Rooftop Air Conditioning Systems Using R-410A

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ABSTRACT

Over the last few years, new directives and local regulations have led to a growing consciousness about the environmental impacts of product life cycles. As a result, rooftop air conditioning systems are facing a major conceptual design change; equipment is being designed for minimum initial investment with advanced features to meet new demands related to energy efficiency, environment design, ease of installation and service, and user comfort. This paper reviews some potential solutions to address these objectives.

BACKGROUND

Designing a new line of rooftop air conditioning systems represents a major challenge for a development team because the objectives go far beyond a classical approach: mechanical, thermodynamic design, design for easy installation and service (DFEIS), design for manufacturing assembly (DFMA), and design for cost-effectiveness. The development team must also focus on all environmental aspects, including:

- High energy efficiency (nominal and seasonal)
- Life cycle cost (LCC) analysis
- Larger working envelope (i.e., broader range between the minimum and maximum outdoor operating temperature) even with new refrigerants
- Minimization of refrigerant charge size and leakage

The drivers of these design changes are the new emerging EU directives that pertain to product energy use, energy performance of buildings, and the management of fluorinated greenhouse gases (F-gases).

If a unit is properly designed and installed, energy consumption associated with equipment operation typically accounts for more than 80% of the unit's climate impact (depending specially on seasonal efficiency).

DEVELOPMENT OF ALTERNATIVES

This paper analyses two alternative rooftop AC systems: the classic rooftop AC system using R-22, which has been manufactured for the last 30 years, having been introduced originally in the United States; and the high-tech rooftop system using R-410A that was introduced by the air handling unit (AHU) business within the last 10 years. Both types of equipment aim to treat air by heating, cooling, and dehumidifying to reach customer requested conditions.

1. CLASSIC ROOFTOP SYSTEM

Rooftop unit are driven by cost and foot print, whatever the refrigerant. These units are unlikely to remain popular as they cannot meet new environmental constraints and minimum performance requirements.

2. HIGH-TECH ROOFTOP SYSTEM

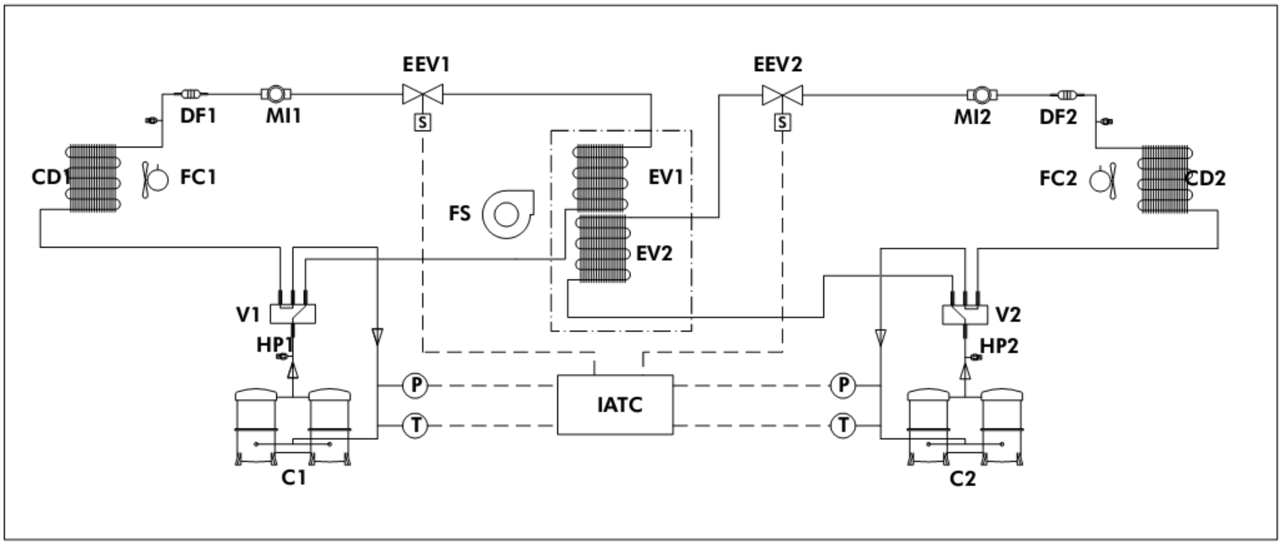
In contrast to the classic rooftop system, the high-tech system, which uses R-410A offers an environmentally superior product. While the initial cost of such a system is higher, running costs are lower compared to the classic R-22 rooftop system. This system has been developed taking into account existing and future energy and environmental requirements. An eco-friendly project was developed to reach an ambitious goal: improve the unit efficiency in order to cope with the new European Building Performance Directive (EPBD) and move to a high quality and high profile product.

1.1 Improved casing to reduce environmental impact

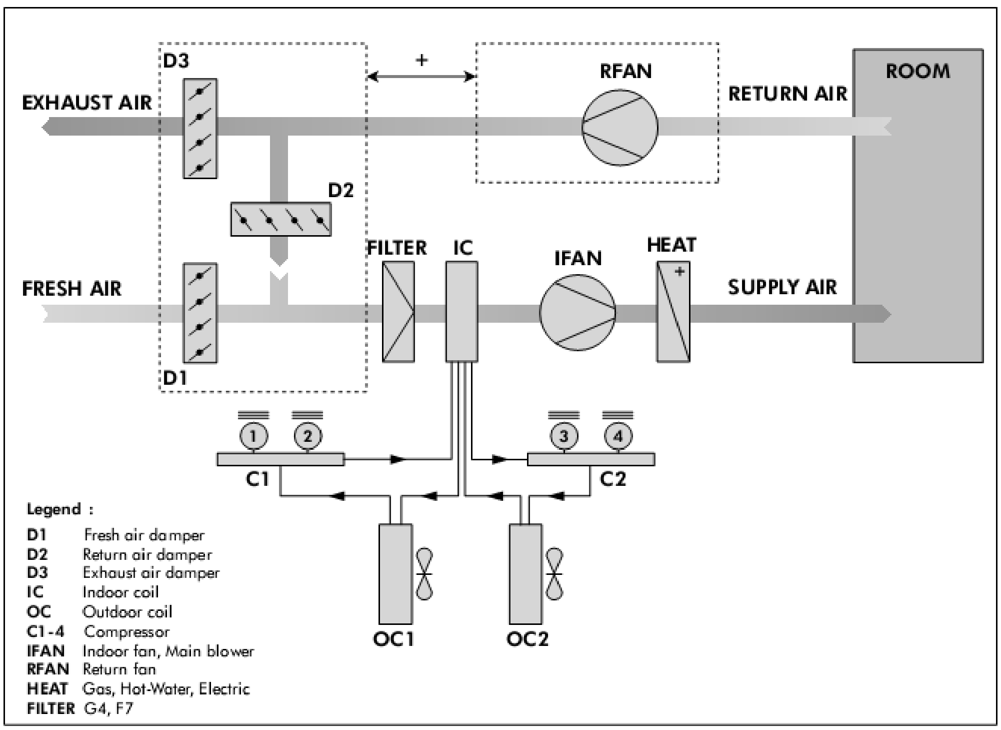
- Double skin 50 mm to improve energy loss and acoustics
- Door with progressive lock to minimise air leakage and avoid thermal bridge
- Packaged unit ready to start
- Plug and play concept

1.2 Improved refrigerant piping and seasonal efficiency

- Minimised the brazing connections and number of components to reduce risk of leakage with bi flow component, expansion valve, filter (reducing by 2 or more). It provides a very simple liquid line without non active components.



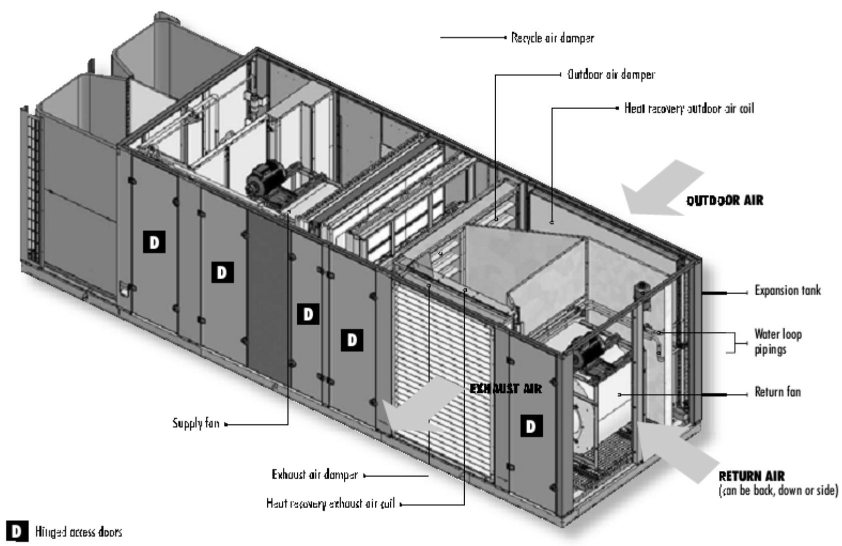
C1	*Compressor 1*	**FC1**	*Propellar fan 1*	**DF1**	*Filter-drier 1*	**MI2**	*Moisture indicator 2*
C2	*Compressor 2*	**FC2**	*Propellar fan 2*	**DF2**	*Filter-drier 2*	**EEV1**	*Electronic expansion valve 1*
CD1	*Condenser 1*	**FS**	*Centrifugal fan*	**B1**	*Liquid tank 1*	**EEV2**	*Electronic expansion valve 2*
CD2	*Condenser 2*	**HP1**	*Condensing pressure tap 1*	**B2**	*Liquid tank 2*	**V1**	*4-way valve 1 (heat pump version only)*
EV1	*Evaporator 1*	**HP2**	*Condensing pressure tap 2*	**MI1**	*Moisture indicator 1*	**V2**	*4-way valve 2 (heat pump version only)*
EV2	*Evaporator 2*						



- Electronic expansion valve to better control the superheat and reduce compressor power consumption
- Tandem compressor with bi-circuit to improve SEER at part load
- Technical compartment to ease service and facilitate leak detection

  - Recovering the energy of the exhaust to save up to 30% of energy in winter

Unit with 3-damper economizer (optional) and heat recovery by run around coils (optional)



3. BRINGING THE ALTERNATIVE TO MARKET

The limited number of suppliers for some of the components needed to manufacture the high-tech rooftop unit (e.g., micro channel, EC fans) is a barrier in terms of capacity and costs.

In addition, effort is needed to train all the players along the supply chain, namely:

- Internal sales forces
- Final customer
- Prescription for design office
- Installer
- Maintenance

Moving from a product to an optimised system within the building means proposing a product/price to promote a technically efficient solution over the time. This will require a total change of philosophy because the running cost must be a key criterion in selecting a system. Currently, product installers look only at the initial cost and do not consider the cost savings realized during the life cycle of the product. In order for the total life cycle analysis to become a basis for product selection, the end user (customer) must to be involved at the outset of the project, which is not the case today.

Focusing on maintenance cost with progressive performance improvements should itself become an objective. This conceptual approach would have a strong impact on the unit design, for example:

- Filter clogging should be monitored to avoid excessive motor consumption and inform service people
- Controller board should integrate the behaviour of the machine within the building and should be capable of upgrading the software for continuously improving the comfort and energy performance

- Energy utility management should take into account the energy cost and potential of the equipment by unloading the compressor or analysing the unoccupied period by using indoor air quality (IAQ) sensors.
- Easy and safe access to any component
- Building Management Systems (BMS) represent a technology solution enabling the optimum unit behaviour as long as the operator has some expertise in thermodynamic know-how. Unfortunately today, most of the BMS are used for ON/OFF scheduling and diagnostic, not for the purpose of optimum system management

CONCLUSIONS

Today, the market is not ready for a large-scale implementation of high-tier products.
To be successful, there needs to be concomitant awareness and pressure from many directions, including regulators, building operators/owners, installers, and service providers. For example, building operators and owners must have the technical knowledge to recognise the importance and environmental improvement of new rooftop systems and integrated building systems. This can be accelerated with national incentives or commissioning inspection witch are rare today.