
An AHU with ducted return at the terrace of Centenary Hospital, Kandivali, Mumbai

Selection of Air Handling Units

Part 2 of 2

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Coil Section

Coils are used to heat, cool and dehumidify air. The heat source can be hot water, steam, electric resistance or hot refrigerant vapor (as with a heat pump). Cooling and dehumidification can be provided via expansion of refrigerant (direct expansion or DX), or indirectly through the circulation of chilled water or glycol. In dry climates, cooling can also be effected by spray coils that reduce the dry bulb temperature of the air, but increase its humidity.

Selection of Heat Transfer Coil

The heat transfer coil can be arranged in draw through or blow through configurations. The coils use chilled water, hot water, direct expansion or low pressure steam around 5 psig.

The evaporative coil is manufactured from copper pipes, and is staggered for greater heat transfer. The louvered aluminum or copper plate fins are bonded into the tubes. The fins have hydrophilic anti-corrosive coating.

In Part 1 of this article, published in the May-June 2014 issue, the caption of *Figure 6* should read *Noise attenuator* – Technical Editor

Cooling Medium

The cooling medium is water from chilled water unit, water glycol solution from brine plant or refrigerant used in DX systems.

Heating Medium

The heating medium is water from local boiler plant or municipal network, or water glycol solution. An electrical heater bank is also used as an option to hot water coil, but the former is more widely used due to lower failure rates. The selection of hot water coil depends on the available hot water temperature.

Selection of Hot Water Coil

Hot water coil face area, air velocity and air quantity is the same as for a cooling coil.

About the Author

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- One row deep hot water coil is used when hot water outlet temperature is 60˚C and inlet water temperature is 55˚C.
- Two row deep hot water coils is used when hot water outlet temperature is 45˚C and inlet water temperature is 40˚C.
- If hot water coil capacity is lower than chilled water capacity, centralized heat pump will not work on heating mode. The following example illustrates coil selection:
  - At ambient temperature of 5°C to 45°C
  - Chilled water at outlet/inlet 7/12°C
  - Chilled water coil rating for above parameters is 80 kW, i.e. chilled water plant (heat pump) capacity in cooling mode is 80 kW

In the winter season, if ambient temperature is 5°C and inside room sensible load is very high, e.g. the heating capacity is 10 kW, the heat pump will not work as the heating capacity is very low. In addition, it is difficult to design and match a hot water coil with face area suitable for 10 kW capacity with a cooling coil of capacity 80 kW. In such cases, in winter season, one has to use electrical heater instead of hot water coil.

Direct Expansion Evaporative Coil

DX evaporative coils are used in conjunction with air cooled condensing units, for small capacity condensing units. This section is manufactured from copper pipes. Louvered aluminum plate fins are bonded into the tubes for better heat transfer.

Intertwined DX Coil

See *Figure 10.*

- Distributors are connected in equal distribution way as per the required cooling capacity of the condensing unit. (If there are 10 tubes and 2 distributors, the first tube is connected with the first distributor and the second tube with the second distributor and 3rd tube with again 1st distributor).
  - Due to the connection, maximum surface area is covered by each distributor.
  - A different refrigerant is used in each distributor.
  - If one line is choked out of four distributors, the system can still be run – achieving maximum performance of the coil due to this configuration.
- The coil is not separated by distributor configuration.
- Each cooling coil has an independent condensing unit; in case of failure of one condensing unit, the refrigerant gas flows in the other evaporative coil also. This configuration avoids coil bypass.
- This intertwines the DX cooling coil in conjunction with the condensing unit. This coil is also manufactured from copper pipes. Louvered aluminum plate fins are bonded into the tubes for better heat transfer.

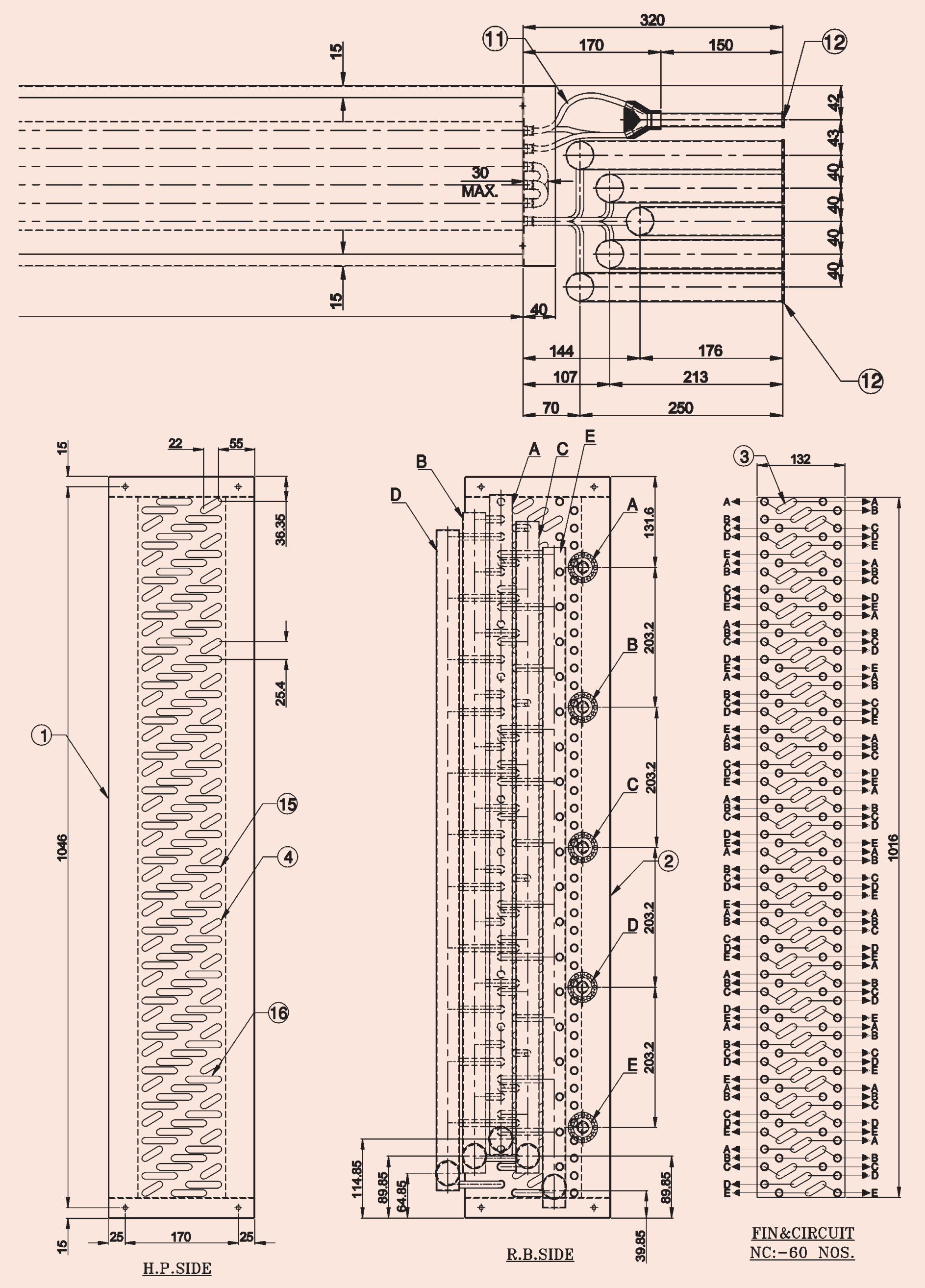

Figure 10: Intertwined DX coil

However, in a normal DX coil configuration, the coils are separated in parts.

1. All tubes of the first distributor are connected to the first set of pipes; then comes the connection for the second distributor.
2. If one distributor fails, the entire surface area gets separated and will not have any cooling effect.

The DX evaporative cooling coil can be use with various refrigerants, such as R 407C, R410A, R134A and R22.

Dehumidified air quantity for this type of evaporative coil is selected as per heat load calculations.

The recommended bypass factors for cooling coils are given in *Table 2.*

Table 2: Recommended bypass factors for cooling coils

Type of Cooling Coil	Coil face velocity (fpm)				
	300	400	500	600	700
	Bypass Factor (BF)				
2 row	0.225	0.274	0.314	0.346	0.373
3 row	0.107	0.143	0.176	0.204	0.228
4 row	0.052	0.076	0.099	0.120	0.140
5 row	0.025	0.040	0.056	0.071	0.086
6 row	0.012	0.022	0.032	0.042	0.052

The most commonly used coil face velocity is 2.57m/s. The cost economics of the AHU depend on coil face velocity, coil face area, coil rows deep and static pressure.

Lower coil face velocity is more beneficial because its gives:

- Larger coil face area
- Lower heat transfer coefficient
- Smaller pressure drop
- Low power consumption

However, the space requirement is higher.

On the other hand, an AHU with higher coil face velocity has a smaller footprint, higher power consumption and chances of water carry-over. This is due to the smaller coil face area, higher heat transfer coefficient and larger pressure drop.

While selecting the coil, the designer should consider following parameters of the coil:

Inside Room Condition

- Dry bulb temperature
- Wet bulb temperature
- Relative humidity

The following additional parameters should also be taken into consideration for coil selection:

- Ambient dry bulb temperature (DBT), wet bulb temperature (WBT) and relative humidity (RH) for summer, monsoon and winter.
- Dehumidified air quantity and fresh air quantity through the evaporative coil.
- Grains per pound and effective sensible heat factor (ESHF).
- Apparatus dew point (ADP).
- Entering air temperature (DBT) of return air + fresh air at the intake of evaporative coil for all three seasons.
- Entering return air DBT before the coil.
- Entering return air RH before the coil.
- Leaving air DBT after the coil.
- Leaving air WBT after the coil.
- Leaving air RH after the coil.
- Evaporative cooling coil capacity in kcal/hr or kW.
- Sensible heat in kcal/hr.
- Grand total heat (GTH) in kcal/hr.
- Sensible heat ratio (SHR) of coil.
- Air velocity across the coil.

The following data of evaporative cooling coil should be verified:

- Entering water temperature
- Leaving water temperature
- Number of distributors (in case of DX coil)
- Number of thermostatic expansion valves
- Face area of each evaporative coil
- Pressure drop across the coil
- Coil bypass factor
- Number of rows deep
- Coil tube material
- Coil tube thickness
- Coil tube diameter
- Type of fin (plain/ corrugated)
- Fin thickness and number of fins per inch
- Material of construction of fins
- Header material (MS/ Cu)
- Header inlet and outlet diameters
- Condensate drain size
- Drain pan material
- Drain pan insulation

Access

Access sections are frequently omitted from AHUs, either through designer oversight or intentionally due to space or budget constraints. But skimping on access can prove short sighted as each component within an air hander will require routine service, repair or replacement many times over the life of the unit. Coils must be cleaned frequently to maintain proper heat transfer, and must be accessible from front and back for this purpose. The more difficult it is to reach a component, the less likely maintenance will be performed, which will result in lower overall efficiency and reduced life.

Humidifier

Humidification is often necessary in colder climates where continuous heating will make the air drier, resulting in uncomfortable air quality and increased static electricity. There are numerous methods for delivering humidification including steam, ultrasonic dispersion, infrared heating and atomization of water. Careful consideration is necessary to determine which method is best suited for a given project, but humidifiers in general are maintenance intensive. They must, therefore, be installed in easily accessible locations since serious damage and

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IAQ issues can arise if humidifiers are not operating properly for extended periods. Some commonly used types of humidifiers are:

Evaporative

Dry air blown over a reservoir will evaporate some of the water. The rate of evaporation can be increased by spraying the water onto baffles in the air stream.

Vaporizer

Steam or vapour from a boiler is blown directly into the air stream.

Spray Mist

Water is diffused either by a nozzle or other mechanical means into fine droplets and carried by the air.

Ultrasonic

A tray of fresh water in the airstream is excited by an ultrasonic device forming a fog or water mist.

Wetted Medium

A fine fibrous medium in the airstream is kept moist with fresh water from a header pipe with a series of small outlets. As the air passes through the medium, it entrains the water in fine droplets. This type of humidifier can quickly clog if the primary air filtration is not maintained in good order.

Flexible Connection

A flexible connection allows joining of the AHU and duct. It compensates for small positional inaccuracies of the duct and the AHU, and prevents vibration transmission from the unit to the duct. It is necessary to select an airtight and flexible cloth with good weathering qualities that will withstand the temperatures inside and outside the duct. Flexible connector fabric should be non-porous with neoprene coating, fire retardant and high resistance to abrasion.

Heat Recovery

In many applications the requirement is for highly efficient recovery of a combination of sensible and latent heat. Depending on the building's use, it is thus possible:

- To reduce to a very large extent the energy required to heat the building (Low Energy House).
- To reduce considerably the size of and thus the capital expenditure on the heating system for the building.
- To reduce considerably the size of and thus the capital expenditure on the cooling system for the building (if necessary).

Figure 11: Plate type heat recovery unit

The heat recovery device is an indirect energy recovery system. Heat exchangers of many types are available and may be fitted to the AHU between supply and extract air streams for energy saving and capacity increase. The more common types are:

Recuperator or Plate Cross Flow Heat Exchanger

It is a sandwich of plastic or metal plates with interlaced air paths. Heat is transferred between air streams from one side of the plate to the other. The plates are typically spaced 4 to 6mm apart. It can also be used to recover cooling, and has heat recovery efficiency up to 70%. It recovers up to 65% of sensible load only and 0% latent load.

The plate material is made of raw or epoxy coated aluminum, and is corrugated. Heat transfer surface is increased by creating turbulence. The frame structure material is extruded aluminum profile and sealing is done with silicone based material.

This energy recovery system is quite effective but bulky, expensive, very difficult to clean and maintenance intensive. It can trap condensate, resulting in the growth of moulds. It is the most widely used, as cross contamination is almost zero.

Thermal Wheel or Rotary Heat Exchanger

Figure 12: Thermal wheel type heat recovery unit

It is a slowly rotating matrix of finely corrugated metal, operating in both opposing air streams. When the AHU is in heating mode, heat is absorbed as air passes through the matrix in the exhaust air stream during one half rotation, and released during the second half rotation into the supply air stream in a continuous process. When the AHU is in cooling mode, heat is released as air passes through the matrix in the exhaust air stream during one half rotation, and absorbed during the second half rotation into the supply airstream. Heat recovery efficiency goes up to 85%. Wheels are also available with hydroscopic coating to provide latent heat transfer and the drying or humidification of air streams.

A rotary heat exchanger comprises of a rotor, casing and drive mechanism. Three categories of rotors are available:

- Condensation rotor
- Enthalpy rotor
- Sorption rotor

All the rotors are manufactured for laminar air flow using one flat and one corrugated strip of material.

Drive Mechanism

The rotor is driven by a motor; two types of drive mechanism

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are available and selected as per the requirement. The drive mechanisms are:

- Constant drive with motor and gearbox, thermostat, etc.
- Variable drive with frequency inverter

Run Around Coil

It consists of two air-to-liquid heat exchanger coils in opposing air streams, piped together with a circulating pump and using water or a brine as the heat transfer medium. This device, although not very efficient, allows heat recovery between remote and sometimes multiple supply and exhaust airstreams. Heat recovery efficiency is up to 50%.

Heat Pipe

A heat pipe operates in both opposing air paths, using a confined refrigerant as the heat transfer medium. The heat pipe uses multiple sealed pipes mounted in a coil configuration with fins to increase heat transfer. Heat is absorbed on one side of the pipe by evaporation of the refrigerant, and released at the other side by condensation of the refrigerant. Condensed refrigerant flows by gravity to the first side of the pipe to repeat the process. It has heat recovery efficiency up to 65%.

Volume Control Dampers

The dampers cut off air supply when the AHU is off, or restrict the flow at start-up. In a recirculation system, the dampers function is to regulate the air flow and protect the cross-flow heat exchanger against frosting. Damper opening can be set manually or by an actuator.

Figure 13: Aerofoil damper

Dampers are opposed blade type. The blade should have aerodynamic shape and the dampers should have geared wheels. The damper should be at the outlet of the AHU, return air and fresh air, or combination exhaust, return and fresh air mixture. The outlet aerofoil blade louver damper is used for flow control.

Differential Pressure Gauge

It is widely used to measure fan and blower pressures, filter resistance and air velocity with pressure probe measurement across the filter. It also monitors filter status.

Static Pressure

Static pressure is the most important parameter for the selection of an AHU fan drive motor. The use of a correct fan drive motor will reduce the energy cost. The pressure drop chart *(Table 3)* will be helpful for the selection of static pressure.

Automation and Control Elements

AHUs are optionally equipped with automated systems. The basic function of the automation systems is to stabilize the temperature of supply, exhaust or room air, depending on the needs. They can also control room air humidity, and protect the AHU parts against damage in adverse conditions (freezing of DX or chilled water coil, frosting of cross-flow exchanger, etc.)

These function are performed by sensors and actuators connected by a controller. AHU operation status (i.e. clogged filter, activation of protections) are signaled by lamps to help the service personnel diagnose problems.

Table 3: Pressure drop chart

Sr. No.	Components	Status	Pressure Drop at 2.54 m/s in mm (wg)
1	EU-1 Synthetic media rod filters	Dirty	
2	EU-2 Combination of non woven synthetics, glass fiber paper, HDPE and metallic meshes	Dirty	9.0
3	EU-3 Combination of non woven synthetics, glass fibre paper, HDPE and metallic meshes	Dirty	10
4	EU-4 Combination of non woven synthetics, glass fibre paper, HDPE and metallic meshes	Dirty	12
5	EU-5 Combination of fine non woven synthetics, melt browns, glass fibre paper, felts, etc.	Dirty	15
6	EU-6 Combination of fine non-woven synthetics, melt browns, glass fibre paper, felts, etc.	Dirty	18
7	EU-7 Combination of fine non woven synthetics, melt browns, glass fibre paper, felts, etc.	Dirty	24
8	EU-8 Sub-micronic glass fibre paper	Dirty	45
9	EU-9 Sub-micronic glass fibre paper	Dirty	45
10	EU-10 Sub-micronic glass fibre paper	Dirty	75
11	EU-11 Sub-micronic glass fibre paper	Dirty	75
12	EU-12 Sub-micronic glass fibre paper	Dirty	75
13	EU-13 Sub-micronic glass fibre paper	Dirty	75
14	Activated carbon filter	Dirty	25
15	Volume control damper	Dirty	1.5
16	Cooling coil (12 to 14 fins per inch), 4 rows deep	Dirty	10
17	Cooling coil (12 to 14 fins per inch), 6 rows deep	Dirty	12.5
18	Cooling coil (12 to 14 fins per inch), 8 rows deep	Dirty	17
19	Hot water coil (12 fins per inch), 1 row deep	Dirty	1.5
20	Hot water coil (12 fins per inch), 2 row deep	Dirty	3
21	Fan chamber	Dirty	2
22	Intake louvered grille	Dirty	2
23	Moisture eliminators in GSS	Dirty	2
24	Supply air plenum	Dirty	6
25	Supply air diffuser with collar damper	Dirty	8.2
26	Supply air grille with collar damper	Dirty	2.2
27	Return air diffuser	Dirty	7.5
28	Return air grille	Dirty	2.5

Note: Pressure drop of the components is directly proportional to air velocity, i.e. if air velocity is more than 2.54m/s, pressure drop also increases proportionately.

The automated systems feature a weekly clock to reduce energy consumption, for example on holidays or at night. Each AHU has a service switch to disconnect the power supply during maintenance and repair operations.

A few control elements are:

i. Anti Freezing Thermostat

It operates at the minimum acceptable temperature of air passing through water coil, signals temperature decrease

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behind the water coil below the critical value, and emits a signal for activation of protection procedures.

ii. Electrical Pre-heater Control Thermostat

It switches on and off the electric pre-heater. If the air temperature behind the heater drops below a set value, a signal from the thermostat switches the system control module, which heats external air.

iii. Overheat Protection Thermostat

Overheat protection for electric heater is used to switch off the heater, and automatically resume once the temperature drops by the hysteresis value.

iv. Duct Temperature Sensor

It is used to measure the temperature of the air supplied to or exhausted from a room.

v. Room Temperature Sensor

It is used to measure the inside room air temperature.

vi. Regulator

Using sensor signals, it determines a proper control signal for executive elements (e.g. throttles and valves modulating motor).

vii. Combined Temperature and Relative Humidity Sensor

It measures temperature and humidity.

viii. Two Way/ Three Way Valve

With a modulating motor, it controls agent flow through water exchanger (heater or cooler).

ix. Pressure Switch

To give a signal when the set pressure drop value is exceeded, it informs about clogged air filters or incorrect fan operation.

x. Damper Actuator

It controls the closing and opening of multi-leaf dampers.

xi. Limit Switch

It disconnects fan power supply when inspection doors are open.

xii. CO Detector

It is used for control of carbon monoxide levels.

xiii. Variable Frequency Drive

It is used to regulate the AHU supply air flow rate. Variable frequency drive varies the fan speed by adjusting the frequency and voltage to the motor.

Rating Performance and Mechanical Characteristics

The rating performance and mechanical characteristics of an AHU are certified by Eurovent.

Rating Performance (as per EN 13053)

- Air flow – available static pressure
- Power input
- Octave band in-duct sound power level
- Radiated sound power level
- Heating capacity
- Cooling capacity
- Heat recovery
- Water pressure loss

Mechanical Class Certification as per EN 1886

Please see *Table 5.*

Table 5: Mechanical class certification as per EN 1886

Mechanical class certification as per EN 1886	Best Class → Lowest Class			
Casing strength	**D1**	**D2**	**D3**	
Maximum deflection mm/m	*4*	*10*	*>10*	
Casing air leakage	**L1**	**L2**	**L3**	
Maximum air leakage l/s/m² at +700pa	*0.22*	*0.63*	*1.90*	
Maximum air leakage l/s/m² at -400pa	*0.15*	*0.44*	*1.32*	
Filter bypass leakage	**F9**	**F8**	**F7**	**F6**
Maximum leakage of nominal air flow %	*0.50*	*1.00*	*2.00*	*4.00*
Casing thermal transmittance	**T2**	**T2**	**T3**	**T4**
Maximum U transmittance W/m²/K	*0.50*	*1.00*	*1.40*	*2.00*
Thermal bridge factor	**TB1**	**TB2**	**TB3**	**TB4**
Kb mini (thermal bridge factor value)	*0.75*	*0.60*	*0.45*	*0.30*
	+++	++	+	-

Conclusion: Emerging Trends in AHUs

Although much of the technology in AHUs has remained relatively unchanged for decades, some relatively new components and practices are being incorporated that can be useful in the right application.

- Direct-drive fans couple the fan wheel directly to the motor shaft and are typically applied with variable frequency drives (VFD). This eliminates the drive losses associated with belts and can result in higher efficiency and lower overall noise.
- Fan arrays use multiple small, direct-drive fans in lieu of a single large fan. Applied properly, the fan array can reduce the overall space required for the AHU while providing redundancy and energy-efficient operation.
- Energy recovery is increasingly applied in AHUs and may be required by energy codes in certain applications having high percentages of outdoor air.
- Dedicated outside air units are increasingly being applied in lieu of traditional air units that mix outdoor air and return air. Treated air (dehumidified or humidified) from these units can be supplied directly to occupied spaces or can be injected into mixing boxes into other AHUs dedicated to temperature control.
- Condensate collection from cooling coils can save a considerable amount of water and money.
- UVC lights (ultraviolet light in the C band) reduce the growth of bacteria, mold, and algae on coils and drain pans.
- Commissioning is a must for all AHUs, regardless of size and complexity. Periodic re-commissioning is also necessary since sensors and dampers drift over time.