upper Floors)	35-45	30-40
Department Stores (Main Floor)	40-50	35-45
Small Retail Stores, Supermarkets	40-50	35-45
Restaurants	35-45	30-40
Transportation		
Ticket Sales Office	35-45	30-40
Lounges, Waiting Rooms	40-50	35-45
Public Buildings		
Court Rooms (unamplified speech)	30-40	25-35
Court Rooms (amplified speech)	35-45	30-40
Post Offices, Lobbies	35-45	30-40
Places of Worship		
Sanctuaries	20-30	25-35

Guidelines in Selecting Units for Sound.

1. The human ear cannot distinguish a difference of 3 db or less. Example: An NC or RC level of 34 will sound the same as 37 to the listener.
2. Most human ears can distinguish a difference of 5 db.
3. Remember that the dB scale is logarithmic. Increasing the sound level by 10db will double the perceived loudness of the sound, and decreasing it by 10db will make the sound seem half as loud.

▼ Return Function Selection & Performance

Appearance considerations may call for the return function in the ceiling to be filled by the same model of diffuser as supplies the air. Any supply diffuser can be used in a return function. To select the appropriate diffuser follow the following procedure.

1. Divide the desired return CFM by .75.
2. Find the resulting CFM in the performance data for the size desired.
3. Get the Sound and Total Pressure values from the table of the resulting CFM. The resulting Total Pressure is the maximum amount that will occur.

Example #1: Using a Carnes SSEA model, 18", returning 800 CFM.
- 800 / .75 = 1067 CFM.
- The resulting Total Pressure (from Page A9) is .11 with an NC level of 34, and an RC of 34N.

Example #2: Using a Carnes SSEA model, 24", returning 1400 CFM.
> 1400 / .75 = 1867 CFM.
> The resulting Total pressure (from Page A9) is .12, with an NC level of 35, and an RC of 35N.

▼ No-Ceiling Corrections-

Certain designs may not have ceilings, thereby eliminating the Coanda Effect (sometimes also called Ceiling Effect) as a throw-enhancing factor. Since all published throw data assumes the presence of a ceiling, apply these corrections to arrive at throws where there is no ceiling. Select the diffuser size and appropriate velocity. 2. Multiply the selected throw by .707. 3. The resulting value is the no-ceiling throw.

▼ Cold Air Corrections

Although the industry norm for performance data is under isothermal conditions (ASHRAE Standard 70-1991), where the primary air (the air being introduced into the room) is the same temperature as the room air, a significant percentage of operating conditions involves cooler primary air entraining warmer room air. Cooler primary air is less buoyant and will reduce the throw, resulting in throw values that are significantly shorter than the cataloged performance data.
To obtain throw values when he primary air is 20° cooler than the room air, multiply the throw of the selected diffuser at the chosen velocity or flow by .65.

Example #1: Using a Carnes SSEA model, size 12", supplying 785 cfm.
The throws to 150, 100 and 50 fpm are 8', 11' & 19', respectively. Multiplying each by .65 yields throws of 5', 7' & 12'.
Example #2: Using a Carnes SSEA model, size 24", supplying 2500 cfm.
The throws to 150, 100 and 50 fpm are 12', 17' & 29', respectively. Multiplying each by .65 yields throws of 8', 11' & 19'.

▼ Damper NC and Total Pressure Correction Factors

Severe dampering at the diffuser will result in an increase in sound levels and total pressure. Dampering at the diffuser should be reserved for fine balancing. A majority of balancing should be provided by dampers upstream in the supply duct. The remote location of a majority of dampering allows for acoustical lining before the diffuser. When the damper is in a partially closed position, the sound level will increase as follows:

Effective Damper Opening %	100%	82%	71%	50%
NC Level Increase (Add)	0	4	7	15
Total Pressure Increase (Multiply)	1.0	1.5	2.0	4.0

▼ Pressure Equations

> Total Pressure (P_t) is the sum of Velocity Pressure (P_v) and Static Pressure (P_s).
> Static Pressure (P_s) can be obtained by $P_t - P_v = P_s$. Velocity Pressure is listed in the following table.

Velocity Pressure for various Duct Velocities

Duct Velocity	300	400	500	600	700	800	900	1000	1200
Velocity Pressure (P_v)	0.006	0.010	0.016	0.022	0.030	0.040	0.050	0.062	0.090

- Duct Velocity is given in Feet per Minute.
- Velocity Pressure is given in Inches of Water.

Design Tips

Placing units which throw directly toward each other.
Grilles of equal capacities should be sized for throw equal to 1/2 the distance between them.

High ceiling or wall placement and getting air down to the occupied zone.
Select and place units so they can discharge directly toward each other and the air streams meet at speeds greater than 50fpm. The air streams will converge and proceed downward. The horizontal plus vertical distance will equal the cataloged throw.

Figuring Throw to a wall.
Units discharging toward a wall should be sized to throw to a 50fpm terminal velocity at the opposite wall.

Lengthening the Throw by taking advantage of the Coanda effect.
Ceiling diffusers use the Coanda effect to attain their throws and this effect can be used as well with high-sidewall mounted supply grilles. Placing the grille within 1 foot of the ceiling will allow upward adjustment of horizontal front blades to extend the cataloged throws. *To obtain the new throw at the specified terminal velocity, divide the cataloged throw by .3.*

Electrocoating

Carnes pioneered this technology in this industry in the United States in 1967. After first cleaning the product with surfactants and a water rinse, we apply an iron phosphate pretreatment which acts as rust inhibitor and insures proper paint adhesion. The product is then immersed in the paint tank, where an electric charge is applied, adhering the paint to all metal surfaces. It is a drip-free, self-cleaning process and coats all surfaces, including concealed or irregular surfaces, guaranteeing maximum protection.

NOTES:

THE EFFECT OF BLADE ANGLE ADJUSTMENT ON THROW, DROP AND SPREAD:

Throw vs. Spread:
Maximum throw values occur with vertical blades set at 0° deflection and the normal stream expansion in this case is roughly 8° - 14°. As the deflection settings are increased, throw values will tend to shorten, and the air stream will spread more quickly (Figure 1). This is partially due to the increased exposure of primary air to room air and the resulting entrainment of larger quantities of room air.

Adjustment of the horizontal blades to the same settings will have the same effect on throw values and spread characteristics. Parallel adjustment of horizontal blades toward the ceiling can cause an increase in throw, subject to ceiling effect.

Drop vs. Occupied Zone Impingement:
For complete design, drop should be considered along with throw in laying out the air distribution in a room.

For isothermal delivery and 0° blade deflection, vertical expansion alone will cause a drop of approximately 1 foot for every 8 feet of throw. A cooling differential will cause further drop. Blade deflection other than 0° will have a direct effect on drop. Aligning all the blades to an upward deflection will result in less drop. Aligning the blades to downward deflection will increase the drop. **Figure 2** shows typical drops at 0° blade deflection and primary air 20°F cooler than room air. **Chart 1** shows the data in a graphical format.

Figure 1

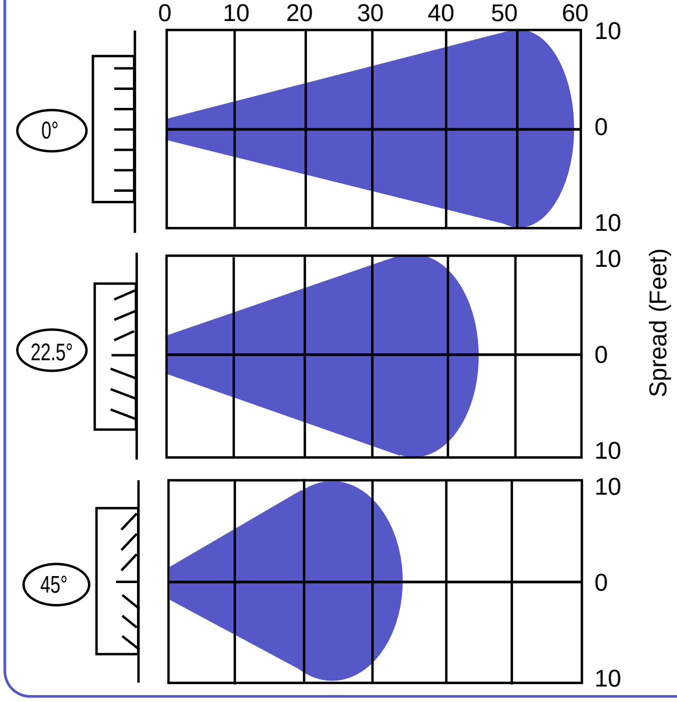

Figure 2

Drop at various throws & velocities.
- 20° ΔT cooling conditions.
- Blades set to 0° deflection.
- Ceiling more than 2 feet above outlet.

Duct Velocity	Throw Distance (Feet) 10	15	20	25	30	40	50
400	4	5.5	7.5	9.5	11	16	19
600	3	5	7	9	10.5	15	18
800	2.3	3.5	5	6	8	11	14
1000	2	3	4.5	5.5	6.5	8.5	12
1200	1.5	2.5	4	5	6.5	8	12

Chart 1