




## Air Distribution Products

# Ravistar engineering guide



Terminology  
Comfort Criteria  
Space Air Diffusion  
Selection Fundamentals  
Selection Procedures  
Conversion Factors

## Terminology

---

### Air Distribution

The transportation of a specified air flow to or from the treated space by means of ductwork.

### Air Diffusion

Distribution of the air in a space, called the treated space, by means of devices, called air terminal devices, in a manner so as to meet certain specified conditions, such as air change rate, pressure, cleanliness, temperature, humidity, air velocity and noise level.

### Terminal Velocity

The point at which the discharged air from an outlet decreases to a given velocity usually 0.25 m/s.

### Throw

The distance measured in meters that the airstream travels from the outlet to the point of terminal velocity.

### Drop

The vertical distance between the centre of an outlet and the bottom of the airstream at the end of horizontal throw.

### Envelope

The geometrical surface of the points of an air jet corresponding to terminal velocity.

### Spread

The maximum total width of the air pattern in the envelope.

### Air Flow

The Air flow is the rate of quantity of Air passing through the Air outlet to the room so as to achieve the desired design conditions such as temperature, Noise level etc.

### Static Pressure

Pressure inside the duct which is necessary to overcome friction resistance measured in N/M<sup>2</sup>.

### Total Pressure

Sum of at the static & velocity pressure.

### Induction

Process by which the primary air sets into motion an air volume, called secondary air, in the room.

### Coanda Effect

Also called ceiling or wall effect. Tendency of an air stream to follow a wall plane when the stream is in contact with the wall. This effect increases throw and reduces drop.

### Noise Levels

Decibel is the unit used to measure sound. It is logarithmic ratio of two sound pressure levels (SPL  $L_p$ ) (or) sound power levels (SWL  $L_w$ ) where one is a reference level.

The most commonly used criteria are Noise criteria curves (N.C. level), Noise rating curves (N.R. levels) and dB (A).

### Air Terminal Devices

A device located in an opening provided at the boundaries of the treated space in order to improve a predetermined air movement within the space.

### Supply

The air flow entering the treated space.

### Exhaust

The airflow leaving the treated space by means of following methods. Extraction, Relief, Recirculation & Transfer.

### Register

A grille with a damper.

### Grille

An air terminal device with multiple passages for the air, usually placed on side walls, bulkheads.

### Linear Grille

A grille with fixed linear blades, usually used in large continuous lengths.

### Adjustable Grille

A grille with aerofoil blades (Louvres) which can be adjusted to vary the air diffusion direction.

### Diffuser

Supply air terminal device square rectangular or circular usually placed in the ceiling and consists of deflecting members for diffusion.

### Slot Air Terminal Device

A device with one or multiple slots for continuous long rectangular opening with or without adjustable member to vary the air flow rate & direction.

### Nozzle

An air terminal device designed to generate a low energy loss and thus produce a maximum throw by minimum entrainment.

### Damper

A device used to control the volume of air passing through a terminal by varying cross-sectional area.

### Louvre

A device used for intake air from atmosphere with bird screen and the blades at 45° inclination to eliminate rainwater.

### Fire Damper

Device which is installed in an air distribution system between two fire separating compartments and is designed to prevent propagation of fire and smoke.

### Sound Attenuator

Device which is inserted into the air distribution system and designed to reduce airborne noise which is propagated along the ducts.

## Introduction

The design and selection of air distribution equipment in today's buildings presents one of the more unique challenges for mechanical designers. Unlike other mechanical equipment required for these environmental systems, the air distribution equipment selection must combine a proper choice of engineered products efficiently providing conditioned air to the space while adding architectural features which compliment the interior design.

With today's emphasis on occupant comfort, air quality and energy conservation, the proper selection of air outlets cannot be overlooked. It is the intent of this section to provide a concise approach to the proper selection of air distribution outlets. The general information is given below while the actual selection procedures of the air outlets are given in the respective technical guides.

## Comfort Criteria

### Comfort

The true measure of the performance of any environmental system is that it maintains comfort of the occupants of the space it serves. Provided the total amount of heated or cooled air required to thermally satisfy the requirements of the space is available, the comfort level within the space becomes totally dependent upon the space air distribution. In general, comfort when related to anatomy can be described as the condition that exists when the heat generated by the body is balanced by some of the metabolic heat transfers through convection, conduction and radiation with the air, wall surfaces and other heat transfer mechanisms in the space.

The definition of "comfort" allows us to identify and control the factors which influence the metabolic heat transfer within the space. These factors are:

- Dry bulb temperature
- Relative humidity
- Mean radiant temperature of the surroundings
- Air movement
- Metabolism
- Clothing worn by occupants

Of these, metabolism and clothing are predetermined by the function of the occupants within the space. Dry-bulb temperature and relative humidity are controlled by the thermal effects of the air distribution system. The air movement is a function of the selection of the air diffusion devices employed and is the primary controllable factor by which comfort is affected in the space. Proper air diffusion prevents thermal stratification and stagnation in order to approach a homogenous mixture of room air. Mean radiant temperatures can also be affected by proper location of outlets to prevent substantial heat transfer to and from room surfaces.

### Draft Temperature

Extensive studies have resulted in relationships between local temperatures, velocities and comfort reactions. On the basis of the temperature and velocity at a specific point, an

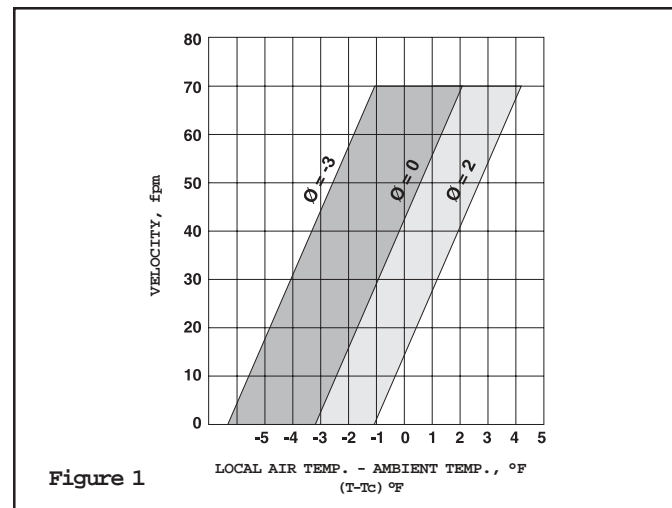
effective draft temperature can be calculated for that location. The draft temperature is calculated by the equation :

$$\emptyset = (T - T_c) - 0.07 (V - 30)$$

where :

- $\emptyset$  = draft temperature
- T = local temperature
- T<sub>c</sub> = control temperature
- V = local velocity

Research indicates that a high percentage of people are comfortable where the effective draft temperature difference is between -3°F and +2°F and the air velocity is less than 70 fpm. This comfort zone is illustrated as the shaded area in Figure 1.



## Space Air Diffusion

Proper selection of air diffusion devices requires a basic knowledge of the mechanics of room air distribution. Figure 2 on page no. 3 illustrates the interactions of the major factors influencing room air distribution. These factors are described below :

### Primary Air

Primary Air is defined as the conditioned air discharged by the supply outlet plus entrained room air which lies within an envelope of arbitrary velocity, usually taken as 150 fpm. It is this air which provides the motive force for room air motion.

### Total Air

Total Air is defined as the mixture of primary air and entrained room air which is under the influence of supply outlet conditions. This is commonly considered to be the air within an envelope of 50 fpm (or greater) velocity. Temperature difference between total air package and the room air creates buoyant effects which causes cold supply air to drop and warm air to rise.

**Drop**

The drop of the cool total air, as shown in figure 2, is the result of the vertical spread of the airstream due to entrainment of room air and the buoyancy effect due to the density differences between the total air package and the surrounding primary air. The term "density" is very important as drop is primarily dependent upon the mass flow of the total air. Drop can be minimised by spreading the air uniformly over the ceiling surface, thus reducing the mass flow per unit surface area.

**Spread**

The "Spread" of an outlet is defined as the divergence of the airstream in a horizontal or vertical plane and is a function of the outlet geometry.

**Surface Effect / Coanda Effect**

Drop can also be effectively reduced by use of the surrounding ceiling surface. When the supply air velocity is sufficiently high, a negative or low pressure area is created between the moving air mass and the ceiling at or near the supply air outlet. This low pressure area causes the moving air mass to cling to and flow close to the ceiling surface. This principle is known as the "Coanda Effect". Good air distribution design makes use of room surfaces to help keep the supply air outside the occupied zone.

**Occupied Zone**

The Occupied Zone is usually defined as the area within 6 ft. of the floor and not within 1 foot of the boundaries of the space (walls, etc.). As this is the area of occupancy, it is desirable to avoid excessive draft velocities and temperature differences within the space.

**Room Air**

Finally, we come to the medium through which all metabolic heat transfer occurs and thus the most critical factor in controlling human comfort - the room air. The room air consists of all the other air within the space which is not included in the total air package. Proper air distribution attempts to condition this room air to maintain draft velocities and temperatures within those ranges shown in figure 1. This velocity of air within the occupied zone is known as "Room Velocity".

Room air movement is created by its gradual induction toward the primary and total airstreams. It is this constant mixing that provides the mechanisms for heat transfer between the supply and room air. When air movement does not occur (usually as a result of insufficient outlet velocities or poor outlet location), a stagnant layer of room air is formed. Above that layer (or below in the case of overhead heating), proper heat transfer does not exist and temperature stratification occurs. This is illustrated by the temperature gradient curve shown in figure 2. It is always desirable to keep the stagnation layer above the occupied zone in cooling and as near to the floor as possible when heating from above.

**Convection Currents**

The total air package can easily be influenced by several factors within the space. One of these factors which occur in exterior zones of buildings is the natural convection currents which result from a hot outside wall during cooling (Figure 2) or a cold outside wall during heating. The upward movement of air in the vicinity of the hot surface tends to oppose the total air movement in overhead cooling. This can act to reduce the outlet throw values or even cause the colder total air to leave the ceiling and create drop into the space. The downward movement of cold air in the vicinity of a cold surface can create cold draft within the occupied space. In the case of overhead heating, the only effective way to minimise these drafts is to direct a high velocity jet of warm air over the wall surface to reduce the difference between the temperature of the surface and that of the room air. Maintaining surface temperatures as near that of the space as possible also minimises radiation heat transfer potential between the surface and the occupants, resulting in improved comfort response.

**Return**

The return air inlet has very little effect on room air diffusion regardless of inlet type or location. However, return air inlets should be located at sufficient distance from the supply outlet so that short circuiting of supply air does not occur. It may also be desirable to locate the returns in the stagnant zone to remove unwanted warm or cool air. For cooling, a high sidewall or ceiling return will remove warm air from the space.

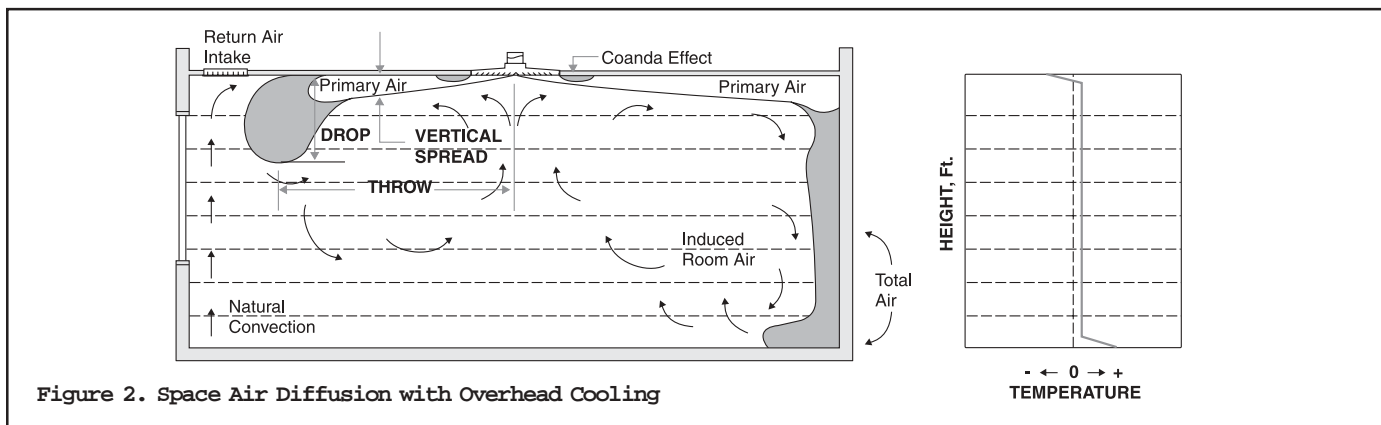


Figure 2. Space Air Diffusion with Overhead Cooling

## Selection Fundamentals

Several factors influence the selection of an air outlet. These factors can be divided into two groups - design factors and performance factors.

### Design Factors

#### Function

The most obvious question is that of primary function - supply or return. Diffuser designs, grille blade profiles and blade spacing are all performance derived, thereby making the outlet's function "non-interchangeable", in most cases.

#### Location

Our field of selection is further narrowed by knowing where the outlet is to be located within the space (i.e. sidewall, ceiling or floor). This more than anything else determines the generic type of outlet to be used. Two factors can influence outlet location, desired performance and/or architectural/physical constraints. Performance - location considerations could include spot cooling or perimeter heating. Physical/architectural constraints could, for example, consist of an inaccessible ceiling forcing the use of sidewall or floor outlets.

#### Air Volume

The actual air volume required to handle the heating/cooling load will also have an effect on the model of outlet used. Generally, the larger the volume per outlet, the more difficult it is to handle comfortably. Some air outlets, due to design considerations and basic concept, are more effective at handling large air volumes (i.e. RWH, RSD).

#### Natural Convection

Natural convection air currents created by cold walls/windows or localised heat sources should also be considered when planning room air motions. For example, convective air velocities of over 50 fpm can be expected on some cold window applications and will, if unchecked, dominate the room air motion. The air outlet may be required to blow warm air down the window or wall from the ceiling or up from the floor. Each situation would require different treatment and totally different outlet performance. The buoyancy effect of warm air makes it more difficult to blow down the cold window while it would assist the throw of a floor outlet.

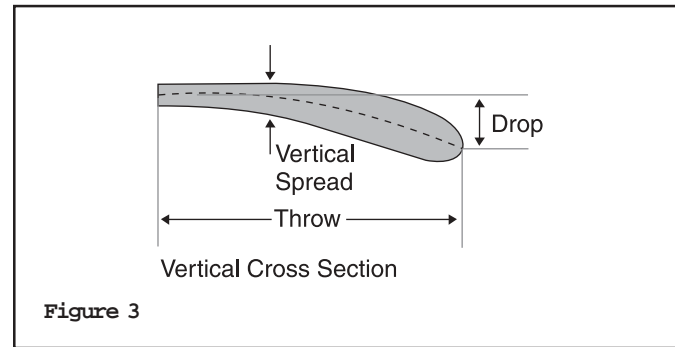
### Performance Factors

#### Throw

Throw is by definition the distance from the outlet face to a point where the velocity of the airstream is reduced to a specified velocity, usually 150, 100 or 50 fpm (Figure 3). Throw is primarily a function of mass flow and outlet velocity and therefore can be reduced by decreasing either of these values.

#### Drop

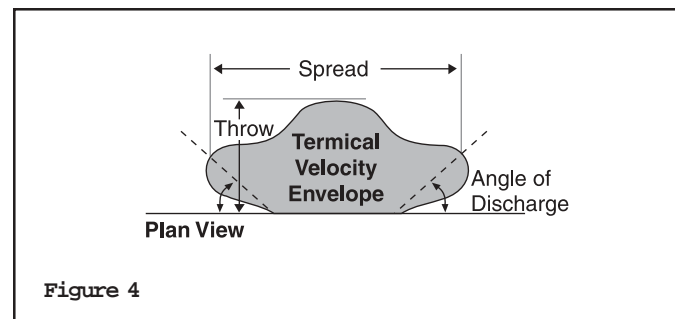
Whenever cool supply air is introduced into a warmer space, its natural tendency will be a downward movement. If the supply air projects into the occupied space, uncomfortable



drafts will occur. Drop can be minimised by utilising the surface effect of ceilings. Outlets located in or near the ceiling will exhibit less drop than outlets located on exposed ductwork. Reducing the supply air volume and increasing supply air temperature will also reduce drop.

#### Spread

Delivering the air in a spread pattern tends to reduce both the throw and drop of an air outlet. Dissipating the airstream over a wider area increases entrainment and reduces the mass flow per unit surface area (Figure 4).



#### Sound / Pressure Drop

Pressure drop and sound are important to the overall system design and performance, however they do not directly affect the room air distribution.

#### Noise Control

Noise control in airconditioning systems is in many cases just as critical as the environmental conditioning itself. Sound is transmitted through the duct system and is also generated by some of the duct elements including diffusers, dampers, volume control and straightening devices, terminal boxes, fans and even the ducts themselves. Noise is defined as objectionable or unwanted sound. The absence of sound created by the airconditioning system can also be annoying. Properly designed, this sound can mask unpleasant noise of conversations, office machinery, etc. to create a more workable environment. The attenuators technical guide may be referred for further details.

## Selection Procedures

### Outlet Selection

The outlet type and size must be carefully selected so as to provide uniform air temperatures and satisfactory velocities within the occupied zone. In addition noise levels must be acceptable. If these criteria are met then a high level of comfort will be achieved for the occupants of the conditioned space.

In order to properly select and size an outlet, a number of performance factors must be taken into account which are detailed below :

#### 1. Throw

Achieving the proper throw for a specific application is critical to proper outlet selection. Throw data is usually presented at terminal velocities of 150fpm, 100fpm and 50fpm. Generally outlets should be selected so that the throw at 50fpm terminal velocity equals the distance from the outlet to the boundary of conditioned space. In most cases this criteria will produce acceptable results.

When an airstream strikes a surface it tends to spread and follow the surface until the velocity dissipates. The total horizontal and vertical distance travelled by the air stream is equal to the tabulated throw of the outlet (Figure 5). For high ceiling applications it may be desirable for the throw to exceed the space boundary (ceiling) and travel down the wall toward the occupied zone. However penetration of the occupied zone should usually be avoided.

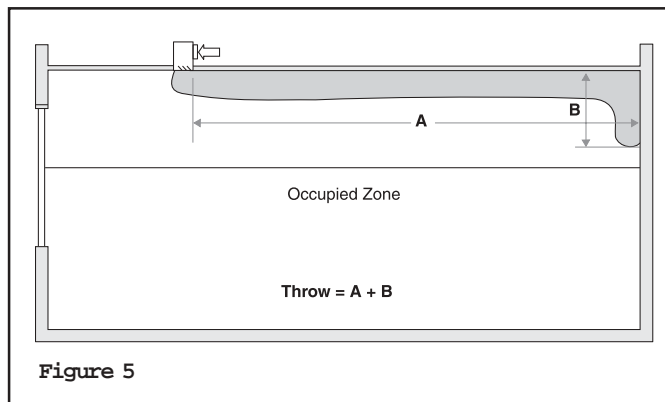


Figure 5

In addition to physical boundaries created by walls or partitions, boundaries can be created by the collision of two air patterns (Figure 6). Where two patterns will meet, the outlets should be selected so that the throw is equal to one half the distance between the outlets. For high ceiling applications it may again be desirable for the throw to travel downward toward the occupied zone. Throw is again equal to the horizontal and vertical distance travelled by the air stream. It should be noted that most catalogue throw data is presented for isothermal conditions, i.e. supply air temperature equals room temperature. During cooling the denser supply air will shorten the horizontal throw. Refer to the technical guides for the corrections for non-isothermal jets.

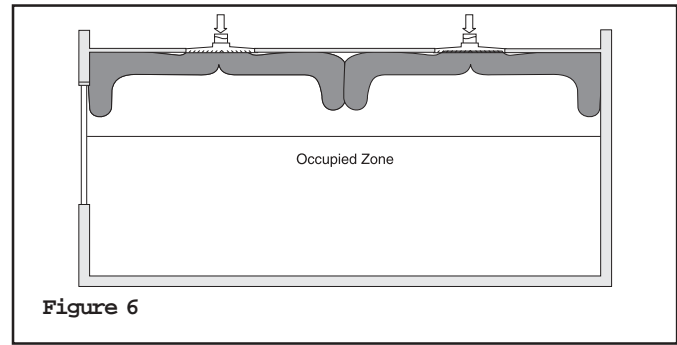


Figure 6

When selecting outlets for VAV application, both minimum and maximum air quantities must be considered for throw. Although many models of outlets provide excellent horizontal air pattern at extremely low flows, throws may be reduced below acceptable limits. Slot diffusers and light troffer diffusers tend to maintain reasonable throws at low air value and are therefore a good choice for this application.

In many applications it is desirable to limit the throw due to ceiling layout, walls, partitions or other boundaries which may obstruct the air pattern and cause unacceptable velocities in the occupied zone. There are several methods which may be used to minimise throw from outlets.

#### Spread

Spreading the air pattern dissipates the air stream over a wider area and increases entrainment. This reduces the mass flow per unit surface area, which in turn reduces throw. Some outlets are designed to produce a spread pattern due to their geometry while others have adjustable vanes.

#### Air Volume

Throw is directly related to mass flow, therefore a reduction in air volume per outlet will reduce the throw. This can be achieved by utilising more outlets with less air volume per outlet. For Linear Diffusers or Grilles the same thing can be achieved by dividing the outlet into active & inactive sections (Figure 7). Each active section handles smaller quantity of air, thereby reducing the throw. In order to effectively separate the air pattern, the outlet should be divided by minimum inactive length as illustrated in table below :

Length of <b>Active</b> Sections, Ft.	1	5	10
Length of <b>Inactive</b> Sections, Ft.	1	2	3

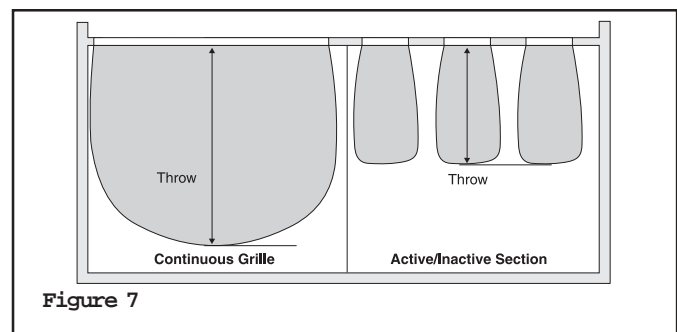


Figure 7

## 2. Drop

Since a velocity of 50fpm or less is desirable in the occupied zone, drop should be limited to a terminal velocity of 50fpm, at 6 ft. from the floor.

For sidewall application following criteria influences the selection.

- Mounting the grille close to the ceiling creates a surface effect and reduces drop.
- Deflecting the air pattern upward reduces drop.
- Spreading the air pattern reduces drop.
- Reducing the air volume reduces drop.
- Reducing the throw reduces drop.

## 3. Noise Criteria

Most air outlets are catalogued with a single NC (Noise Criteria) sound pressure rating based on a 8db room absorption. This NC value assumes an average room and an approximate distance of 5 feet from a single sound source. These assumptions are reliable for most applications.

Outlets should be selected so that the tabulated NC levels are within these design goals.

Based on the above general information and criteria the air distribution products can be selected from the technical data and selection procedure guides enclosed in this binder.

Air Terminal Device	Types
Ravistar Grilles	Adjustable Supply, Exhaust, Linear Bar, Air Transfer, Acoustic Transfer, Linear Floor
Ravistar Diffusers	Continuous Slot, Linear, Multicone Ceiling, Circular, Perforated Face, Laminar Flow, Hi-Flo Jet, Adjustable Vane, Spot Diffusers/Jet Nozzles, Swirl, Exhaust Valves
Ravistar Dampers	Volume Control, Fire & Smoke, Opposed Blade, Pressure Regulating
Ravistar Louvres	External Louvres, Screening Applications
Ravistar Attenuators	Rectangular / Square, Circular

## Conversion Factors

Item	To Convert From Imperial Units	To SI Units	Multiply By
Length	inches	millimetres	m m 25.4
	feet	metres	m 0.3048
Area	square inches	square millimetres	m m <sup>2</sup> 645.16
	square feet	square metres	m <sup>2</sup> 0.0929
Volume-Air Flow	std. cubic feet per minute	cubic metres per hour	m <sup>3</sup> /h 1.699
	std. cubic feet per minute	litres per second	L/s 0.472
Velocity	feet per second	metres per second	m/s 0.3048
	feet per minute	metres per second	m/s 0.00508
Pressure	inches of water (60°F)	pascal (20°C)	Pa 248.84
	lb. force per square inch (psi)	pascal	Pa 6894.757
Energy	B.T.U.	joule	J 1055.056
Power	Horsepower	watt	W 746
		kilowatts	K W 0.746
Temperature	Fahrenheit	Celsius, Centigrade	C (F-32) (5/9)
Heat flow rate	B.T.U. per hour	watt	W 0.293
		kilowatt	K W 0.000293
Weight	ounce	gram	g 28.350
	pound	kilogram	kg 0.4536
Density	pounds per cubic foot	kilograms per cubic meter	kg/m <sup>3</sup> 16.018
Torque	inch pound	newton metre	N m 113

- Specifications and data are subject to change without prior notice due to continuous product development.
- Normal tolerances shall be applicable.



**Ravistar India Pvt. Ltd.**

Office & Works : D-99, Sector-2, Noida-201301 (U.P.), India  
Tel. : 95 (120) 2531869, 2531878, 2537624 Fax : 95 (120) 2543431  
E-mail : [ravistar@vsnl.net](mailto:ravistar@vsnl.net) Visit us at : [www.ravistar.com](http://www.ravistar.com)