

Performance of Variable Refrigerant Flow (VRF) Systems

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SYLVAIN COURTEY
Head of Ventilation Department
Eurovent Certita Certification
s.courtesy@eurovent-certification.com

Summary

After two years of the work of the Launching Committee for the Eurovent certification programme for Variable Refrigerant Flow (VRF) systems, the Operational Manual and Rating standards for VRF have been validated in May 2013. This certification programme concerns air cooled and water cooled outdoor units cooling only, heating only and reversible.

The tests will be based on the European standard EN 14511 which has been recently updated in order to take into account systems with multiple indoor units. The tests will be performed in European accredited and independent laboratories.

The following performances will be certified:

- Cooling and heating capacities
- Efficiencies in cooling and heating (EER and COP resp.)
- A-weighted global sound power levels

Introduction

The Eurovent Certified Performance mark exists since 1994. From the beginning the Eurovent certified Performance mark for air conditioners has been one the flagship certification programmes. This scheme covers all air cooled and water cooled air conditioners up to 100 kW. It can be estimated that Eurovent certified air conditioners covers more than 80% of the European market. For many years it is well recognized on the European market but also in the Middle East and in Asia.

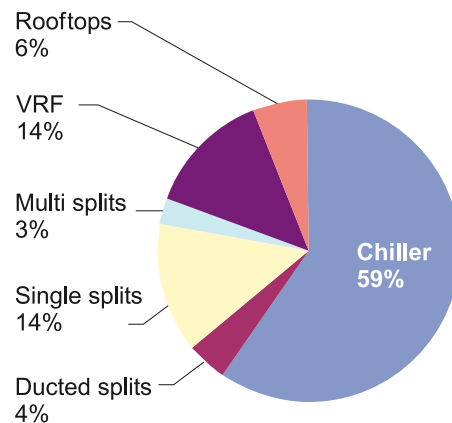


Figure 1. Estimated market share of cooling systems in Europe in 2008 (Final report of Task 2 – Air Conditioning products July 2012).

In 2007 a dedicated certification programme for Rooftop units has been created in order to differentiate this type of direct expansion cooling system from the other package, split and multisplit units.

Until recently VRF systems were the only type of direct expansion cooling systems not covered by a dedicated certification programme. As one can see in the below chart, VRF systems represent a significant market share among cooling systems in Europe.

Moreover, if we look at the evolution of the market for VRF systems in Europe, it can be seen that this market segment had the highest growth during the last decade among cooling systems and has the highest potential for the following decade (see **Figure 2**).

As a result the need for a certification programme for VRF systems was critical, that is why a Eurovent Launching Committee was set up in 2011 in order to work on the preparation of a certification programme for such systems.

Definition of VRF systems

Variable Refrigerant Flow (VRF) systems are direct expansion multi-split cooling and/or heating systems. It can integrate a large number of indoor units (up to several dozens), each indoor unit having its own regulation system. Outdoor units are typically combinations of single modules that can be connected with each other in order to increase the capacity of the system. These types of systems include in general variable speed compressors. As for classical multi-split systems, VRF systems can be air cooled or water cooled, cooling only, heating only or reversible and can be able to generate simultaneously heating and cooling.

The typical characteristics of such systems are as follows:

- Refrigerant: R410A
- Scroll compressor
- Electronic expansion valve
- Indoor heat exchanger: coil with tubes and fins with different types of fans
- Outdoor heat exchanger: coil with tubes and fins with axial or centrifugal fans for air cooled systems and plate heat exchangers for water cooled systems.

Cooling capacities of VRF systems lie in general between 10 and 56 kW (4 to 20 HP) for single modules whereas complete systems can have capacities up to 150 kW.

Distribution of VRF outdoor units
ETPL database of UK's ECA (2010)

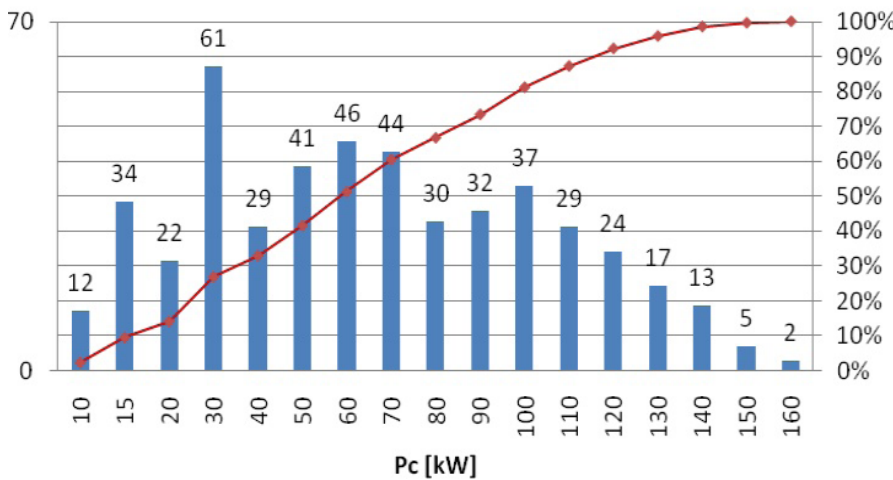


Figure 3. Distribution of capacities of VRF outdoor units (Final report of Task 2 – Air Conditioning products July 2012).

Estimated stock of central air conditioning products (cooling capacity)

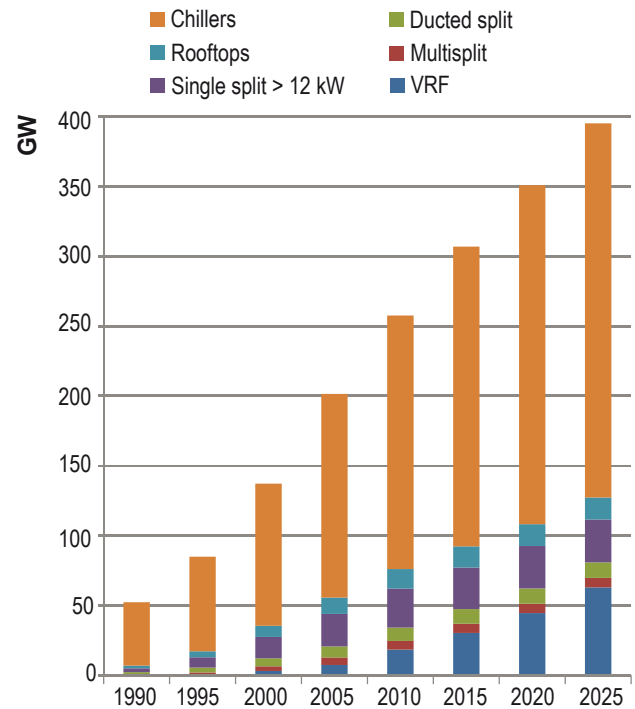


Figure 2. Evolution of market shares of the different cooling systems in Europe (Final report of Task 2 – Air Conditioning products July 2012).

Cooling capacities of indoor units lie in general between 2 and 7 kW. This means that typical systems can include up to 50 indoor units connected.

Eurovent Certification programme for VRF systems

Scope

The scope of the programme covers all single modules and combinations of modules with the following characteristics:

- air cooled or water cooled
- with cooling or heating capacities up to 50 kW (18 HP)
- for systems with cooling capacities higher than 50 kW the certification is possible as an option. In this case tests are performed in manufacturer's laboratory by independent and accredited test agencies

Certified Performances

The following performances are certified:

- Cooling capacity of the outdoor unit at standard condition (kW)
- Heating capacity of the outdoor unit at standard conditions (kW)
- Energy efficiency of the outdoor unit in cooling mode (EER) at standard conditions (kW/kW)
- Energy efficiency of the outdoor unit in heating mode (COP) at standard conditions (kW/kW)
- A-weighted global sound power level (dB(A))

Tolerances

The tolerances for the different certified performances are given in **Table 1**.

Testing requirements

Tests are performed with 2 to 4 indoor units (ducted or cassette). The connection ratio shall be 100% +/-5%.

Thermal tests are performed according to the European standard EN 14511-3. In particular the Appendix I of this standard defines the method for multi split units with a large number of indoor units. Indeed, for such systems it is impossible to assess the performance of every possible combination of outdoor and indoor units as the number of combinations is potentially infinite. Therefore the standard defines a method to assess the performance of the outdoor unit only as it is presented in the catalogue of all VRF manufacturers.

The following requirements shall be met during the tests:

- Electrical consumption of each indoor units shall not exceed 110% of the declared nominal consumption
- For ducted units the airflow rate of each ducted unit shall not exceed 110% of the declared nominal airflow.
- The length of the refrigerant piping shall be between 5 and 7.5 m, however the length can be higher if the installation of the system requires it.
- The testing method can be the calorimeter method (for units with capacity up to 20 kW) or the enthalpy method (from 20 to 50 kW).

Acoustical tests are performed according to the European standard EN 12102:2013 with the same conditions as for the thermal tests. The tests can be performed in reverberant chambers or in anechoic chambers.

The testing conditions according to EN 14511-3:2013 are given in **tables 2 and 3**.

Table 1. Tolerances of the certified performances.

	2013-2014	2015
Cooling and heating capacities	-8%	-5%
Energy efficiency EER and COP	-10%	-8%
A-weighted global sound power levels	+2 dB(A)	0 dB(A)

Table 2. Testing conditions for air to air VRF systems.

Air / Air	Outdoor unit		Indoor unit	
	Dry Temp	Wet Temp	Dry Temp	Wet Temp
Cooling mode	35°C	24°C	27°C	19°C
Heating mode	7°C	6°C	20°C	15°C max
Acoustic tests	35°C	-	27°C	19°C

Table 3. Testing conditions for water to air VRF systems.

Water / Air	Outdoor unit		Indoor unit	
	Dry Temp	Wet Temp	Dry Temp	Wet Temp
Cooling mode	30°C	35°C	27°C	19°C
Heating mode	10°C	7°C	20°C	15°C max
Acoustic tests	30°C	35°C	27°C	19°C

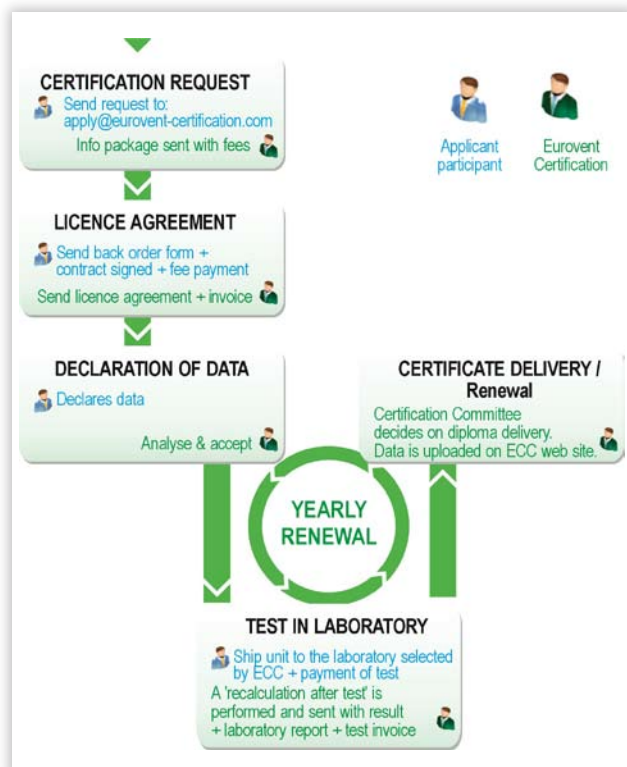


Figure 4. Illustration of the certification process.

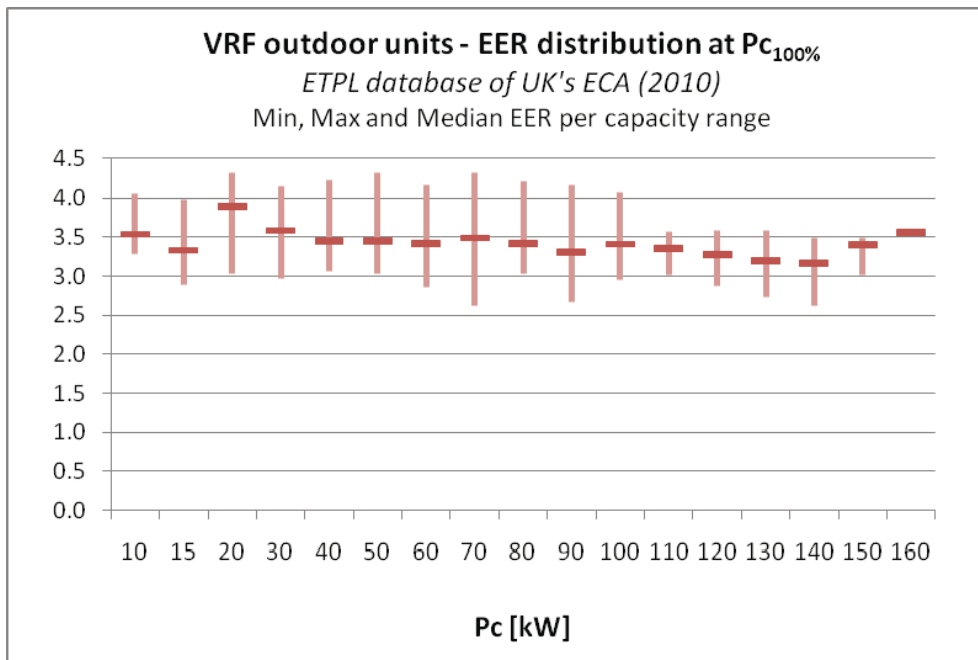


Figure 5. Distribution of efficiencies of VRF outdoor units according to the cooling capacity (Final report of Task 4 – Air Conditioning products July 2012).

Certification process

Eurovent Certification programmes are based on continuous monitoring of manufacturers production. For the VRF certification programme, each year 8% of the certified outdoor units are tested in an independent and accredited laboratory. If the performances of the tests are not according to the claimed performances within the above defined tolerances the performances of the manufacturer are rerated according to the measured values.

Future steps of the certification programme for VRF systems

End of 2013

The first VRF certified manufacturers will be published on the Eurovent certified Performance website (www.eurovent-certification.com) and on the Certiflash website (www.certiflash.com).

2014-2015

The scope will be extended to outdoor units with capacity higher than 50 kW thanks to tests performed in manufacturer's laboratories by independent and accredited test agencies.

As it can be seen in the charts below the efficiencies of systems composed of combinations of single outdoor modules (>50 kW) are similar to the efficiencies of systems with single outdoor modules (<50 kW). Therefore the certification of the performances of single modules (up to 50 kW) provides already a quite good understanding of the performances of all combinations. However the certification of combinations with cooling capacity higher than 50 kW will bring more transparency to the market.

2017

An Eco-design regulation on air conditioning systems will be published in the following months by the European Commission and will come into force likely by the 1st of January 2017. This regulation will cover all types of air conditioning systems including VRF. The regulation will define Eco-design requirements and in particular minimum efficiency requirements. These minimum efficiencies will be based on seasonal efficiency which takes into account of the difference of efficiency of such system according to outdoor conditions (see **Figure 6**).

Taking into account the seasonal efficiency of VRF systems will allow to get efficiency data closer to the reality than efficiency at standard conditions. Nevertheless it can be seen from **Figure 7** that efficiency at standard conditions are still a good parameter for comparing VRF systems with each other as the efficiency at standard condition EER is highly correlated with the seasonal efficiency.

The Eurovent Certification programme for VRF systems will take into account the seasonal efficiency as soon as it will be implemented in the European regulation.

Conclusion

The Eurovent certification programme for Variable Refrigerant Flow (VRF) systems is now available. The setting up of this programme required to update the European standard dedicated to this type of products. As for other Eurovent certification programmes this scheme is based on real units testing in independent and accredited European laboratories. The certification

Base-case VRF system - Outdoor unit
Cooling mode : part-load performance curve

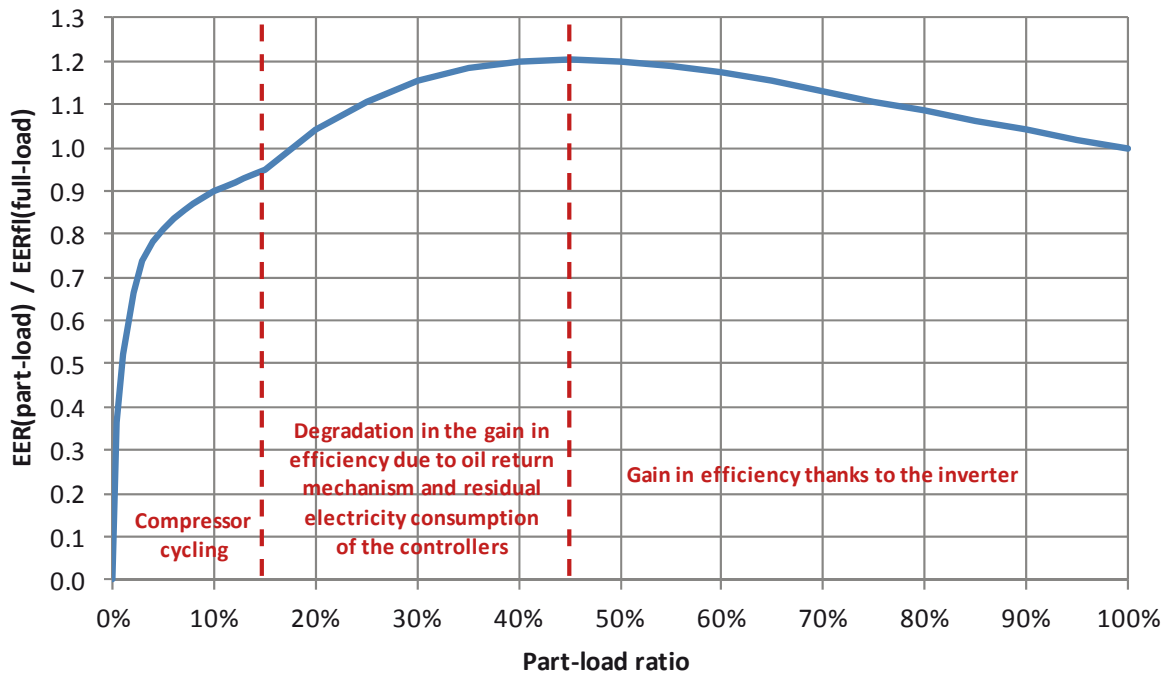


Figure 6. Estimation of the cooling efficiency of VRF system at different part-load conditions (Final report of Task 4 – Air Conditioning products July 2012).

VRF systems: IEER vs. EER
- database of the AHRI certification program
- evaluation of the improvement design options

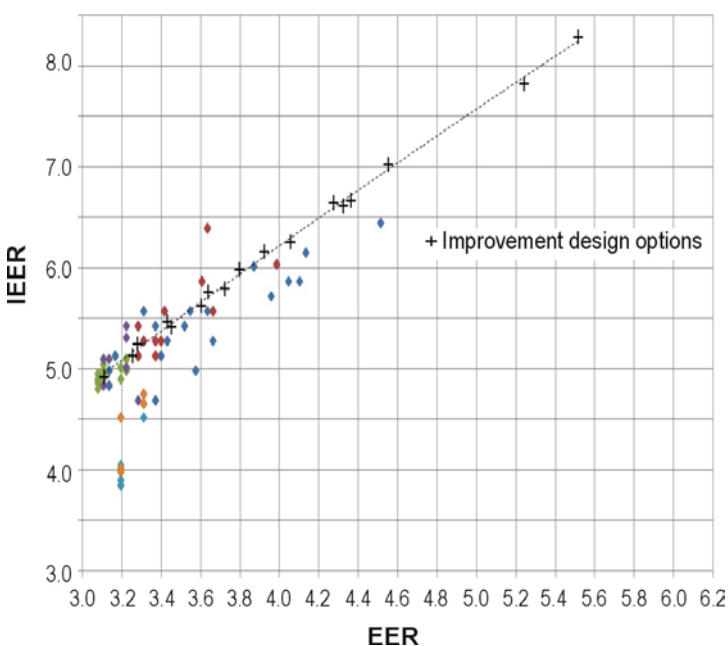


Figure 7. Correlation between efficiency at standard conditions EER and seasonal efficiency (Final report of Task 6 – Air Conditioning products July 2012).

process is based on continuous monitoring of manufacturers production with yearly selections and testing campaigns.

By setting up this certification programme the Eurovent Certified Performance mark covers now all main types of cooling systems from packaged, split and multi-split air conditioners to rooftops and chillers. The Eurovent Certified Performance mark thus allows the European air conditioning industry to level up the playing field and to ensure to the end users real performance data based on proven certification processes. ■

Acknowledgements

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