

AIR CONDITIONING AND REFRIGERATION Journal

The magazine of the Indian Society of Heating, Refrigerating and Air Conditioning Engineers

Issue : July-September 2005



The Mega Mall in Mumbai has 250 ductable splits that provide 1885 tons of cooling. Photo courtesy of Voltas Ltd.

Packaged Cooling for Comfort

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Packaging a product provides a great convenience. Thus we have packaged foreign tours and packaged holidays which take care of all the hassles of visas, hotel reservations, airline bookings, special food and sight seeing.

Packaged air conditioners and ductable splits provide a similar convenience for engineers involved in designing comfort air conditioning systems where control of temperature and good air distribution are the main objectives. Engineers need not concern themselves with selecting a compressor, matching its capacity with a suitable condenser and evaporator, sizing the refrigerant piping, choosing an adequate size blower and providing electric wiring. All of that has already been worked out by a team of experienced engineers and a neat bundle of various components put together to make a package that can be installed as a single unit for a small office, retail shop or restaurant or in multiples for bigger offices, larger shops or restaurants.

Standard comfort package ACs and split ACs are available from many companies and our company can offer a variety with reciprocating (both hermetic and semi hermetic) as well as scroll-compressors, 4-row deep evaporator coils and an intelligent management system comprising a programmable microprocessor controller that can communicate with a PC through a master controller.

Some unique installations of comfort ACs have been carried out in shopping malls, auditoriums, multiplexes, entertainment centers, showrooms, server rooms and operating theatres and these will be described in some detail for the benefit of those young engineers who are entering the growing market for packaged and ducted split air conditioners.



Packaged and ductable split ACs.

Shopping Malls

Packaged and ductable split ACs have become very popular for this application. Their usage involves placing the air conditioners in designated rooms, strategically located on the floor in the case of packaged units, or on the loft above the toilets or above the false ceiling in the passage areas, where splits are involved. A few precautions at the design stage will ensure a satisfactory installation and these are:

- Lofts should be airtight to prevent toilet odours from spreading through the air distribution system. RCC or tile-coba loft construction is recommended compared to POP material, with adequate clear height for equipment and service personnel. Access doors to the loft should be air tight and large enough for service entry.
- Air distribution to each shop must be capable of proper control and balancing through volume control dampers. This will avoid complaints of over cooling and under cooling from store owners. Avoiding long duct runs and providing insulation on all supply ducts will further help in maintaining even space temperature.
- Air discharge in atriums should be at lower levels for greater occupant comfort. Discharging cool air from a high level will only cool the air at heights where there is no human occupancy.
- Shop owners should not be permitted to stack goods in the supply and return air path or by creating lofts within their shops.
- Air-cooled condensers or condensing units are normally located on the rear side of the mall on wall mounted brackets.

Mall builders or construction companies prefer packaged / split ACs for the following reasons:

- Lowest capital cost.
- The operating cost is borne by the users and hence is not a criterion for selection of equipment. The initial capital cost is the prime factor.
- No floor space requirement, in the case of split units. With packaged units also, the space requirement matches the AHU room spaces required in the case of central plants. In any case, such rooms are permitted to be excluded from the FSI calculations.
- Simplicity of installation and maintenance.
- Ease of operation as no operators are required. Modern- day units are provided with microprocessor controllers, which enable single button operation and basic fault diagnosis.
- Progressive completion is possible. This factor is very important for the 'lessor' as the revenue starts flowing in immediately on part completion.
- Individual metering is possible for anchor shops by providing separate units.

The "Mega Mall" in Oshiwara, near Lokhandwala complex, Mumbai has installed 250 ductable split ACs with a total capacity of 1885 tons and is the largest single installation of

ductable split units in the country.

Multiplexes, Theaters, Discotheques, Entertainment Centres and Marriage Halls

Such applications are characterized by large occupancy levels and require special care in selection of cooling coils. Low to medium occupancies, say upto 350 persons, can be handled by normal comfort units with 4-row evaporators as a standard, except that some precautions for low noise levels are required for applications like multiplexes, theatres and auditoriums. Ensure that:

- Supply/ return air ducts are designed for low velocities of 800 fpm to 1000 fpm.
- Supply/ return air ducts are acoustically lined.
- Acoustic insulation is provided in the packaged unit plant rooms or in areas around the indoor units of the ductable splits.
- Grilles are selected for NC 25 from the rating charts.
- Blower fan rpm is 1000 or lower.
- Condensers / condensing units are not located on the walls of the air conditioned space, to prevent transmission of noise and vibration inside. They should be located on the walls of areas like toilets, passages etc.

As an added precaution where standard packaged units are used for such applications, the compressor can be shifted to inside the outdoor condenser unit and this will help to further reduce the noise level in the air conditioned area.

Where high occupancy levels, above 350 persons are encountered the normal comfort AC cannot be used since the 4-row cooling coil is not capable of handling the high latent load.

The best method of air conditioning such areas is by using air handling units (AHUs) with one or two sections of 5 or 6 row DX coils. Each section can then be connected to the standard condensing unit of ductable splits. The air handling units can be single skinned or double skinned and with regular or low noise blowers, depending on the noise level requirement.

Other norms mentioned earlier like acoustic insulation of ducts, lower blower fan speeds, grille selection for lower NC levels etc. are equally important here.

A large number of multiplexes and theatres have been air conditioned with such units, quite successfully.

Such built-up systems offer the following advantages:

- Lowest capital cost.
- Least space requirement.
- Simplicity of installation and maintenance.
- Ease of operation; no operators required.
- Progressive completion is possible.

Server Rooms

In earlier days, servers required very low temperatures of 18–20°C with 5 micron filtration of air and air supply from below the false flooring.



A Server room cooled by a standard packaged AC.

With servers becoming sturdier day by day, only temperature control with 15-20 micron filtration and air supply from the top of the area is being increasingly accepted, thereby making standard packaged and ductable split units very popular for such applications.

Such areas need high air quantity from the AC units due to the high sensible loads and can work without any fresh air intake since they are occupied by humans for very brief intervals only.

Standard packaged units can be used for such areas by locating the units inside the air conditioned area in between the server racks. A plenum on top of the packaged unit discharges supply air in 3 or 4 directions, as desired. Due to the absence of ducting, the air quantity delivered by these units is higher.

Only temperature control ($\pm 1^\circ\text{C}$) is possible with such systems.

Factories or Showrooms

One variation in the air conditioning system for such areas is the use of standard packaged units by locating the units inside the air conditioned area.

- In the case of factories, packaged units can be located along the periphery of the manufacturing area. A plenum on top of the packaged unit discharges supply air, in 1,2 or 3 directions, as desired. This is a very cost effective way of factory air conditioning since cooling is provided at the lower levels only, leaving the top of the area slightly warmer. Also, in India, workers are generally not accustomed to low temperatures and hence maintaining a temperature of 24-26°C is acceptable, unless some specific process or equipment needs a lower temperature.
- In the case of showrooms also, the packaged units can be located in between the racks or in niches in the walls. For showrooms, the compressor can be shifted to inside the outdoor condenser unit. This further reduces the noise level in the air conditioned area.

Hospital Operation Theatres (O.T.)

These critical applications involve maintenance of temperature, humidity, cleanliness, desired number of air changes and air velocities. Let's examine the two types of systems involved viz. systems with specified fresh air changes and those with 100% fresh air applications:

Specified fresh air changes (say 4-6 per hour)

Standard packaged units can be used for such applications with the following changes:

- The cooling coil should be at least 4-rows deep. This is a standard on our units.
- Heaters provided in the supply air ducts with controls to take care of humidity control.
- For minor O.T.'s or less critical areas, fine filters are provided in the supply air ducts at the outlet of the evaporator blower. In smaller towns and in O.T's of Municipal Corporations, due to constraints of funds, packaged units with fine filters are provided instead of room air conditioners.
- When HEPA filtration is needed, a booster fan can be provided ahead of the packaged unit outlet in the supply air stream. This makes the packaged unit blower and motor redundant and they can be removed.

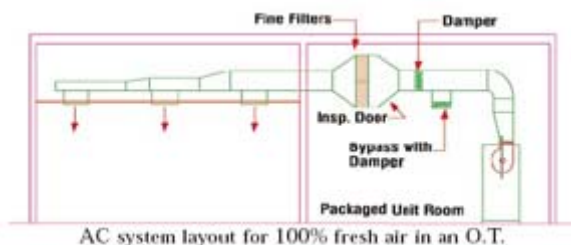
A better method is the use of single or double skinned AHU, with a high static blower design, connected to condensing units. The fine filters can be located in the plenum at the outlet of the evaporator blower. The HEPA filters can be located in the plenum itself or at the terminals, depending on the cleanliness levels desired. Laminar flow can also be used with these systems.

100% fresh air

There are two methods of air conditioning involving 100% fresh air.

1. The common method is the use of a single or double skinned AHU, with a high static blower design and a 6- row DX coil connected to the condensing unit. This is a separate topic, not covered in this article.
2. Standard packaged units with 4-row coils can also be used for such applications. This method can be better explained with the help of an example. For an area of 350 sq. ft., the capacity required will be about 6.1 tons with a dehumidified supply air requirement of 1000 cfm.

Suppose we wish to select a 7.5 ton packaged unit for this application. The nominal air quantity delivered by this unit is 3000 cfm. Hence, 2000 cfm after the outlet of the evaporator fan needs to be bypassed within the packaged unit room itself. This will mix with the 1000 cfm fresh air, improving the inlet conditions to the coil. In other words, 2000 cfm of air passes over the cooling coil again, increasing the contact factor or in other words, reducing the bypass factor.



The bypass factor for a 13 FPI, 4-row DX coil with 600 fpm face velocity is about 12%.

This is effectively reduced and can be calculated approximately as under:

$$\text{Effective bypass factor} = \frac{(1000 \times 0.12) + (2000 \times 0.12 \times 0.12)}{3000}$$

$$= 0.05 \text{ i.e. } 5\%$$

This lowered bypass factor of 5% can then be used in the heat load calculation to arrive at the improved ADP.

This is a simple empirical method compared to working out of the inlet conditions of the mixed air passing over the evaporator coil.

A large number of operation theatres, in hospitals of the Municipal Corporation in Mumbai, have such systems and have been running successfully for many years.

Redefining the Standard Comfort Packaged AC

Areas with high sensible loads, due to the presence of a large number of PC's or areas with large, exposed glass windows or skylights or areas with large equipment loads, require a higher amount of cooled and dehumidified air quantity as compared to typical comfort applications.

The air quantity requirements are about 500 cfm per ton as compared to about 400 cfm per ton for standard comfort applications.

The system in earlier days involved the installation of one or two additional packaged units to match the higher cfm requirements, making the system unnecessarily expensive with a larger space requirement.

The word 'standard' has been redefined now with the introduction of high air quantity packaged units to cater to such specific requirements.

A standard 8.5 ton packaged unit delivering 3000 cfm is fitted with a 5.5 ton compressor, all other components remaining the same. Thus, the unit now delivers 3000 cfm and 5.5 tons i.e. about 545 cfm/ton.

The additional benefits are:

- Saving of floor space
- Lower maintenance requirements due to reduced number of units

Intelligent Management Systems

The demand for operation and monitoring of equipment from a single point, like a PC, is growing day by day. A number of building management systems (BMS) are available in the market to cater to this requirement.



These systems are effective but expensive. A very cost effective solution (VSCADA™) has been introduced indigenously by our company to meet international standards in controlling and monitoring HVAC installations.

The system comprises of a programmable microprocessor controller installed on each packaged or ductable split unit panel which communicates with a master controller. The master controller in turn communicates with the PC through a data converter.

A modem connected to the PC makes remote monitoring possible.

Main Features:

- Allows user friendly graphical interface
- Can be integrated to other Building Management Systems with a variety of protocols

General Features:

- Continuous monitoring and display of return air temperature, humidity, date and time
- Programming for the entire year including 15 holidays and 2 starts/stops per day.
- Display of previous 5 trip conditions, thereby enabling quick fault diagnostics.
- Monitoring of the on/off status of all the units.
- Start/stop operation and settings from the PC
- Provides unit-to-unit communication facility enabling equal hours of operation.
- Avoids erroneous data entry by validation of input data with a 2 level password.
- Can accept a signal from smoke or fire alarm systems.

The diagram given above explains the system components.

Conclusion

Standard packaged air conditioners for comfort are gradually eating into the share of central DX and chilled water system. Several medium sized office buildings have also been fully air conditioned with packaged ACs. For reasons explained in this article “builders” prefer such units because of their low cost and speed of installation.