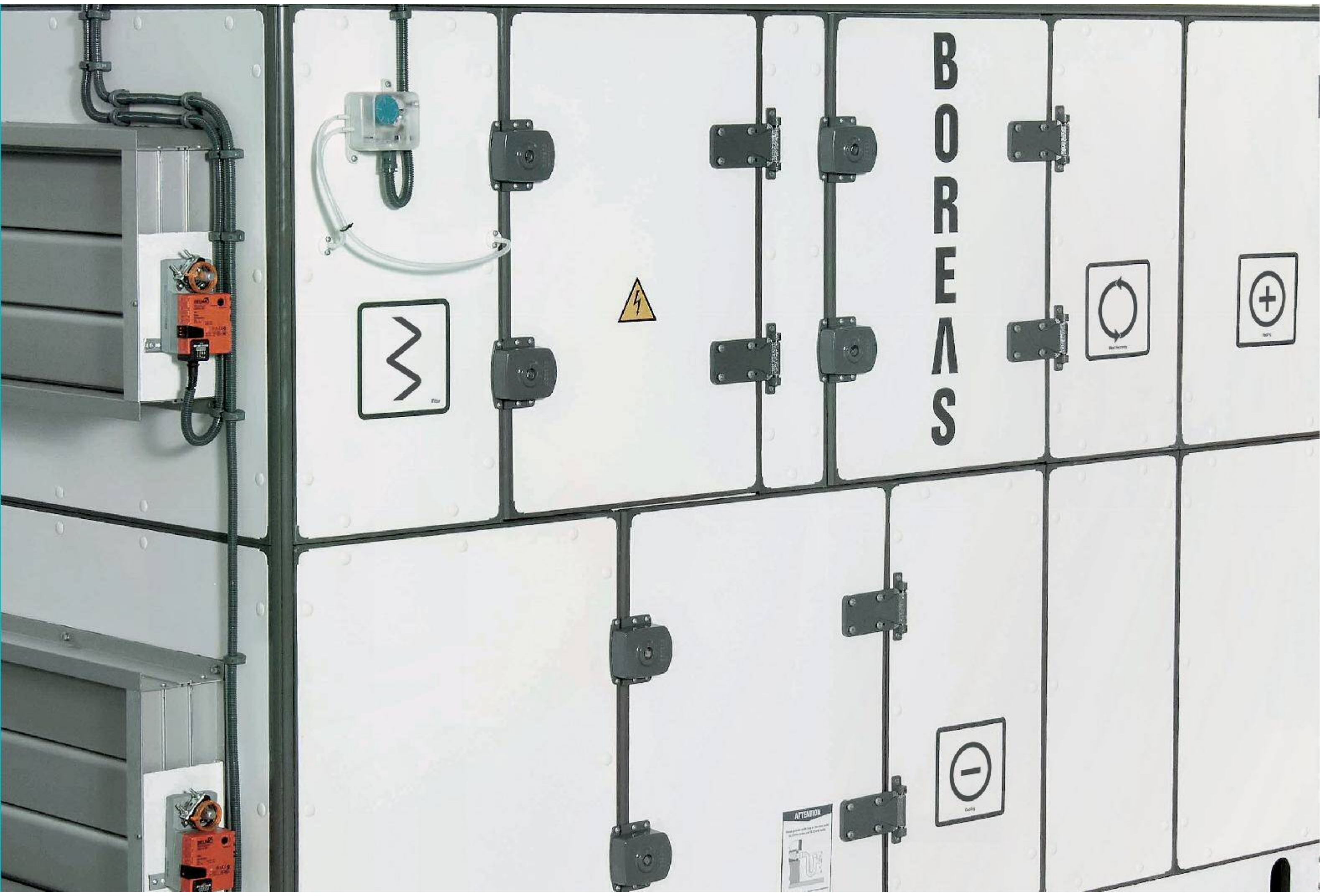


BOREΛS

POOLSIDE DE-HUMIDIFYING AIR HANDLING UNIT

BOREAS

Poolside De-Humidifying Air Handling Unit

CONTENTS

De-Humidification in Indoor Swimming Pools

Humidity in indoor pool spaces is an element that disrupts the conditions of comfort and is detrimental to the concrete, steel, and wood sections of the building when unless it is controlled.

During winter months and summer evenings when the outdoor temperature is lower than indoor temperature, the water vapor in the air causes visible condensation on wall surfaces, and particularly on window glasses.

In cases where relative humidity remains over 60% for extended periods, it will inevitably have detrimental effects on the building elements. When chlorine gas that evaporates from the pool water reacts with the condensed water it produces hydrochloric acid which is an abrasive chemical, accelerating corrosion.

High humidity also facilitates the growth of bacteria and fungi that are harmful to human health. Maintaining humidity between 50 and 60 % will significantly reduce the numbers and activity of microorganisms.

In summary, humidity is a component of air that needs to be controlled in pool spaces.

Table of Condensation Amounts (kg/h m^2)

Air Temperature (°C)	RELATIVE HUMIDITY (%)																	
	50	55	60	50	55	60	50	55	60	50	55	60	50	55	60	50	55	60
20	0.273	0.256	0.235	0.328	0.310	0.289	0.382	0.365	0.344	0.436	0.419	0.398	0.525	0.508	0.487	0.615	0.598	0.577
21	0.264	0.241	0.220	0.318	0.296	0.275	0.373	0.350	0.329	0.427	0.404	0.383	0.516	0.493	0.473	0.605	0.583	0.562
22	0.249	0.227	0.205	0.304	0.281	0.260	0.358	0.335	0.314	0.412	0.389	0.368	0.502	0.479	0.458	0.591	0.568	0.547
23	0.235	0.212	0.191	0.289	0.266	0.245	0.344	0.320	0.299	0.398	0.375	0.354	0.487	0.464	0.443	0.576	0.553	0.532
24	0.220	0.197	0.176	0.275	0.252	0.230	0.329	0.306	0.284	0.383	0.360	0.339	0.473	0.449	0.428	0.562	0.539	0.517
25	0.206	0.183	0.161	0.260	0.237	0.215	0.315	0.291	0.270	0.369	0.345	0.324	0.458	0.435	0.413	0.547	0.524	0.503
26	0.191	0.168	0.146	0.246	0.222	0.200	0.300	0.276	0.255	0.354	0.331	0.309	0.444	0.420	0.398	0.533	0.509	0.488
27	0.177	0.153	0.131	0.231	0.208	0.186	0.286	0.262	0.240	0.340	0.316	0.294	0.429	0.405	0.384	0.518	0.495	0.473
28	0.162	0.139	0.117	0.217	0.193	0.171	0.271	0.247	0.225	0.325	0.301	0.279	0.415	0.391	0.369	0.504	0.480	0.458
29	0.148	0.124	0.097	0.202	0.178	0.151	0.257	0.233	0.205	0.311	0.287	0.260	0.400	0.376	0.349	0.490	0.465	0.438
30	0.134	0.109	0.071	0.188	0.164	0.126	0.242	0.218	0.180	0.296	0.272	0.234	0.386	0.361	0.324	0.475	0.451	0.413
Water Temperature (°C)		24			26			28			30			32			34	

The figures in the table above were calculated for a pool surface area of 1 m^2, and assuming a Pool Activity Factor of 1. Follow Example 1 for different surface areas and Pool Activity Factors.

Design Conditions of Swimming Pools

Pool Type	Air Temperature, °C	Water Temperature, °C	Relative Humidity, %
Recreational Pools	24 - 29	24 - 29	50 - 60
Therapy Pools	27 – 29	29 – 35	50 – 60
Competition Pools	26 – 29	24 – 28	50 – 60
Diving Pools	27 – 29	27 – 32	50 – 60
Rehabilitation Pools	29 – 32	29 – 32	50 – 60
Hotel Pools	28 – 29	28 – 30	50 – 60
Thermal Baths	27 – 29	36 – 40	50 – 60

Reference: Ashrae HVAC Applications 2015 Handbook, Section 5.

Pool Type	Activity Factor (F_a)
When Pool Cover is in Use	0.02
Pools Outside Service Hours	0.5
Residential Pools	0.5
Floor Pools	0.65
Therapy Pools	0.65
Hotel Pools	0.8
Public Pools	1
Thermal Baths	1
Wave Pools	1,5

Wp = 4 x 10-5 x A x (pw - pa) x Fa Wp : The amount of evaporation, kg/hour

A : Pool surface area, m2

Pw : Vapour saturation pressure at surface temperature of pool, kPa

Pa : Saturation pressure at dew point temperature of the space, kPa

Fa : Activity factor

The "Evaporation Amount Table" above that was prepared using this equation is used for making practical and quick calculations.

EXAMPLE 1: Let us calculate the amount of evaporation that will occur in a 55 m^2 hotel pool with a pool surface temperature of 28°C, in an ambient temperature of 27°C and relative humidity of 55%.

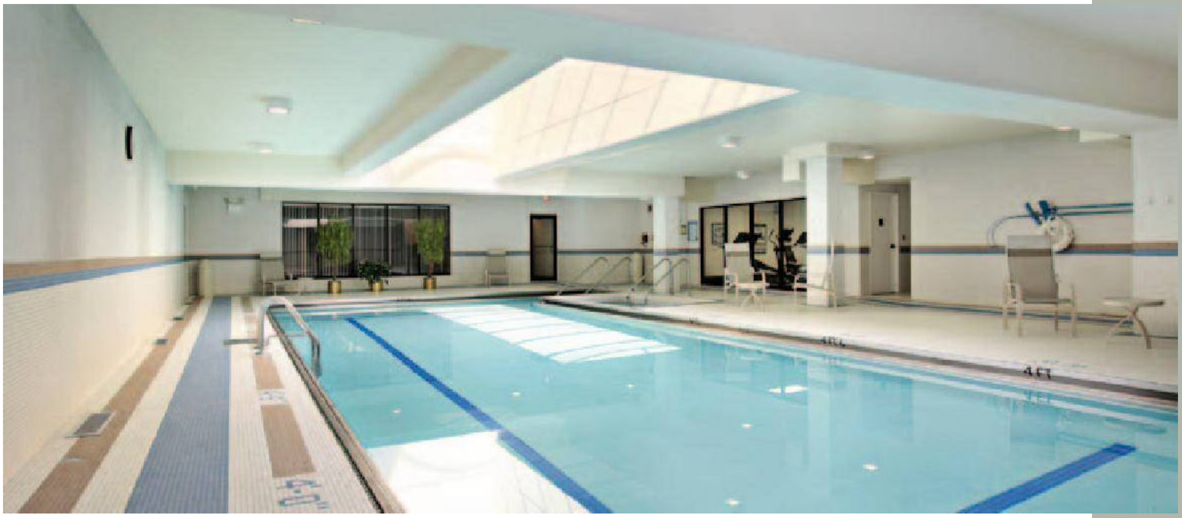
SOLUTION: The evaporation coefficient which corresponds to the ambient conditions and water temperature provided is read from the Evaporation Amount Table.

The non-activity dependent evaporation on the surface of 1 m^2 of pool surface with a pool surface temperature of 28°C, in an ambient temperature of 27°C and relative humidity of 55% is read from the table as 0.262 kg/h m^2 .

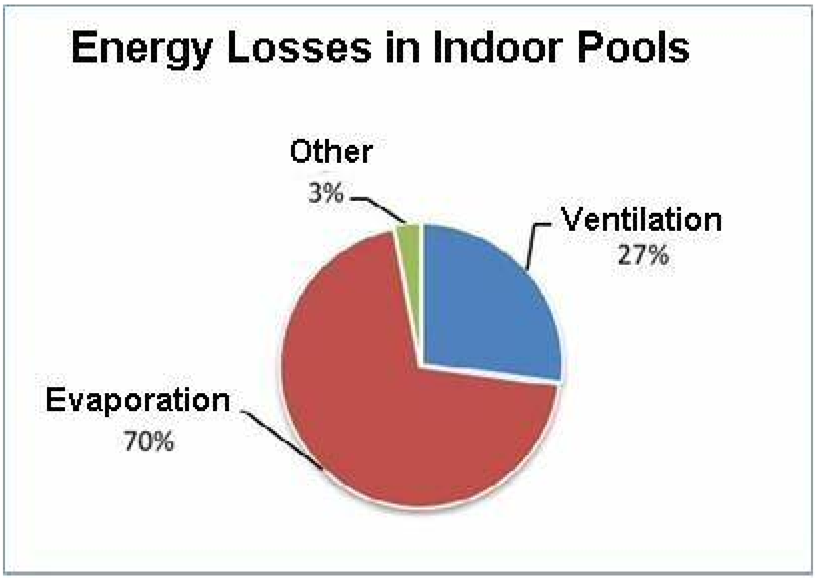
The Pa value according to the type of pool is determined from the activity

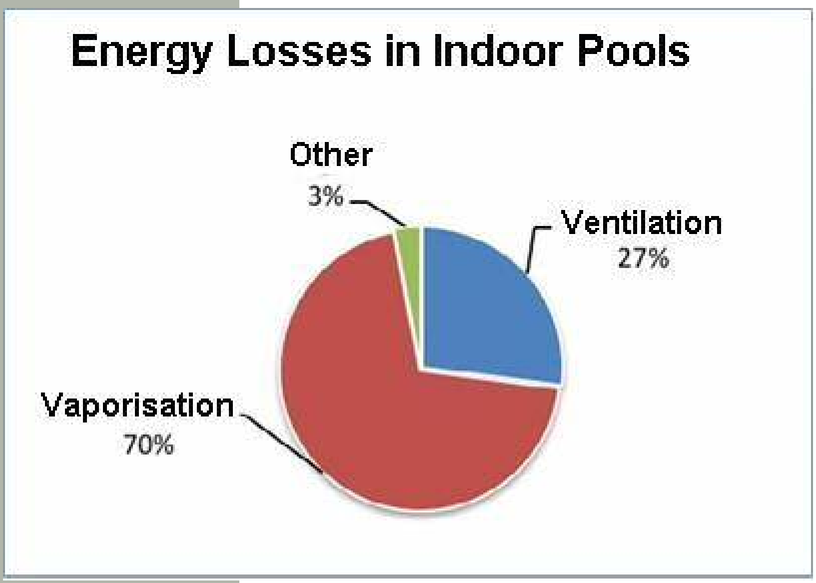
Factor table. → 0.8 (For Hotel Pools) Evaporation Amount is calculated as:

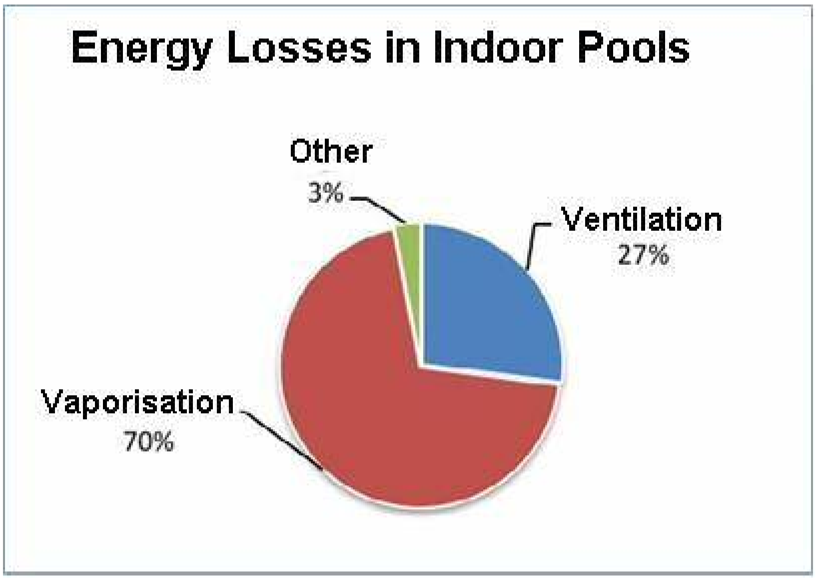
0.262 x 55 x 0.8 = 11.53 kg/h.



Tips for Energy Conservation in Indoor Pools







Ventilation

Ventilation is of critical importance for creating suitable indoor air quality, user comfort, and humidity control in indoor pool spaces.
According to Ashrae Standard Nr. 62-1 on "Ventilation for Acceptable Indoor Air Quality", a minimum of 2.4 L/s•m2 must be provided for the total surface area of the pool and deck, and a minimum of 4 l/s fresh air per person must be provided if there is a spectator stand. The standard also states that more fresh air can also be used for the control of humidity. Ashrae's "System and Applications Handbook" recommends 4-6 changes of air for rehabilitation pools and pools without spectators, and 6-8 changes of air for pools with spectators.

Ventilation system design is of critical importance in terms of energy efficiency. Constant de-humidification is required in indoor poor areas due to Evaporation. While the pool is in use, the minimum amount of fresh air required by the principles must be adjusted, and the fresh air should be increased depending on the number of spectators; fresh air can also be disabled when the pool is not in use.

The ASHRAE HVAC Handbook recommends that relative humidity levels of indoor environments be maintained between 40-60%. If relative humidity level is maintained below 50% evaporation from the pool and from people will increase, and if it exceeds 60%, it causes moulding and deformations in the building structure while also exceeding conditions of comfort for people. Furthermore creating a slightly negative pressure in the pool area will prevent the transfer of warm and humid air to other sections of the building and prevents the pool smell from seeping into adjacent spaces.

Ambient Temperature

Maintaining a proper balance between air and water temperatures will influence the comfort of users as well as energy efficiency. It is recommended that the air temperature be maintained two degrees higher than the temperature of the pool water. Cases where air temperature is higher than water temperature only apply to pools for the elderly, health pools, and hydro-massage pools. Air temperature may need to be maintained between 25°C to 27°C for reasons of comfort for users. High water temperature and low air temperature greatly increase the rate of evaporation, and this issue must be taken into consideration while designing the de-humidification system. The use of pool covers stops evaporation to a large extent, thus evaporation can be decreased outside the hours of operation in such cases of high air and low pool water temperature.

Pool Cover

K The use of covers in indoor pools minimises evaporation. When evaporation decreases, the indoor environment's need for ventilation and de-humidification is minimised. The practice of covering pool surfaces when the pool is not in use also reduces heat losses, reducing operational costs in a most effective manner. A saving of 50-70% can be achieved during periods when pool covers are used.

De-humidification

K Since there are many types of de-humidification requirements for climate control for indoor pools, a selection needs to be made between several de-humidification strategies with completely different initial investment and operational cost structures.

Rather than systems which do not utilize condenser heat, systems which use this to reheat the air, and recover energy by heating pool water should be selected.

The design of collective use pool buildings can be complicated and require consideration of many issues, such as suitable air current to prevent problems of condensation on building walls, air distribution at suitable velocity, and minimum air flow at the surface of the pool to maintain low evaporation.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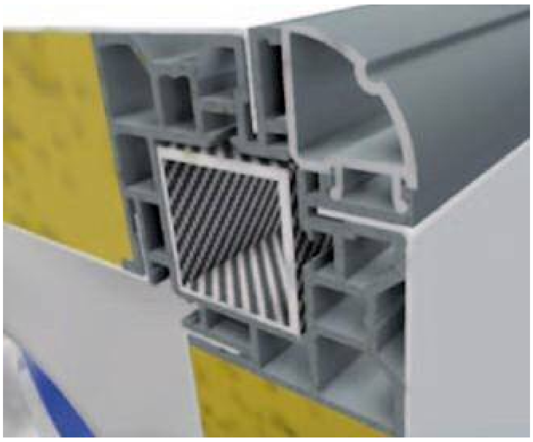
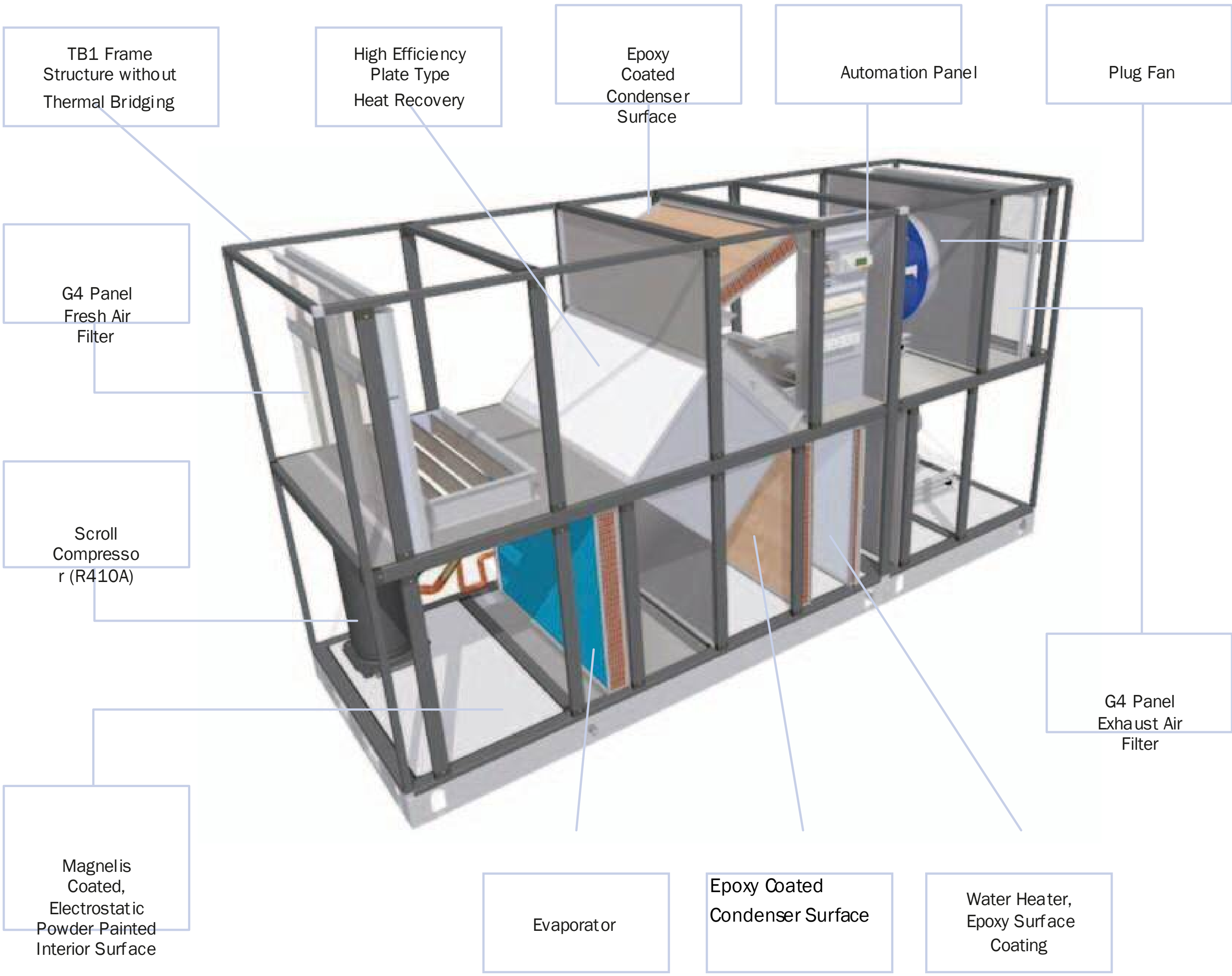
DESIGN PROPERTIES OF THE BOREAS POOLSIDE DE-HUMIDIFYING AIR HANDLING UNIT

Frame Structure

The frame structure of the BOREAS Poolside De-Humidifying Air Handling Unit comprises electrostatic oven painted box profiles manufactured from steel material with dimensions of 30x30 and 30x60 mm and a thickness of 2 mm, and aluminum corner and plastic fittings.



The BOREAS Poolside De-Humidifying Air Handling Unit is class D1, the highest class according to the EN 1886 Mechanical Strength test.



Panel Structure

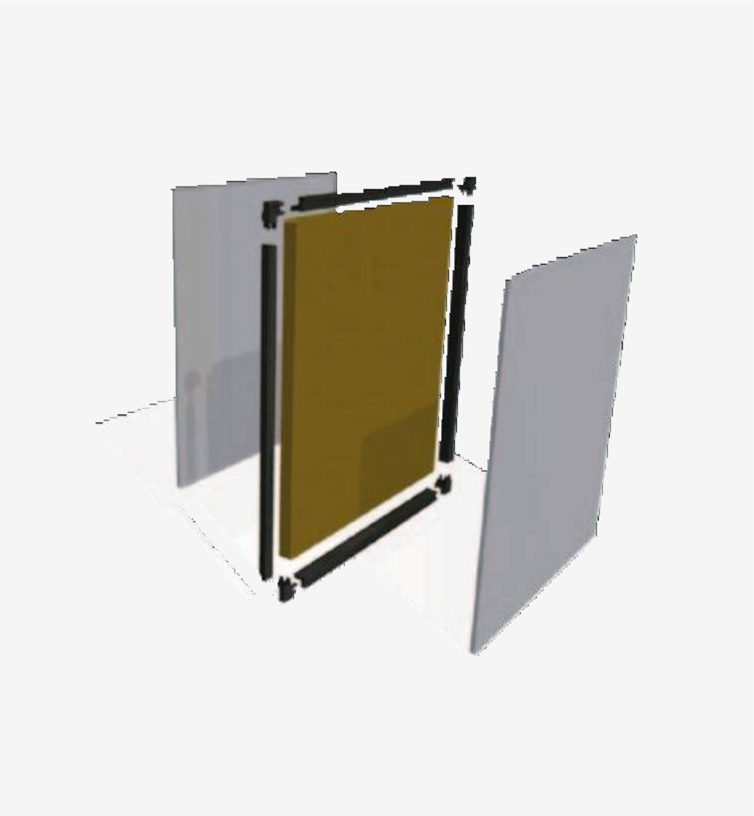
B Panel structure which forms the casing of the BOREAS Poolside De-Humidifying Air Handling Unit is the most and effective equipment that affects the overall mechanical performance of the unit.

The panel structure of the BOREAS Poolside De-Humidifying Air Handling Unit is designed to prevent thermal bridging between the internal and external environment. 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 a thermal bridge free structure. This property has significant part in achieving a thermal bridge free class of TB1 for the entire frame in tests conducted in accordance to the EN 1886 standard. The air leakage class has been measured as L1 due to EPDM hermetic seals used on connecting surfaces between the panel and the frame profile.

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.

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.

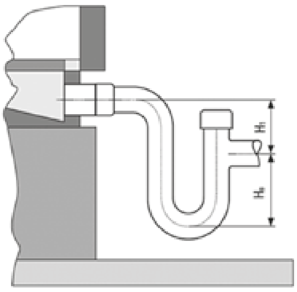
Custom manufactured EPDM-based porous seals with low thermal transmittance factor are used on the joints of panels and profiles.



The 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 possible. Otherwise, wet spaces will form within the unit and cause growth of micro organisms.

Drain pans are manufactured from stainless steel sheet as a standard. The pan's double inclined design allows the water to accumulate in the corner. The water is then 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.



Negative Pressure

$H_1 = \frac{P}{10} + 20$ mm

$H_S(mm) = P \times 0.075$ mm

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 internal pressure of the air handling unit 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.

Hygiene Properties and Corrosion Resistance

The BOREAS Poolside De-Humidifying Air Handling Unit is manufactured with high corrosion resistance. This is achieved with the practices mentioned below.

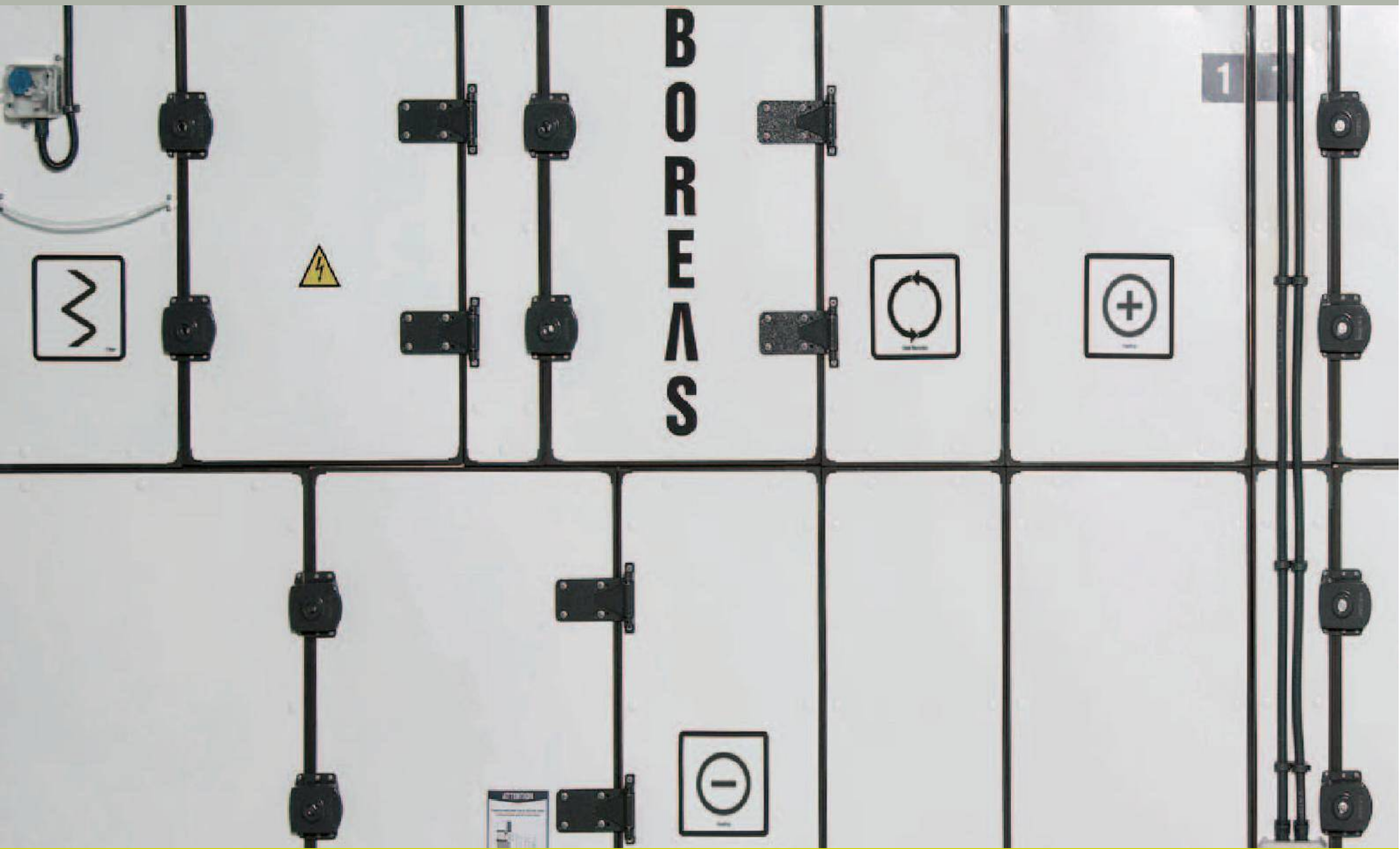
All interior metal surfaces are electrostatic oven painted. The evaporator surface is manufactured to conform to hydrophilic, while other exchanger surfaces are manufactured to conform to epoxy coated hygiene standards.

All plastic materials used do not permit the growth of bacteria and funguses due to special additives.

The entire interior surface has a smooth design and is thus easy to clean.

Boreas Psychometric Calculation Software

Evaporation calculations can be performed with great accuracy for all types of pools, with the Boreas Indoor Pool evaporation estimator. The software calculates evaporation amounts based on various use conditions, water temperature, air temperature, and pool surface area, according to the ASHRAE calculation method.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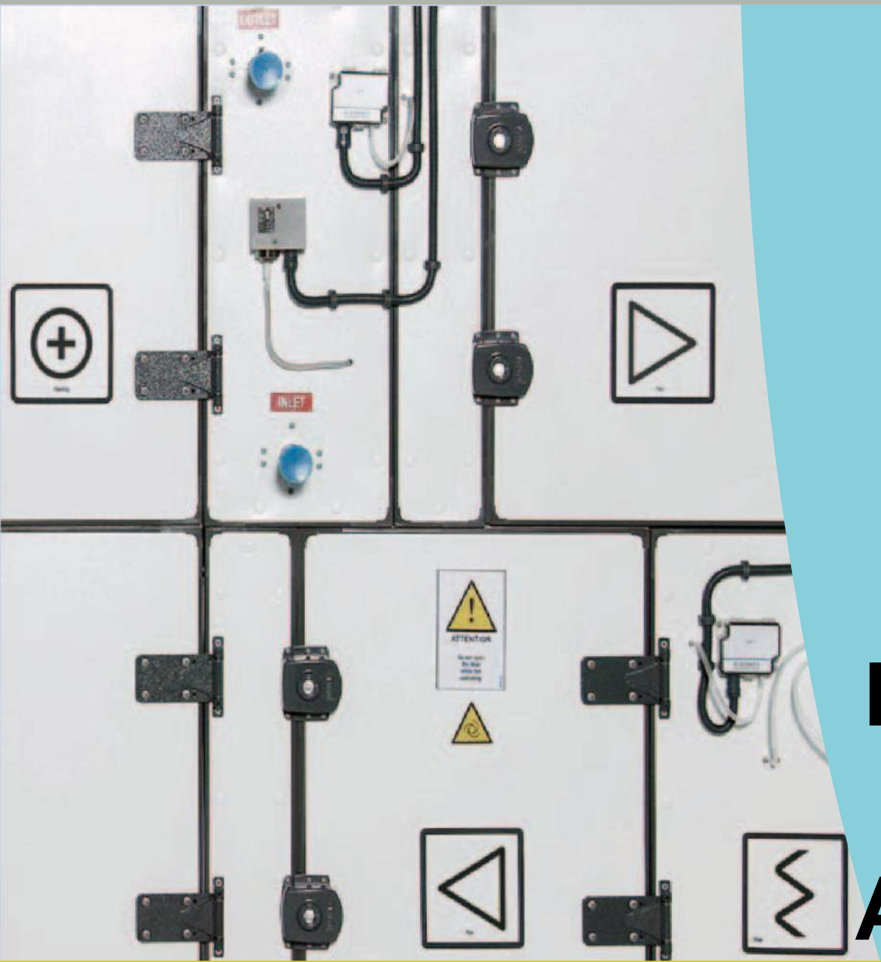
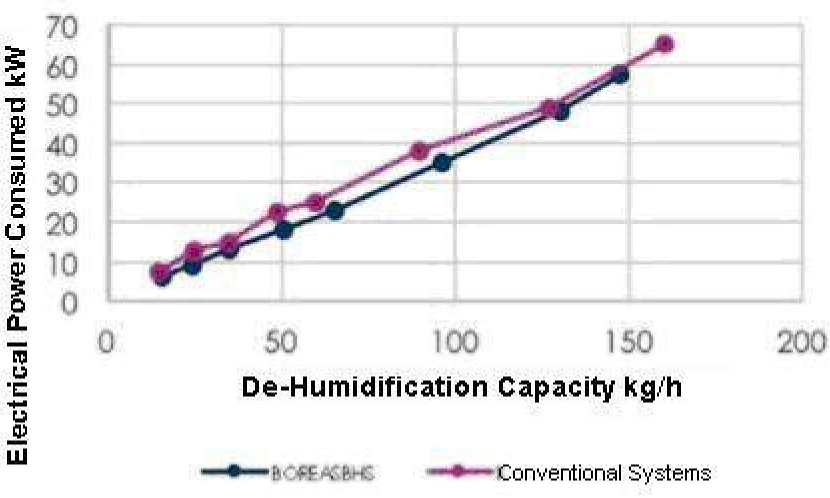


TECHNICAL PROPERTIES OF THE BOREAS POOLSIDE DE-HUMIDIFYING AIR HANDLING UNIT

Operating Principle

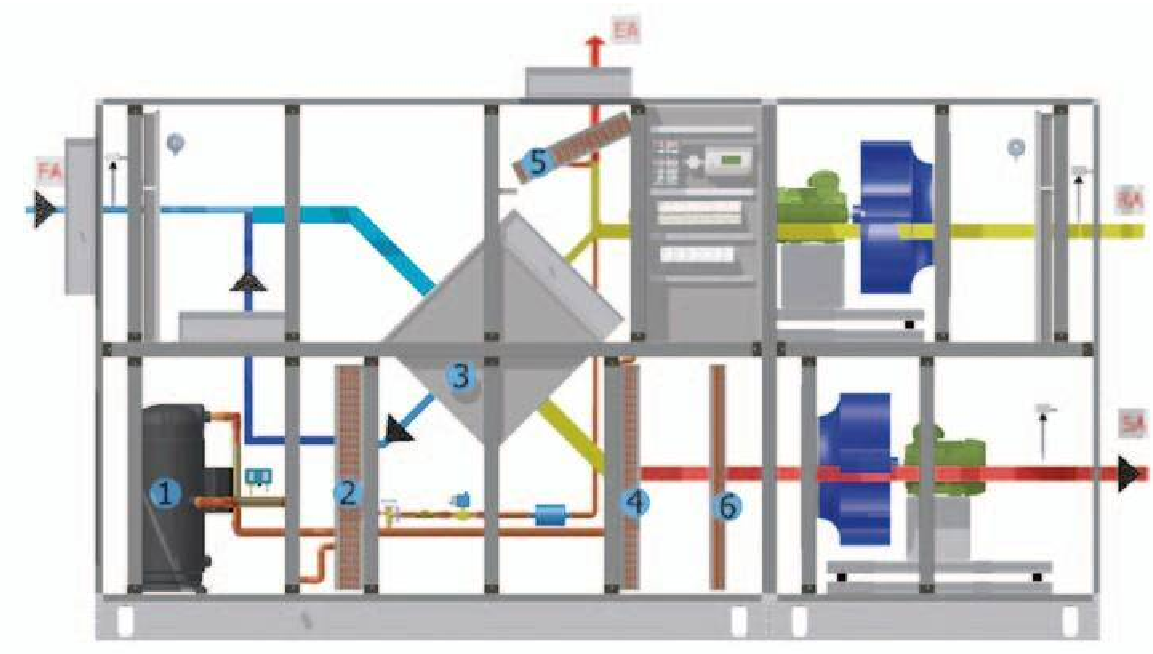
The BOREAS Poolside De-Humidifying Air Handling Unit is different from conventional system poolside de-humidifying air handling units due to its low overall power consumption. In conventional system poolside de-humidifying air handling units, while supplying the fresh air needed, the moisture from the humid air received from the pool environment is exhausted in equal ratio to the fresh air.

This leads to unnecessary energy losses and in consequence, an increase in the electrical energy spent in the compressor. Since exhaust is performed before the cooling process, Boreas does not waste energy, and provides the desired de-humidifying capacity with a smaller compressor capacity. Thus over 8% of electricity is saved as compared to conventional units. In addition to the heat energy absorbed by the cooler while cooling is performed for de-humidification purposes, the work applied by the compressor is also transferred in the form of heat energy to the supply air via the condenser. This causes uncontrolled blast temperatures (45-50°C) and disrupts the comfort conditions of the pool space other than in winter conditions.



A specially designed air cooled dual condenser system is used in the BOREAS Poolside De-Humidifying Air Handling Unit. One of these condensers is placed on the fresh air line while the other is placed on the exhaust line.

While the needed fresh air is being supplied, the exhausted return air is passed over the exhaust condenser without being subjected to cooling, and discharged into the outside environment. Thus the heat energy generated by the compressor for the cooling process is discharged over the exhaust condenser, and not added to the supply air temperature. With this method, supply air temperature can be controlled and maintained in the range +33 °C / +35 °C which does not disrupt the conditions of comfort.



1- Compressor
2- Evaporator
3- Plate Type Heat Recovery
4- Fresh Air Condenser
5- Exhaust Condenser
6- Water Heating Coil

FA: Fresh Air
SA: Supply Air
RA: Return Air
EA: Exhaust Air

Dimensions

TABLE OF DIMENSIONS FOR THE BOREAS POOLSIDE DE-HUMIDIFYING AIR HANDLING UNIT

MODELS		BHS 2500	BHS 4000	BHS 5500	BHS 8000	BHS 10000	BHS 15000	BHS 20000	BHS 25000
DIMENSIONS	L	4100	4100	4100	4920	5100	5100	5250	4920
	H	1574	1574	1574	2256	2888	2888	2888	2888
	W	612	918	1224	1224	1224	1530	2142	2448
Weight	kg	1080	1320	1545	1950	2275	2740	3515	4520

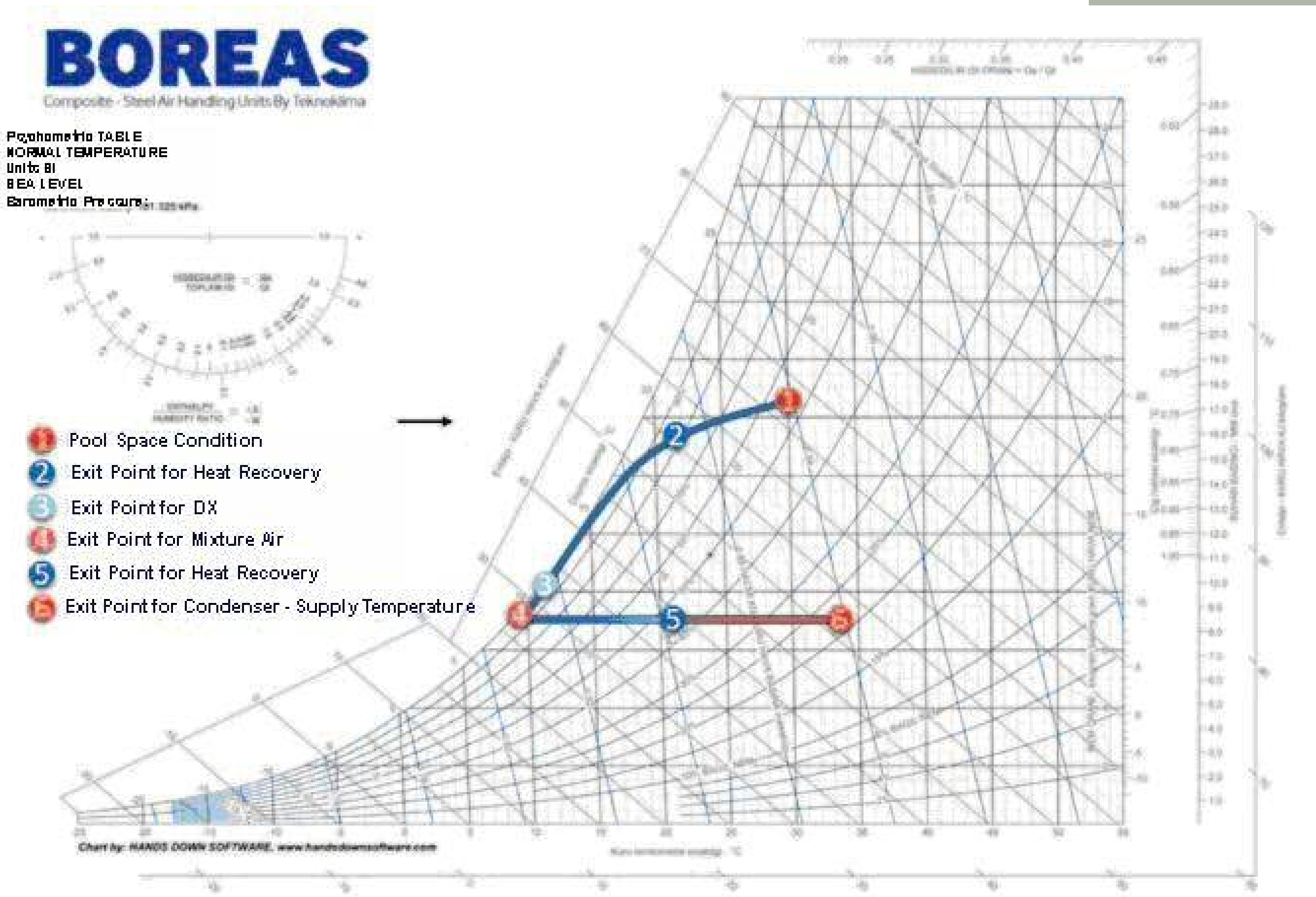
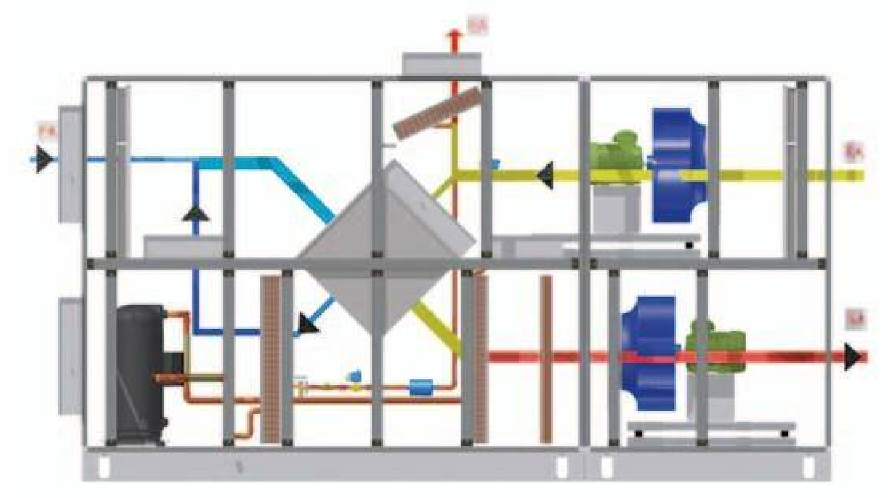


TABLE OF TECHNICAL SPECIFICATIONS FOR THE BOREAS POOLSIDE DE-HUMIDIFYING AIR HANDLING UNIT									
MODEL		BHS 2500	BHS 4000	BHS 5500	BHS 8000	BHS 10000	BHS 15000	BHS 20000	BHS 25000
De-humidification Capacity	kg/h	15.7	24.5	35	51	65.5	96.5	130	147.5
Pool Area[1]	m²	55	85	122	178	229	337	455	515
Pool Area[2]	m²	165	257	368	536	690	1015	1368	1550
Air Flow Rate	m³/h	2500	4000	5500	8000	10000	15000	20000	25000
Cooling Capacity	kW	13.5	20.9	30	44.4	55.3	79.8	104	117
Water Heater Capacity	kW	30	53	67	97	121.5	184	252.5	345
Heat Recovery Capacity	kW	7.3	11.5	16	22.2	32.5	48.2	64	81
Fresh Air External Pressure	Pa	350	350	350	350	350	350	350	350
Exhaust Line External Pressure	Pa	400	400	400	400	400	400	400	400
Aspirator Motor Power	kW	0.75	1.5	2.2	3	4	7.5	11	7.5 x 2
Ventilator Motor Power	kW	0.75	1.5	2.2	3	4	7.5	11	5.5 x 2
Electrical Power Drawn	kW	5.8	8.6	12.8	17.5	22.6	35.4	48	56

1. *In Pool Surface Area calculations according to the Ashrae HVAC Applications 2015 Handbook, Pool Water Surface Temperature was taken as 27°C, the Ambient Temperature as 30°C, Relative Humidity as 55%, and Activity Factor as 1.5.*
2. *In Pool Surface Area calculations according to the Ashrae HVAC Applications 2015 Handbook, Pool Water Surface Temperature was taken as 27°C, the Ambient Temperature as 30°C, Relative Humidity as 55%, and Activity Factor as 0.5.*

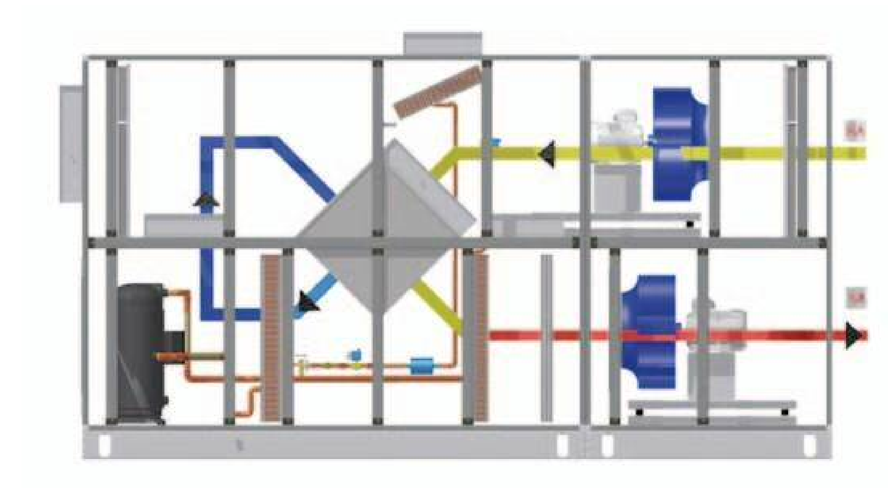
Operating Scenarios

Scenario 1 - Daytime Operation – Heavy Pool Activity



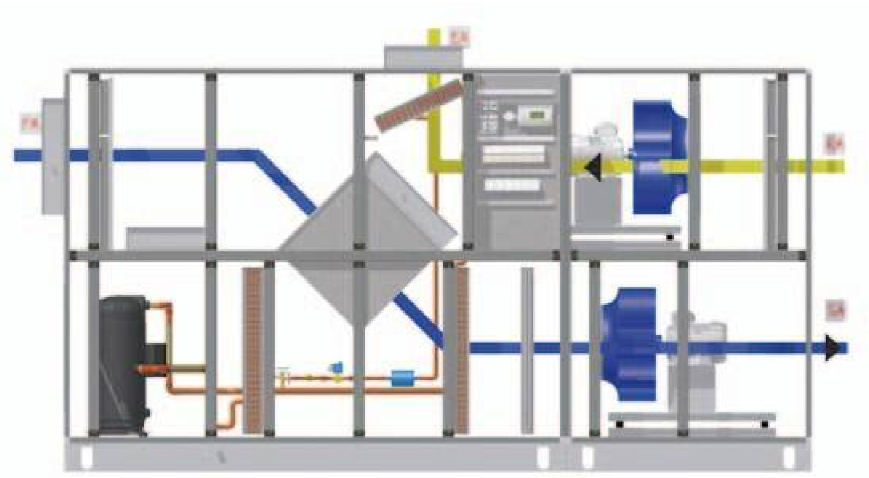
Air Flow Rate	Operates with 30% (maximum) Fresh Air and 70% Return Air
Cooling System	The Cooling System is Enabled (De-Humidification is Performed)
Condenser	Both or One of the Condensers will be Enabled
Fans	The Return Fan and Supply Fan are Enabled

Scenario 2 - Light Pool Activity

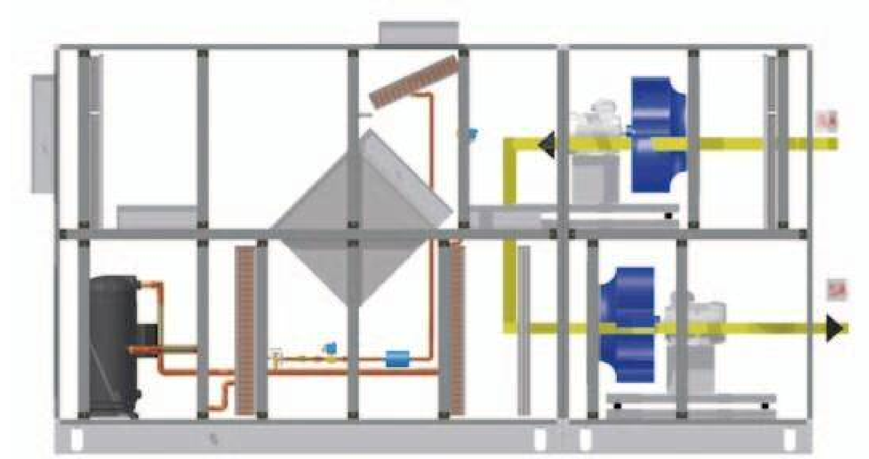


Air Flow Rate	Operates with 100% Return Air, Fresh Air is not Needed
Cooling System	The Cooling System is Enabled (De-Humidification is Performed)
Condenser	The Supply Line Condenser is Enabled, the Exhaust Condenser is Disabled
Fans	The Return Fan and Supply Fan are Enabled
Hot Water Heating Coil	Will Come Online as Needed

Scenario 3 - Seasonal Transition Operation – No De-Humidification Process



Air Flow Rate	Operates with 100% Fresh Air.
Cooling System	The Cooling System is Disabled (De-Humidification is not Performed)
Condenser	The Supply Line Condenser is Disabled, the Exhaust Condenser is Disabled
Fans	The Return Fan and Supply Fan are Enabled
Hot Water Heating Coil	Will Come Online as Needed



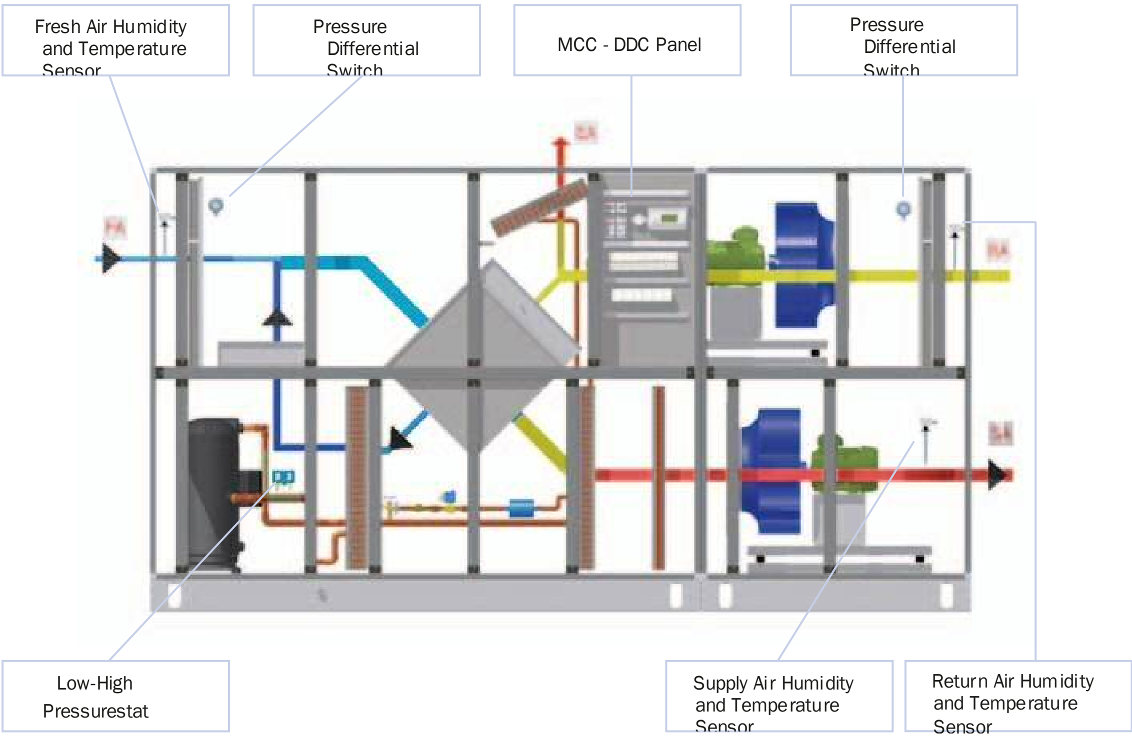
Scenario 4 – Night Time Operation – No De-Humidification Process

Air Flow Rate	Operates with 100% Return Air.
Cooling System	The Cooling System is Disabled (De-Humidification is not Performed)
Condenser	The Supply Line Condenser is Disabled, the Exhaust Condenser is Disabled
Fans	The Return Fan is Disabled, the Supply Fan is Enabled
Hot Water Heating Coil	Will Come Online as Needed

The Automation System

The automation system of the BOREAS Poolside De-Humidifying Air Handling Unit includes all control and power components needed to implement operating scenarios on the unit and within the MCC-DCC panel.

All scenarios are pre-loaded in the control card. Power supply from the mains is sufficient for commissioning, no additional automation application is needed.



Control Point	Application Point	Equipment Used
Humidity and Temperature Control	Outdoor Air Temperature, Return Air Temperature, Supply Air Temperature	Humidity and Temperature Sensor
Filter Dirtiness Control	Fresh Air Filter and Return Air Filter	Pressure Differential Switch (0-250Pa)
High -Low Pressure Control	Lift and Force Line of the Compressor	Low-High Pressurestat with Manual Reset
Damper Control	Fresh Air, Mixture, Bypass, Intake Line Dampers	Proportional and On/Off Damper Motor

BOREAS POOLSIDE
DE-HUMIDIFYING AIR HANDLING UNIT

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