AIR HANDLING UNITS
TECHNICAL CATALOG

HSK®

30th year

Tecnical Publication Nr: 1

HSK®

"Powered by Self Quality"

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Air Handling Units Technical Catalog

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1. AIR CONDITIONING

"Air conditioning" is defined as the conditioning of indoor air in order to maintain its temperature, humidity, cleanliness and air movement at levels suited to human health and comfort or the industrial processes conducted.

Air Conditioning Procedures

1.1 Purpose and Fields of Application or Air Conditioning

Air conditioning is done for comfort or industrial purposes.

1.1.1 Comfort air conditioning

People feel comfortable in specific temperature and humidity ranges and in environments where the air is clean. "Comfort air conditioning" is the conditioning of air to achieve such an environment. People living in environments with proper comfort air conditioning get tired less, get sick less, and work with higher efficiency.

The factors that should be controlled to achieve comfortable conditions with air conditioning systems are the following:

a) Air Temperature

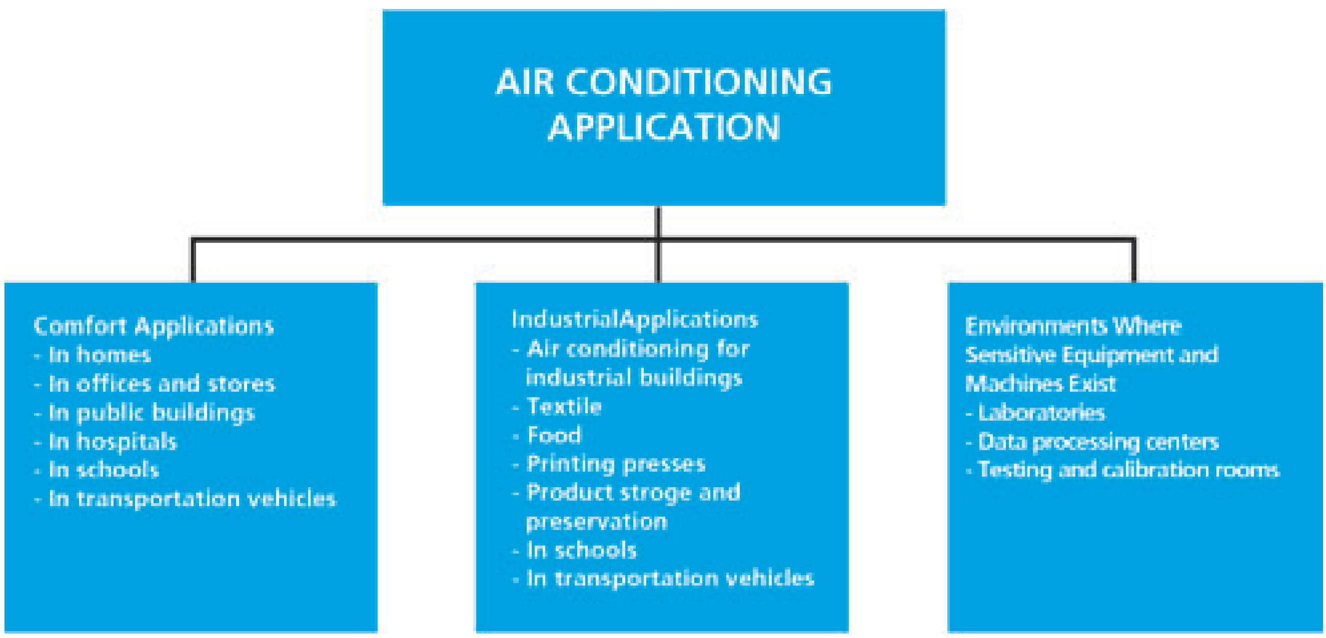
It is quite important that ambient temperature be maintained at the desired level regardless of the outdoor temperature. Though the range changes somewhat in winter and summer conditions, people are comfortable in the approximate temperature range 21-26°C. According to ISO 7730, these values are specified as 20-24°C in the heating season, and 23-26°C in the cooling season, both at 50% relative humidity. The air conditioning system used should be capable of cooling the indoor environment 6-7°C lower than the outdoor temperature in the summer.

b) Relative Humidity

Relative humidity is defined as the ratio of the water vapour in the air to the maximum amount of water vapour that can exist in the air at the same temperature. Relative humidity has a significant effect on comfort. The relative humidity range desired for comfort is roughly 35-60%.

C) Cleanness

Removal of foreign materials like dust and microbes from



the air is quite important for human health. In recent years, many diseases have been diagnosed that result from contaminated or low quality indoor air. Thus, one of the conditions expected from air conditioning equipment is to receive the outdoor air by filtration and removing dust, dirt and microbes.

d) Air Velocity

The air movement velocity varies with the temperature and the conditions of use of the space. In spaces such as meeting rooms and offices where high mobility operations are not conducted, the air velocity should be 0.15 m/s for cooling and 0.3 m/s for heating. In spaces of higher activity such as shopping centers, the air movement velocity can be increased a little more and conditioned between the values of 0.2-0.35 m/s.

1.1.2-Industrial Air Conditioning

Industrial production required that appropriate environmental conditions be created. In order to store the manufactured products, these conditions must be such that they preserve the structure of the product. While conditioning industrial spaces, and creating conditions where products will be manufactured and stored, the conditions required for the health and maximum efficiency of the working staff are taken into consideration and these conditions are optimized.

1.2 Classification of Air Conditioning Systems

1.2.1 Central Systems

These systems are used primarily for the conditioning of larger buildings. Air handling units, air ducts, vents and/or fan coil units etc. constitute the system components. Heating-cooling-ventilation and humidity control is achieved by circulating water, air or coolant within the tubes and ducts of the system. Central systems can be classified in three main groups;

a) All-Air Systems

These are systems where air is used as heat transfer fluid. These systems provide sensible and latent cooling by transferring air conditioned by cooling-de-humidification processes to the living space through ducts and provide heating by conditioning heated air and transferring it to the living space through ducts.

b) All-Water Systems

The living space is heated or cooled by fan coil units places in each living space. The cold water required for cooling is transferred to the installation by pumps from a central cooling group (a chiller), while the hot water required for heating is transferred to the installation by pumps from the central boiler system. The comfort conditioning of spaces is achieved by thermostat.

c) Air-Water Systems

Air and water systems employ the process of cooling or heating spaces in a way that will also meet people's fresh air requirement, by transferring clean air that is conditioned in a central unit or water that is cooled in a central cooling group to fan coil units.

1.2.2 Local Systems

a. Packaged Units

These are units which contain all equipment within a single body, that are capable of heating, cooling, and dehumidification and that allow for command control.

- Floor Standing
- Floor Type
- Ceiling Mounted
- Window Type

b. Split Type Air Conditioners

These are units that consist of two parts -an internal and external unit-, which are capable of heating, cooling and dehumidification and which allow command control.

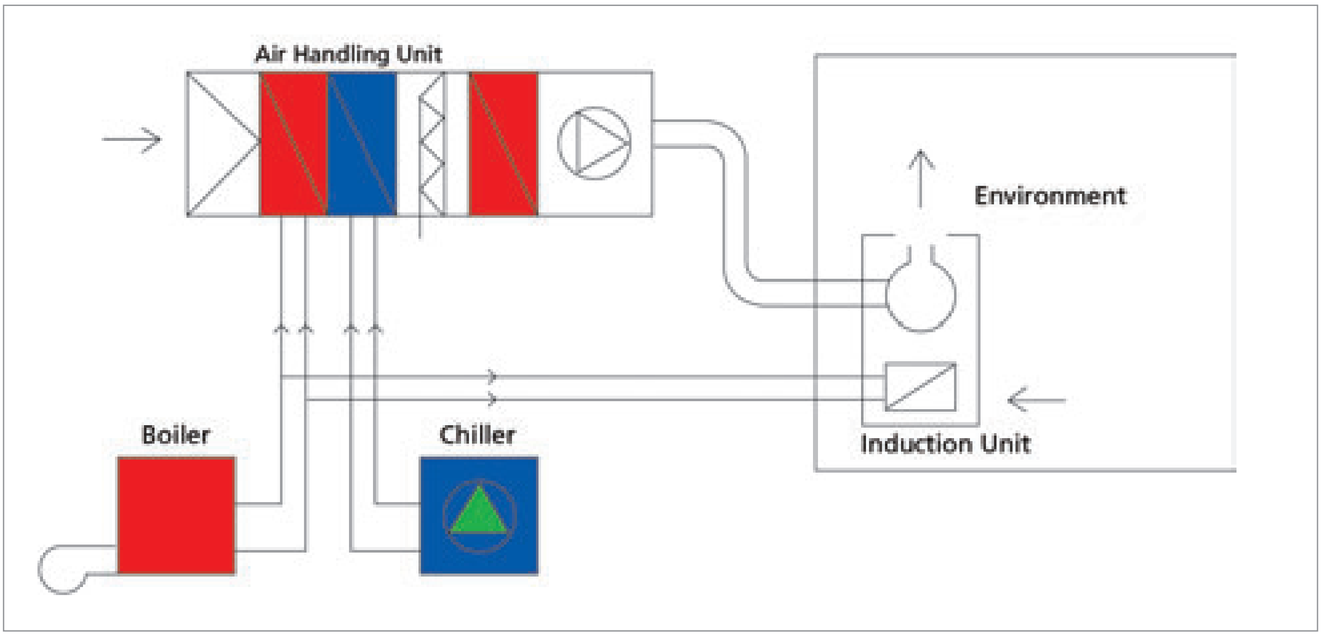
- Wall Mounted
- Ceiling Mounted
- Window Mounted
- Floor Type
- Floor Standing
- Duct Type
- Concealed Duct Type

1.3 Air Conditioning System Elements

Elements which constitute the system that conditions a space are the boiler, the water cooling group (chiller), the air handling unit, ducts and installation elements. Selection of these elements to be compatible with each other has an impact on the overall performance of the system.

The following factors should be considered in the selection of air conditioning systems:

- Initial investment cost
- Comfort conditions
- Noise
- Aesthetics
- Operating cost
- Ease of installation
- Energy expenditure
- Ease of operation



Water-Air System Schematic

1.3.1 Water Cooling Group

Circuit Elements

a) Compressor
b) Condenser
c) Compensating Element
d) Evaporator
e) Other Heat Exchangers
f) Pressurized Tanks
g) Filter-Dryer
h) Oil Separator
i) Liquid Separator
j) Adjustment Devices
k) Operating Devices
l) Safety Devices
m) Indicators
n) Other elements

a) Compressor

Compressors are classified in the following manner according to their body structure:

- Open compressors
- Semi-hermetic compressors
- Hermetic compressors

Another classification method is based on the compression principle

- Piston type compressors
- Screw compressor
- Centrifugal compressors
- Rotary compressors
- Scroll compressors

b) Condenser

We condensers according to type and structure

- Air cooled condensers
- Water cooled condensers
- Evaporative condensers

c) Compensating Element

These are grouped in four classes:

- Capillary tube
- Automatic fixed pressure expansion valves
- Thermostatic expansion valves
- Various float valves

d) Evaporator

It is nearly impossible to make a classification for coolers. This is because coolers in all conceivable types that fit diverse applications are manufactured. However, common types are:

- Block coolers
- Finned block coolers
- Shell and tube coolers
- Plate type coolers

e) Other Heat Exchangers

In cooling systems, various heat exchangers are used in addition to the condenser and cooler.

- Heat-steam heat exchanger
- Liquid separator exchanger
- Exchangers used for oil-water separation
- Exchangers used to cool superheated steam (desuperheaters)
- Exchangers used in various brine systems

f) Pressurized Tanks

The most commonly used pressurized tanks include:
- Liquid tanks used as coolant depositories
- High pressure side tank, low pressure side tank used in liquid pump systems
- Liquid transfer tanks
- Oil separator tanks

g) Filter-Dryer

The compensating element has one of the most important jobs in the cooling system. Here, the coolant is forced to pass through a small section. Thus the coolant should be free of contaminants. The passage of foreign materials is prevented by equipping the liquid line with a filter-dryer.

h) Oil Separator

In cooling systems, a quantity of oil leaves the sump along with the hot coolant exiting the outlet of the compressor. The amount of oil can vary according to the compression ratio and the operating regime of the system. Particularly in low temperature applications, since the return of the oil leaving the compressor has critical importance, an oil separator is mounted on the compressor outlet.

i) Liquid Separator

It prevents the liquid coolant coming from the system to enter the compressor and in time evaporates this liquid and gives it to the system.

j) Adjustment Devices
- Fixed pressure return valve
- Evaporator pressure regulator
- Liquid injection valve
- Liquid injection valve
- Water temperature adjustment valve

k) Operational Devices
- Thermostat
- Low pressure ?cut-out switch
- Capacity control pressurestats
- Various solenoid valves
- Outlet line check valve
- Stop valves

l) Safety Devices
- Low and high pressurestat
- Safety valve
- Oil pressurestat
- Freeze-free thermostat

m) Indicators
- Manometers
- Thermometers
- Liquid flow indicators
- Oil level indicators
- Liquid level indicators
- Flow measurement devices

n) Other Elements

Other elements completing the cooling system which we have described in general are:
- Other heat carriers that serve as intermediaries, water, air, brines
- Pumps and fans which help them circulate
- The tubing system in which this circulation occurs
- Water cooling towers and the like

1.3.2 Boiler

Hot Water Boiler

The quality of operation of a boiler is gauged by looking at three values that operate in opposite directions.

The first factor is the boiler's "thermal efficiency". Efficiency values for hot water boilers vary between 75 -90% depending on fuel type and construction.

The second factor is the "amount of average heat" generated on unit heating surface. The larger this value is, the smaller the boiler in the same capacity is.

The third factor is "pressure drop" in boilers on the gas side. This value should be as low as possible.

Consequently, a truly good boiler is one which has high thermal efficiency, whose heating surface has been selected optimally and which has low pressure loss.

Types of Hot Water Boilers

Many different types of hot water boilers are available for application. Hot water boilers are grouped in the following manner according to the type of burning chamber and general form:

a) Cast Iron Boilers: They are used in hot water and low pressure steam generation.

a) Steam boilers with blast burner

b) Steam boilers with atmospheric burner

b) Steel Boilers

c) Semi-cylindrical Steel Boilers

d) Cylindrical steel boilers

e) Radiant type steel boilers

f) Special boilers manufactured for natural gas

2. AIR HANDLING UNIT

Air handling units condition indoor air with their heating, cooling, humidification and de-humidification functions. Furthermore, air handling units supply the fresh air requirement of the environment with filtered air.

2.1 Air Handling Unit Performance Standards

Up until the 1970's air handling units were expected to provide a determined temperature or humidity, yet with today's developing technology the changing concept of comfort has led to a new approach to air handling units. In line with the needs of our age, air handling units are expected to have other features than temperature and humidity adjustment. For this reason, many detailed studies have been conducted in recent years with respect to elements used in air handling units and standards have been developed by independent organizations.
There are two European Standards (EN) in existence that classify the construction properties and equipment performance figures of air handling units.

EN 1886
"Air handling units - Mechanical Performance"

EN 13053
"Air handling units - Ratings and performance for units components and sections"

According to these standards, mechanical strength, block air leakage, filter bypass leakage, thermal conductivity, thermal bridging, and acoustic isolation tests are conducted. In order to perform these tests, a model box bearing similar design properties to the air handling unit is manufactured and tests are performed on this model box.

The unit casing, is among the major elements of the air handling unit. For comparability of unit casings with respect to quality, classes have been developed and test methods have been declared for each specified criterion.

The properties sought in air handling unit casings are the following:
- Low thermal conductivity coefficient
- Low heat bridging
- Low sound permeability
- Low air leakage
- Capability to bear air handling unit elements and with stand the positive and negative pressures created within the unit
- For its materials to be environmentally friendly, hygienic and have the desired fire rating
- That rain or snow does not permeate units that are places outdoors

2.1.1 Mechanical Strength

There are two basic criteria for mechanical strength:
- Relative bending value of the body at design conditions (mm/m)
- Mechanical strength of the body at maximum fan operating pressure, indicates that there is no permanent deformation in the body under this pressure.

Relative Bending Test - conducted at 1000 Pa pressure and under vacuum (prEN 1886)
Relative Fan Pressure Test - conducted at 2500 Pa pressure and under vacuum (prEN 1886)

Casing Strength EN 1886		
Strength Class	Maximum Relative Curvature mm/m	Resistant to Maximum Operating Pressure of Fan
D1	4	Yes
D2	10	Yes
D3	Not required	Yes

2.1.2 Air Leakage from the Body

Air leakage tests are performed in the following manner depending on the construction and nominal operating conditions of the air handling unit:

- All cells operating under vacuum at 400 Pa negative pressure
- For systems with an operating pressure less than 700 Pa, the test is conducted at 700 Pa; while in cases with higher operating pressures, the test is conducted under operating pressure.

The permitted leakage amounts are determined with respect to the class of filter used in the cell being tested.

Casing Air Leakage EN 1886		
Leakage Class	Maximum Leakage (-400 Pa) L x s-1 x m-2	Filter Class (EN 779)
L1	0,15	Better than F9
L2	0,44	F8-F9
L3	1,32	G1-G7

Casing Air Leakage EN 1886	
Leakage Class	Maximum Leakage (-700 Pa) lxs-1xm-2
L1	0,22
L2	0,63
L3	1,90

2.1.3 Filter Bypass Leakage

Filter bypass leakage pertains to the amount of unfiltered air that passes through the filter cell. Unfiltered air flow, is the sum of air leaking from the edges of the filter casing without passing through the filtering element and the air escaping from the panels into the vacuum cell succeeding the filter cell. Filter bypass leakage tests are conducted under a pressure differential of 400 Pa on the filter section. The following table shows the acceptable leakage rates (%k) of the design air flow by class of filter.

Maximum permissible filter bypass leakage EN 1886					
Unit Filter Class	G1-F5	F6	F7	F8	F9
Bypass Leakage Factor k (%)	6	4	2	1	0.5

2.1.4 Thermal Conductivity

The temperature and humidity of the air within the casing should be different from the outside air. To save energy, heat transfer between the unit's internal air and the outside air should be reduced. In other words, thermal resistance of the air handling unit casing should be increased. High thermal resistance of the casing is important not only in terms of heat loss, but also in terms of condensation that may occur on the unit casing. If the casing has low thermal resistance, the temperature on the surface of the casing can drop below dew point temperature. This causes condensation on the unit surface. Especially in highly humid environments, the dew point is very close to ambient temperature. Small temperature drops on the unit surface lead to condensation on the surface. This is especially common in tropical climates. However, depending on the humidity within the unit, condensation can also occur on the interior surface of the casing. Condensation on unit surfaces leads to an increaser in heat loss on the casing as well as expediting corrosion and unhygienic conditions.

Since more than 90% of the unit casing surfaces consist of panels, low heat conduction coefficient in panels means that the thermal connectivity coefficient of the unit casing will be low as well. Panels used in HSK air handling units consist of an interior sheet, an exterior sheet, and insulating material. The insulating material is places in pieces between the interior and exterior sheets. Since interior and exterior sheet thicknesses used for panels are much less then the thickness of the insulating, sheet thickness does not have much effect on the thermal conductivity coefficient of the panel.

Polyurethane foam or rockwool is used as insulating material for HSK air handling units.

a) Heat Conduction Equation

The heat conduction equation has been found as a result of experimental observation. Though it was discovered initially by Biot, it was named after the French physicist and mathematician Joseph Fourier, and came to be known as Fourier's law.

$$Q = -kA\frac{dT}{dx}$$

Q = Heat Flow (W)

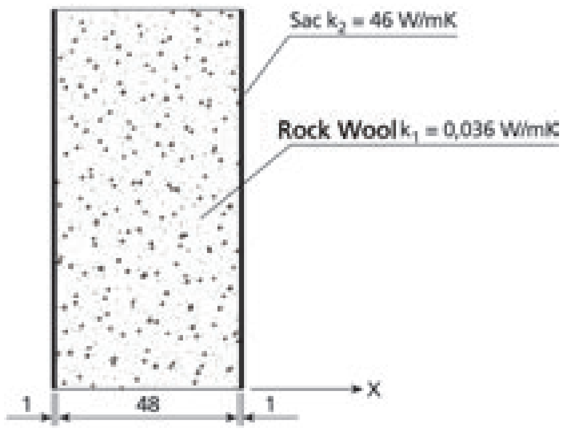
K = Heat transfer coefficient (W/mK)

A = Area (m^2)

dT = Temperature Differential (K)

dx = Thickness (m)

There is a significant temperature difference between the air inside the air handling unit and the ambient temperature. This temperature difference causes thermal conduction. In order to minimise the value of thermal conduction, i.e. the heat loss from the unit surface, 48 mm thick rockwool insulation with a density of 52 kg/m² and heat conduction coefficient of 0.036 (W/mK) is used inside the panel. The heat conduction coefficient of the 1 mm thick sheet material constituting the panel is 46 (W/mK).



For example, we can calculate the heat conduction value by calculating heat conduction by taking the interior unit panel temperature as 17°C, the ambient temperature as 32°C for a surface area of 60 m².

$$Q = -kA\frac{dT}{dx}$$

$$Q = -kA\frac{T_2 - T_1}{L}$$

$$Q = kA\frac{T_1 - T_2}{L}$$

$$Q = \frac{T_a - T_i}{\frac{L_2}{k_2A} + \frac{L_1}{k_1A} + \frac{L_2}{k_2A}}$$

$$Q = \frac{32 - 17}{\frac{0,001}{46 \times 60} + \frac{0,048}{0,036 \times 60} + \frac{0,001}{46 \times 60}} = 674,97 \text{ W}$$

b) Measurement of the Heat Conduction Coefficient

The heat conductivity value in air handling units pertains to the amount of heat that is transferred from an unit of unit or model-box exterior surface in a unit of time at a unit of temperature difference. Tests conducted to determine this value are performed at a stable state where the difference between the unit's interior temperature and the ambient temperature are fixed at 20°C. While the rate of heat exchange within the unit is kept between 100-110 per hour, the air velocity on the exterior unit surface must be below 0.1 m/s. The following values classify the thermal conductivity values calculated from the test results according to European standards.

Heat Conduction Coefficient (U) EN 1886			
Class	Heat Conduction Coefficient W/m2K	Panel Quality	Risk of Condensation
T1	U≤0.5	Highest	Very Low
T2	0.5<U≤1.0	High	Low
T3	1.0<U≤1.4	Medium	Medium
T4	1.4<U≤2.0	Low	High
T5	Not required	Very Low	Highest

2.1.5 Thermal Bridging Factor

The possibility of condensation on the unit casing can be estimated with the heat conduction coefficient of the casing. However, even when the heat conduction coefficient indicates that condensation will not occur on the unit surface, since the temperature distribution on the surface is not homogeneous, surface temperature at areas of thermal weakness can fall below dew point temperature, leading to condensation. This case demonstrates that heat conduction coefficient alone is not sufficient to estimate whether condensation will occur on the unit surface.

The thermal bridging value is determined using the same setup as in measuring the thermal conductivity value.

- The highest temperature on the unit's exterior surface when heat transfer is stable (tmax)
- Interior temperature under stable conditions (ti)
- Ambient temperature under stable conditions (ta)

The thermal bridging factor Kb is calculated using the following equation:

$$Kb = (ti - t_{max}) / (ti - ta)$$

As the thermal bridging value approaches 1, the probability of condensation on unit surfaces decreases and as the value approaches 0, the risk increases. Since the problem of condensation on unit surfaces is very common in practical conditions, the thermal bridging coefficient should definitely be taken into consideration among other factors when selecting an air handling unit. Exterior and interior surface temperatures of an ideal casing should be homogeneous and close to the ambient temperature to which it is exposed. For this purpose, in order to approach a thermally ideal casing, HSK designers have developed the Flexline and Hijyenline air handling units that do not have heat bridging.

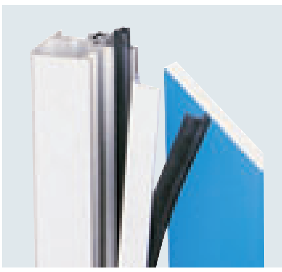
Thermal Bridging Factor (kb) EN 1886			
Class	Thermal Bridging Factor (k_b)	Panel Quality	Risk of Condensation
TB1	0.75< kb< 1	Highest	Very Low
TB2	0.6≤kb< 0.75	High	Low
TB3	0.45≤ kb<0.6	Medium	Medium
TB4	0.3≤kb< 0.45	Low	High
TB5	Not required	Very Low	Highest

2.2 Carcase and Panel Structures of HSK Air Handling Units

2.2.1 BLUELINE Aluminum Carcase Air Handling Unit

The HSK patented aluminum profile interlocking system which does not require screws or nuts in aluminum profile connections, used in BLUELINE Air Handling Units preserve the strength of aluminum. Thus the steel screw is prevented from weakening the aluminum.

Carcase

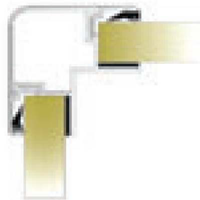


The profiles making up the carcase structure are manufactured from extruded aluminum material. Nylon-6 plastic containing 30% glass wool is used as gusset members. Corner fish plates from galvanized sheet are mounted for extra strength and load bearing.

Panel

The sandwich panel is insulated with 25 mm thick polyurethane heat and sound insulation with a B2 fire rating, and its interior and exterior surfaces are manufactured from galvanized sheet material. Sheet thicknesses can be selected between 0.8 mm and 1.2 mm as desired. The exterior surface is galvanized sheet coated with an epoxy prime and final coat and covered with protective plastic film. HSK patented hermetic, double sealed design allows panels to lock onto the carcase without requiring screw connections.

Lack of Thermal Bridging



Blueline Air Handling Units are not recommended for use in hygienic applications due to their lack of heat bridging.

Design Properties and Advantages

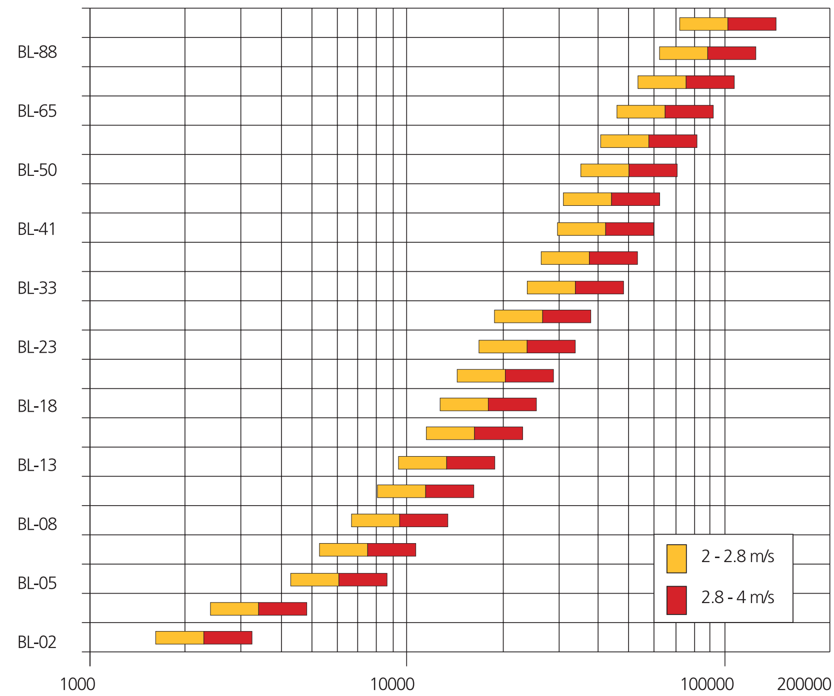
- HSK patented profile interlocking system that does not require screws or nuts and special hermetic double sealed design
- Corner fish plates from galvanized sheet for strength and load bearing
- Light design with aluminum profile
- Air dampers with hidden gear mechanisms on the inside, air dampers (including flanges) with full aluminum and low resistance blade profiles
- Stainless steel slanted water drain pan
- Belt pulley system that allows easy adjustment

Model	DIMENSIONS (L)																												
	B	H	AS	VA	PF	IB	EI	SB	IS	D1	D2	D3	TF1	TF2	YN	S1	S2	S3	PR	RR	PN	LDF	ACF1	ACF2	ACF3	HF	BN	PAF	BH
BL-02	800	600	800	600	800	300	300	700	900	500	500	900	1300	1300	1500	1100	1300	1500	800	700	940	900	900	1300	1750	1300	1300	900	300
BL-03	900	700	900	700	800	300	300	700	900	500	500	900	1300	1300	1500	1100	1300	1500	900	700	940	900	900	1300	1750	1300	1300	900	300
BL-05	1100	900	1100	900	900	300	300	700	900	700	700	1100	1300	1300	1500	1100	1300	1500	1100	700	940	900	900	1300	1750	1300	1300	900	300
BL-07	1300	900	1100	900	900	300	300	700	900	700	700	1100	1300	1300	1500	1100	1300	1500	1300	700	940	900	900	1300	1750	1300	1300	900	300
BL-09	1300	1100	1100	900	900	300	300	700	900	700	700	1300	1300	1300	1500	1100	1300	1500	1300	700	940	900	900	1300	1750	1300	1300	900	300
BL-11	1500	1100	1300	1100	900	300	300	700	900	700	700	1300	1300	1300	1500	1100	1300	1500	1300	700	940	900	900	1300	1750	1300	1300	900	300
BL-13	1700	1100	1300	1100	900	300	300	700	900	700	700	1300	1300	1300	1500	1100	1300	1500	1300	700	940	900	900	1300	1750	1300	1300	900	300
BL-16	1700	1300	1300	1100	1100	300	300	700	900	900	900	1500	1300	1300	1500	1100	1300	1500	1750	700	940	900	900	1300	1750	1300	1300	900	300
BL-18	1900	1300	1300	1100	1100	300	300	700	900	900	900	1500	1300	1300	1500	1100	1300	1500	1750	700	940	900	900	1300	1750	1300	1300	900	300
BL-20	2100	1300	1300	1100	1100	300	300	700	900	900	900	1500	1300	1300	1500	1100	1300	1500	1750	700	940	900	900	1300	1750	1300	1300	900	300
BL-23	2100	1500	1500	1300	1300	300	300	700	900	900	900	1750	1300	1300	1500	1100	1300	1500	1950	700	940	900	900	1300	1750	1300	1300	900	300
BL-26	2300	1500	1750	1750	1550	300	300	700	900	900	900	1750	1300	1300	1500	1100	1300	1500	1950	700	940	900	900	1300	1750	1300	1300	900	300
BL-33	2500	1700	1750	1750	1750	300	300	700	900	1100	1100	1950	1300	1300	1500	1100	1300	1500	2150	700	940	900	900	1300	1750	1300	1300	900	300
BL-37	2500	1900	1750	1750	1750	300	300	700	900	1100	1100	2150	1300	1300	1500	1100	1300	1500	2550	700	940	900	900	1300	1750	1300	1300	900	300
BL-41	2500	2100	1750	1740	1750	300	300	700	900	1300	1300	2350	1300	1300	1500	1100	1300	1500	2550	700	940	900	900	1300	1750	1300	1300	900	300
BL-45	2610	2140	1740	1740	1740	340	340	740	940	1410	1410	2410	1340	1410	1540	1140	1340	1540	2540	740	940	940	940	1340	1790	1340	1340	940	300
BL-50	2910	2140	1740	1740	1740	340	340	740	940	1410	1410	2410	1340	1410	1540	1140	1340	1540	2540	740	940	940	940	1340	1790	1340	1340	940	300
BL-57	3310	2140	1940	1940	1940	340	340	740	940	1410	1410	2410	1340	1410	1540	1140	1340	1540	2540	740	940	940	940	1340	1790	1340	1340	940	300
BL-65	3710	2140	2140	2140	2140	340	340	740	940	1410	1410	2410	1340	1410	1540	1140	1340	1540	2540	740	940	940	940	1340	1790	1340	1340	940	300
BL-75	3910	2340	2140	2140	2140	340	340	740	940	1410	1410	2610	1340	1410	1540	1140	1340	1540	2540	740	940	940	940	1340	1790	1340	1340	940	300
BL-88	4510	2340	2210	2210	2210	340	340	740	940	1410	1410	2610	1340	1410	1540	1140	1340	1540	2540	740	940	940	940	1340	1790	1340	1340	940	300
BL-100	5180	2340	2210	2210	2210	340	340	740	940	1410	1410	2610	1340	1410	1540	1140	1340	1540	2540	740	940	940	940	1340	1790	1340	1340	940	300

Model	CELL WEIGHTS (kg)																					
	BL02	BL03	BL05	BL07	BL09	BL11	BL13	BL16	BL18	BL20	BL23	BL26	BL33	BL37	BL41	BL45	BL50	BL57	BL65	BL75	BL88	BL100
AS	84	105	150	165	184	250	260	285	381	389	430	495	554	600	677	800	850	1050	1170	1277	1200	1250
VA	84	105	150	165	184	250	260	285	381	389	430	495	554	600	677	800	850	1050	1170	1277	1200	1250
PF	102	135	213	221	245	332	340	449	454	462	563	662	963	1057	1076	1004	1027	1250	1600	1283	1394	1406
IB	34	39	51	57	66	74	82	91	99	108	120	129	164	178	190	229	239	268	295	331	377	429
EI	30	35	47	50	53	60	64	70	77	82	92	99	112	138	140	157	199	213	213	252	274	392
SB	82	99	139	164	196	223	254	293	325	358	404	441	551	611	665	756	804	913	1019	1167	1348	1521
IS	88	108	154	183	221	253	288	334	372	410	465	509	636	708	773	868	931	1060	1184	1360	1573	1782
D1	47	55	80	93	101	110	120	148	162	176	186	197	252	266	306	346	382	414	455	504	562	595
D2	50	58	83	96	105	113	125	151	167	179	189	200	256	270	309	349	387	419	457	509	565	600
D3	57	67	92	109	127	141	153	176	195	213	237	252	309	341	371	403	446	492	549	621	706	774
TF1	84	97	109	128	135	147	159	169	186	198	209	214	249	253	281	316	345	384	420	430	475	500
TF2	89	102	114	133	140	152	164	174	191	203	214	219	254	258	286	320	350	390	425	433	480	505
YN	197	216	260	289	310	348	378	400	457	485	515	544	625	656	687	724	804	900	976	1073	1200	1348
S1	104	117	151	157	180	212	240	262	282	306	334	345	408	437	466	487	510	570	610	738	839	913
S2	116	130	170	183	200	238	269	294	315	344	375	388	459	492	525	548	600	678	706	826	945	1035
S3	128	143	189	209	220	264	298	326	348	382	416	431	510	547	584	609	690	786	802	914	1051	1157
PR	115	140	190	233	255	280	302	404	508	550	650	658	798	920	970	1038	1088	1230	1300	1495	1620	1720
RR	105	130	190	213	193	260	330	380	422	465	525	573	716	795	864	985	1045	1186	1324	1517	1752	1977
PN	104	114	130	140	150	195	205	218	237	280	298	307	337	354	371	395	462	584	610	653	743	817
LDF	79	94	105	129	135	147	162	175	189	206	222	230	267	285	310	344	378	421	465	470	520	552
ACF1	87	106	123	152	169	180	200	226	274	287	300	314	391	438	445	479	548	590	670	777	878	960
ACF2	111	140	163	213	240	251	281	327	406	430	448	468	605	693	700	735	855	909	1050	1248	1427	1585
ACF3	143	188	219	300	342	354	400	476	600	640	665	694	923	1067	1077	1112	1310	1380	1613	1947	2240	2513
HF	89	108	119	149	152	164	183	196	204	231	249	265	295	288	349	384	425	470	523	508	564	598
BN	113	120	137	148	155	172	182	190	209	213	223	228	260	268	300	326	347	407	415	422	453	461
PAF	76	87	100	114	122	133	144	155	176	183	192	201	230	243	254	288	316	351	382	411	453	472

1. Heating cell (IB) weights have been prepared for single cell

2. Cooling cell (SB) weights have been prepared for 4 row coll.

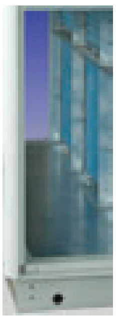


Quick Selection Chart

2.2.2 FLEXLINE Steel Carcase Air Handling Unit

The HSK Flexline Air Handling Unit, is a high end Eurovent certified air handling unit which is superior primarily with its panel design without heat bridging, its galvanized steel carcase profiles and insulated condensation pan.

Carcase



Galvanized steel box profiles 22 mm thick, with dimensions of 30x30 - 30x60 are used to increase the rigidity of the carcase and to assemble the panels. Profile connections are made with gusset cast aluminum gusset elements. Panel connections to the carcase are made with protective covers, and screws that are protected from corrosion. Special hermetic seals are used on assembly surfaces between the panels and the profile. In order to keep the velocity on the filters to a minimum, the filter cross-section has dimensions that allow it to cover the air flow cross-section completely. A new filter casing design has been developed to allow easy service access to filters and to provide a high level of impermeability.

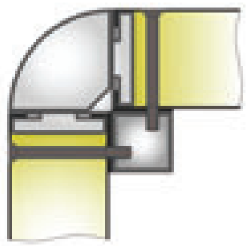
Panel Structure

Panel thickness: 50 mm

Insulation material: Rock wool with a fire rating of A1, of various densities

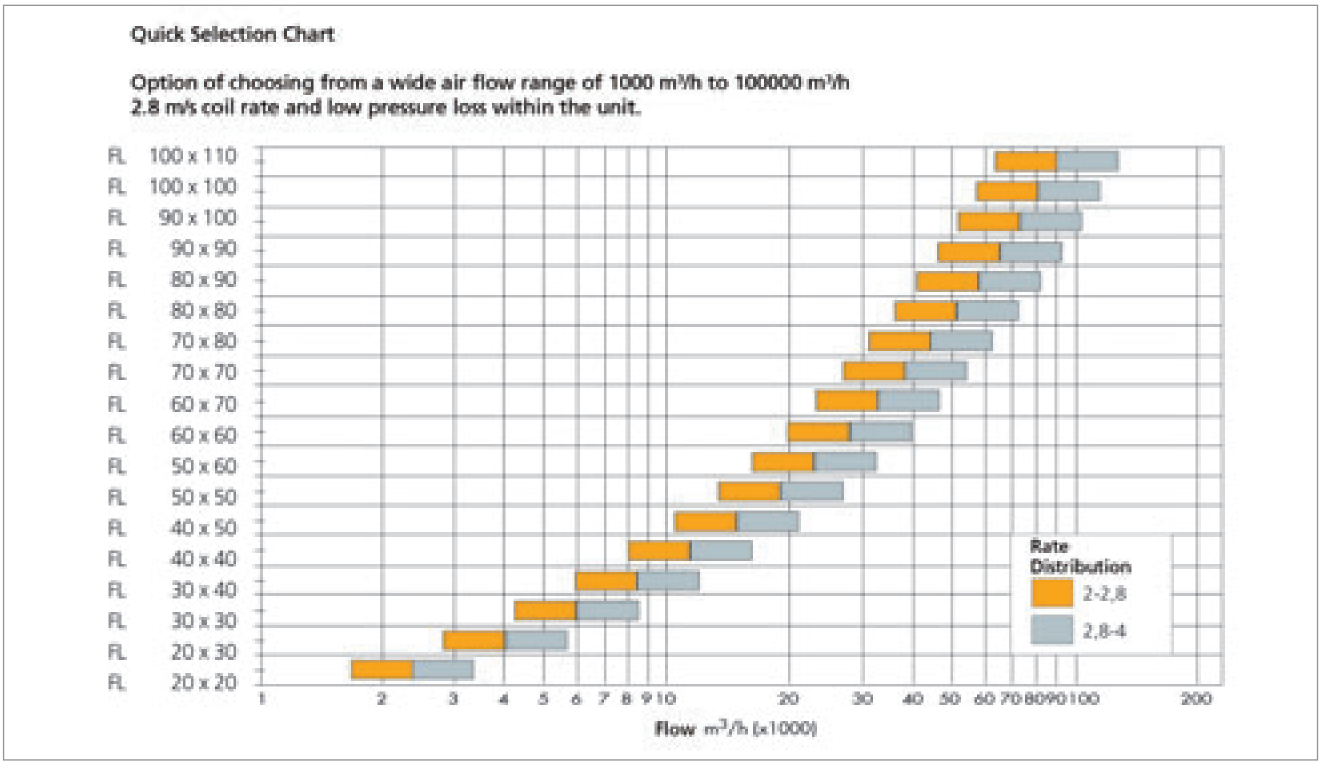
Interior and exterior surface material: Interior and exterior surface sheets have been manufactured from galvanized steel sheet. The exterior sheet surface is coated with 5 µ epoxy prime coat, a 20 µ polyester furnace paint top coat with colour code RAL 7035 and plastic film over the paint. Interior and exterior sheet thicknesses can be selected within the range 0.8 - 1.2 mm depending on requirements and place of use.

Profile material: Corner profiles from ABS material (Acrylonitrile-Butadiene-Styrene) with a high thermal resistance and PVC (Poly Vinyl Chloride) edge profiles are used between the interior and exterior sheets. Profile materials can withstand temperatures of up to 80°C.



Lack of Thermal Bridging

HSK designers continue and advance their efforts by prioritizing energy



Quick Selection Chart

efficiency. The R&D work conducted with this purpose have led to the "Panel-Carcase connection" which prevents thermal bridging by preventing metal to metal contact.
Thermal bridging is an undesired condition which increases the unit's heat loss and consequently lowers its energy efficiency. Since this increases the probability of condensation as well, it causes reduction in the useful life of the unit due to microbiological propagation and corrosive effects.

Design Properties and Advantages

- High thermal and mechanical attributes with Eurovent certification
- The face section of the unit is manufactured proportionally to multiples of 306, depending on the unit's filter dimensions. Thus a modular structure is obtained and filter bypass leakage is minimized.
- As a result of HSK designers' energy efficiency oriented efforts, panel-carcase connections which prevent thermal bridging by preventing metal to metal contact are used in Flexline air handling units.

Frame Drill Technology

A new milestone toward the sustainable development of HSK's quality and the increase of its competitive power has been the Frame Drill technology developed by the HSK R&D tem and patented by HSK. Developed in 2007, the Flame Drill technology has been a new production method, business model which increases assembly precision in air handling unit production, enabling units to be manufactured from standard parts and thus easily assembled at the installation site or out of the factory.
Its advantages are:

- Modularity
- Quality standardization
- Zero defect production
- Convenience of transport
- Rapid delivery
- Air handling units that can be assembled on site

Today, the delivery time for Air Handling Units is around 8-10 weeks. Customer satisfaction surveys we, as HSK have conducted have revealed that customers wish this time to be 2-4 weeks. Until now this wish was deemed impossible considering all processes from the procurement of main materials such as coils, fans, to production, painting and assembly of panels. Parts could not be stocked beforehand since connection points were not known in advance. With the Frame Drill technology, the main body of the air handling unit can be manufactured in advance with very precise positioning, stocked and thus delivered in a very short period of time. Since coils, fans, and other equipment have been standardized in Quickline air handling units which have been developed as a reflection of this production philosophy and which bear the properties of Flexline designs, allowing deliveries up to 20,000 m³/h in 2 weeks.

2.2.3 HIJYENLINE Steel Carcase Hygienic Air Handling Unit

The unit has been designed by HSK R&D department to facilitate air conditioning with healthy, fresh and clean air. The basic logic in its design, is to form a structure which does not allow dirt accumulation, which is clean and whose cleanliness can be controlled. Hijyenline air handling unit conforms to VDI6022-1, VDI 6022-3, DIN 1946-4, EN 13053 hygiene standards and has TÜV-NORD, DIN1946-4 EN1751 VDI hygiene certification.

Carcase

Profiles forming the skeleton have been manufactured from furnace painted, 2 mm thick, galvanized steel material of dimensions 30x30-30x60. Since profiles are hidden between the panels, internal surfaces comprise smooth lines. Thus the accumulation of dust and contaminants is prevented. Sealing is achieved with closed cell seals. Thus the unit conforms to EN 1886 filter leakage class “F9” and body sealing class “B”. Condensation does not occur thanks to the unit’s design that does not allow heat bridging by cutting of contact between interior and exterior surfaces.

Panel Structure

In line with the requirements of hygienic air handling units, panels, profiles and sealing elements are manufactured from material which does not aloe microbiological propagation and which can be chemically cleaned. Not allowing heat bridging, the special design eliminates the possibility of condensation, preventing contamination of the system.

Panel thickness: 50 mm

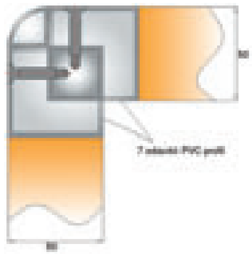
Insulation material: Rock wool with a fire rating of A1, of various densities

Interior and exterior surface material: Internal and external surface sheets are manufactured from galvanized sheet metal conforming to the EN 10142-Fe DX52d+Z Standard. The exterior sheet surface is coated with 5 µ epoxy prime coat, a 20 µ polyester furnace paint top coat with colour code RAL 7035 and plastic film over the paint. Interior and exterior sheet thicknesses can be selected within the range 0.90 -1.2 mm depending on requirements and place of use.

Profile material: Corner profiles from ABS material (Acrylonitrile-Butadiene-Styrene) with a high thermal resistance and PVC (Poly Vinyl Chloride) edge profiles are used between the interior and exterior sheets. Profile materials can withstand temperatures of up to 80°C.

Lack of Thermal Bridging

Panel-carcase connection without heat bridging, developed specially for hygiene applications.



Design Properties and Advantages

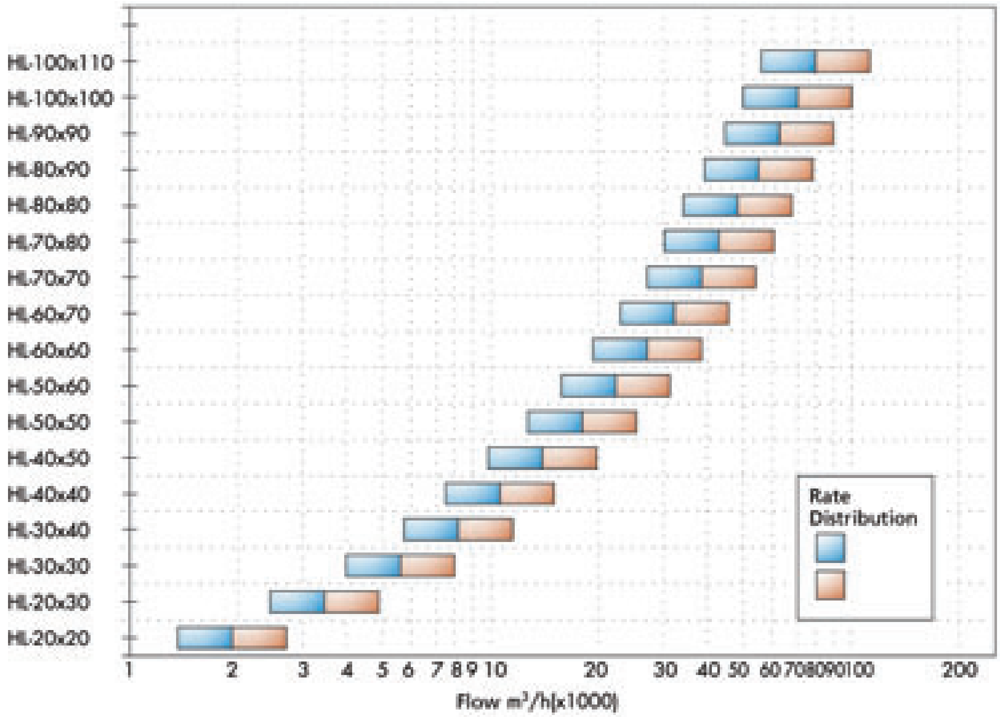
- Conforms to VDI6022-1, VDI 6022-3, DIN 1946-4, EN 13053 hygiene standards.
- Manufacture from recyclable, environmentally friendly materials.
- Standard viewing glass and internal illumination allow viewing and control of equipment inside the air handling unit. Lighting fixtures have been places between the interior and exterior surfaces of the panel to which they are connected, with a very special design by HSK R&D engineers. Thus the lighting fixtures are prevented from creating a protuberance on the surface, leading to the accumulation of dust and dirt.
- Special design without heat bridging.

Corrosion Resistance

The following measures have been taken in Hijyenline air handling units, in order to prevent corrosion as per hygiene air handling unit standards.

- Galvanized\galvanized and furnace painted\stainless steel interior wall on base panels or all panels.
- Hidden frame consisting of hot dip galvanized and furnace painted, profile carcases.
- Heating and cooling coils manufactured from aluminum surfaces coated with epoxy and mirrors and covers from stainless steel material to avoid the corrosive effects of disinfectants
- Use of copper collectors to prevent moisture related corrosion of battery collector surfaces
- Stainless steel drain pan which does not hold water due to its double directional slant
- Stainless steel framed drop eliminator manufactured from polypropylene profiles, with a heat resistance up to 130°C.

Air damper suited to automatic control applications, manufactured from eloxal coated aluminum profiles, with hidden screws and sealed airfoil blades



Quick Selection Chart

Classification of HSK Air Handling Units According to EN 1886

	EN 1886		Flexline	Blueline
Casing Strength (mm/m)	D1	4	X	X
	D2	10		
	D3	>10		
Casing Air Leak -400 Pa (l/sm^2)	L1	0.15	X	
	L2	0.44		X
	L3	1.32		
Casing Air Leak +700 Pa (l/sm^2)	L1	0.22	X	
	L2	0.63		X
	L3	1.9		
Thermal Conductivity (W/m^{2}K)	T1	U<0.5	X	
	T2	0.5<U<1		
	T3	1<U<1.4		
	T4	1.4<U<2		X
	T5	-		
Heat Bridging (kb)	TB1	0.75<kb<1	X	
	TB2	0.6<kb<0.75		
	TB3	0.45<kb<0.6		
	TB4	0.3<kb<0.45		X
	TB5	-		
Fitler Leakage Classes (+400Pa)	F9	0.5	X	
	F8	1		
	F7	2		X
	F6	4		
	G1-G5	6		

Operating ranges of HSK air handling units
- Fresh air inlet: -25 °C to 60 °C
- Exhaust air outlet: 0 °C to 80 °C
- Maximum operating pressure/temperature of heating/cooling groups: 13 bar / 110 °C
- Minimum operating temperature of heating/cooling groups: 5 °C

Extreme conditions: Along with interior air temperature and humidity, outdoor conditions are also quite important in terms of condensation control. The control of condensation limits should not be overlooked.

Operating voltage: 220-440 VAC / 1-3 Phase / 50-60 Hz

Notes:
It is important that the information on the model plate and within the user manual should be taken into consideration. If there is risk of freezing, freeze protection and antifreeze should be used for heating and cooling groups.

Condensation limits: The following diagrams demonstrate the ambient conditions required for the onset of condensation in Flexline, Hijyenline, and Blueline air handling units.

2.2.3.1 Positive Pressure Door Application

Positive pressure or negative pressure occurs within the air handling unit, depending on the position of the fan. Since in scroll case fans, exhaust occurs at the fan cell outlet, positive pressure occurs in all cells coming after the fan cell. And fans without scroll cases, exhaust occurs inside the fan cell, positive pressure occurs in the fan cell and all cells coming after the fan cell.

In cells where positive pressure occurs, the service door is manufactured to open inwards and the door is positioned to sit on the aluminium frame on the outside to prevent air leaks. Liquid seal is applied on the front connections of door locks and sealing elements are found below the precision screw. Thus the conditioned air is prevented from escaping through the lock. The effect of positive pressure totally eliminates the possibility of air leaks.
Furthermore, the guide lever can be easily removed without removing the lock and upon demand, an additional lever can be mounted to allow service doors to open from within the air handling unit.

2.2.3.2 Air Sterilization with the Ultraviolet Method

Light which has a wavelength that is shorter than visible light, but longer than X-rays is called "ultraviolet" light.

This special light which is used as disinfectant is called "low wavelength light" or "UV-C" light. This wavelength falls in the UV-C band which is between 200 nm (nanometers) and 280 nm.

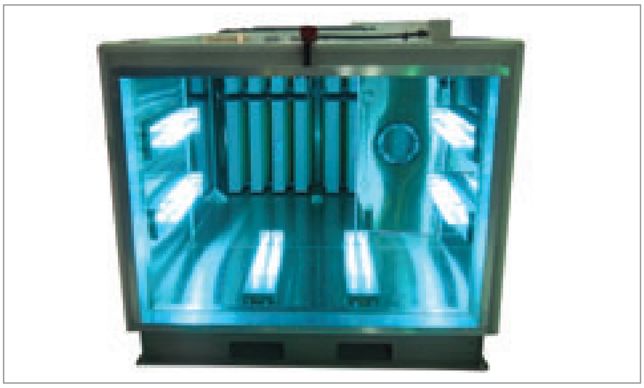
Air used in air handling units is cleaned with filtering systems. The coarse dust and particles in the air are captured with filters. Micro-organisms which are suspended in air and can not be captured by regular filter systems, i.e. bacteria, viruses, moulds and funguses which threaten the health of humans, have their effect on personnel working in indoor spaces and on the product being manufactured. This leads to many financial losses.

Ultraviolet (UV) systems prevent all these microbiological problems. UV rays allow air sterilization.

UV rays also neutralize bacteria which cause unwanted odours in the environment. UV air sterilization is a biological purification.

- UV-C emitters radiate light with a wavelength of 235.7 nm (nanometers).
- This wavelength acts on the building blocks of micro-organisms such as bacteria, viruses, funguses, yeast, mould, and mould spores, preventing them from propagating and causing them to die.

Positive pressure door application



Ultraviolet air sterilization within the air handling unit

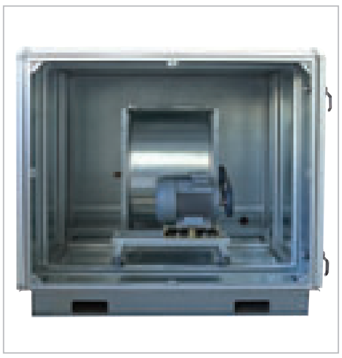
- It eliminates 99.9% of air borne micro-organisms.
- It prevents air borne transmission of contagious diseases.
- UV-C disinfected air minimizes SBS (Sick Building Syndrome) related complaints, which are respiratory tract, mucous tissue and muscle pains.
- International studies (Lancet) have shown that UV-C disinfected air reduces work loss in collective work environments by an average of 40%.
- Its conformance to the VDI 6022 (Association of German Engineers) norms in addition to the 1946-6 norm implemented in hospitals brings about an improvement in hygiene standards.
- It provides air disinfection without using chemical products and harming human health or nature.
- It uses UV-C emitting lamps which do not produce ozone gas.
- Areas of use: Hospitals (intensive care, operating room, corridors, waiting rooms), public health clinics, examination rooms, waiting halls, public offices and organizations, schools, hotels, plazas/offices, movie/theatre halls.

2.3 Elements Making Up the Air Handling Unit

2.3.1 Fans

The air handling unit includes a fan cell for the purpose of facilitating air circulation through an aspirator and/or ventilator, depending on the requirements of the environment. While forward curved fans are preferred for units within the low pressure range, forward curved or reverse curved fans can both be used for units within the medium and high pressure ranges. In addition to these, Aerofil fans are commonly preferred due to their efficiency and low noise level operation. Depending on design conditions Plug (without scroll case, single inlet, direct coupled) fans can also be used.

Fans used in HSK air handling units are manufactured from galvanized sheet metal. Forward and backward curved fans are statically balanced according to the ISO 1940-G6.3 standard. Flexible connection is used between the fan exhaust and the unit body to dampen vibrations. Flexible connections which may be used from the outside for connecting to the ductwork are also available as an option. The connection of the fan to another cell is made by a diffuser. The basic purpose of the diffuser is to distribute the air flow in the subsequent cell evenly within the cell. Fanların ünite gövdesinden lastik izolatörlerle veya yaylı titreşim izolatörleri ile izole edilmesiyle, titreşimin gövdeye aktarılması önlenmektedir. Spring vibration isolators can also be used upon demand.



Radial Fan

Plug Fan

		EFFICIENCY	AREA OF APPLICATION
Central Fans	Profile blade	It is the most efficient of centrifugal fans.	General ventilation/air conditioning
		Best operating conditions are 40-50% of maximum air flow.	Mostly for larger systems (for all pressures)
		Power is maximum at maximum efficiency. Power decreases at higher air flows.	Substantial energy saving in large, industrial fresh air systems
	Backward Inclined Rare Blade	Efficiency is a little lower than the profile blade fan	General ventilation/air conditioning
		Efficiency similar to profile blade	Some industrial applications where the profile blade may be subject to corrosion and wear and tear.
		Only the maximum efficiency is a little lower.	
	Radial blade	Higher pressure characteristic as compared to profile and backward inclined fans	Primarily high pressure industrial applications for transporting materials in industry.
		Fan should not be operated in the region where the curve breaks to the left of maximum pressure	Sometimes coated with a special material, the wheel is easily cleaned on site.
		The power rises continuously. This should be taken into consideration while selecting a motor.	Not suited for ventilation/air conditioning.
	Forward Inclined Dense Blade		Mostly very low pressure ventilation/air conditioning applications.
		The fan should be operated at the right of maximum pressure.	
		Best operating conditions are 50-60% of maximum air flow.	
		Maximum efficiency is lower as compared to other centrifugal fans.	
		This should be taken into consideration while selecting a motor.	

Fan Laws

To be used in fan selection, manufacturing firms provide their customers with fan characteristics curves indicating the variation of fan pressure, efficiency and power with fan air flow for specific types, size and rotation speed (rpm) of fan. Unless otherwise specified these characteristics are valid for air at 101.325 kPa, 20°C and 1.244 kg/m^3 conditions.

Equations providing the relationships between characteristic variables for dynamically similar fans, are called "fan laws". These variables are: D for fan size; n for rotation speed; gas density; Q for gas flow; p or p for total or static fan pressure; N for fan power and fan efficiency.

- The 1st law indicates the effects of fan size, speed and gas density on flow, pressure and power.
- The 2nd law indicates the effects of fan size, pressure and gas density on flow, speed and power.
- And the 3rd law indicates the effects of fan size, flow and gas density on speed, pressure and power.

Law	Formula
1	$\frac{Q_2}{Q_1} = \left(\frac{D_2}{D_1}\right)^3 x \left(\frac{n_2}{n_1}\right)$
	$\frac{p_2}{p_1} = \left(\frac{D_2}{D_1}\right)^2 x \left(\frac{n_2}{n_1}\right)^2 x \left(\frac{\rho_2}{\rho_1}\right)$
	$\frac{N_2}{N_1} = \left(\frac{D_2}{D_1}\right)^5 x \left(\frac{n_2}{n_1}\right)^3 x \left(\frac{\rho_2}{\rho_1}\right)$
2	$\frac{Q_2}{Q_1} = \left(\frac{D_2}{D_1}\right)^2 x \left(\frac{p_2}{p_1}\right)^{0,5} x \left(\frac{\rho_1}{\rho_2}\right)^{0,5}$
	$\frac{n_2}{n_1} = \left(\frac{D_1}{D_2}\right) x \left(\frac{p_2}{p_1}\right)^{0,5} x \left(\frac{\rho_1}{\rho_2}\right)^{0,5}$
	$\frac{N_2}{N_1} = \left(\frac{D_2}{D_1}\right)^2 x \left(\frac{p_2}{p_1}\right)^{1,5} x \left(\frac{\rho_1}{\rho_2}\right)^{0,5}$
3	$\frac{n_2}{n_1} = \left(\frac{D_1}{D_2}\right)^3 x \left(\frac{Q_2}{Q_1}\right)$
	$\frac{p_2}{p_1} = \left(\frac{D_1}{D_2}\right)^4 x \left(\frac{Q_2}{Q_1}\right)^2 x \left(\frac{\rho_2}{\rho_1}\right)$
	$\frac{N_2}{N_1} = \left(\frac{D_1}{D_2}\right)^4 x \left(\frac{Q_2}{Q_1}\right)^3 x \left(\frac{\rho_2}{\rho_1}\right)$

Fan Selection

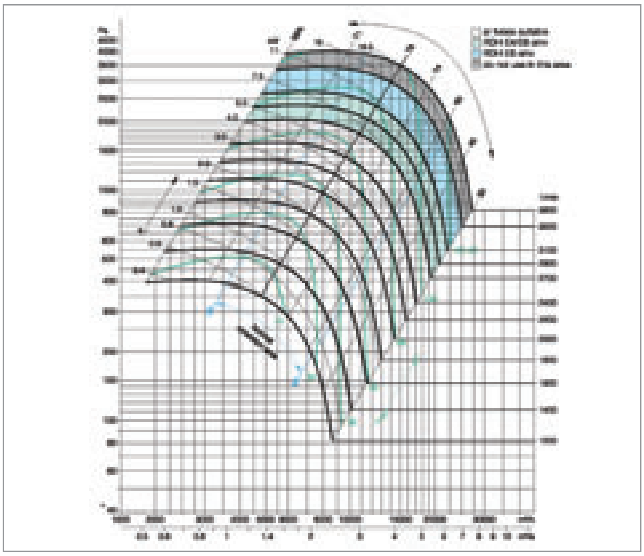
System requirements influencing fan selection are air quantity, static pressure, non-standard air density, noise level or use of the fan's operating environment, as well as properties of the useable area and load. If these requirements are known, the point which determines the selection of an fan to be used for air conditioning purposes, is the cheapness of the combination of capacity and build class, and its efficient operation at an acceptable noise level.

When a choice is to be made with respect to noise, exhaust speed can not be a criterion. The best noise properties are achieved in conditions when the fan works with the highest efficiency. Permitted exhaust speeds of fans operating at high static pressures is also high, since the highest efficiency is only possible with a high quantity of air. In this case, efforts at limiting exhaust speed in order to lower the noise level also depends on the noise level of the environment and on the nature of occupation of the space in which the fan operates. To select a fan with a low noise level requires that the fan operate at as high an efficiency as possible and that the ducts adjoining the fan be designed appropriately.
If a good balance can be achieved between low initial cost and fan efficiency, a slightly smaller fan can be selected than that is required for highest efficiency. On the other hand, if long operating hours are in question, a larger and more efficient fan should be selected. It might be more economical to select a larger engine, drive and starter when selecting a smaller fan; or to select a larger fan when a heavier fan structure is called for.

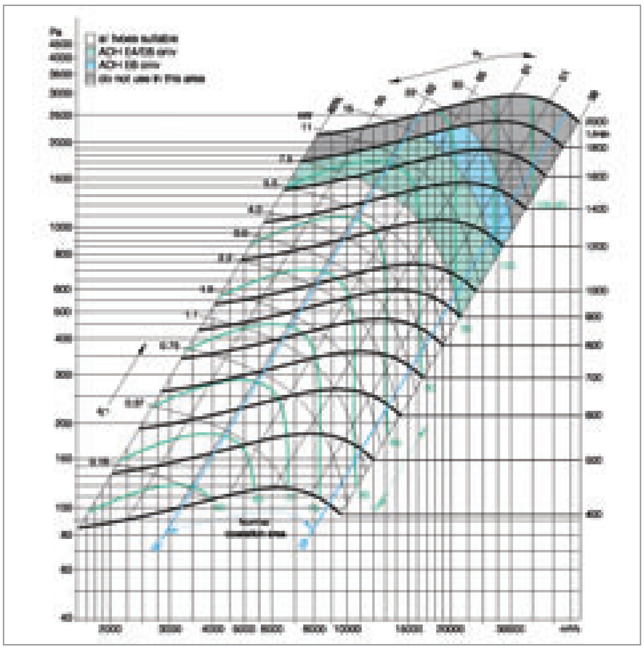
Fan Performance Comparisons

The following figure shows and compares performance values for backward curved rare blade fans, forward inclined dense blade fans and with Aerofil blade fans. Fans with a wheel diameter of 40 cm was selected for comparison and operating points were determined.

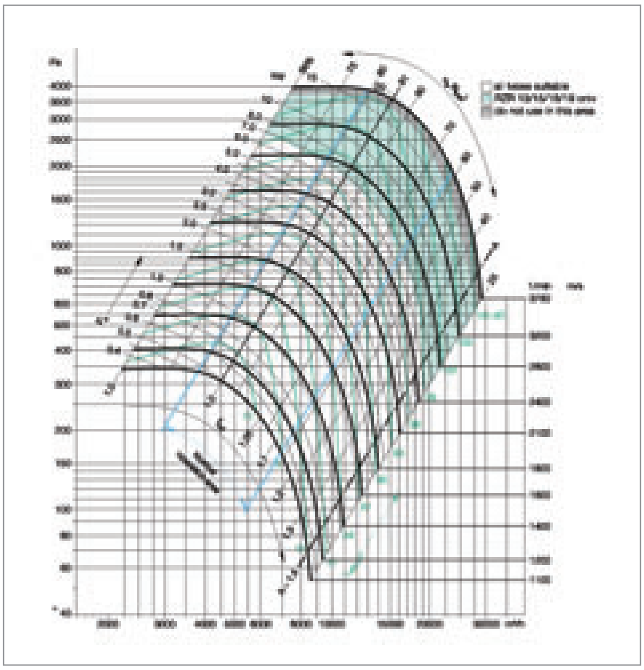
Operating Point	Air Flow (m^3/h)	Pressure (pa)
A	10000	650
B	10000	1000
C	6500	650
D	6500	1000
E	4000	650
F	4000	1000



Backward Curved Rare Blade



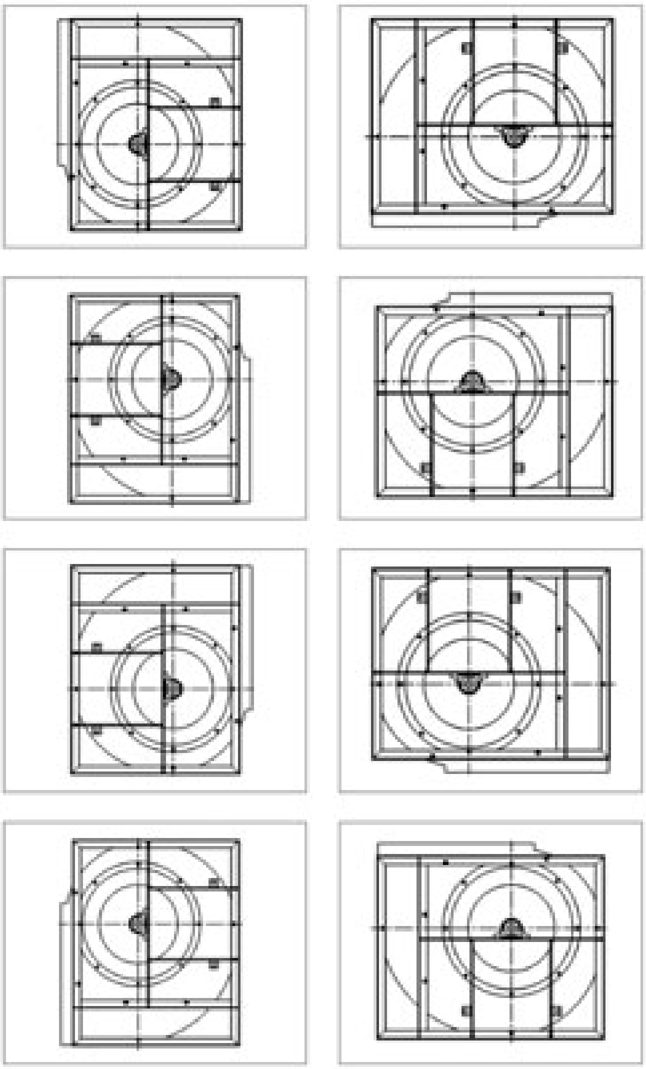
Forward Curved Dense Blade



Backward Curved Airfoll Blad

Fan Assembly

Fans are manufactured by testing, and with different intake and exhaust positions, ready for assembly. Rubber isolators or spring isolators are used to prevent vibration on the unit base. It is very important that motor and fan blade axes are centered on the same plane. To prevent lateral loads, the belt must be installed on the fan wheel at the right angle. Fan intake and exhaust directions which may be applied in various ways depending on place and purpose of operation are shown below.



Fan Cell - Accessories

Fan cells can be manufactured with a Fan Protective Cover or Belt-Wheel Guard which protect the rotating elements and blades from external influences and similarly protect people from damages that can arise from moving elements.
Sight glass and lighting equipment are optionally added to the system to allow viewing the inside of the unit without opening the service door.
Fan cells can intake and exhaust air from and to the environment without ductwork, depending on system design. In such applications, a hood is placed on fan intake/exhausts in order to prevent rain and snow and materials like flying paper and leaves from entering the cell.
Fan-duct connection is made with flexible elements to avoid transmitting unit vibrations to air ducts.
Upon customer demand, earthquake isolators or spring vibration isolators are placed between the fan base and unit base as vibration attenuating elements.

Spring Isolators

Due to their exceedingly long useful life and suitability for collapse, steel springs are isolators which are also used for fan applications. In outdoor applications or applications located in corrosive environments, extra protection is achieved with coating and paint. Open spring isolators are attached to the base or fan by nuts on the top and bottom covers. Springs in an application are selected to have the same collapse distance, in order to provide a fixed balance. Frequency of the vibration source is also important in the selection of springs. In an application containing more than one vibration source, calculations should be based on the source with the lower frequency. A system capable of isolating low frequency vibrations can also isolate high frequency vibrations.

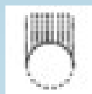
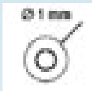
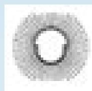
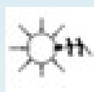
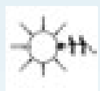
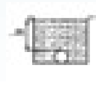
2.3.2 Motors

Electrical motors can be selected in the IP54, IP55, IP65 protection, and EFF1, EFF2 energy classes depending on place of use and on demand. Motors used in HSk air handling units are F isolation class, 380 V 50 Hz triphase, enclosed, fan cooled and equipped with short circuit rotor as a standard. The motor can be cooled more easily thanks to its aluminum frame. Electrical motor selections are made by adding transfer losses up to 12-25% depending on the shaft power drawn by the fan. Maximum user safety is attained through the optional belt-wheel guard. Belts and wheels are in compliance with the DIN 2215 standard. Data regarding the protection, energy efficiency and isolation classes of motors have been listed below.

IP Protection Class Number

When you purchase any protective box, you see an "IP" number indicating the protection class on the box. The protection class number is indicated with the letters IP and a two digit number (IP AB). The first digit (A) indicates protection against solids and dust, while the second digit (B) indicates protection against liquids.

You can see the summary of the protection class in the following table.

	A Protection Against Solid Objects		B Protection Against Liquids	
0	No Protection		No Protection	
1		Against objects with a diameter of more than 50 mm (the back of a hand)		Against dripping water
2		Against objects with a diameter of more than 12.5 mm (a finger)		Against water dripping from vertical to an angle of 15°.
3		Against objects with a diameter of more than 2.5 mm (hand tool)		Against water spraying (0.07 l/min) from vertical to an angle of 60°.
4		Against objects with a diameter of more than 1 mm (cable vein)		Against water spraying (0.07 l/min) from all directions
5		Against dust particles		Against low pressure irrigation (12.5 l/min) from all directions
6		Dust proof		Against high pressure irrigation (100 l/min) from all directions
7				Against temporary submersion into a depth of 15-100 cm
8				Against being submerged in water at the specified depth

Efficiency Class

Efficiency classes pertaining to fan motors used in HSK air handling units are as follows. HSK recommends that its customers select EFF1 energy class motors which are energy efficient and thus save energy.

Rated Power		Motor Efficiency %			In case EFF is used instead of EFF3
kW	HP	EFF3	EFF2	EFF1	kWh/year
1.5	2.0	<78.5	78.5 – 85.0	>85.0	877
3.0	4.0	<82.6	82.6 – 87.4	>87.4	1197
7.5	10	<87.0	87.0 – 90.1	>90.1	1780
15	20	<89.4	89.4 – 91.8	>91.8	2632
30	40	<91.4	91.4 – 93.2	>93.2	3803
45	60	<92.5	92.5 – 93.9	>93.9	4352
75	100	<93.6	93.6 – 94.7	>94.7	5584
90	121	<93.9	93.9 – 95.0	>95.0	6659

Insulation Class

Insulation class indicates the motor's ability to resist ageing and failure do to heat. Below is a table regarding these classes.

Insulation Class	Maximum Operating Temperature	Operating Life at the Specified Temperature (h)
A	105°C	20000
B	130°C	20000
F	155°C	20000
H	180°C	20000

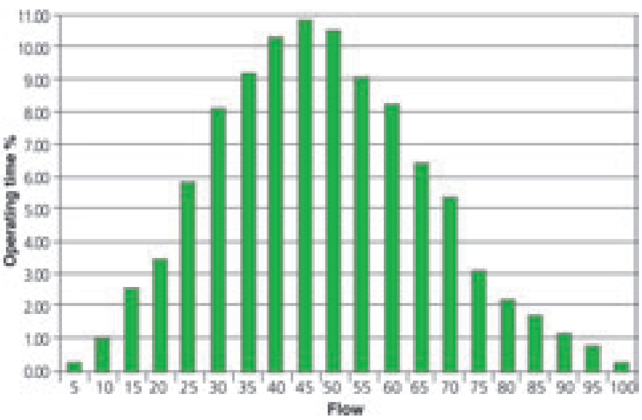
In the preceding table, operating life expectancies in a specified temperature have been given for each class. The following table indicates the variation in motor life expectancy as a function of variation in the maximum operating temperature.

Insulation Class	Specified Maximum Operating Temperature	Actual Maximum Operating Temperature	Operating Life at the Specified Temperature (h)
B	130°C	120	40000
F	155°C	155	20000
H	180°C	190	10000

Insulation classification is made with respect to the motor element with the lowest class. For example, if a motor element belongs to the B class, the motor will be designated as B class even if all the remaining elements are F class. In HSK systems, motors are selected in the F insulation class as a standard.

2.3.3 Frequency Converter

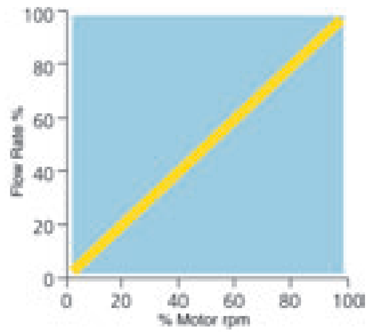
Most fan motors used in air handling units are short circuit motors which are also known as induction motors or asynchronous motors. They are selected because they are cheap, require little maintenance cost and are highly reliable. In these models, the only way to control the motor speed is changing the supply current (alternative current) frequency. The Frequency Converter does exactly that.

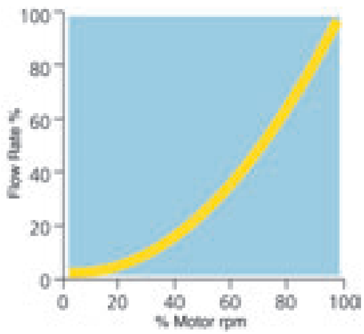


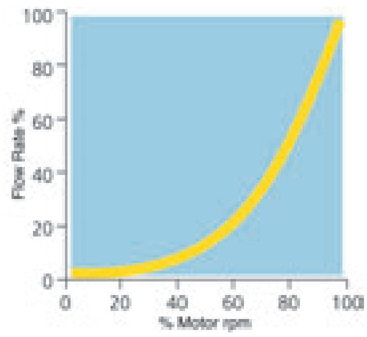
Air handling systems rarely need maximum design flow. Frequency converter alters the rpm of the fan motor in air handling units, adjusting the system air flow. In this way, while the required amount of fresh air is supplied, a high level of energy is saved. The following figure shows that 90% of the fan's operation occurs at 70% rpm.

Energy Efficiency in Frequency Converter Systems

The relationship between pressure, air flow, rpm and power is expressed through "relationship laws". These laws can be used for both radial and axial fans. These laws indicate that air flow is directly proportional to fan rpm, while pressure is directly proportional to the square of rpm.







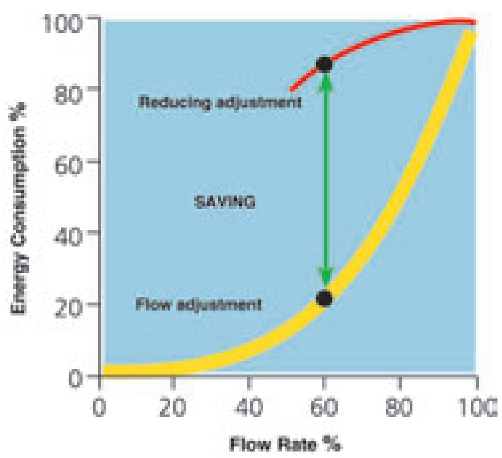
The most important point in terms of energy economy is that power consumption is proportional to the third power of fan rpm. This means that a drop in rpm will provide a significant reduction in energy consumption. Consequently, as seen in the figures as well, the power expended to bring the air flow to 75% is 40% of the energy of the motor operating at full speed.

The power consumption drops to 12.5% when the flow is reduced to 50%.

A comparison between the motor rpm adjustment with traditional flow adjustment methods has been shown below. Air flow adjustment methods that are not preferred today are the following:

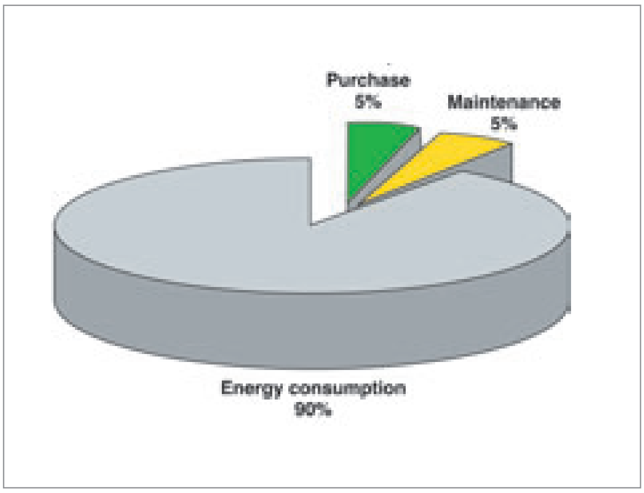
Reducing air flow with the aid of a damper and valve
- Use of intake gates in radial fans to limit air flow entering the fan
- Use of viscous and induction current couplings for adjusting the moment of rotation between the ventilator and motor
- Start/Stop adjustment
- Changing blade angle in axial fans

The disadvantage of these applications for flow adjustment is that none of them have a direct effect on power consumption. Some of these elements allow facilities serving to



reduce power consumption; however none of these are as efficient as using flow control adjustment with frequency convector for power economy. For example, Start/Stop control, the increased number of starts and shut downs cause much higher mechanical tension and pressure increases resulting from fluctuations in the power source. The adjoining figure compares the power consumption of flow control with frequency converter and that of reducing power by damper.

An inspection of the following graph on fan costs, it is seen that the largest expense during the fan's operating life results from energy consumption. In the light of this information, HSK recommends the use of frequency converter systems for their high controllability and the energy economy they provide.



Control Systems in Fan Cells

The following equipment can be used in fan cells depending on the requirements of the automation system and on safety instructions.

- A Differential Pressurestat is mounted, measuring the pressure differential between the fan intake and exhaust. Thus the operating state of the fan can be monitored.
- The cell is equipped with a Panic Button to allow sudden shut down of the fan in an emergency.
- A PTC Thermistor is mounted between motor windings to disable the motor in case the fan motor overheats.
- A Frequency Converter is mounted to control pressure and flow values by altering fan rpm.

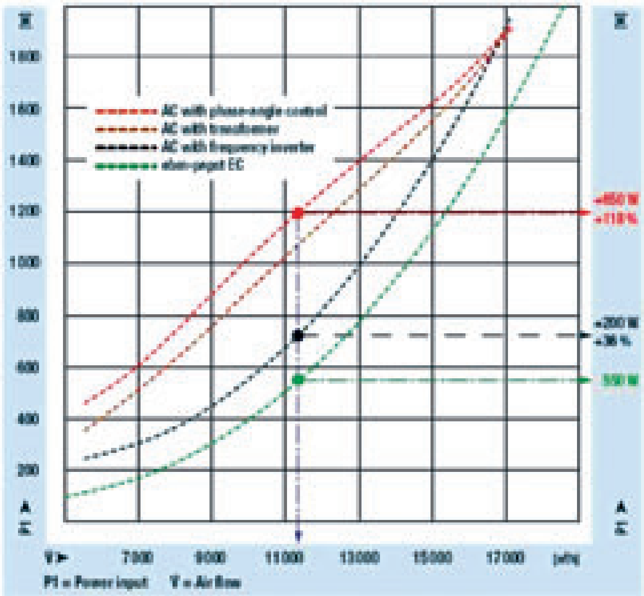
2.3.4 EC (Electronically Commutated) Motor Fans

Depending on global and nationwide research, the highest potential whereby electrical energy saving can be achieved has to do with electrical motors. The leading factor in implementing this responsibility is EC technology with the high energy economy it provides.

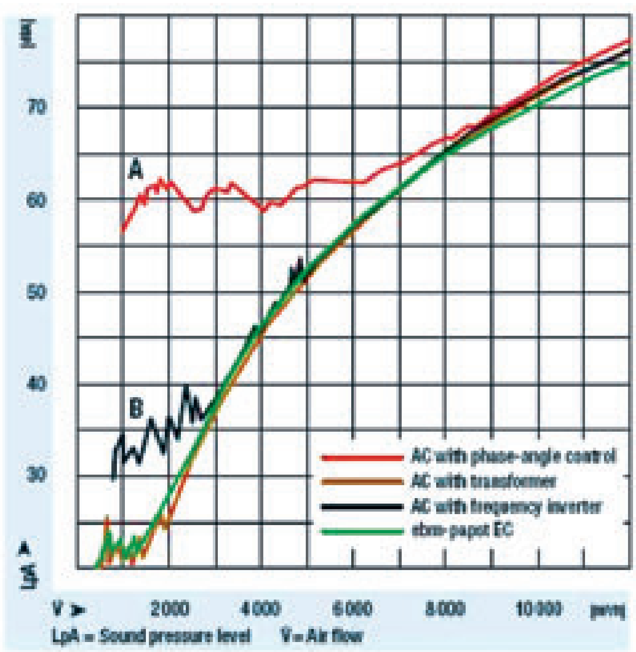
The (smart plug-and-play) product equipped with an EC motors, details distinguishing it from other products on the market, advantages for the manufacturer and end user:

- Process controller, speed control device or driver, electrical filters and overload protection (for motor and electronics) elements are all within the motor.
- Low noise and vibration levels are achieved throughout the entire operational range.
- 100% speed control is available without using additional components.
- The unit can operate with 0-10 VDC or 4-20 mA set and actual signals.
- Components such as direct drive, motor and belt contain maintenance free rollers.
- Wide diameter and performance range (Up to 630 mm in diameter - 6kW in motor power). Pressures as high as 2200 Pa can be accommodated with EC motor powers.
- A paint option is available for applications such as hygienic air handling units, which prevent corrosion and bacterial adhesion.
- Modbus
- (LAN) CAD 5 connection (through a special interface) to the existing Ethernet network in the application area
- Fixed performance throughout the full supply current range = 3 phase - 380-480 VAC - 50/60 Hz – Operation is possible at different supply voltage and frequency settings (different countries).
- Integrated DC supply source for sensors
- Programmable analogue outlet
- Integrated PID - Access to and ability to modify PID parameters depending on the algorithm
- Integrated alarm outlets
- EMC compatibilities
- Soft start
- Possibility of Master - Slave connections
- Ability to rotate at low speed on standby upon demand (adjustable minimum offset speed)
- Access to a wide range of failure, error and actual details throughout the operation period, depending on the EEPROM memory.

Comparison of Efficiency According to Fan Speed Control Types:



Noise Level Comparison:



2.3.5 Heating – Cooling Coils

Coils are selected by the "Airware Air Handling Unit Selection Software" from cold water, hot water, steam and direct expansion types, to provide optimum performance conditions. In accordance with system requirements, copper tube-aluminum fin or steel tube-steel fin coils are used in HSK air handling units. While copper tubes up to 2 bar pressure is used in steam applications, the use of steel tubing is required for higher pressure steam applications. Standard tube diameters used are 3/8", 1/2" and 5/8". In aluminum finned designs, fins are coated with epoxy, providing high corrosion resistance.

Number of Rows

While designing in a specified fin geometry, care should be taken with the number of rows of the coil, which has an impact on the design efficiency.

If the number of rows is increased while other factors remain the same capacity increases, surface area increases, air side pressure drop increases, the demand for water flow and consequently the water speed increases. The opposite happens if the number of rows is reduced.

As a general rule, capacity obtained from unit surface area drops as the number of rows increases, rendering the coil less efficient. So, if a 2 row coil is converted to 4 coils, it does not provide 2 times the capacity. Thus, the lowest possible number of rows should be used in order to increase efficiency.

Heating coils are usually designed as having 1 pr 2 rows. Cooling coils on the other hand need a larger number of rows and can usually contain up to 8 rows. Since ¢Tm (average logarithmic temperature differential) is high in heating coils, fair results can be obtained with fewer rows. (assuming 90°C/70°C water conditions and -3°C/+36°C air conditions).

Lines and spacing in coils used in HSK air handling units are usually between 2.1-3.2 mm.

Number of rows is among the most important factors influencing pressure drop. This value should also be taken into consideration for coil selection.

Number of Circuits

This is the required number of intakes for the coolant to circulate within the coil at a specific pressure drop and flow range. If the number of circuits increases while all other factors remain the same, water flow decreases, capacity decreases, water side pressure drop decreases. The opposite happens if the number of circuits is reduced.

Number of Passes

The number off passes, is the number of tubes which a circuit travels from the inlet point to the outlet point. Unless otherwise specified, number of passes should be an even number in water coils. The inlet number is also an even number so the inlet collector and outlet collectors face the same direction.

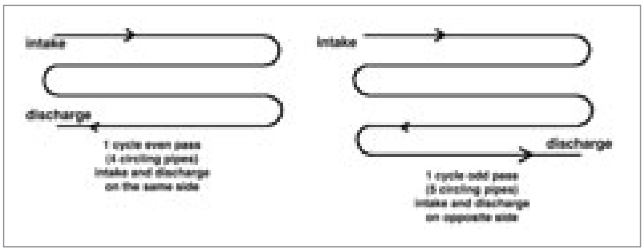
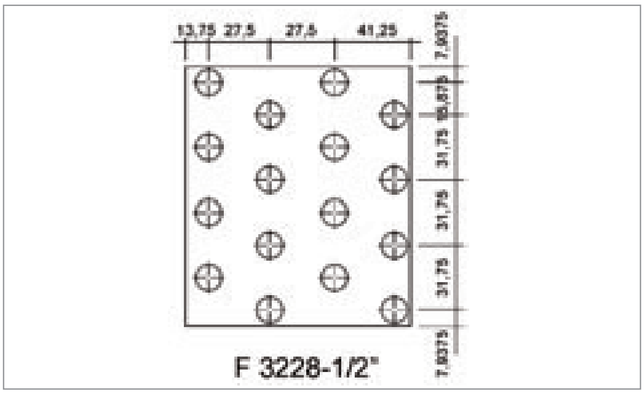


Figure 3.4. Intake - Discharge Directions According to Odd or Even Numbered Passes in Water Side Coil

To achieve a more efficient heat transfer, counter-current flow should be maintained between the water and air sides. Offset fins are also more efficient than straight fins. Consequently, offset fin alignment and counter-current design are preferred in HSK air handling units.

Pressure Drops (mmSS)						
Speeds	1.5	2	2.5	3	3.5	4
Single Row Coil	1	1.6	2.3	3	3.6	4.7
Double Row Coil	2	3.3	4.6	6	7.8	9.6
Triple Row Coil	3	4.67	6.6	8.4	10.92	12.8
4 Row Coil	4.3	6.7	9.4	12.6	16.38	19.2
5 Row Coil	5.67	9.2	13.2	17.6	22.8	28.3
6 Row Coil	7.4	11.7	17.5	22	28.6	36
7 Row Coil	7.97	13.6	18.9	25.6	33.3	41.2
8 Row Coil	9.6	14.9	21.7	29.4	38.2	47.2



Staggered Fin

2.3.5.1 Constructive Properties of Coils

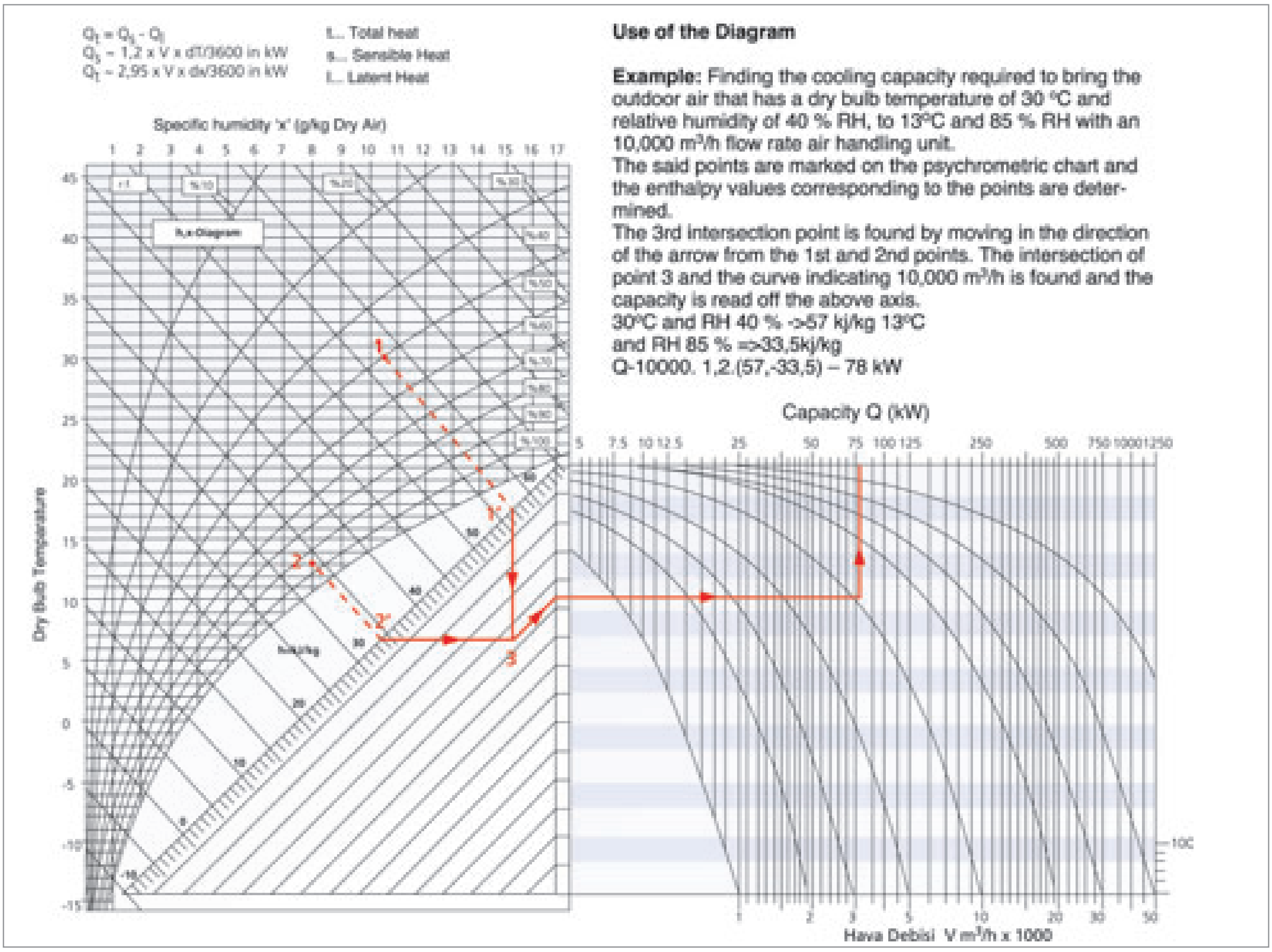
Coil casings are manufactured from galvanized steel plate as a standard. A combination of backward curved collars and free mirror system is used in mirrors. Thus the mirrors are prevented from weathering and cutting the tube during thermal expansion or contraction. Long intermediate mirrors are used for additional strength. Aluminum, hot dip galvanized steel, stainless steel, and copper material can also be used in casings if desired.

Aluminum, epoxy coated aluminum and copper fins are manufactured with collar heights which adjust fin spacing in automatic blocks. Fin surfaces are plain or corrugated. 3/8"-1/2" and 5/8" copper tubes are mechanically inflated, providing tight contact with fin collars. This inflation system, forges an excellent mechanical connection between the fin and tube in all defined operating conditions, facilitating the utmost level of heat transfer between air and internal coolant.
Collectors are made from steel tubes in hot/cold water coils and from copper tubes in steam coils. Connections are manufactured from steel pipes with external screws; they can also be manufactured with flanges upon demand. Collector material can also be selected as stainless steel upon demand. Air vent and drain connections on collectors are standard.
All connections between coil systems are made manually, using copper based welding alloys.

2.3.5.2 COIL CAPACITY SELECTION MONOGRAM

Depending on design conditions, the capacities of heating and cooling coils that will be used within the air handling unit can be determined quickly and correctly, using the following monogram.

Air Flow Rate – Cooling and Heating Capacity Monogram



2.3.5.3 Testing of Coils

Unless otherwise specified, all coils can be tested after assembly, by immersion into a water filled pool under a pressure of 20 kg/cm2. Testing can also be performed under a pressure of 30 kg/cm2 upon demand.

2.3.5.4 Cleaning Coils

All coils are washed externally with chemicals and water-steam following manufacture. A drying step is implemented as a standard after washing.

2.3.5.5 Measures Against Freezing

Water coils are protected against freezing. For this purpose, a 30% glycol mixture provides freeze protection against outdoor temperatures down to -14°C. However, since the temperature value drops in systems using glycol mixtures, a reduction occurs in heat transfer efficiency. This should be kept in mind during selection.

Freezing Point of Mixture According to Glycol Ratio		
Freezing point for 100%	≈	0°C
Freezing point for 90% water + 10% Ethylene Glycol	≈	-3°C
Freezing point for 80% water + 20% Ethylene Glycol	≈	-8°C
Freezing point for 70% water + 30% Ethylene Glycol	≈	-14°C
Freezing point for 60% water + 40% Ethylene Glycol	≈	-22°C
Freezing point for 50% water + 50% Ethylene Glycol	≈	-34°C
Freezing point for 40% water + 60% Ethylene Glycol	≈	-49°C
Freezing point for 30% water + 70% Ethylene Glycol	≈	-65°C

Theoretical C Values According to Mixture Ratio
C value for 100% Water ≈ 1 kcal/kg °C
C value for 50% Water+%20 Ethylene Glycol ≈0,94 kcal/kg °C
C value for 65% Water+%35 Ethylene Glycol ≈ 0,87 kcal/kg °C
C value for 50% Water+%50 Ethylene Glycol ≈ 0,80 kcal/kg °C

2.3.5.6 Freeze-Free Thermostat

It is used for to protect coils against freezing. 6 meter long sensor capillaries, any 30 cm length along the pipe falling below the set value is sufficient for the device to transition to warning state. Typically, the capillary tube is attached to the air outlet side (not the fresh air inlet side) of the front heating coil with clips, covering the entire surface area. In case the required electrical or automatic connections and the freeze-free thermostat issue warnings, the fan should be stopped, fresh air dampers should be shut down and the heating coil valve should be brought to the open condition.

2.3.5.7 Condensation Pans

Cooling cells are equipped with single or double outlet drain pans. Double slanted stainless steel condensation pan is a standard in Flexline and Hijyenline air handling units. Traps should be connected to drain pipes of pans. Drain outlets should be directed to the plant's independent drainage facility. It is recommended that a drains system be installed for multiple outlet drain pans. The "H" measurement must always be larger than the minimum and maximum pressure generated by the fan.

2.3.5.8 Drainage System

The majority of cooling coils have been placed to allow intake air to pass through then onto the units. As a result, they are subjected to negative (-) static pressure. If measures to balance pressure on the condensation drainage line have not been taken, the air that is suddenly and rapidly sucked back from drainage tubes will cause the condensate to accumulate in the drain pan. The water which collects as the unit continues to operate will be carried along with the air current and cause the water filling the drain pan to seep into air intake ducts and/or water flooding damage in the building. For this reason, traps are placed under pans to avoid water accumulation in HSK air handling units.

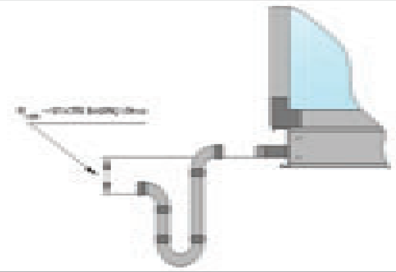
Mounting the condensation drain trap and connecting the pipeline:

A drain pipe line should be connected to the drain connection of the unit, according to specified conditions. Pipes connected to the drainage line must definitely be inclined and unused drainage connections on the outlet line should be shut off with a blind cap. In order to determine the trap height "H", first the negative static pressure within the system should be determined. The worst case conditions should be taken into consideration at all times, for instance contamination on filters on the fan return air flow.

Example:

Negative Static Pressure	= 65 mmSS
For safety	= 20 mmSS
Height "H"	= 85 mmSS

Hmin= STATIC PRESSURE + 20mm



2.3.5.9 Drop Eliminator

Imported polypropylene drop eliminators with a heat resistance of up to 135°C are used. In temperatures exceeding this temperature, stainless steel painted and galvanized and aluminum drop eliminators can be used.

Direct Expansion (DX) Coils

DX coil involves transferring the heat taken from the evaporator with a using a coolant, to the coolant and releasing the heat to the atmosphere. The coolant is directly evaporated at the source to which the heat will be transferred (hence within the air handling unit). Unlike other systems, the use of another coolant in heat transfer is not required. In heat transfers made with traditional cooling groups (chillers), heat is first transferred to water, then to the heat exchanger within the cooling group and here it is finally transferred to the coolant. The heat transferred to the coolant is released to the atmosphere with a compressor.

2.3.5.10 Advantages of the DX system

The DX coil systems offer many advantages. The losses being very small compared to traditional systems is the most significant advantage. Other advantages can be listed as follows:

- High cooling action coefficients, low operating costs, Start-up in a very short time, Much lower maintenance costs as compared to other systems,
- Easy assembly and low assembly cost,
- Reduction in operational costs for heating and cooling,
- The fact that heating and cooling can be made with a single outdoor VRF (Variable Refrigerant Flow) unit (heat pump),
- The fact that it provides a new, easy and quick solution with a single investment to small and medium scale facilities,
- The fact that it can be used in applications requiring medium scale power (14-130 kW/h in stages in a single unit),
- The fact that freeze risks of air handling unit water coils do not exist in this system,
- The fact that it only consumes the power it requires, since it is locally controlled,
- The fact that the malfunctioning unit does not effect other units, since the system is not centralized,
- The lack of energy losses in coolant tubes, which is an issue in traditional systems,
- The fact that it has a longer useful life than traditional units,
- Low noise level.

Disadvantages of the DX system

DX coil systems have their disadvantages as well as advantages. These can be listed as follows:
Investment costs are somewhat higher as compared to traditional systems.
While system is in operating in cooling mode, condenser efficiency drops and capacity losses occur when outdoor temperature rises above 43°C.
While the system is operating in heating mode, capacity losses are experienced during the defrost operation required by the condenser unit. However, these disadvantages can be improved by some additions to the system (electrical heating coil or water heating coil). Although the defrost operation is an unwanted condition, it can not be avoided. If no additional improvements are considered, the system air flow can be halted throughout the defrost period (approximately 5 minutes).

2.3.6 Electrical Heaters

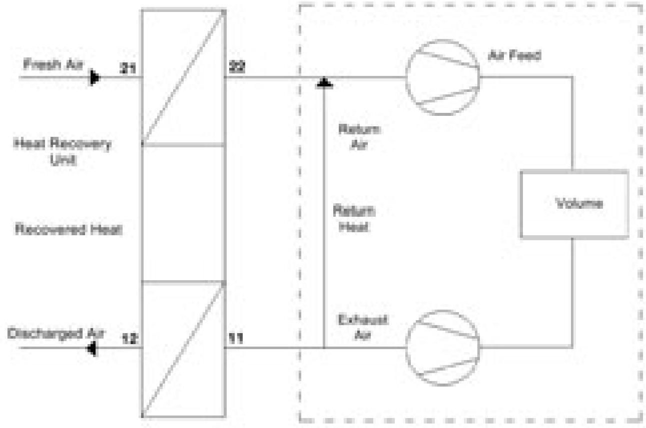
In standard electrical heater coils, finned galvanized steel tubes are used. The use of stainless steel tubes is also possible as an option. All electrical coils are placed within a galvanized sheet casing. Ceramic terminals and safety thermostat used for controlling maximum temperature are standard pieces. Electrical heaters can be placed inside any commercial or industrial air conditioning, heating, or ventilation equipment. High capacity electrical heating coils can be split into the desired stages upon demand.

2.3.7 Heat Recovery Systems

Heat recovery systems used in HSK air conditioning systems preheat (cool) the fresh air taken in outdoor conditions using exhaust air, bringing the enthalpy and temperature of fresh air to interior space conditions. However, in these systems, if energy is taken from another system, heat recovery does not occur. According to VDI 2071, the transfer of mass is not heat recovery. Thus, heat recovery can not be achieved by mixing air.

Basic Principle of Heat Recovery

Sensible heat is transfer is made primarily in heat recovery units. Latent heat can be transferred depending on the

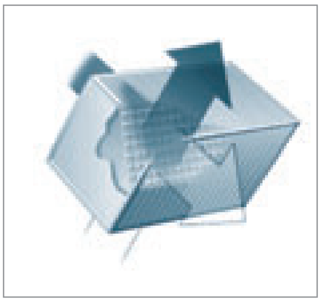


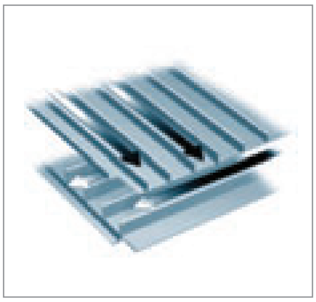
structure of the heat recovery unit. Heat recovery units can be divided in 2 general categories:

- Recuperative Systems
- Regenerative Systems

a) Recuperative Systems

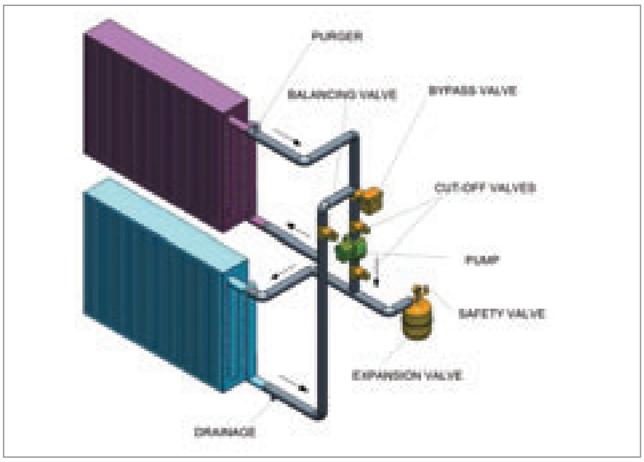
The air that transfers heat, makes the transfer in a specific area. The air expelled with outdoor air, is separated in this area with a heat transfer layer. Air flow can be parallel or counter-current. If humid air is below dew point temperature, condensation will occur and lead to latent heat transfer. Matter transfer will not occur unless there is a leak. These systems have risk of freezing and heat is not transferred by a carrier. Air currents should converge on at least one point in the area. It is not possible to turn of heat transfer. Outdoor air our exhaust air should be bypassed for control of heat transfer.





b) Regenerative Systems

Heat is transferred via air passing over two interconnected coils. One of the coils is at the side of outdoor air and the other at the side of exhaust air and these are connected with tubing. The fluid facilitating heat transfer circulates within these tubes. Chemically treated water is usually used as fluid. Antifreeze is added if necessary. The fluid facilitating heat transfer circulates within the system with the aid of a pump. The flow in this system is regulated with valves. If the air exhaust from the system falls below the dew point, condensation occurs. This leads to an additional latent heat transfer. There is risk of frosting.



The enclosed circulation system allows the process to occur even when the outdoor air and exhaust air are at long distances to each other. Air currents do not have to come together, but additional energy to facilitate the circuit is needed. This is the electrical power required to operate the pump that facilitates the circuit. The amount of recovered heat can be easily regulated by controlling the flow of water. The system can be shot down.

2.3.7.1 Plate Heat Exchanger

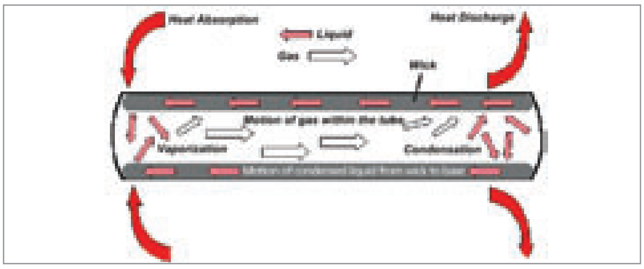
Operating on the recuperative principle, these are aluminum or steel plate heat recovery systems. The system operates on the counter-current principle.

Fresh air and exhaust air pass through two separate layers. Plates are designed to facilitate maximum heat transfer and should provide a minimum of 60% heat recovery to meet the condition of being economical. There is a drop eliminator at the air exhaust side. The heat recovery cell includes a bypass damper to control air flow and prevent freezing. There is a stainless steel condensation pan on the exhaust side and the

HSK Heat Recovery Air Handling Unit Using Plate Type Heat Exchanger

drainage pipe (stainless steel) of this pan is hermetically extended outside the unit. It is hygienically important to mount a filter outside the filter on the intake side and before the heat recovery coil on the exhaust side.

2.3.7.2 Heat Pipe Heat Recovery Unit



Operates on the regenerative principle. In this system, coolant is used to transfer heat and the unit operates on the principle of the coolant vaporizing upon meeting the system return air and rising within the tube and then transferring its heat to cold air and condensing back into liquid. The system can operate in the -30°C and 55°C temperature range without any problems. The heat recovery cell includes a bypass damper to control air flow. The heating pipe can be used horizontally side by side or vertically stacked. Horizontal types can be designed to conduct heat recovery also in summer conditions when required.
A drop eliminator is mounted on the exhaust side. There is a stainless steel condensation pan and the drainage pipe (stainless steel) of this pan is hermetically extended outside the unit. Mounting a filter before the heat recovery coil is recommended to prevent contamination.

2.3.7.3 Horseshoe Heat Recovery Unit

This is a sort of heat type heat recovery unit. It is used in places where relative humidity and outdoor temperature are high. In this system, the cooling coil is placed within the unit between the precooling and reheating sections of the horseshoe heat recovery unit. The warm and moist air is cooled by passing it through the precooling coil first. Then the air passing through the cooling coil also passes through the reheat coil, and conditioned to the desired temperature and relative humidity. The system does not contain any moving parts. The process is achieved with the thermal energy carried by the coolant which flows naturally within the horseshoe heat recovery system due to the temperature differential.

2.3.7.4 Rotor Type Heat Recovery Unit

Operates on the regenerative principle. It consists of a circular aluminum mass containing pores to allow the passage of air. Heat recovery is achieved with the turning of the rotor. The heat and temperature of the exhaust air is transferred to the rotor blades with the turning motion of the heat exchanger rotor. The transferred moisture and heat energy is passed on to fresh air by the continued rotation. In addition to heat transfer conducted during the winter, it is also possible to save energy and conduct dehumidification with the same unit in the summer. The heat wheel is usually commanded by speed control. Heat recovery ratio usually varies between 60-80% in rotor heat recovery systems. Heat recovery which occurs below this range is not economical.

The use of heat recovery units
- Reduces the annual heat (chill) consumption.
- Reduces the peak heating (cooling) power.

Computation of Heat Recovery and Unit Efficiency:
In cases where condensation and humidity transfer does not occur, the heat (chill) gain (Q, kW) will be equal to the sensible heat exchange of fresh air.
Here m is the mass flow (kg/s) of the fresh air passing thro-

$$Q = m_{hava} \times C_p \times (T_{çth} - T_{gth})$$

ugh the heat recovery unit, Cp is the specific heat of fresh air (kJ/ kg-K), Tçth and Tgth are the exhaust and intake temperatures (°C) of fresh air respectively.

In chill recovery applications where the temperature differential between exhaust and fresh air and the relative humidity of fresh air are high, a portion of the humidity within fresh air condenses in the heat recovery unit. In this case, the chill gain of fresh air is calculated as a function of enthalpy (h, kj/kg) between the unit intake and exhaust.

$$Q = m_{hava} \times (h_{çth} - h_{gth})$$

2.3.7.5 Double Rotor Air Handling Units

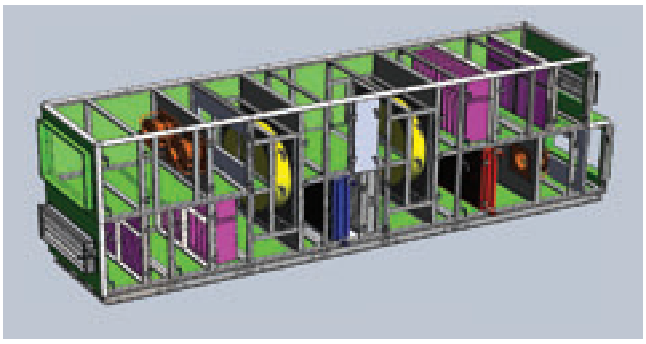
Double rotor air handling units are systems which provide high energy efficiency especially in conditions of high temperature and high humidity. For double rotor air handling units to operate with the expected energy efficiency, they should be operated without interruption with 100% or nearly %100 fresh air.

One sorption rotor and one sensible rotor is used in double rotor air handling units.

Sorption Rotor: The total heat transfer wheel also conducts a high amount of latent heat (moisture) transfer in addition to sensible heat recovery. The moisture transfer capabilities of these total heat transfer wheels which have been coated with adsorptive surfaces have been increased. The capacity is fixed and high throughout the year. The heat wheel fill is manufactured by winding one row of plain and one row of shaped standard aluminum bands. Surfaces have been covered with a special molecular sieve or silica gel, offering superior adsorption.

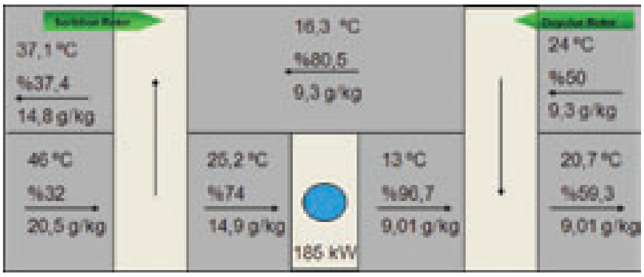
Sensible Rotor: These are condensation heat wheels that have been manufactured to transfer sensible heat. The fill consists one row of plain and one row of shaped standard aluminum layers.

Comparison Between Double Rotor Air Handling Unit and %100 Fresh Air - Air Handling Units Without Heat Recovery



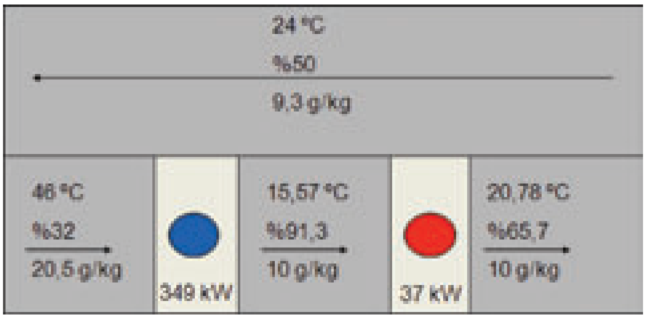
Double Rotor Air Handling Unit

In case the system has been equipped with a double rotor heat recovery system, 185 kW of cooling power is required. Temperature, relative humidity and specific humidity values on each point has been indicated on the following figure.



ouble Rotor Air Handling Units Design Values

If the system does not include a heat recovery application, 349 kW of cooling power and 37 kW of heating power is required. Temperature, relative humidity and specific humidity values on each point has been indicated on the following figure.



Design Values for a 100% Fresh Air Air Handling Unit without Heat Recovery

A comparison between the total power required for both systems, it is seen that the double rotor air handling unit is 48% more efficient than the air handling unit which does not include heat recovery.

2.3.7.6 Temperature and Enthalpy Efficiency in Heat Recovery Units

Exhaust temperature of fresh air reaches the intake temperature of exhaust air (Tgeh, °C) under ideal conditions. Temperature efficiency (h) is defined with respect to sensible heat change of fresh air.

In practice, depending on the position of the heat recovery unit, the intake temperature of fresh air into the heat recovery unit can be taken as equal to outdoor air temperature;

$$\eta = \frac{T_{cth} - T_{gth}}{T_{geh} - T_{gth}}$$

and the intake temperature of exhaust air can be taken as equal to the indoor ambient temperature. In this case the heat efficiency equation is expressed as follows.

$$\eta = \frac{T_{cth} - T_d}{T_{ig} - T_d}$$

The equation indicated above for heat efficiency provides valid results in terms of unit efficiency for conditions not involving condensation. However in cases where condensation occurs on the fresh air side of the heat recovery unit or where humidity transfer occurs on the unit, heat efficiency is insufficient in indicating unit efficiency. For such cases, the enthalpic efficiency expression is used, which is calculated as a function of fresh intake and exhaust air enthalpies and the enthalpy of the exhaust air entering the heat recovery unit.

Enthalpic efficiency is expressed as follows, similarly to heat efficiency.
hçth: Enthalpy of fresh air exiting the heat recovery unit

$$\eta_t = \frac{(h_{cth} - h_{gth})}{(h_{geh} - h_{gth})}$$

hgth: Enthalpy of fresh air entering the heat recovery unit
Enthalpy of exhaust air entering the heat recovery unit

Pressure Drop:
The fan power required to accommodate the pressure drop

$$P = 2 \times V_{debi} \times \Delta P / \eta_{fan}$$

in the heat recovery unit is calculated with the equation:
Here,
P stands for fan power (W),
Vdebi stands for unit flow rate (m3/s),
ΔP stands for the pressure drop within the unit (Pa) and
hfan stands for fan efficiency.
The coefficient "2" is used to calculate the total power of the outdoor exhaust and fresh air sides.

2.3.8 Filters

The basic function of filter cells is to prevent the accumulation of dust on the internal surfaces of coils and panels, extending the efficient lifetime of the air handling unit. Dust accumulation is an unwanted condition which reduces the heat transfer efficiency of coils. Additionally, use of high particle efficiency filters is required for environments where the air must be kept free of air-borne harmful micro organisms (pharmacological production facilities, operating rooms, clean rooms, microchip production facilities).
For this reason, various filter classes with the ability to filter particles of various diameters have been developed.

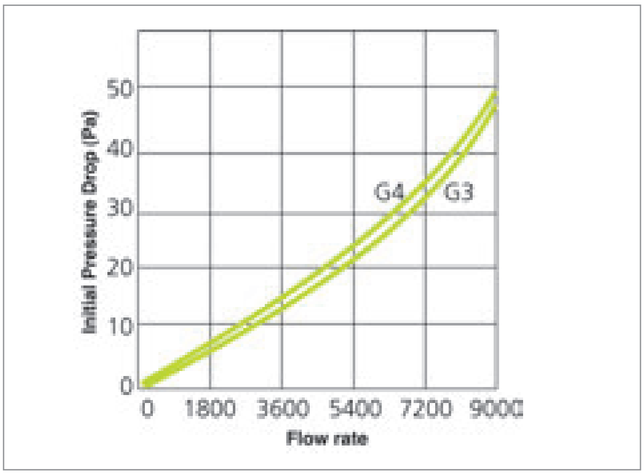
HSK filter cells are distinguished for their design which reduces filter pass pressure losses by minimizing the rate on the filter. To this end, cell dimensions are designed in proportion to filter dimensions. The special spring clip casing design provides a high level of impermeability. This feature which is particularly important for HSK Hijyenline air handling units, prevents microbiological proliferation. In addition to these features, filter cells have been designed to facilitate easy maintenance thanks to their wide filter covers and spring clip filter casings. Differential pressurestats for measuring filter occupancy can also be used as an option.
In HSK air handling units, various filtering options are applied and optimum options are offered depending on the place of use and upon requirements.

Filter Classes

Particle Size	Examples of Particle	Filter Classes	Examples of Applications
Larger than µm	Insects, textile fibres and hair	G1 G2	For simple applications (for example for insect protection in compact devices)
Coarse dust filter for particles	Dost, suspended ash, pollen, spores, cement dust	G3 G4 G5	Pre and ambient air filter for civil protection facilities; paint spraying cabin air exhausts and kitchen exhausts etc.; contaminant protection for air conditioners and compact units (e.g. window type air conditioners, ventilators); pre filter for filter classes between F6 and F8
Fine dust filter for particles between 1-10 µm	Pollens, cement dust, particles causing dust settling and stains, bacteria and microbes on host particles	F5	Outdoor air filter for places with low demands (e.g. factory hangars, storage areas, garages)
		F5 F6 F7	Pre and ambient air filtration for ventilating stations; final filter in air conditioning installations for shopping malls, offices and some manufacturing venues, pre filter for filter classes between F9 and H11
Fine dust filter for particles between 1 -10 µm	Oil fume and agglomerated soot; tobacco smoke, metal oxide smoke	F7 F8 F9	Final filters in air conditioning installations for offices, manufacturing venues, command centers, hospitals, data processing centers; pre filter and active carbon for filter classes between H11 and H13
Floating substance filter for particles smaller than 1 µm	Microbes, bacteria, viruses, tobacco smoke, metal oxide smoke	H10 H11 H12	Final filter for environments such as laboratories, pharmacological manufacturing venues, food manufacturing venues
		H11	Final filter for clean spaces of classes 100.000 or 10.000
	Oil fumes, soot and radioactive materials that are in the process of being generated	H12 H13	Final filter for clean spaces of classes 10.000 or 100, final filter in civil protection facilities, exhaust air filter in core technology facilities
	Aerosols	H14 H15 H16	Final filter for clean spaces of classes 10 or 1
Separation of materials that are harmful when inhaled	Kitchen exhaust filters, harmful airborne materials, smog, combustion gas, solvent fumes, food odours, foul odours	Active Carbon Filters	Exhaust filters bound by environmental protection regulations, all environments where harmful gases exist

Panel Filter:

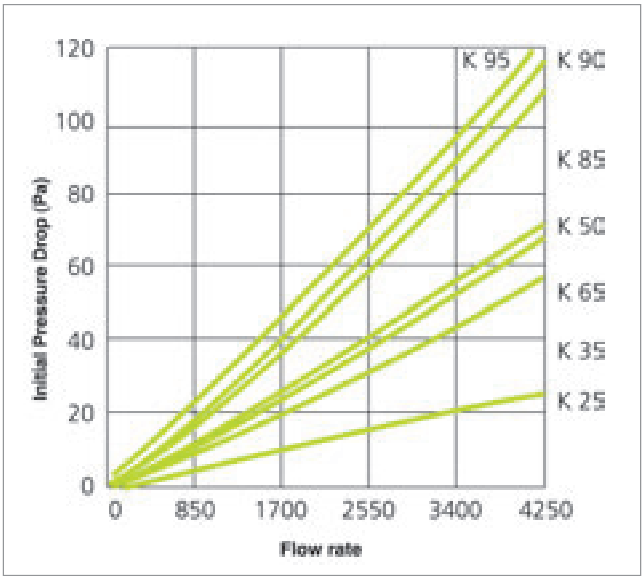
Manufactured in G3 and G4 classes, these filters are produced from high quality galvanized steel, PVC or fibreglass material. The decisive point in the design of these filters which have a gravimetric efficiency of 85 - 95%, is creating a corrugated structure and hence a larger filtering surface. Panel filters which can withstand temperatures of up to 180°C are used in HSK air handling units for pre-filtration to lengthen the useful life of higher particle efficiency filters. Their being washable is a significant advantage which lowers their operational and maintenance costs and which make them popular. Shown below is the Flow Rate-Pressure Drop graph for the standard dimension filter module.



Bag Filter:

Manufactured in various classes from G4 to F9, bag filters are produced with galvanized frames as a standard. The filtering element is produced from fibreglass. Its extended surface design leads to low flow rates, thus facilitating low pressure loss, high dust capturing capacity, long use and low energy costs. Bag filters are capable of providing solutions for all types of air handling units. Particularly bag filters known as rigid type bag filters, with a plastic frame design are quite popular since they can be used in both downstream and upstream.

Shown below is the Flow Rate-Pressure Drop graph for the standard dimension filter module.



Bag Filter Models						
G3	G4	F5	F6	F7 F8	F8 F9	F9
K25	K35 K35	K50	K65	K85	K90 K0011	K95

Active Carbon Filter:

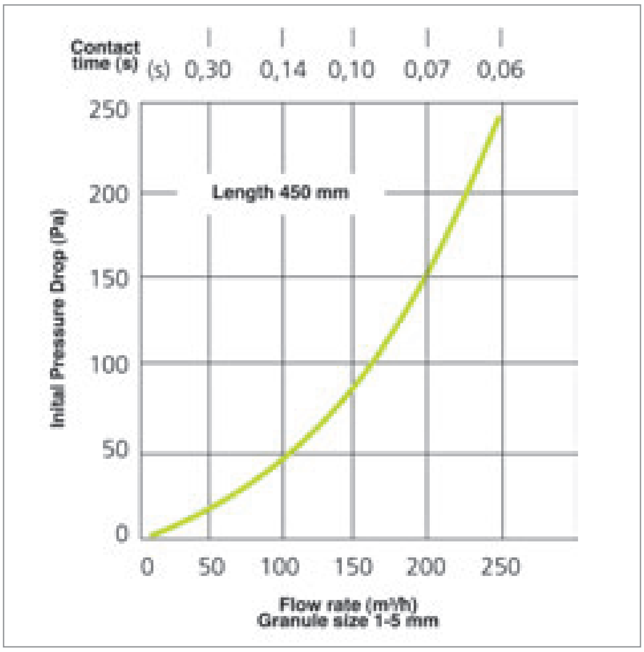
Manufactured as cylindrical cartridges, active carbon filter are used in the filtration of harmful and malodorous gases. These filters are preferred in HSK air conditioning systems in cases where the return air as well as fresh air needs to be purified of these harmful and malodorous gases. A table concerning the use of active carbon filters has been shown below.

Areas of Use	Contaminants
Automotive Industry	Aliphatic and odorous solvents
Food Industry	Odour compounds
Airport air inlet	Kerosene and hydrocarbons
Solvent storage tanks	Organic solvents
Hood (aspirators)	Odour compounds
Cigarette filters	Tar and phenols
Fruit storage spaces	CO_2 level control

Carbon filters can be used efficiently up to 40°C temperature and 70% relative humidity. In case high efficiency pre-filtration (F7-F9) is used in applications, filters are not filled with dust particles which allows them to continue their true function of capturing gas molecules more efficiently and for a longer period of time.

Absorptivity of regular carbon decreases with increasing humidity, yet this is not an issue for active carbon. Furthermo-

re, in cases where the contact time is increased by lowering flow rate, active carbon filters operate more efficiently.
Another point which should be taken into consideration in carbon filter selection is that they are 10-20% more adsorptive when loaded to 50% of their total capacity. Shown below is the Flow Rate-Pressure Drop graph for the standard dimension filter module.
Filter selections which take all these filter properties into consideration increase useful life and lower maintenance-operational costs.

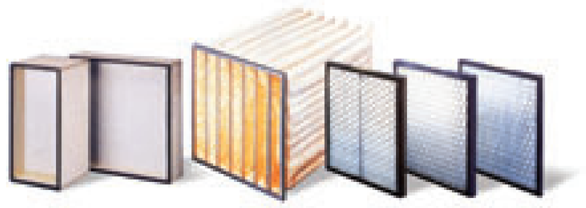


HSK’s recommendations regarding filter selection have been summarized below.

HSK’s Recommendations for Filter Selection

- Low efficiency pre-filtration before high efficiency filtration is important for lengthening filter lifetimes.
- Pressure drop should be measured by using manometers after filter cells. Filter occupancy ratio should be determined in this way and filter replacement should be made by taking this value into consideration.
- Care must be taken to ensure that air does not bypass the filter. Do not forget that a filter is only as good as the quality of its transfer connections.
- Dust capturing capacities should be taken into consideration while comparing filters.
- HEPA filters should not be placed within the air handling unit. In cases requiring the use of HEPA filters, the placement of filters inside the duct or on diffusers will lead to better results in terms of operating efficiency.
- Filters should be placed as far from humidifier cells as possible. Since contact of water droplets on the filters increases the probability of microbial propagation, it may cause system contamination and serious health problems.
- Filters should not be loaded more than the manufacturer’s recommendation.
- High efficiency filtering and filters which are used in a full state increase operational costs of fans.
- During fan selection, the average pressure calculated with respect to the completely full and completely empty state of fans should be used. In fan selections based on only completely empty or completely full state pressure losses, system will either be incapable of producing the desired pressure, or produce excessive pressure, damaging equipment.
- The possibility of freezing on the filter should not be ignored. Freeze-free coils should be used in cases where the risk of freezing is high.

Filter frames:



- Standard frames

These are designed with the purpose of placing bag filters, rigid filters, and active carbon filters in the system in a way that prevents leaks. They are manufactured from galvanized steel or stainless steel.

There are three locking depths (25 mm, 50 mm, 100 mm). Filters are fixed on the frame with expanded polyurethane seal placed between the filter and frame and spring clips used to tighten this seal. Filter cells can be designed to allow maintenance from the fresh air side and from the dusty side and service doors of the required sizes are added to the cells as a standard.

- Quick assembly frames

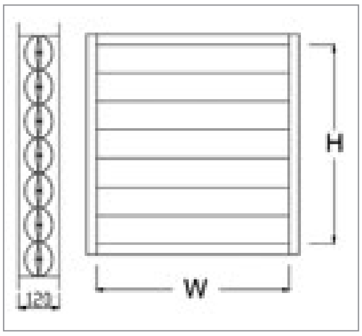
These are designed for similar purposes as standard frames, yet filters are fixed on the frame with steel fortified, profile seals. A reinforced fibreglass lever arm and press plate system is used for tightening. The locking depth is 25 mm. Depending on design, filters can be replaced only from the fresh air side.

2.3.9 Dampers

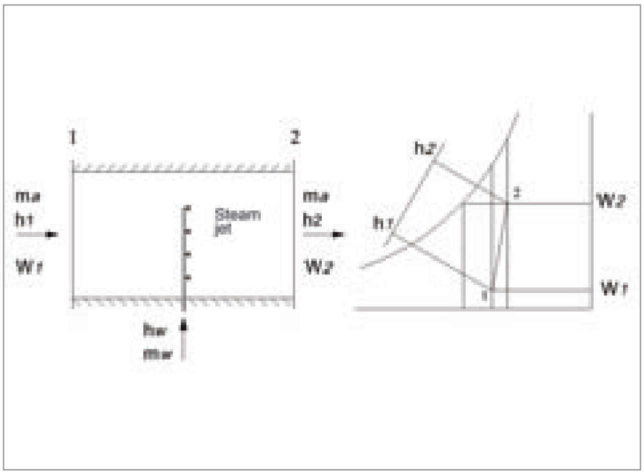
Dampers are equipment which allow flow rate adjustment by altering the air passage cross-section by its blades rotating on horizontal pins. These are used in air mixing and heat recovery units, for the purpose of handling the precise flow rate adjustment in an economical fashion.

They are manufactured form aluminum as a standard. Their blades which move in opposite directions allow precise adjustment of the air flow rate. Blades are designed to offer no resistance to air flow and attached to the frame with hidden gear bearings and bushings. Thanks to the hidden gear design, moving parts are protected from dust and dirt, which enables a long life for the damper. Furthermore, special hermetic seals are mounted on blades. There is a mechanism lever on air mixing applications as a standard. A cast aluminum flap lever is used for adjusting the position of the damper. Additionally, damper opening control is handled with a servo motor controlled by the automated system in air handling units commanded by an automatic control system.

Dampers are attached to the system with 40 mm unperforated flanges. The main purpose here is to achieve a high level of impermeability.



The pressure loss graph by blade spacing and air speed is as follows. During design damper pressure loss is calculated with respect to 45° opening of the damper and fan selection is made according to this figure.



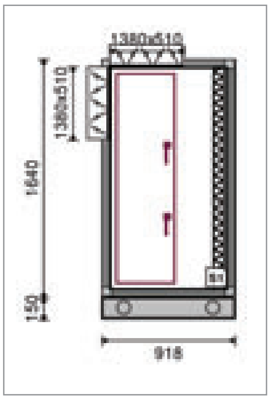
Dampers have been designed to operate at 2000 Pa differential pressure up to 1 meter blade lengths. Operating temperatures vary between -20 °C and 120 °C, while the maximum permitted air flow rate is 15 m/s.

The closed state of dampers has a critical importance for the system. During damper opening adjustment made manually while the unit is in operation, the system will overload if the damper is completely closed. In this case, the probability of damage to panels and equipment is quite high. To prevent this from happening, a manometer should be used which senses system pressure and sends signals to the control system. In this way the fan can be stopped instantly and the damage to the system be prevented.

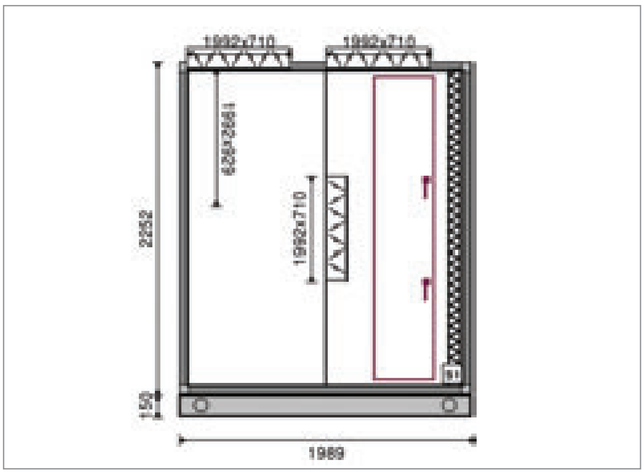
2.3.10 Mixing Chambers

The two-way mixing chamber is used in cases where fresh air is mixed with return air. The basic goal here is to minimize energy consumption by taking advantage of the heating/cooling ability of the return air. In this system, fresh air is only required to supply the air change rate needed for comfort.

Damper openings can be controlled manually or by servo motor, but the main issue which requires attention is to provide the air mixture rate needed for the system. Thus dampers are designed to allow synchronous control.



The three-way mixing chamber has been designed for similar purposes. However, this system includes a fan for return air and while the desired portion of return air is given back to the system, the remainder can be exhausted.



Dampers used on both types of mixing chambers have opposing blades and have been designed to allow them to be controlled individually.
While setting dimensions of fresh air dampers in mixing chambers, the dimensions are determined to allow operation with100% fresh air as required by the free-cooling system which can be used in transitional seasons.

2.3.11 Silencers

Silencers are elements which bring noise levels to desired levels while attenuating noise within air handling units or ventilation ducts. Sound attenuation is achieved through the porous material found within the silencer.
In HSK applications where low noise levels are called for, silencing units are placed in front of and/or behind fan cells. The sound attenuation is achieved by the sound absorbent material which has been manufactured from foam glass with a fire rating of A2. The foam glass is selected in the range 20-50 kgm3. Bock thicknesses of sound attenuating elements are 200 mm as a standard.
Frontal surfaces of silencers should be covered with sheet metal to prevent the air from passing directly over the foam glass material. If the air would be passed directly over the foam glass material, very high pressure losses will occur in the porous environment, hence on the foam glass.
While silencers serve basic their function of attenuating sound, they cause pressure losses resulting from air flow within the air handling unit or the ventilation duct. For this reason, silencers that are placed at specific distances should be designed to make sure their frontal surfaces that are perpendicular to air flow will lead to minimal pressure drops, hence eliminating needless pressure losses. For this reason, frontal surfaces of silencers have plain, triangular and curved forms. Pressure losses occurring within the silencer cell has been examined for a simulated silencer cell selected for the experimental setup.
Studies have shown that intake and discharge frontal surfaces of silencers should have a curved form. It has been ob-

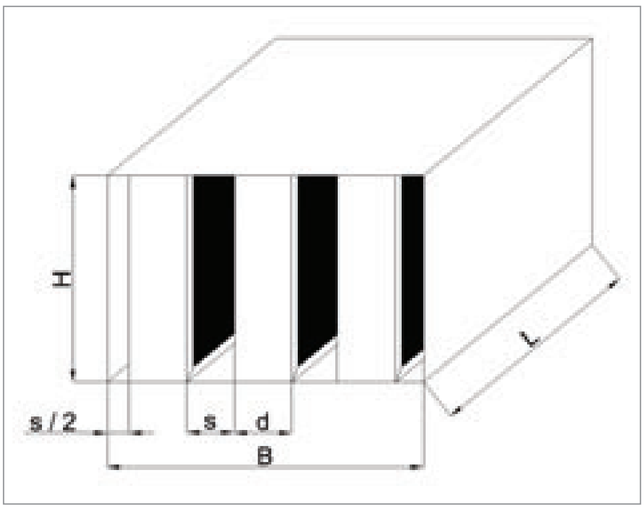


Table 1 - Pressure drop analysis for a nominal silencer cell.

Damper	Total pressure drop generated in the damper cell (Pa)	Decrease in the pressure drop generated in the damper cell (%)	Frontal surface drawing
Frontal surface flat	70	0	
Frontal surface triangular	66	6	
Frontal surface curved	52	26	

served that this provides a 26% reduction in pressure losses occurring within the silencer cell. Experimental studies have also shown that maximum sound attenuation is achieved with the silencer with curved intake and discharge surfaces. For this reason, silencers with curved intake and discharge surfaces are preferred in HSK air handling units.
For the silencing to occur as required, the design air velocity within the silencer is less than 8 m/s. Additionally, placing an empty cell after the fan cell in order to ensure a more efficient operation for silencers placed after the fan cell is a common application in HSK air handling units.

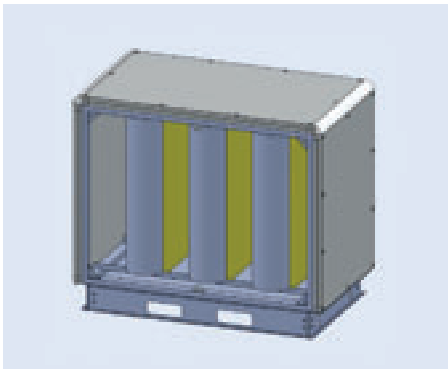


Figure 1 - Silencer Cell with Cylindrical Frontal Surface

Silencer lengths vary according to the maximum noise level permitted in the system. The required silencer dimensions for the desired sound attenuation level are determined by the Airware program.
Silencers should not be used right after cells such as dehumidifying heat recovery systems, where condensation occurs.
Silencers and acoustic blocks should be designed as replaceable. Sound attenuation elements are manufactured to resist weathering and the effects of cleaning.
In order to prevent the drifting of glass fibres within the air handling unit, lateral sides of attenuating elements are coa-

ted with glass tissue with a fire rating of A2. In very dusty or humid environments, the use of porous galvanized steel plates is recommended. The porous plate is also required to provide the specifications of the hygienic air conditioner. For this purpose, this application is a standard for Hijyenline air handling units. Furthermore, sharp corners are avoided within the silencer cell in air handling unit applications, to facilitate cleaning.
Ventilation and air conditioning systems should not be used unless their silencers are up to acceptable specifications. Acoustic block should be controlled throughout the application, and replaced or properly repaired if needed.

2.3.11.1 Sound and Acoustic Insulation

The principle of comparing the level of a sound source placed within the air handling unit to that of one at a specified distance outside the unit is called “acoustic insulation.”
Sounds can be classified according to their intensity, or in other words their loudness. This is the pressure level of the sound and measured in ”decibels" (dB). The louder the sound is the higher the decibel value of sound pressure is.
Sound power is the measurement in Watts of power issued from sound sources such as machines or devices. Sound power varies according to operating conditions (rotational speed, load carried, etc.) of the sound sources (machine, etc.). It is not influenced by the conditions it is in. Sound pressure on the other hand, varies according to the distance from the sound source, the angular position and the acoustic properties of its environment. For this reason, the most significant parameter by which sound sources should be monitored for damage and unwanted effects is "sound pressure" which also includes environmental conditions. Sound pressure levels are measured for specific values between 125 Hz and 8 kHz.

Range of Sound Pressure

20 μPa has been accepted as the lowest sound level which can be heard by the average person and for this reason, it is called the hearing threshold. 100 Pa on the other hand is a very high level which causes pain, and for this reason it is called the pain threshold.
In this way, the linear scale which comprises extends to very large numbers over a vast range is transformed into a simpler scale which begins at the hearing threshold (0 dB) and ends at the pain threshold (130 dB).

dB(A) is a unit used for sound evaluation particularly emphasizing the medium and high frequencies to which the human ear is most sensitive. The dB(A) unit used commonly in sound dampening and sound control, has to do with a subjective evaluation of the loudness of sound.

Table 1: SOUND PRESSURE	
dB	μPa
0	20
14	100
34	1000
54	10000
74	100000
94	1000000
114	10000000
134	100000000

The following table indicates the state by which the human ear perceived a change occurring in the sound level.

Tablo 2	
Change in Sound Level (dB)	Change in the Loudness of Perceived Sound
3	Barely sensible
5	Perceptibly different
10	Two fold
20	Four fold

Transition from sound power to sound pressure:

$$S_{PL} = S_{WL} + 10\log\left[\frac{Q_\theta}{4\pi r^2} + \frac{4}{R_c}\right]$$

S_{PL} = Sound Pressure Level dB (Reference level 2x10-5 Pa)
S_{WL} = Sound Power Level dB (Reference level 10-12 W)
r = Distance to sound source (m)
Q_Θ = Orientation factor (Depends on the position of the sound source)
R_c = Room coefficient (Depends on the room area, materials used in room's construction and on the materials within the room)
Before and after the noise measurement, the background noise in the environment must also be measured. If the difference between the measured levels and the background noise is more than 10 dB no action is required, if it is less than 10 dB background noise should be eliminated and if it is leas than 3 dB, a reliable measurement can not be taken.

The condition where more than one sound level exists together:

While two sound levels generate sound energy, they also contribute to the sound pressure level on points that are away from the sources.
If both sources generate the same level of energy, and there is a point which is equidistant from both sources, the sound intensity at this point will be twice the sound intensity that a single source would create on that point. Since sound

SOUND ATTENUATION VALUES OF AIR HANDLING UNIT EQUIPMENT										
Frequency	Hz	63	125	250	500	1000	2000	4000	8000	Ortalama
Panel Filter (G4)	dB	1	1	1	1	1	1	1	1	1.00
Bag Filter (F7)	dB	1	1	1	1	1	1	2	2	1.31
Coil (1-4sıra)	dB	1	1	2	3	4	4	6	8	4.59
Coil (5-8sıra)	dB	2	2	3	3	6	6	9	10	6.53
Honeycomb Humidifier % 85	dB	3	2	2	3	5	6	12	15	9.31
Plate Type Heat Recovery	dB	2	2	3	4	4	6	7	9	5.62

intensity is directly proportional to the square of sound pressure, doubling sound intensity will cause a 3 dB increase in sound pressure. For example, in case two 50 dB sources are working the total sound pressure level will be 53 dB. Depending on number of sources, the sound pressure (depending on sound intensity) will cause an increase of 6 dB in the presence of 4 sources and 9 dB in the presence of 8 sources.

Taking the Average of Sound Values

The averages of sound pressure levels can be calculated with the following formula:

$$L_0 = 10.\log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{0,1.L_1}\right] \text{dB}$$

2.3.11.2 Vibration

Vibration can be defined as the oscillation around the balance point of a parameter defining motion in mechanical systems. The solution in vibration insulation is to place a flexible connection of the appropriate propertied between the object which is the vibration source and the object which needs to be insulated from vibration.

- When applied correctly vibration dampers:
- Carry static loads.
- Connect machine elements.
- Control dynamic loads and movements.
- Store mechanical energy and release it in a controlled fashion.
- Dampens mechanical energy and converts it into heat.
- Controls free vibrations.

SELECTION OF VIBRATION DAMPENING ELEMENTS

The preliminary data which should be known before selecting dampening elements:

- Type of machine to which dampening will be applied,
- Mass of the unit or machine,
- Approximate position of the centre of mass,
- Number and position of vibration buffers,
- Operational speed and drive mechanism of the machine,
- Frequency of the drive force causing vibration.

Useful preliminary information:

- Connection details of insulation buffers,
- Operating conditions,
- The floor on which the machine will be mounted and its position,
- The desired insulation efficiency,
- Acceptable permeability during resonance,
- Cost limitations.

After the selected insulation buffers are mounted, care should be taken to ensure that the natural frequency of the system is sufficiently removed from the drive frequency. The desirable ratio of the drive frequency to natural frequency is at least 2.5.

Sample Problem:

A 4 kW electrical motor which is located on an upper floor of a steel constructed building drives an air fan. The total mass of the motor and fan is 252 kg and the fan operates at 1460 rpm. Select the suitable insulating elements for this system which will be set on six insulating elements with negligible dampening.

Solution:

The recommended steps for the selection of proper insulating elements are applied.

1. Determining the load on a single insulating element (Wi):

$$W_i = \frac{m.g}{6} = \frac{252 \times 9.8}{6} = 411.6 \text{ N}$$

2. Calculating the drive frequency (f):

$$f = \frac{1460 dev/dk}{60 s/dk} = 24.3 \text{ Hz}$$

3. Calculating the force permeability (T.R):

Table 1 – Insulation Efficiency Values

Power of Motor Driving the Machine [kW]	Recommended insulation percentage [%]		
	Basement or Ground Floor	Heavy Concrete Structure Upper Floors	Light Steel Structure Upper Floors
≤4	–	50	90
4 – 10	50	75	93
10 – 30	80	90	95
30 – 70	90	95	97.5
75 – 225	95	97	98.5

From Table 1, the figure V = 90% is read for a 4 kW motor placed on an upper floor of a light steel constructed building.

$$T.R. = 1 - \frac{V}{100} = 1.00 - 0.90 = 0.10$$

4. Calculating the natural frequency of the system (fn):
It is taken as ʻ = 0 assuming no dampening, and calculated

$$T.R. = \frac{\sqrt{1^2 + (2\zeta r)^2}}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}}$$

from the equation:

$$r = \frac{f}{f_n} = \sqrt{\frac{1}{T.R.} + 1} \quad ve \quad f_n = \frac{f}{\sqrt{\frac{1}{T.R.} + 1}} = \frac{24.3}{\sqrt{11}} = 7.3\ \mathrm{Hz}$$

5. The static collapse determination (‰st) is calculated as follows:

$$\delta_{st} = \frac{g}{4\pi^2 f_n^2} = \frac{(9800\ \mathrm{mm/s^2})}{4\pi^2\,(7.3)^2} = 4.66\ \mathrm{mm}$$

6. Calculation of spring coefficients (k):

$$k = \frac{W_i}{\delta_{st}} = \frac{411.6\ \mathrm{N}}{4.66\ \mathrm{mm}} = 87.62\ \mathrm{N/mm}$$

7. Selection of proper insulating elements from the catalogue:

Load capacity in 6.35 mm (1/4") collapse	Spring Coefficient [N/mm]	MODEL
533,8	84,1	A
689,5	108,6	B
822,9	129,6	C
978,6	154,1	D
1112,1	175,1	E
1245,5	196,1	F
1378,9	217,2	G

The catalogue of a firm manufacturing these types of elements can be used to select the suitable vibration damper. It is usually recommended that the load bearing capacities of the selected dampening elements not be exceeded. Since the actual load exerted on a damper is 411.6 N, it is seen that type A elements with a load bearing capacity of 533.8 N can bear the required load and that the static collapse will be slightly above the collapse calculated as 4.66 mm. This is because the spring coefficient of these elements (84 N/mm) is slightly lower than that is needed (87.62 N/mm).

8. Calculation of actual insulation efficiency (st) with the selected dampers:

$$\bar{S}_{st} = S_{st}\,\frac{GerçekYük}{YükKapasitesi}$$

To calculate the insulation efficiency which will occur in case the selected dampers are used, we need to calculate the true static collapse from the equation:

$$\bar{S}_{st} = 4.66\,\frac{411.2}{533.8} = 3.56\ \mathrm{mm}$$

Using the insulation efficiency diagram provided in Figure 1, the projected insulation efficiency is calculated as V = 0.87. Hence we can say that if Type A insulating elements are used, drive forces will be dampened 87% as they are transferred to the floor.

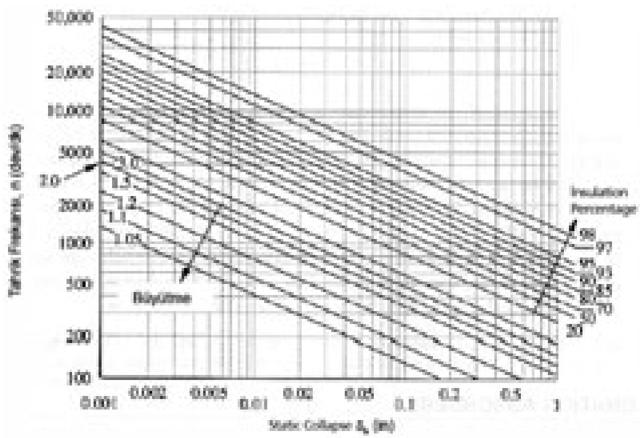


Figure 1- Variation of insulation efficiency with static collapse and frequency

2.3.12 Humidification

The humidification unit is used to control the relative humidity of the ambient air by increasing the absolute humidity of air in the air handling unit. Various types of humidifiers can be used in HSK air handling units according to the application type.

The selection of the humidifier is determined by the parameters listed below:

a) Humidity ratio to be added
b) Procurement of water that can be used or is conditioned.
c) Control tolerance of the site that will have its humidity controlled.

Following table summarizes the affect of relative humidity of the ambient air on human health. Humidity settings can be adjusted precisely through the humidification units of the HSK air handling units.

	AMBIENT RELATIVE HUMIDITY (%)										
	0	10	20	30	40	50	60	70	80	90	100
Health Problems											
ASHRAE Recomm											
Safety Margin											
Microbiological Propegation											

There are two main types of adiabatic humidification. Water is pumped from a container to a collector and then spread over cellulose based humidification cartridges as a thin film in one of types. In other type, on the other hand, it is sprayed directly into the air flow that is passing through the air handling unit. This type of humidifiers has relatively low efficiency and limited control. Water conditioning should be performed and care should be taken for disinfection to minimize the risk of microbial infection in this type of humidifying.

2.3.12.1 Adiabatic Humidifying Chamber

Water tank; 100, 200 or 300 mm thick core; water distribution collector; pipe distribution system; circulation pump; water filter; check valve; float valve; filling and drainage connections; service access, and sight glass. A very high saturation efficiency can be achieved with three core types:

Standard

Core Thickness : 100 mm
Humidity ratio : Up to 60%
Humidity Generation : 6 g/h water evaporates per 1 kg of dry air.

Optional

Core Thickness : 200 mm
Humidity ratio : Up to 85%
Humidity Generation : 8 g/h water evaporates per 1 kg of dry air.

Porous and durable fibre pads which have been manufactured with a special process are wet and the water is made to mix into the air by vaporization from the core surface. This design provided excellent contact between air and water, ensuring optimal water distribution and minimal water consumption. Collector and distribution elements can be easily mounted and dismounted. The humidifier unit and other components can be easily removed through the side panel. Thick galvanized steel construction renders the unit sturdy and durable. The full isolation prevents condensation on the panel's exterior surface, and hence rusting. The entire chamber is constructed as water proof and sealing is achieved with silicone.

Circulation pumps have been mounted within the unit and their connections have been made. The standard pump is 220 V or 380 V/50 Hz.
The water container is manufactured from galvanized steel, with welded connections (stainless steel containers can be supplied).

2.3.12.2 Spray Air Washer Adiabatic Humidifying Chamber:

Spray air washer humidifiers consist of a single row of spray humidifiers placed on a standard 1540 water proof frame in all models. 2 parallel row and 2 traverse rows of spray nozzles can be implemented upon demand. The saturation efficiency is between 70-95%.

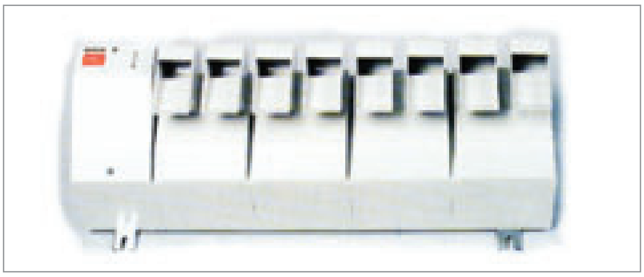
Drop retainers are manufactured from polypropylene material or optionally from stainless steel material. Polypropylene drop retainers are manufactured in two different forms. At air speeds between 2.5-4 m/s, a separator which has a smoother surface stopping the water from drifting off the fin is used. At air speeds between 4-6 m/s, the rough texture of the surface is designed to retain the water even at these speeds. The entire chamber is constructed as water proof and sealing is achieved with silicone.

Water container connections are gas sealed. The check valve, water filter, and float valve are standard pieces of the system. The pump is mounted outside the unit, but pipe connections are not made. Pipe connections should be made on the field. The standard pump is supplied by electricity at 220 V / 3 phase/ 50 Hz. The water container manufactured from thick galvanized steel (stainless steel containers can be supplied), welded and protected by butiminous paint. The interior distribution pipes, spray banks and nozzles are manufactured from PVC material, and easily dismounted and serviced. Inner cones of spray nozzles are stainless steel. In outdoor units, electrical resistances can be added to the water container to prevent freezing.

2.3.12.4 Ultrasonic Humidifiers

Ultrasonic humidifiers work by mechanically breaking down the tiny particulates of water droplets that can easily be absorbed by the air. Stulz branded ultrasonic humidifiers that are manufactured by the German technology are used in HSK air handling units. Stulz ultrasonic humidifiers transform a 220v main power supply to a voltage of 48V by using a built-in transformer.

An alternative current of 48V and 50 Hz is rectified by passing over an electronic circuit (rectifier) and is transformed to a high frequency signal of 1.65 MHz. This frequency signal is transferred to the transducer which is mounted on a water container. Transducer transforms this to a high frequency mechanical vibration.



Double shelled transducer changes its thickness 1.65 million times per second with the effect of the high frequency signal of 1.65 MHz. Due to the fact that the transducer surface vibrates in high speed, the atomization of the water particulates that are much smaller than the water surface is ensured. The moist generated is absorbed by the air easily. This type of humidifiers are supplied by demineralized water. Therefore the undissolved particulates are prevented from circulating through the air flow in powder form.

2.3.12.4 Steam Humidifiers;

Steam cylinder, immersed electrodes, stainless steam distributors and electronic control module are standard. Water inlet-outlet connections to the steam unit are made. The steam that is produced in the steam cylinder is released to the air through the distributor. The number of distributors and the steam cylinders vary according to humidifying requirements.

Steam humidifiers are fed either by supplying the steam that was produced in a boiler in a facility directly to an air handling unit, or as in common usage, by heating the water in a plastic cylinder that immersed electrodes were mounted to as a resistance of anode-cathode basis and spraying the steam that was produced through steam distribution collectors replaced in the air handling unit.

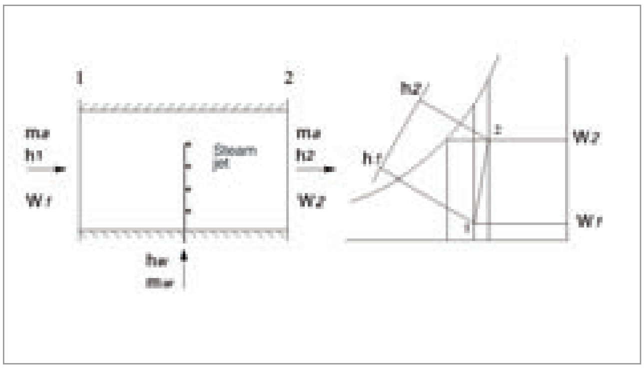
First of the designs uses current steam supply, and the steam supply and condense drainage are controlled by the control system that was installed in the facility. In the alternative design on the other hand, steam cylinder and all controls are built-in as a package. Humidifiers of this type have a capacity range that can be used in sites requiring varying capacities.

2.3.12.5 Immersed Electrode Steam Humidifiers

Immersed electrode steam humidifiers contain following components:

- Steam cylinder, electrodes, stainless steel steam distributors, condense drainage, water level control, components measuring and controlling the electrical conductivity.
- Much quicker boiling is ensured in the immersed electrode steam humidifiers when compared to the systems with electrical resistance.

Steam humidifying process



Saturated Steam Temperature (°C)	Water Vapour Enthalpy kJ/kg (water)
100	2675,44
110	2690,93
120	2705,83
130	2720,05
140	2733,51
150	2746,13

Variables can be determined by using $\frac{h_2 - h_1}{W_2 - W_1}$ = hw relation.

What requires attention is the fact that providing us with 1 of the requirements is a must. hw values can be obtained from the adjacent table. Among the temperatures provided in the table, the values that will be used frequently are 100°C and 110°C. It can be easily interpolated if a value is provided from those five values.

The steam flow is calculated by using mw = ma . (W2-W1) relation.

Sample Calculation:
The air that has air mass flow rate is 100 kg/min, dry bulb temperature is 20°C and wet thermometer temperature is 8°C is humidified with saturated steam that has a 110°C temperature value. What should the steam flow be provided that the dew point temperature is desired to be at 13°C?

$$\frac{h_2 - 24{,}6}{9{,}4 - 1{,}8} = 2{,}691 \text{ kJ/g} \qquad \mathbf{h_2 = 45{,}015 \text{ kJ/kg}}$$

Since two separate terms of point 2 (h and Tç) were determined, the point can be determined on psychrometry.
mw = 100 * 60 (0,0094 - 0,0018) = 45,6 kg/h

2.3.12.6 Humidifier Design Evaluation

Immersed electrode humidifiers can be either on/off controlled or proportional controlled.

Highly improved electronic control and command system is used in ultrasonic humidifiers. Ultrasonic humidifying units are directly installed in the air handling units or air ducts. Steam is produced directly in the air flow.

In the electrode humidifiers, on the other hand, steam that is produced in the main unit is transferred to the air handling unit or to steam distributors that are installed in the air ducts through hoses.

Precautions against corrosion are taken and a draining pan is used when it needs to be installed in the air handling unit. In some cases it is possible to shorten the plenum section that is required by the humidifier. Please contact HSK Engineering Department in case a problem occurs due to the entire length of the unit.
Humidity retainers are mounted to prevent water droplets going into the other sections of the air handling unit if the air velocity in the air handling unit is over 2.7 m/s or the humidifying chamber is shortened.

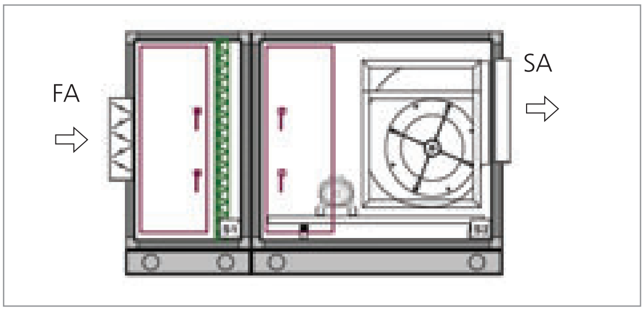
The accessories that need to be mounted into the chamber can be mounted at our factory if the humidifiers are supplied by ourselves. Main unit, control unit, water supply and drainage installations are required to be installed at the site.

2.3.12.7 Some Recommendations for Humidifiers

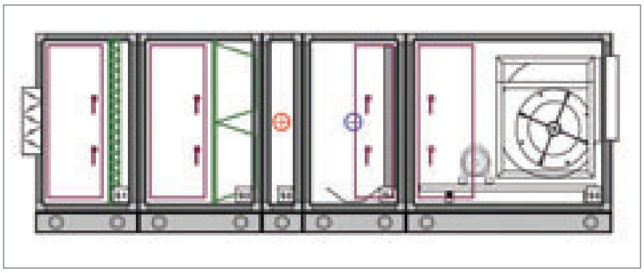
1- Non-mineral water should be used in the ultrasonic humidifiers to minimize maintenance requirements.
Appropriate biocides/sterilization agents should be used in circulating water to minimize the infections that will arise from bacteria.
3- The device, particularly water container and its wet surfaces, should be cleaned and maintained frequently and carefully.
4- It should be ensured that appropriate condensate drainage have been connected to the steam distribution collectors in the live steam humidifiers.
5- Humidity sensors should be placed far enough from the humidifiers where there exists air mixture.
6- Accumulation of solid objects should not be allowed in the evaporative humidifiers. Particulates should be removed or conditioned water should be used.
7- Obstacles that will cause water droplets to be developed such as filters, bends should be replaced in ultrasonic and atomized humidifiers. Technical assistance should be sought from the manufacturer to determine the minimum installation distance.
8- The air with high relative humidity should not be humidified, e.g. the air at the cooling coil outlet.

2.4 Configurations and Application Areas

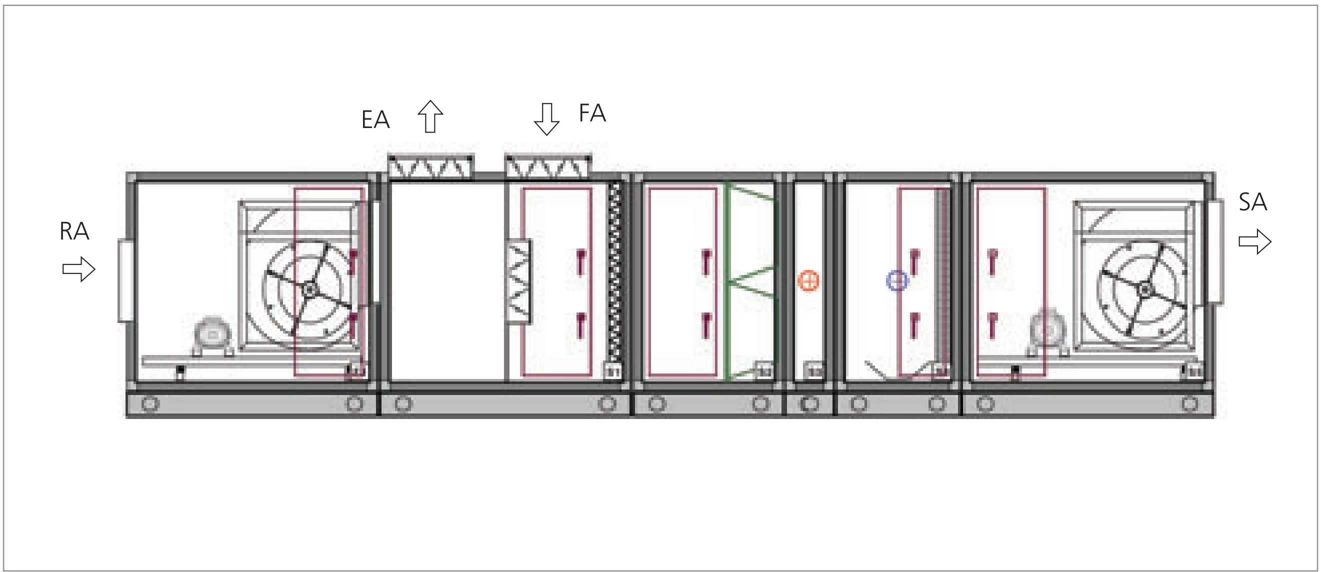
Modular design of the air handling units makes it possible for us to create different solutions for different applications. Some of the basic configurations are shown below.



Filter chamber with damper and fan chamber is shown in Figure 1. The objective in this system is supplying the fresh air intake through a panel filter.



An air handling unit operating with 100 % fresh air is modelled in Figure 2. S2 chamber illustrates the bag filter and droplet retainers, and condensation pan is seen in S3 and S4 chambers along with the heating and cooling coils.



The design in Figure 3 is an air handling unit operating with mixed air. S1 in this figure shows the mixing chamber. This chamber determines how much of the intake air from the system is to be exhausted and how much to be added to the mixed air by working together with the dampers on it. These dampers can be controlled through servo motors governed by the automation system upon request. This allows comfort conditions to be ensured through minimum energy savings.

Air handling unit with heat recovery is shown on Figure 4. Heat recovery unit [S2] supplies the intake heat from the exhaust air to the fresh air and considerably increases the system efficiency.

Air handling unit with rotor-type heat recovery is shown on Figure 5.

In addition to those applications, new units such as humidifying chamber, electrical heater chamber, and silencer can be added to the unit upon system requirements and customer request.

2.5 Free Cooling

There are situations that the temperatures of the air that is required for the ambient and of the outdoor environment is very approximate to each other during seasonal transitions. Therefore during these periods, air handling units are designed in a way to provide free cooling. Free cooling is important for substantial energy savings.

Free cooling is supplied by having the dampers on open position in order to take the advantage of these favorable external environment conditions and consequently saving energy when the external environment conditions are close to those of the site that is desired to be conditioned. Depending on seasonal conditions, free cooling can be supplied by using 100% fresh air for a while without operating the cooling group during Spring and Autumn seasonal transitions.

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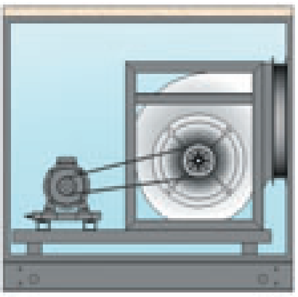
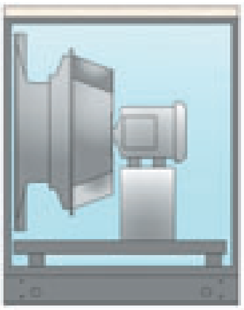
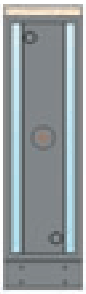


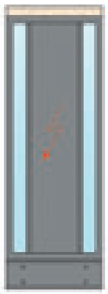
AS/VA
Aspirator/Fan Cell



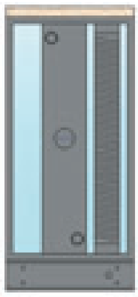
PF
Plug (Asp-Fan) Fan Cell



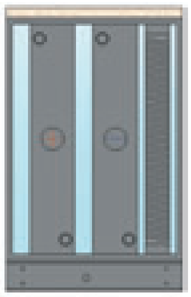
IB
Heating Coil Cell



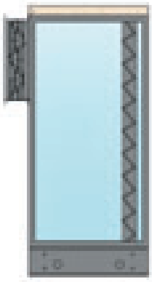
EI
Electrical Heater Cell



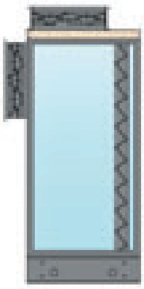
SB
Cooling Coil Cell



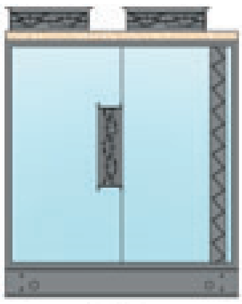
IS
Heating-Cooling Coil-Cell



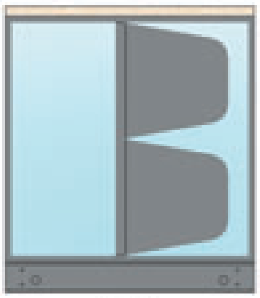
D1
Single Damper Filter Cell



D2
Double Damper Filter Cell

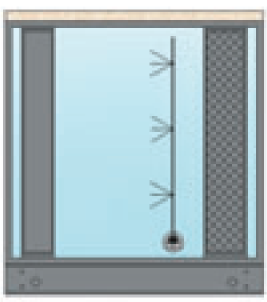


D3
Filter Mixing Cell

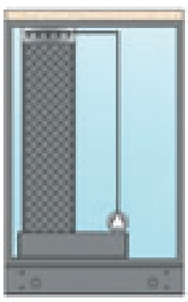


TF
Bag Filter Cell

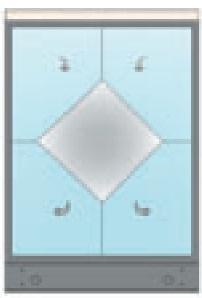
S1/S2
Silence Cell
S1: 30 dB(A) Reduction
S2: 35 dB(A) Reduction



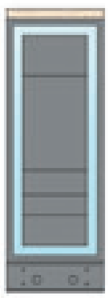
YN
Washer Humidifier Cell



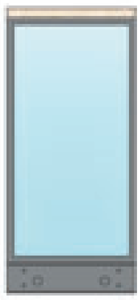
PN
Wetted Pad Humidifier Cell



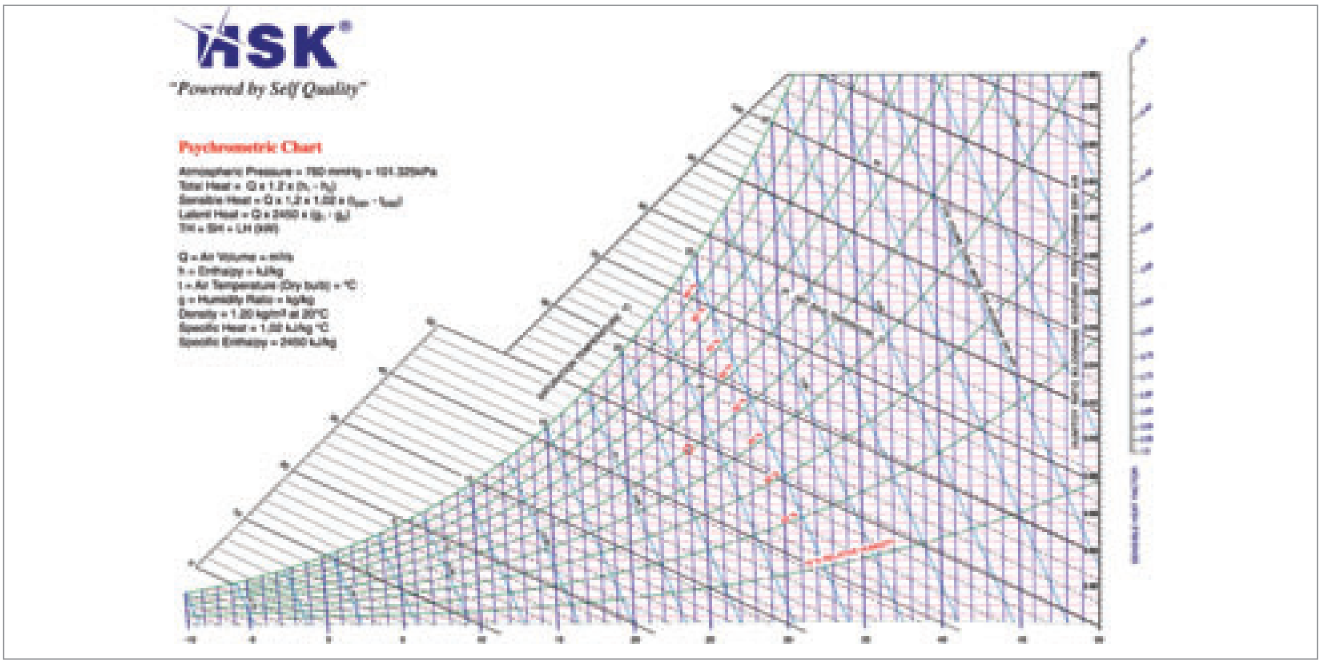
PR
Plate Type Heat Recovery Cell



RR
Rotary Heat Recovery Cell



BH
Empty Cell



Psychrometric chart

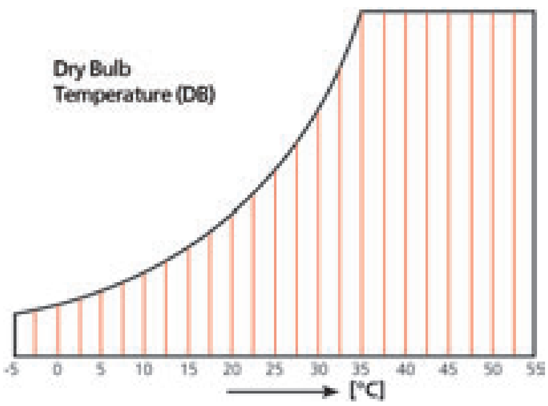
3. PSYCHROMETRY

The science of studying the thermodynamic properties of moist air is called psychrometry. Since intermediate fluid in the air conditioning process is the ambient air that is being controlled and there is a certain amount of moist in the atmospheric air, properties of the moist air such as pressure, temperature, specific volume and enthalpy should be known.
In fact the goal of the psychometric studies and the broad meaning in practice is to determine the condition of the atmospheric air relative to the moist. All thermodynamic properties of the moist air can be determined through psychrometric chart. Any other properties can be read from the chart provided that two properties of the air is known.

3.1 Properties of Moist Air

3.1.1 Dry Bulb Temperature (DBT)

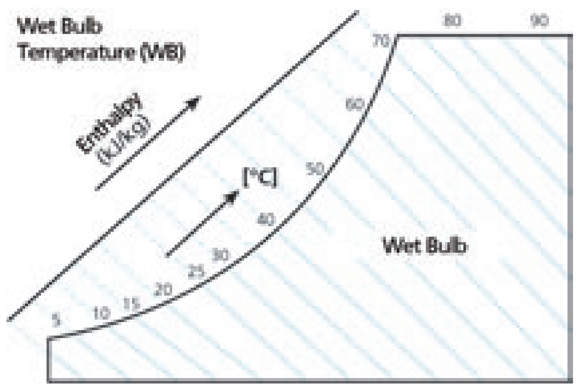
The air temperature measured by any ordinary thermometer is known as the dry bulb temperature.



3.1.2 Wet Bulb Temperature (WBT)

Reading of a thermometer whose sensing bulb is covered with a wet cotton cord when a rapid stream of the air is passing over is called wet bulb temperature.

Since the humidity ratio of the ambient air affects the evaporation (cooling) rate of the cord, relative humidity of the environment is determined from the differential from the dry bulb thermometer with the help of a scale.



3.1.3 Dew Point Temperature (Saturation Temperature)

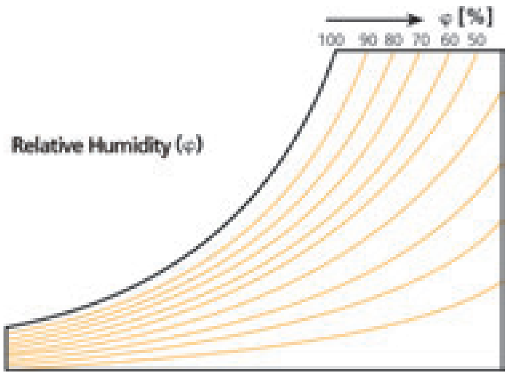
This is the temperature at which an air at any relative humidity ratio would reach water vapor saturation by gradually cooling.

3.1.4 Relative Humidity (φ)

This is the ratio of the partial pressure of water vapor of the air to the saturated moist at the dew point.

w = (Ps /Psd)x100

Ps: Partial pressure of water vapor in air at any temperature and humidity [Pa]
Psd: Partial pressure of water vapor in saturation point (dew point) of the current [Pa]

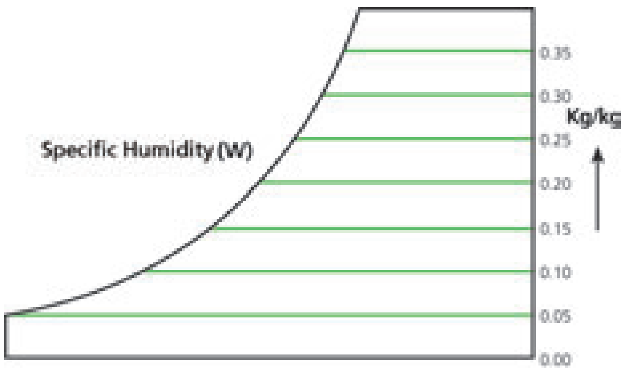


3.1.5 Specific Humidity (w)

This is the ratio of water vapor to 1 kg dry air in terms of kg or gr.
where w=water mass / dry air mass

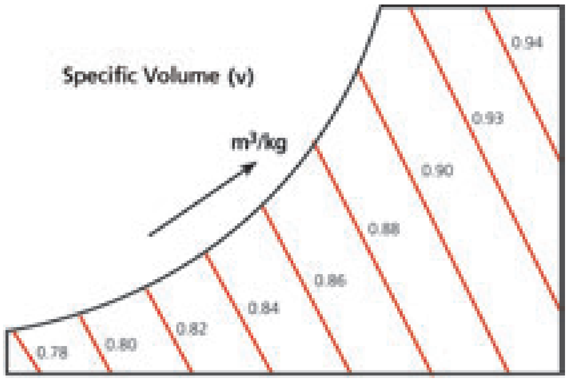
w= 0.622 Ps/ (Pt-Ps) [kg/kg dry air]

Ps: Partial pressure of water vapor [Pa]
Pt: Overall pressure of moist air (Pt=101.3 kPa at sea level)



3.1.6 Specific Volume (v)

It indicates the space occupied by 1 kg dry air with respect to air and water vapor mixture. [m^3/kg]



3.1.7 Density (δ)

This is the mass of a 1 m of material. It is indicated as kg/m3. Density and the specific volume is inverse of each other (Ú=1/v)

3.1.8 Sensible Heat

This is the heat amount of air that is expressed in kJ per kg and that can be determined from the temperature differential.
q = Cp Δt = Cp (t2-t1) [kJ/kg or Kcal/kg]

3.1.9 Latent Heat

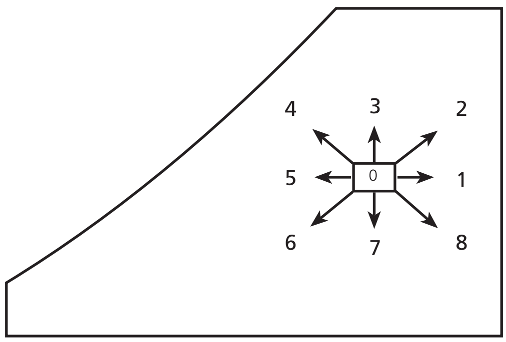
This is the heat that moist in the air reaches to vaporize. [kJ/kg or Kcal/kg]

3.1.10 Total Heat (Enthalpy) (h)

It is the amount of heat that air and moist mixture is required to be supplied during heating or cooling. It is the sum of latent and sensible heat.

h= Cpt + hs [kJ/kg k.h.]

Cp: Specific heat of dry air (0.1 kJ/kgK)
hs: Total heat of saturated water vapor [kJ/kg]



3.2 Processes that are performed on psychrometric chart;

01: Sensible heat
02: Heating and Humidification
03: Humidification
04: Cooling and Humidification
05: Sensible Cooling
06: Cooling and Dehumidification
07: Dehumidification
08: Chemical Dehumidification

3.2.1 Sensible Heating process

In the event that moist air is heated without a gain or loss of moist, this process is called sensible heating.

Hot water coils, steam coils, electrical heaters or heat pumps are used to increase the amount of sensible heat of air in an air handling unit.

To give an example, if we perform the sensible heating process through a heating coil, specific humidity and dew point values of the intake and outlet air from and to the coil will remain unchanged while dry and wet bulb temperatures will rise during the sensible heating process. The reason why specific humidity remains unchanged is the fact that water vapor and the amount of dry air in moist air does not during the heating process.

EXAMPLE: (Sensible heating of the moist air)

Saturated air at 3000 m³/h flow rate and 2°C temperature is heated up to 40°C through sensible heating with the help of a heating coil. Find out the amount of heat that is required to supply for the coil.

The air entering into the heating coil at 2°C in conditions 1.

Enthalpy: $h1 = 12{,}5$ kJ/kg (dry air)
Specific humidity: $W1 = 4{,}25$ g (moist) / kg (dry air)
Specific volume: $v1 = 0{,}785$ m³/kg (dry air)

The air going out of the heating coil at 40°C in conditions 2.

Enthalpy: $h2 = 51.4$ kJ/kg (dry air)
Specific humidity: $W1 = W2 = 4{,}25$ g (moist) / kg (dry air)

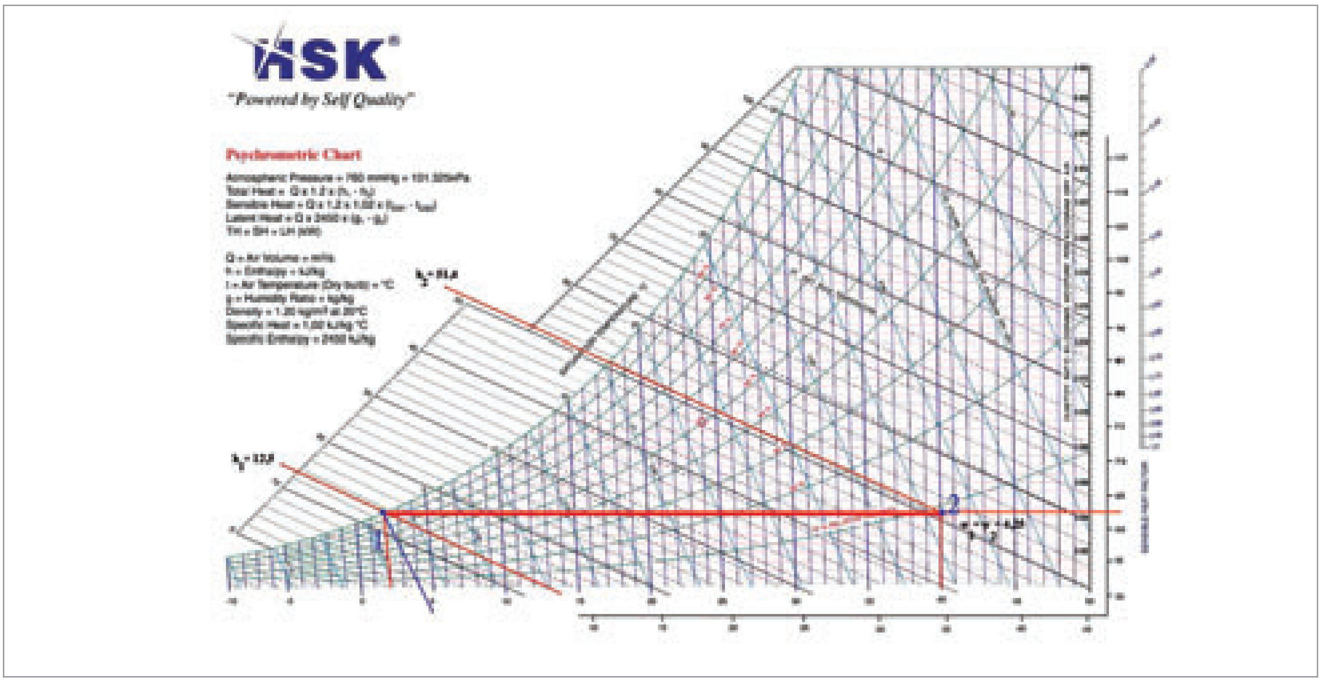
Dry air mass in the system:
$ma = 3000 / 0{,}785 = 3822$ kg (dry air) / h

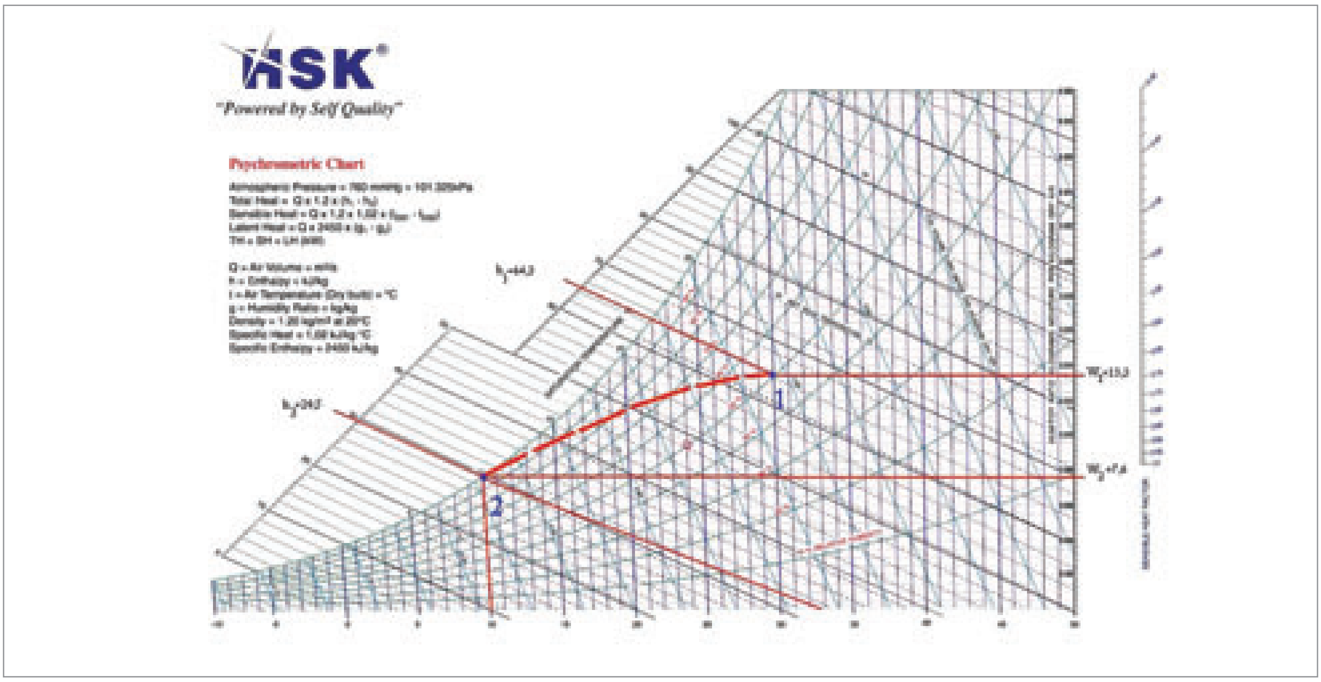
$q1 = ma\,(h1-h2)$ It is calculated through the formula of the amount of heat that is being supplied to the system in constant regime.
$q1 = 3822\,(51{,}4 - 12{,}5) = 148676$ kJ/h $= 41{,}3$ kW

3.2.2 Sensible Cooling Process

The cooling process of the moist air without a gain or loss of moist is called sensible cooling. Specific humidity and dew point temperature values of the air getting into and out of the coil during sensible cooling remain constant.

The air entering into the unit is passed over a cooling coil in air handling units during the cooling process. The air that passes over the cooling coil cools off by transferring its heat to the liquid that is passing through the tubes. The heated water that obtains the heat of the air while passing over the





coil is cooled in the water chiller and sent back to the coil with the help of a pump.

The process of cooling of the air in sensible cooling continues to the dew point temperature at the latest; i.e. when the air is cooled down to the dew point temperature, that is called sensible cooling. If the cooling process is continued below the dew point temperature, this is called simultaneously cooling and dehumidification.

3.2.3 Simultaneous Cooling and Dehumidification

Unlike sensible cooling, moist air that goes into the cooling coil is cooled down below the dew point and water vapor in the air is condensed. Therefore there is both sensible heat and latent heat transfer.

EXAMPLE (Sensible cooling of the moist air)

Moist air with 17,000 m^3/h and 50% relative humidity at 30°C dry bulb temperature is being passed over a cooling coil until it becomes saturated at 10°C. Calculate the cooling capacity that is required for this process to be conducted.

Of the air that is 30°C and has Ø=50% relative humidity, and enters into the cooling coil in conditions 1

Enthalpy: h1 = 64.3 kJ/kg (dry air)
Specific humidity: W1 = 13.3 g (moist) / kg (dry air)
Specific volume: v1 = 0.877 m3/kg (dry air)

The air going out of the cooling coil at 10°C in conditions 2;

Enthalpy: h2 = 29.5 kJ/kg (dry air)
Specific humidity: W2 = 7,6 g (moisture) / kg (dry air).

It can be found from the chart through the properties of the moist air at 101.325 kPa = 12.01 kJ/kg (water).

Dry air mass in the system
ma= 17,000 / 0.877 = 19,834 kg (dry air) / h

Formulae for cooling the moist air:
ma h1 = ma h2 + q2 + mw hw2
ma W1 = ma W2 + mw
mw = ma (W1 - W2)
q2 = ma ((h1 - h2) - (W1 - W2) hw2, through energy and mass equations;
q2 = 19834 (64,3 - 29,5) - (0,0133 - 0,0076) 42,01) = 675000 kJ/h = 187 kW
is calculated.

4. BUILDING AUTOMATION SYSTEMS (BAS)

Today computers assume most of the work that people do and perform them perfectly.
"Systems and installations regarding Heating, Cooling, Ventilation, Air Conditioning, Power and Water Distribution, Lighting, Safety, Fire Protection" that meet the requirements in the buildings, the environments that we work and live in have been increased and become complex. Consequently this made utilizing computers for reliable building operation compulsory; hence the "Building Automation Systems" have been introduced to our lives.
Those systems ensure an optimal operation in the building through software that are developed in a way that makes them adaptable to the technical and administrative requirements of the planners.

OPERATING PRINCIPLE

It is based on information exchange of the computer and the field personnel. Digital or analog data retrieved from the field elements such as sensing elements (sensors) that were built in the installations and the systems throughout the building, valve and damper motors, on/off control devices and electric motor control panels are evaluated by the microprocessors.
Having been evaluated as the software prescribed, these information allows controlling field control elements such as damper, valve motor, and devices such as pump and fan.
Field computers (microprocessors) that are placed where systems are densely placed transmit any kind of information and control signal received from and sent to the field.
A central computer evaluates the building-wide situation and transmits the results to the user simultaneously through a monitor and a printer.

BENEFITS OF BUILDING AUTOMATION SYSTEMS

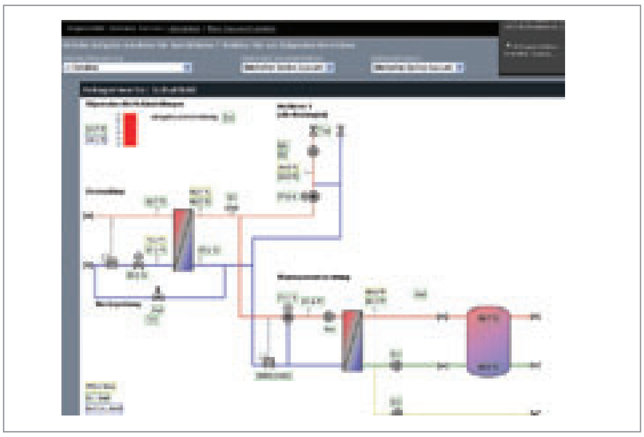
Since troubles in the installations and systems are promptly spotted, device life is extended; discontents that might arise from malfunctions are removed swiftly. Among other benefits are;

Provides Information

All types of information that can be produced during the operation periods of all controlled systems can be monitored with the help of the Building Automation System.

- On / Off data (pump, fan, etc.)
- Operating Times
- Values of physical magnitude such as temperature / humidity / pressure / differential pressure.
- Malfunction and Alarm situations

These kinds of information can be read simultaneously or periodically or optionally from the screen and stored in the memory of the computer.
These information and simultaneous alarm can also be retrieved from the printer in forms of alarm report and status report.
System diagrams can be monitored on the screen with their respective active data and the alarms that are occurred in the field can be transmitted in visual form with a coloured warning on the screen as seen in the example below.



Scheduled Operation

The systems will be run and stopped according to a specific time table (daily, weekly, holiday).
Energy consumption will be reduced since the systems can be run and stopped when required.
Due to the fact that the uncontrolled operations can be monitored and stored in the memory of the computer, it will help identifying when and by whom the operations are performed without the knowledge of the automation system.

Reduces Energy Costs

Energy costs such as fuel and electricity are minimized through the following automatic control software:

- Actual/set value controls (PID);
- Outdoor temperature compensation control;
- Rapid heating;
- Night-time Air Conditioning;
- Optimal Start up - Stopping

Reduces Mistakes

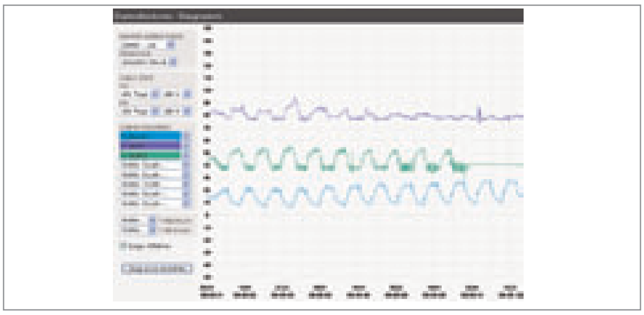
The operation will be facilitated through central control of the systems; therefore mistakes arising from negligence will be minimized.

Reduces Staff

Due to the fact that the processes regarding the operation, stopping, supervision and control of the devices are performed automatically, the number of personnel will be reduced.

Uninterrupted Service through Protective Maintenance

Periodic maintenance schedules can be prepared by accumulating the operating hours of the devices.
Efficiency and life cycle of the devices and the systems will be increased by performing periodic maintenance works (lubrication, cleaning, changing filters, etc).
Deficiencies will be remedied through keeping the statistics of malfunctions.
Protective maintenance schedule can be determined by interpreting periodic maintenance and malfunction statistics together, therefore uninterrupted service can be provided through the precautions that will be taken.
Number of personnel for maintenance works will also be reduced.



Extends the Life of the Device

Minimizing the mistakes of the enterprise, removing possible mistakes by identifying them as soon as possible will increase the long term availability of the system (system life).
Since the malfunctions will be noticed promptly and can be responded, the efficiency of repair and maintenance personnel will be increased and number of personnel will be reduced.
Additionally, malfunctions can be stopped before skipping to other devices.

Ensures the Same Operating Hours in Devices with Redundancy

Same amount of operation time can be ensured through sequential operation in devices with redundancy (pump, boiler, etc).

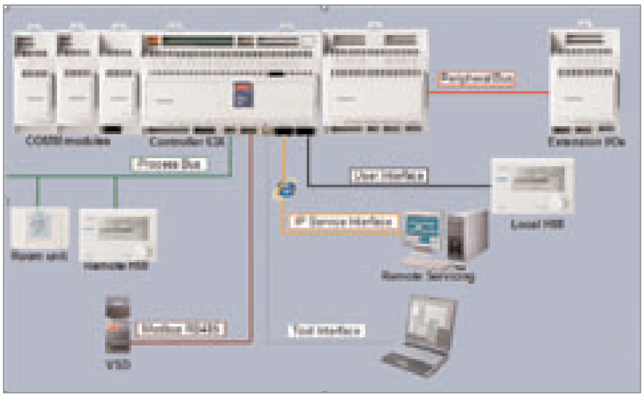
Quick Monitoring

Temperature and humidity values that are desired to reach through redundant air handling units in your system will be constantly monitored therefore the new desired set values can be provided quickly.

Sequential Activation

During the reloading process in the event that the power outage and resumption of power is occurred, high power devices in the system can be start up following a specific sequence in order for the power system not to be overloaded due to the heavy current they draw.

OVERALL SYSTEM DIAGRAM
DEPRECIATION

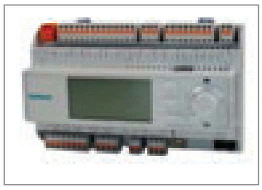


Studies conducted show that the building automation system pays for itself in 2.5 years through energy, maintenance and personnel savings.
Comfort requirements are not exchanged for this savings under no circumstances at all.

AREAS OF USE

- Business Centers
- Banks
- Hotels
- Hospitals
- Factories (Pharmaceutical, Textile, Food, Tobacco, etc)

Automatic Control;



HSK control systems, in line with the requirements of people and products, provides entire software, hardware, engineering and solution services including turnkey installation of the air conditioning systems, cabling, production and assembly of MCC + DDC panels and programming in hospitals, shopping centers, factories, energy plants and anyplace where people live in.

Given today's conditions, a building automation system is a must in modern facilities to create a safe and comfortable environment using less labour and less energy. Temperature, pressure, flow, humidity and air quality controls are performed easily through automation systems. This also allows the creation of desired production and comfort conditions.
HSK automatic control systems include software and hardware solutions for automation of the ventilation systems that are applied in new and modern as well as current buildings.

The purpose of the automatic control systems is automating the monitoring, operation and control processes regarding the ventilation devices in the building for energy savings. It also becomes easy for the system to integrate with the current BMS systems through open protocols such s KNX, Lon, Bacnet, Modbus. Given today's conditions, an automatic control system is a must in buildings and production areas to create a safe and comfortable environment using less labour and less energy.
Through Flexline and Quickline air handling units as HSK, we provide advanced technology and turnkey automatic control system solutions. We provide wide range of solutions in the systems we install from the most extreme field equipments to software.

Smart and Economic;
Air flows, temperatures, energy improvements and operating periods can be controlled in an automatic control system. This is standard for the entire Quickline series HSK air control units. In practical terms, all the functions we can think of for air control units are available in the system and waiting to be activated. Additionally, they have various energy saving functions. These functions are rapid cooling, density corrected air flow and climate related air flow. All settings and readings can be monitored and changed by entering user ID and password on user friendly LCD terminals when required.
The control system is in conformity with all the communication standards (TCP/IP, EIA 485 and EIA 232). Communication modules can be used to communicate with KNX, LON, Bacnet and Modbus.
Control devices of the Quickline series air handling units have built-in web communication function to connect with the network. All you need is an ordinary computer with the network connection.
Electronic and mechanic components of Quickline operate compatibly since the control equipment is integrated and its software is tailor-made. This also allows you to be one step ahead of control systems that were manufactured by using standard components.
HSK automatic control systems have substantially lower costs when compared to the conventional control components, and planning, preparation, programming, structuring and assembly of the control systems.

Automatic Control Valve Sizing in Water-Side Systems

Definitions:
M : Flow rate (L/S)
KVs : Flow rate that the valve will pass when open at full load (100%) under differential pressure of 1 bar.
ΔPa : Differential pressure on the valve (kPa). This value should normally be equal of greater than differential pressure of the section the flow rate of which is changed in the system.
Q : Thermal load (kw).
ΔT : Temperature differential of the heating fluid between inlet and outlet of the load.

Formulae:
Kv : M x 36 / $\sqrt{\Delta Pa}$,
M = Q / 4,18x ΔT

In case the flow rate is not known, it can be calculated from thermal load and the inlet and outlet temperatures of the fluid. The valve with the closest KVs value to the calculated Kv value is selected.
The pressure that is exerted the automatic control valve must be selected equal to or greater than the pressure exerted the load the flow rate of which is changed.
In the event that the pressures that are exerted on devices in the system the following values can be used for prediction. For precise calculation however, one should use the data from the manufacturers.

Air handler valves: 5 - 20 kPa
Fan-coil valves: 5 - 20 kPa
Central heating system boiler valve: 1,5 - 4 kPa

Example: Calculation of heating and cooling automatic control valves to be installed on an air handling unit with 40 kW heating coil power and 50 kW cooling coil power.
Pressure drop of 10 kPa in heating and 15 kPa in cooling is acceptable.

There exist differential pressures of 70-90°C in heating and 7-12°C in cooling.
For heating valve: M = 40 / 4,18 x 20 = 0,478 L/S
Kv = 0,478 x 36 / 3,1622 = 5,44

Selected valve is DN20, PN16, KVs is 6.3
For cooling valve: M = 50 / 4,18 x 5 = 2,392
Kv = 2,392 x 36 / 3,873 = 22,23

Selected valve is DN40, PN16, KVs is 25.0

4.1 Field Elements

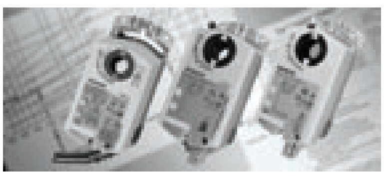
4.1.1 Motorized Flow Control Valves

a) Two-way:
It is used to adjust the flow rate of the water entering the system proportionally or On/Off controlled.

b) Three-way:
Allows the water coming from the system and the boiler to mix and determines the ratio of mixture.

4.1.2 Damper Motors (Normal -Spring Return)

a) Normal: Air flow is used to control the control dampers in heating-cooling and ventilation systems.



b) Spring return: Air flow that has a safety function in heating-cooling and ventilation systems is used to control the control dampers (e.g. freeze protection, smoke control, hygiene).

4.2 Sensors

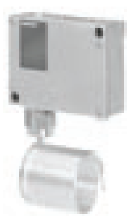
4.2.1 Heat Sensors

a) Duct type: It is used to measure the temperature in ventilation ducts.

b) Room type: It is used to measure the indoor temperature in Heating-Cooling-Ventilation systems.

c) Outdoor type: It is used to measure the outside temperature.

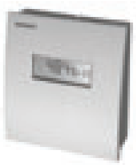
d) Freeze-free thermostat: It is used to protect the heating coils in the heating-cooling-ventilation systems against the risk of freezing.



4.2.1 Humidity Sensors

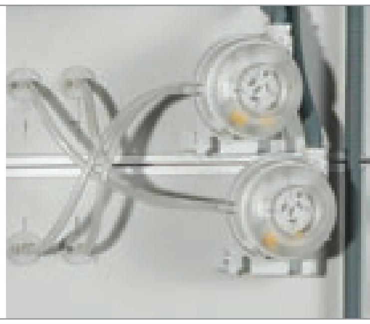
a) Duct type humidity sensor: It is used to measure the indoor humidity and temperature in Heating-Cooling-Ventilation systems.

a) Room type humidity sensor: It is used to measure the indoor humidity and temperature in Heating-Cooling-Ventilation systems.

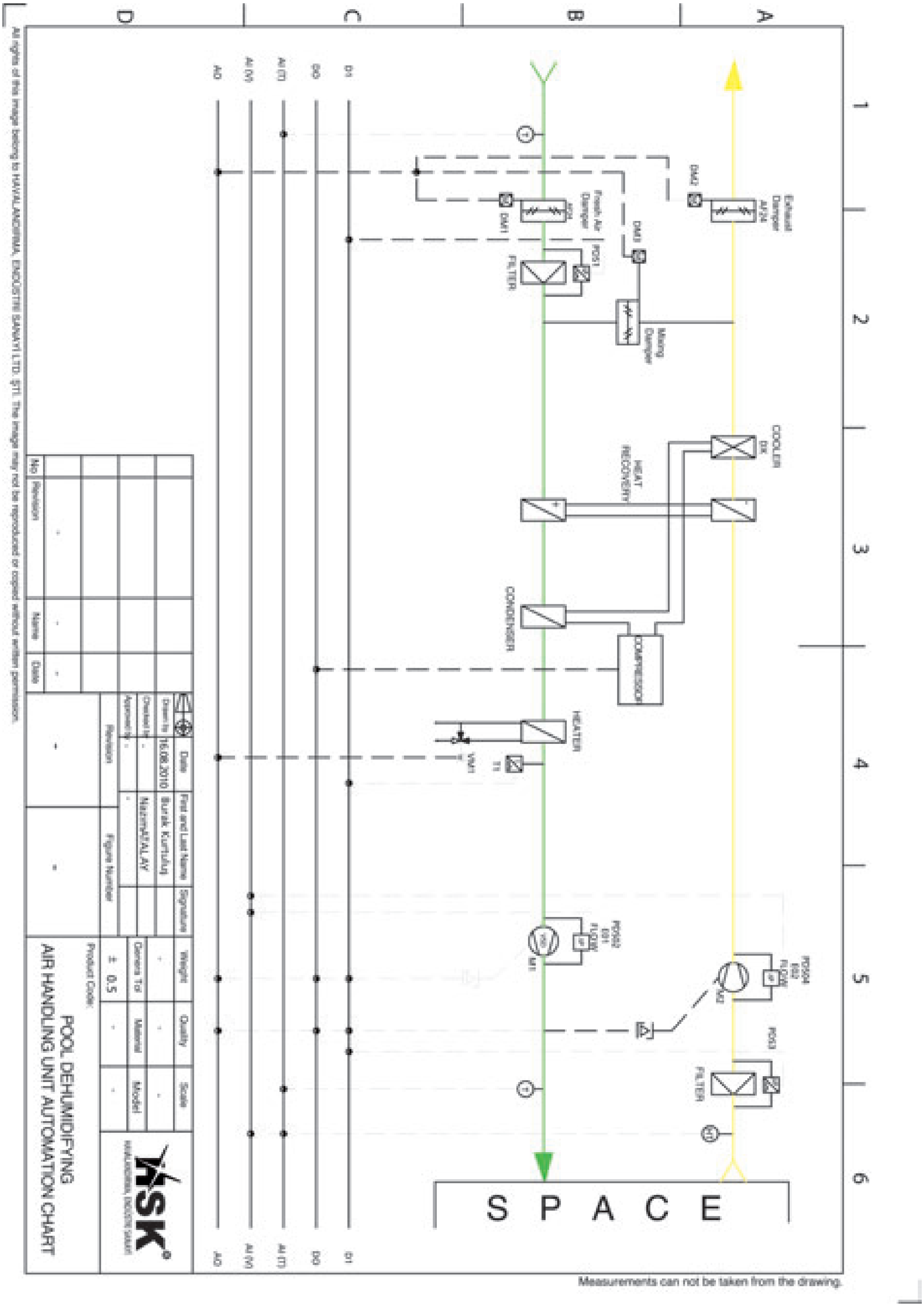


4.2.3 Pressure Sensor

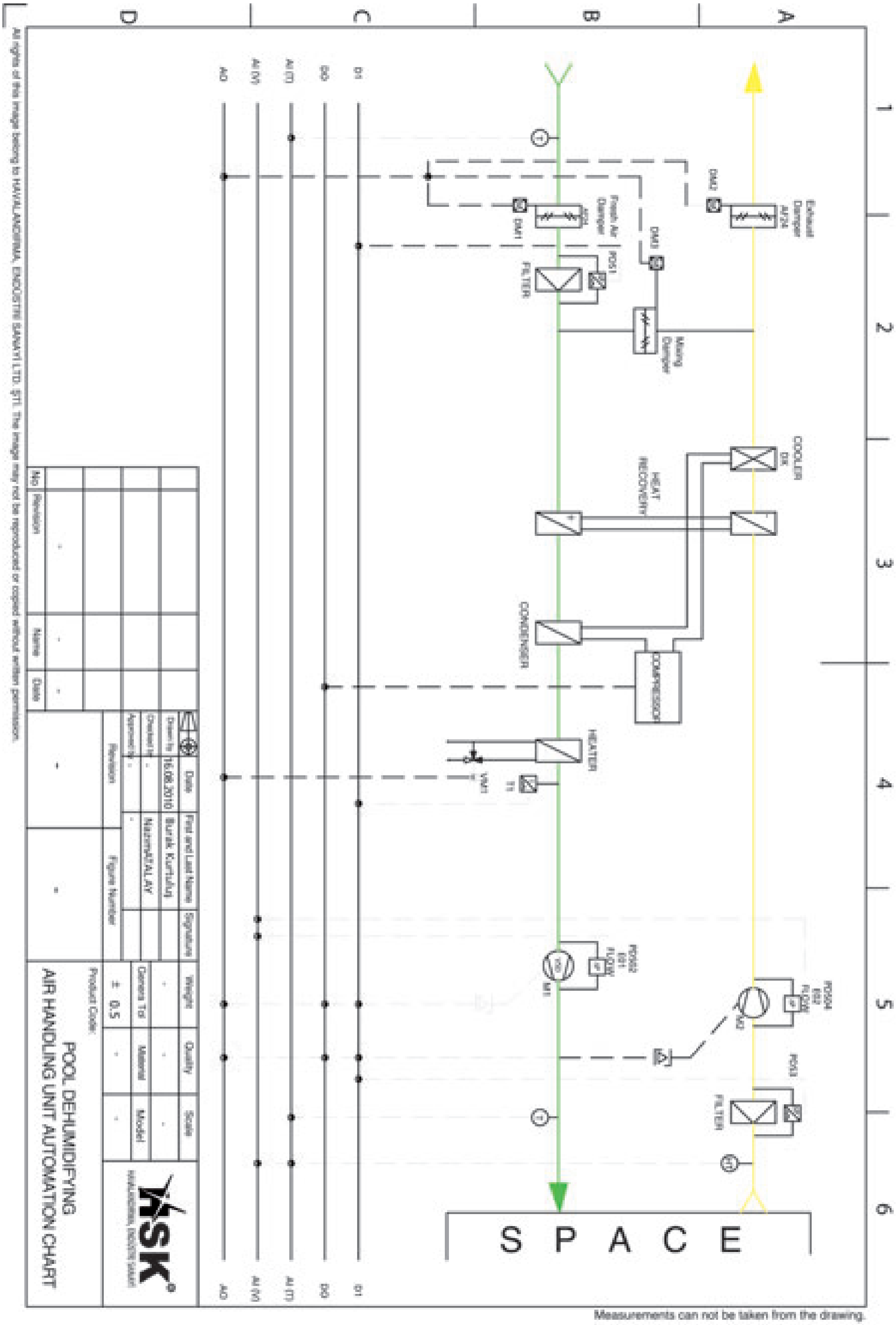
a) Differential pressure switch: It is used to sense the dirtiness of the air filters and determine whether the fans are operating properly or receiving "belt breakage" warning.



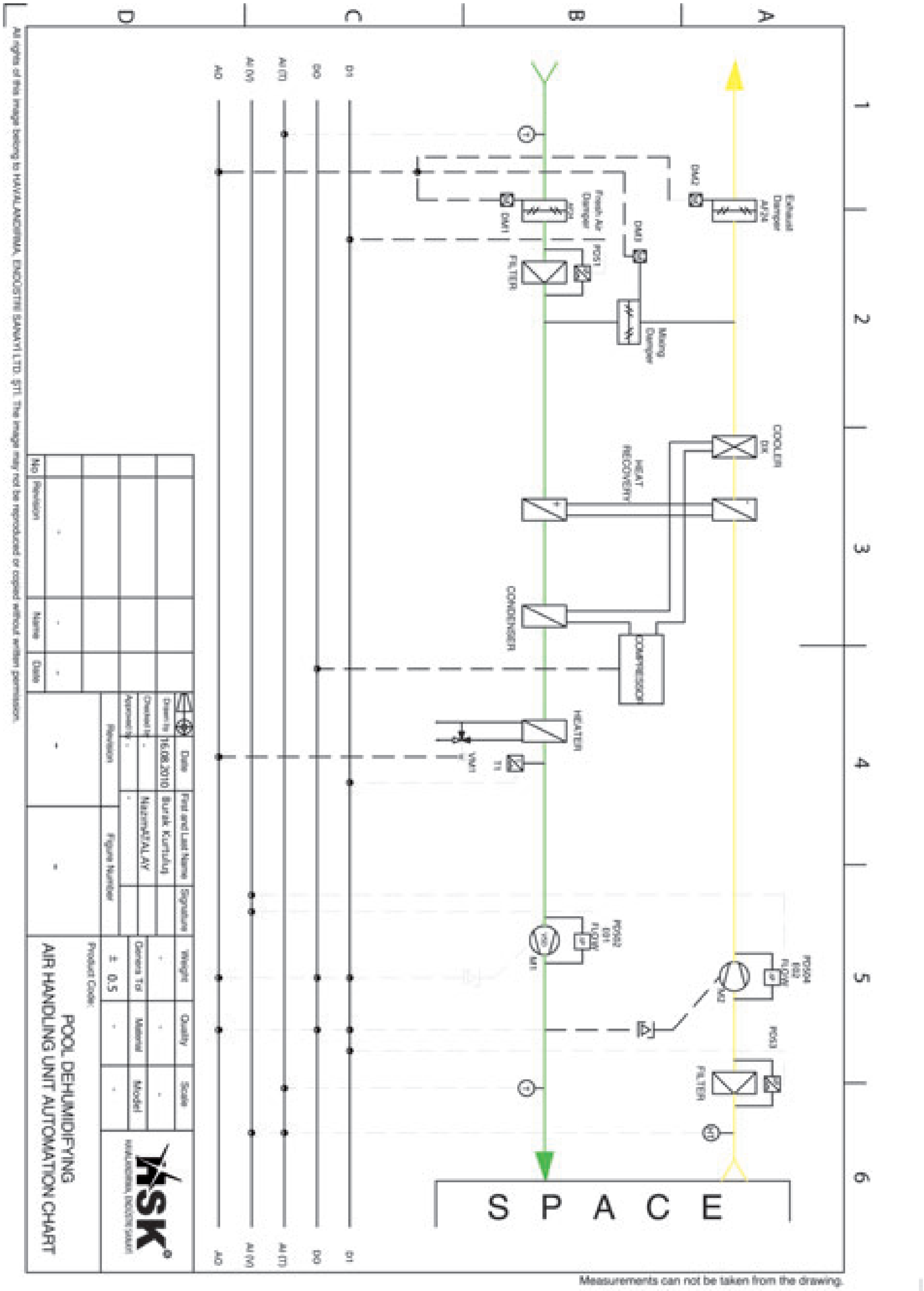
b) Differential pressure sensor: It is mainly used to adjust flow rates of the fans and monitor the filter dirtiness in a sensitive way.



Flexline Air Handling Unit



Poolline Poool Dehumidifying Air Handling Unit



Mediline Package Hygienic Air Handling Unit

5. OUR DISTINCTIONS

5.1 AIR HANDLING UNIT TESTING AND PERFORMANCE MEASUREMENT ROOM

In order to be able to measure the performances of air handling units when they are still at the manufacturing area and manufacture them according to the international standards, HSK has put the “Air Handling Unit Testing and Performance Measurement Room” into service in 2000.

“Air Handling Unit Testing and Performance Measurement Room”

Having been using for product development studies in the scope of R&D and periodically testing (1/250 AHU) of the manufactured products, this test room is one of the most important tools in ensuring the products reflect high quality and technology. Investors can also see the products they purchase before they ship out of the factory and while ensuring the required values.

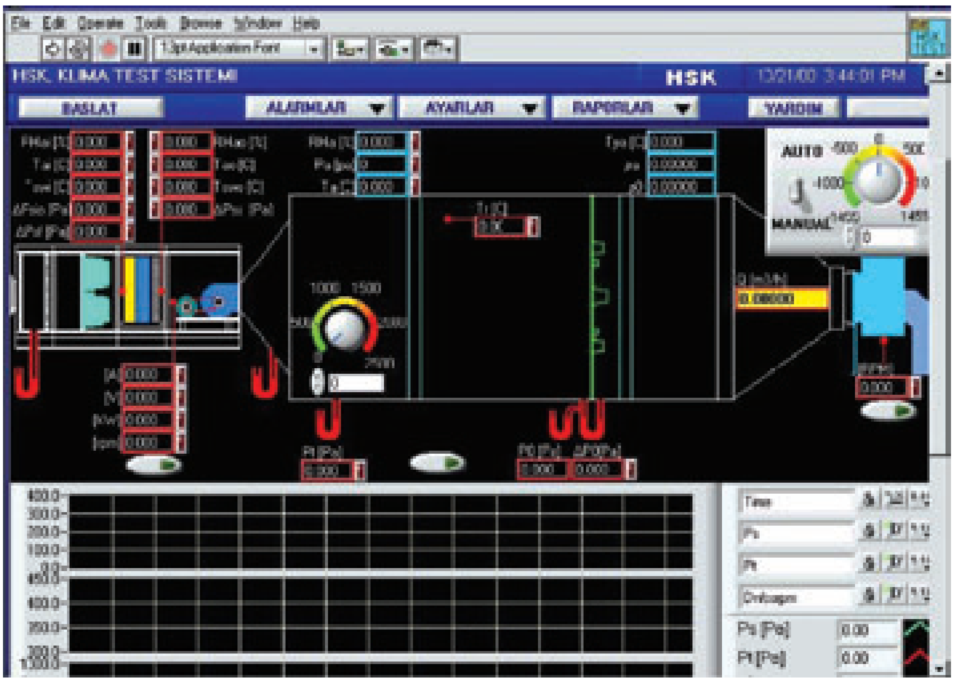
This type of test room was established for the first time among the air conditioning manufacturing industry and university and research institutions in Turkey. HSK has made significant progress towards becoming a world renowned brand through facility and equipment modernization to provide better and more quality products and services for its customers.
Having been established with the meticulous work of HSK R&D department that lasted one year, this test room was built in conformity with the American AMCA / ASHRAE Standards.

The measurements that are performed in the test room according to the AMCA / ASHRAE standards are combined in three groups:

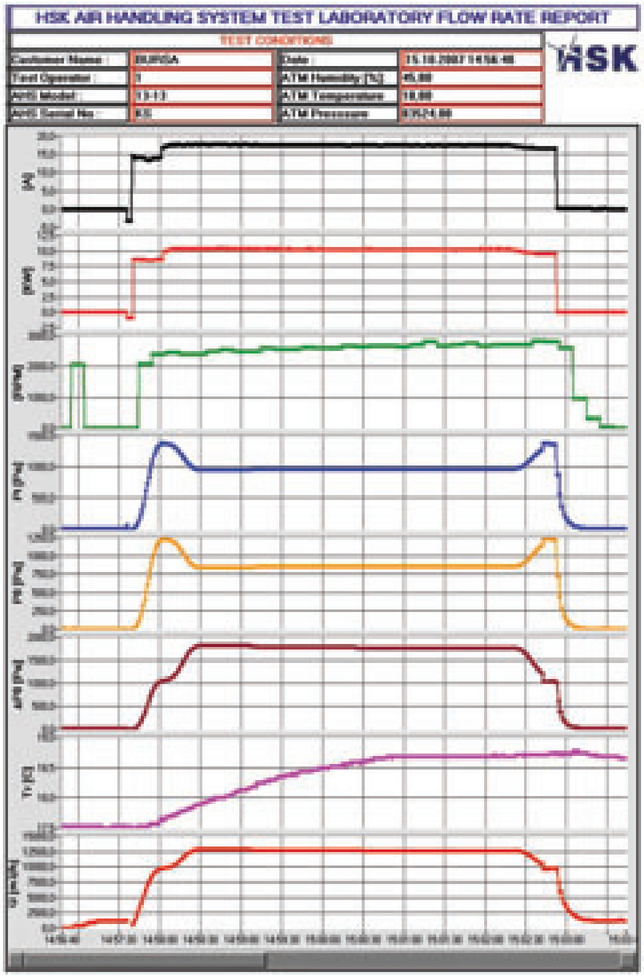
a) Measurements Performed in the Air Handling Unit:
- Inlet and outlet air temperature and humidity values
- Internal static pressure loss on chamber basis
- Internal static pressure loss on air handling unit basis
- Current and power of the fan motors
- Voltage and frequency of the feeder
- RPM values of the fans

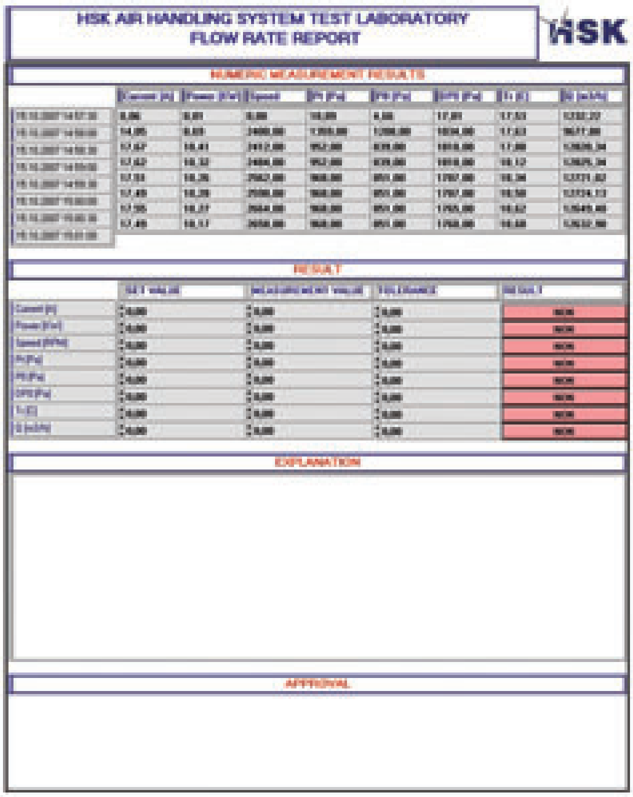
b) Measurements Performed in the Test Tunnel:
- Test pressure
- Nozzle initial pressure
- Nozzle initial temperature
- Nozzle pressure differential

c) Atmospheric Measurements:
- Dry bulb temperature
- Atmospheric humidity value
- Atmospheric pressure values



The following is a sample test report.





As a consequence of these measurements air handling unit flow rate is calculated. Thermal capacities of the coils will also be able to be measurement in the test room in the following periods. Inlet and outlet temperature, humidity and pressure loss values of heating and cooling coils will consequently be measured.

Pressure loss of the ductwork that air handling unit will be installed on can be simulated during performance tests and the performance can be measured accordingly. The software calculates the flow rate automatically upon entering the external pressure loss during flow rate measurement.

Special software for the Air Handling Unit Testing and Performance Measurement Room that is developed for laboratories is selected in compliance with data collection devices, measurement sensors and computer-aided testing system that is independent of ambient conditions.

5.2 "AIRWARE" AIR HANDLING UNIT SELECTION SOFTWARE

Being the latest addition to Airware software family, Web-based Airware has brought a new perspective to air handling unit selection software products. Web-based Airware outclasses the Airware selection software in terms of structure and content in many ways.

Structural advantages of Airware Web software:

- Being available in any place where it is accessible;
- Being easily updated due to retrieving data from the database;
- Due to the fact that it is connected to a single database, it is easy to have analyses by creating queries on data;
- Due to the fact that it is created as object-oriented, it is possible to be developed constantly without losing its integrity;
- Software updates that are available simultaneously to the users all around the world.

Web-based Airware has lots of advantages in terms of content. Airware is the modeled version of the AHU design through using virtual objects. By modeling the torque and torque transmission, the most appropriate motor and the optimal belt-wheel selection becomes possible, and coordinates of the flanges can be determined in a very flexible manner in the software. Airware also allows the design of double deck air handling units as a separate model, and it takes into consideration both winter and summer operating conditions when selecting the heat recovery exchanger or rotor. Airware selection software provides an important resource for production department by identifying raw materials and semi finished goods in the product tree.

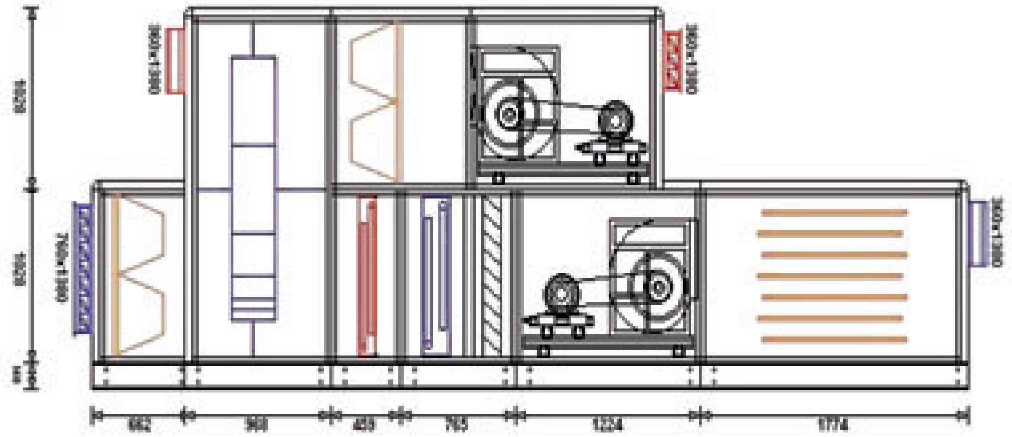
Airware has flexible cell model. Cells that are unnecessarily long can be manufactured shorter by changing the cell length (L), thus savings can be ensured. It also has a powerful drawing class library. It draws the air handling unit according to the technical drawing principles and generates image files that can be read by Autocad. Drawing class libraries have an infrastructure that animation properties can be added to. Finally an up-to-date pricing is possible thanks to web application.

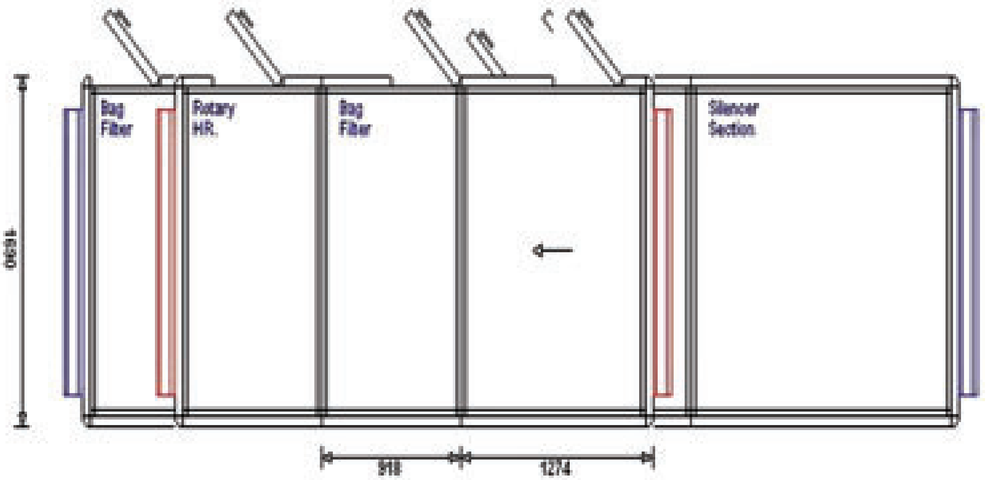
Selection outputs of an air handling unit that is designed by Airware Web software are shown below.

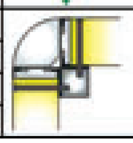
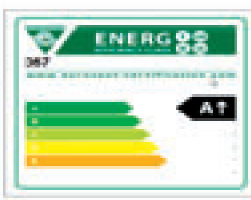
AHU TECHNICAL DATA SHEET

Date: 20.05.2010	Rev. Date: 20.05.2010	Rev. No: 0	Page: 4/1	Serie: Flx Rotary Type 30x50
AHU Reference: AHU (05)		Air Volume: Supply : 8500m3/h , Return : 8500m3/h		

Serie	Flx Rotary Type 30x50		
Dimension	5790 x 2156 x 1690	Face Vel. on Coils	2,09 m/s
Weight	0,00 kg	Supply Motor Power	4,00 kW
Supply Air Volume	8.500,00 m3/h	Exhaust Motor Power	3,00 kW
Return Aeir Volume	8.500,00 m3/h	Fan	ADH E0-0355 (supply) - ADH E0-0355 (return)
Heating Capacity	41,98 kW	Cooling Capacity	42,14 kW

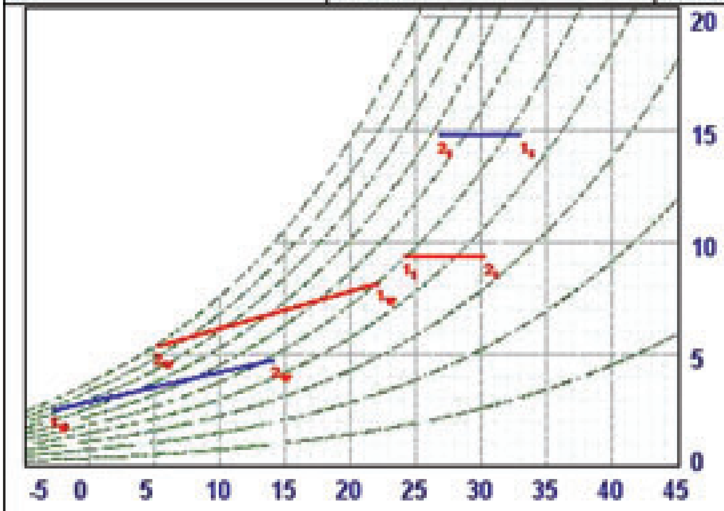




Caing / Frame		Mechanical Class		Airbone Sound Pow.		Certification
Thickness	50	Casing Strength	D1	125 Hz.	74	 
Insulation	Rock Wool (50mm 55kg/m3)	Casing Air Leakage	L1	250 Hz.	66	
External Sheet	Painted Steel Sheet (1mm)	Thermal Transmit	T1	500 Hz.	59	
Internal Sheet	Galvanized Steel Sheet (0.8mm)	Thermal Bridging	TB1	1 kHz.	55	
Frame	Galvanized Steel Profile (30x30 2mm)	Filter By-Pass Leakage	F9	2 kHz.	50	
Base	Standart Type 150mm	Unit SFP (w/l/s)	2.09	4 kHz.	47	
Note:				8 kHz.	38	
				Average	66	

Filter Section		1. Section on Supply		
Air Volume 8500 m3/h	Filter Bag Filter F5 Cam Elyaf 300	Panel Filter Bag Filter F5 Cam Elyaf 300	Pressure Drop (Mean) 213,19 Pa	
Accessories			Initial dP 26 Pa	Final dP 400 Pa

Rotary Heat Recovery Section			
Air Volume 8500 m3/h	Model ST1-N-W-1350		
Supply Pres Drop 157,57 Pa	Supply Velocity 3,35 m/s	Return Pres Drop 157,57 Pa	Return Velocity 3,35 m/s
Total Enthalpy 24,34 kJ/kg	Sensible Enthalpy -24,47 kJ/kg	Supply Efficiency 68,00 %	Return Efficiency 68,00 %
Rotor Type ST1	Rotor Diameter 1350 mm	Wall Height Normal(2) mm	Rotor Style Winded



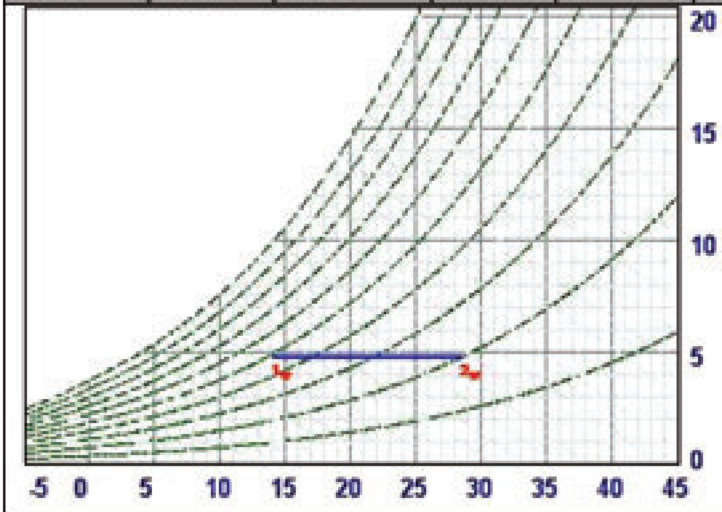
WINTER:	SUPPLY			RETURN		
	IN	OUT	DIFF	IN	OUT	DIFF
Td(C)	-3,0	14,8	17,8	22,8	5,0	-17,8
Tw(C)	-3,7	2,7	6,4	15,4	-2,5	-17,9
Rh(%)	85,1	47,9	-37,2	48,6	39,0	48,4
h(kj/kg)	32,1	142,0	109,9	428,6	11,6	-377,0
Ro(kg/m3)	1,3	1,2	-0,1	1,2	1,3	0,1
X(g/kg)	2,5	0,0	-2,4	8,2	0,1	-8,1

SUMMER:	SUPPLY			RETURN		
	IN	OUT	DIFF	IN	OUT	DIFF
Td(C)	33,0	26,8	-6,2	24,0	30,2	6,2
Tw(C)	23,8	9,3	-14,6	17,1	10,7	-6,3
Rh(%)	46,7	66,8	20,1	50,0	34,7	-15,3
h(kj/kg)	710,3	272,9	-437,4	478,2	306,5	-171,6
Ro(kg/m3)	1,1	1,2	0,0	1,2	1,2	0,0
X(g/kg)	14,8	0,1	-14,6	3,3	0,1	-3,2

Coil Section - Heating	3. section on Supply	

Air Volume	Model	Rows	Coil Inlet Diameter	Efficiency
8500 m3/h	NR1.00FP2.80F20.11	1.00	26.90	

Air Side			Fluid Side					
Face Velocity	Total Load	Pressure Drop	Fluid Type	Fluid In Temp.	Fluid Out Temp.	Fluid Flow	Max. Press. Drop	Circulation Number
2,09 m/s	41.98 kW	11.81 Pa	Water	7 C	12 C	1.85 m3/h	25 kPa	13.00



WINTER:	SUPPLY			RETURN		
	IN	OUT	DIFF	IN	OUT	DIFF
Td(C)	14,0	28,4	14,4	-	-	-
Tw(C)	8,6	9,9	1,3	-	-	-
Rh(%)	47,3	20,0	-27,3	-	-	-
h(kj/kg)	260,5	286,7	26,2	-	-	-
Ro(kg/m3)	1,2	1,2	-0,1	-	-	-
X(g/kg)	4,7	0,0	-4,7	-	-	-

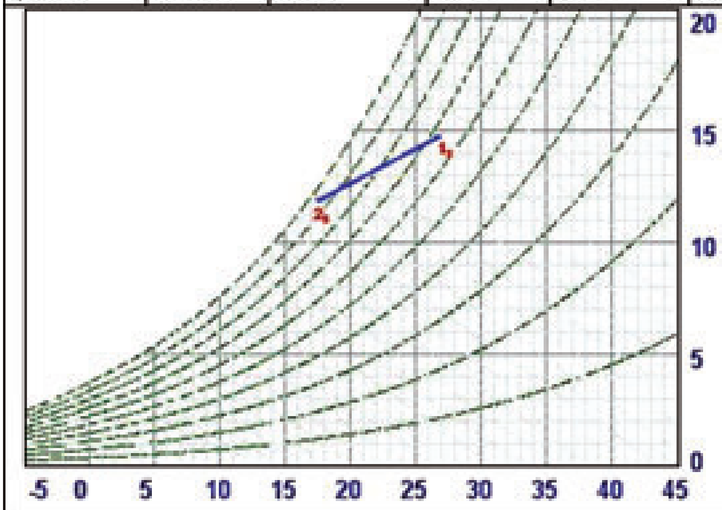
SUMMER:	SUPPLY			RETURN		
	IN	OUT	DIFF	IN	OUT	DIFF
Td(C)	33,0	33,0	-	-	-	-
Tw(C)	23,8	23,8	-	-	-	-
Rh(%)	46,7	46,7	-	-	-	-
h(kj/kg)	710,3	710,3	-	-	-	-
Ro(kg/m3)	1,1	1,1	-	-	-	-
X(g/kg)	14,8	14,8	-	-	-	-

Accesories:

Coil Section - Cooling	4. section on Supply	Designed for wet conditions

Air Volume	Model	Rows	Coil Inlet Diameter	Efficiency
8500 m3/h	NR4.00FP2.10F105.41	4.00	42.20	

Air Side			Fluid Side					
Face Velocity	Total Load	Pressure Drop	Fluid Type	Fluid In Temp.	Fluid Out Temp.	Fluid Flow	Max. Press. Drop	Circulation Number
2,09 m/s	42.14 kW	64.65 Pa	Water	7 C	12 C	7.22 m3/h	25 kPa	52.00

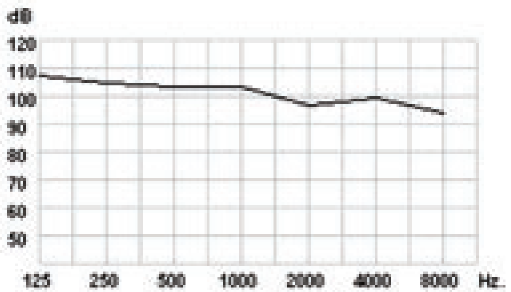


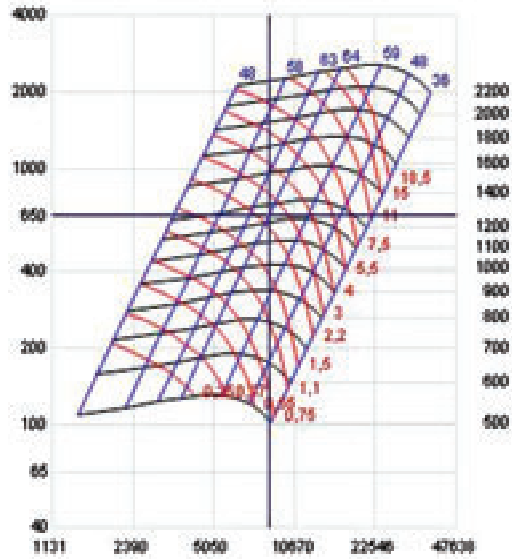
WINTER:	SUPPLY			RETURN		
	IN	OUT	DIFF	IN	OUT	DIFF
Td(C)	-3,0	-3,0	-	-	-	-
Tw(C)	-3,7	-3,7	-	-	-	-
Rh(%)	85,1	85,1	-	-	-	-
h(kj/kg)	33,1	33,1	-	-	-	-
Ro(kg/m3)	1,3	1,3	-	-	-	-
X(g/kg)	2,5	2,5	-	-	-	-

SUMMER:	SUPPLY			RETURN		
	IN	OUT	DIFF	IN	OUT	DIFF
Td(C)	26,8	17,3	-9,5	-	-	-
Tw(C)	22,1	4,6	-17,5	-	-	-
Rh(%)	66,8	96,0	29,2	-	-	-
h(kj/kg)	645,8	177,1	-468,7	-	-	-
Ro(kg/m3)	1,2	1,2	0,0	-	-	-
X(g/kg)	14,8	0,1	-14,6	-	-	-

Accesories:

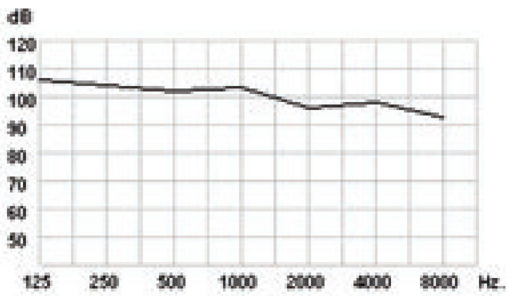
Fan Section	5. Section on Supply				
Air Volume 8500 m3/h	Fan Outlet Velocity 11,51 m/s	Model ADH E0-0355	Wheel Diameter 355 mm	dB(A) 83	Protection Class
Int. Static Pressure 460.9 Pa	Ext. Static Pressure 200 Pa	T. Static Press. 660.9 Pa	Vel. Press 79 Pa	Total Press 739.9 Pa	
Fan Speed 1228.25 rpm	Motor Speed 2890 rpm	Shaft Power 2,76 kW	Nom.Mot.Power 4 kW	Abs.Mot.Power 3.036 kW	
Fan Pully 200.00 mm	Motor Pully 85.00 mm	Belts 635 mm	Efficiency 63 %		
Accessories:					

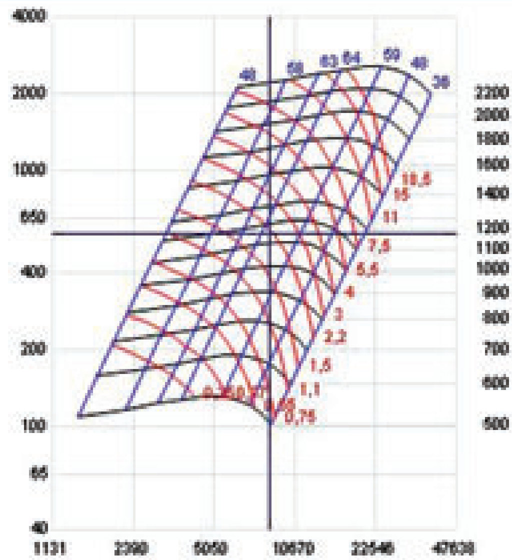




Silencer Section		6. Section on Supply				
Air Volume 8500 m3/h	Pressure Drop 13,68	dB Average Loss 58,06 dB				
125 Hz 10,54 dB	250 Hz 31,33 dB	500 Hz 45,04 dB	1000 Hz 54,52 dB	2000 Hz 66,13 dB	4000 Hz 45,67 dB	8000 Hz 42,95 dB

Fan Section	1. Section on Return				
Air Volume 8500 m3/h	Fan Outlet Velocity 11,51 m/s	Model ADH E0-0355	Wheel Diameter 355 mm	dB(A) 82	Protection Class
Int. Static Pressure 370.76 Pa	Ext. Static Pressure 200 Pa	T. Static Press. 570.76 Pa	Vel. Press 79 Pa	Total Press 649.76 Pa	
Fan Speed 1228.25 rpm	Motor Speed 2890 rpm	Shaft Power 2,42 kW	Nom.Mot.Power 3 kW	Abs.Mot.Power 2.662 kW	
Fan Pully 200.00 mm	Motor Pully 85.00 mm	Belts 660 mm	Efficiency 63 %		
Accessories:					





Filter Section		2. Section on Return		
Air Volume 8500 m3/h	Filter Bag Filter F5 Cam Elyaf 300	Panel Filter Bag Filter F5 Cam Elyaf 300	Pressure Drop (Mean) 213,19 Pa	
Accessories			Initial dP 26 Pa	Final dP 400 Pa

IN-DUCT SOUND POWER LEVEL dB (SUPPLY)

SECTIONS	Hz125	Hz250	Hz500	Hz1000	Hz2000	Hz4000	Hz8000	AVERAGE
INLET	82	78	73	70	61	60	55	76
Bag Filter Section (300mm)	-1	-1	-4	-6	-6	-8	-8	
Rotary Heat Recovery Section	-1	-2	-2	-2	-5	-6	-6	
Heating Section	0	-1	-1	-1	-1	-1	-1	
Cooling Section	-1	-1	-1	-2	-2	-2	-2	
Fan section	85	83	81	81	75	77	72	
Silencer Section (500mm)	-11	-31	-45	-55	-66	-46	-43	
OUTLET	74	52	36	26	9	31	29	66

IN-DUCT SOUND POWER LEVEL dB (RETURN)

SECTIONS	Hz125	Hz250	Hz500	Hz1000	Hz2000	Hz4000	Hz8000	AVERAGE
INLET	84	82	80	81	74	76	71	80
Fan Section	84	82	80	81	74	76	71	
Bag Filter Section (300mm)	-1	-1	-4	-6	-6	-8	-8	
Rotary Heat Recovery Section	-1	-2	-2	-2	-5	-6	-6	
OUTLET	82	79	74	73	63	62	57	76

AIRBORNE SOUND POWER LEVEL dB

Hz125	Hz250	Hz500	Hz1000	Hz2000	Hz4000	Hz8000	AVERAGE
74	66	59	55	50	47	38	66

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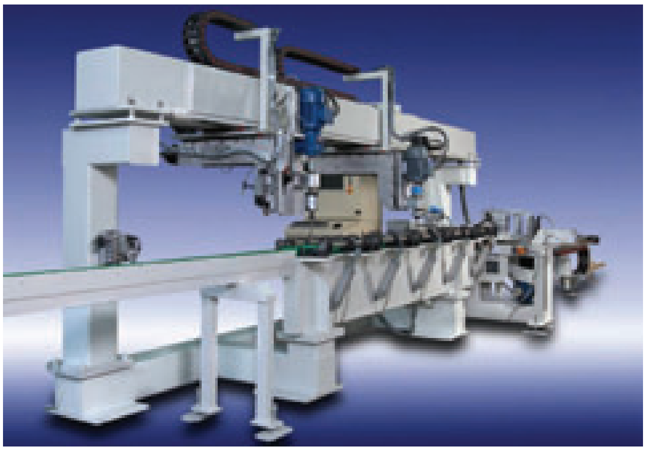
5.3 Frame Drill® Technology



A new milestone toward the sustainable development of HSK's quality and the increase of its competitive power has been the Frame Drill technology developed by the HSK R&D tem and patented by HSK.
The FlameDrill® technology has been a new production method, business model which increases assembly precision in air handling unit production, enabling units to be manufactured from standard parts and thus easily assembled at the installation site or out of the factory.

Its advantages are:
- Modularity
- Quality standardization
- Zero defect production
- Convenience of transport
- Rapid delivery
- Air handling units that can be assembled on site

Today, the delivery time for Air Handling Units is around 8-10 weeks. Customer satisfaction surveys we, as HSK have conducted have revealed that customers wish this time to be 2-4 weeks. Until now this wish was deemed impossible considering all processes from the procurement of main materials such as coils, fans, to production, painting and assembly of panels. Parts could not be stocked beforehand since connection points were not known in advance. With the FrameDrill technology, the main body of the air handling unit can be manufactured in advance with very precise positioning, stocked and thus delivered in a very short period of time. Since coils, fans, and other equipment have been standardized in Quickline air handling units which have been developed as a reflection of this production philosophy and which bear the properties of Flexline air handling units, allowing deliveries up to 20,000 m^3/h in as soon as 2 weeks.

6. CERTIFICATES

ISO 9001:2008 / ISO 14001:2004

All manufacturing processes for our products that are being manufactured in our factory are performed by ISO 9001 Quality Management System procedures.

- ISO 9001 Quality Management System Certificate
- ISO 14001 Environmental Management System Certificate
- OHSAS 18001:2007 Occupational Health and Safety Management System Certificate

GOST Certificate is a safety standard that was set by the Russian Authority in charge of standardization, certification and metrology. As per these standards, products entering the Russian market have to bear the GOST-R mark.

"Conformite Europeene" (CE) is a certification that refers to the minimum safety requirements regarding the use of a product. HSK ensures its products conforming the CE requirements.

HSK branded air handling units have been awarded the Eurovent certificate following the tests performed in TÜV laboratories in Germany in 2001. It is identified that the HSK Air Handling Units that were awarded Eurovent Certified Performance logo have successfully met the prescribed performance values in EN 1886.

TSEK certificates that certify the conformity of the products to relevant standards and that were awarded to manufacturing companies are available. Our company is authorized to use TSE 814 label on the HSK branded products that it manufactures which indicates TSEK branding and their electrical properties.

Hygienic Air Handling Units that we manufacture have been found fully conformant to DIN 1946/4, EN 1751, articles VDI 6022/1-3 and VDI 3803 following the test performed in TÜV NORD laboratories in 2006.

HSK®

"Powered by Self Quality"

30th year

"Powered by Self Quality"

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