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A battery of air-cooled condensers on the terrace of a building, connected to indoor vertical ducted PACs with scroll compressors. Photo courtesy of Blue Star Ltd.

A Packaged Air Conditioners: The Scene in India

By R. Muralidharan Iyengar

General Manager - Technical

Channel Business Group

Blue Star Ltd., Chennai

R. M. Iyengar is a mechanical engineer with 35 years experience in various industries of which the last 10 years has been with Blue Star Ltd. in technical marketing. He is a past president of ISHRAE Chennai chapter and is presently a committee member of ASHRAE South India chapter.

A mini central plant neatly assembled in one compact sheet metal enclosure is a *packaged air conditioner (PAC)* and when assembled in two separate enclosures is a *split air conditioner*. What distinguishes these packaged / split ACs from the more common room ACs such as window units / mini splits is their capability of being connected to a ducted air distribution system with a fresh air intake.

The design of the packaged AC and all its components is capacity matched to enable it to perform at optimum operating conditions with pre-determined ratios of airflow/ton, sensible heat / latent heat removal capacity and kW/ton. Prototype units are then assembled and carefully tested and if found acceptable, the design is frozen and manufacturing details finalized. The capacity range of packaged ACs commonly manufactured in India is 3 ton to 16.5 ton. Air-cooled units are more commonly used because of water shortage all over the country and the hermetic scroll compressor is more popular than the reciprocating type.

Growing Popularity of PACs

With a low installed price per ton, short delivery schedule, dependable performance and reputed manufacturers recommending their use, more and more users are opting for the packaged unit alternative rather than a central chilled water plant with recip/screw chillers. The central plant market size is gradually being eroded by the PAC market.

The PAC market, in turn, is being eroded, but to a smaller extent, by the ductless splits. Literally speaking, the market scene today is a free-for-all with the customer succumbing to market pressures for the lowest price.

Table 1 provides a comparison of the benefits and limitations of packaged air conditioners, designed for the mass comfort sector.

Table 1 : Benefits and limitations of standard packaged air conditioners.

BENEFITS	LIMITATIONS
Low installation cost	Precise control of room conditions is not possible
Readily and easily available	Limitations on air flow and filtration levels
Being totally factory built, ensures better quality and reliability	Smaller compressor and hence higher kW/ton consumption
Less plant room space required	Operating sound levels can be quite high

Simple operation – trained man power is not required	Limitations on the amount of fresh air intake
Modularity permits phase wise air conditioning	Variations in the room temperature due to on/off cycles
Metering of consumed power by individual customers is very easy	Must be greatly over sized for high sensible load applications
Possible to switch off units catering to unoccupied spaces thereby avoiding wastage.	Average life span of about 10 years.

Applications of PACs

Originally conceived and manufactured for the small to medium size commercial sector comprising restaurants, retails shops, banks and offices, manufacturers and their dealers have penetrated a much wider market with great success. Larger capacities and specially designed units, both made in India and imported, have helped to grow the market substantially. Let us now examine the scene in India for different types, as it exists today.

Residential. Most homes in India are not fully air conditioned and hence ducted splits are not commonly used. During the past few years, with dropping prices, aggressive marketing and rise in disposable incomes, window AC's and ductless splits are becoming common place in many bedrooms and living rooms in multi-storey apartment buildings as well as in single family and joint family bungalows. The VRF unit imported from China or Japan is being installed in several large multi-room mansions. The installed price of such units is much higher than regular ductless splits but some of the benefits, quite often overrule the price factor. See details of VRF units further on in this article.

Small Commercial. The packaged / ducted split AC is ideally suited for the thousands of restaurants, sari shops, jewellery shops, small food stores, car showrooms, bowling alleys, banks and offices spread out in all urban areas of the country. Installed as a single unit or in multiples, depending on the area and cooling load, these units are connected to an air distribution ductwork to evenly spread the cooling effect. Outside air is introduced in the return air path to provide a feeling of freshness for customers and staff unlike window and mini-split ACs which are not designed to provide such a facility.

Large Commercial. Even though the largest capacity PAC manufactured in the country is only 16.5 tons, which can handle a small office building floor area of approximately 3000 ft², multiple units have been installed in many larger office buildings, adding upto 700 or 800 tons. Similarly, several shopping malls designed for central chilled

water systems have installed PACs with total capacities of anywhere around 750 tons, mainly for economic considerations.

Such large installations of PACs suffer from increased maintenance costs because of the large number of units involved, and inconvenience to occupants in case of breakdowns, since it is not possible to have a standby for each unit. To a major extent the problem of not having a standby is taken care of by having multiple refrigeration circuits in a single unit. Since the lifespan of PACs is about 10-12 years against 18-20 years for a central plant, the owner must take this factor into account before taking a final decision in his choice of the AC system.

Types of Units Commonly Used in India

The first packaged air conditioners made in India appeared in the market in the early 1950s with water-cooled condensers and semi-hermetic compressors. Availability of water was not a problem in those days and semi-hermetic compressors were considered more reliable than hermetic and easily repairable in case of a burnout, which was fairly common at that time with undependable power supply in most parts of the country.

As the market grew, water became scarcer by the year, power supply improved, hermetic compressors became more reliable and today air cooled units with hermetic compressors dominate the scene. India companies have gained more confidence and today produce a wider variety of units but still import the newer designs such as the VRF unit. Some other designs and capacities not made in India are covered in another article. Most of the units are designed for normal comfort applications with indoor conditions of 27°C DB, 19°C WB and 35°C ambient.

Water-Cooled Floor Standing Ductable Package.

This is the first and oldest design and is produced by only two companies since the demand is quite small. Shell-and-tube condensers are used because they are easier to clean and maintain. They are available in capacities of 5 ton to 16.5 ton and external static pressure of 6-10 mm wg. See **Photo 1**.



Photo 1: Water-cooled package.

Air-Cooled, Floor Standing, Ductable Split.

With the same sheet metal enclosure as the water-cooled model shown in **Photo 1**, the S&T condenser is replaced by a remote mounted air-cooled condenser with propeller fans, to be installed in an open space with free air discharge See **Photo 2**.



Photo 2: Remote air-cooled condenser.

Air-Cooled, Ceiling Suspended, Ductable Split.

The DX evaporator with blower, motor and filters are part of the “indoor unit” while the “outdoor unit” consists of the hermetic compressor and condenser with propeller fan or the "condensing unit" as it is called in refrigeration parlance. Free air discharge is recommended for best results. Should it be necessary to mount the condensing unit indoors, a centrifugal blower and discharge air ductwork can replace the propeller fans. The manufacturer's guidance and approval must be obtained before making such a change.

Capacities available are 3 ton to 16.5 ton with external static pressure of 5 to 12 mm wg. See **Photo 3**.



Photo 3: Ductable split, air-cooled.

Air-Cooled, Floor Standing, Free Air Discharge.

Available in capacities of 2 to 4.5 tons with aesthetically designed indoor units, such ACs are ideal for small commercial establishments, with no need of ductwork. The indoor unit is left exposed and is unobtrusive in performance while the outdoor unit is mounted where there is plenty of cool outside air available. See *Photo 4*.



Photo 4: Free air discharge, floor standing.

Water-Cooled, Ductable Splits.

Where water supply is not problem these units, available with both floor mounted or ceiling suspended ductable indoor units are available in capacities of 3 ton to 11 ton. A large 360 ton installation was recently completed in Ahmedabad, with the condensing units installed on the terrace, alongside the cooling tower and the indoor units installed in a loft directly below, with conditioned air supplied to a large open shopping area.

Precision Air Conditioners.

The IT revolution has paved the way for a totally new concept — equipment cooling. If the room temperature gets too high or too low, data integrity and system reliability suffer. Very high and very low humidity can also be a major problem. It can cause data alteration, oxide shedding and loss of data in the magnetic media.

Manufacturers recommend set tolerances for conditions to be maintained in the equipment rooms. Typically these are $22\pm 1^{\circ}\text{C}$ and $50\pm 5\%$ RH.

Moreover, the sensible load in equipment rooms is very high – almost 90-95% of the total load component. Therefore the air conditioning system has to be designed with very high air quantity to remove that much sensible heat.

Dust is the worst enemy of electronic equipment and filtration levels have to be strictly quantified and maintained. Last but not least, an air conditioning system catering to an electronic equipment room has to be rugged enough to be in operation 24x7.

Precision air conditioners solve all these problems. They are stand-alone units with scroll / reciprocating compressors. The evaporators could be single circuit or dual circuit (to operate on chilled water when a central plant is operational). It is provided with either top discharge or floor discharge as per the equipment requirements. The microprocessor controller is designed to cater to precision tolerances of temperature and humidity. They are provided with an integral humidifier / heater to add moisture / heat as required. They are also equipped with filters conforming to required filtration levels. See *Photo 5*.

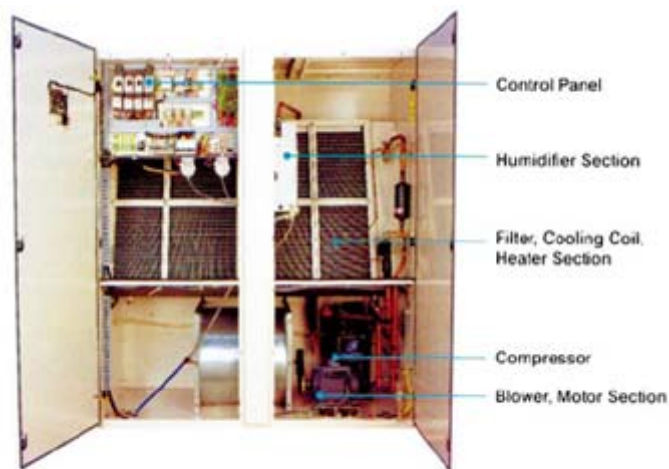


Photo 5: Precision air conditioner down discharge.

High Sensible Heat & High Performance ACs.

There are many applications that do not require all the features of a Precision AC such as the humidifier, heating coil, down discharge, redundancy on compressor and blower, but still need high sensible heat removal capacity of up to 90%, against the normal 70% of a comfort AC and the capacity to perform at ambients of 45°C instead of the normal 35°C .

One manufacturer has introduced such special versions to cater to these requirements with an EER of 10 compared to less than 9 of a standard comfort AC.

VRF Air Conditioning System.

The VRF(Variable Refrigerant Flow) system is the latest and most glamorous entrant into the packaged air conditioner market. This technology originated in Japan and is now picking up in China and Korea. At present there are more than 20 manufacturers of VRF type products in the world.

In general, VRFs consist of a number of indoor units connected to a single outdoor unit. They allow refrigerant flow from the outdoor unit to be varied. The technology used is either an inverter-driven compressor for speed control or a digital scroll compressor. A VRF system is provided with only one distribution port on the outdoor unit. Each indoor unit is provided with an electronic expansion valve, which continually adjusts the flow of refrigerant to respond to the load requirements in individual areas. Thus the temperature inside is maintained at virtually constant levels as against the variation caused due to on / off cycles of conventional packaged ACs. For larger capacities, multiple outdoor units can be used.

Capacities are designated in HP or kW instead of tons. Being modular, outdoor units are so compact that they can be carried through commercial freight elevators. Another advantage over the standard packaged unit is that it can accommodate relatively larger lengths of refrigerant piping.

All these advantages come at a premium. These systems are imported into India and hence for full-duty projects, they prove to be a costly option. They are comparatively viable in case of duty-free zones. See *Photo 6*.



Photo 6: VRF system.

Future Trends

The largest capacity PAC available today is 16.5 tons with three hermetic scroll compressors of 5.5 ton each operating at 50Hz and an ambient temperature of 35°C. With an 11 ton scroll compressor already available in the market, the maximum capacity of packaged units will increase to 22/33 tons. This increase is necessary to cope with the larger buildings being built today and the ever growing popularity of PACs.

Fully packaged, air-cooled, outdoor units similar to the rooftop type in the US market will appear on the scene to cater to the needs of smaller towns where low height buildings spread out over a larger land area are common. Such units can also be used in industrial buildings which are usually single storey.

VRF units with digital scroll compressors are in the development phase with Indian manufactures at this time and will be in the market shortly to compete with the imported variety.

Reverse cycle heat pumps for both cooling and heating will gradually appear on the scene in central and north India to cater to the needs of the extreme climates in these areas.

Conclusion

The market for packaged air conditioners is expected to grow annually at a rate of 20% to 25% and the growing variety and capacity will help cater to a larger range of applications.

