BOREAS

Modular Steel Air Handling Unit

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Eurovent Range BRS 15.06.010 Class TB1, T2, D1, L1, F9

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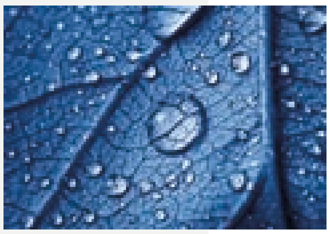
CONTENTS

AIR CONDITIONING

Air Conditioning



Air conditioning is the process by which temperature, humidity, and indoor air quality conditions are kept under control for the purposes of comfort or industrial processes. Air conditioning applications can be grouped under the three broad headings of Comfort Applications, Hygiene Applications, and Process Applications.

Comfort Applications

Studies have shown that people exhibit the highest performance in living and working spaces at 22°C. Performance increases by approximately 1% with each 0.6% change in ambient temperature. Therefore, air conditioning is significant with respect to work performance and comfort of the environment. Some examples of areas of application are:

- Residential and commercial buildings
- Hotels, industrial spaces,
- Vehicles, trains, and airplanes.

Hygiene Applications

These are applications where air conditioning processes needed for maintaining hygienic conditions required for application areas with methods and equipment that are in compliance with hygiene conditions. Some examples are:

- Operating rooms and intensive care units
- Drug manufacturing facilities, Food industry manufacturing and storage facilities
- Electronic processes

Process Applications

These are applications implemented for ensuring the climate conditions required by the process applied. Some examples are:

- Industrial environments
- Laboratories
- Cooking and food processing areas
- Textile factories
- Physical testing centers
- Data processing centers
- Operating rooms in hospitals
- Pharmaceutical plants.

Air Conditioning Systems

Air conditioning system are principally divided in two groups, central and stand-alone systems.

1- Central Systems;

They are further grouped in 5 subgroups, which are full air, full water, VRF (variable refrigerant flow system), air-water, and air-VRF systems. Full water systems are two and four pipe Fan Coil systems. Air - water systems are achieved by adding fresh air to these systems. Similarly, VRF systems are those where dozens of indoor units can be connected to one outdoor unit, using a refrigerant gas such as R410A as coolant; and air-VRF systems are achieved by adding fresh air to VRF systems.

2- Stand-alone Systems are divided in the following 3 groups:

1. Packaged Air Handling Units,
2. Split Air Handling Units,
3. Ducted Split Air Conditioners.

Central Full Air Air Conditioning Systems

These are systems where air is used as heat transfer fluid. The HVAC equipment is placed centrally. Full air systems transfer air that has been cooled and dehumidified to the conditioned room, providing sensible and latent cooling; and transfer heated air to the conditioned room, providing heating. Full air systems are capable of air filtration and supplying fresh air.

Classification of Full Air Systems:

a) Fixed air flow
b) Variable air flow
c) Single duct
d) Multi-duct
e) Single zone
f) Multi zone

a) Fixed Air Single Duct Single Zone Systems

These are the simplest systems which serve a single zone, have fixed air flow, and variable air discharge temperature. The temperature of air blown into the space is automatically controlled.

b) Fixed Air Flow Mixed Air Systems

These systems comprise heating and cooling coils, fresh air and exhaust air mixture dampers, humidifier, aspirator, and fans.

c) VAV (Variable Air Volume) Systems

VAV systems have been developed particularly for multi-zone applications and spaces with varying loads. The use of VAV systems is not optimal in terms of fixed cooling load. In VAV systems, air flow is modulated in the main supply fan equipped with frequency converter capacity control in the main unit, and the air is transferred to VAV boxes and discharge grilles in spaces. Air output in the air handling unit discharge is fixed. The amount of air supplied to the room is changed via VAV boxes, compensating for variations. VAV boxes balance room's cooling load by adjusting the amount of cold air supplied with the command it receives from the room.

Central Fan Coil (All-Water) Systems

These are all water systems. Hot and cold water prepared in a center is sent to fan-coil units distributed within the building. Hot water is generated in a boiler while the cold water is generated in a chiller. Fan-Coil units include a fan and coil. The heated or cooled air is taken from the room via the fan, passed over the coils, and returned to the room.

If cold water circulates within the coil, the system cools, and if hot water circulates within it, the system heats. A pump is used for water circulation. These systems are generally used in hotels, hospitals, and offices. Fan-Coil units are placed in front of windows, in suspended ceilings, below ceilings, or within the floor. There are 2 types of fan-coil systems:

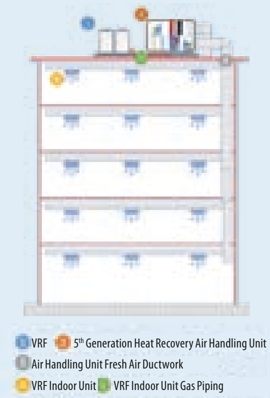
1) 2 Pipe Systems (1 distribution, 1 collection pipe)
2) 4 Pipe Systems (2 distribution, 2 collection pipes)

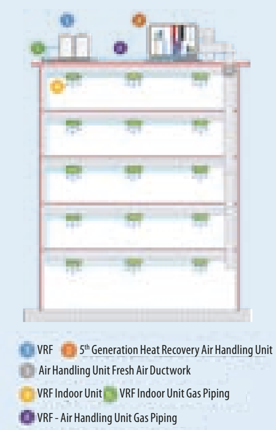
Air-Water Mixed Air Handling Units

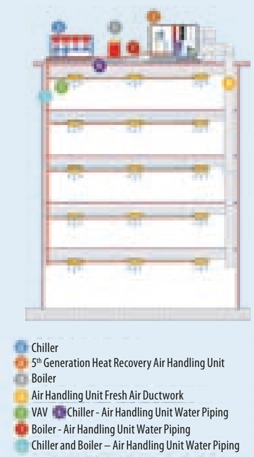
There is no ventilation in conventional fan-coil systems. These only provide heating and cooling. 2 applications are made in fan-coil systems to make up for this lack.

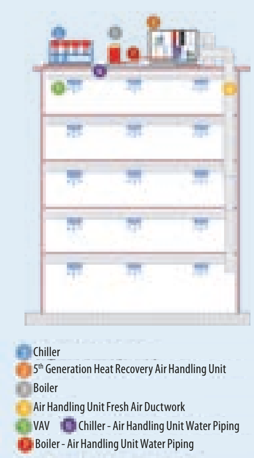
1- Each fan-coil unit is provided with fresh air from the outdoor through its own duct connection.

2- Having heat recovered, pre-conditioned and calculated by the automated system, fresh air is supplied to the environment by the air handling unit system.









VRF (Variable Air Flow) Systems

VRD systems comprise a central condenser-compressor unit and subsidiary indoor units. While advanced automation features enable each of dozens of indoor units to be operated at different conditions of comfort, the unit meets the demand for heating by operating as a heat pump during the winter. Each indoor unit of 3 pipe systems of the energy recovery type can operate independently in the cooling or heating mode during the same season.

Air-VRF Mixed Air Handling Units

VRF systems do not include ventilation. These only provide heating and cooling. 2 applications are made to make up for this lack.

1- A central duct air handling unit is used, which feeds fresh air into the system. In these systems, fresh air that has been pre-conditioned and subjected to heat recovery can also be humidified to the extent desired.

2- In spaces which require fresh air of low flow rate, the demand for fresh air is met using compact ventilation units with heat recovery.

Air Handling Unit

Air handling units are devices which can carry out air conditioning processes such as ventilation, heating, cooling, humidification, de-humidification, filtration, and heat recovery under automatic control.

Ventilation

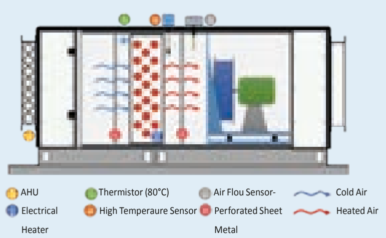
The movement of air in the air handling unit is achieved with the aid of fans. Fixed or variable air flow can be provided depending on the system design.

Cooling and Dehumidification

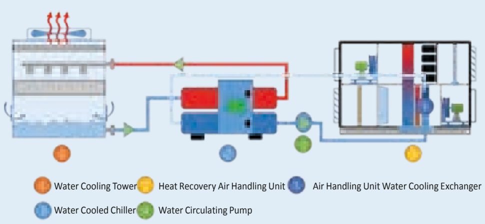
Cooling is achieved via air to water or refrigerant to air (DX) heat exchangers.

- Conditioned cold water required in the water system is generated by the chiller and sent to the cooling exchanger in the air handling unit with the aid of the pump. Warm air that is passes over the exchanger, and is cooled by transferring its heat to the water with the help of the exchanger.
- In the refrigerant system, the evaporator and expansion valve in the air handling unit, or the condenser, compressor and gas installation in the VRF outdoor unit or condenser/compressor section in combination provide the required supply for cooling. The liquid phase refrigerant that comes from the VRF or condender/compressor unit undergoes pressure loss by passing through the expansion valve

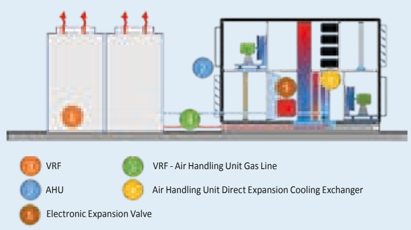
Electrical Heater - Air Handling Unit



Water Cooled Chiller - Air Handling Unit



VRF- Air Handling Unit



and evaporates by receiving the heat needed for evaporation from the air passed over the evaporator. Air is cooled in this manner.

Heating

Heating can be achieved in air handling units via water, electrical, refrigerant (heat pump), natural gas (open and closed combustion chamber) systems.

- Hot water required in the water system is generated in the boiler and sent to the water heating exchanger in the air handling unit with the aid of the pump.
- In the electrical heating system, air is heated with the aid of resistances placed within the air handling unit.
- In the refrigerant system, the condenser/compressor unit or VRF outdoor unit integrated in the air handling unit operate in the heat pump mode, using the heat exchanger within the air handling unit as a condenser. Thus, it provides heating by transferring the waste heat generated in the cooling cycle to the air.
- In the natural gas system, heat energy generated by the direct or indirect combustion unit is transferred to the air passed over it, increasing the temperature of the air.

Heat Recovery Systems

Heat recovery equipment is indispensable in designing air conditioning systems with a minimum energy expenditure. Heat recovery systems are divided in two main groups as Recuperative and Regenerative Systems.

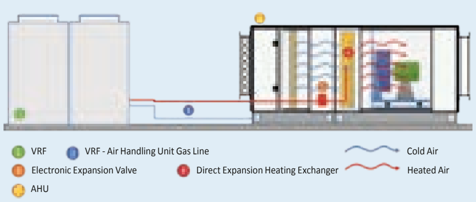
Recuperative systems

- Plate Type Heat Recovery is achieved by passing the conditioned return air and fresh air over an exchanger, in such a way that they do not mix.

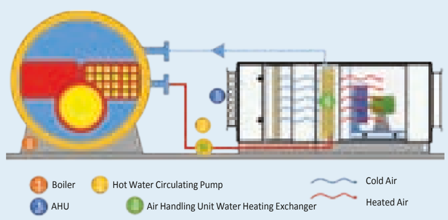
Regenerative systems

- Run Around Heat Recovery is achieved by passing the conditioned return air and fresh air over two separate exchangers containing water. Water circulation is achieved in the system with the aid of a pump.
- Heat Pipe Heat Recovery utilizes the principle of evaporation and condensation of the refrigerant within a single two section exchanger placed on the conditioned exhaust air line and on the fresh air line.
- In the Rotary Drum Heat Recovery system, heat recovery takes place between fresh air and indoor air that are at different temperatures and humidity levels with the help of a rotary type heat exchanger. It enables the transfer of only sensible heat, or of both sensible and latent heat.

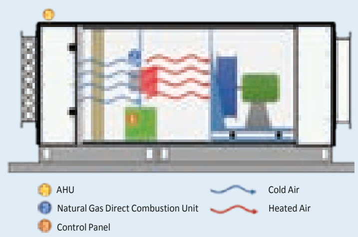
VRF- Air Handling Unit



Boiler - Air Handling Unit



Burner - Air Handling Unit



Filtration

Since air handling units facilitate operation with a high percentage of fresh air, filtration is highly significant for the protection of equipment within the unit, as well as the hygiene conditions of the conditioned environment. All filters of the G (gross filter), and F (fine filter) series filters can be used with filter units placed within the air handling unit.

Humidification

2 different humidification systems can be applied in the air handling unit, which are adiabatic humidification and isothermal (steam) humidification.

1. In adiabatic humidification, thermal energy for the vaporization of water is not supplied externally, it is applied in two different ways:

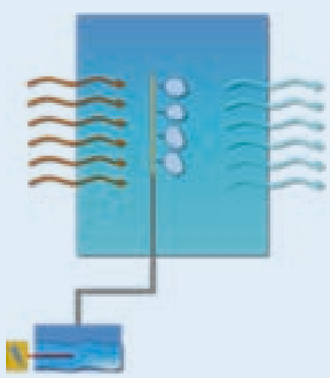
- Vaporization over moistened medium

Porous media capable of absorbing water, placed within the air handling unit is moistened with water, forming a moist surface. Air passing over this surface acquires moisture by evaporating the water.

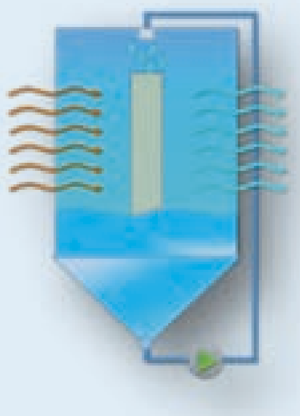
- High pressure water spray

Nozzles placed within the air handling unit cause water pressurized up to 100 bar to be converted to mist. These water particles mix into the air, providing humidification.

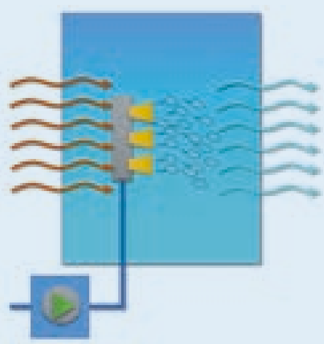
2. Isothermal (steam) humidification requires external heat energy; steam that is generated in the steam generator integrated into the air handling unit frame or that is ready in the plant is mixed into the air within the air handling unit with the aid of diffusers, providing humidification.



Steam Humidification



Humidification via Moistened Medium



Humidification via High Pressure Spray

Historical Development of Air Handling Unit Housing

1st Generation air handling units

Were manufactured with a generalized frame and welded connections. The panel structure was single walled, not insulated and was manufactured from DKP sheet metal. This led to a product with long manufacturing periods, low useful life, with high energy losses.

2nd Generation air handling units

Transitioned to another design where the panel structure was double walled, insulated, manufactured of galvanized or painted sheets, with an Aluminum frame. Condensation that occurred in the housing at critical climate conditions due to thermal bridging upset the conditions of comfort and shortened the unit's useful life.

3rd Generation air handling units

Were designed wit Aluminum frames and reduce thermal bridging to comply with the light structure concept and aesthetics in parallel with the developments in structural design. The panel structure was double walled, and manufactured with insulated painted sheet metal. However, due to the structural properties of Aluminum, flexions and dissolutions occurred at connection points during transport and assembly, which led to problems related to housing strength. Plastic based thermal barriers began to be used to remove thermal bridging via frame profiles, but this led to problems related to mechanical strength.

4th Generation air handling units

Transitioned to a design with a steel housing, which allowed assembly not with welding, but with specialized fittings. In this way, problems with welded housing design which caused problems in 1st and 2nd generation air handling units were eliminated as well as structural problems encountered in air handling units with Aluminum housing. Designs were introduced where contact between metal parts in panel structures was partially prevented. However a thermal bridge-free unit could not be achieved due to the high thermal transfer coefficient of the steel frame.

Technical Properties	1st Generation	2nd Generation	3rd Generation	4th Generation	5th Generation
Thermal Bridging	Thermal Bridging	Thermal Bridging	Reduced Thermal Bridging	Reduced Thermal Bridging	Thermal Bridge-free
Panel Structure	Single Wall	Double Wall	Double Wall	Double Wall	Double Wall
Insulation	None	Rock Wool	Rock Wool	Rock Wool + Polyurethane	Rock Wool + Polyurethane
Sheet Metal	DKP + Painted	Galvanized + Painted	Galvanized + Painted	Galvanized + Painted	Magnelis + Painted
Frame Structure	Welded	Aluminum	Aluminum	Steel	Composite + Steel
Corrosion Resistance	Low	Low	Medium	Medium	High

The 5th Generation air handling unit

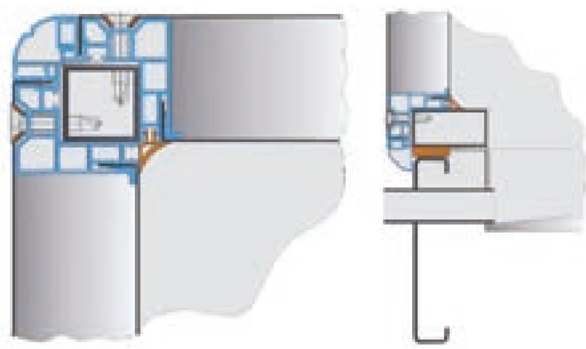
The first objective in designing BOREAS, was to create a product that would eliminate all negative aspects and carry all positive aspects of the previous generation air handling units. Consequently, a frame structure with minimal energy losses, capable of trouble free operation in critical climate conditions, with high resistance values against varying loads that may be exerted on the housing structure, with higher structural values than steel frame housing yet lighter than Aluminum housing were determined as design inputs for the 5th Generation Air Handling Unit BOREAS, and the design of BOREAS was completed.


BOREAS

BOREAS AIR HANDLING UNIT

Panel Structure

- Provides trouble-free performance, and hygienic and extended life cycle in critical climate conditions by using MAGNELIS® sheet, which has 5 times higher corrosion resistance than standard galvanized sheet.
- PVC profile comprising the panel frame acts as a heat barrier between the inner and outer sheet metal surfaces. The porous nature of the PVC profile enhances both the structural strength and heat insulation as well.
- Concave profiles on the panel joint interface on the inside allow formation of smooth edges that can be cleaned. Thus, details that have hygienic properties can be obtained even in a comfort air handling unit. This property prevents thermal bridging that can be formed through the frame profile.
- The typical insulation is provided by using 50 mm rock wool with 70 kg/m³ density. An optional insulation by using 50 mm polyurethane materials with 40 kg/m³ applied through injection is available as well.



Frame Structure

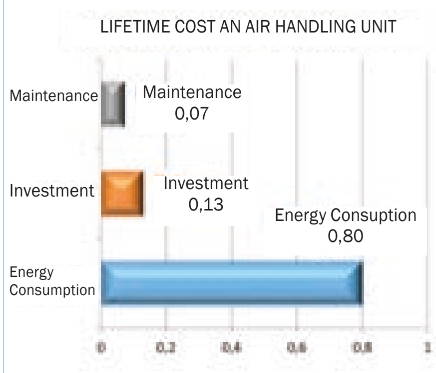
A frame that has higher mechanical strength than that of a steel profile, and that is lighter than an aluminum frame structure is achieved through using rectangular profiles manufactured from composite material. Due to the fact that the composite material has a much lower heat transfer factor when compared to steel and aluminum, it ensures a TB1 Thermal Bridge Free class according to EN 1886 by preventing the formation of thermal bridges at the joints between the frame and the panel, and between the fittings.

The Advantages

Investors

With its innovative composite frame design, BOREAS Air Handling Units are manufactured by using components that are resistant to extreme operating conditions, long lasting, and have world-class certifications. The results of BOREAS at the EN 1886 certification tests which can only be achieved by high-end air handling units ensure the performance it guarantees for years to come. Its advanced selection software enables users to select the products that have the best performance/price ratio. BOREAS achieves lowering the energy leaks from the casing of an air handling unit below the acceptable limits by delivering L1 (< 0.15 $l \times s^{-1} \times m^{-2}$) casing air leakage class, TB1 (0.75 ≤ k_b < 1.00) thermal bridging class, and T2 (0.5 < U ≤ 1) thermal transmittance class.

TECHNICAL SPECIFICATIONS ACCORDING TO EN 1886:2007					
Mechanical Strength (mm x m^{-1})	**D1**	D2		D3	
	4	10		>10	
Casing Air Leakage ($l \times s^{-1} \times m^{-2}$)	**L1 (f400)**	L2 (f400)		L3 (f400)	
	0.15	0.44		1,32	
	L1 (f700)	L2 (f700)		L3 (f700)	
	0.22	0.63		1,90	
Filter Bypass Leakage (%k)	**F9**	F8	F7	M6	G1-M5
	0.5	1	2	4	6
Thermal Transmittance (W x m^{-2} x K^{-1})	T1	**T2**	T3	T4	T5
	U < 0,5	0.5 < U ≤ 1.0	1.0 < U ≤ 1.4	1.4 < U ≤ 2.0	2.0 < U
Thermal Bridging	**TB1**	TB2	TB3	TB4	TB5
	0.75 < k_b < 1.00	0.60 ≤ k_b < 0.75	0.45 ≤ k_b < 0.60	0.30 ≤ k_b < 0.45	k_b < 0.3



End Users

Delivering complete and continuous multi-stage filtering, heating, cooling, humidification, dehumidification and heat recovery through automated controls, Boreas Air Handling Unit provides highly efficient air conditioning that does not compromise on hygiene in comfort applications, as well as ventilation for living spaces.

- Thanks to its access doors that enable easy operating and maintenance, every corner of the unit can be reached easily.
- Inner edges and corners are rounded to prevent accumulation of dirt. Maintenance costs are lowered by providing easy service and maintenance conditions.

The unit has a high level of energy efficiency, and the factors delivering this are as follows:

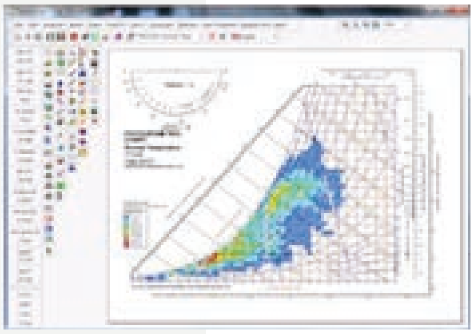
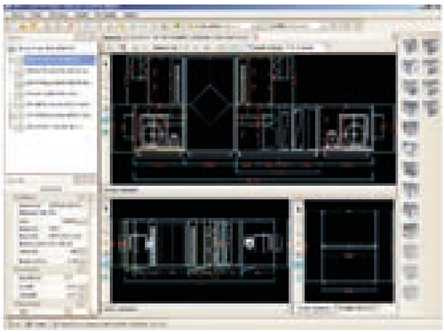
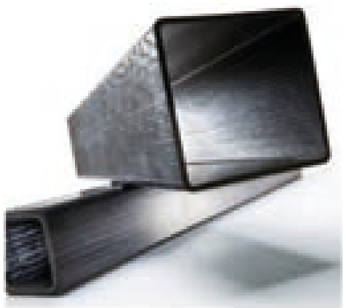
- Using highly energy efficient components;
- Very low, if any, loss of energy due to its L1 air leakage class, T2 and TB1 casing thermal transmittance and thermal bridge classes respectively.
- Design specifications that have low internal resistance.

Extended life cycle that requires low maintenance is achieved by using Magnelis® sheet metal and composite materials. The filter frame with compression mechanism provides easy service.

Design Offices and Consultants

Offering 40 different models that can meet a wide range of demand between 2,000 m^3/h and 100,000 m^3/h, Boreas Air Handling Unit can easily and rapidly be sized in various dimensions thanks to its modular nature. It enables different types of heating, cooling, humidification, dehumidification, heat recovery and filtering applications through wide variety of components. BOREAS meets various specifications for different using and operating conditions with its D1 (4 mm x m^{-1}) mechanical strength class, L1 (< 0.15 l x s^{-1} x m^{-2}) casing air leakage class, TB1 ($0.75 \leq k_b < 1.00$) thermal bridging class, and T2 ($0.5 < U \leq 1$) thermal transmittance class. With its T2 thermal transmittance value and TB1 thermal bridging value in particular, it is suitable for extremely high and extremely low temperature climate conditions.

Its unique web-based air handling unit selection software enables easy, fast and reliable product design and selection, as well as delivering detailed reports and drawing printouts in .dxf format. It meets all mandatory requirements for a selection software according to Eurovent OM-5. Boreas Licensed Psyhometric Chart and Analysis Software facilitate calculations and design.

Installers

Multi-purpose handling rings and forklift fork holes provided for stand designs of all models allow the units to be moved horizontally and vertically with ease at construction sites. With the specially designed section assembly method, sections of the air handling unit can be assembled easily and rapidly even on uneven surfaces. Each section of the unit has its own tag to make it easier to assemble.

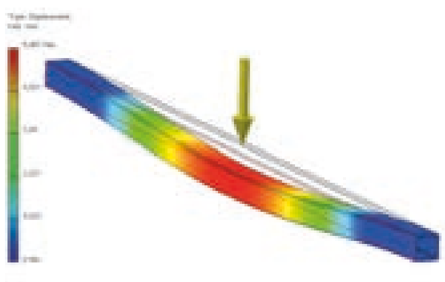
Our Innovations And Differences

Using Composite Material

Composite materials are made from two or more materials that, on their own, are not suitable for the desired outcome, by combining them physically and in macro design under certain conditions to deliver the expected properties.

Composite materials contain a fibre material as a core, and a matrix material composing the larger volume covers that core. Of these two material groups, the fibre constitutes the strength and load carrying properties, whereas the matrix material prevents crack propagation that might occur during transition to plastic deformation and delays breaking of the composite material. Another purpose of the material used as matrix 11 is to keep the fibre materials together under load and distribute the load between the fibres homogeneously.

The fact that the composite materials have low specific gravity provides a huge advantage for them in light constructions. Additionally, the fact that they are corrosion resistant and provide heat, sound and electrical insulation, gives fibre reinforced composite materials an edge for relevant applications.



Among these main advantages are:

- High rise mechanical strength
- Easy formability
- Electrical properties (very good insulation or conductivity)
- Corrosion and chemical resistance
- Heat insulation and fire resistance
- Vibration absorption

The fact that the composite materials are widely used in all aspects of life and that the abovementioned properties are also expected from the materials that frame structures are made of inspired us to combine them in BOREAS. Thus, composite materials were used in BOREAS to provide a frame structure that delivers both insulation and strength.

Benefits of Air Handling Units Manufactured From Composite Material

The BOREAS air handling unit manufactured by using composite profiles are differentiated from 4th generation steel-framed units and 3rd generation aluminum-framed units thanks to its properties listed below.

- Vibrations derived from the moving parts inside the air handling unit are transferred to the floor minimally thanks to the frame structure of the AHU manufactured from composite material that has vibration absorption property.
- Due to the fact that the composite profile has a high yield point, permanent deformation of the frame structure of the unit under variable loads is prevented during moving, assembly and operation.
- Corrosion is prevented on the frame structure manufactured from composite material. Thus, compared with the aluminum and steel framed air handling units, the unit operates smoothly under extreme climate conditions and the ambient conditions that might result in corrosion.
- Thermal bridging property, the key criterion in loss of energy and surface condensation, is provided at the highest level thanks to the fact that the composite material has very low thermal transmittance factor

as compared to aluminum and steel.

- Composite material has a high level of fatigue resistance, therefore it ensures the frame structure to have a longer life cycle in terms of mechanical properties than those of the aluminum and steel-framed air handling units.
- The technical properties of the frame structure manufactured from composite profile are superior to the aluminum and steel-framed air handling units, and this gives a lighter weight than those two. This, in result, lowers the overall weight of the air handling unit and creates a much lower load for the structure.

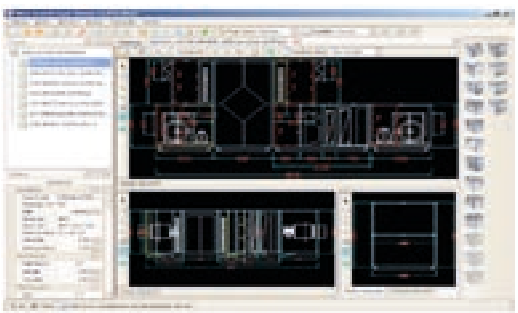
Boreas Air Handling Unit Selection Software

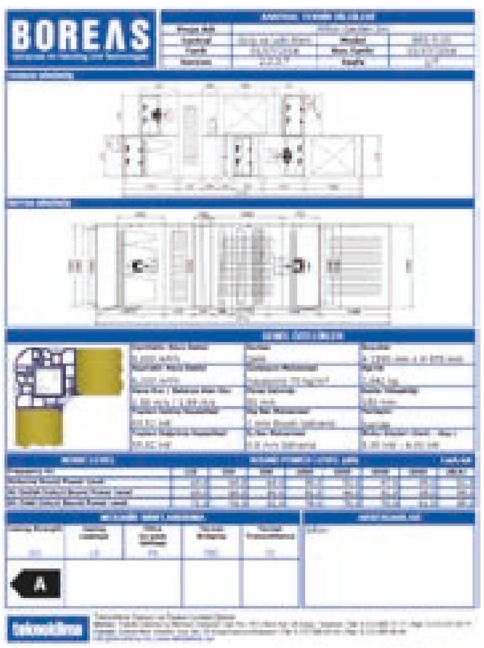
BOREAS Air Handling Unit Selection Software is a Windows-based selection tool that meets Eurovent requirements, access the data-base over the Internet, has user friendly interfaces, defines the product completely, can select the products from various manufacturers of air handling unit components, can deliver 3-surface-appearance printouts in .dxf file format, can display the price of the product you have designed and selected, and can produce complete selection outputs as per Eurovent software requirements.

By using Boreas Air Handling Unit Selection Software, you can:

- produce air handling unit design, selection, drawing printouts in .dxf file format and technical data output for a wide range of flow rate and capacity intervals within modular sizes;
- access the updates instantaneously upon the improvements on the selection software;
- choose among the latest approved .dll files from domestic and foreign manufacturers for fans, batteries, and heat recovery exchangers;

EUROVENT CERTIFIED PERFORMANCE
AHU No. 15.06.010
Range BRS
www.eurovent-certification.com





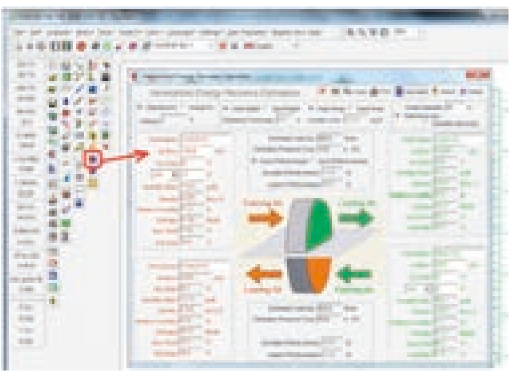
- obtain detailed and reliable technical data printouts and all the technical data for the air handling unit you have selected in .pdf file format;
- design the unit in minimum size and at the lowest cost by dynamically changing the length of fans, batteries, heat recovery units and filter sections within the modular sizes and optimizing the dimensions.
- due to the fact that it is a custom software for BOREAS Air Handling Units, ensure that the designed and selected products are the same with the manufactured and delivered products.

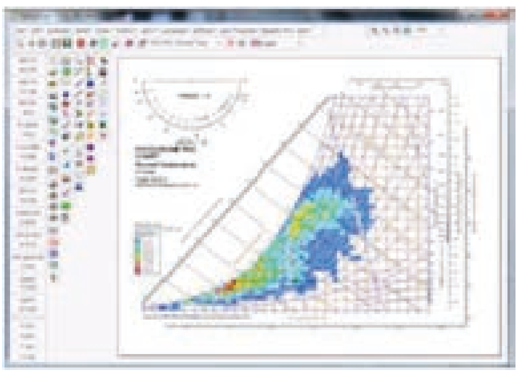
Boreas Psychrometric Calculation Software

You can perform all of the calculations required for your project, store and print them with the BOREAS licensed Psychrometric Calculation Software.

With the BOREAS Psychrometric Calculation Software you can:

- calculate all air conditioning processes;
- select climate conditions for countries and regions;
- calculate the evaporation amounts in pool sites;
- calculate and design the cross section of the air duct;
- use either IP or SI units;
- prepare a report containing dotted Psychrometric charts, process flow charts and the thermal values for the dots on the chart;
- perform calculations for drum type and plate type heat recovery systems.

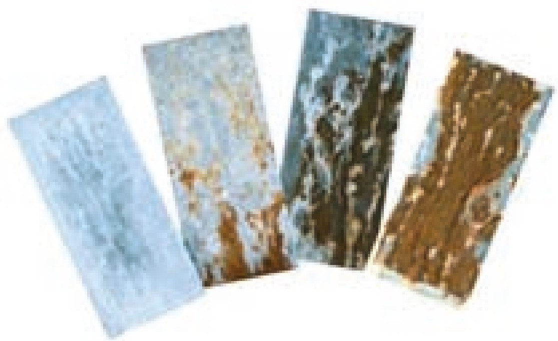




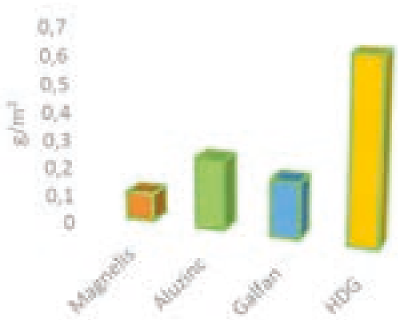
Magnelis® Sheet Metal

Magnelis® is manufactured at a traditional industrial hot dip galvanized line, however it is dipped into a molten zinc bath with a unique metallic chemical compound containing 3.5% aluminum and 3% magnesium. 3% magnesium covers the entire surface with a smooth and durable layer, and provides much better protection against corrosion in comparison with coatings containing lower magnesium. Since it extends the life cycle of the product, it is important for the air handling units which are operated under corrosive ambient conditions.

A high corrosion resistance is provided for BOREAS Air Handling Units, on demand, by using Magnelis® sheet metal for inner and outer panel sheets and internal parts. Thanks to this property, the unit can be operated trouble-free under the ambient conditions that have high humidity and cause corrosion. Through high corrosion resistance, metal parts require minimum maintenance and hygienic requirements are met for the metal parts that have contact with air.



Weight Loss in the Toughest Conditions



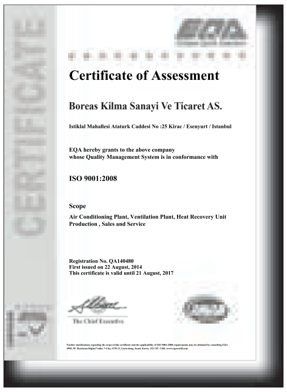
	Anti-corrosive Properties of Products			
	HDG ZN	**Galfan**	**Aluzinc**	**Magnelis**
In an environment containing chloride (swimming pool)	**Baseline**	**+**		**+++**
In an environment containing ammonium (barn, farm, greenhouse)	**Baseline**	**+**	**=**	**++**
In an environment containing SO2 (industrial acidic environment)	**Baseline**	**+**		**+**
Temporary protection (transport, storage)	**Baseline**	**+**	**+++**	**++**
Edge protection	**Baseline**	**+**	**-**	**+++**
Corrosion on a deformed part	**Baseline**	**+**	**-**	**++**

Quality Certifications

Eurovent Certification

The BOREAS Air Handling Unit is Eurovent Certified as Mechanical Strength Class D1, Casing Air Leakage Class L1, Thermal Transmittance Class T2, Thermal Bridging Class TB1, and Filter Bypass Leakage Class F9 according to the results of tests performed in accordance with EN 1886. Eurovent Certification documents the technical specifications and performance of air conditioning and cooling products within the framework of European standards. Therefore two different Eurovent certified products need not have the same mechanical performance specifications; tests carried out according to EN 1886 can yield various results between manufacturers and products, and the results are published on the Eurovent website.

ISO 9001



Certificate of Assessment

Boreas Kilma Sanayi Ve Ticaret AS.

Istiklal Mahallesi Ataturk Caddesi No :25 Kirac / Esenyurt / Istanbul

EQA hereby grants to the above company
whose Quality Management System is in conformance with

ISO 9001:2008

Scope

Air Conditioning Plant, Ventilation Plant, Heat Recovery Unit Production , Sales and Service

Registration No. QA140480
First issued on 22 August, 2014
This certificate is valid until 21 August, 2017

The Chief Executive

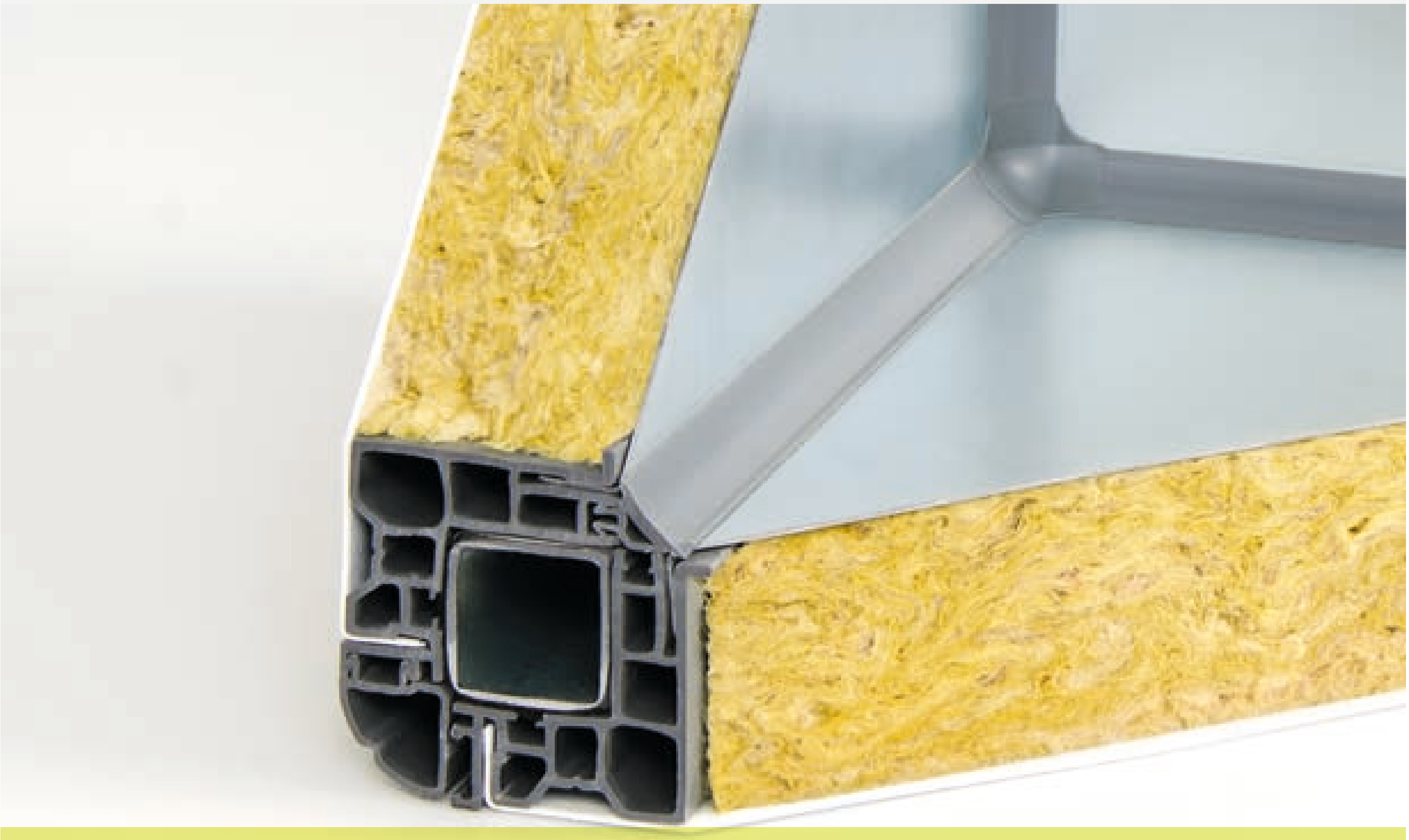
In order to have its processes monitored and improvable within the scope of total quality approach, Boreas Klima awarded its ISO 9001 certificate in 2013. ISO 9001 is a management system implemented on national and international levels to ensure improvement on the organization's sense of quality, increase efficiency and market share, an efficient management, decrease costs, improve employee satisfaction, improve internal communications, ensure an extensive monitoring and control in all activities, lower the number of returns, decrease customer complaints, and increase customer satisfaction.

Hygiene Certification

Boreas Air Handling Unit hygiene version tested by TÜV-SÜD according to VDI 6022 and DIN 1946-4 standards. As a result of tests performed, both the product structural features as well as the leakage class and thermal bridging class has been shown to meet the both standards required. Important properties of the BRS-H encoded hygiene version are all kinds of measures taken against corrosion on internal structure and components, thanks to it's smooth surfaces cleaning is very easy to perform and it can be controlled in a sustainable manner.

EAC Declaration

Declaration of the EAC Customs Union is the name of the certificate that is prevailing at the Eurasian Custom Union. The member countries of the EAC Customs Union are Russia, Belarus, Kazakhstan, Armenia and Kyrgyzstan.



DESIGN SPECIFICATIONS OF BOREAS AIR HANDLING UNIT

40 models are available with air flow capacities of 2,000 m^3/h and 100,000 m^3/h to meet a wide range of demand. The unit has a reduced field wiring through flexible automated control solution and is compatible with all common communication protocols.

Outer walls of the double walled, thermal bridge free, 50 mm rock wool insulated panels are manufactured from 1-mm-thick galvanized and painted sheet metal, and the inner walls are 0.8 mm galvanized or, on demand, stainless sheet metal.

1

F9 leakage class filter assembly and all types of filter application in G3-F9 range

2

Required flow rate and pressure are supplied by low noise and high efficiency fans and motors

5

Water systems or DX coolers and heaters are selected from Eurovent certified products to provide the best performance.

6

Easy monitoring through rectangular and wide sight glasses and LED lighting

7

Inner edges and corners are rounded to prevent accumulation of dirt and manufactured to meet easy assembly, maintenance and cleaning requirements. Suitable for hygienic applications in places such as hospitals, laboratories and clean rooms.

Superior energy efficiency through high efficient heat recovery aplications

3

Metal casting door hinges that allow adjusting in three axes and locked door handles work without a risk of corrosion between the temperature range of -40°C and +80°C.

4

Low grid resistance hidden gear driven "Anodized" aluminum dampers

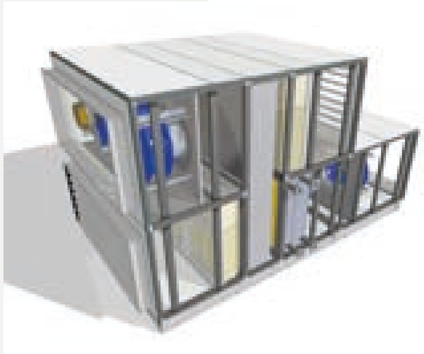
8

150-mm-high stands with forklift openings for moving also have eye bolts to be carried with cranes

9

Boreas air handling units are manufactured by automated systems to ensure, control and maintain comfort requirements

10



In addition to financial implications of thermal bridging, what is really important condensation of the moisture content of the air on cold surfaces. Condensation causes growth of micro organisms on wet surfaces, consequently leads to health issues and shortens the lifetime of the unit due to corrosion. Furthermore, the joints on the inner walls of the panels on the adjacent surfaces of similar products cause heat leakages, and they also allow dirt accumulation and enable micro organisms to grow, both damaging hygienic conditions. There are efforts to cover such spaces with mastic application but the quality of this work depends on the skill and experience of the person performing the application, this consequently results in hygienic issues.
To eliminate the problems experienced in the 3rd and 4th generation air handling units we have mentioned above, an innovative approach has been applied in the design of BOREAS air handling unit. The frame structure can be made of composite material optionally, thus achieving a lighter, thermal bridge free structure and high mechanical properties. The panel structure composed of frames that were manufactured from PVC profiles provide a thermal bridge free unit. Thanks to the rounded angle seals used on the panel joints on inner walls, a structure that is easier to clean and prevents dirt accumulation is achieved, notwithstanding the skill and experience of the installer.

Frame Structure

Boreas Air Handling Unit is composed of rectangular profiles made out of 2-mm-thick steel material in 30 x 30 mm and 30 x 60 mm size, and the corner and mullion joints that keep them together. BOREAS Air Handling Unit has the highest D1 class according to EN 1886 Mechanical Strength Test due to its usage of steel frame which has greater mechanical properties than aluminum framed structures. As an optional material, composite frames with much lower thermal transmittance factor than aluminum and steel profiles provide a heat insulation and ensure a completely thermal bridge free frame structure.Composite profiles with much lower thermal transmittance factor than aluminum and steel profiles provide a natural heat insulation and ensure a completely thermal bridge free frame structure. Continuous base frame design along

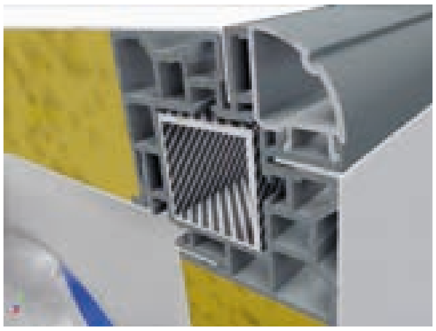
the section edges was designed to transfer the weight of the sections to the floor as a distributed load. 150-mm-high base frame structure is standard, and contains fork holes for forklift and circular holes to allow sections to be moved horizontally and vertically at construction sites. A very strong thick EPP strip on relevant surfaces is used to prevent thermal bridging between the base frame and the section frame structure.

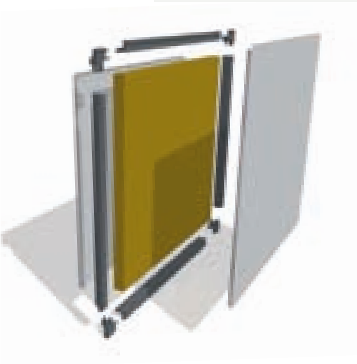
Panel Structure

Panel structure which forms the casing of the air handling unit is the most and effective equipment that affects the overall mechanical performance of the unit. The panel structure of BOREAS is designed to prevent thermal bridging between internal and external environment. The contact between inner and outer surface sheet metals that are mounted on the panel structure made up of PVC-based panel profiles is completely prevented, thus providing thermal bridge free structure. Rigid panel structure contributes greatly to its L1 class in Casing Air Leakage Tests.

Typically, 50 mm rock wool in 70 kg/m^3 density is used as panel insulation material. With its PVC frame structure and standard insulation, its Thermal Transmittance Class is T2 according to EN 1886. This class can be upgraded to T1 by using optional Polyurethane insulation material. Connecting screws that are used to connect panels to the frame structure are hidden on the outer sheet metal, and provides a smooth, aesthetic view on the outside. Screw caps on the screw heads prevent contact with the external environment to avoid corrosion and thermal bridging.

PVC profiles with an operating range of -40 °C / +80 °C are manufactured to offer high resistance against the effects of UV radiation. Trouble-free operation is provided in extreme climate conditions by optionally using highly corrosion resistant Magnelis® sheet metal. Panel sheet metals which, as a standard, is 0.8 mm thick on the inside and 1.0 mm thick on the outside can optionally be applied in 0.8 and 1.2 mm thickness, respectively. Custom manufactured EPDM-based porous seals with low thermal transmittance factor are used on the joints of panels and profiles.





Dimension Tables

MODEL	FILTER PLACEMENT	QUANTITY			INNER DIM.	OUTER DIM.	FLOW RATE (m³/h)					
		1/1	1/2	1/4	H X W (mm)	H X W (mm)	V1 (<1.6 m/s)	V2 (1.6-1.8 m/s)	V3 (1.8-2.0 m/s)	V4 (2.0-2.2 m/s)	V5 (2.2-2.5 m/s)	V6 (2.5-3.0 m/s)
6x6		1	0	0	612 x 612	842 x 712	2157	2427	2697	2966	3371	4045
6x9		1	1	0	612 x 918	842 x 1018	3236	3641	4045	4450	5056	6068
6x12		2	0	0	612 x 1224	842 x 1324	4315	4854	5393	5933	6742	8090
9x9		1	2	1	918 x 918	1148 x 1018	4854	5461	6068	6674	7585	9101
9x12		2	2	0	918 x 1224	1148 x 1324	6472	7281	8090	8899	10113	12135
9x15		2	3	1	918 x 1530	1148 x 1630	8090	9101	10113	11124	12641	15169
9x18		3	3	0	918 x 1836	1148 x 1936	9708	10922	12135	13349	15169	18203
12x12		4	0	0	1224 x 1224	1454 x 1324	8629	9708	10787	11866	13484	16180
12x15		4	2	0	1224 x 1530	1454 x 1630	10787	12135	13484	14832	16854	20225
12x18		6	0	0	1224 x 1836	1454 x 1936	12944	14562	16180	17798	20225	24270
12x21		6	2	0	1224 x 2142	1454 x 2242	15102	16989	18877	20765	23596	28316
12x24		8	0	0	1224 x 2448	1454 x 2548	17259	19416	21574	23731	26967	32361
15x15		4	4	1	1530 x 1530	1760 x 1630	13484	15169	16854	18540	21068	25282
15x18		6	3	0	1530 x 1836	1760 x 1936	16180	18203	20225	22248	25282	30338
15x21		6	5	1	1530 x 2142	1760 x 2242	18877	21237	23596	25956	29495	35394
15x24		8	4	0	1530 x 2448	1760 x 2548	21574	24270	26967	29664	33709	40451
15x27		8	6	1	1530 x 2754	1760 x 2854	24270	27304	30338	33372	37923	45507
15x30		10	5	0	1530 x 3060	1760 x 3160	26967	30338	33709	37080	42136	50563
18x18		9	0	0	1836 x 1836	2066 x 1936	19416	21843	24270	26697	30338	36406
18x21		9	3	0	1836 x 2142	2066 x 2242	22652	25484	28316	31147	35394	42473
18x24		12	0	0	1836 x 2448	2066 x 2548	25888	29125	32361	35597	40451	48541
18x27		12	3	0	1836 x 2754	2066 x 2854	29125	32765	36406	40046	45507	54609
18x30		15	0	0	1836 x 3060	2066 x 3160	32361	36406	40451	44496	50563	60676
18x33		15	3	0	1836 x 3366	2066 x 3466	35597	40046	44496	48945	55620	66744

Full Filter

Half Filter

Quarter Filter

V1 (m/s)	V2 (m/s)	V3 (m/s)	V4 (m/s)	V5 (m/s)	V6 (m/s)
1,6	1,8	2	2,2	2,5	3

Velocity classification according to EN 13053

18x36	18	0	0	1836 x 3672	2066 x 3772	38833	43687	48541	53395	60676	72811
21x21	9	6	1	2142 x 2142	2372 x 2242	26428	29731	33035	36338	41293	49552
21x24	12	4	0	2142 x 2448	2372 x 2548	30203	33979	37754	41529	47193	56631
21x27	12	7	1	2142 x 2754	2372 x 2854	33979	38226	42473	46721	53092	63710
21x30	15	5	0	2142 x 3060	2372 x 3160	37754	42473	47193	51912	58991	70789
21x33	15	8	1	2142 x 3366	2372 x 3466	41529	46721	51912	57103	64890	77868
21x36	18	6	0	2142 x 3672	2372 x 3772	45305	50968	56631	62294	70789	84947
21x39	18	9	1	2142 x 3978	2372 x 4078	49080	55215	61350	67485	76688	92025
21x42	21	7	0	2142 x 4284	2372 x 4384	52856	59463	66070	72677	82587	99104
24x24	16	0	0	2448 x 2448	2678 x 2548	34518	38833	43147	47462	53934	64721
24x27	16	4	0	2448 x 2754	2678 x 2854	38833	43687	48541	53395	60676	72811
24x30	20	0	0	2448 x 3060	2678 x 3160	43147	48541	53934	59328	67418	80902
24x33	20	4	0	2448 x 3366	2678 x 3466	47462	53395	59328	65261	74160	88992
24x36	24	0	0	2448 x 3672	2678 x 3772	51777	58249	64721	71193	80902	97082
24x39	24	4	0	2448 x 3978	2678 x 4078	56092	63103	70115	77126	87643	105172
24x42	28	0	0	2448 x 4284	2678 x 4384	60406	67957	75508	83059	94385	113262

Full Filter
Half Filter
Quarter Filter

V1 (m/s)	V2 (m/s)	V3 (m/s)	V4 (m/s)	V5 (m/s)	V6 (m/s)
1,6	1,8	2	2,2	2,5	3

Velocity classification according to EN 13053

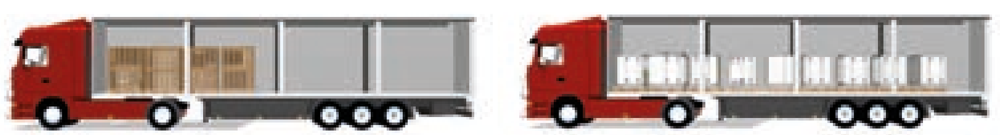
Modular Structure

The dimensions of BOREAS's modular structure have been determined on the basis of standard filter measurements according to EN 775. In this way, the suitable cross section for filtration is achieved in air handling units operating with high percentages of fresh air, and filter surface areas can be used fully. Enclosed areas that may disrupt the lines of air flow have been avoided in the cross section of air flow, eliminating extra internal losses. This leads to reduced internal pressure losses and reduced energy requirements for fan drive. For the same reason, by-pass sealing is measured as F9, the highest level. The module measurement has been determined as 102 mm, 1/6th of the full scale filter. This makes it possible to design air handling units with smaller steps.

SmartPack

SmartPack has been designed particularly to eliminate problems of transport within the building and to reduce high transport costs at long distances. The method determined for SmartPack is to make a full inventory of all parts as intermediate products, package them in a way that will be convenient for assembly, and assemble the unit on site with trained technical teams.

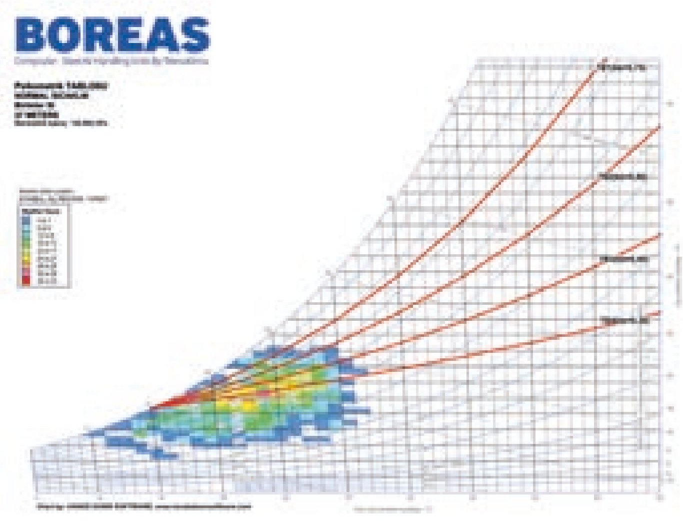
The weakness of fittings is an issue in the most commonly used method where the unit is transported to the field after assembly and disassembly in the factory. In another method, packages that contain a great number of components are shipped without any assembly and the assembly is carried out from scratch on site. In this case project errors emerge on site and the solutions applied lead to loss of time and quality. When the assembly is carried out fully in remote sites, the experience of local workers, technical drawings, and assembly guides are insufficient. In the SmartPack application, all designs and assemblies specific to the project are made in advance in a computer environment, assembly of intermediate products in accordance with the project is completed in the factory environment, and shipped in packages that do not contain empty spaces. Assemblies that are completed in advance in a 3D computer environment allows on site assemblies monitored by a supervisor to be completed in full and with no errors.



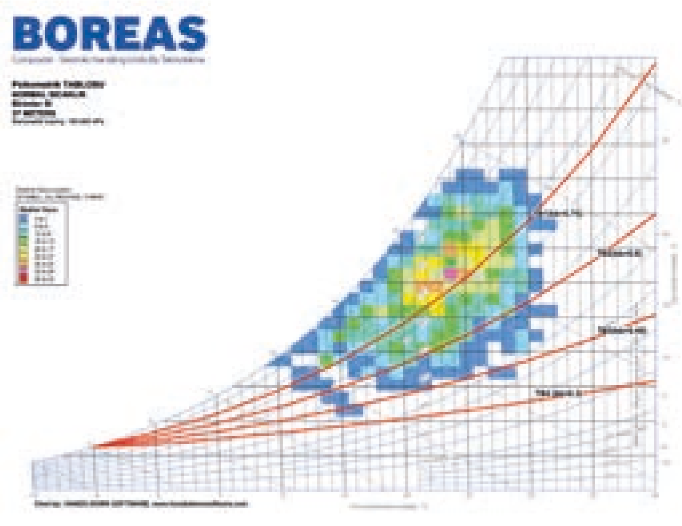
Corrosion and Corrosion Resistance Properties

Air handling units are devices which carry out the ventilation and air conditioning processes that are needed for providing the conditions needed in living spaces in general. The maintenance of comfort and hygiene conditions of the environment is the most significant criterion while performing these functions. Wet surfaces that may occur within air handling units create areas that are amenable for the growth of micro organisms. It is of critical importance for these areas to be kept under control, and brought to special conditions that do not permit the growth of micro organisms. These wet spaces prepare the ground for corrosion as well as the growth of micro organisms. This will shorten the unit's useful life, and prevent it from carrying out its functions fully.

In technical classifications determined for air handling units in EN 1886, the most significant criterion in the creation of uncontrolled wet surfaces is the thermal bridging class. The classification which determines the magnitude of the thermal bridge in the EN 1886 standard ranges from TB1 to TB5. On this scale, TB1 denotes the best case of the least thermal bridging, while TB5 denotes the worst case of the most thermal bridging. In the following example, the values for points where condensation begins in summer conditions are provided in terms of TB value. BOREAS which has a TB1 thermal bridging class minimises uncontrolled wet spaces even in extreme climate conditions. It also offers high corrosion resistance due to its highly corrosion resistant composite profile carcase structure and the use of Magnelis® sheet metal. With these properties, it ensured the conditions of comfort and hygiene needed continuously and for an extended period, even in extreme climate conditions.



Summer Condition



Winter Condition

BOREAS which has a TB1 thermal bridging class does not permit the creation of uncontrolled wet spaces even in extreme climate conditions. It achieves the highest class of thermal bridging and corrosion resistance due to its highly corrosion resistant composite profile carcase structure and the use of Magnelis® sheet metal. With these properties, it ensured the conditions of comfort and hygiene needed continuously and for an extended period, even in extreme climate conditions.

Technical Specifications of the Boreas AHU According to EN 1886

1. Mechanical Strength: D1

The amount of deflection of the air handling unit frame is measured on the Model Box under a pressure of ±1000 Pa is measured, and the air handling unit is checked for permanent deformation under a pressure of ±25000 Pa.

Casing Class	Maximum Displacement (mm/m)
D1	4
D2	10
D3	10 <

2. Casing Air Leakage Class: L1

These are tests where the amount of possible air leakage from the air handling unit casing under 400 Pa negative and 700 Pa positive pressure

Casing Air Leakage Class	Max. Air Leakage Percentage f_{-400} ($l \times s^{-1} \times m^{-2}$)	Max. Air Leakage Percentage f_{700} ($l \times s^{-1} \times m^{-2}$)
L1	0,15	0,22
L2	0,44	0,63
L3	1,32	1,9

3. Filter Bypass Leakage Class: F9

Classification is made on the basis of the percentage of the air flow passing unfiltered from the air handling unit filter frame under 400 Pa positive pressure to total air flow.

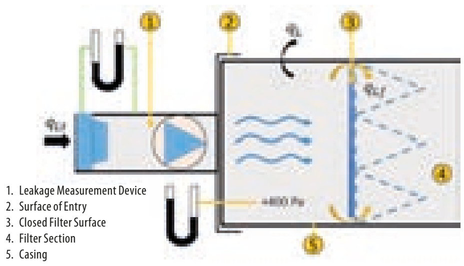
$$q_{Lt} = q_L + q_{Lf}$$

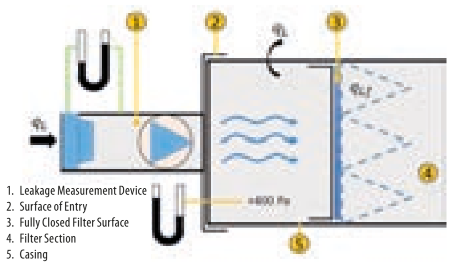
q_{Lt} : *Total Air Leakage*

q_L : *Casing Air Leakage*

q_{Lf} : *Air Leakage between the Filter Frame and Casing*

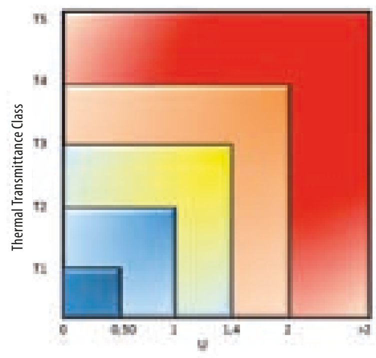
Filter Class	G1-M5	M6	F7	F8	F9
Max. Filter Leakage Percentage %k	6	4	2	1	0,5





4. Thermal Transmittance Class: T2

This is the test and classification for determining the thermal transmittance of the air handling unit casing and panel structure. Tests are carried out by maintaining a temperature difference of 20 K between the air handling unit interior and exterior, and a 0.1 m/s air velocity over the exterior surface.

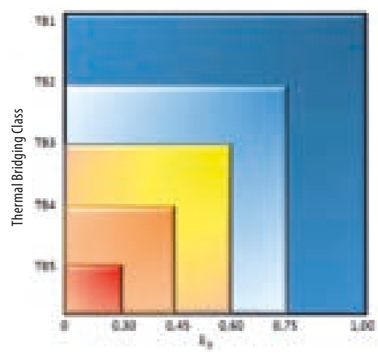


$$U = \frac{P_{ei}}{A\ x\ \Delta t_{air}} (W\ x\ m^2\ x\ K^{-1})$$

P_{ei} : *Electrical power of the heater and circulation fan*
A : *Exterior surface area of Model Box*
Δt_{air} : *The temperature difference between the Model Box interior and exterior*

5. Thermal Bridging Class: TB1

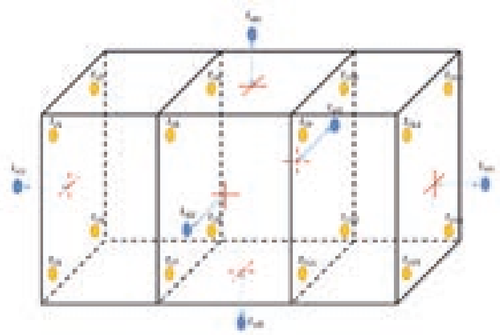
This is a test which determines and classifies thermal bridges that may occur between the interior and exterior environment of the air handling unit casing. The calculation is based on those points with the highest temperature on the exterior surface where the temperature difference between the internal and external environment is 20 K. A high class indicates a low condensation risk on the air handling unit casing while a low class indicates a high condensation risk.



$k_b = \Delta t_{min} / \Delta t_{air}$ $\quad \Delta t_{min} = t_i - t_{maxi}$ $\quad \Delta t_{air} = t_i - t_{aimaxi}$

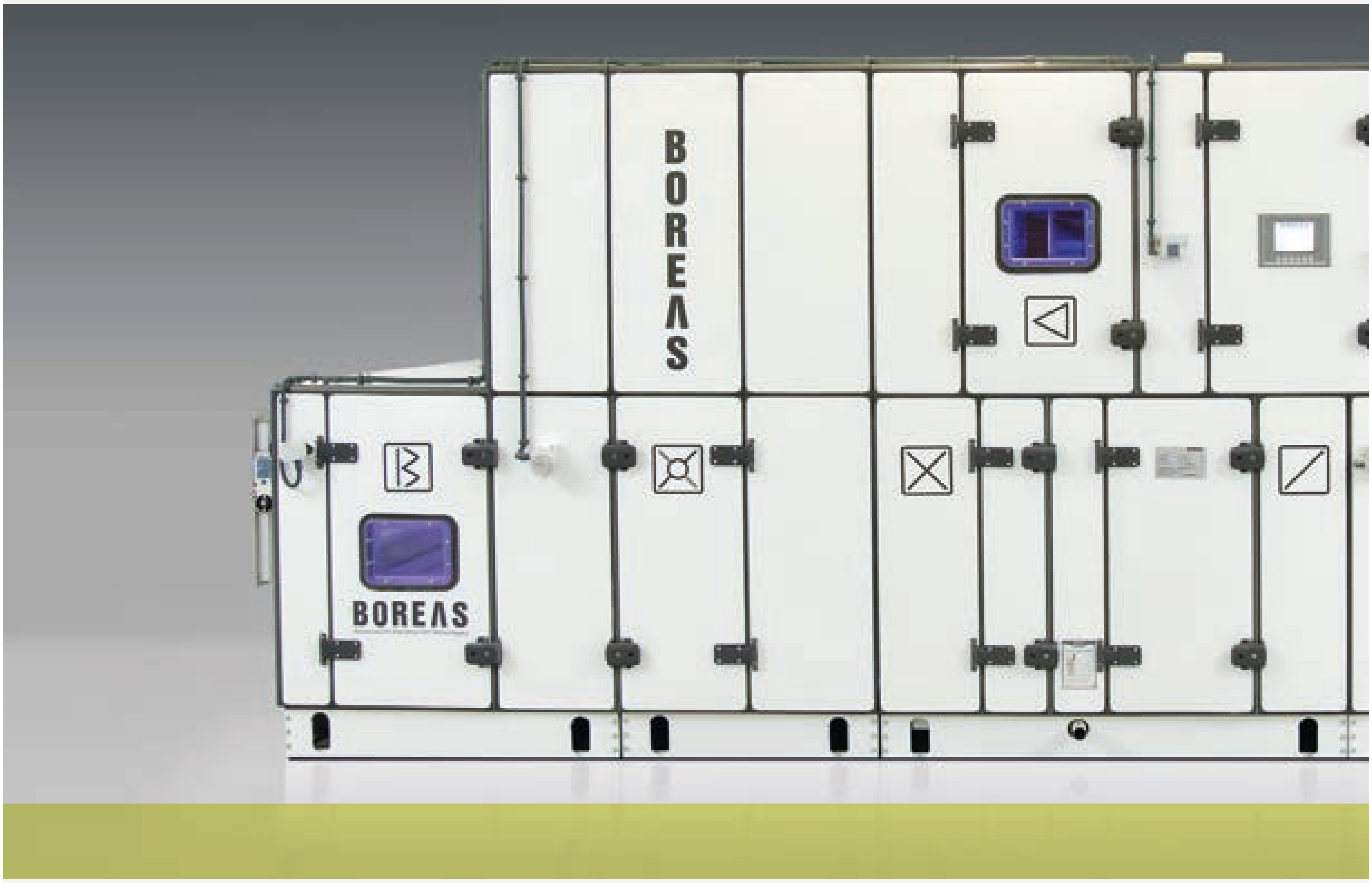
t_i: *Internal Air Temperature*, t_a: *External Air Temperature*, t_{max}: *Max. Temperature of Exterior Surface*

Temperature Measurement Points on the Model Box



Technical Specifications According to EN 1886:2007

Mechanical Strengh (mm x m⁻¹)	D1	D2		D3	
	4	10		>10	
Casing Air Leakage ($l\ x\ s^{-1}\ x\ m^{-2}$)	L1 (f400)	L2 (f400)		L3 (f400)	
	0,15	0,44		1,32	
	L1 (f700)	L2 (f700)		L3 (f700)	
	0,22	0,63		1,90	
Filter Bypass Leakage (%k)	F9	F8	F7	M6	G1-M5
	0,5	1	2	4	6
Thermal Transmittance ($W\ x\ m^{-2}\ x\ K^{-1}$)	T1	T2	T3	T4	T5
	U < 0,5	0,5 < U ≤ 1,0	1,0 < U ≤ 1,4	1,4 < U ≤ 2,0	2,0 < U
Thermal Bridging	TB1	TB2	TB3	TB4	TB5
	$0,75 < k_b < 1,00$	$0,60 \le k_b < 0,75$	$0,45 \le k_b < 0,60$	$0,30 \le k_b < 0,45$	$k_b < 0,3$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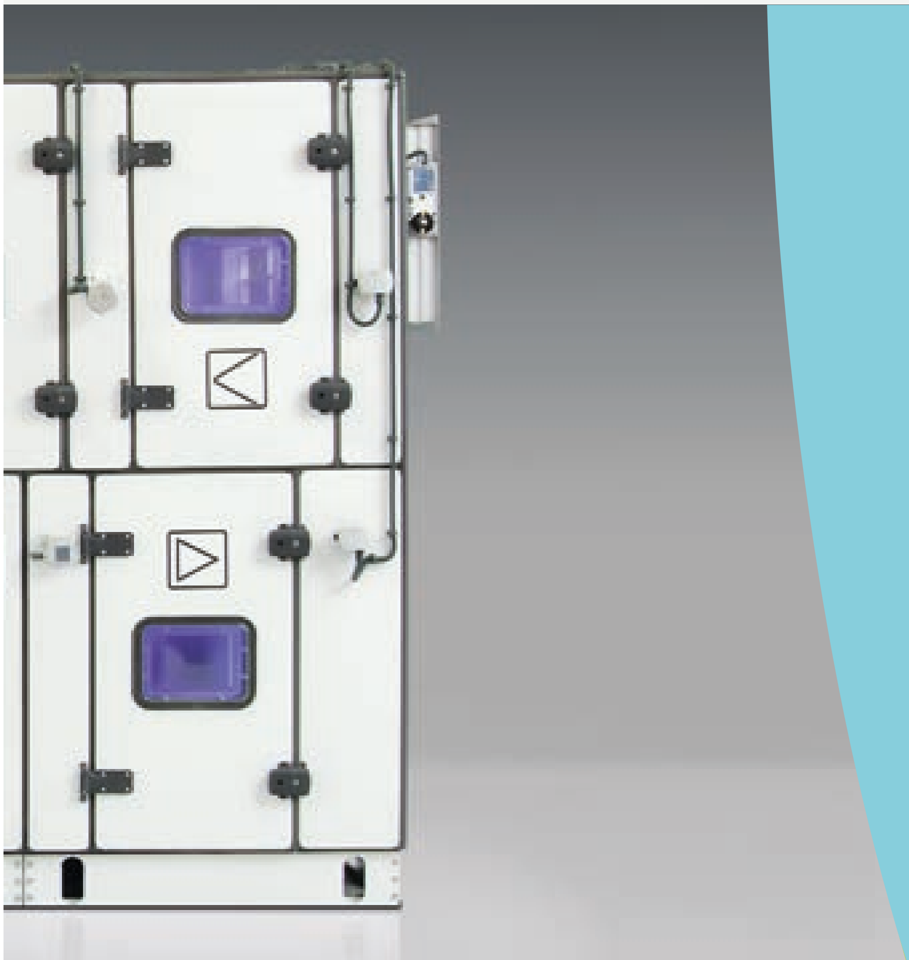
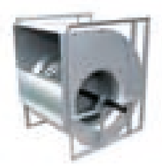
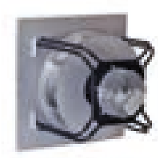


COMPONENTS OF THE BOREAS AHU

Fan Selection

Fans are used in air handling units to ensure the circulation of the sufficient amount of air depending on design conditions. Fans are divided in two groups, centrifugal and axial depending on their area of use. Axial fans that do not have high pressure response due their structure are rarely used in air handling units. Commonly used centrifugal fans with a spiral body are divided in three groups as ‘Forward Inclined Dense Blade, Backward Inclined Rare Blade, and Airfoil Blade’. The uses and operating points of these fans are determined according to the fan’s efficiency. Another frequently used centrifugal fan type are Plug fans that do not have a casing. Plug fans (EC Plug Fans in particular) are widely selected due to their high efficiency, low system losses, and convenient use.

Examples of Centrifugal Fans Commonly Used in Air Handling Units			
Forward Inclined Dense Blade Fan	Backward Inclined Rare Blade Fan	Plug Fan	Plug EC Fan
			
- Low Pressure - High Air Flow - General Purpose Ventilation - Medium Efficiency - Belt and Wheel System	- High Pressure - High Air Flow - Comfort Applications - High Efficiency - Belt and Wheel System / Frequency Inverter	- High Pressure - High Air Flow - Comfort and Hygiene Applications - High Efficiency - Frequency Inverter	- High Pressure - High Air Flow - Comfort and Hygiene Applications - High Efficiency - Automatic RPM Control

Information Required for Fan Selection

The following information is needed for fan selection:

1. Air Flow Rate
2. Unit Internal and External Pressure Values
3. Density of Air Depending on Temperature and Elevation
4. Conditions of the Operating Environment
5. Fan Type, Power Transmission Type (Belt and Wheel, Direct Coupled)

1. Air Flow Rate

Air Flow Rate is the amount of air that will be circulated, determined in accordance with the properties of the environments that will be served by the air handling unit. The volume of the environment and the purpose of use are the most important criteria in determining air flow rate. There are various methods of calculation such as the Air Change Rate Method, the Unit Area Method, the Amount Needed per Person Method, the Air Velocity Method, and the Heat Transfer Method, and the one commonly used is the Air Change Rate Method.

Type of Space	Air Exchange Rate (1/hour)
Living Room	6 - 8
Kitchen	15-30
Public Restroom	10-15
Library	3-5
Operating Room	15-20
Conference Hall	10-15
Laboratory	8-15

For instance what is the ventilation requirement for a library with a height of 3.5 m, width of 12 m, and length of 19 m? The volume of the library: Vl = 3.5 x 12 x 19 m, Vl = 798 m^3, Aer = 5, Q = 5 x 798 = 3,990 m^3/h

2. Unit Internal and External Pressure Values:

Internal unit losses are pressure losses caused by the filter, exchangers, heat recovery units, dampers, the system impact factor, and other equipment used. The External Pressure Loss is the loss of pressure that occurs after the conditioned air leaves the air handling unit and before it reaches the space. Causes of external pressure losses are equipment such as straight ducts, elbows, reductions, duct dampers, duct filters, and grilles. The dimensions and positioning of the air handling unit and installation equipment are highly significant in the generation of these pressure values. The ideal dimension criteria for air handling units and duct systems have been determined in relevant standards. Correct positioning of fans in air handling units and duct systems is very important for achieving design conditions. For example, summary calculation has been provided below of the distance needed for flow lines to become stable at the discharge of fans. The correctness of this distance has a direct influence on the fan efficiency as well as pressure value.

$$\text{If air velocity} > 13\ \text{m/s};\ L_e = \frac{V_0\sqrt{A_0}}{4.500},\ \text{If air velocity} \leq 13\ \text{m/s};\ L_e = \frac{\sqrt{A_0}}{350}$$

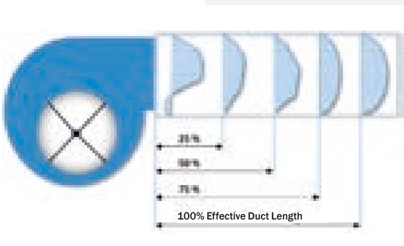
V_0 : *Air Velocity in Duct , m/s*

L_e : *Duct Length, m*

A_0 : *Duct Area, mm*^{2}

Example: Air will be transported at a velocity of 15.2 m/s through a duct system with a height of 0.6 m and width of 1 m, by means of a centrifugal fan. Calculate the length of the straight line that should be allowed after the fan discharge for this scenario.

$$L_e = \frac{15{,}2\ x\ \sqrt{(600\ x\ 1000)}}{4500} = 2{,}62\ \text{m}$$



3. Density of Air Depending on Temperature and Elevation:

The elevation of the unit's position on the earth and the temperature of the air conditioned in the air handling unit, are factors which influence the density of this air. A fan creates a certain volumetric air flow at its selected rpm. However, the mass of the air displaced by a fixed rpm fan depends on the density of the air. Fan selection charts are prepared for normal temperature and pressure conditions (20 °C, 101, 325 kPa) and must be corrected for differing elevation values.

$$\text{Barometric Correction Factor (BCF)} = \frac{\text{Barometric Pressure at Current Elevation}}{\text{Barometric Pressure at Sea Level}}$$

Corrected Unit Internal Pressure Losses $(P_{C\,Unit}) = P_{unit} \times BCF$

Barometric Pressure $(Pa) = 101.325 \times (1 - 2.255802 \times 10^{-5} \times H\ (Height,m))^{5.2561}$

Elevation (m)	Temperature (°C)	Pressure (kPa)
-500	18,2	107,478
0	15,0	101,325
500	11,8	95,461
1000	8,5	89,874
2000	2,0	79,495
3000	-4,5	70,108
4000	-11,0	61,640

As can be seen from the table, air pressure drops with increasing elevation above sea level. The formula for air pressure as a function of elevation is the following:

As elevation rises, the density of air drops. The air density can be calculated with below ideal gas equation.

d = (P-Pw)/(RaxT)
d : Density of air (kg/m^3),
P : Barometric Pressure (kPa)
Pw : Saturation Pressure of Water Vapour at 15 °C 1,7055 kPa,
Ra : Gas Coefficient of Dry Air 0.287055 kj/kgK)
T : Temperature, K

4. Operating Environment:
Selecting fans according to the environments in which they operate is important for system efficiency as well as useful life. For example, an easily cleaned and smooth surface is desired for the unit interior in hygienic air handling units. Therefore rare blade, non-snail fans without belt and wheel systems are preferred. If the fan is to operate at a high temperature environment or to suck the greasy air from a kitchen hood, the greasy and hot air should be removed from the unit without coming into contact with the electrical motor. In these cases, single air intake fans with high temperature resistance is preferred.

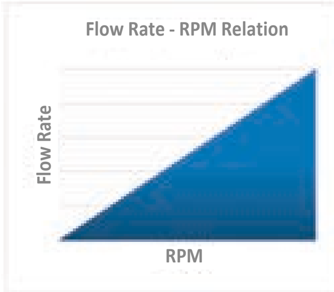
5. Fan Type, Power Transmission System:
Commonly used centrifugal fans used in air handling units can be listed as Forward Inclined Dense Blade Fans, Backward Inclined Rare Blade Fans, Airfoil Blade Fans and Plug fans. Each fan type has aspects that are superior to others and high efficiency operating points. Fans types other than plug fans usually include a belt and wheel system as a power transmission mechanism. Therefore, the losses from these transmission mechanisms lead to extra power consumption. At this point, Plug fans that are direct coupled to the motor shaft take center stage. While this property ensures that a the total efficiency of the fan-motor system is higher than belt-wheel driven systems, they take up less space due to their compact design, and allow fan sections to be designed shorter.
Fan selection should be made by considering the 5 preceding articles. Fan selections that are made by adhering to these points allow the design of a system with a long useful life, that is capable of providing the technical properties desired.

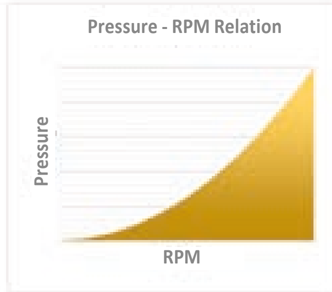
Fan Laws

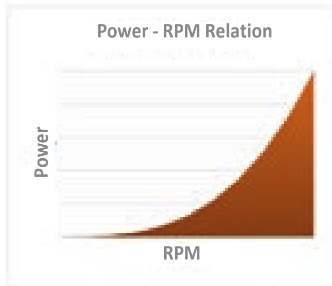
Law Nr.	Dependant Variables				İndependant Variables
1a	Q_1	=	Q_2	X	$(D_1/D_2)^3$, (N_1/N_2)
1b	P_1	=	P_2	X	$(D_1/D_2)^2$, $(N_1/N_2)^2$, p_1/p_2
1c	W_1	=	W_2	X	$(D_1/D_2)^5$, $(N_1/N_2)^3$, p_1/p_2
2a	Q_1	=	Q_2	X	$(D_1/D_2)^2$, $(P_1/P_2)^{1/2}$, $(p_2/p_1)^{1/2}$
2b	N_1	=	N_2	X	(D_2/D_1) , $(P_1/P_2)^{1/2}$, $(p_2/p_1)^{1/2}$
2c	W_1	=	W_2	X	$(D_1/D_2)^2$, $(P_1/P_2)^{3/2}$, $(p_2/p_1)^{1/2}$
3a	N_1	=	N_2	X	$(D_2/D_1)^3$, (Q_1/Q_2)
3b	P_1	=	P_2	X	$(D_2/D_1)^4$, $(Q_1/Q_2)^2$, p_1/p_2
3c	W_1	=	W_2	X	$(D_2/D_1)^4$, $(Q_1/Q_2)^3$, p_1/p_2

D: Fan Diameter, N: rpm, p: Density of Air, Q: Volumetric Air Flow Rate,
P: Total or Static Pressure, W: Power

Example: A space that requires an air flow of 3000 l/h will be ventilated using the Boreas Air Handling Unit. The sum of unit internal and external pressure losses is 500 Pa. A fan requiring a power of 2.9 kW mile at 700 rpm has been selected according to the conditions specified.
The air flow rate required at hours of low occupation will be 2500 l/h. How much difference will a drop of 500 l/h in the fan's flow rate cause in the fan's power requirement?







Law Nr. 1b;

$$Q_1 = Q_2\, x\, (P_1 / P_2)^{1/2} \qquad 3000 = 2500 \text{ x } \sqrt{(500/P_2)} => P_2 = 347\ Pa$$

Law Nr. 2c;

$$W_1 = W_2\, x\, (P_1 / P_2)^{3/2} \qquad 2{,}9 = W_2\, x\, (\frac{347}{500})^{(3/2)} => W_2 = 1{,}68\ kW$$

Specific Fan Power - SFP

Specific Fan Power is a function of the electrical energy drawn by the fan through air flow rate. It is not a fixed value for fans, and varies with variations in flow rate and pressure. It indicates the unit electrical energy per unit of air flow rate.

SFP = Pe/V

Pe = Electrical power input drawn by the fan system or the entire air displacement system (W)
V = Flow Rate (m^3/h)

SFP classification is as follows in the EN 13779 standard.

Class	P_SFP (W÷(m^3÷s))
SFP 1	< 500
SFP 2	500 – 750
SFP 3	750 – 1250
SFP 4	1250 – 2000
SFP 5	2000 – 3000
SFP 6	3000 – 4500
SFP 7	> 4500

ErP (Energy Related Products) Directives for Fans

This directive is obligatory for EU member countries and applies to all integrated device components exported to Europe. It will take effect in Turkey as of September 2015.
The purpose of the ErP (energy related products) directive is to protect the global climate by increasing the efficiency of energy utilization while raising the percentage of renewable energy resources. ErP directives necessitate high efficiency levels for fans. They apply to all fans with a power input of 125 Watt - 500 kW. The total efficiency of the system, comprising the fan, motor, electronic rpm adjuster, and motion transferring equipment is considered in determining the compliance of a fan to this directive.

Description	Code	Efficiency
Super Premium	IE4	
Premium	IE3	-
High	IE2	High
Standard	IE1	Medium
Below Standard	Undefined	Low

Electrical Motors

Equipment which convert electrical energy to mechanical energy. Electrical motors supply the mechanical energy needed by fans for displacing air in air handling units. While power transmission is applied with a belt and wheel system, it can also be applied by direct coupling of the fan. The majority of the electrical energy needed for the air handling unit is consumed by electrical motors. Therefore their efficiency and selection of the appropriate motor is very important with regard to energy consumption. The following table shows the efficiency classification of motors according to EN 60034-30.

Fan motors used in BOREAS Air Handling Units are selected and manufactured to operate in harmony with each other, and to ensure high system efficiency.

Fan Sections

The fan section is the section where the fan and motor system is located. Applications include forward inclined dense blade, backward inclined rare blade, and backward inclined airfoil blade fans, and plug fans depending on points, conditions, and areas of operation. The same casing structure is used in all fan types, but the base systems and vibration insulation equipment used vary. There are three different applications in the Boreas air handling unit, according to fan type and mode of application:

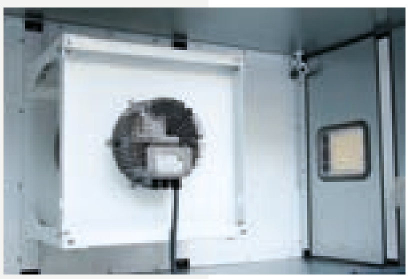
- Centrifugal Fan Section
- Plug Fan Section
- Fan Surface Section

Centrifugal Fan Section

Power transmission from motor to fan is usually achieved with a belt and wheel system. The motor and fan system should be placed on a single base and insulated to prevent the transmission of vibrations that may occur at the motor and fan during operation to section mounts. Rubber chocks are used as standard vibration insulation material. A spring version is also offered as an option. Flexible connections should be used between the fan and casing panel to prevent transmission of the vibration at the fan discharge to the casing. The motor fan base system comprises the belt tension apparatus, motor base, fan base, and fixed base. After assembly within the air handling unit has been completed, each fan motor complex is subjected to a Run Test, checking for:

- Deflection,
- Mechanical friction,
- Belt and wheel connection,
- Belt tension,
- Flexible connection of air discharge,
- Electrical cable connections
- Fan motor complex fittings,
- Vibration attenuator,
- Unit internal intake and discharge distance.

Sufficient clearances required in the directions of intake and discharge are left while positioning centrifugal fans within the section. Wheel dimensions are determined by considering the force limits that can be born by fan shaft bearings. In this way, maximum useful life of shaft bearing is ensured.



BELT AND WHEEL SYSTEM

The system used for transmitting the energy of motion generated by the motor to the fan. Its correct design is very important due to energy losses.

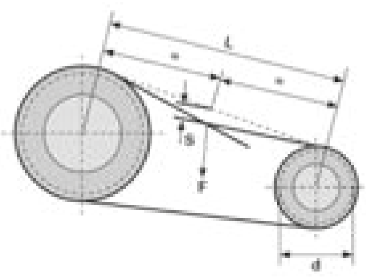
Care should be taken with the following issues with respect to design:
- The fan wheel dimensions should be determined by considering the wheel diameter which corresponds to the maximum and minimum force values that can be born by the fan shaft.
- The fan wheel dimensions should be determined by considering the wheel diameter which corresponds to the maximum and minimum force values that can be born by the motor shaft.
- A wheel of a larger diameter than the radius of the fan intake should not be selected, otherwise the intake area will become narrower, leading to unforeseen resistances and negatively influence the fan's flow rate performance. The properties of the wheel and belt selected should be in conformance.
- Fan and motor wheel grooves must be aligned. This is very important for proper transmission of this motion as well as the useful life of belts.

Wheel Calculation:
Fan rpm x Fan Wheel Diameter = Motor rpm x Motor Wheel Diameter

The belt and wheel loss from fan shaft power to motor power is assumed to be within 10-20%.

Type V grooved wheels and belts are used as standard equipment in BOREAS Air Handling Units. The belt and wheel system used in SPA, SPB, and SPC specifications are manufactured considering the previously stated control points and calculations. Since they are moving systems, it is beneficial for wheel and belt settings to be checked at regular intervals.

Belt Tension Control



Profile	Effective Diameter of Smaller Wheel (mm)	Flexion force F (kg)
SPZ	67 – 95 100 - 140	10 – 15 15 - 20
SPA	100 – 132 140 – 200	20 – 27 28 - 35
SPB	160 – 224 236 – 315	35 – 50 50 - 65
SPC	224 – 355 275 – 560	60 – 90 90 - 120

F (N) : Flexion Force
L (m) : Axis Opening
S (mm) = L(m)x16 Belt Flexion

VIBRATION ISOLATION SYSTEM

In the centrifugal fan section, the Fan Motor Complex is fixed to the section floor with a stationary base, while the fan is connected to the panel as a moving joint with a flexible connector. Anti-vibration mounts are used between the fan base and stationary base. In this way, the vibrations created by the fan motor complex are absorbed by the mount, and transferred to the casing at minimum levels. Transmission of fan vibrations to the casing panel is prevented with the flexible connector used at the fan's discharge end.

Information that must be known while selecting vibration attenuating elements:
- Mass of the fan motor complex
- Approximate centre of mass of the fan motor complex
- Number and position of anti-vibration mounts
- Rpm of fan
- Frequency of the drive force creating the vibration

The method of calculation that should be applied while selecting the insulating element:

- The load received by each insulating element is calculated
- The frequency of the drive creating the vibration is determined
- Transmittance is calculated (T.R. = 1 - (V/100))
- The core frequency of the system is calculated considering the attenuation factor of the insulating material used in vibration insulation.
- The static deflection of vibration insulators is calculated
- The spring coefficient is calculated
- After static deflection and spring coefficient have been calculated, an insulating element is chosen which meets these specifications. In this selection, attention should be paid to the desired load capacity and the desired static deflection or spring coefficient.

A backward inclined rare blade centrifugal fan with a motor power of 4 kW is used in the BOREAS Air Handling Unit. The total mass of the fan motor complex is 252 kg, and the fan rpm is 1460 revolutions per minute. The use of 6 insulating elements with negligible attenuation is considered. Let us select the proper insulating material for this fan motor complex.

1. Determining the loads received by the insulating element:
Wi = mg/6 = (((252) x (9,8)))/6 = 411,6 N
Wi : The load received by each insulating element (N)
m : Mass of the fan motor complex (kg)
g : Gravitational acceleration (m/s2)

2. Calculating the drive frequency:
f = (1450 rpm) / (60 opm) = 24.3 Hz
f : Drive Frequency (Hz)

3. Calculating the power transmittance:
V is taken to be 90% for a motor power of 4 kW since the air handling unit floor is a light steel structure.
T.R = 1 - (V/100) = 1 – 0.9 = 0.1
V : Insulation Efficiency
T.R : Power Transmittance

4. The system's core frequency is calculated
$fn = f/(\sqrt{((1/(T.R))+1)}) = 24,3/(\sqrt{11}) = 7.3$ Hz
fn : Core Frequency of System (Hz)
f : Drive Frequency (Hz)
T.R : Power Transmittance

5. An insulating element with a load capacity of 533.8 N is chosen, which is used in BOREAS Air Handling Units.

6. Determining static deflection:

$$\delta_{st} = \frac{g}{4\pi^2(f_n^2)} = \frac{9800\ mm/s^2}{4\pi^2(7,3)^2} = 4,66\ mm$$

δst : System deflection (mm)
fn : Core Frequency of System (Hz)

7. Calculating the spring coefficient:

$$k = \frac{W_i}{\delta_{st}} = \frac{411{,}6\ N}{4{,}66\ mm} = 87{,}62\ N/mm$$

k : Spring coefficient
Wi : The load received by each insulating element (N)
δst : System deflection (mm)

8. Calculating the actual insulation efficiency occurring in the selected insulating element:

$$\delta_{st}^{-} = \delta_{st}\left(\frac{Load}{Spring\ load\ capacity}\right) = 4{,}66\left(\frac{411{,}2}{533{,}8}\right) = 3{,}56\ mm$$

δst : The amount of actual deflection of the insulating element (mm)
δst : System deflection (mm)

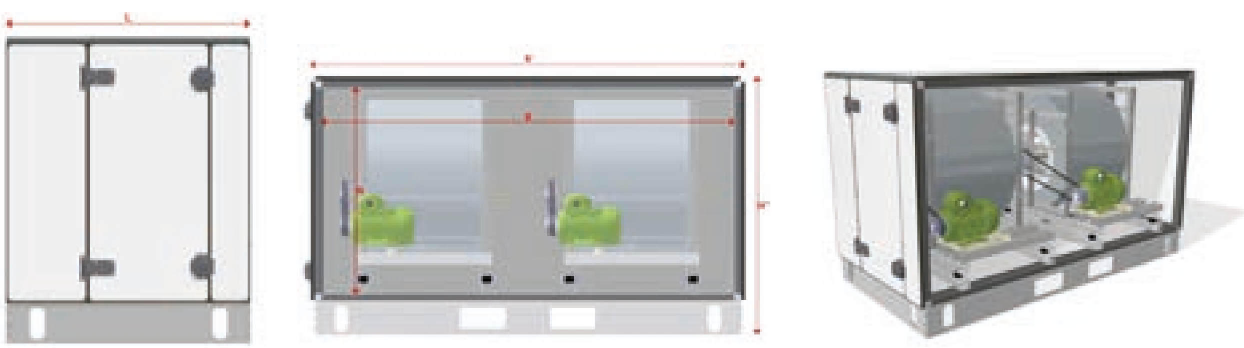
Insulation efficiency is calculated from the chart to be V = 0.87 for 3.56 mm. Therefore, we could say that the drive forces will be transmitted to the floor after being reduced by 87% using the selected insulating element.

Tablo 1.
Values recommended for insulation efficiency (1)

Power of the Machine Drive Motor (kW)	Recommended Percentage of Insulation (%)		
	Basement or Ground Floor	Heavy Reinforced Concrete Upper Storeys	Light Steel Upper Storeys
≤ 4	-	504	90
4-10	50	75	93
10-30	80	90	95
30-70	90	95	97,5
75-225	95	97	98,5

Tablo 5.
Technical specifications of insulating elements in SI Units

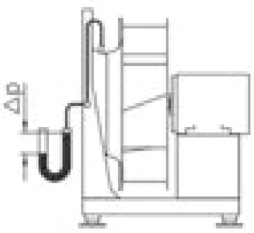
Load capacity at a deflection of 6.35 mm (1/4") (N)	Spring coefficient (N/mm)	MODEL
533.8	84.1	1
689.5	108.6	2
822.9	129.6	3
978.6	154.1	4
1112.1	175.1	5
1245.5	196.1	6
1378.9	217.2	7



CENTRIFUGAL FAN SECTION DIMENSION TABLE

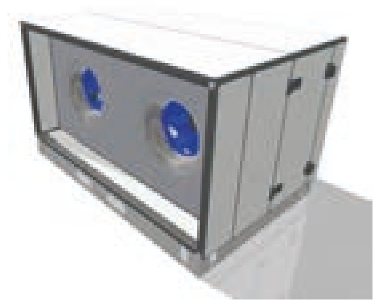
Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	774	774	876	876	978	1080	1182	1080	1284	1386	1386	1488	1386	1488	1488	1590	1692	1692	1488	1590	1692	1692	1896	1896	2100	1692	1896	1896	2100	2100	2202	2202	2304	1896	2100	2100	2202	2304	2202	2304

Plug Fan Section



$$q_{v}=K\times\sqrt{(\frac{2}{\rho}\times\Delta P_{DÜ})}$$

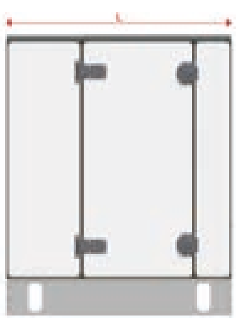
Power transmission from motor to fan is different than it is in centrifugal fans. The motor shaft is directly coupled to the fan. In this way, power losses in the range of 10-20% which occur in belt and wheel systems are eliminated. Since the fan is directly coupled with the motor, frequency inverters are used as standard equipment for rpm control. Since plug fans do not have pressurization volumes as do centrifugal fans, they operate by creating positive pressure in the fan section. Therefore, the dimensions of fan sections are important.

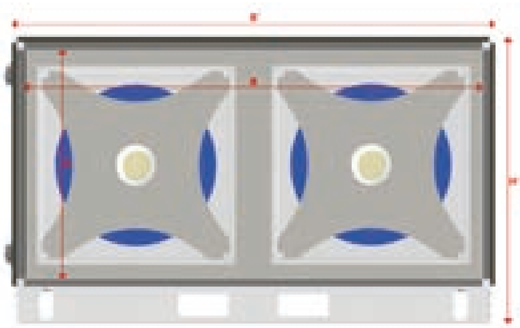


The use of plug fans is common in applications requiring precise flow rate control and in hygiene applications. Plug fans can be easily cleaned since there is no cabin housing the fan blades, and since they have rare blades.

Flow rate control can be made with a frequency inverter from pressure variation, using probe leads offered as standard equipment in plug fan funnels.

Plug fans take up less space than centrifugal fans, by virtue of their design. Thus, the dimensions of fan chambers are smaller. The base system of the fan motor complex comprises the motor base and stationary base. There is no belt tensing apparatus since there is no belt and wheel system. Rubber based anti-vibration mounts used in centrifugal fans are used for vibration insulation. Flexible connectors are used between the fan intake and the casing panel. In Plug fans, the use of EC Plug fans manufactured with EC rather than AC fans is becoming more widespread.





PLUG FAN SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	672	774	774	774	856	978	1080	978	1080	1080	1284	1182	1080	1284	1284	1386	1488	1488	1284	1386

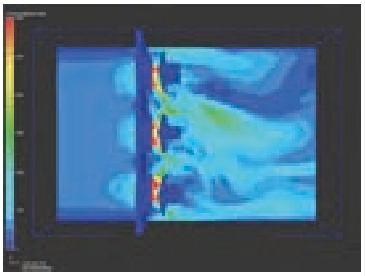
Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	1488	1488	1488	1386	1692	1488	1488	1692	1692	1692	1692	1794	1794	1692	1692	1794	1590	1794	1794	1998

They are notable for their compact structure, efficiency and convenience of operation. The plug fan system consists of the motor, fan funnel, and frequency inverter. In EC plug fans, all of this equipment is housed within a single casing. Thanks to this feature, it can be fitted into a smaller volume as compared to centrifugal fans.
Assembly in accordance with information provided by the manufacturer in placing the plug fans within the fan section is important for achieving the calculated flow rate and pressure performance values.

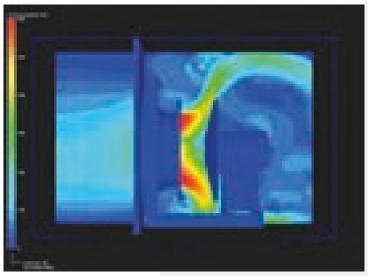
Fan Series

In air handling units, it is important for the air passing within the sections to disperse homogeneously over the air cross section, in terms of the efficiency of heating-cooling exchangers, heat recovery systems, filters, humidification systems, and air handling unit air side unit internal pressure losses. This point should be considered with particular care in determining the dimension of the air handling unit cross section and in selecting fans. Fan series comprising four, six, eight, nine, and twelve fans can be applied in BOREAS Air Handling Units, depending on the cross section of air flow. The passage of an equal amount of air at every point of the cross section can be achieved by installing the fans in the cross section of air flow with symmetric measurements, and maximum efficiency can be gleaned from all equipment in this way.
In this application, selection is made by keeping total pressure constant and dividing the total air flow rate by the number of fans that will be used. Fans can be grouped among themselves, and all fans can be controlled all at once or separately. Since fans with smaller diameters than in single fan applications can be selected, the length of the fan section is reduced, and the air handling unit takes up less space.

Fan Series Application

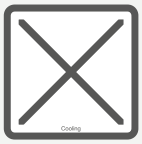


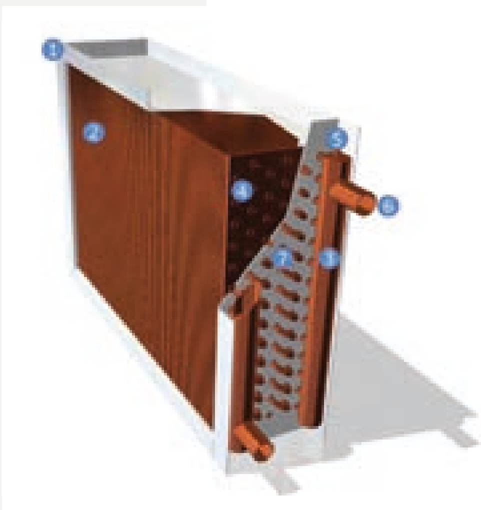
Single Plug Fan Application



In the CFD study shown above, we can see a comparison between the flow distributions of a Fan Series application with 12 fans and a single fan application. While flow homogenizes some distance from the fan discharge in the single fan application, the flow becomes immediately homogeneous at fan discharges in the Fan Series application. The case is similar in the intake sections.

Coil Sections





These are heat exchangers used in air handling units, to carry out heating, cooling, and mechanical dehumidification processes. Water systems and refrigerant systems are used in air handling unit applications.

Water Coils

In water systems, the hot water needed for conditioning is supplied from the boiler, and the cold water from the chiller. The conditioned water prepared in the boiler is transferred to water heating and heating coils within the air handling unit, by means of the pump and necessary piping. The water heating coil heats air by transferring its energy to cold water passed over it while the water cooling coil cools the air by removing the energy of the hot air passing over it.

GENERAL STRUCTURES OF WATER COILS

1. Casing can be manufactured from galvanized steel, painted steel, Magnelis® stainless material depending on the application. Sheet metal thickness varies between 1.2 to 2.5 mm depending on coil size. There are bends in both height and width to increase rigidity of casing and to facilitate assembly.

2. Fin Surface: The sum of fin surfaces constitutes the heat transfer surface of the coil. Fins can be manufactured from aluminum or copper. Pitch is the distance between consecutive fins. The recommended pitch in air handling unit coils is 2.1 to 3.2 mm. As pitch decreases, the total heat transfer area increases, but the air side pressure loss rises.
Smaller pitches will also cause dirt to easily accumulate on cross section of air flow, and render cleaning difficult. This causes a drop in efficiency in addition to being improper for hygienic conditions. Therefore the pitch should be between 2.1 and 3.2 mm.

Fin surfaces can be treated with various surface coatings depending on the purpose of use.
a) Hydrophilic Coating: Wet surfaces occur due to condensation of the moisture in the air passing over cooling coils. In order to prevent accumulation of water droplets on the surface, the friction coefficient between the droplets and the surface should be decreased. Hydrophilic coating, by virtue of low surface tension, enables water droplets to flow off the surface without facing a lot of resistance.

b) Epoxy coating is a method of coating applied for increasing corrosion resistance of heat transfer areas of coils. It is used in air handling unit applications operated in highly corrosive environments.

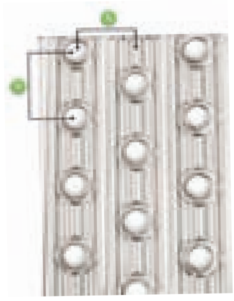
c) Heresite Phenolic Coating is a type of coating which provides high corrosive resistance. It is suited for environments with climates of high acidity and salinity.

d) Blygold Coating is a polyurethane based type of coating which provides high corrosive resistance. It provides resistance to chemicals without damaging heat transfer performance.

3. The Collector is the main element within the coil in which the pipes that circulate water, and the circuits connecting them, where water intake and discharge from the coil takes place. Its diameter is usually determined depending on exchanger capacity and the number of circuits. In water coils, it is manufactured as a standard for painted steel material, and optionally from copper material for higher corrosive resistance. Copper collector is standard in hygiene applications.

4. Exchanger Geometry: The diameters of pipes that allow the circulation of fluid within the exchanger and their placement in the exchanger cross section vary. Therefore, different exchanger geometries exist. The most commonly used in air handling units is the 32 x 28 ½ geometry. The number of coil pipes and the heat transfer area will change as coil geometry changes with the same number of rows and the same height. All thermal capacity values will change accordingly.

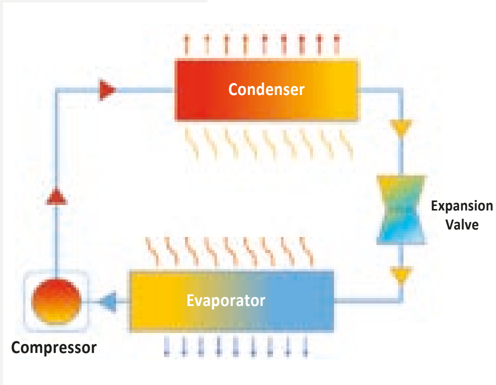
Geometry	A Measurement	B Measurement	Pipe Diameter
32x28 - 1/2	27,5 mm	31,75 mm	1/2
38x33 - 5/8	33 mm	38,1 mm	5/8
25x22 - 3/8	21,65 mm	25 mm	3/8



5. Purger is used for purging the air which accumulates within the coil. It can be operated manually or automatically.

6. Collector Connecting Pipe is the connecting point used for connecting the coil to the water works. It is manufactured with external thread as standard. It can also be manufactured with ready flanges as an option.

7. Number of Rows and Number of Circuits: The number of rows indicates the number of rows of pipes constituting the coil on the direction of air flow. The number of circuits is the required number of intakes and discharges needed for the coolant to circulate within the coil at a specific pressure drop and flow range, depending on the total number of pipes.



Gas Coils

In gas systems, the energy needed for cooling and heating is supplied by the refrigerant pulling heat from the air by evaporating, and by expelling heat to the air by condensation. The general system elements are the evaporator, condenser, compressor, and the expansion valve. The evaporator and expansion valve is positioned in the air handling unit and connected to the outdoor VRF unit housing the condenser and compressor. In cooling mode, the refrigerant draws heat from the air passing over it to evaporate within the evaporator. Thus, the air is cooled.

In heating mode, the evaporator operates as a condenser by means of a four way valve, transferring the energy of the refrigerant to the air passing over it.

While the refrigerant is determined in accordance with technical specifications, R410A is commonlu used. Overall casing structures of gas coils and sections comprising them are similar except for the distributor. There is a distributor which connects to circuits with capillary pipes at the DX exchanger intake, and a copper collector at its discharge.

Coil Sections

The dimensions of the heat exchanger are determined to ensure lowest air velocity while making maximum use of the cross section of air flow. Other parameters determining heat performance are calculated for each coil depending on operating conditions. Only water, only gas, or both water and gas heating cooling heat exchangers can be applied in coil sections.

- Water Heater + Water Cooler (Conventional Heating, Cooling System)
- Water Heater + Gas Cooler (VRF Connected Heating, Cooling System)
- Gas Cooler and Heater (VRF Connected Cooling and Heat Pump Heating System)

AMOUNT OF CONDENSATION AND DRAINAGE SYSTEM

If surface temperature values in cooling coils are lower than the dew point of air, the water vapor contained within the air passing over the exchanger will condense into the liquid phase. This condensed water must be collected from the exchanger surface and removed from the unit as soon as possibe. Otherwise, wet spaces will form within the unit and cause growth of micro organisms. This leads to a very undesirable deterioration in hygiene conditions. The amount of condensate water is calculated as in the following example.

Example: In a system with a mass flow rate of 10700 kg/h, air with a temperature of 30°C and relative humidity of 65% is cooled down to 13°C and 100% relative humidity at the evaporator output. Calculate the amount of condensate which forms in this case.

$$q = max\,(W_1 - W_2)$$

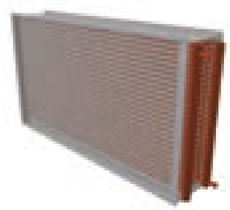
q : *The amount of condensate water (kg/h)*

ma : *Mass flow rate (kg/m^3)*

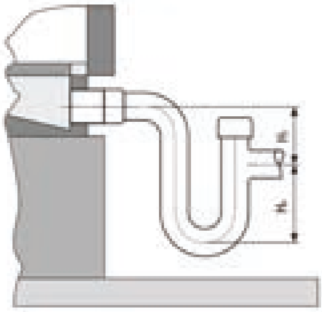
W_1 : *Specific humidity in the beginning (kg/kg)*

W_2 : *Specific humidity in the end (kg/kg)*

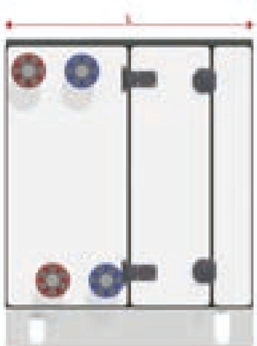
Specific humidity according to 30 °C and 65%, 0.01741 kg/kg
Specific humidity according to 13 °C and 100%, 0.00933 kg/kg
q = 10700 x (0.01741 – 0.00933) = 86.45 kg/h

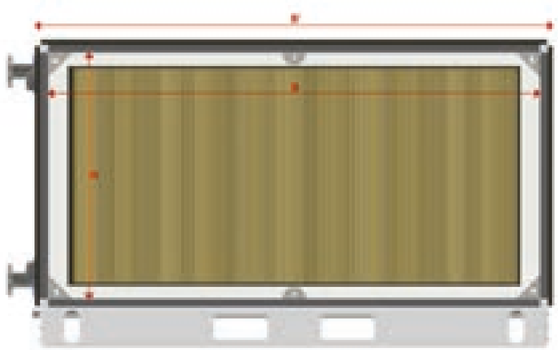


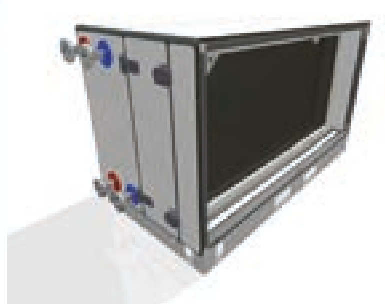
Drain pans are manufactured from 1.2 mm stainless steel sheet as a standard. The pan's double inclined design allows the water to accumulate in the corner. The water there is drained with a drainage pipe and collective trap system. The rounded design of the edge connecting to the drainage pipe allows water to be drained 100% from the pan, keeping the pan dry at all times.
Insulation and exterior steel covering has been applied under condensation pans preventing thermal bridging as well as any condensation that may occur beneath the pan. Drop eliminators manufactured of Polypropylene material are used to prevent water droplets that condense on the exchanger surface from drifting with air to other sections.
Another important piece of equipment in the drainage system is the trap. The purpose of this system is to eliminate the effects of the pressure difference between the section housing the pan and the drainage line, facilitating the drainage of water. It is also to prevent odours that may form in the sewage installation from reaching the air handling unit interior. For this reason, the calculation and selection of the drainage system is very important. An error in application will cause flooding within the air handling unit.



Positive Pressure Application	Negative Pressure Application
$H_s = P/10 + 50\ mm$	$H_1 = P/10 + 20\ mm$
$H_1(mm) = 35\ mm$	$H_s(mm) = P\ x\ 0{,}075\ mm$







COIL SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	366	366	366	366	366	366	366	366	366	366	366	366	366	366	468	468	468	468	468	366

Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	366	366	366	366	366	366	366	468	366	468	468	468	468	366	468	468	468	468	468	468

Heat Recovery Systems

Air Handling Units are devices which can operate with high percentages of fresh air. As they supply conditioned fresh air into the areas they serve, they remove air that is in the environment, which meets the conditions for temperature but is of poor air quality to the outside. We can define heat recovery in brief as the process where the energy held by this expelled air is transferred to fresh air. However, it is essential that the fresh air does not mix with the dirty air removed from the space during this energy transferral. With this method, fresh air of high quality and at the desired conditions can be supplied to the conditioned environment with lower operational costs. For example, as compared to an air handling unit with no heat recovery applied, an air handling unit equipped with heat recovery at suitable design conditions has

- Need for a lower capacity chiller and boiler
- Need for a lower capacity pump
- Need for a smaller exchanger at the air handling unit.

Thus, operational costs and lifetime cost of an air handling unit equipped with heat recovery according to these properties will be much less than otherwise.

Sample Application;

Data	Winter Condition	Summer Condition
Volumetric Flow Rate	10000 m^3/h	10000 m^3/h
Indoor Environment Conditions	20°C	26°C KT, 28°C YT
Outdoor Environment Conditions	3°C	39°C KT, 28°C YT
Density of Air	1.2 kg/m^3	1.2 kg/m^3
Specific Heat of Air	1.004 kj/kg-K	-
Specific Humidity of Outdoor Air	-	0,0194 kg/kg
Enthalpy of Outdoor Air	-	109.2 kj/kg-K
HRU Sensible Heat Efficiency	65,00%	
Air Handling Unit Output Condition	40°C	15°C KT, 14.5°C YT

Calculation of Heat Gain:

$Q = m_{air} \; x \; C_p \; x \; (T_{th,c} - T_{th,g})$ *(the case where there is no condensation and humidity transfer)*

$Q = m_{air} \; x \; C_p \; x \; (h_{th,c} - h_{th,g})$ *(the case where there is condensation)*

$\eta = \dfrac{T_{th,c} - T_{th,g}}{T_{eg,g} - T_{th,g}}$ *(equal efficiency)*

$T_{th,c} = 3 + 0{,}65 \; x \; (20 - 3) = 14{,}05 \; °C$

$Q = 1{,}2 \; x \; \dfrac{10000}{3600} \; x \; 1{,}004 \; x \; (14{,}05 - 3) = 36{,}98 \; kW$ *(heat gain)*

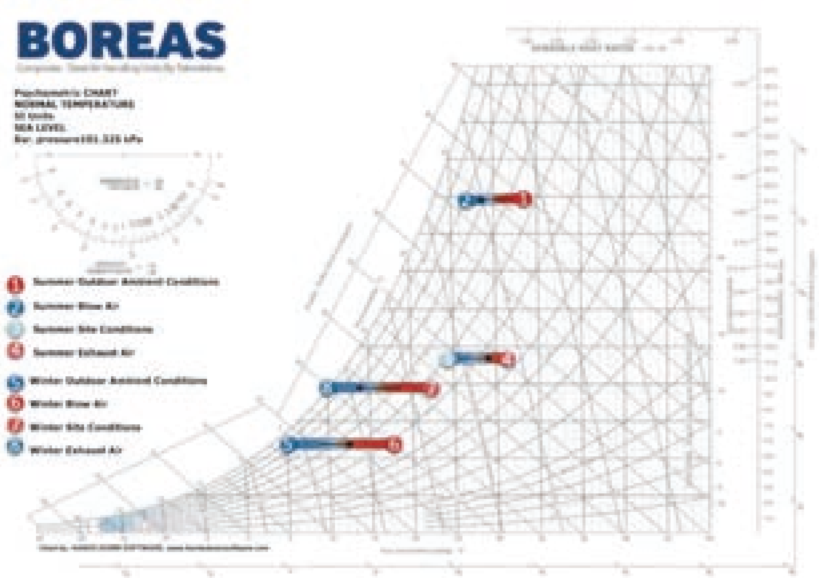
HRU Output Temperature $= 39 + 0{,}65 \; x \; (26 - 39) = 30{,}55 \; °C$

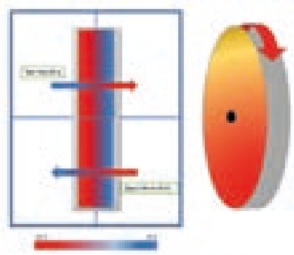
$Q = 1{,}2 \; x \; \dfrac{10000}{3600} \; x \; (109{,}2 - 102{,}4) = 22{,}6 \; kW$ *(cooling gain)*

Rotary Heat Recovery

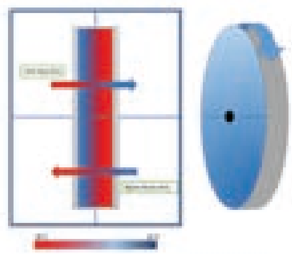
This type of heat recovery exchanger, also known as a heat wheel carry the humidity and heat over rotating fillings. The fillings are manufactured by wrapping thinly waved aluminum strips into a disk. It effects

heat transfer between the hot and cold water currents passing over its surface that is split into two equal parts, by rotating at 10-20 revolutions per minute. The transfer of both sensible and latent heat is possible with heat wheels, depending on the properties of the filling used. With these properties, their efficiency ranges between 70-85%. Rotary heat exchanger is a system which is widely preferred due to its efficiency values as well as the small space it occupies within the air handling unit.
The rotation of the motor is performed by a motor and belt apparatus. The motor has two operating options, which are fixed and variable speed. Due to the perforated nature of the drum, in this type of heat recovery, the probability of exhaust air seeping into fresh air is a possibility, although small.

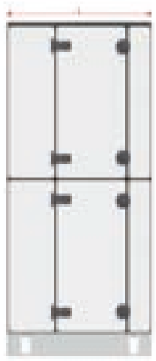


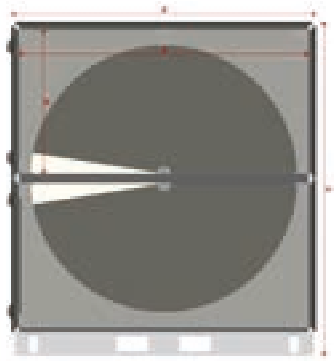


Rotary Heat Recovery Winter Application Temperature Variation
Fresh Air Intake Exhaust Air Intake

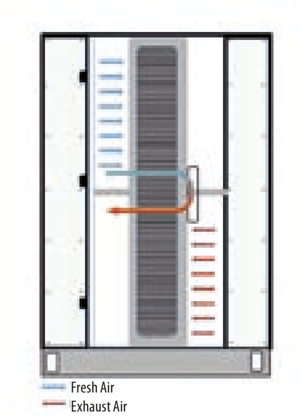


Rotary Heat Recovery Summer Application Temperature Variation
Fresh Air Intake Exhaust Air Intake





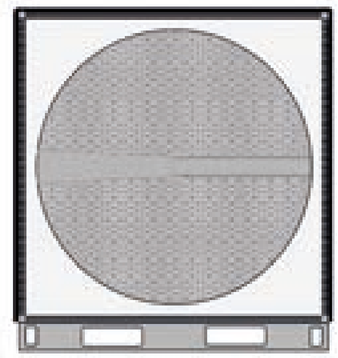
ROTARY HEAT RECOVERY SECTION DIMENSION TABLE																																								
Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	1514	1514	1514	2126	2126	2126	2126	2738	2738	2738	2738	2738	3350	3350	3350	3350	3350	3350	3962	3962	3962	3962	3962	3962	3962	4574	4574	4574	4574	4574	4574	4574	4574	5186	5186	5186	5186	5186	5186	5186
L	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610	610



CLEANING THE EXHAUST AIR ON THE FRESH AIR LINE

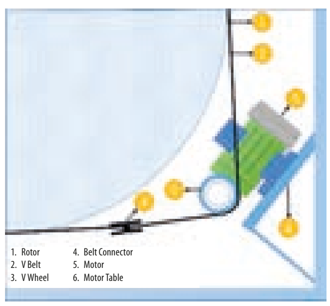
The heat wheel carries a certain amount of exhaust air among the pores of its filling to the fresh air line, causing it to mix with fresh air. But this can be prevented with the sweeping chamber. The sweeping chamber sweeps the exhaust air trapped within the fin pores with the aid of a certain amount of fresh air pressure differential, causing it to mix once again with the exhaust air.
For the fresh air to be able to sweep the exhaust air, a higher pressure must be created at the fresh air side than the exhaust side. If this pressure difference is

- Between 0-200 Pa, a sweeping unit is not needed
- Between 200-500 Pa, the sweeping unit is applied as 2 x 5°
- Between 500-800 Pa, the sweeping unit is applied as 2 x 2.5°



DRIVE UNIT

The motion of rotation of the heat wheel is carried out by a belt and wheel system which transmits the rotation of the motor to the drum. The motion can be controlled with a fixed rpm or variable rpm. The drum rotates at 15 rpm in standard operation.



FAN PLACEMENT

1- The Use of a Sweeping Unit is Appropriate
- In positive pressurization in Fresh Air Fan,
- In negative pressurization in Exhaust Fan ,

2- The Use of a Sweeping Unit is Appropriate (Pt > Pe)
- In positive pressurization in Fresh Air Fan,
- In negative pressurization in Exhaust Fan ,

3- The Use of a Sweeping Unit is Appropriate (Pt > Pe)
- In negative pressurization in both fans

4- The Use of a Sweeping Unit is Not Appropriate
- In negative pressurization in Fresh Air Fan,
- In positive pressurization in Exhaust Fan

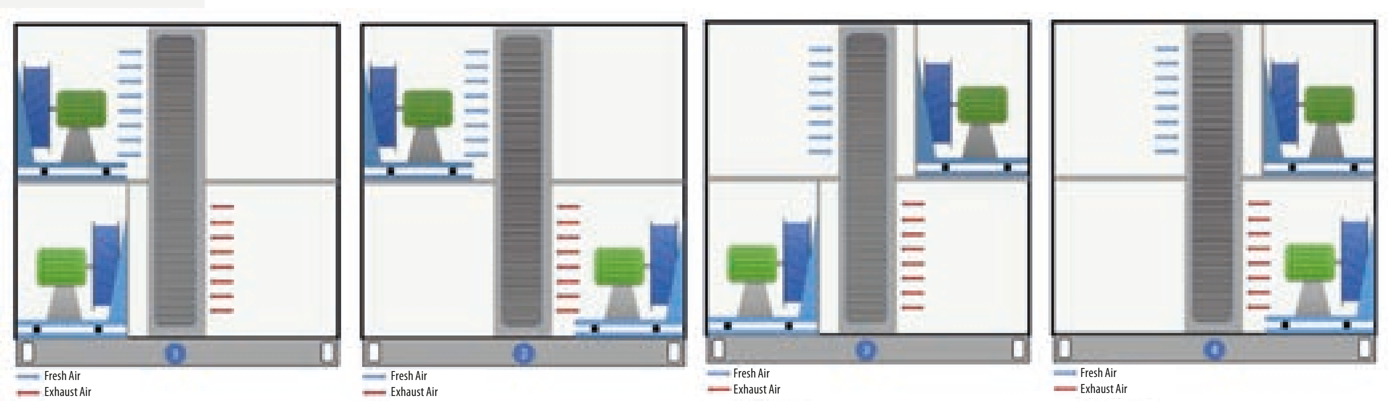


Plate Type Heat Recovery

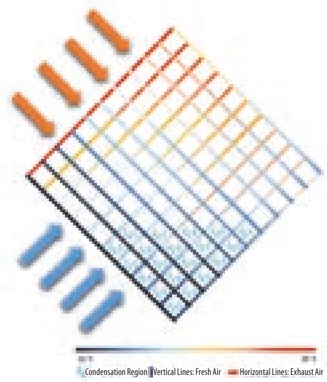
The heat from the exhaust side is recovered by passing the exhaust air between two lines formed by plates of high thermal efficiency, which are in contact with each other to prevent mixing between fresh air and exhaust air. Although plates are usually manufactured from aluminum material, plastic or cellulose based products are also used. The unit can have counter flow or cross flow. Efficiency values of up to 65% and 90% can be achieved in counter flow and cross flow units respectively. This type of heat recovery is widely preferred due to its convenience of use and operation.

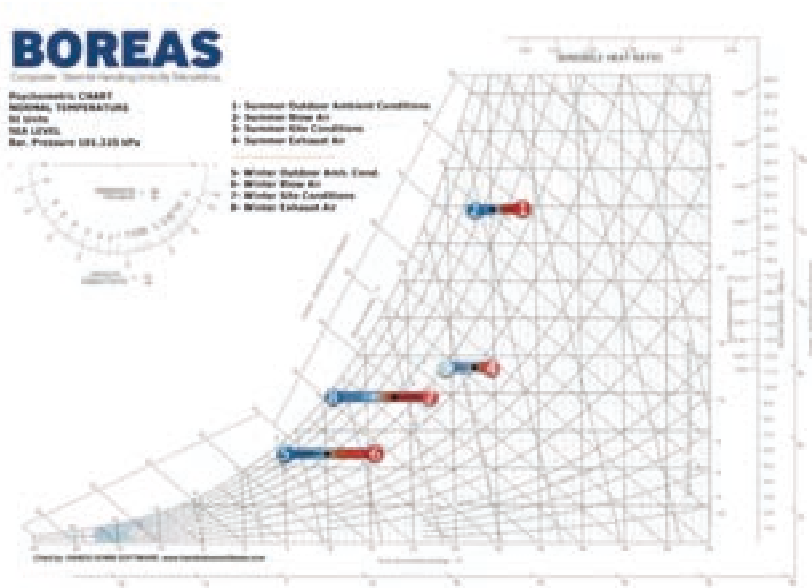
Winter Application Fresh Air Line Temperature Variation:
As fresh air that has a lower temperature passes over the aluminum surface whose temperature has been raised by the warmer exhaust air it acquires heat and increases in temperature.

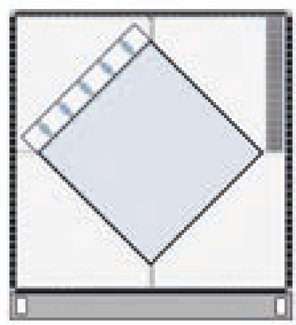
Winter Application Exhaust Air Line Temperature Variation:
As exhaust air that has a higher temperature passes over the aluminum surface whose temperature has been reduced by the cooler fresh air it losses heat and reduces in temperature.

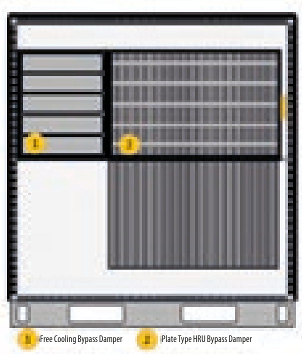
Summer Application Fresh Air Line Temperature Variation:
As fresh air that has a higher temperature passes over the aluminum surface whose temperature has been reduced by the cooler exhaust air it losses heat and reduces in temperature.

Summer Application Exhaust Air Line Temperature Variation:
As exhaust air that has a lower temperature passes over the aluminum surface whose temperature has been raised by the warmer fresh air it acquires heat and increases in temperature.





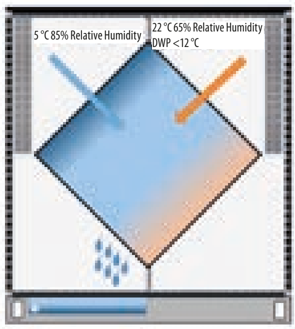




FREE COOLING IN PLATE TYPE HEAT RECOVERY

At certain times during the transitional seasons of spring and autumn, 100% fresh air can be used, cooling the indoor space without operating any cooling apparatus. This operation is called Free Cooling. In order to glean high efficiency from the Free Cooling application, heat transfer must occur between the return air and fresh air. Therefore, Bypass Dampers are used in Plate Type Heat Recovery systems.

During Free Cooling, the Bypass damper placed on the fresh air line assumes the open position while the Bypass damper placed on the plate type heat recovery intake assumes the closed position. Thus the fresh air does not pass through the plate type heat recovery unit, and no heat transfer occurs between it and the return air.



CONDENSATION CONTROL IN PLATE TYPE HEAT RECOVERY

When the water vapour in the air reaches saturation temperature it condenses and assumes the liquid phase. If temperature in one of the chambers within the plate type heat recovery unit is at dew point temperature or below, condensation will occur. Therefore a drain pan system is applied at plate type heat recovery output sections that have a risk of condensation depending on operating conditions.

FREEZE CONTROL IN PLATE TYPE HEAT RECOVERY

At low outdoor ambient conditions, there is a risk that the condensate droplets which form in the heat recovery system may freeze and clog aluminum plate gaps. In this case, air passage gaps will be occluded, negatively affecting heat recovery efficiency. One of the following solutions must be applied to prevent this.

- The cold fresh air is warmed in a pre-heater until the freeze risk is eliminated.
- The flow rate of fresh air is occasionally reduced, increasing the efficacy of return air, and melting the frost.
- Fresh air passage at the coldest corner is checked with a valve, not permitting freezing.

The fact that the quality of air conditioning will suffer during these measures should not be overlooked. As a solution, temperature of air blown into the space can be kept under controlled by means of an electrical or water heater.

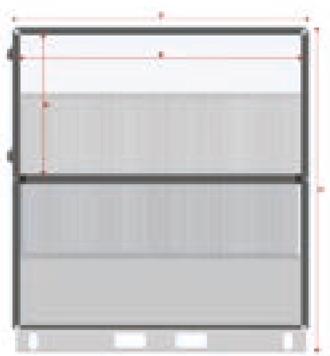


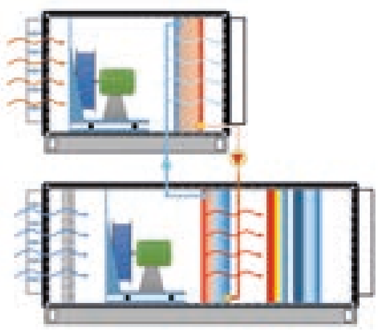
PLATE TYPE HEAT RECOVERY SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	916	916	916	1284	1284	1284	1284	1590	1488	1488	1692	1692	1692	1692	1692	1692	1692	1692	1998	1998

Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	1998	1998	1998	1998	1998	2916	2916	3120	2916	2916	2916	2916	2916	3732	3732	3732	3732	3732	3732	3732

Run Around Tip Isı Geri Kazanım

This type of heat recovery functions with a closed circuit water cycle operated with the aid of a pump by water type heat exchangers on a fresh air and exhaust air line. The circulating water acquires the heat from the warm air side and carries it to the cold air side, providing heat recovery. This type is widely used particularly in applications where the exhaust and fresh air lines must be positioned apart from each other.



FREE COOLING IN RUN AROUND TYPE HEAT RECOVERY

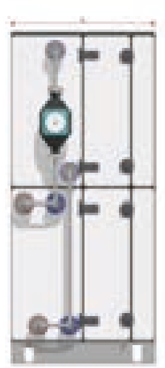
When conditions have been met for the Free Cooling application, the pump must be disabled and the water circulation stopped.

FREEZE CONTROL IN RUN AROUND TYPE HEAT RECOVERY

Run Around heat recovery units can reach high efficiencies in low temperature winter applications. Heat transfer occurs from air to water, and then from water to air. Since water is used for energy transfer, it is a system with a high freeze risk. Therefore an antifreeze similar to ethylene glycol must be added to the circulating water in low ambient temperature applications. Since antifreeze will reduce system efficiency, it is critical to correctly determine the amount used.

CONDENSATION CONTROL IN RUN AROUND TYPE HEAT RECOVERY

Since condensation risk will occur on the fresh air line and the exhaust line depending on summer and winter operating conditions, a stainless steel double inclined drain pan is used below both heat exchangers. Pans are also insulated underneath as standard equipment.



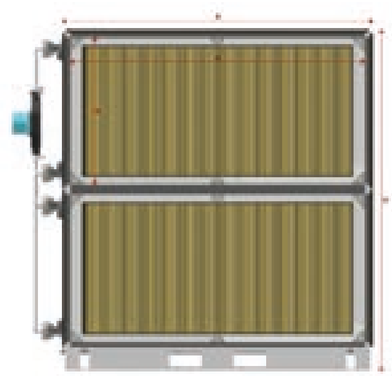
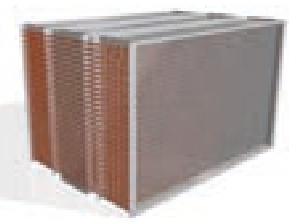


PLATE TYPE HEAT RECOVERY SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	916	916	916	1284	1284	1284	1284	1590	1488	1488	1692	1692	1692	1692	1692	1692	1692	1692	1998	1998

Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	1998	1998	1998	1998	1998	2916	2916	3120	2916	2916	2916	2916	2916	3732	3732	3732	3732	3732	3732	3732

Heat Pipe Heat Recovery



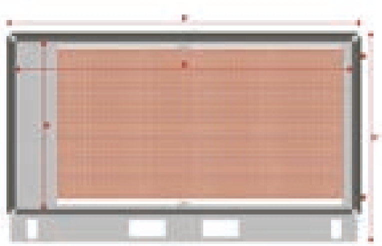
Heat Pipe heat exchangers operate on the principle whereby the refrigerant used within heat exchangers draws heat from the high temperature air and evaporates and relinquishes heat to the low temperature heat and condenses.

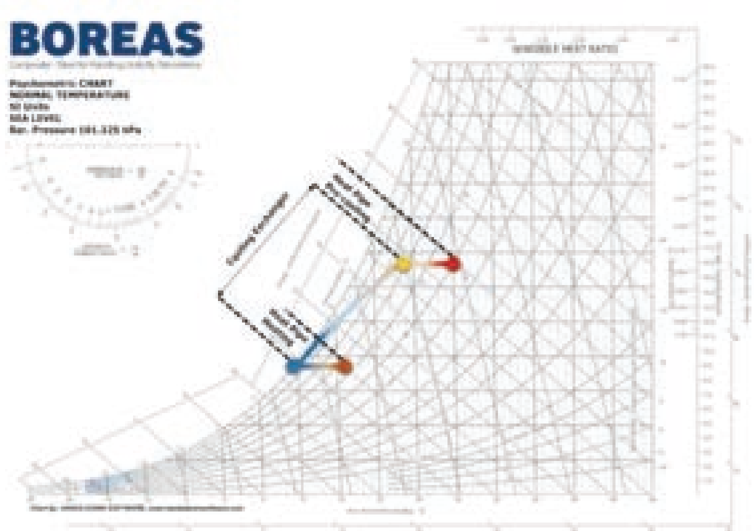
HEAT PIPE HEAT RECOVERY WINTER-SUMMER APPLICATION

In the winter application, heat transfer occurs from the exhaust air that has a higher temperature than the outdoor are to the R134A refrigerant within the Heat Pipe heat exchanger. The evaporating refrigerant rises due to the tilt of the pipes, moving toward the fresh air side. It transfers its heat to the low temperature fresh air, as the fresh air passes over the heat exchanger. The cooling refrigerant condenses back into liquid phase and moves toward the exhaust air side by the effect of gravity, due to the tilt of pipes. The cycle continues thus as long as there is a temperature difference between the fresh air and exhaust air. The Heat Pipe's operating principle requires that its pipes be placed fully vertical or at an angle due to the type of application. Therefore, it can not function except during the season for which it is chosen to operate. In other words, if it has been selected for summer operation, it cannot function during the winter and vice versa.

HEAT PIPE HEAT RECOVERY DEHUMIDIFICATION - HUMIDIFICATION APPLICATION

Heat Pipe heat recovery systems are also widely used in dehumidification and drying processes. They are manufactured as two separate heat exchangers interconnected with a copper pipeline. The cooling exchanger (gas or water) is positioned between the two heat exchangers. The first heat exchanger of the Heat Pipe carries out pre-heating while its last heat



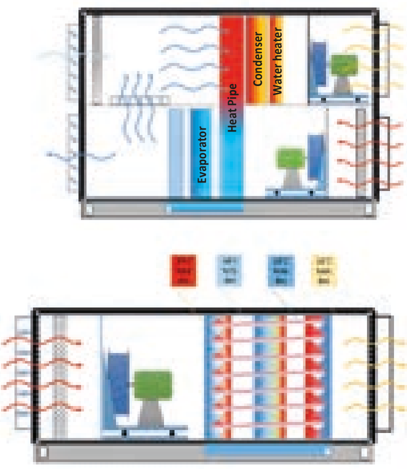


HEAT PIPE ISI GERİ KAZANIM HÜCRESİ BOYUT TABLOSU

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	656	656	656	656	656	656	656	656	656	656	656	656	656	656	758	758	758	758	758	656

Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	656	656	656	656	656	656	656	758	656	758	758	758	758	656	758	758	758	758	758	758

exchanger carries out after cooling. In this way, the total cooling load imposed on the cooling exchanger that performs the actual dehumidification process is reduced while the heating load required for the drying process that will be needed after dehumidification will be eliminated. With a similar logic, this method that is widely used in comfort air handling units is also used in packaged poolside dehumidification air handling units which carry out dehumidification for indoor swimming pools.

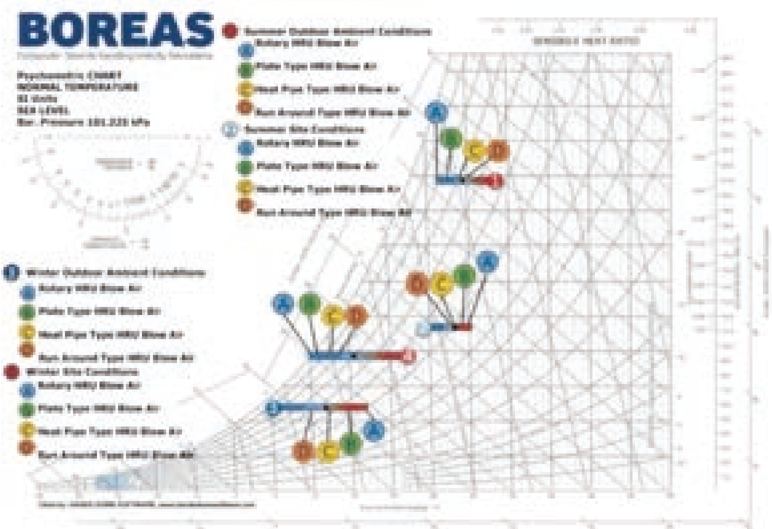


HEAT PIPE DX AIR HANDLING UNIT APPLICATION

Keeping evaporator inlet temperatures of direct expansion air handling units within operating limits ar high outdoor temperatures is very important for unit efficiency. To this end, heat pipe application is made for pre cooling before the evaporator. In this way high performance can be achieved from the direct expansion air handling unit even in high outdoor temperature conditions.

Comparison of Heat Recovery Systems

Heat recovery systems applied in air handling units have superior and weaker aspects as compared to one another. These properties have been summarised in the table below. Four heat recovery methods have been computed for the same conditions, and the side diagram shows a comparison of air output values of heat recovery systems according to summer and winter operating conditions.



A- Rotary Heat Recovery

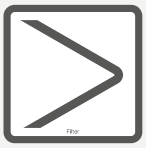
B- Plate Type Heat Recovery

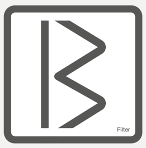
C- Heat Pipe Heat Recovery

D- Run Around Type Heat Recovery

Properties	Rotary Heat Recovery	Plate Type Heat Recovery	Heat Pipe Heat Recovery	Run Around Type Heat Recovery
Depending On Air Flow	Counter Flow Parallel Flow	Counter Flow Cross Flow Parallel Flow	Counter Flow Parallel Flow	Counter Flow Parallel Flow
Mode of Heat Transfer	Sensible (50 - 80%) Total (55 - 85°%)	Sensible (50 - 80%) Total (55 - 85%)	Sensible (45 - 65%)	Sensible (55 - 65%)
Surface Velocity (m/s)	2,5 - 5	0,5 - 5	2 - 4	1,5 - 3
Air Side Pressure Drop (Pa)	60 - 250	5 - 450	100 - 500	100 - 500
Operating Temperature Range (°C)	- 55 / 95	- 60 / 800	- 40 / 35	- 45 / 500
Various Features	Humidity Transfer Capability Compact Section Measurements Low Pressure Loss	Contains No Moving Parts Low Pressure Losses Easy to Clean	Contains No Moving Parts The Location of Fan is not Important	Exhaust Line can be Separated The Location of Fan is not Important
Limitations	Requires Frequent Maintenance at Cold Climate Conditions	Latent Heat Transfer Possible with Custom Manufactured Product	Limited Supplier	The Right Simulation Model Needed for High Efficiency
Air Leakage	1 - 10%	0 - 5%	0%	0%
Control	Heat Wheel Speed Control Unit	Bypass Damper	By Changing the Angle of Inclination of Position	Bypass Valve or Pump Speed Control

Filter Systems

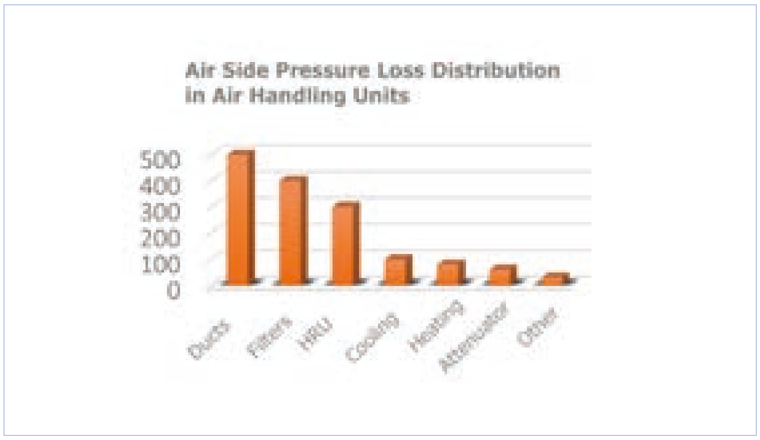




During the air movements within the air handling units, particles of a visible or microscopic scale are also carried. The nature of the particles differ according to the internal and external atmosphere. They come in a wide range of sizes from a grain of sand to bacteria or chemical molecules. Filtration of particles within a certain size range as required by the conditions of the work operating environment is of critical importance for human health as well as process requirements and the efficiency and useful life of the equipment within the air handling unit. In air handling units G3-G4 filters are generally used for pre-filtration and M5-M6-F7-F8-F9 Bag Filters are used for fine filtration. In addition to these, Active Carbon Filters are used, as well as Metallic Filters for oil filtration.

Influence of Filters on Energy Consumption

Total static pressure is one of the main factors determining the total electrical power needed by a fan motor group in an air handling unit. This pressure is caused by ducts, filters, heat recovery units, cooling coil, heating coil, attenuators, and other equipment within the air handling unit. Filters take up a significant portion of this pressure. While initial pressures are low, the pressure losses they cause grow with the rising dirt level. Therefore filters should be changed at filter replacement pressure values recommended by the En13053 standard. Otherwise as the level of dirt increases, total static pressure will rise, which will lead to higher power consumption.

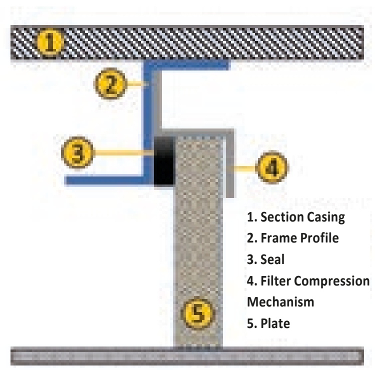


Filter Class	Manufacturer's Pressure Data		Recommended Final Pressure Value (EN13053)
	Initial	Final	
G1-G4	60 Pa	250 Pa	150 Pa
F5-F7	100 Pa	450 Pa	250 Pa
F8-F9	120 Pa	450 Pa	350 Pa

Filter Classification			
EN 779:2012	Medium Efficiency	Initial Filter	G2 ≥65%
			G3 ≥80%
			G4 ≥90%
	High Efficiency	Pre-Filtration	M5 ≥40%
			M6 ≥60%
		Fine Filtration	F7 ≥80%
			F8 ≥90%
			F9 ≥95%

Filter Frame Leakage Class According to En 1886

According to EN 1886, the filter frame leakage level used in the air handling unit is classified as G1_M5-M6-F7-F8-F9. If a lower class filter frame system is used than the filter class, the filter will not be able to meet the specifications of its class. This test is carried out in two stages. In the first stage total leakage is measured, while in the second stage leakage from the casing is measured. The leakage is calculated in the following way according to the measurements taken, and the filter frame class is determined.



$$q_{Lt} = q_L + q_{Lf}$$

$$k = \frac{q_{Lt}}{\text{Flow rate}}$$

q_{Lt} : Total Air Leakage

q_L : Air Leakage from Frame

q_{Lf} : Air Leakage Between the Filter Frame and Casing

Example:

For a filter section comprising 4 full filters:

Section Surface Area: 1.49 m^2

Surface Velocity: 2.5 m/s

Air Flow Rate: 3.725 m^3/s (4 x 0.93 m^3/s (for a velocity of 2.5 m/s))

q_{Lt} : $27{,}5\ x\ 10{-}3\ m^3/s$

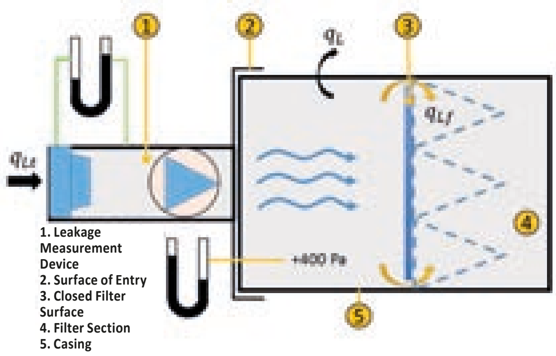
q_L : $14{,}5\ x\ 10{-}3\ m^3/s$

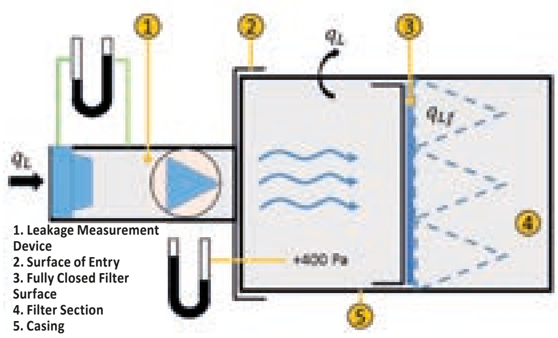
q_{Lf} : $13\ x\ 10{-}3\ m^3/s$

k : 35 % (Class F9.)

The filter frame used in the BOREAS Air Handling Unit is class F9, the highest class according to the EN 1886 standard.

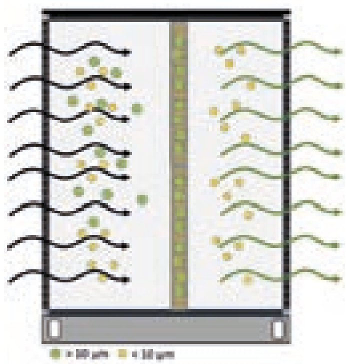
Filter Class	G1-M5	M6	F7	F8	F9
Maximum Filter Leakage Percentage %k	6	4	2	1	0,5

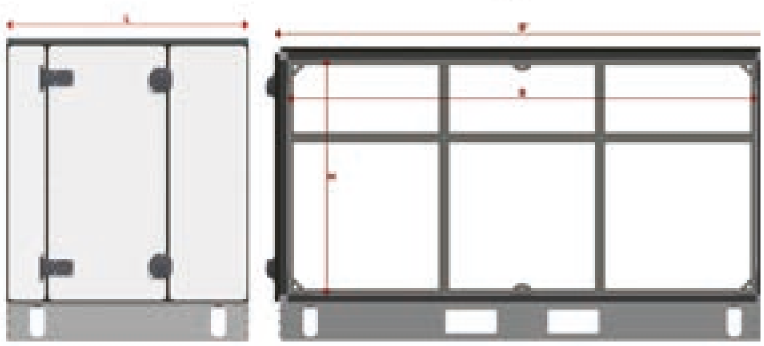




Panel Filter Section

Class G3-G4 filters according to EN 779, used for pre-filtration in the air handling unit. They are placed in the first section where air enters in the air handling unit. While polyester fibre is most commonly used as filter material, polypropylene, polyurethane, and metal are also used. Filter frames can be manufactured of galvanized steel, stainless steel, PVC, or fibreglass material. Thanks to its zigzagged structure, it has higher surface area. Gross filters are suited for filtration of particles larger than 10 µm. They are sent already mounted on the unit as a standard. The reason for this is to prevent the dust etc. particles that exist within the ductwork to enter the air handling unit during commissioning. Therefore it should be installed during initial startup.



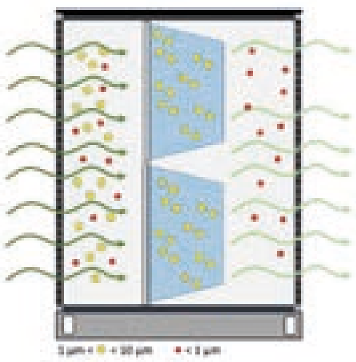


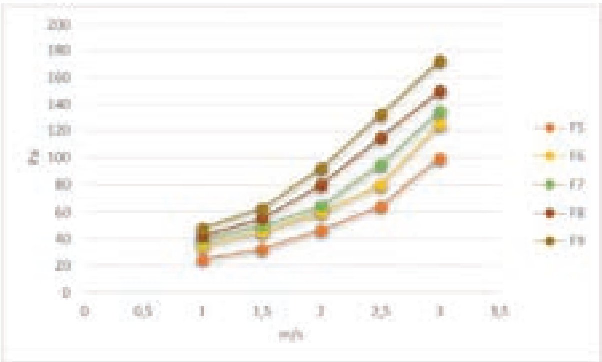
PANEL FİLTER SECTION DIMENSION TABLE

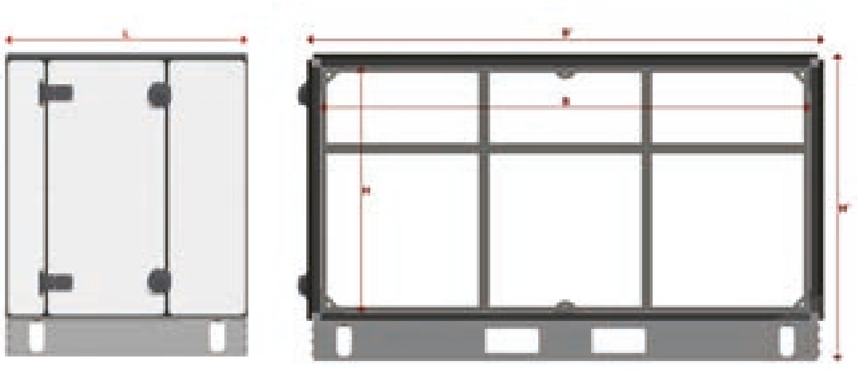
Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264

Bag Filter Section

Class M5-M6-F7-F8-F9 filters according to EN 779, used for fine filtration in the air handling unit. They are placed after the pre-filter and before the heat exchangers in the air handling unit. Synthetic fibre is used as filter material. Filter frames can be manufactured of galvanized steel, stainless steel, PVC, or fibreglass material. It has 300 and 600 mm pocket size alternatives. Full filter, half filter, and quarter filter applications are also made as cross section measurements. Bag filters are suited for filtration of particles between 10 μm and 1 μm. They are sent on the unit, unmounted as a standard. They are installed after the air handling unit has been commissioned and the pre-filters have been replaced.







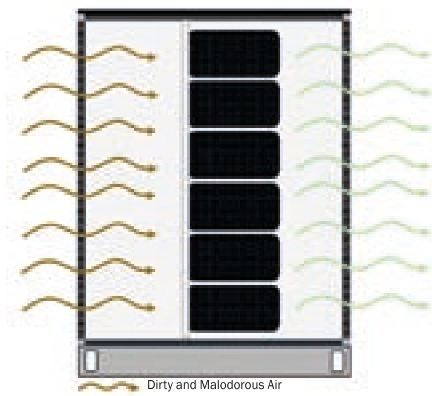
BAG FİLTER SECTION DIMENSION TABLE																																								
Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774	774

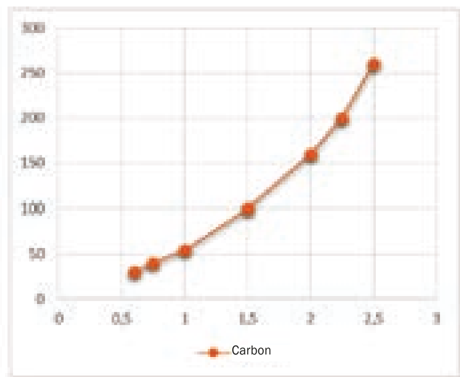
Active Carbon Filter Section

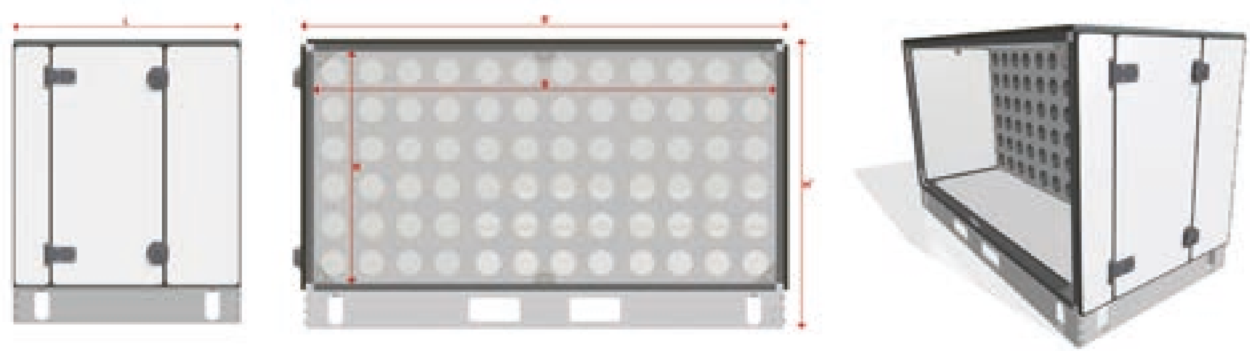
Odour and gas particles within the air (0.01 microns and smaller) can not be filtered with standard filters due to their extremely small sizes.

Carbon filters are used for filtering air which contains odours and harmful gaseous particles. There are also applications as cylindrical cartridges and panel filters.

Cylindrical cartridges are widely used in air handling units. Cylinder diameters vary between 140 to 160 mm while lengths vary between 400 to 600 mm. Each cartridge can be replaced independently of the others.







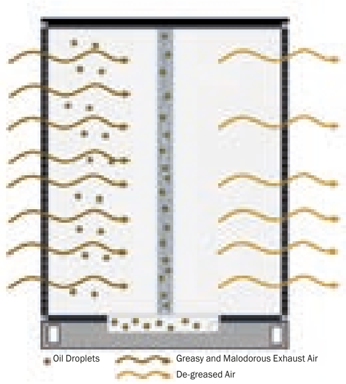
CARBON FILTER SECTION DIMENSION TABLE

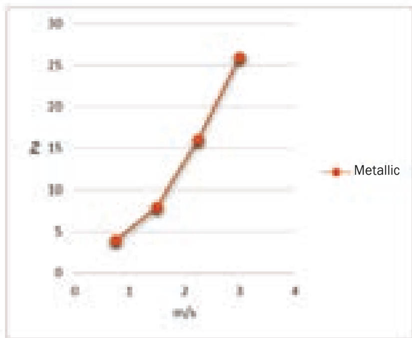
Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400

Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400

Metallic Filter Section

It is used in filtering air which contains particles of oil. Kitchen hood applications are common. Oil droplets that are suspended in air adhere to the filter's metallic surface, and are removed from the air. These oil droplets which accumulate on the surface are washed away with standard cleaning agents, collected in the drain pan that is offered as standard equipment, and drained using proper methods. Filter material is manufactured of aluminum or stainless wire. Section measurements are the same as in the panel filter section.





Multistage Filter Application in Air Handling Units

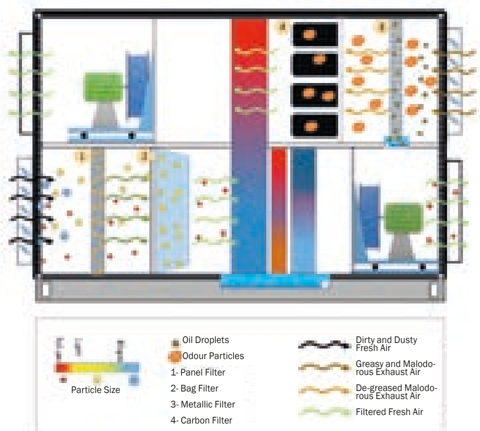
Single filter application is not recommended in air handling units since it will not be beneficial for the quality of filtration or be cost effective. The use of filters in the following order is recommended for the fresh air line and exhaust line.

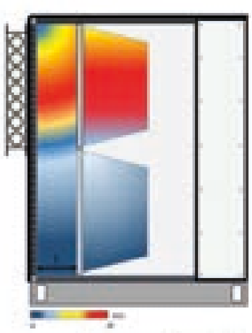
On the fresh air line:

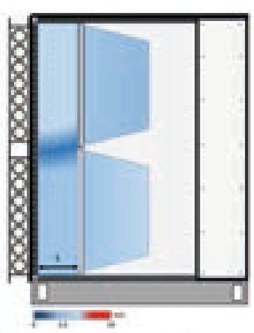
- Metallic Filter (if the fresh air contains oil particles)
- Pre-Filter (Panel)
- Bag Filter
- Carbon Filter (if the air contains odours and harmful gases)
- HEPA Filter (should be applied at minimum distance to space and at the duct exit)

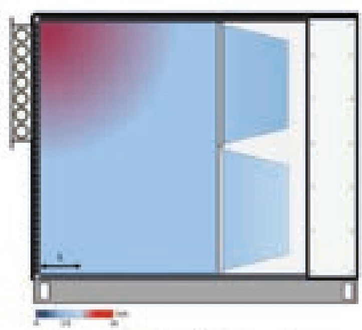
On the exhaust air line:

- Metallic Filter (if the fresh air contains oil particles)
- Pre-Filter (Panel)
- Carbon Filter (if the air contains odours and harmful gases)
- L Distance is insufficient
- The use of Full Face Damper
- Application with sufficient L Distance




L Distance is insufficient

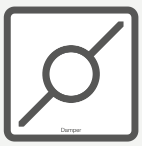

The use of Full Face Damper


Application with sufficient L Distance

For filters to fully filter the air passing over them, the air must pass over the filter surface in the velocity range of 2-3 m/s, homogeneously distributed over the entire filter surface. If there is a difference in measurement between the filter surface area and the cross section of air flow, for the air to distribute homogeneously over the filter surface:

- A sufficient L distance should be left between the cross section of air flow and the filter surface.
- Another method is to use a full face damper equalizing the cross section of air flow to the filter surface area.

Mixing Sections



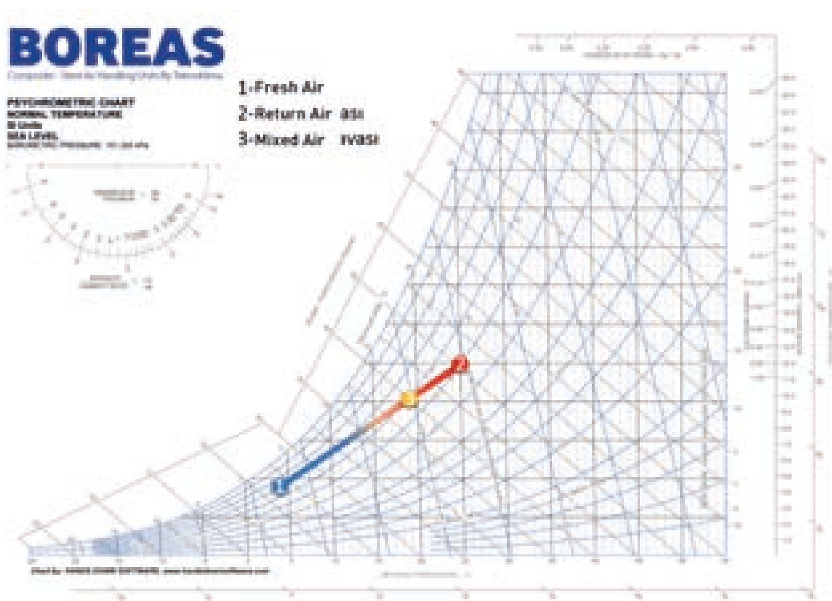
In the mixing section, a certain amount of fresh air is mixed into the return air, fulfilling the fresh air requirement of the conditioned environment. The factor determining the mixing ratio is quality of return air. If return air quality is poor (if it contains odours, dust, low levels of oxygen etc.) the use of heat recovery systems is recommended instead of mixing in comfort and hygiene applications. Mixing ratios are adjusted with the aid of dampers. Dampers are adjusted manually or with the aid of a proportional damper motor. Example:
Fresh air at 4°C dry bulb and 2°C wet bulb temperature and with a flow rate of 2 m^3/s is mixed adiabatically with return air at 25°C dry bulb and 50% relative humidity. Let us find the dry and wet bulb temperatures of the mixed air.

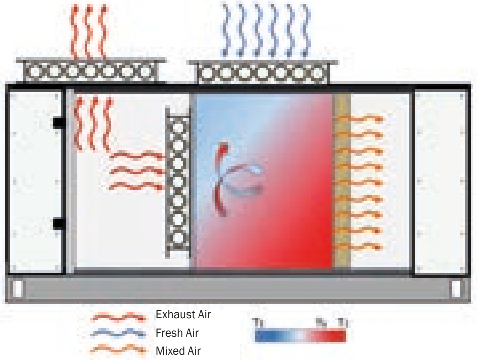
$$v_1 = 0{,}789\ m^3/h$$

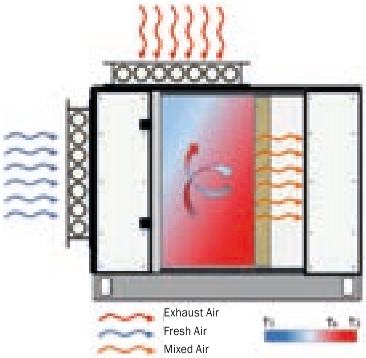
$$v_2 = 0{,}858\ m^3/h$$

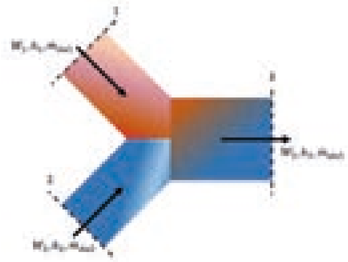
$$m_{da1} = \frac{2}{0{,}789} = 2{,}535\,\frac{kg}{s} \quad \textit{(dry air)}$$

$$m_{da2} = \frac{6{,}25}{0{,}858} = 7{,}284\,\frac{kg}{s} \quad \textit{(dry air)}$$



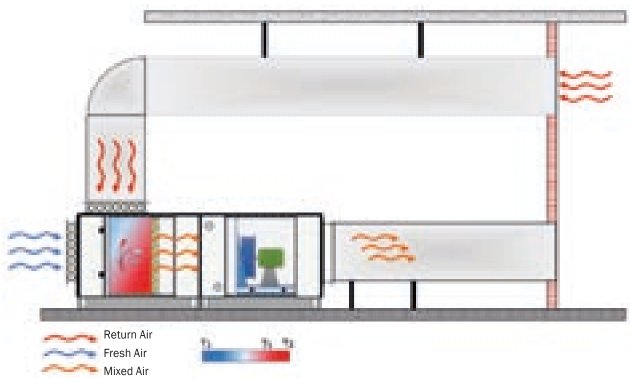


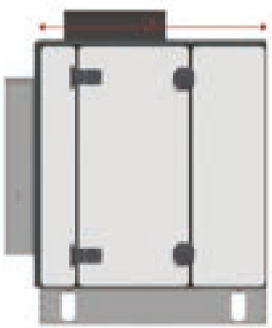


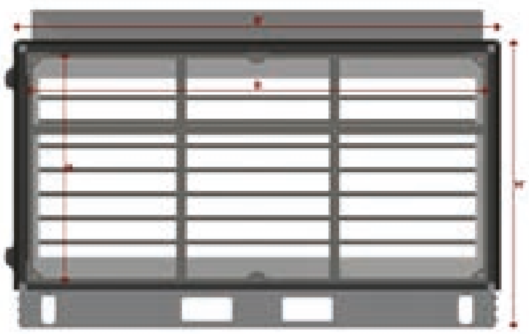


Double Damper Filter Section

A single fan is used in the double damper mixing section for the circulation of return air and fresh air. Therefore the exhaust process is not carried out at the air handling unit, and a separate exhaust fan is used instead. Fresh air taken from the outside environment is mixed with a certain amount of return air drawn from the space, pre-conditioning it. Mixing ratios are set by manual adjustment of dampers or with the aid of a damper motors with proportional control. Two dampers operate contrary to each other, if the fresh air damper is 80% open, then the return air damper is in the 80% closed position. Filter stages must be used after the mixing as a standard.





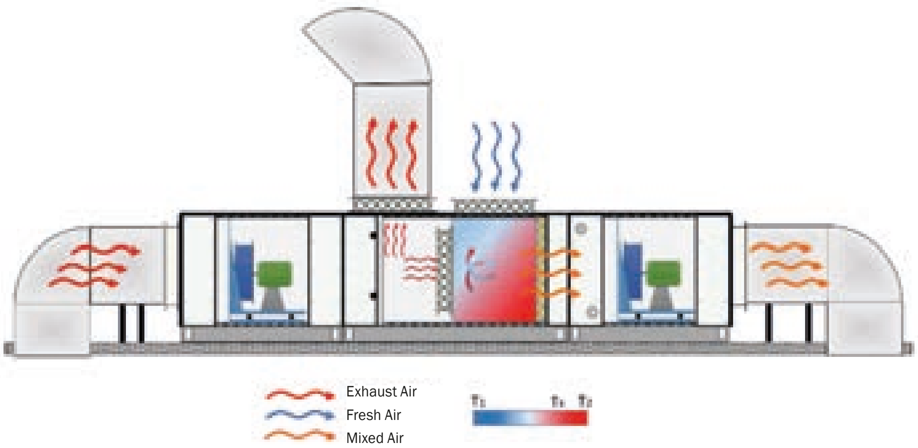


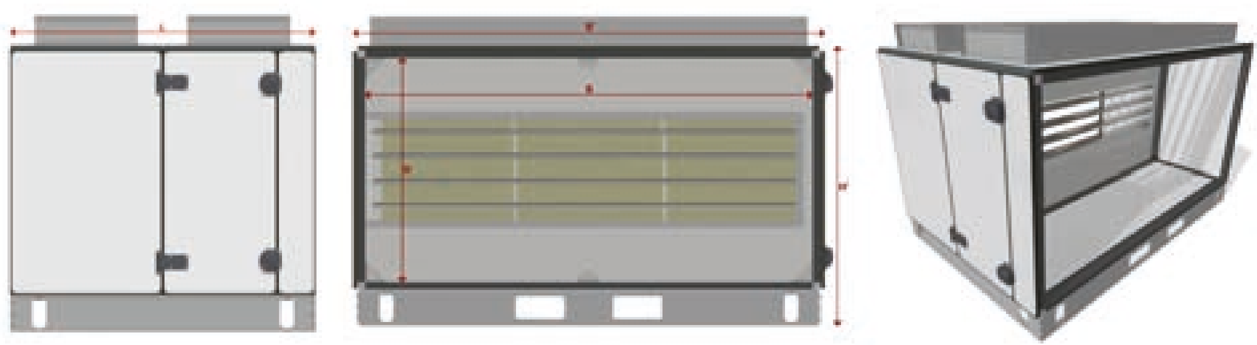
DOUBLE DAMPER MIXING SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	366	366	366	468	468	468	468	570	570	570	570	570	774	774	774	774	774	774	774	774	876	876	876	876	876	1080	1080	1080	1080	1080	1080	1080	1080	1182	1182	1182	1182	1182	1182	1182

Triple Damper Filter Section

Two separate fans are used in the triple damper mixing section for the return air and for discharge into the conditioned environment. Therefore exhaust is performed in this section. Fresh air taken from the outside environment is mixed with a certain amount of return air drawn from the space, pre-conditioning it. Mixing ratios are set by manual adjustment of dampers or with the aid of a damper motors with proportional control. The fresh air damper and exhaust damper operate contrary to each other, and the intermediate damper is closed in the amount that will make sure the mixture has the desired ratio. Filter stages must be used after the mixing as a standard.

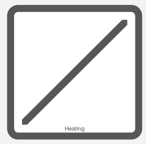




TRIPLE DAMPER MIXING SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	876	876	876	978	978	978	978	1284	1284	1284	1284	1284	1590	1590	1590	1590	1590	1590	1896	1896	1896	1896	1896	1896	1896	2202	2202	2202	2202	2202	2202	2202	2202	2508	2508	2508	2508	2508	2508	2508

Electrical Heater



Sensible Heating of Moist Air;

This is the process by which moist air is warmed up, increasing its temperature without loss or gain of humidity. Specific humidity remains constant during this process. The following formula can be used to calculate heating capacity.

$Q = V \times \rho \times C_p \times (T_2 - T_1)$

Q : Heating Capacity (kW), ρ: Air Density (kg/m^3)

Cp : Specific Heat of Air (kj/kg^{0}K), Air Flow (m^3/h)

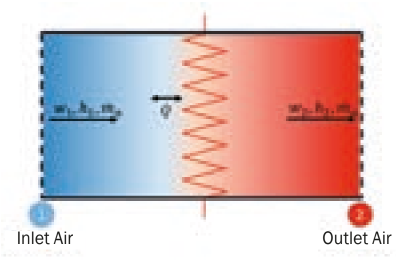
For example, 7500 m^3/h of fresh air at 5°C dry bulb temperature and 85% relative humidity shall be heated to 25°C with the aid of the electrical heater within the air handling unit. Let us calculate the electrical heater capacity and the number of resistances required. (The cross section height of the air handling unit is 918, and the cross section width is 1224 mm. The resistance length that can be selected is 1000 mm. Resistance capacity is 12 w/cm.)

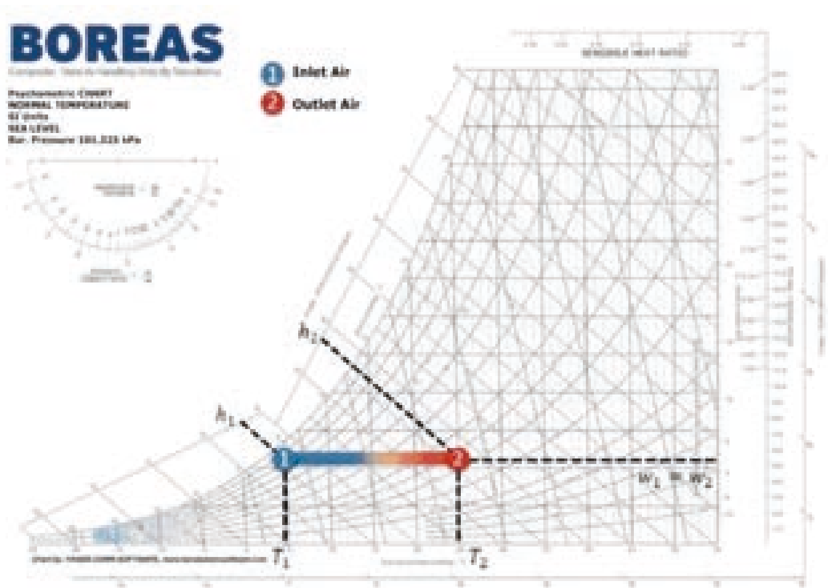
$$Q = 7500/3600 \times 1{,}2 \times 1{,}02 \times (25 - 5) = 50{,}2kW$$

$$Q = 12\frac{W}{cm} \times 100 = 1200\ W,\ \text{Heater Elements Quantity} = \frac{50{,}2}{1{,}2} = 41{,}8 \cong 42\ \text{pcs}$$

Electrical Heater Section

In the electrical heater section, the temperature of air is increased with sensible heating. Resistance rods are used as electrical heaters. Resistances can be manufactured with a unit power of 10-12 W/cm, and 240 V, 50 Hz monophase, 400 V, 50 Hz triphase. The resistance casing is manufactured from galvanized steel sheet. All cables used in resistance connections have fire resistant sleeves. Resistances can be manufactured at various stages and with tyristor control as required.

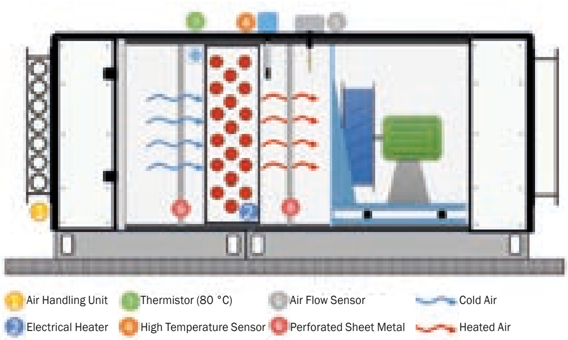




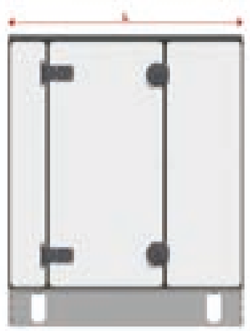
Safety Measures in the Electrical Heater Section

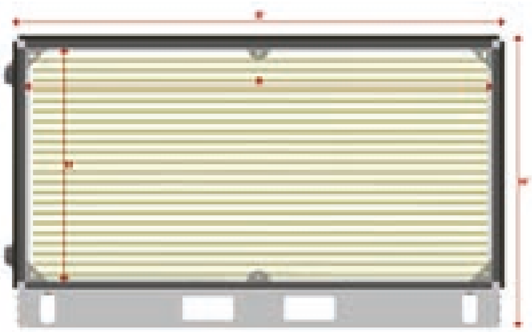
Thermal energy generated during the operation of the resistance is transferred to the air serving the heating function in the air handling unit. The air current created by the fan also causes the resistance to cool, preventing its temperature from reaching dangerous levels. Therefore, air flow must not be stopped in any way when the resistor is online.

The measures that can be taken to ensure this are listed below.



- Safety thermostat: The thermostat sensor placed in the vicinity of the resistance is connected to the electrical installation to bring resistances offline when the set value of 80° is exceeded.
- Air Flow Sensor: An air flow must exist for resistances to come online. Therefore air flow is controlled. During start-up of the air handling unit, resistances come online after confirmation of air flow has been received. If air flow has been disrupted for any reason during operation, it is ensured that resistances will come offline.
- Pressure Differential Switch: Provides control like the air flow sensor, but senses air flow from pressure difference.
- Door Sensor: The power is cut to the electrical heater in case the door of the resistance section or one of the subsequent sections opens during unit operation. Otherwise there is a risk that the air may by-pass the resistance. At the same time, this measure would prevent someone who opens the door during operation from hurting himself/herself.
- The Use of Perforated Sheet Metal: Perforated sheet metal used before and after the resistance heater ensures homogeneous distribution of air, and performs screening, preventing air handling unit parts from heat damage.





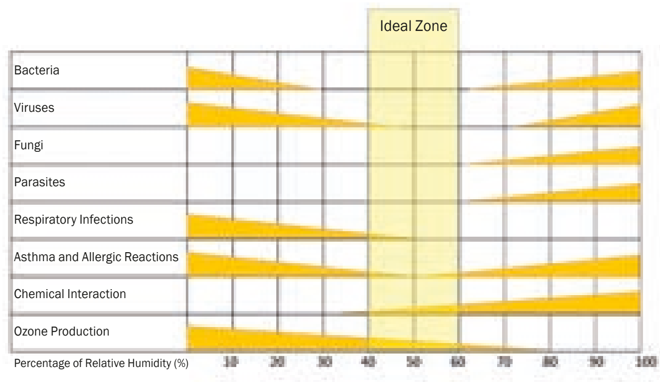
ELECTRICAL HEATER SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	570	570	570	570	570	570	570	570	570	570	570	570	570	570	1080	1080	1080	1080	1080	1080

Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080

The Effects of Humidity on Comfort, Health, and the Environment

- **Humidity and Skin Conditions:** The itching and cracking skin that occurs in cold weather, as well as skin fissures that occur due to cracking skin on hands, knees, and elbows are conditions that may occur in all humans, although they are more common in advanced age. The general cause of skin cracking is insufficient moisture on the surface of skin. The effects of this condition may be alleviated by maintaining humidity in the environment between 40-60%.
- **Allergic Rhinitis and Asthma:** Dust, pet hairs etc. that are common allergies of humans can be kept under check by controlling humidity in living environments. Humidity values that are kept constant under control prevents sudden changes in temperature and humidity that seriously affect and cause shocks in asthma patients.
- **The Sterling Study and Relevant Comments:** The determination of humidity in living spaces is difficult due to the fact that variation in the amount of humidity has various effects on ambient conditions. For instance, while increasing humidity is beneficial for asthma patients, it also lays ample ground for the growth and proliferation of bacteria, that are allergenic in themselves. Therefore care should be taken to ensure that conditions that will expedite the growth of biologic organisms that adversely affect human health are not created while determining the ideal humidity value.

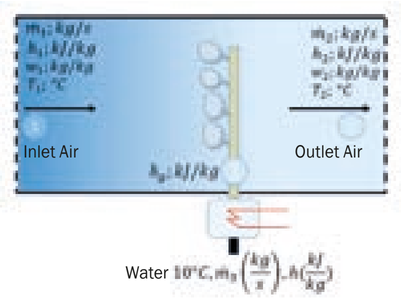


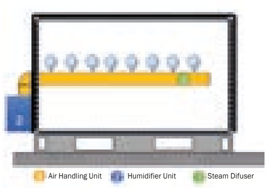
The Sterling Diagram shows the relationship between relative humidity range and factors that influence the health of people at regular room temperature. The horizontal scale of the diagram shows the 0%-100% relative humidity range. The vertical axis of the graph shows biological organisms, pathogens that cause breathing problems, the relationship between ozone production and chemical interaction.

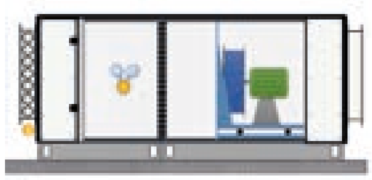
According to the Sterling Graph:

- Bacteria growth increases in the 0-30% and 60-100% range.
- While respiratory infections increase at 40% relative humidity, there is insufficient data for values above 50%.
- While allergic problems increase over 60% relative humidity, environments lower than 40% relative humidity causes a rise in asthma related problems.
- Conditions favourable to chemical interactions occur as 30% relative humidity is exceeded.
- Ozone production decreases with the increase in relative humidity.

Steam Humidifier Section







Steam humidification with electrode, heater type steam humidification, and steam injection humidification types are used in the air handling unit. Generating steam from water or using ready steam, the humidity is transferred to air with the aid of diffusers placed within the air handling unit.

Steam Humidification with Electrode: Electrodes are placed within the steam cylinder. When the conductive water within the cylinder (could be tap water) comes in contact with electrodes, the electrical circuit closes, and the water begins heating due to resistance.

Heater Type Steam Humidification operates according to the principle of electrical water heaterrs. The heating elements positioned within the steam cylinder cause water to heat.

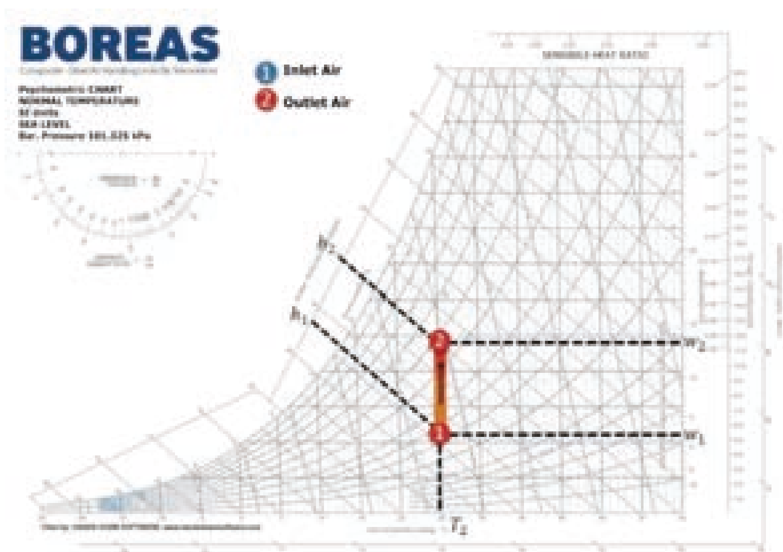
Steam Injection Humidification is the method used where the steam that is readily found in the process is connected to the diffuser.

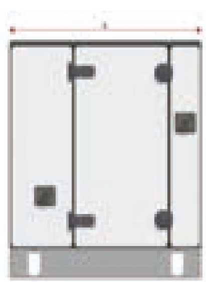
$m_1 + m_3 = m_2$ (kg/s, Mass Flow Rate)

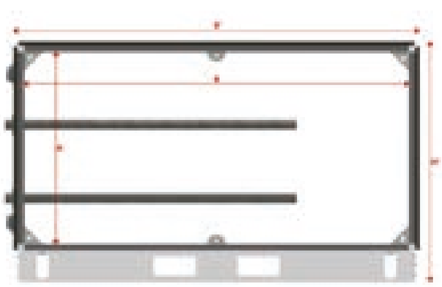
$m_1 + h_1 = m_3 \, x \, h_3 = m_2 \, x \, w_2$ (kW, Enthalpy Equation)

$m_1 + w_1 + m_3 = m_2 \, x \, w_2$ (kg/s, Humidity Flow Rate)

$m_1 + w_1 + m_3 = w_2 \, x \, m_1 + w_2 \, x \, m_3$ (kg/s, Mass Flow Rate of Steam)





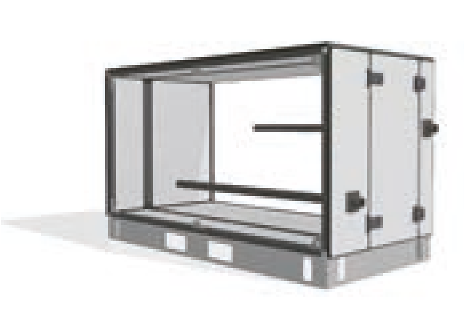


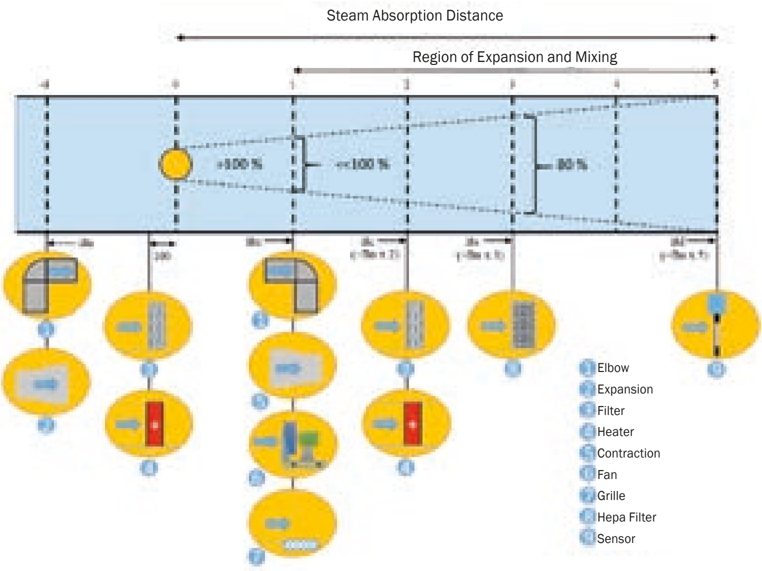
STEAM HUMIDIFICATION SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	1080	672	672	672	672	672	672	672	672	672	672	672	672	672	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080

PLACEMENT OF STEAM DIFFUSER IN STEAM HUMIDIFICATION

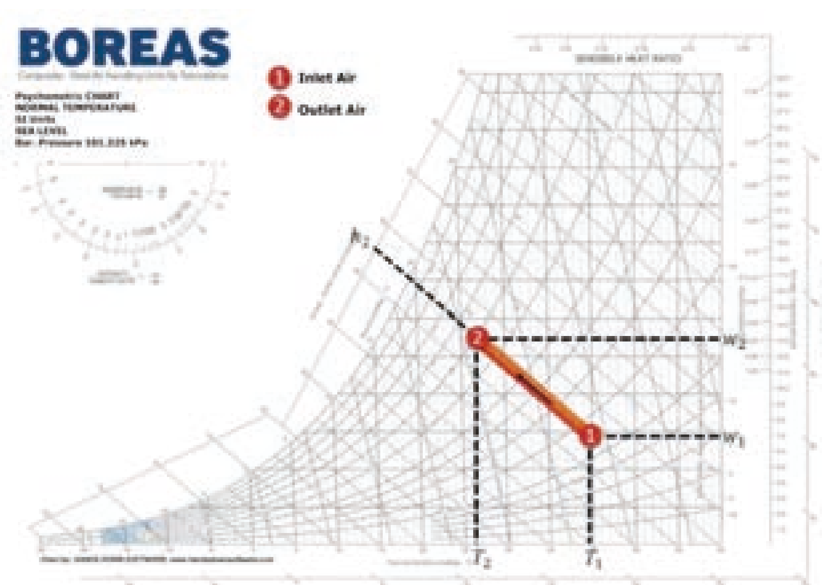
The distances that should be left between the diffuser and the equipment that will be placed before and after it are an important criteria in efficient diffusion of steam to air in steam humidification. Unless these distances have been left correctly, steam will come into contact with these surfaces before dispersing into air, and its efficiency will fall. The Bn value seen in the following diagram varies depending on the humidity content of the air before the diffuser (g/kg), the amount of steam to be added (g/kg), the diffuser length selected (mm), the velocity of air in the cross section (m/s), and the humidifier capacity (kg/g).



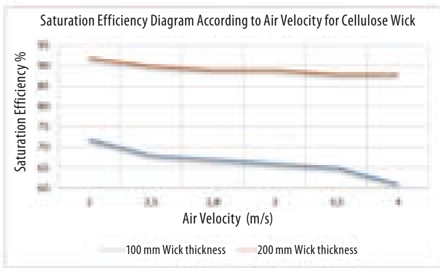


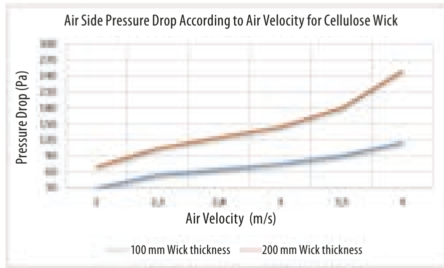
Evaporative Wick Adiabatic Humidifier Section

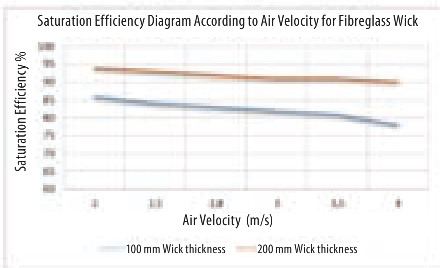
Evaporative humidifiers generally comprise a water pool, pum, and wicks. The water in the tank is sent over the wicks with the aid of the pump, wetting the wicks. Air passing over moistened wicks evaporates the water on the wick with its latent heat, incorporating it. In this way a drop in temperature occurs as humidity is added to the air.

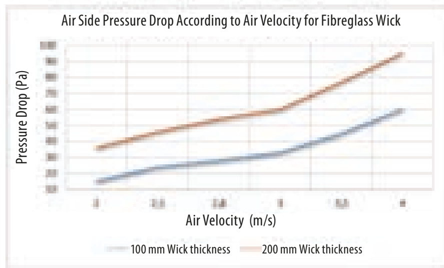


Two separate wicks manufactured from cellulose and fibreglass material are used in evaporative humidifers. Cellulose wicks are made of cellulose paper that can be moistened and that have been soaked with chemicals that render it durable. Fibreglass wicks are fibreglass plates with additives that can hold water and allow the fibreglass to absorb water. Technical specifications of the cellulose and fibreglass wick are as follows.



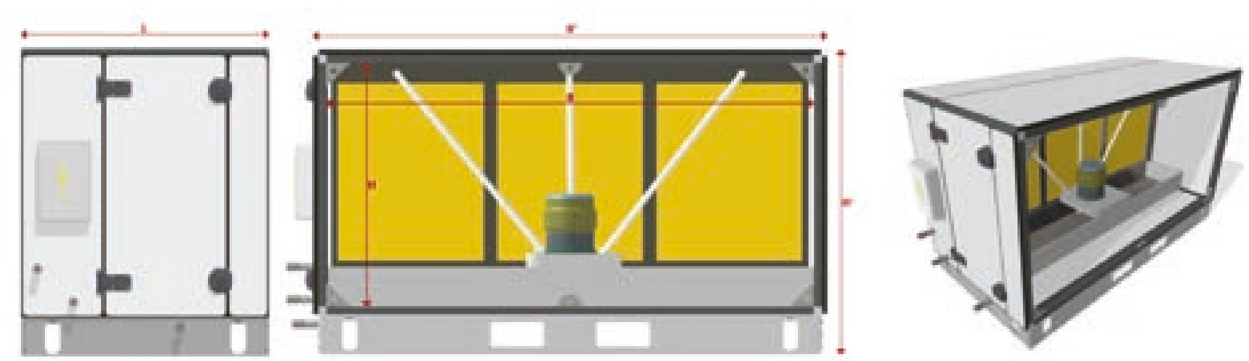






Elements that Make up the Wick Evaporative Humidifier:

- Pool (stainless steel sheet)
- Float valve (for automatic water fill)
- Overflow system
- Water Pump
- PVC Water Pipes
- Water Control Valve
- Wick
- Wick Frames (stainless steel sheet)



WICK HUMIDIFICATION SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066
L	1080	672	672	672	672	672	672	672	672	672	672	672	672	672	1080	1080	1080	1080	1080	1080

Model	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080

High Pressure Humidification Section

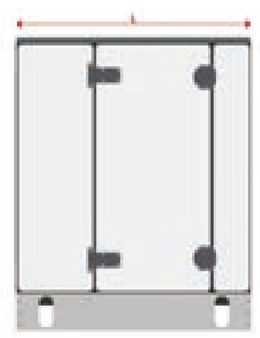
The high pressure humidification system comprises the cassette network system carrying on it the nozzle system that causes the humidification water to disperse into particles under high pressure, and the pump unit that conditions the humidification water. The cassette network system and section interior are manufactured entirely from stainless steel. The system ensures hygienic humidification by not using return water. General features of this system are:

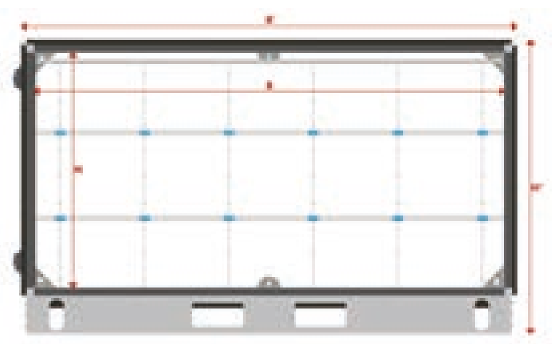
- 99.7% humidification
- 480 l/h capacity in a single air handling unit
- Capacity range of 78 l/h - 8100 l/h
- Stainless steel air handling unit interior
- Precise electronic control by means of inverter and solenoid valve
- Drainage down to 3%, 97% water evaporation efficiency
- hygienic humidification where return water is not used
- Modbus communication

The high pressure humidification system is custom manufactured for conditions needed. The nozzles used are tested at twice their operating pressure (at 150 Bar). Connection between the cassette network system and pump unit is carried out with special hydraulic hoses capable of resisting 200 Bar pressure.

Humidification Control System:

The high pressure control system can be controlled with a fixed or variable electronic card design depending on the control structure desired. In the fixed control system, the humidification unit within the air handling unit can be controlled with a single dry contact outlet. In this case, the humidification unit carries out humidification at the specified capacity for the period required with a start or stop command given to it. In the variable control system, the unit can be operated with a variable electronic card installed, according to air handling unit operating range, outdoor temperature, return air temperature, and the set values desired. In this case electrical motors (and consequently pumps) that are driven with the aid of one or more inverters will come online between the pre-determined scenario and set values and remain online for the period desired.





HIGH PRESSURE HUMIDIFICATION SECTION DIMENSION TABLE

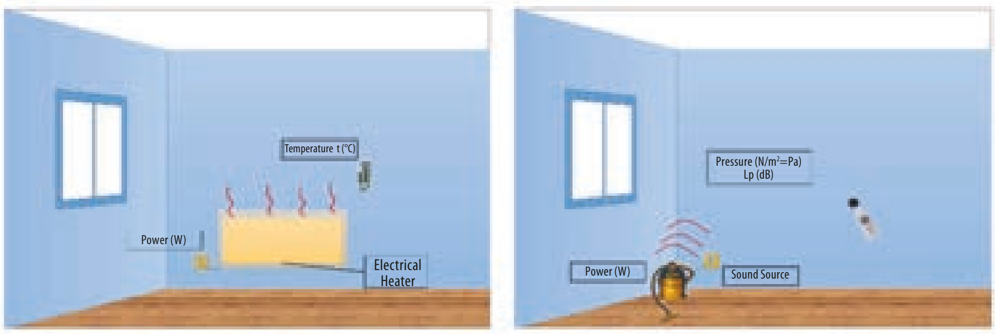
Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Attenuator Systems

Sound can be defined as pressure variations that can be detected by our ear. Sound can sometimes occur in its undesired and disturbing form, which we call noise. The concept of discomfort varies according to our response to the sound. While some may enjoy high volume music, it can be bothersome to others. The sound does not need to be of a high volume to be disturbing. For example a scratchy record, a tap which drips water, or a creaking door can sometimes be as bothersome as the sound of a jet plane.

Sound Pressure and Power

We can use the analogy between temperature and heat to describe the physical properties of sound, pressure and power. An electrical heater unit within a room releases a certain amount of energy per unit time (Joules/second). In other words it has a certain power (Watt = Joules/second). This is a measure of how much heat the radiator can generate without the influence of environmental factors. The released energy disperses into the environment increasing the temperature of the room, and can be measured with a simple thermometer. However the temperature at any point in the room varies not only depending on the power of the heater or its distance to that point, but also to the heat absorbed by the room's walls or the heat transmitted to the outside environment from the door or windows.



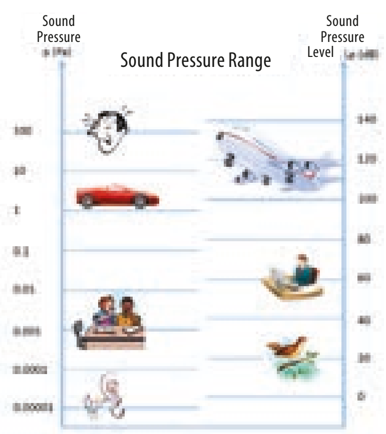
A source of sound within a room releases a certain amount of sound per unit time (Joules/second). In other words it has a certain power (Watt = Joules/second). This is a measurement of how much acoustic energy the sound source can generate independent of environmental factors. The energy generated disperses into the environment, raising the sound pressure in the room. However the sound pressure at any point in the room varies not only depending on the power of the source or its distance to that point, but also to the sound energy absorbed by the room's walls or the sound energy transmitted to the outside environment from the door or windows.

$$I = \frac{P}{4\pi r^2} = \frac{\rho^2}{\rho c}$$

P : Power (W)
I : Intensity (j / sm^2)
ρ : Pressure (Pa)
r : Distance from source (m)
c : The Speed of Sound

Sound Pressure Range

20 µPa is accepted as the lowest sound level that can be heard by an average person. This value is called the threshold of hearing. 100 Pa on the other hand is a very high level and causes pain. Therefore it is called the threshold of pain. Our ear is sensitive not to linear, but to logarithmic increases. Therefore the decibel (dB) scale which is the logarithm of the ratio of a measured value to a reference value is used in determining acoustic parameters.



$$L_p = 20log\frac{P}{P0} dB\ (ref. 20\mu Pa)$$

$$P_o = 20\mu Pa = 20x10^{-6}Pa$$

Sound pressure in decibels is expressed as Lp = 20 log (P/Po). Here P is the measured sound level (in Pa) while Po is the reference sound level.

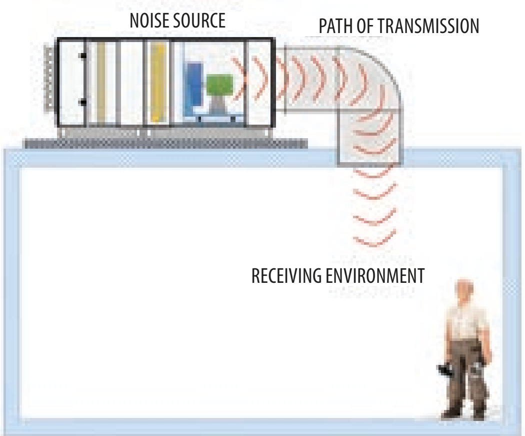
- A 3 dB change in the beginning (1.4 fold increase-decrease) is a barely noticeable level.
- A 10 dB change (3.16 fold increase-decrease) however creates the impression that the sound has become twice as strong.

Variation in Sound Level (dB)	Variation in the Perceived Strength of Sound
3	Barely Sensible
5	Noticeably Different
10	Twice as Much
15	Very Different
20	Four Times as Much

Preventing Noise

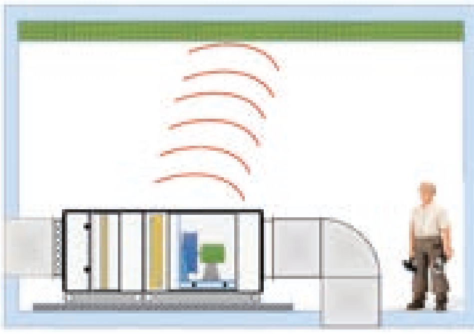
All possible measures for preventing noise from bothering people are noise control. The propagation of noise occurs as Source – Path of Transmission - Receiving Environment. Measures that can be taken for noise control are:

- Reduction or prevention at the source
- Reduction in the environment of propagation and the path of transmission
- Reduction in the receiving environment



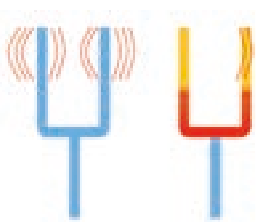
Dampening materials are bituminous compounds.

- Absorbing Materials
- Materials with open pores: Rock wool, plastic foams, curtains, and pressed textile scraps etc. materials.

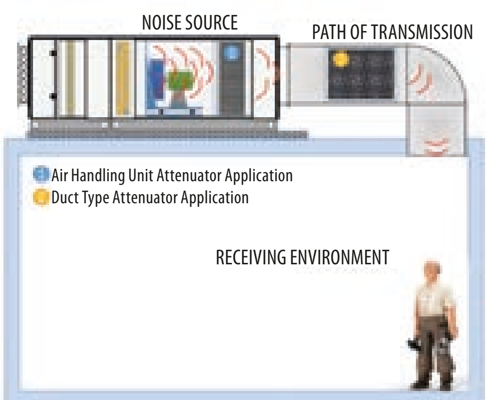


Absorption: sound energy propagating in the air is converted to heat energy.

Insulation: The passage of sound energy through the insulation is prevented by the insulation.



Dampening: Structural sound energy is converted to heat energy.

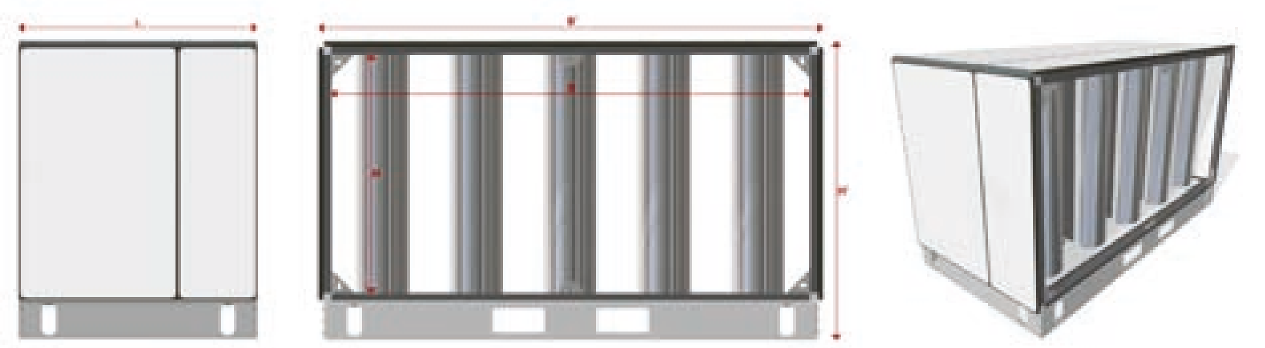


Attenuator Section

The attenuator section is placed before and/or after the fan section which is the source of sound in the air handling unit, and is used to reduce the effect of the sound which reaches the area around the air handling unit and/or living spaces which are receiving environments, via the ductwork.

Open pore rock wool capable of absorbing sound is used in making attenuators. This rock wool is filled inside attenuator coulisses and the coulisses placed by leaving the necessary coulisse clearances within the section.

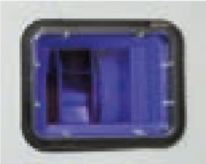
A metal piece with a rounder surface is used as standard in the air entry surface of each coulisse to increase attenuator performances and keep air side pressure drops low.



ATTENUATOR SECTION DIMENSION TABLE

Model	6x6	6x9	6x12	9x9	9x12	9x15	9x18	12x12	12x15	12x18	12x21	12x24	15x15	15x18	15x21	15x24	15x27	15x30	18x18	18x21	18x24	18x27	18x30	18x33	18x36	21x21	21x24	21x27	21x30	21x33	21x36	21x39	21x42	24x24	24x27	24x30	24x33	24x36	24x39	24x42
B	612	918	1224	918	1224	1530	1836	1224	1530	1836	2142	2448	1530	1836	2142	2448	2754	3060	1836	2142	2448	2754	3060	3366	3672	2142	2448	2754	3060	3366	3672	3978	4284	2448	2754	3060	3366	3672	3978	4284
B'	712	1018	1324	1018	1324	1630	1936	1324	1630	1936	2242	2548	1630	1936	2242	2548	2854	3160	1936	2242	2548	2854	3160	3466	3772	2242	2548	2854	3160	3466	3772	4078	4384	2548	2854	3160	3466	3772	4078	4384
H	612	612	612	918	918	918	918	1224	1224	1224	1224	1224	1530	1530	1530	1530	1530	1530	1836	1836	1836	1836	1836	1836	1836	2142	2142	2142	2142	2142	2142	2142	2142	2448	2448	2448	2448	2448	2448	2448
H'	842	842	842	1148	1148	1148	1148	1454	1454	1454	1454	1454	1760	1760	1760	1760	1760	1760	2066	2066	2066	2066	2066	2066	2066	2372	2372	2372	2372	2372	2372	2372	2372	2678	2678	2678	2678	2678	2678	2678
L	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794	1794

Accessories

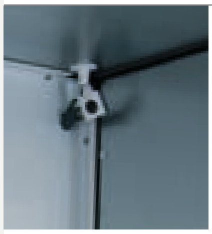


SIGHT GLASS

Installed on access doors of sections, making it possible to view the section interior without having to stop the air handling unit.
Since it has a wider surface than standard sight glass types and completely transparent polycarbonate glass, it facilitates viewing. Since it is double walled, it provides insulation.

UV (ULTRAVIOLET) LAMP

The air passing through the air handling unit contains dust, solid particles, and organic contaminants (micro organisms). Filtration of dust and particles within the air is carried out with standard filtration methods (G, M, and F class filters) used. Removal of micro organisms (organic contaminants) that can only be seen with the help of a microscope and which have deleterious effects on human health from the air is not possible using standard filtration methods. For this purpose, low wavelength UV (ultra violet) light is used, severing the molecular bonds in micro organisms' DNA, stopping their activity and ensuring sterile air. Of the entire UV band of 90-400 nm (nanometer), the section between 200-280 nm is called UV-C, and used for sterilization.
The device is installed within an air handling unit section and the conditioned air is sterilized before leaving the unit. Both electronic and mechanical safety measures are taken to prevent technical staff from exposure to the rays, to avoid harmful effects to human health.



CAMERA

The BOREAS Air Handling Unit optionally comes with a camera system instead of inspection glasses for viewing the operation of the fan, filter and any other sections needed. In this way the information on the fan's operation, possible malfunction etc. can be obtained with convenience, and can also be remotely viewed via web access.

LIGHTING

Used to illuminate section interiors. The weather proof lighting fixture comprises LED light and on-off switch. The lighting fixture is installed within the panel. Thanks to its special design, it does not form a protuberance within the panel's inner and outer surface, and allows easy cleaning of interior surfaces. The open and shut switch is installed in the direction of access on the relevant section.

ACCESS DOOR SAFETY SWITCH

It is used to obtain information about whether section doors are open or shut. In this way, if a door opens during unit operation, a door open warning is created, and power to the unit is cut according to the scenario.

ACCESS DOOR STOPPER

It is used to prevent the door from closing when section doors are open. In case the access door is brought to the fully open position, the mechanical locking system comes online. In order to close the door, the mechanical lock must be manually disabled and the door be closed again.

WATER COIL VALVE + VALVE MOTOR

Flow control valves are used in controlling refrigerant flow rates of water exchangers used in air handling units. There are two- and three-way applications. In the two-way application the water flow rate can be controlled proportionally or as on/off. In three-way application, the water coming from the system can also be mixed with water coming from the boiler, ensuring more precise control.

PANIC BUTTON

The panic button can be pressed in case of an emergency, for cutting out the main power of the air handling unit. It is supplied with DDC panel as a standard.

REPAIR AND MAINTENANCE SWITCH

It is used to cut main power over the unit during air handling unit maintenance, so the air handling unit can be services safely.

DIFFERENTIAL PRESSURE SWITCH

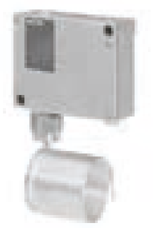
It is used to receive signal information in case the pressures which occur in the 0-500 Pa range within the air handling unit reach the required value. There are two models which are 0-250 Pa and 0-500 Pa. It generates warning information when the pressure difference between the two specified points reaches the pressure set on the differential pressure switch. It is generally used in air handling units for

Filter dirtiness control

Fan flow information, belt breakage information.

DAMPER MOTOR

Damper motors are used in air handling units to control air flow rate by adjusting damper openings. They come in on/off controlled versions that ensure the damper is fully open or fully closed, or versions with proportional control that allow adjusting the damper to the desired opening level. Spring return damper motor applications are also offered for safety purposes in smoke protection, smoke control, and hygiene applications. The damper motor loads the spring within it and maintains it in this position as long as there is power. In case energy is cut, it releases the spring making sure the damper quickly reaches the off position.



ANTI FREEZING THERMOSTAT

It creates a warning signal in the event that the temperature of air passing over the water exchangers used within the air handling unit approaches freezing temperature, activating the freeze control scenario. In this case, the fresh air fan stops, the fresh air damper assumes the off position, and the exchanger valve is brought to the open position. When conditions return from freezing to normal, the system resumes its normal operating scenario.

HUMIDITY AND TEMPERATURE SENSOR

It is positioned on the intake and discharge lines of the air handling unit, and used to measure air humidity and temperature.

FREQUENCY CONVERTER

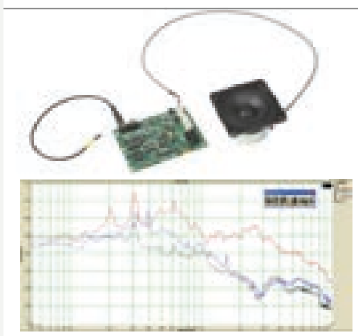
The frequency converter is a motor drive which facilitates setting fan speed by controlling motor speed. Frequency converters are electronic devices which convert a fixed frequency AC power input to adjustable frequency output, and control motor speed by controlling the frequency of electrical power supplied to the motor.

WATER COIL CONNECTION FLANGE

It is used in air handling units to connect the water coils to the water supply line. Flanges with interior threads, and diameters suited to collector diameters are used as per DIN standards.

WEATHER CANOPY AND HOOD

The roofing sheet and hood are used to protect air handling units placed outdoors from the deleterious effects of snow and rain water. The tilted design of the roofing sheet allows the snow and rain water to be quickly drained from above the air handling unit. Hermetic sealing system is used in roofing sheet seams. The drip edge along the edges of the roofing sheet allows draining water without it coming into contact with air handling unit surfaces. The tilted wing structures used in hood design prevent water droplets drifting with the flow of air into the air handling unit. The wire mesh system used in front of hoods prevent animals, leaves, paper etc. pieces from entering the air handling unit. The roofing sheet and hood are manufactured from painted galvanized steel sheet. The galvanizes sheet is processed, and painted before use. It can also be manufactured from stainless steel sheet upon demand. All fixing screws used are stainless.



Red – Original, Blue – Passive,
Black – Active (ANC On)

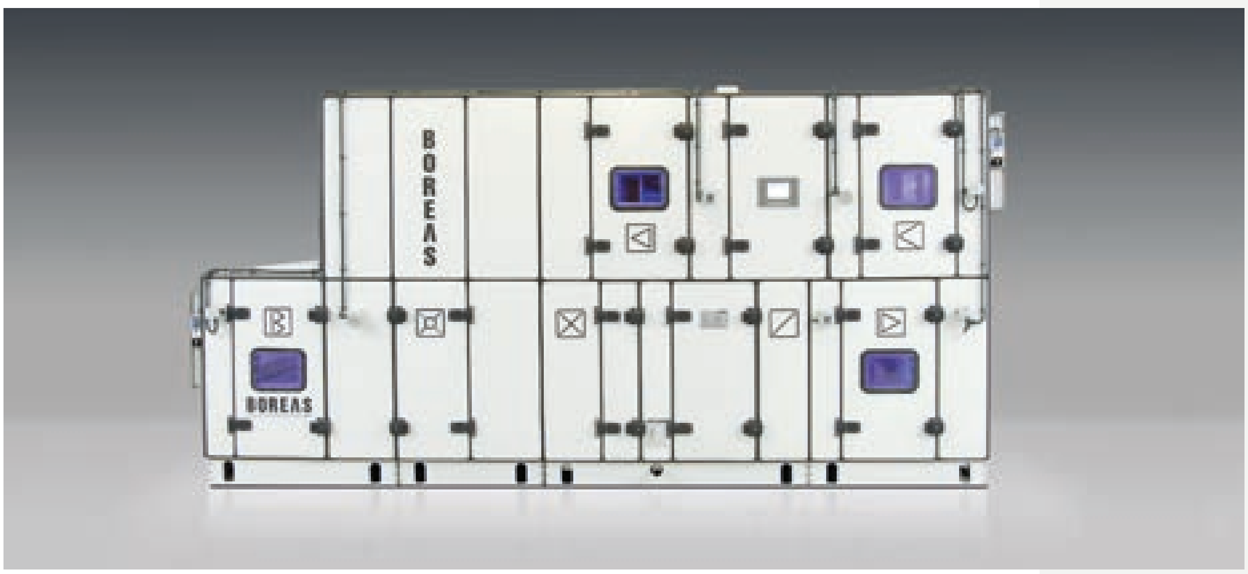
ACTIVE ATTENUATOR

Active attenuators generate counter signals directed to the original sound generated at the noise source, dampening the noise. The ANC (Active Noise Control) Unit comprises a microphone and speakers which generate counter signals. Active attenuators ensure up to 10 dB(A) reduction in noise by detecting changes in the noise spectrum, and by generating counter noise to dampen it. They can be applied on the air handling unit or duct. They take up much less space than standard attenuator units.

Control Systems

The needs of environments where air conditioning is applied can vary during the day according to season, time, purpose of use, outdoor conditions, and building structure. Automation systems should be used in air handling units to achieve, control, and maintain comfort conditions in the environment, depending on these various operating conditions. With the use of automation systems:

- Precise control over ambient conditions is carried out on a continuous basis,
- Energy is saved by consuming only as much power as is needed,
- The air handling unit can be constantly monitored through the pre-determined control and alarm points, precautions can be taken, and periodic maintenance can be performed on schedule, extending the useful life of the unit,
- Free cooling can be used at seasonal transitions, keeping energy expenditure to a minimum,
- Filter contamination can be monitored and filters can be replaced at the right time,
- Safety measures for water exchangers can be taken with freeze control,
- Capacity can be controlled by two - or three - way valve in water



exchangers,
- Capacity can be controlled by electronic expansion valve in gas exchangers,
- Variable or fixed flow control can be carried out by varying motor rpm by referencing air flow rate or differential pressure with the frequency inverter,
- Proportional control can be carried out in electrical heaters, by the use of a thyristor,
- Damper openings can be controlled as on/off or proportionally using damper motor,
- All electromechanical measures can be taken with regard to the air handling unit,
- A high level of safety measures can be taken in occupational health and safety by defining control and safety points such as low-high temperature alarm, low-high pressure alarm, filter contamination alarm, high current alarm, air flow on-off alarm, door open-shut alarm etc.,
- High safety measures can be implemented in emergencies via the fire scenario,
- All air handling unit functions can be monitored and controlled from a single point,
- And the air handling unit operation intervals can be planned on an hourly, daily, and weekly schedule with scheduling programs. With the use of each feature listed above, the air handling unit provides the desired conditions of comfort in the environment in a precise manner, and with minimum energy expenditure.

Control Equipment Used in the Air Handling Unit

POWER AND CONTROL PANEL

The power and control panel is housed within the same casing at the Boreas air handling unit. All methods and applications during the project development and manufacturing of the panel are carried out in accordance with CE directives. In the power section, the equipment required for mains power supply and distribution are located. On the control section, there is the control which enables easy integration with existing BMS systems via open protocols such as KNX, Lon, Bacnet, and Modbus, as well as connection ports for all sensors. The power and control panel is manufactured in the IP56 class to protect against the elements. A ventilation grill and circulation fan is applied in the panel space to keep the panel's ambient temperature under control.

The control equipment that are described in detail in the accessories section are the following:

- Differential Pressure Switch
- Humidity and Temperature Sensor
- Damper Motor

- Anti Freezing Thermostat
- Frequency Converter
- Flow Control Valve
- Flow Switch
- Internal Air Temperature Sensor
- CO_2 Sensor

Control Scenarios in the Air Handling Unit

The following standard automation scenarios are used in the BOREAS Air Handling Unit:

- Rotary Heat Recovery Air Handling Unit
- Plate Type Heat Recovery Air Handling Unit
- Fresh Air Air Handling Unit
- Mixing Air Handling Unit

Different scenarios can also be created depending on request and need.

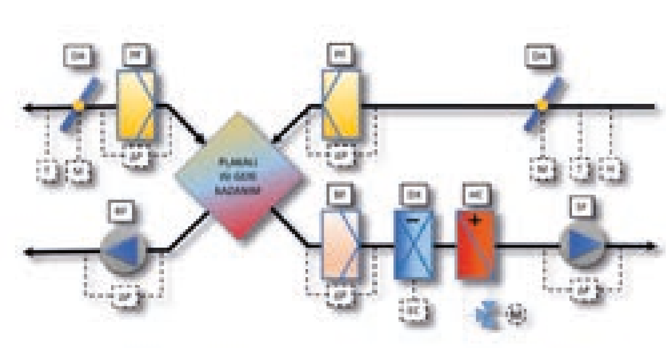
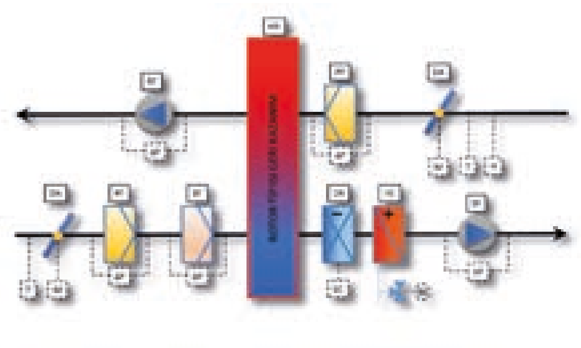
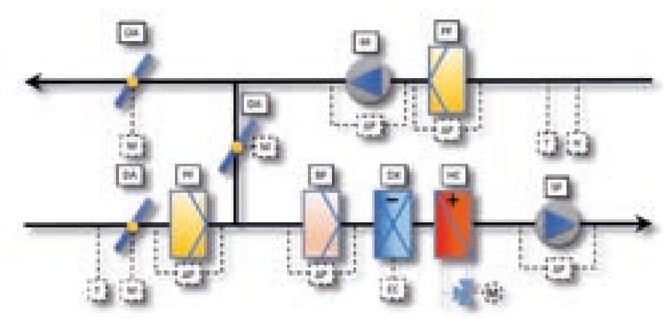


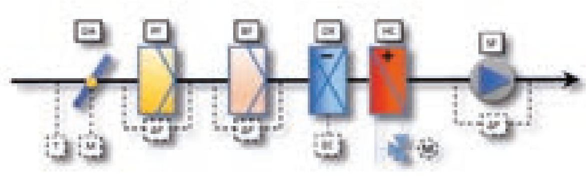
Plate Type Heat Recovery Air Handling Unit Control Flow Chart



Rotary Heat Recovery Air Handling Unit Control Flow Chart



Mixing Air Handling Unit Control Flow Chart



100% Fresh Air Air Handling Unit Control Flow Chart

RF: Return Fan | HR: Heat Recovery | PF: Panel Filter | DA: Damper | BF: Bag Filter | T: Temperature Sensor | M: Damper Motor

HC: Water Heating Coil | SF: Fresh Air Fan | DX: Direct Expansion Cooling Coil | H: Humidity Sensor | EC: Electronic Expansion Valve | ΔP: Differential Pressure

Useful Information

Issues That Should be Taken into Consideration while Selecting Air Conditioning Units

The following priority questions should be selected before selecting fans

1. What is the type of application of the air handling unit?

a. Hygiene Application → Plug Fan or EC Plug Fans are recommended.

b. Comfort Application → Plug Fans are recommended

c. General Purpose Ventilation → Reverse Inclined Rare Blade Fan or Forward Inclined Dense Blade Fan are recommended.

2. What are the desired flow rate and pressure values?

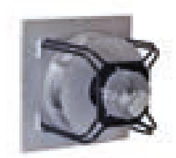
a. High Flow Rate – High Pressure → Plug Fan, EC Plug Fan, or Reverse Inclined Rare Blade Fan are recommended.

b. High Flow Rate – Low Pressure → Forward Inclined Dense Blade Fan is recommended.

3. What is the fan efficiency value?

a. Medium efficiency → Forward Inclined Dense Blade Fan is recommended.

B. High Efficiency → EC Plug Fan, Plug Fan, or Reverse Inclined Rare Blade Fan are recommended.

Examples of Centrifugal Fans Commonly Used in Air Handling Units			
Forward Inclined Dense Blade Fan	Backward Inclined Rare Blade Fan	Plug Fan	Plug EC Fan
			
- Low Pressure - High Air Flow - General Purpose Ventilation - Medium Efficiency - Belt and Wheel System	- High Pressure - High Air Flow - High Efficiency in Comfort Applications - Belt and Wheel System / Frequency Inverter	- High Pressure - High Air Flow - High Efficiency in Comfort and Hygiene Applications - Frequency Inverter	- High Pressure - High Air Flow - High Efficiency in Comfort and Hygiene Applications - Automatic RPM Control

It is recommended consider the following questions and their answers while selecting a humidification system.

1. What type of humidification should be selected according to the air handling unit application type?

a. Hygiene Application;

i. Steam Humidification is recommended.

b. Comfort Applications;

i. Jet Type Humidification is recommended.

c. General Purpose Ventilation

i. Wick Humidification is recommended.

It is recommended consider the following questions and their answers while selecting an exchanger.

1. What should coil properties be according to the air handling unit application type?

a. Hygiene Application;

i. Surface Coating - Hydrophilic or Epoxy coating is recommended.

ii. Frame Material – Painted Galvanized Steel or Stainless Steel is recommended.

b. Comfort Applications;

i. Surface Coating - Epoxy coating or aluminum is recommended.

ii. Frame Material – Painted Galvanized Steel or Galvanized Steel is recommended.

c. General Purpose Ventilation

i. Surface Coating - Aluminum is recommended.

ii. Frame Material – Galvanized Steel is recommended.

2. What should be permissible pressure drops?

a . Fluid Side Pressure Loss

i In Water Cooling Coil – below 30 kPa is recommended.

ii. In Water Heating Coil – below 20 kPa is recommended.

iii. In Gas Coil – below 50 kPa is recommended.

b . Air Side Pressure Loss

i. In Water Cooling Coil – below 150 kPa is recommended.

ii. In Water Heating Coil – below 80 kPa is recommended.

iii. In Gas Coil – below 150 kPa is recommended.

3. What Should be the Row Number of Coils?

a. In Water Cooling Coil – below 8 rows is recommended.

b. In Water Heating Coil - 2 or maximum 4 rows are recommended.

c. In Gas Coil – below 8 rows is recommended.

4. What Should be Coil Surface Air Velocity?

a. The recommended selection range for all coil types is 2.5-3 m/s.

Property	Situation	Capacity	Air Side Pressure Loss	Fluid Side Pressure Loss
Number of Rows	If increasing	Increases	Increases	Decreases
Pitch Measurement	If increasing	Decreases	Decreases	Increases
Number of Circuits	If increasing	Decreases	Decreases	Decreases
Number of Pipes	If increasing	Increases	Increases	Increases

Issues That Should be Taken into Consideration while Selecting AHU

It is recommended consider the following questions and their answers while selecting filters.

1. What should filter properties be according to the air handling unit application type?

a. Hygiene Application;
i. Pre-filter – G4 Class Panel Filter is recommended.
ii. Fine Filter – F9 Class Rigid Frame Bag Filter is recommended.
b. Comfort Applications;
i. Pre-filter – G3 or G4 Class Panel Filter is recommended.
ii. Fine Filter – F7, F8, or F9 Class Bag Filter is recommended.
c. General Purpose Ventilation
i. Pre-filter – G2 or G3 Class Panel Filter is recommended.
ii. Fine Filter – F5 or F6 Class Bag Filter is recommended.

2. What should be the filter replacement intervals?

a. It is recommended that pre-filters be replaced before air side pressure drop exceeds 150 Pa.
b. It is recommended that fine filters be replaced before air side pressure drop exceeds 250 Pa.

It is recommended consider the following questions and their answers while selecting a heat recovery system.

1. What type of heat recovery should be selected according to the air handling unit application type?

a. Hygiene Application;
i - Run Around Type Heat Recovery is recommended.
ii. Heat Pipe Heat Recovery is recommended.
b. Comfort Applications;
i – Rotary Heat Recovery is recommended.
ii. Plate Type Heat Recovery is recommended.
c. General Purpose Ventilation
i – Rotary Heat Recovery is recommended.
ii. Plate Type Heat Recovery is recommended.

2. What type of heat recovery should be selected in cases where the Intake and Discharge lines should be positioned separately?

a. Run Around Type Heat Recovery is recommended.
b. Heat Pipe Heat Recovery is recommended. (to a maximum separation of 5 m)

3. What type of heat recovery should I use when heat recovery with both latent and sensible heat is required?

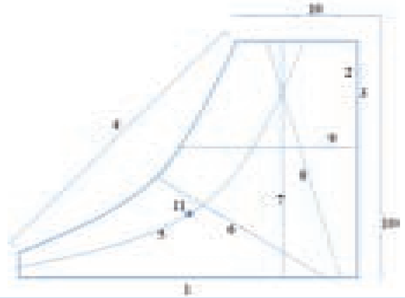
a. Sorbtion Type Heat Recovery is recommended.
b. Plate Type Heat Recovery manufactured from cellulose material is recommended.

4. What should be the maximum Pa selected for air side pressure drop?

a. Recommended value is below 250 Pa for Rotary Heat Recovery.
b. Recommended value is below 200 Pa for Plate Type Heat Recovery.
c. Recommended value is below 150 Pa for Run Around and Plate Type Heat Recovery.

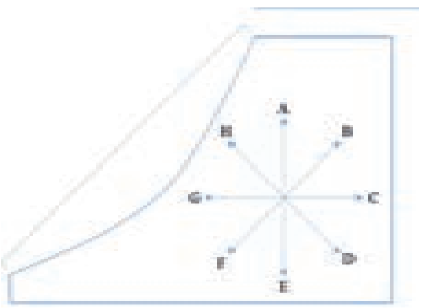
HOW TO USE THE PSYCHROMETRIC CHART

Figure 1



Lines And Scales	
1	Dry Bulb Temperature Scale
2	Humidity Ratio Scale
3	Dew Point Temperature Scale
4	Enthalpy Scale
5	Relative Humidity Line
6	Wet Bulb Temperature Line
7	Dry Bulb Temperature Line
8	Specific Volume Line
9	Humidity Ratio Line
10	Sensible Heat Ratio Index
11	Sensible Heat Ratio Index Origin

Figure 2

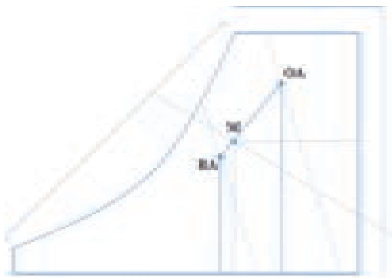


PROCESSES	
A-Humidity Only	E-Dehumidify Only
B-Heat & Humidity	F-Cool & Dehumidfy
C-Sensible Heat Only	G-Sensible Cool Only
D-Chemical Dehumidify	H-Evaporative Cool

Problem 1

Return Air (RA) of 10800 m³/h, at 27 ºC dry bulb temperature and 20 ºC wet bulb is mixed with Outside Air (OA) of 3600 m³/h at 35 ºC dry bulb temperature and 25 ºC wet bulb. Using the psycrometric chart, determine the Mixed air (M) condition.

Figure 3



Locate the OA and RA points on the chart. Connect the points using a straight line.

OA = 0,873 m³/kg
RA = 0,895 m³/kg
OA = 3600 / 0,873 = 4123,2 kg/h
RA =10800 / 0,895 = 12067 kg/h
Total = 16190,2 kg/h
Mixed Air (M) Dry Bulb :
35 x 4123,2 / 16190,2 = 8,91 ºC
27 x 12067 / 16190,2 = 20,12 ºC
Point M dry bulb = 29,0ºC
Read the other proterities of point M:
Wet Bulb = 21,3 ºC
Enthalpy = 62,1 kj/kg
Specific Humidty = 12,9 g/kg
Relative Humidity = 51,1%

Problem 2

Outside Air (OA) of 9000 m³/h is at 0 ºC and 85% relative humidity and is to be heated to 35 ºC. Using the psycrometric chart, determine the final relative humidity, wet bulb and amount of sensible heat energy needed.

Figure 4

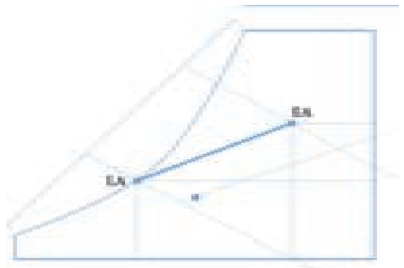
Locate the Outside Air (OA) Point on the chart. Draw a horizontal line to the 35 ºC dry bulb line. The final point is the intersection of the horizontal line and the 35 ºC dry bulb line.

Point 2:
Wet Bulb Temperature = 15,6 ºC
Relative Humidity = 9,23%
Enthalpy = 43,4 kj/kg
Point OA:
Enthalpy = 8,05 kj/kg
Specific Volume = 0,778 m³/kg
The required sensible heat energy is;
Q_s = V x ρ x Cp x ΔT
Q_s= (9000/(3600x0,778))x1,005x(35–0)
Q_s = 113 kW

Problem 3

Entering Air (EA) of 10000 m³/h at 30 ºC and %50 RH goes through a cooling coil with Leaving Air (LA) at 12,5 ºC and 98% RH. Determine the total heat removed, moisture removed (dehumidification) and the sensible heat ratio.

Figure 5

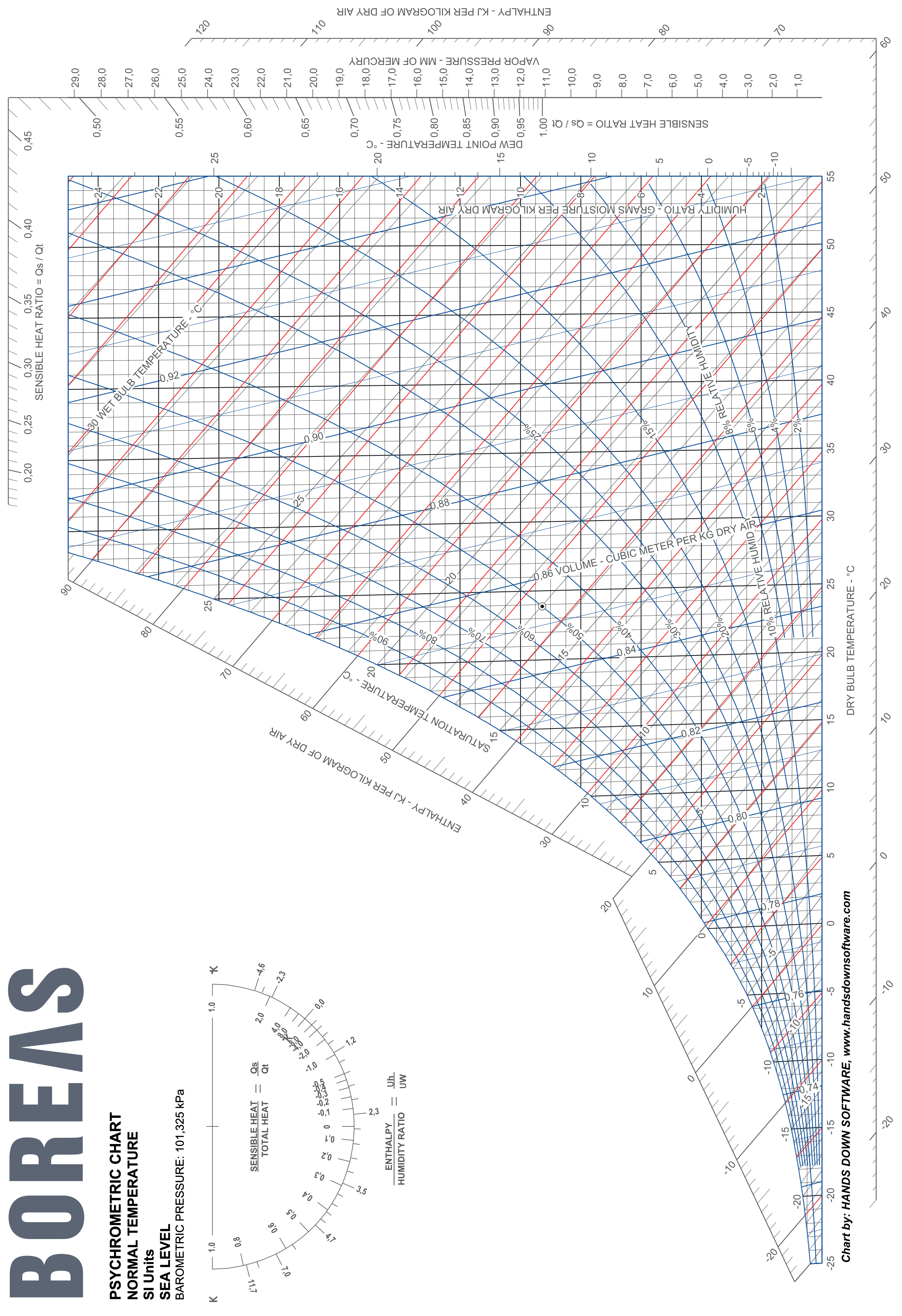


Point EA:
Enthalpy = 64,32 kj/kg
Humidity Ratio = 13,37 g/kg
Specific Volume = 0,877 m³/kg
Point LA:
Enthalpy = 34,97 kj/kg
Humidity Ratio = 8,88 g/kg
The Total Heat Removed is;
Q_t = (34,97-64,32)x(10000/3600)/0,877
Q_t = -92,97 kW
The Moisture Removed is;
W=(8,88-13,37)x(10000/0,877)/1000
= -51,2 kg/h
The Sensible Heat Ratio is determined by drawing a parallel line from the SHR index to the SHR Scale and reading the value.
SHR = 0,609

Commonly Used Equations

Q_s = V x ρ x Cp x ΔT Q_t = V x ρ x Δh $W_{humidification}$=V x ρ x ΔX

Q(kW) Heat, V(kg/s) Volume Flow, ρ(kg/m³) Density , Cp(kJ/(kg K) Specific Heat, T(ºC) Temperature, h(kJ/kg) Enthalpy, W(kg/h) Humidity, X(g/kg) Humidity Ratio


BOREAS
PSYCHROMETRIC CHART
NORMAL TEMPERATURE
SI Units
SEA LEVEL
BAROMETRIC PRESSURE: 101,325 kPa
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Uh / UW
ENTHALPY - KJ PER KILOGRAM OF DRY AIR
VAPOR PRESSURE - MM OF MERCURY
SENSIBLE HEAT RATIO = Qs / Qt
DEW POINT TEMPERATURE - °C
HUMIDITY RATIO - GRAMS MOISTURE PER KILOGRAM DRY AIR
WET BULB TEMPERATURE - °C
VOLUME - CUBIC METER PER KG DRY AIR
RELATIVE HUMIDITY
SATURATION TEMPERATURE - °C
DRY BULB TEMPERATURE - °C
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

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