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The REHVA European HVAC Journal

Special issue for ACREX India 2014 exhibition

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History and future of refrigerants


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Increasing need for reliable performance data of HVAC products

OLLI SEPPÄNEN
Professor
Editor-in-chief

Energy efficiency is at the heart of the European Union's 2020 Strategy for smart, sustainable and inclusive growth and of the transition to a resource efficient economy. Improved energy efficiency is one of the most cost effective ways to enhance the security of energy supply, and to reduce emissions of greenhouse gases. In many ways, energy efficiency can be seen as Europe's biggest energy resource. This is why the Union has set itself a target for 2020 to save 20% of its primary energy consumption.

More than 40% of the EU's primary energy is used for buildings. Approximately 2/3 of this is used in residential buildings, and 1/3 in commercial (tertiary) buildings. The share of energy use for heating and ventilation in the energy used for buildings is roughly two thirds. The European Commission has estimated that energy use of buildings can be reduced by approximately 30% in buildings using cost efficient measures.

Substantial steps have been taken towards this objective. Directives and regulations to improve the performance of products for cooling and ventilation of building are an essential part of the EU's activities in this area. Eco-design regulations for energy related products, regulations for energy performance of buildings and the requirements for nearly zero energy buildings by 2020 are examples of the strong commitment to reduce energy consumption of buildings and GHG emissions.

All actors in the value chain, from building designer to building operator and building owner, are looking at a common goal: better performing buildings and systems. Good performance of systems is based on good and reliable products. Building products and systems need to be characterized with increasing quantity of performance data. The energy saving quest for the designer and the engineer is about the need to find, manage and analyse a huge quantity of performance data to deliver better project performance within the given short timeframe.

The building industry and product suppliers need to operate in a very rapidly changing environment. Product complexity is going up, but a new product and a new concept need to be properly characterized technically. The amount of technical data needed to describe material or product performance according to a new set of rules or conditions is increasing manifold. A large choice of design, materials, components and equipment being part of the ultimate solution, the quantity of alternative product and performance data to design has increased tenfold due to this wide and rich market offering. Also, modern building performance simulation programmes need accurate performance data not only in design conditions but also in changing conditions with varying load.

The main focus of this issue of the REHVA Journal is on energy efficiency of air conditioning products, particularly how certified performance data can support high performance buildings. The contents will give some information on European activities in the improvement of energy efficiency, including information on commonly used voluntary product performance certification programmes and some background information on performance testing. ■

The importance of the seasonal performance in addition to the peak load efficiency

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Keywords: chiller, chiller performance, part load efficiency, seasonal efficiency, EER, SEER

Summary

The development of labels and minimum energy performance standards for air conditioners/chillers /heat pumps since the years 1970's was first based on the efficiency at standard rating conditions. This led to an energy efficiency competition between manufacturers based on full capacity and for temperature design conditions.

Initiated in the USA, seasonal performance standards for these products have been developed for air conditioners and chillers. These standards enable to compare the products on a figure of merit that should be closer to the real life performance than standard rating efficiency. From the USA, these standards have then spread all around the globe. They have now become the reference in Europe for manufacturers, customers and for legislators.

This article depicts the recent developments in this field in the last years in Europe. The main specificities of these seasonal performance standards are described as well as the differences with their counterparts in the USA. Further information required to improve efficiency of these products for specific sites and projects is described. Eventually, the impact of that electric equipment on the electric grid is discussed, which shows how ratings under design conditions can be complementary to seasonal performance indices.

Introduction

Cooling equipment operate typically less than 1% of the time at maximum capacity. Standard ratings at full capacity and design temperature conditions mainly help in sizing the equipment: they give the rated cooling capacity that will be available in extreme conditions (above 35°C in cooling mode for air cooled air conditioners / chillers). However, cooling may occur at much lower temperature, starting from 0°C or less for highly glazed high-rise commercial buildings or above 15 or 25°C only for dwellings depending on the building characteristics and of the country and people habits. For these reasons, the performance under peak load is generally not representative of the cooling equipment performance over a season. The same rationale applies to the heating mode.

Seasonal performance indices allow the effects on performance of temperature variations and of cooling/heating load variations to be taken into account in a single figure of merit. For this reason, they give a better indication of the real efficiency of the products in the field than do EER and COP figures at full load under rated conditions. These metrics enhance the comparison of the energy performances of different products by taking more variables into account. They consequently help in designing products that are not only efficient for standard rating conditions but in average over a season. **Figure 1** shows the comparison of the EER and ESEER (Eurovent seasonal energy efficiency ratio, see below more explanations on the ESEER) for water cooled chillers. The seasonal performance indicator clearly highlights the excellent part load performance of centrifugal chillers equipped with magnetic bearings, whereas their performance under standard rating conditions is not outstanding.

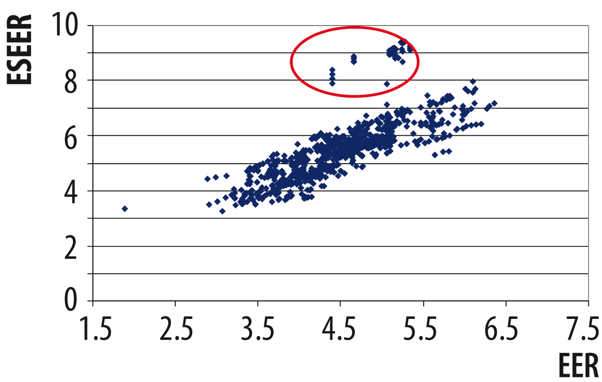

Figure 1. EER and ESEER for water cooled chillers, Eurovent data 2010, source [1]

Seasonal performance metrics developments

The USA has been the leaders in the adoption of seasonal energy efficiency indices. Seasonal performance test standards were first introduced in the USA in the late 70's at the time of the oil crisis, for central air conditioners, and then for chillers in the 80's. Korea and Japan followed for air conditioners, and China has also been adopting seasonal performance standards during last years.

In Europe, the first seasonal metrics was adopted between 2004 and 2006 by Eurovent Certification for chillers. This metrics is based on the IPLV, the metrics in use for chillers in the USA. It consists of weighting the efficiency at four points along an outdoor temperature / load curve by the respective energy weight of these four points over a season. Eurovent took part in a European project [2], in which an average load curve, four points and weighting coefficients were derived. The metrics is still in use and is named ESEER, acronym standing for European Seasonal Energy Efficiency Ratio.

Between 2006 and 2009, the Lot 10 preparatory study [3] worked jointly with the industry to develop a European seasonal performance index for air conditioners (below 12 kW) in cooling and in heating mode. To properly take into account the electric backup in heating mode, it was decided to adopt the same approach as in the USA standard AHRI 210/240 [4], which is based on a bin method and so is a different approach than for the chillers' ESEER.

In the meanwhile, legislative proposals were being discussed for boilers on a functional basis [5]: the goal was to rate all heating means (which all share the same heating function) with the same metrics, independently of the technology (boiler or heat pump) or fuel type (fuel, gas or electricity). Both preparatory studies were asked by the stakeholders to end up with a single metrics comparable for all heating means. This metrics is now used in the legislation [6] and is known as the seasonal space heating energy efficiency. Fossil fuels and electricity energy input are made comparable thanks to the introduction of a primary energy ratio of 2.5. For air conditioners (below 12 kW) and water based heat pumps (all sizes), seasonal metrics in final energy, are now defined in the EN14825 standard [7], and are known as SEER (cooling mode) and SCOP (heating mode).

Between 2009 and 2012, the ENTR lot 6 Ecodesign preparatory study [1] defined seasonal performance indices for air conditioners / air based heat pumps above 12 kW and for chillers. As opposed to what happened in the USA (there are two different metrics for air conditioners and for chillers), manufacturers decided to adopt the same shape in the seasonal metrics for all product types. The same primary energy ratio of 2.5 enables to rate electric, heat and fuel driven air conditioners / chillers on a single common scale.

More recently in 2013, a seasonal performance metrics was also defined for refrigeration and process chillers, with an ad-hoc load curve for all year operation and much larger loads at lower ambient than for air conditioning conditions [8].

Structure and parameters of the different seasonal performance indices

Two main types of seasonal performance metrics have been used, there are respectively based on the bin method and on the IPLV (integrated Part Load Value) method.

For IPLV type indices (method used to compute the IPLV for chillers in the USA and the ESEER for chillers in Europe), a typical load curve is defined. It is a relationship between outdoor temperature and the building load. It is then reduced to four points, e.g. in the case of the ESEER, (100%, 35°C), (75%, 30°C), (50%, 25°C) and (25%, 20°C). Four weighting coefficients are computed (A, B, C and D), which represent the energy weight of each of these points over a year. A test and calculation procedure enables to compute the EER for these four points, which are then weighted to derive the seasonal metrics as follows:

$$\text{ESEER or IPLV} = A \times EER_A + B \times EER_B + C \times EER_C + D \times EER_D.$$

The second approach is based on a bin method. A typical meteorological year is binned to derive a distribution of hours for each outdoor temperature, typically with bins of a 1°C length. A typical load curve is then defined and the product is sized for design conditions (e.g. 100% capacity at 35°C outdoor for air cooled equipment). The next step is to compute the efficiency of the equipment for each outdoor temperature. There, several methods exist that demand more or less testing points/modelling hypothesis regarding the performance behaviour of the product when outdoor temperature and load varies. In the case of the EN14825 test standard [7], four points are evenly distributed along the load curve (100%, 75%, 50%, 25%). The outdoor temperature for these points is defined by the load curve. Tests are defined to compute the efficiency for these four points depending on each control technology (cycling, multi-stage, continuous capacity variation). Efficiency between these points is interpolated. Additional hypothesis enable to compute efficiency below 25% and above 100%. Then, the SEER (seasonal efficiency ratio) and the SCOP (seasonal coefficient of performance) can be computed by integration on the whole temperature distribution.

Several climates are now considered in the EN14825 standard. The legislation bases upon Strasbourg as the average climate, which is close to the average EU climate. Strasbourg is used for heating and also for process refrigeration / air conditioning operating all year long [8]. In cooling mode, a weighted average climate has been derived. Athens and Helsinki climates are proposed on a voluntary basis to give a better indication over Europe of the seasonal performance for heat pumps and larger cooling products.

As compared to its US counterparts, several refinements have been introduced in the European seasonal performance standard [7]:

– Seasonal performance standards are not only used for performance ratings but also to compute the energy consumption of the products in order to assess the life cycle cost of products to build minimum performance standards for the EU market. Hence, the number of full load equivalent hours has been evaluated on a realistic number of hours of use of the installations and a full load equivalent hours per year is proposed together with each load curve. In the US standard, all hours of the year are used to compute the equivalent full load hours, leading to very high energy consumption figures [4]. This may be justified (or corrected afterwards) in the case of a central air conditioner, operating 24 hours a day all year long but is not justified in Europe.

– Not only cooling and heating is accounted for but also low power modes; for each load curve, typical hours of operation have been defined for "thermostat off" periods (hours when the unit is on but there is no cooling / heating load), "standby or off mode" hours (to include the contribution of standby and off mode power to the consumption of the product) and to evaluate the consumption of the "crankcase heater", if any. One of the reasons behind is linked to study that showed that these low power mode consumptions could be very high on a yearly basis [3]. The other reason is that air conditioners escaped the standby/off mode European Directive [9]. Indeed, manufacturers argued that the global optimization of a seasonal metrics could be less expensive that separate standby requirements.

– Last but not least, the European standard includes the impact of heat exchangers' pressure drops on the efficiency of the products. This is a very important aspect of chiller performance comparisons: whether it is not considered, it may be possible to increase the chiller performance but that the system including the chiller and the circulators may be less efficient because of higher circulators' consumption. For a long time, European chiller manufacturers were reluctant to include the impact of the pressure losses on the performance of their products because of the competition with the USA products for foreign markets, and this compensation was not included. Since 2013, new Eurovent ratings for chillers do include the supplementary electricity consumption required to cope with the condenser and evaporator pressure losses and the corresponding cooling capacity loss. Although the impact was small at full load, this compensation makes a huge difference under part load conditions and then on the seasonal performance. An example is given in **Figure 2**: typical pressure drops for a 1000 kW water cooled chillers (a base case chiller of average efficiency is considered – noted BC – as well as improved products – noted I1, I2 …) are used to compute the difference of SEER when accounting (net value) the inclusion of pressure losses. The SEER difference varies from about 9 to 15%. Note that this impact could be much higher for a specific chiller, given the pressure drop distribution shown in **Table 1 and Figure 2**.

Seasonal performance indicators and energy consumption at site

The default load/temperature profiles used in the standards never match with specific site load curves: a standard seasonal figure can only give a rough estimate of the energy consumption of a product for a specific installation, and for specific site lead to very different results. This is especially the case when several chillers are used in cascade. In that case indeed, the base load chiller may operate all the year close to the full load and the peak chiller at low loads. What is required here consists in performance maps giving the efficiency variations for at least outdoor temperature / different capacity ratio. An example of such a map has been proposed in the ENTR Lot 6 Ecodesign preparatory study [1].

However, the data required to perform efficiency calculations for a given site is not easily accessible. In general, this data is only given by manufacturers to engineering study for a specific project. This makes it very difficult to compare the merit of different chillers and/or chiller combinations in real life. This is probably an important axis for progress in the coming years in Europe. It will be

Table 1. Impact of pressure losses' compensation, following EN14825 standard, on the SEER of large water cooled chillers of varied performance. [1]

Reference water pressure drops	
Heat exchanger	**Pressure drop**
Evaporator	45 kPa
Condenser	35 kPa

SEER calculation results		
Product	**$SEER_{net}$**	**$SEER_{gross}$**
BC	5.06	5.51
I1	5.85	6.45
I2	6.45	7.18
I3	6.90	7.77
I4	6.64	7.41
I5	6.97	7.82
I6	7.71	8.77
I7	8.01	9.16

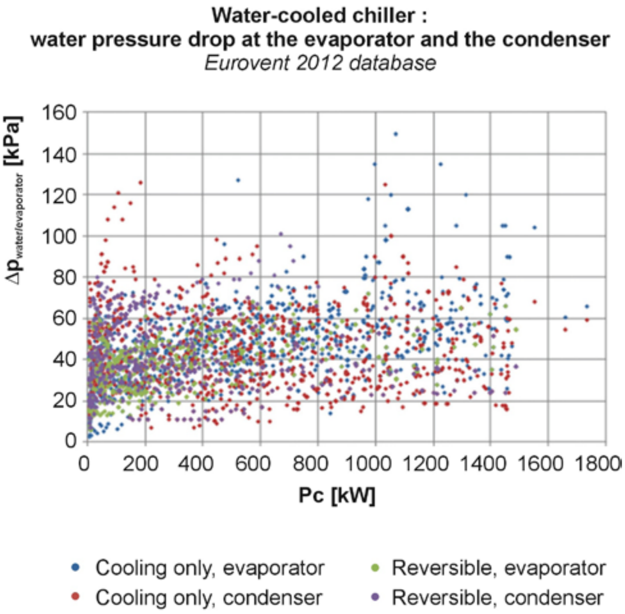

Figure 2. Pressure losses of water cooled package chillers in Eurovent catalogue, 2012 data. [1]

necessary to define a common standard to exchange this data, which hopefully could be made compatible with recognized building simulation tools and future BIM (Building Information Modelling) formats. The main issue however to be solved will be for manufacturers to guarantee the accuracy of this large data set.

Seasonal performance indices, « instead of » or « in addition to » standard rating performance ?

Cooling / heating capacity of air conditioners / chillers / heat pumps vary with source temperatures. Standard rating conditions are then necessary to define the capacity of the products. For this reason, in cooling mode, the standard rating condition (35°C outdoors for air cooled equipment) remains an important reference as it gives unequivocal operating conditions to define a reference cooling capacity. In real life however, the design cooling conditions will vary from site to site. This means full load performances need to be known for varied temperature conditions at full capacity (for both evaporator and condenser sides) in order a proper sizing can be performed for a specific location.

In addition, efficiency under design conditions also matters when the electricity consumption of heating / cooling products pumps electricity from the grid at peak power time, which would be summer time for cooling products and winter time for heating products. In these conditions, power plants need to be added to answer specifically the cooling/heating needs, and the local electricity grid may need to be reinforced to cope with the grid overload. The order of magnitude of this externality is typically comparable to the manufacturer selling price of chillers per kW cooling [1]. Whether this is not properly addressed, the likely consequence is that the average electricity price will increase for all end-users to compensate the investments required.

In economies that are summer peaking as California, minimum SEER for air conditioners are completed with minimum full load EERs, in order to limit the impact of the air conditioners on the electric grid. In addition, several economies have requirements both at full and part load for air conditioners (in cooling and in heating mode) and for chillers.

However, the impact of these thermo sensitive electric end uses is presently limited at the scale of the EU inter-connected electric grid. In general, electric load can be balanced between Northern and Southern countries for the various seasons and the development of the solar photovoltaic panels helps mitigating the impact of growing air conditioning loads in the summer. The potential issues are mainly for countries with limited interconnections or specific end uses patterns. For instance, cooling contributes importantly to the summer peak in Southern countries (as Spain or Italy) and was made partly responsible of black-out situations in the past. In cold weeks of the winter period, electric heating (including electric heat pump) participates importantly in the winter peak in Central and Northern Europe. However, most of the thermo sensitivity is due to electric heating and is mainly a French issue, because of the large penetration of electric radiators in dwellings.

Further penetration of electric cooling and heating equipment may however increase their impact on the EU electric grid. It may become necessary in the future to increase the efficiency of those products not only on a seasonal basis, but also at design conditions. If a methodology to constrain the product efficiency at design conditions is not yet available in Europe, examples abroad could serve as a reference. For instance, a methodology has been developed in California [9], which could be used to integrate the grid overcosts in the product life cycle cost analysis and to establish simultaneously energy efficiency requirements on a seasonal basis and on an EER basis. Alternatively, the introduction of electricity tariffs varying in time to reflect the evolution of the generation cost during the day and along the year could also enable to lead such product optimizations.

Conclusion

Most heating/cooling product energy efficiency metrics have been converted to seasonal indicators. This is likely to give efficiency figures closer to real life performances thanks to the introduction of outdoor temperature and building load variations in the energy efficiency calculation. This enables product design to optimize their products for profiles of use closer to real life usage.

However, the gains for the end-user / customer could be higher if, for a specific site / project, engineering design office could compare the performances of heating / cooling products for the specific load / temperature curve. This is not yet possible as information regarding the mapping of efficiency when product capacity and source temperatures vary cannot be easily accessed at design stage for all the products to be compared.

It may happen in the future that standard rating performance indices are used in addition to seasonal performance metrics. Indeed, if electric vapour compression cooling and heating products penetration continues growing, it may become necessary to require both seasonal and peak load requirements on products in order to limit the impact of these thermo sensitive products on the electric grid. ■

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Requirements for Seasonal Efficiency for Air-conditioning Units

Performance of air-conditioners used to be compared at a fixed condition. However, this condition does not represent the usual operating conditions of the equipment over a season, which becomes especially important for the calculation of the energy efficiency. Seasonal performance first appeared in Eurovent Certification programme for chillers in 2006. The European Commission defined a seasonal efficiency for residential Air Conditioners applicable since 1st January 2013; consequently Eurovent Certita Certification has updated its programme in accordance with this regulation.

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Keywords: air conditioning, seasonal efficiency, certification, SCOP, SEER, Eurovent Certita Certification, energy label

Launched in 1994, the Air Conditioners certification programme was the first programme of Eurovent Certita Certification (ex Eurovent Certification Company).

After almost 20 years it is well recognized on the market as well as the mandatory energy efficiency labelling for air conditioners below 12 kW since 2003.

Scope of the programme

Air Conditioners certification programme concerns comfort units, air-to-air and water-to-air below 100 kW (nominal capacity in cooling mode). It also applies to units intended for both cooling and heating by reversing the cycle. Concerning multi-split air conditioners, only systems with two indoor units are included.

Process of Certification

The purpose of all Eurovent Certita Certification Certification Programmes is to encourage honest competition and to assure customers that equipment is correctly rated on the market. The purpose is achieved by verifying the accuracy of ratings claimed by manufacturers by continuing testing of production models, randomly selected, in independent laboratories.

One particularity of Air Conditioners programme is to apply the "**Certify-all**" principle, meaning:

All products of the relevant certification programme manufactured or sold by a Participant inside the defined scope must be certified. When applicable, "Certify-all" principle means at least "all products inside the defined scope presented, at least, on the European market".

"Certify-all" brings clarity and transparency and therefore increases the value of the whole system.

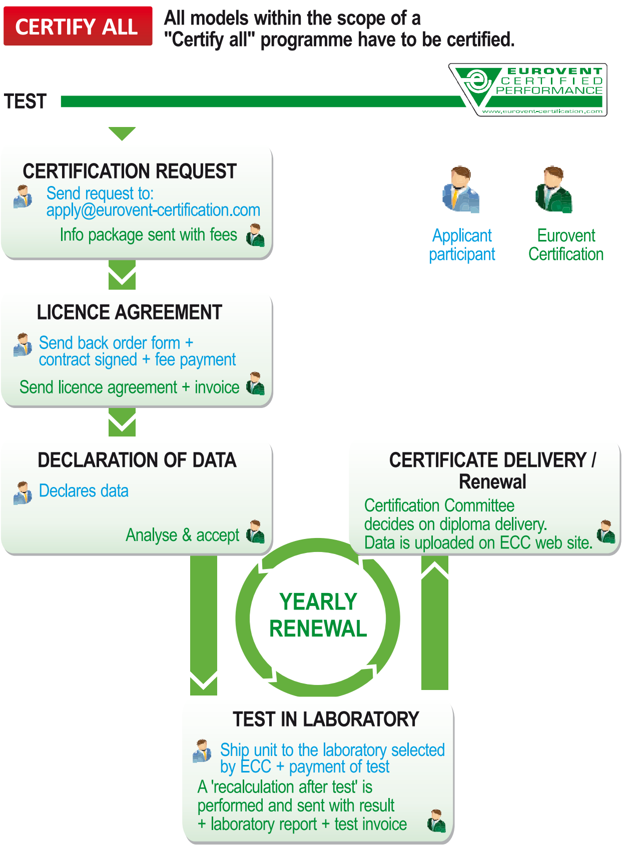

Figure 1. Steps in the certification process of the product performance.

Table 1. Requirements of minimum energy efficiency of air condition units with cooling capacity under 12 kW in the European market according to the EC regulation (see the definitions of abbreviations in the article by Sandrine Marinhas in this issue).

	Air conditioners, except double and single duct air conditioners SEER	SCOP (Average climate)
If GWP of refrigerant > 150 for < 6 kW	4,6	3,8
If GWP of refrigerant ≤ 150 for < 6 kW	4,14	3,42
If GWP of refrigerant > 150 for 6–12 kW	4,3	3,8
If GWP of refrigerant ≤ 150 for 6–12kW	3,87	3,42

GWP = Global Warming Potential

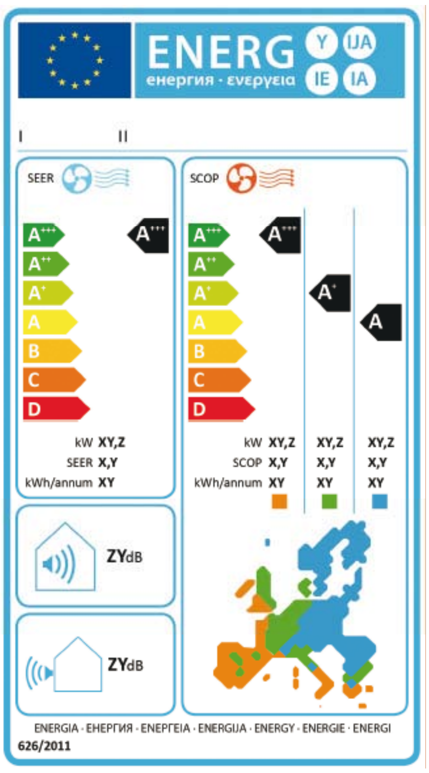

Figure 2. The model of the required energy label for all air conditioning unit in the European market from the beginning of 2013.

The certified performances depend on the product (below or above 12 kW) and the applicable EU Directives.

Directive Requirements for Air Conditioners below 12 kW

Commission Regulation (EU) No 206/2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to EcoDesign requirements for air conditioners and comfort fans gives requirements for all air conditioners with the cooling capacity under 12 kW (AC1) introduced on the European market after the 1st January 2013.

Table 2. Energy Classification for Conditioners except double ducts and single ducts.

Energy Efficiency Class	SEER	SCOP
A+++	SEER ≥ 8.50	SCOP ≥ 5.10
A++	6.10 ≤ SEER < 8.50	4.60 ≤ SCOP < 5.10
A+	5.60 ≤ SEER < 6.10	4.00 ≤SCOP < 4.60
A	5.10 ≤ SEER < 5.60	3.40 ≤ SCOP < 4.00
B	4.60 ≤ SEER < 5.10	3.10 ≤ SCOP < 3.40
C	4.10 ≤ SEER < 4.60	2.80 ≤ SCOP < 3.10
D	3.60 ≤ SEER < 4.10	2.50 ≤ SCOP < 2.80
E	3.10 ≤ SEER < 3.60	2.20 ≤ SCOP < 2.50
F	2.60 ≤ SEER < 3.10	1.90 ≤ SCOP < 2.20
G	SEER < 2.60	SCOP < 1.90

The Directive defines energy efficiency as shown in the **Table 1**.

Moreover, Commission Regulation (EU) No 626/2011 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of air conditioners makes mandatory energy labelling of all air conditioners with the cooling capacity below 12 kW introduced on the European market after the 1st January 2013. The Directive defines, for each function, the energy class going from A+++ (more efficient) to G (less efficient). The classification is given in the **Table 2**.

New Energy Efficiency Ratio and Standard for Air Conditioners below 12 kW

The SEER and SCOP, mentioned in the Directive, represent the usual operating conditions of the equipment over a season. This operating condition can be better assessed by comparing equipment at representative reduced capacities (**Table 3**).

European standard EN 14825 provides part-load conditions and calculation methods for calculating the SEER and SCOP of such units when they are used to fulfil the cooling and heating demands.

Other energy consumptions can occur when the unit is not used to fulfil the cooling and heating demands such as those from a crank case heater or when the unit is on standby. These consumptions are considered in the calculation methods for reference SEER and reference SCOP.

Fixed capacity air conditioners deal with varying loads by varying the operation time. The efficiency of the system is dependent on the effectiveness of the controlling thermostats. Variable capacity air conditioners, by continuous or step control of the compressor, can more closely match the varying load improving system efficiency.

Certification for Air-Conditioners below 12 kW

These Seasonal Energy Efficiency Ratio for cooling mode (SEER) and Seasonal Coefficient of Performance for heating mode (SCOP) came in addition, since the 1st January 2013, to the well-known Energy Efficiency Ratio (EER and COP).

Some new characteristics are currently being tested with a view of being certified, as the performances at Bivalent Temperature[1] or at Operation limit temperature[2], and also the annual electric power consumptions. These new items will better help customers to compare and make their choices.

The certified performances available on the Eurovent Certified Performance Website are listed in **Table 3**.

Figures 3 and 4 show the distribution of the Seasonal Performance in relation with the capacity.

Figure 5 shows the SEER in relation with the SCOP.

These graphs show that the requirements for the European regulation were more stringent for the heating mode than for the cooling mode, as the cut-off is more vertical than horizontal. Indeed, as shown in **Figure 5**, strong parallel requirements on both performances would have generated a more angular shape of the distribution.

SCOP limits SEER when SCOP is between 3.4 and 3.75. For a SCOP above 3.8 the amplitude of SEER is increased (SEER up to 7 to 8). Correlation between SCOP and SEER becomes chaotic for high SCOPs: these units are for sure on the radar screen of certification for verification of their high declared performance.

Certification for Air-Conditioners above 12 kW

Currently, the certified data are EER and COP at Standard Rating Conditions and Sound Power Level (**Table 4**).

[1] Bivalent temperature: lowest outdoor temperature point at which the heat pump is declared to have a capacity able to meet 100 % of the heating load.

[2] Operation limit temperature: lowest outdoor temperature at which the heat pump can still deliver heating capacity, as declared by the manufacturer.

Table 3. Testing conditions for rating of air conditioning units and the information available from the units tested and certified by the Eurovent Certita Certification.

Cooling Mode	Heating Mode
Performances in Standard rating conditions (according to standard EN 14511)	
Cooling Capacity @ 35°C EER @ 35°C	Heating Capacity @ 7°C COP @ 7°C
Seasonal Performances (according to standard EN 14825)	
Design Capacity	Design Capacity Bivalent Temperature Performance @ T°biv TOL (Operation limit temperature) Performance @ TOL
SEER Annual electric power consumption	**SCOP** Annual electric power consumption
Auxiliary Power consumption (Standby mode, Off mode...etc.)	
Sound Power Level (according to standard EN 12102)	

Table 4. Rating conditions and standards used to measure the performance of the air conditioning units with cooling capacity over 12 kW.

Cooling Mode	Heating Mode
Performances in Standard rating conditions (according to standard EN 14511)	
Cooling Capacity @ 35°C EER @ 35°C	Heating Capacity @ 7°C COP @ 7°C
Sound Power Level (according to standard EN 12102)	

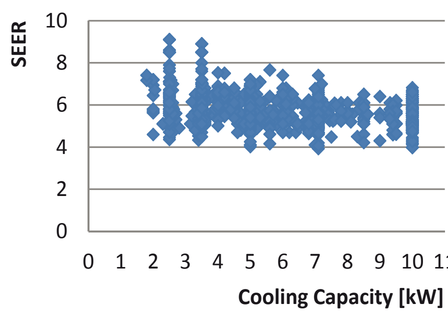

Figure 3. Seasonal Energy Efficiency Ratio for cooling mode (SEER). Each dot represents a different unit. (Eurovent 2013 certified data for Air conditioning units <12kW).

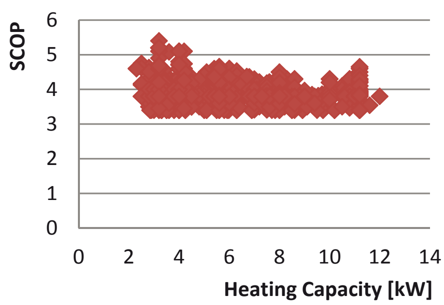

Figure 4. Seasonal Coefficient of Performance for heating mode (SCOP). Each dot represents a different unit. (Eurovent 2013 certified data for Air-conditioning units <12kW).

Seasonal Efficiency for Air Conditioners above 12 kW ongoing?

The objective of the Eco-design Directive is to improve the energy efficiency and to reduce the environmental impacts. The seasonal performance of air conditioning units represents better the energy efficiency of the unit than peak performance. A first draft of regulation based on Eco-design Directive, including the seasonal performance criteria was in consultation with stake holders already in 2013.

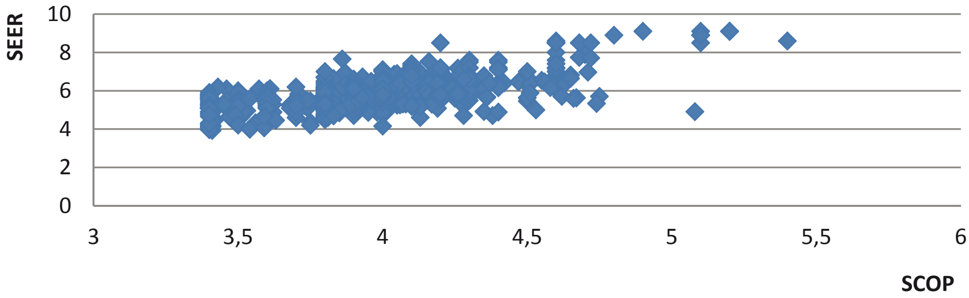

Figure 5. SEER vs. SCOP (Eurovent 2013 certified data for Air conditioning).

This document contains products in relation with:

- ENER[3] Lot[4] 21 (central air heating products)
- ENTR[5] Lot 6 (air conditioning products)
- ENTR Lot 1 (high temperature process chillers)

This future directive will impact:

- Heat Pumps air-to-air ≥ 12 kW
- Heat Pumps water-to-air up to 1 MW
- Chillers (reversible Heat Pumps in cooling mode) air-to-water and water-to-water up to 2 MW

and also:

- Air Conditioners air-to-air ≥ 12 kW
- Air Conditioners water-to-air up to 2 MW

The preparatory study identified the following significant environmental aspects to be regulated:

- Energy efficiency
- Carbon dioxide and nitrogen emissions,
- Sound power levels.

The energy performance requirements related to the seasonal performance SCOP/SEER with calculation methods very similar to those already existing in EN 14825.

[3] ENER= Directorate General of Energy

[4] Lot= product group

[5] ENTR= Directorate General of Enterprise and Industry

Consequently, if the timeframe doesn't change, all Air Conditioners (below and above 12 kW) have to have Seasonal Performances Data from January 2017 and will have to respect the Directive requirements.

The Air Conditioners programme offered by Eurovent Certita Certification will integrate these parameters as soon as possible in order to /offer to our participants a programme in line with the future EU directives.

Data publication

Making the certified data easily available for end-users and consultants has always been a priority for Eurovent Certita Certification. Our directory of certified data, available since the creation of the company, and launched as an interactive website around 2001, brings reliable data to end-users. In addition to the certified data a dedicated description page for each certification programme containing the outline of the programme, definitions and rating conditions is made accessible and constantly updated to help visitors understand the value of certified data (http://www.eurovent-certification.com)

Conclusion

We are at the turning point concerning the Energy efficiencies for all thermodynamic systems (Air Conditioners, Rooftops, Liquid Chilling Packages …). The usual energy efficiencies achieved at full load are going to disappear gradually in order to be replaced by new performances which will better describe these units in terms of energy consumption. Soon, the new European Regulation will change also the current market by fixing higher requirements. With them, the verification of the published data by a third-party body, such as Eurovent Certita Certification for e.g., remains a useful added value to verify the announced performances as a complement to the market surveillance, and to help comparing the products thanks to the online database. ■

Performance of Variable Refrigerant Flow (VRF) Systems

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Keywords: variable refrigerant flow, VRF, testing, performance, air conditioning, testing conditions

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.

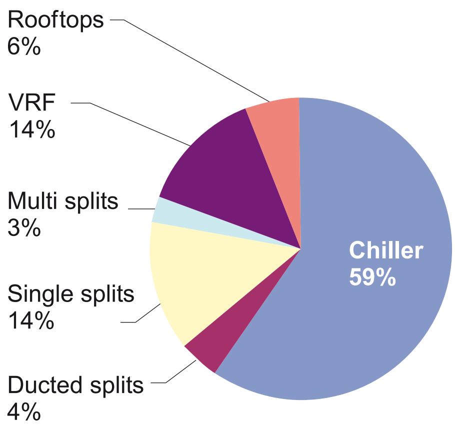

Figure 1. Estimated market share of cooling systems in Europe in 2008 (Final report of Task 2 – Air Conditioning products July 2012).

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 integrates 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 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.

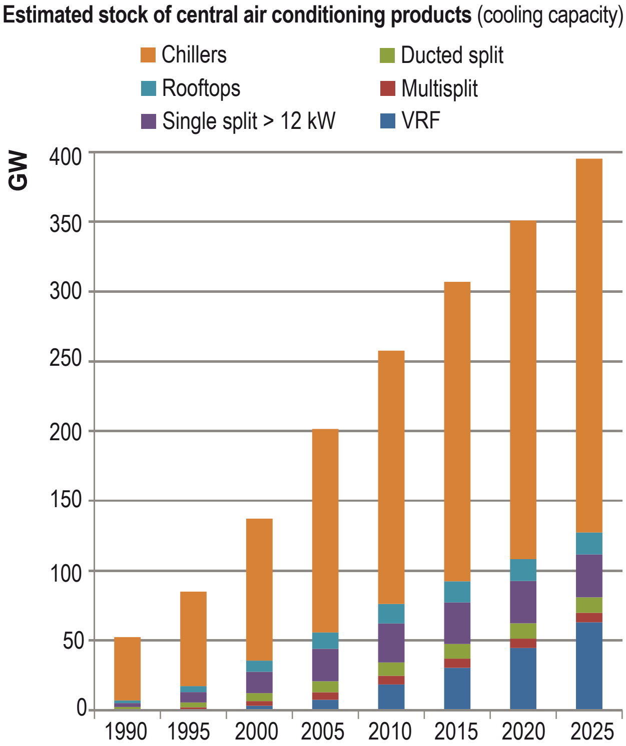

Figure 2. Evolution of market shares of the different cooling systems in Europe (Final report of Task 2 – Air Conditioning products July 2012).

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.

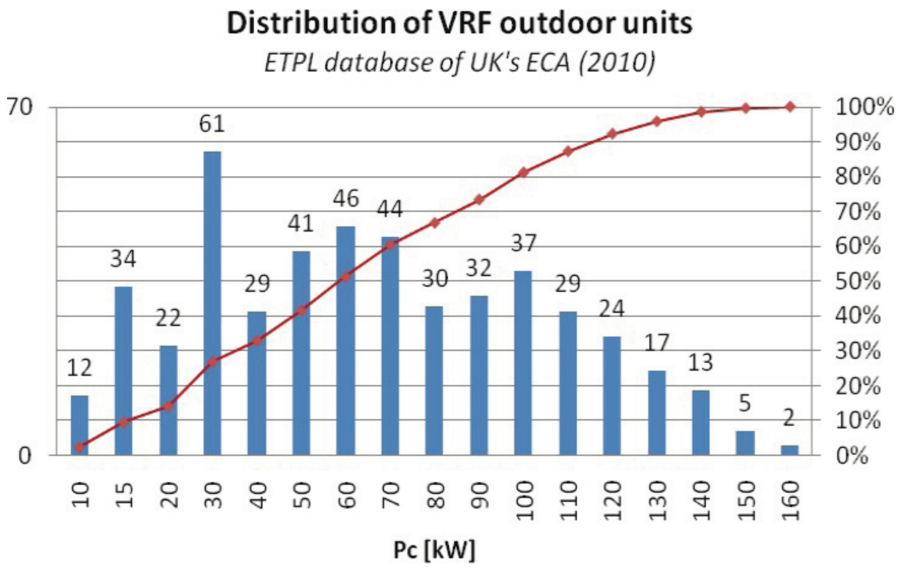

Figure 3. Distribution of capacities of VRF outdoor units (Final report of Task 2 – Air Conditioning products July 2012).

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

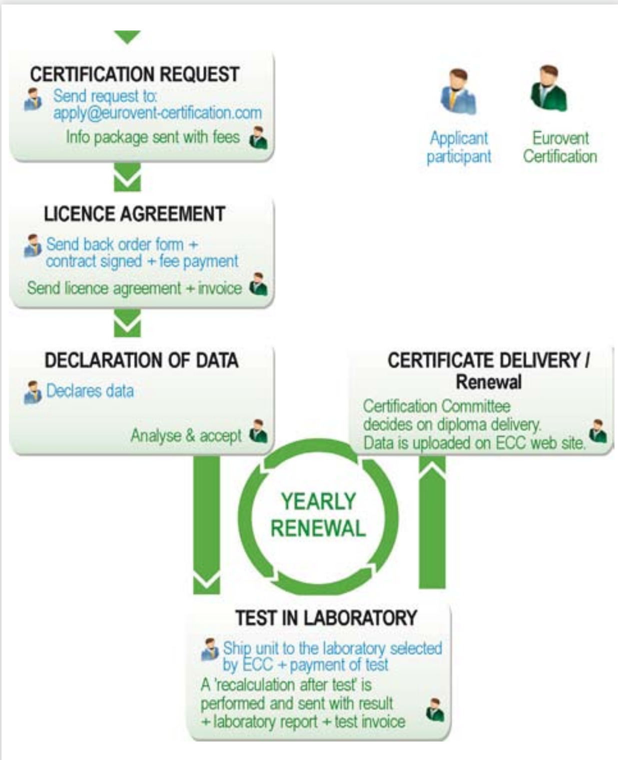

Figure 4. Illustration of the certification process.

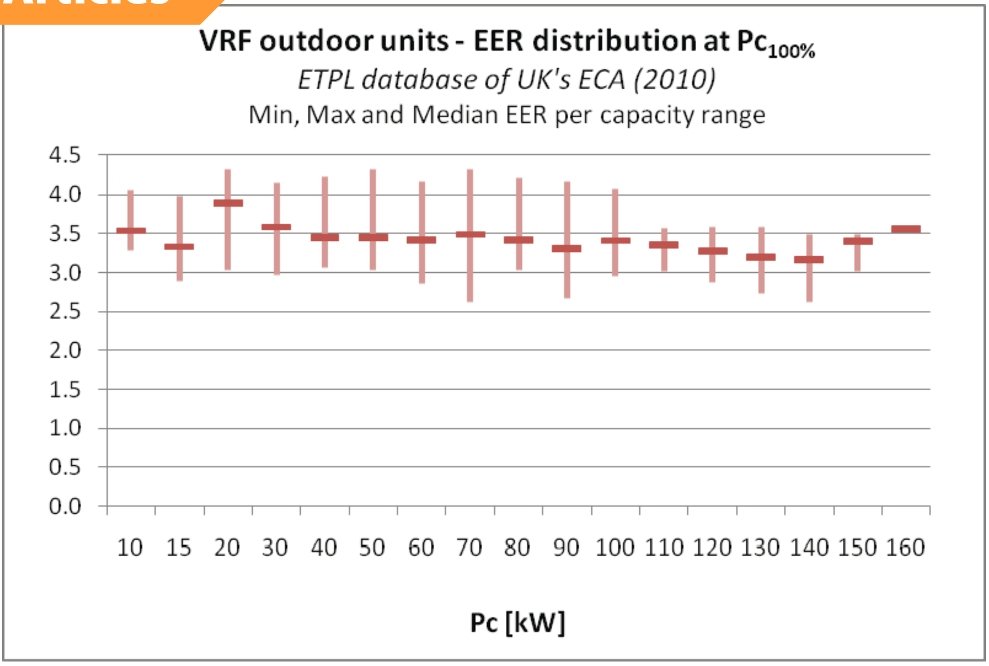

Figure 5. Distribution of efficiencies of VRF outdoor units according to the cooling capacity (Final report of Task 4 – Air Conditioning products July 2012).

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

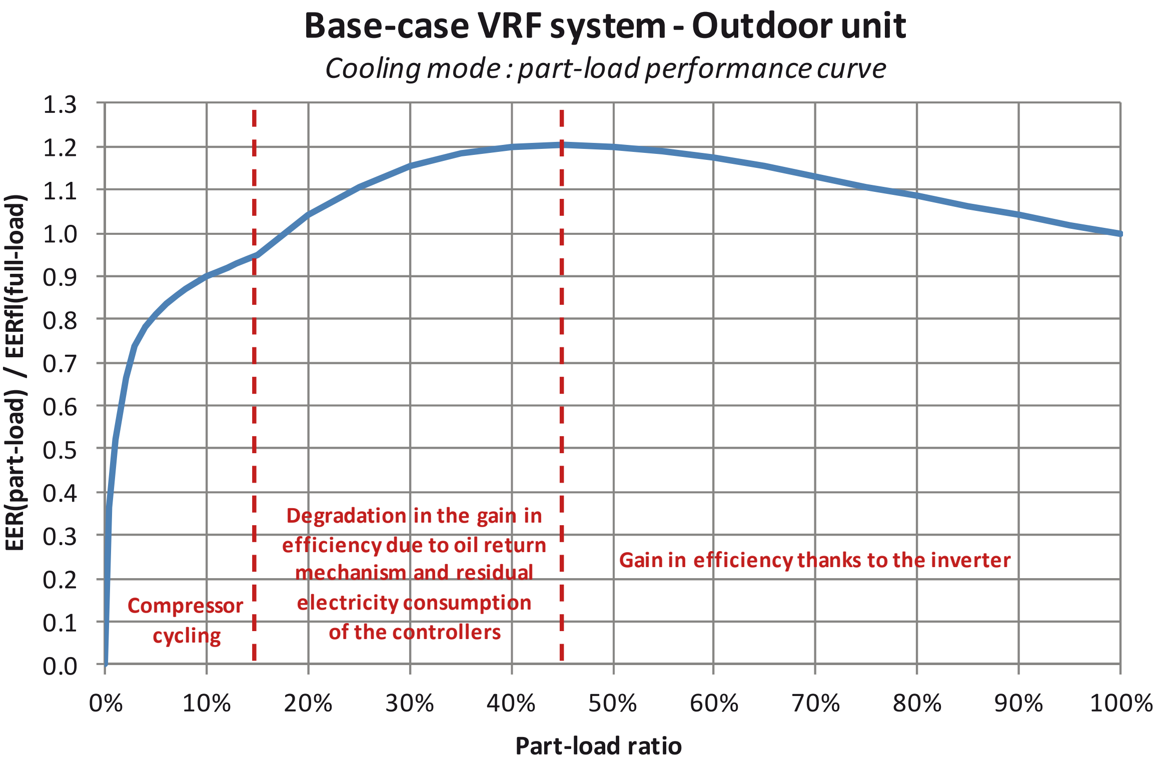

Figure 6. Estimation of the cooling efficiency of VRF system at different part-load conditions (Final report of Task 4 – Air Conditioning products July 2012).

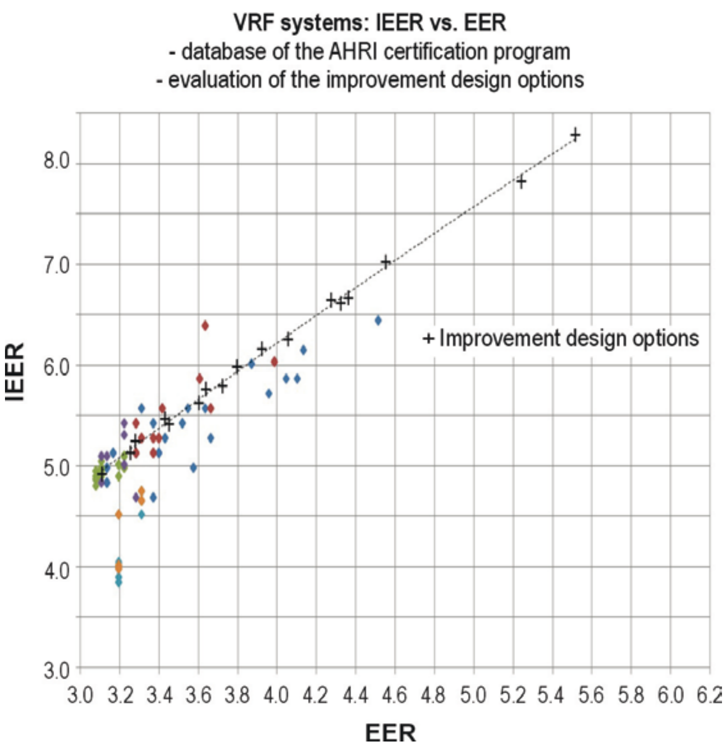

Figure 7. Correlation between efficiency at standard conditions EER and seasonal efficiency (Final report of Task 6 – Air Conditioning products July 2012).

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

By setting up this certification progamme 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

All charts and figures given in this article are based on the remarkable work done by Armines for the European Commission during the preparatory study on Air Conditioning and Ventilation systems in the context of the Ecodesign directive. The study and all related documents can be found in the project website at www.ecohvac.eu.

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Operational Manual for Variable Refrigerant Flow systems www.eurovent-certification.com
Rating Standard for Variable Refrigerant Flow systems www.eurovent-certification.com
Final report of Tasks 1 to 7 – Air Conditioning products July 2012 www.ecohvac.eu

Terms used to describe the performance of chillers, air conditioners and heat pumps

COLLECTED BY DR SANDRINE MARINHAS, EUROVENT CERTITA CERTIFICATION

While chillers, air conditioners and heat pumps used to be rated at one standard condition, a process is on its way for the development and generalisation of figures for seasonal values, which goal is to come closer to the behaviour of the units over the year in order to better represent its efficiency. We expose here as simply as possible the main terms for these units and the key equations.

Terms	Cooling mode	Heating mode	unit
reference design conditions reference temperature conditions cooling mode: 35ºC dry bulb (24ºC wet bulb) outdoor and 27ºC dry bulb (19ºC wet bulb) indoor heating: for average: -10°C, colder : -22°C and warmer: +2°C climates	$T_{designc}$	$T_{designh}$	°C
load or demand load of the building at certain temperature conditions	P_c	P_h	kW
full load load at reference design conditions	$P_{designc}$	$P_{designh}$	kW
part load ratio load divided by the full load	PLR		%
capacity capacity a unit can deliver at certain conditions	DC		
capacity ratio load divided by the declared capacity	CR		
bin hours duration at a given temperature for a specific location	h_j		h
bivalent temperature (CR=100%) lowest outdoor temperature where capacity is equal to the load		$T_{bivalent}$	°C
operation limit temperature lowest outdoor temperature where the unit still delivers capacity		T_{OL}	°C
reference annual demand(s) representative annual demand(s)	Q_c	Q_h	kWh
efficiency (energy efficiency ratio and coefficient of performance) capacity divided by the effective power input at standard conditions: at conditions of EN 14511	EER	COP	kW/ kW
at part load: at conditions of EN 14825 (degraded for fixed stage units)	EER_j	COP_j	
electric back up heater (below Tbivalent) supplementary electric heater, with a COP of 1		elbu	kW
thermostat off corresponding to the hours with no load	TO		
standby unit partially switched off but reactivable by a control device or timer	sb		
off unit completely switched off	off		
crankcase heater (to limit refrigerant concentration in oil at compressor start) where a crankcase heater is activated	CK		
auxiliary power consumptions $\sum h_{aux}.P_{aux} = h_{TO}.P_{TO} + h_{sb}.P_{sb} + h_{CK}.P_{CK} + h_{off}.P_{off}$	TO, sb, off, ck		kWh
degradation coefficient for fixed stage units (same equations for COPj) efficiency loss due to the cycling of respectively chillers and ACs $EER_j = EER.\frac{CR}{c_c.CR+(1-c_c)}$; $EER_j = EER.\left(1 - C_d.(1 - CR)\right)$ = *EER.(Part Load Factor)*	Cc / Cd		% kW/ kW
reference seasonal efficiency [reference: EN 14825, 2013] seasonal efficiency calculated for the reference annual demand $SEER = \frac{Q_c}{\frac{Q_c}{\frac{\sum h_j.P_{c,j}}{\sum h_j.\left(\frac{P_{c,j}}{EER_j}\right)}}+\sum h_{aux}.P_{aux}}$; $SCOP = \frac{Q_h}{\frac{Q_h}{\frac{\sum h_j.P_{h,j}}{\sum h_j.\left(\frac{P_{h,j}-elbu_j}{COP_j}+elbu_j\right)}}+\sum h_{aux}.P_{aux}}$	SEER	SCOP	kWh/ kWh
active seasonal efficiency seasonal efficiency excluding auxiliary consumptions	$SEER_{on}$	$SCOP_{on}$	kWh/ kWh
European seasonal energy efficiency ratio [reference: Eurovent Certification, 2008] Antecedent term used for SEER before European standard was issued $ESEER = 0.03.EER_{100\%} + 0.33.EER_{75\%} + 0.41.EER_{50\%} + 0.23.EER_{25\%}$	ESEER	-	kWh/ kWh
integrated part load value [reference AHRI, 1998] (EER in kW/Ton) First equivalent to ESEER, with weighting coefficients related to the United States $IPLV = 0.01.EER_{100\%} + 0.42.EER_{75\%} + 0.45.EER_{50\%} + 0.12.EER_{25\%}$	IPLV	-	kW/ Ton

Refrigerants – Part 1: Properties and air-conditioning applications

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Keywords: refrigerants, safety of refrigerants, CFCs, HCFCs, HFCs, refrigeration cycle, COP

Abstract

The paper on refrigerants has been divided in two parts. Refrigerants' thermodynamic, physical, chemical, safety – related and environmental properties have been presented and discussed in the first part of the paper. Influence of those properties, which is of the utmost significance on the vapor – compression process efficiency and design has been presented. The design of HVAC system is influenced by the choice of the vapor – compression process, which means that refrigerant choice defines HVAC design as well. Throughout the history, refrigerant development took place due to different reasons, such as safety, stability, durability, economic or environmental issues, thus giving the boost to new research and equipment improvement in terms of safety and efficiency. Recent legislation worldwide and in EU is still not quite completed concerning refrigerant issues. The delicate subject of refrigerants is widely discussed, viewpoints of different parties are opposite, depending on positions and interests, and compliance on that issue is not easy to achieve. In the second part of the paper about refrigerants, past present and future of refrigerants and suitable applications will be discussed, with emphasis on natural refrigerants.

Introduction

Refrigerants are the working fluids used in the counter clockwise thermodynamic working cycles. Depending on temperature levels of the heat source and the heat sink, the application area of the working cycle can be refrigeration, air- conditioning, or heat-pumping. Refrigerant circulates within the refrigeration machine, absorbs the heat from the heat source at lower temperature level and rejects it into the heat sink at higher temperature level. In absorption and mechanical vapor compression systems refrigerants usually pass the phase change, namely evaporation or condensation. Gas refrigeration cycles are also available and phase change of the working fluid in such cycles does not occur. Gas refrigeration cycles are less efficient compared to vapor – compression cycles and will be omitted in the considerations that follow.

The choice of the refrigerant is not only the technical problem, it is subject to lot of interests, public and industrial groups advocate their positions and neutral position in all that multiple source information is not always easy to achieve.

Throughout the history of refrigeration organic and inorganic natural working fluids, chlorofluorocarbons CFCs, hydro chlorofluorocarbons HCFCs, fluorocarbons HFCs have been used and some of them abandoned for certain reasons, such as security, cost or environmental, defining in some way the direction of development of refrigeration and HVAC industry.

The refrigerant issue is becoming more important in present time due to the fact that refrigeration or heat pumping can contribute to better utilization of renewable heat contained in the environment on low temperature level, thus making possible easier design of zero energy buildings.

Refrigerant properties

Refrigerant selection involves compromises between conflicting desirable properties. The working fluid desirable properties are related to thermodynamic and physical properties which lead to efficient cooling or heating factor and effective design of equipment, such as high evaporation heat, high volumetric refrigeration capacity, low temperature at the end of the compression. Other physical properties comprise the favorable position of critical and the freezing point, low specific heat capacity, low specific volume, low viscosity and high thermal conductivity. Desirable chemical and safety properties comprise chemical stability within the working conditions in the refrigeration unit in the presence of used materials and lubricating oil, non-flammability, non-toxicity, good miscibility with oil. If possible, the refrigerant must be odorless, but easy detection in the air is desirable. Safety properties of refrigerants considering flammability and toxicity are defined by ASHRAE standard 34 [1]. Toxicity classification of refrigerants is assigned to classes A or B. Class A signifies refrigerants for which toxicity has not been identified at concentrations less than or equal to 400 ppm by volume, and class B signifies refrigerants with evidence of toxicity at concentrations below 400 ppm by volume. By flammability refrigerants are divided in three classes. Class 1 indicates refrigerants that do not show flame propagation when tested in air (at 101 kPa and 21°C). Class 2 signifies refrigerants having a lower flammability limit (LFL) of more than 0.10 kg/m³ and a heat of combustion of less than 19 000 kJ/kg. Class 3 indicates refrigerants that are highly flammable, as defined by an LFL of less than or equal to 0.10 kg/m³ or a heat of combustion greater than or equal to 19 000 kJ/kg.

Table 1. Safety classification of refrigerants as defined by ASHRAE standard 34.

		SAFETY GROUP	
increasing flammability→	higher flammability	A3	B3
	lower flammability	A2	B2
		A2L*	B2L*
	no flame propagation	A1	B1
		lower toxicity	higher toxicity
		increasing toxicity→	

* A2L and B2L are lower flammability refrigerants with a maximum burning velocity ≤ 10 cm/s.

New flammability class 2L has been added since 2010 denoting refrigerants with burning velocity less than 10 cm / sec.

Desired environmental properties comprise that refrigerants should not affect the ozone layer (the presence of chlorine in the working fluid molecules is not acceptable), that the impact on global warming should be as low as possible and that working fluid decomposition by-products should not have negative effects on the environment.

Some refrigerants (chlorofluorocarbons CFCs and hydro chlorofluorocarbons HCFCs) can affect the ozone layer. Ozone (O_3) is naturally formed in the atmosphere and it absorbs the sun's harmful UV rays. The chlorine contained in CFCs and HCFCs distorts the natural equilibrium of the ozone in the atmosphere and affect its concentration, which, in turn, increases the risk of skin cancer, weakens human immune system leading to diseases, causes the flora and fauna imbalance, plankton depletion and species count decrease.

Another negative effect of HFCs, which belong to the greenhouse gasses (CO_2, CH_4, NO_2, HFCs, PFCs and SF_6) is the global warming. The greenhouse gasses emitted into atmosphere allow the short wave radiation of the Sun passing through, but are less permeable for the long wave radiation of the Earth's surface. This is why the certain amount of energy reaching the surface of the Earth through the atmosphere stays trapped as if in a greenhouse and causes the temperature to rise. This distorts the total energy balance of the Earth and causes dramatic climate change.

The refrigerant impacts on the environment are evaluated with the ozone Depletion Potential (ODP) and the Global Warming Potential (GWP). ODP is expressed as a relative potential of ozone depletion compared to influence of R-11 which has ODP=1. The Global Warming Potential (GWP) is the relative measure of the substance impact on the greenhouse effect in relation to the impact of a kilogram of CO_2. The CO_2 is retained permanently in the atmosphere, which is why the GWP of greenhouse gasses which can have lower lifetime in the atmosphere is calculated over a specific time interval, commonly 20, 100 or 500 years.

Finally, some demands of economic nature, such as low price and good availability are also important for refrigerant selection.

There is no "ideal" working fluid available. Neither one among working fluids has all the required properties and the above – mentioned requirements are fulfilled only partially. When selecting the refrigerant, the device application and temperature range must always be analyzed in order to be able to determine the optimal refrigerant. In technical practice, which is subject to changes over time, priority is always given to certain refrigerants for certain purposes.

Influence of refrigerants on process efficiency

The design and efficiency of the refrigeration equipment depends strongly on the selected refrigerant's properties. Consequently, operational and equipment costs depend on refrigerant choice significantly. Vapor – compression unit consists of compressor, condenser, expansion device and the evaporator, connected with refrigerant pipelines.

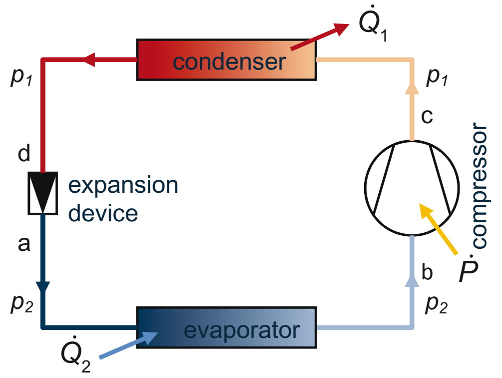

Figure 1. Single-stage compression refrigeration unit schematics.

The basic vapor – compression cycle is considered to be one with isentropic compression, with no superheat of vapor and with no subcooling of liquid (**Figure 2**).

When zeotropic mixtures are used as refrigerants, gliding temperatures influence cycle efficiency as well as system design. An example of the process operating with zeotropic mixture is given on **Figure 3**. Temperature glide appears during evaporation and condensation at constant pressure. Use of counter flow heat exchangers can sometimes help to utilize that temperature glide efficiently, but problems can appear with leakage of refrigerants from such systems as the initial refrigerant composition and thus properties can be disturbed.

The specific compression work w, the specific cooling performance q_2, volumetric refrigerating capacity q_{0v}, the cooling factor COP_2 are calculated for above presented processes as follows:

$$w = h_c - h_b \quad [\text{kJ/kg}], \tag{1}$$

$$q_2 = h_b - h_a = h_b - h_d \quad [\text{kJ/kg}] \tag{2}$$

$$q_{0v} = \frac{q_2}{v_b} = q_2 \rho_b \quad [\text{kJ/m}^3] \tag{3}$$

$$COP_2 = \frac{q_2}{w} = \frac{h_b - h_a}{h_c - h_b} \tag{4}$$

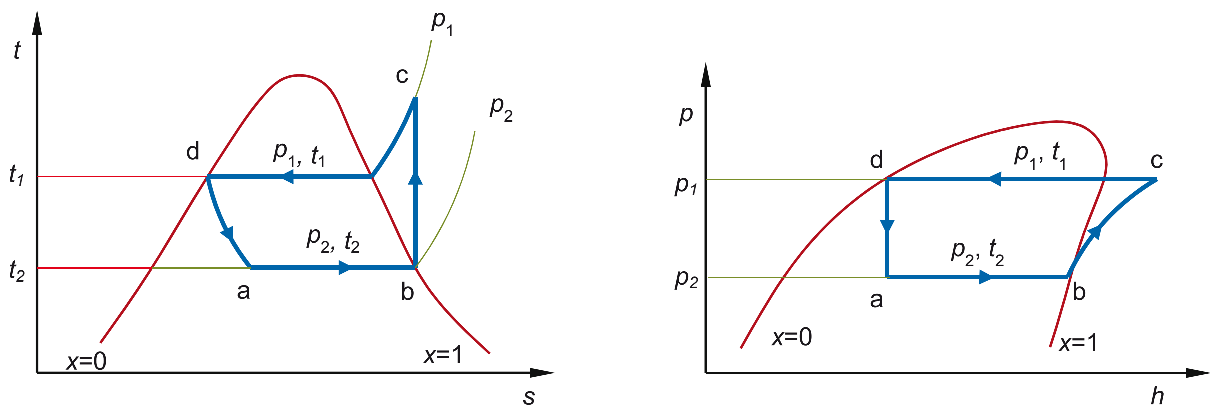

Figure 2. Single-stage vapor - compression subcritical process with a single – component or azeotropic refrigerant in temperature - entropy ***t,s-*** and pressure – enthalpy ***p,h-*** diagrams.

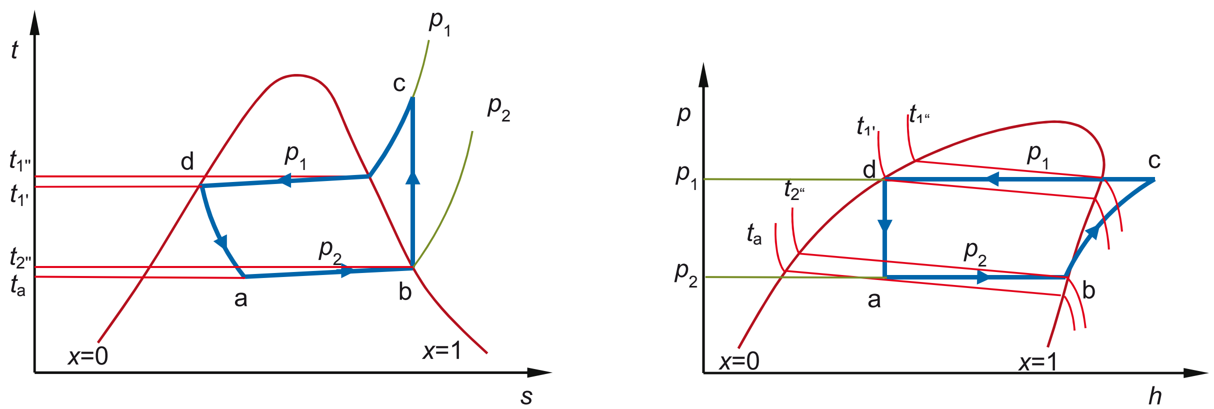

Figure 3. Single-stage vapor – compression subcritical process with a zeotropic mixture refrigerant in temperature – entropy ***t,s-*** and pressure – enthalpy ***p,h-*** diagrams.

The refrigerant mass flow is calculated from the required cooling capacity and the specific cooling performance.

$$\dot{M} = \frac{\dot{Q}_2}{q_2} \quad [\text{kg/s}] \tag{5}$$

The power necessary for the isentropic compression may be calculated as

$$\dot{P}_{is} = \dot{M}\, w \quad [\text{kW}] \tag{6}$$

The effective power on the compressor shaft is bigger and is calculated as

$$\dot{P}_{ef} = \frac{P_{is}}{\eta_{is}} \tag{7}$$

Comparison of different refrigerants gives a good overview of achievable cycle performance for a basic referent cycle. **Table 1** gives comparison for refrigerating reference cycle with evaporation temperature −15°C and condensing temperature +30°C. Cycle data for zeotropic refrigerants in **Table 1** are given for combination of temperatures $t_{2"}$ and $t_{1'}$ [2]. Cycle data are available from different sources, e.g. IIR - Refrigerant cycle data [2], ASHRAE Fundamentals Handbook [3], or can be evaluated from suitable software such as REFPROP [4]. The selection of refrigerants in **Table 2** has been made in order to present the overview of cycle data for historically used natural inorganic refrigerants such as ammonia R-717, carbon dioxide R-744, sulfur dioxide R-764 (which is not in use anymore), chlorofluorocarbons CFCs such as R-11 or R-12 and hydro chlorofluorocarbons HCFCs such as R-22, and azeotropic mixture R-502 which dominated in 20th century and are also phased out. Amongst newly used refrigerants hydro fluorocarbons HFCs R-32 and R-134A are presented as well as zeotropic mixtures of HFCs R-404A, R-407C, R-410A, and azeotropic mixture of HFCs R-507. Finally, natural hydrocarbons HCs R-600A and R-290, together with propylene R-1270 are listed.

As it can be seen from data presented in **Table 2** pressures in the system are temperature – dependent and are different for each particular refrigerant. Evaporation and condensing temperatures are close coupled with corresponding pressures for single – component refrigerants, while for zeotropic mixtures temperature glide appears during the phase change at constant pressure. Pressures influence design and thus equipment costs, but also the power consumption for compression and thus operational costs. Refrigerant transport properties, such as liquid and vapor density, viscosity, thermal conductivity or surface tension, define heat transfer coefficients and consequently temperature differences in heat exchangers thus directly influencing pressures in the system as well as necessary heat transfer surface of heat exchangers. Molecular mass or volumetric refrigerating capacity of some refrigerants influences application of certain compressor types. For example, ammonia systems are not suitable for application of centrifugal compressor due to low molecular mass of ammonia. On the contrary, R-11 with relatively high molecular mass and low volumetric refrigeration capacity represented a good candidate for application of centrifugal compressors. The higher the volumetric refrigeration capacity is, the smaller compressor displacement can be, which results in smaller compressors for refrigerants with high volumetric refrigeration capacities. Excellent example is R-744 with highest volumetric capacity among all the refrigerants presented in **Table 2**. R-744 compressors are smaller compared to compressors for some other refrigerants.

Achievable efficiency of the entire process is in a great deal a consequence of the refrigerant used. For example, R-11 which has been banned since 2006 can produce highest COP among all other refrigerants for the temperature range considered. Effective energy consumption or cooling factor is not equal to the one of the theoretical cycle. Isentropic efficiency η_{is} in equation 7 is also dependent on refrigerant properties. Discharge temperature on the compressor outlet depends on refrigerant and systems pressures, and it must be limited in order to avoid deterioration of oil properties, or even the oil burnout. For the −15/30°C cycle that problem is not so obvious, but when heat pump applications come into consideration, with evaporation temperatures close or significantly lower than 0°C, and condensing temperatures up to 60°C which is approximately upper level of achievable condensing temperatures for most of refrigerants in cycles with a single – stage compression, that can for certain refrigerants result in high temperatures at the end of the compression, which must be avoided by use of modified cycles (e.g. economizer cycle) or different type of the cycle (e.g. two – stage compression). Behavior of some refrigerant during the compression can result in no or low superheating of the vapor at the end of the compression (e.g. R-134A with low superheating, or R-600A where final refrigerant state at the end of the compression can end in saturated area unless proper superheating at the compressor inlet is provided). Systems with such refrigerants are not suitable for utilization of superheated part of vapor heat content in refrigeration cycles with heat recovery for sanitary water

Table 2. Parameters of –15/30°C cycle with different refrigerants.

R number	p_1 bar	p_2 bar	p_1/p_2	q_{0v} kJ/m³	COP_2 –15/30°C	t_c °C
R-717	11,672	2,362	4,942	2 167,6	4,76	99,08
R-744	72,1	22,9	3,149	7979	2,69	69,5
R-764	4,624	0,807	5,730	818,8	4,84	96,95
R-11	1,260	0,202	6,233	204,2	5,02	42,83
R-12	7,437	1,823	4,079	1 273,4	4,70	37,81
R-22	11,919	2,962	4,024	2 096,9	4,66	52,95
R-32	19,275	4,881	3,949	3 420,0	4,52	68,54
R-134A	7,702	1,639	4,698	1 225,7	4,60	36,61
R-404A	14,283	3,610	3,956	2 099,1	4,16	36,01
R-407C	13,591	2,632	5,164	1 802,9	3,91	51,43
R-410A	18,893	4,800	3,936	3 093,0	4,38	51,23
R-502	13,047	3,437	3,796	2 079,5	4,39	37,07
R-507	14,60	3,773	3,870	2 163,2	4,18	35,25
R-600A[1]	4,047	0,891	4,545	663,8	4,71	32,66
R-290	10,79	2,916	3,700	1 814,5	4,55	36,60
R-1270	13,05	3,630	3,595	2 231,1	4,55	41,85

[1] Superheating at compressor suction port 5°C.

heating during the cooling operation. Analyses become more complicated when superheating and subcooling of refrigerant occurs within the cycle. Liquid subcooling and vapor superheating can be intentionally produced by introducing liquid – vapor heat exchanger into the cycle. With heat exchange between the low – pressure vapor and high pressure liquid refrigerant, efficiency increases for certain refrigerants, while for other refrigerants the decrease of efficiency appears.

Finally, pressure drops within heat exchangers and in pipelines connecting refrigeration machine components are essential for system efficiency and are also dependent on refrigerant properties. All presented examples illustrate the fact that refrigerant properties are essential for the refrigeration equipment design and that gives the refrigerant choice the most important position in design of the refrigeration equipment.

Conclusion

Influence of refrigerant properties and refrigeration system design is significant and those properties influence the design of HVAC systems which contain refrigeration subsystems as well. In the future we may expect changes in regulation concerning refrigerants, the construction of systems that are suitable for the use of newly developed and natural refrigerants, the optimization of the system in the sense of compensating the lower efficiency of some refrigerants, but with keeping cost within acceptable limits. ■

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Refrigerants – Part 2: Past, present and future perspectives of refrigerants in air-conditioning applications

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Key words: refrigerants, CFCs, HCFCs, HFCs, natural refrigerants, ODP, GWP

Abstract

The second part of the refrigerant paper deals with the refrigerant development throughout the history, which took place due to different reasons, such as safety, stability, durability, economic or environmental issues, thus giving the boost to new research and equipment improvement in terms of safety and efficiency. Recent legislation worldwide and in the EU is still not quite completed concerning refrigerant issues. The delicate subject of refrigerants is widely discussed, viewpoints of different parties are opposite, depending on positions and interests, and compliance on that issue is not easy to achieve. The chance for "closing the circle" and return to natural refrigerants exists and should not be missed.

Historical overview of refrigerants' development

Beginnings of mechanical refrigeration, starting from early 19th century are characterized by use of natural refrigerants. Water and air were the first refrigerants considered for use in mechanical refrigeration systems. In 1834 Perkins proposed ethyl ether as the working fluid in his patent of the vapor - compression refrigeration system. Perkins system was a closed circuit comprising all the modern vapor-compression system components: the compressor, the condenser, the expansion device and the evaporator. By that time ammonia, sulfur dioxide and carbon dioxide had been isolated and were available for use as well. The first one who used methyl ether, which operated at higher pressure and thus reduced the risk of drawing air into the system and forming an explosive mixture within the machine was Tellier in 1863. First ammonia compressor for refrigerating purposes was designed and constructed by Boyle in 1872, and 4 years later Linde designed the first machine working with ammonia. In 1862 Lowe developed a carbon-dioxide refrigerating system. Carbon dioxide has very low toxicity but required high-pressure machinery and was difficult to use because of its low critical temperature (31,6°C) which does not allow for condensation in many situations. Methyl chloride was used for the first time as a refrigerant in 1878. Most of those early refrigerants were flammable, toxic or both [1,2]. **Table 1** shows properties (molecular weight M, normal boiling point NBP at pressure 1 bar, critical temperature CRT, critical pressure CRP, safety group according to ASHRAE standard 34, ozone depletion potential ODP and global warming potential GWP

Table 1. Properties of early refrigerants.

Substance	R number	Chemical formula	M kg/kmol	NBP °C	CRT °C	CRP bar	Safety group	ODP	GWP_{100}
Carbon dioxide	R-744	CO_2	44,01	-55,6[1]	31,6	73,77	A1	0	1
Ammonia	R-717	NH_3	17,03	-33,3	132,25	113,33	B2 (B2L[2])	0	0
Sulfur dioxide	R-764	SO_2	64,06	-10,0	157,49	78,84	B1	0	0
Ethylether	R-610	$C_4H_{10}O$	74,12	35	194,0	36	-	0	0
Dimethylether	E-170	C_2H_6O	46,07	-25	126,9	53,7	A3	0	0
Methyl chloride	R-40	CH_3Cl	50,49	-24,2	143,1	66,77	B2	0,02	16

[1] – tripple point

[2] – new class introduced since 2010

Table 2. Properties of CFC and HCFC refrigerants dominant in 20th century.

Substance	R number	Chemical formula	M kg/kmol	NBP °C	CRT °C	CRP bar	Safety group	ODP	GWP_{100}
Trichlorofluoromethane	R-11	CCl_3F	137,4	23,71	197,96	44,1	A1	1	4000
Dichlorodifluoromethane	R-12	CCl_2F_2	120,91	-29,75	111,97	41,4	A1	1	8500
Chlorotrifluoromethane	R-13	$CClF_3$	104,5	-81,3	29,2	39,2	A1	1	11700
chlorodifluoromethane	R-22	$CHClF_2$	86,47	-40,81	96,15	49,9	A1	0,055	1700
R22/R115	R-502	$CHClF_2$ + CF_3CClF_2	111,6	-45,3	80,73	40,2	A1	0,33	5600

based on 100 years) of practical refrigerants available for vapor compression cycles at the end of the 19th century.

The second generation of refrigerants, chlorofluorocarbons (CFCs) replaced classic refrigerants in early 20th century. Midgeley and his associates, in their research aimed to find for stable, but neither toxic nor flammable refrigerant in 1928, selected R-12, dichlorodifloromethane as a suitable compound for refrigeration applications [2]. The commercial production of R-12 began in 1931, followed by R-11 in 1932 and R-13 for low temperature applications in 1945. Chlorofluorocarbons (CFCs) and starting in 1950s hydrochlorofluorocarbons represented by R-22 and azeotropic mixture R-502 dominated the second generation of refrigerants. Those refrigerants dominated throughout the second half of 20th century. Ammonia was only natural refrigerant that still remained the most popular refrigerant in industrial applications. [1,2]

Present situation

Present situation is determined by use of refrigerants of zero ODP with no impact on ozone layer, according to demands of Montreal protocol (1987). In 1974 researchers Roland and Molina predicted that emissions of HFCs could damage Earth's atmosphere by the catalytic destruction of ozone in the stratosphere. The hypothesis has been proven in 1985 by measurements which have shown the destruction of the ozone layer over Antarctica. In 1987, the Montreal Protocol limits the production and consumption of CFCs. Between 1990 and the present emissions have decreased substantially as a result of the Montreal Protocol and its subsequent amendments and adjustments coming into force. By 2008, stratospheric chlorine abundances in the stratosphere were 10% lower than their peak values reached in the late 1990s and were continuing to decrease. January 2010 marked the end of global production of CFCs under the Protocol. In 2009 the Montreal Protocol was universally ratified by 196 nations [3]. European regulation concerning that issue is No. 2037/2000 of June 29, 2000 on substances that deplete the ozone layer.

The discontinuation of CFC (2006) and HCFC (2015) use brings us to the today's state of utilization of HFCs, the mixtures thereof and the natural refrigerants. In EU countries HCFC phase-out has been accelerated and those are not in use anymore. Today's refrigerants may not contain chlorine, they must ensure efficient performance and must have a low impact on global warming.

The commercially available refrigeration units mostly use R-134A for fresh produce and R-404A (or R-507A) for frozen produce. Natural refrigerant R-290 is in some countries used in refrigerated display cabinets at medium and low temperatures. R-404A is used in direct central refrigeration systems for low and medium refrigeration temperatures. It may also be used for both fresh and frozen produce. Natural refrigerant CO_2 is used as a refrigerant in the lower cascade of the cascade systems or in transcritical systems. It may also be used either as a heat transfer medium. R-134A dominates as the refrigerant in the home refrigeration units and some regions use the hydrocarbons (e.g. isobutane R-600a) as well [4].

Ammonia is still widely used in industrial systems and its previously decreasing utilization due to halogenated hydrocarbons use is on the increase again [4]. The modern-day refrigeration systems using ammonia are constructed with the tendency of decreasing ammonia charge in the system as much as possible for safety reasons. One way of doing that is to apply indirect systems with the heat transfer medium, so that the ammonia is kept in the refrigeration device, whereas the heat transfer medium flows through the distribution system.

Chillers are important part of HVAC installations. R-134a is used in large chillers equipped with centrifugal compressors and flooded evaporators. R-407C is used in direct expansion systems with counter flow heat exchangers. Recently, R-410A units became competitive with the R-407C units and almost fully replaced

Table 3. Some ozone friendly refrigerants (ODP = 0).

R number	Chemical formula / composition	M kg/kmol	NBP [°C]	CT [°C]	CP bar	Temp. glide [°C]	Safety group	GWP_{100}
R-32	CH_2F_2	-52,02	-51,65	78,11	57,8	0	A2L[1]	580
R-134A	CH_2FCF_3	102,03	-26,07	101,06	40,6	0	A1	1300
R-404A	R143A/125/134A (52/44/4)	97,6	-46,6	72,14	37,4	0,46	A1	3800
R-407C	R32/125/134A (23/25/52)	86,2	-43,8	86,05	46,3	5,59	A1	1600
R-410A	R32/125 (50/50)	72,59	-51,6	70,17	47,7	0,1	A1	1900
R-507	R143A/125 (50/50)	98,86	-47,1	70,75	37,2	0	A1	4000
R-508A	R23/116 (39/61)	100,1	-87,4	11,01	37,0	0	A1	13000
R-717 ammonia	NH_3	17,03	-33,3	132,25	113,33	0	B2L[1]	0
R-744 Carbon dioxide	CO_2	44,01	-55,6	31,6	73,77	0	A1	1
R-600A isobutane	$CH(CH_3)_3$	58,12	-11,6	134,66	36,29	0	A3	20
R-290 propane	C_3H_8	44,1	-42,11	96,74	42,51	0	A3	20
R-1270 propylene	C_3H_6	42,08	-47,62	91,06	45,55	0	A3	20

[1] – new safety classes introduced since 2010

Table 4. Today's refrigerant alternatives [5]

Traditional Service Refrigerants		Medium and Long-Term Alternative Refrigerants					
HCFC/HFC Partly chlorinated		HFS Chlorine fee		Low GWP refrigerants		Halogen free natural	
Single substances	Blends	Single substances	Blends	Single substances	Blends	Single substances	Blends
R-22 R-123 R-124 R-142B	Predominantly R-22 based	R-134A R-125 R-32 R-143A R-152A	R-404A R-507A R-407 serie R-410A R-417A7B7 R-422A/D R-427A	HFO-1234yf HFO 1234ze	HFO-1234yf/ HFO 1234ze/ HFC	R-717 R-290 R-1270 R-600A R-170 R-744	R-600A/ R290 R-290/ R-170 R-723

them in use. Design of micro channel heat exchangers was initiated by development of R-410A equipment. CO_2 is not usually used in chillers, mostly due to low energy efficiency of the process. CO_2 heat pumps for water heating started selling in Japan in 2001. They can heat the domestic water up to 70-80°C. The capacity of those chillers goes up to 100 kW. A transcritical cycle operated VRF systems have also been available on the market in recent years, but problems with lower efficiency and construction of high pressure refrigerant piping never allowed wide application. In recent years Japanese producers have pushed hard R-32 as a suitable refrigerant for VRF systems. New safety class A2L as defined by ASHRAE standard 34 discussed in previous paper (Part 1) comprises R-32 as well and one of arguments for R-32 application is the lower burning velocity as described in class A2L definition. The market share of ammonia chillers is still very small due to important issues as safety, charge reduction and first cost. Recently increased research focused on charge reduction (and thus safety) and energy efficiency of those chillers can give boost to wider use of ammonia chillers in HVAC, besides traditional industrial, food processing and beverage applications. Hydrocarbon chillers production is very low. Refrigerants are R1270, R290 and propane and ethane mixtures. The typical performance ranges from 20 to 300 kW and the amount of the refrigerant from 3 to 34 kilograms [4].

Replacement of R-22 in existing refrigeration systems is still actual. There is a significant number of chillers with high performance, built for a longer operational period, and those chillers are potential candidates for that operation called "retrofit". Retrofit basically means adaptation of the refrigeration system to the new refrigerant with changed safety and control equipment and instrumentation within the system, and with changed system performance. That adaptation is not so simple, especially in the case when transition from mineral oil lubricated systems (HCFCs) to synthetic oil lubricated systems (HFCs) is necessary. A lot of research is ongoing presently in order to find suitable, so called "drop-in" replacement for R22. Experience with previous retrofit of R12 systems using replacement R-134A do not give boost to any enthusiastic expectations. Cost of such an operation should carefully be analyzed, and experience shows that equipment replacement is much more likely to occur instead of retrofit.

The future

GWP of HFCs is another issue addressed by Kyoto protocol (1997). The European Parliament has issued a directive (No. 842/2006) banning the use of HFCs whose GWP is higher than 150 (the "F Gas" Directive) in air-conditioning units of newer cars from 2011 and of all new cars from 2017. Directive also requires periodic leakage check-ups of stationary systems containing HFCs. Changes may be expected in the direction of the ban on HFCs with high GWP use in stationary systems. Review of the F-gas Regulation started in 2010. The European Commission proposal is to broaden the scope of the regulation to refrigerated transport, to modify the frequency of leakage checks based on the CO_2 equivalents of the HFCs used and to modify the obligations regarding training and certification of personnel. A gradual phase-down of HFCs is also proposed using the 2008-2011 total quantity of HFCs in EU as a baseline. The document proposes a freeze by 2015 and a gradual reduction ending with 21% of baseline quantity by 2030. This proposal also includes a ban on HFCs in domestic, hermetically sealed commercial systems and movable air-condi-

Table 5. Possible directions of future development of refrigerants [2]

Refrigerants	**Remarks**
Natural refrigerants (NH_3, CO_2, hydrocarbons HCs, H_2O, air)	Efficiency; flammability for NH_3 and HCs
HFCs with low GWP (R-32, R-152a, R-161...)	Flammability, most of the ones that are subject to the ban have a high GWP
Hydrofluoroethers HFEs	Disappointing thus far, still?
Ethers (HEs) (RE170 – dimethyl ether)	Flammability
Olefins – unsaturated alkenes (R1234yf)	Short atmospheric lifetime and therefore low GWP. Flammability? Toxicity? Compatibility?
HFICs and FICs (R-31I1 (CH2FI), R-13I1 (CF3I)...)	Expensive, ODP>0, but not subject to the Montreal Protocol. Some are toxic. Compatibility?
Fluorinated alcohols (-OH) and ketones [-(C=O)-]	Efficiency? Flammability? Toxicity? Compatibility?
Other	??? - no ideal refrigerant

tioners by January 1st 2015. Refrigerators and freezers for commercial use (hermetically sealed systems) will be prohibited by January 1st 2017 for HFCs with a GWP of 2500 or more and by January 1st 2020 for HFCs with a GWP of 150 or more. Movable room air-conditioning appliances (hermetically sealed) using HFCs with a GWP of 150 or more will be prohibited by January 1st 2020. Industry and trade organizations agree on a phase-down of HFCs but with a less ambitious goals and some modifications. The approval of the proposed action is necessary within the European Council. Then the proposal shall be discussed at the level of the European Parliament. A new regulation cannot enter into force before 2014 and it is very likely that modifications will be adopted during the approval process. However, a phase-down of HFCs will certainly take place in Europe in the near future [6].

Possible future development of refrigerants is not easy to predict. Interesting projection is presented in Calm's paper [2] and the summary is repeated in **Table 5**.

Natural refrigerants

From the viewpoint of the author of this article, natural refrigerants, especially ammonia are presently available, and long experience exists with their application dating far into the beginning of mechanical refrigeration. The "circle" is now somehow closed, we already returned to natural refrigerants, but now with new technologies and with a lot of experience behind us.

Ammonia has no ozone depletion potential (ODP = 0) and no direct global warming potential (GWP = 0). Due to high energy efficiency of refrigerating equipment operating with ammonia, its contribution to the indirect global warming potential is also low. Ammonia is flammable. However, its ignition energy is 50 times higher than that of natural gas and ammonia will not burn without a supporting flame. Due to the high affinity of ammonia towards (air) humidity it is rated as "hardly flammable". Ammonia is toxic, but has a characteristic, sharp smell which makes a warning below concentrations of 3 mg/m^3 ammonia in air possible. This means that ammonia is evident at levels far below those which endanger health. Furthermore ammonia is lighter than air and therefore rises quickly into the atmosphere [7]. New experience shows that with proper care ammonia can be used efficiently and in a secure manner even in HVAC systems. The market opportunity produced by R-22 phase-out should not be missed by ammonia chiller producers. The major obstacles are legal demands in some countries as well as high initial costs as the consequence of present production in small series. Experience shows also that reasonless fear is connected with security of ammonia application and that should be overcome by adequate addressing to technical as well as to general public.

Carbon dioxide has low critical temperature and condensation is not possible at supercritical temperatures.

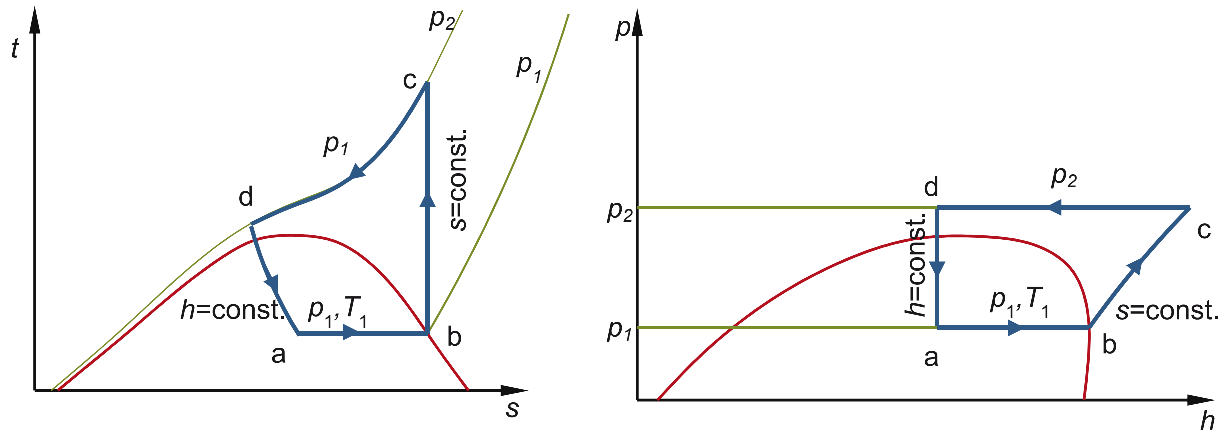

Figure 1. Single-stage vapor - compression transcritical process with R-744 (CO_2) in temperature - entropy t,s- and pressure – enthalpy p,h- diagrams

In that case transcritical process presented in **Figure 1** can be used. Refrigerant cooling down with significant temperature glide at a constant pressure p_1 takes place in a gas cooler (without the phase change) instead in the condenser. Pressure p_1 is not temperature-dependent as in subcritical processes. Temperature glide makes such a process more suitable for countercurrent domestic hot water heating than for application within heating systems with circulation. Internal heat exchange between condensed liquid and suction vapor refrigerant can increase process efficiency. Recent research activities have focused particularly on optimizing plant engineering, and more effective refrigeration plants are being developed to benefit from its extraordinary properties [7].

Hydrocarbons like propane (R290, C_3H_8), propylene (R1270, C_3H_6) or isobutane (R600a, C_4H_{10}) have been used in refrigeration plants all over the world for many years. Hydrocarbons are colorless and nearly odorless gases that liquefy under pressure, and have neither ozone depletion potential (ODP=0) nor significant direct global warming potential (GWP < 3). Thanks to their thermodynamic characteristics, hydrocarbons make particularly energy efficient refrigerants. Hydrocarbons are flammable, however, with current safety regulations, refrigerant losses can be maintained near zero. Hydrocarbons are available cheaply all over the world; thanks to their ideal refrigerant characteristics they are commonly used in small plants with low refrigerant charges [7].

Conclusion

In the future we may expect further research, regulation changes, the design of new systems suitable for the use of newly developed and natural refrigerants, the optimization of the system in the sense of compensating the lower efficiency of some refrigerants, but with keeping cost within acceptable limits. Conclusion is always the same: "No ideal refrigerant", but proper applications suitable for different refrigerants can be found. The chance for "closing the circle" and return to natural refrigerants at a new, high technology level exists and should not be missed. ■

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Net zero energy buildings in focus at ClimaMed 2013 Conference

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Climamed'13 Congress was held on 3–4 October 2013, in İstanbul, Turkey. Climamed conferences are organized by 5 member countries of the REHVA. Founders of Climamed conferences are France, Italy, Spain and Portugal. Turkey joined this group later 4 years ago. Main goal of the conference is discussing regional topics of the Mediterranean climate. This conference was the 7th conference in series since 2004.

Main theme of the congress was the nZEB, especially approaches to the nZEB in these Mediterranean countries. 159 abstracts were received from not only member counties but from 21 countries in the region and all over the world. Finally 90 full papers included in the proceedings book and 66 papers presented orally during the congress and 11 posters were exposed. 22 Technical Sessions were held in 7 parallel rooms during the congress. Technical sessions were designed according to congress themes. Besides, 3 invited lectures were also presented during the congress and a panel was held. Additionally, a seminar was organized by the Eurovent. 429 participants were registered formally at the conference. Including guests and other accompanying people, more than 500 people attended the conference.

Nearly Zero Energy Buildings

The theme of the congress was actually "net zero energy buildings" however the focus was on the nearly zero energy buildings. After EPBD recast announced, nZEB is on the agenda of the EU building and HVAC sector. This topic has been discussed and studied extensively during the conference. Especially approaching nZEB in terms of Mediterranean climate, Mediterranean traditions and finance was the focus point.

We certainly can achieve the nZEB target for new buildings as we achieved the building performance evolution of the last 12 years in Europe. Boundary conditions definition of the global performance evaluation needs still some work and common consensus. But the move towards nZEBs is going to be a major shift, almost a revolution, requiring many changes even to the life of professionals. Buildings of the future shall be quite different from what we are used to design and use today

The general concept of nearly zero energy building was illustrated, introducing the basic concept of "nZEB": low energy demand, high energy efficiency of the system, energy demand cover by RES produced in situ or nearby.

The definition should be clarified first of all. It was highlighted that the indicator to classify the energy performance of an nZEB is expressed in term of primary energy. The boundary where to consider the primary energy indicators has to be clearly accepted by all the countries – a discussion is ongoing at CEN level about the new standard to be adopted. Moreover, a big challenge is how to traduce the "primary energy indicator" in a comprehensible indicator for the market: this issue is at this stage too much academic and it is important to translate this concept to the policy makers, investors and final users.

The other ambiguity is related to renewable energy production on-site or nearby. The definition of nearby is not clear enough. Actually the nZEB concept can be achieved more successfully by designing group of buildings, districts, cities instead of individual buildings. A successful nZEB design ensures a good architectural and urban integration.

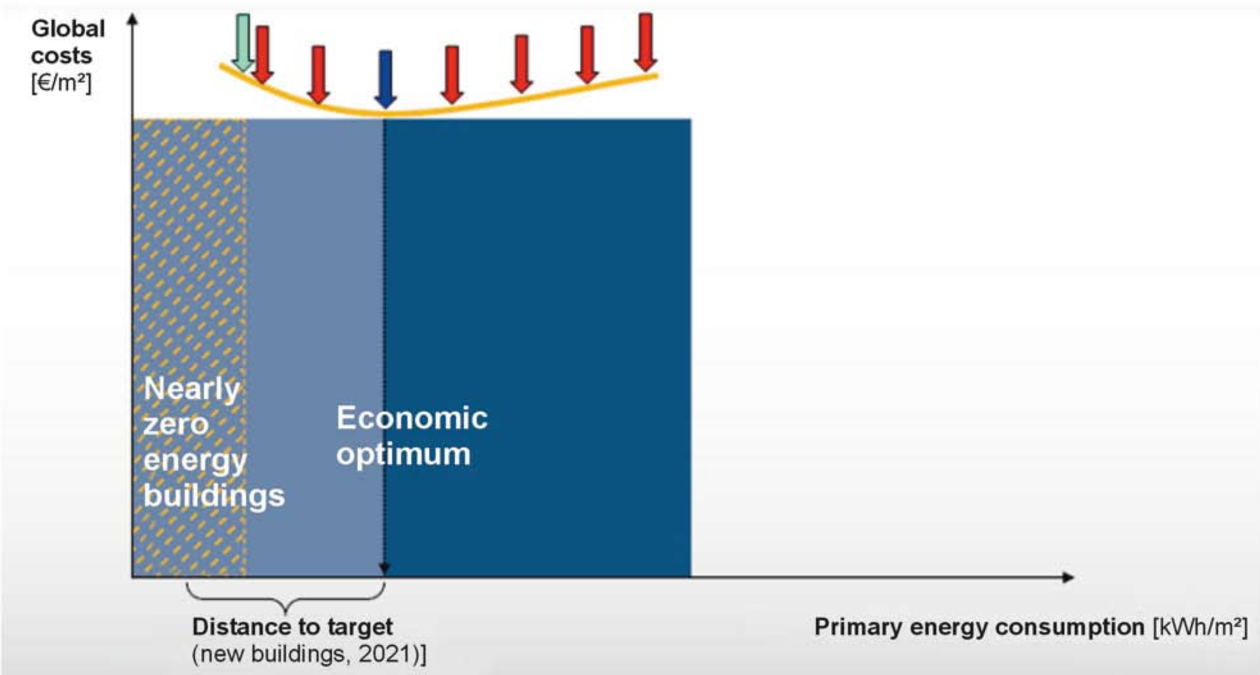


Figure 1. Nearly zero energy buildings may not be cost optimal with current technology and construction practice.

The major challenge is still applying nZEB approach/concept to present building stock. It is expressed as nZERB (nearly zero energy retrofitted buildings). We need to develop this nZERB concept. Urban transformation processes going on especially in developing countries for example in Turkey can be used effectively transforming present building stock.

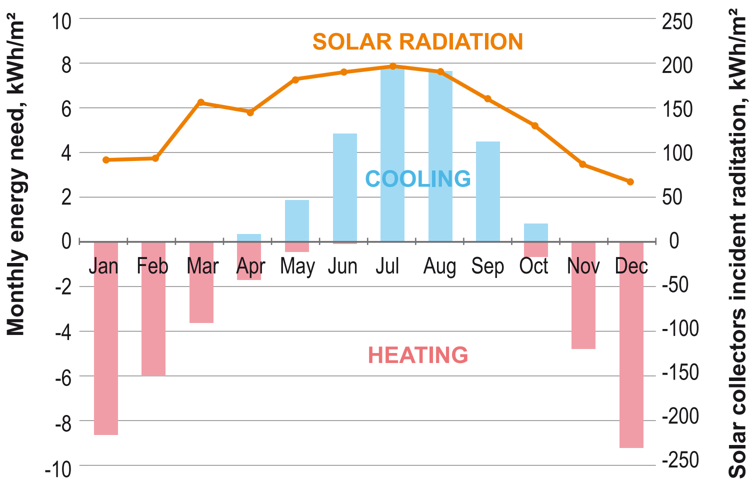


Figure 2. Typical Office Building Energy Need over a Year in Mediterranean Climate.

All these measures should take into account economical/financial aspects using a cost optimal approach (**Figure 1**). The cost optimality has always to be considered when defining the targets of nZEB and cost optimal solutions cannot be achieved without integrated design.

Embedded or embodied energy in the building itself and in its HVAC systems (including renewable energy generation) is very important. Without considering embodied energy satisfactory evaluation of measures cannot be done.

There is yet a clear lack of consensus on what a nZEB should be in the warmer south European climates, where summer cooling plays a fundamental role (**Figure 2**):

- Adequate but not too much insulation;
- Inertia activation;
- Shading;
- Role of natural and mechanical ventilation

This is a challenge at design stage. It is evident that a common and unique vision about "what a nZEB is" has yet to be found for the Med region.

The situation in different Mediterranean countries has been analyzed:

In France, the process, started with the energy certification RT2012, aimed at increasing the energy performance of buildings is going on towards nearly zero energy buildings (**Figure 3**). The new indications of the protocols are addressed firstly to optimize the building envelope and to control the air permeability of buildings. Moreover, the energy classification is now referred to absolute values instead of to the comparison with reference building. New voluntary labels have been set up in order to promote buildings even more efficient than the new regulation; in particular "BEPOS effinergie" is aimed to promote the design and construction of high performing buildings towards positive energy buildings.

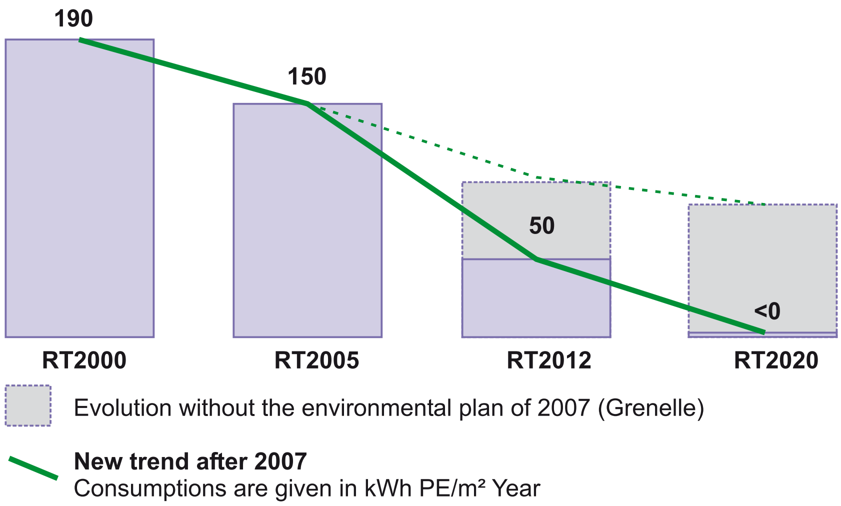


Figure 3. Evolution of the limit for primary energy consumption in French building regulations.

In Italy, the transposition of the EPBD recast has been done in June 2013 by a national law. Now the national law has to be converted into regional laws. The process will require time. By now, only a couple of regions have activated tables to implement the nZEB concept. Critical aspects for these implementations have been highlighted. First, to avoid a "copy and paste" tendency that is to transfer the experiences from Germany and the Scandinavian countries without a critical investigation: in Mediterranean climate, super-insulation is not required, thermal mass activation is needed, mechanical ventilation is not always economically convenient, punctual control of solar radiation along the year is absolutely required.

Also in Portugal, the process of implementing the nZEB concept has to be yet fully developed. There is a definition and a concept, but no values yet. It is highlighted that a major goal is to handle retrofitted buildings: how to plan a deep renovation of the existing building stock toward nearly zero energy building while keeping the costs under control. An open discussion is related to ventilation: natural or mechanical? The national tradition is for natural ventilation: in fact, in the Mediterranean areas, the temperature differences between outdoors and indoors is quite low also in the extreme season. The energy production by RES is also discussed: the use of RES produced "nearby" is considered as locally produced by the Portuguese interpretation, in RES installations specifically linked to a building or a group of buildings.

In Spain, the new concepts about nZEB have been transposed in a law in September 2013. The process is considered as a natural evolution of the energy certification, using the same tools and approach. Basically, the requirements about the building energy performances have been incremented (for example, lower thermal transmittance are required) in order to create a process towards nZEB.

Turkey is stating an ambitious program to follow the EU indications. The first step is the definition of reference buildings for the residential sector, and the application of packages of retrofit measures for cost optimality investigations.

Indoor air quality and nZEB

Human being is in the focal point of the whole air conditioning activities. We air condition the buildings for occupant's comfort and health, we need to give a comfortable and reliable environment to occupants. Productivity is the primary criteria designing some type of buildings, such as office buildings or educational facilities. It is necessary to satisfy the occupant's requirements in nZEB. The design should consider the IAQ requirements.

The other very important issue is the occupant behaviour on energy consumption. **Occupant behaviour can impact the energy consumption with a factor 3–6.** Often main reason why predicted energy use does not match measured energy use is the occupant behaviour. Assumptions regarding occupant behaviour are used as input parameters to energy calculation. Suitable models for occupant behaviour are required for a better prediction of energy consumptions of buildings.

Findings of a presented study demonstrated that predefined heating set-point preferences and air change rates used as assumption in building energy simulation are far away from actual occupant's preferences in buildings. Results of the study highlight significant influences of occupant behavior on the building energy demands. Energy consumption in the simulated high performing building in which occupants personal control is performed by probabilistic functions, raised up to 36% in comparison to the high performing building where the occupants' interaction with the controls is regulated in a deterministic way by fixed schedules.

Revision of Indoor Environmental Quality Standard **EN15251,** need to be complying with nZEB concept. Standard EN15251 brings new approaches. Instead of absolute values, categories and ranges are defined. Moreover, adaptive comfort approach is introduced.

Table 1. The recommended criteria are given for several categories (EN 15251:2007).

Category	Explanation
I	High level of expectation and is recommended for spaces occupied by very sensitive and fragile persons with special requirements like handicapped, sick, very young children and elderly persons
II	Normal level of expectation and should be used for new buildings and renovations
III	An acceptable, moderate level of expectation and may be used for existing buildings
IV	A level that may cause some discomfort; but no health risk.
V	Outside categories. This should only be accepted for a limited part of the year

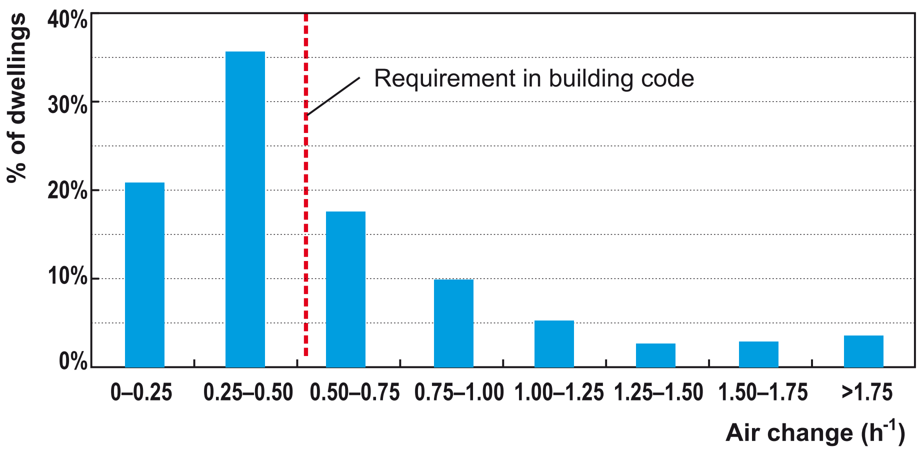


Figure 4. Air change has been measured in 500 Danish homes. In more than half of the homes ventilation was below the requirements in building code.

This European Standard specifies the indoor environmental parameters which have an impact on the energy performance of buildings.

- Set points are effective both on energy consumption, comfort and productivity.
- CO_2 sensors can effectively be used in ventilation applications, especially in demand controlled ventilation applications.
- Ventilation rates are specified for different categories and applications.
- Ventilation rates should consider both people and building (**Figure 4**)
- Air cleaners and ventilation can be combined.
- Occupant behavior should be considered.

Renewable Energy and nZEB

Future developments in the HVAC sector seem toward the renewable supported mixed systems. For such systems energy efficiency will be expected to reach 150%.

Photovoltaic solar power production seems most promising renewable electricity production system. There are many studies continuing on photovoltaic alone or hermetic systems. Simultaneous power and thermal energy producing special vertical sandwiching option of a PHVT module yields higher specific power outputs.

Photovoltaic panels can be used to power the compressor of an inverter air conditioning unit. This hybrid air conditioning unit simultaneously connected to grid and to photovoltaic panels. This option is especially suitable for small installations.

Variable Refrigerant Flow systems bring opportunities to reducing CO_2 emissions for hot water heating systems. Air to water VRF heat pump systems are considered as renewable heat generators and their thermal efficiency values are much higher than the conventional gas firing boilers. New generation VRF systems can work efficiently even in cold winter conditions. Combining VRF with the photovoltaic panels it was proved that net Zero Energy Building target can be achieved. This was shown by the measured data of a case study in Germany. ■

Outdoor air pollution – a leading environmental cause of cancer deaths

IARC scientific publication no. 161: Air Pollution and Cancer
Editors: Kurt Straif, Aaron Cohen and Jonathan Samet

The specialized cancer agency of the World Health Organization, the International Agency for Research on Cancer (IARC), announced on 17 October 2013 that it has classified outdoor air pollution as carcinogenic to humans (Group 1).

After thoroughly reviewing the latest available scientific literature, the world's leading experts convened by the IARC Monographs Programme concluded that there is sufficient evidence that exposure to outdoor air pollution causes lung cancer (Group 1). They also noted a positive association with an increased risk of bladder cancer.

Particulate matter, a major component of outdoor air pollution, was evaluated separately and was also classified as carcinogenic to humans (Group 1). The IARC evaluation showed an increasing risk of lung cancer with increasing levels of exposure to particulate matter and air pollution. Although the composition of air pollution and levels of exposure can vary dramatically between locations, the conclusions of the Working Group apply to all regions of the world.

Air pollution is already known to increase risks for a wide range of diseases, such as respiratory and heart diseases. Studies indicate that in recent years exposure levels have increased significantly in some parts of the world, particularly in rapidly industrializing countries with large populations. The most recent data indicate that in 2010, 223 000 deaths from lung cancer worldwide resulted from air pollution.

The IARC Monographs Programme, dubbed the "encyclopaedia of carcinogens", provides an authoritative source of scientific evidence on cancer-causing substances and exposures. In the past, the Programme evaluated many individual chemicals and specific mixtures that occur in outdoor air pollution. These included diesel engine exhaust, solvents, metals, and dusts. But this is the first time that experts have classified outdoor air pollution as a cause of cancer.

"Our task was to evaluate the air everyone breathes rather than focus on specific air pollutants," explains Dr Dana Loomis, Deputy Head of the Monographs Section. "The results from the reviewed studies point in the same direction: the risk of developing lung cancer is significantly increased in people exposed to air pollution."

The predominant sources of outdoor air pollution are transportation, stationary power generation, industrial and agricultural emissions, and residential heating and cooking. Some air pollutants have natural sources, as well.

"Classifying outdoor air pollution as carcinogenic to humans is an important step," stresses IARC Director Dr Christopher Wild. "There are effective ways to reduce air pollution and, given the scale of the exposure affecting people worldwide, this report should send a strong signal to the international community to take action without further delay."

The International Agency for Research on Cancer (IARC) is part of the World Health Organization. Its mission is to coordinate and conduct research on the causes of human cancer, the mechanisms of carcinogenesis, and to develop scientific strategies for cancer control. The Agency is involved in both epidemiological and laboratory research and disseminates scientific information through publications, meetings, courses, and fellowships.

Download the report in ePUB format from
http://www.iarc.fr/en/publications/books/sp161/index.php

20 years of European Certification of HVAC&R products

"In 2013, CERTITA and EUROVENT CERTIFICATION Company successfully completed the merger of their certification activities within a new corporation named Eurovent Certita Certification.

The combined company becomes a major European certification body in the field of HVAC-R, operating 35 certification programs and generating about € 9 million in turnover. Eurovent Certita Certification is offering various certification schemes tailored to the needs of manufacturers and stakeholders on their specific markets. It focuses on certifying product performances as well as data needed to implement regulations. The main quality marks currently proposed are the marks "Eurovent certified performance", NF, CSTBat, and the European Keymark.

On a market ever more demanding in terms of energy performances and environmental challenges, Eurovent Certita Certification is fit for supplying certified data at a European level and providing the needed confidence on the playing field.

With this special ACREX issue of REHVA Journal we welcome the opportunity to present you 20 years of third party performance certification expertise and know-how, applied to more than 400 manufacturers, 35 HVAC-R product ranges and more than 100 000 product references."

ERICK MELQUIOND
President
Eurovent Certita Certification

Certification schemes proposed for both domestic & industrial facilities:

- **Thermodynamics**:
  Heat pumps, air conditioners, liquid chilling packages, VRF, rooftop …
- **Comfort appliances**:
  Radiators, fan coils, solar collectors and heaters, heating appliances using liquid or solid fuels, mobile liquid fuel heaters, chilled beams …
- **Cooling & refrigeration**:
  Cooling and heating coils, cooling towers, heat exchangers, milk coolers, condensing units, compressors, refrigerated display cabinet...
- **Ventilation**:
  Mechanical ventilation, air handling units, fans, flue pipes, filters, heat recovery …

EUROVENT CERTITA CERTIFICATION launches the 1st European wide certification programme for Residential Air Handling Units (RAHU)

After nearly two years, the Eurovent Launching Committee for Residential Air Handling units (RAHU) – composed by five European manufacturing companies – finalized the Operational Manual and Rating Standards for RAHU. The scope of this new programme includes all residential supply and exhaust ventilation units equipped with heat recovery systems including air-to-air heat-pumps.

The certification programme is based on random testing of units according to the European standard EN 13141:2011. All tests will be performed by independent testing laboratories accredited according to ISO 17025, based in France, Finland and Munich.

The following schedule is being foreseen:

December 2013: Signing of agreement by manufacturers for RAHU programme (please contact: **apply@eurovent-certification.com**). There is no deadline as this is a voluntary registration.

October 2014: Publication of certified data on Eurovent Certification website by 30th September 2014 for all manufacturers signing the agreement before 31st September 2013.

A full description including the certificated characteristics and tolerances is following.

A dedicated Energy Efficiency Label for the Eurovent Certified Performance mark

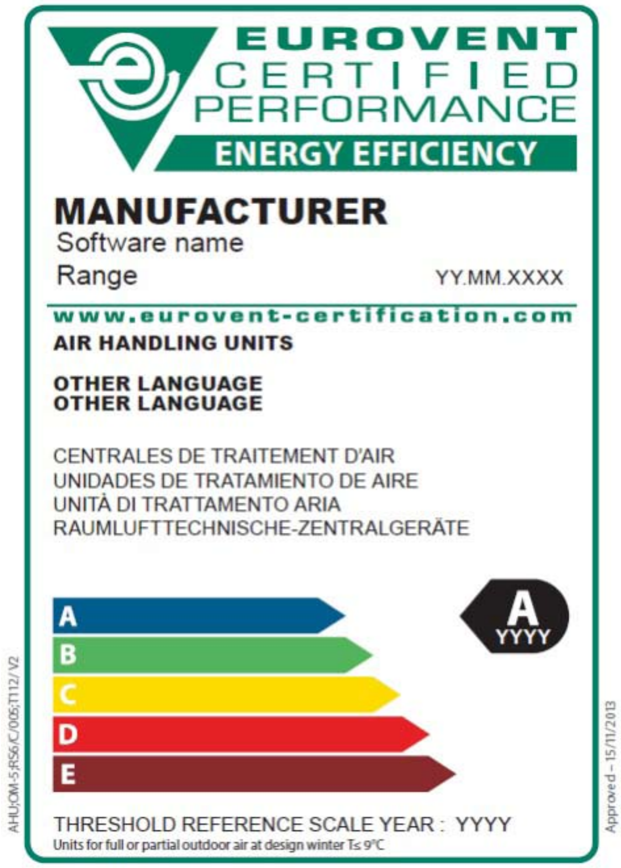
Late 2013, a simplified energy efficiency label was introduced to the market for the mark "Eurovent Certified Performance". While the base energy efficiency parameters (exple: EER for chillers, EEI for Display Cabinets…) and existing thresholds remain unchanged, the look and content were modified.

3 Key features:

1) Five energy classes:
   Products are distributed from top to bottom in classes from A to E. All the products with performance falling under D threshold, even if earlier separated, are now grouped together under the E class.

2) The class A is colored in dark blue making it unique and easy to identify.

3) Clear information is given on the threshold reference scale year. It is displayed at the bottom of the label but also on the black grade arrow.



Exple of the Air Handling Unit label template.

Certification Programmes

- Air Filters Class M5-F9 *
- Air Handling Units*
- Air to Air Plate Heat Exchangers*
- Air to Air Rotary Heat Exchangers *
- Chilled Beams*
- Close Control Air Conditioners*
- Comfort Air Conditioners*
- Cooling & Heating Coils
- Cooling Towers
- Drift Eliminators
- Fan Coils Units*
- Heat Exchangers *
- Heat Pumps*
- Liquid Chilling Packages *
- Remote Refrigerated Display Cabinets
- Residential Air Handling Units (RAHU)
- Rooftop (RT)*
- Variable Refrigerant Flow (VRF)*

* All models in the production has to be certified

Air Handling Units

CERTIFY ALL

Swegon has participated in the program for Air Handling Units from the start. The first priority at that time, and still is, was to find a way for fair competition. This is a long term struggle were we try to cover all aspects from manufacturing to software performance predictions and its agreement with tests. We discuss and take decisions about mandatory performance in software printout, rules for the energy labelling, how to test and what to apply in the, on site, auditor check. Customers should go for Eurovent certified products, to get reliable data, and then they can cut the main cost and take care of the environment by minimising the use of energy.

Committee chair:
Mr Gunnar Berg
Development Engineer, Swegon

Scope of certification

This Certification Programme applies to selected ranges of Air Handling Units.

Participants shall certify all models in the selected product range up to the maximum stated air flow.

A range to be certified shall include at least one size with a rated air volume flow below 7 m³/s (25 000 m³/h).

Certification requirements

For the qualification procedure: the selection software will be verified by our internal auditor. A visit on production site will be organized. During that visit, the auditor will select one real unit per range, as well as several model boxes that will cover all mechanical variations.

The selected units will be tested and performances delivered by the selection software will be compared to the performances measured in an independent laboratory.

For the repetition procedures, the auditor will annually check the software conformity against the production data, and tests will be repeated every 3 to 6 years.

Certified characteristics & tolerances

- External Pressure: 4% or 15 Pa
- Absorbed motor power: 3%
- Heat recovery efficiency: 3%-points
- Heat recovery pressure drop (air side): max. of 10% or 15 Pa
- Water coil performances (heating/cooling): 2%
- Water coil pressure drop (water side): max. of 10% or 2 kPa
- Radiated sound power level casing: 3 dB(A)
- Sound power level unit openings:
  - 5 dB @ 125 Hz
  - 3 dB @ 250 – 8 000 Hz

ECC Reference documents

- Certification manual
- Operational Manual OM-5
- Rating Standard RS 6/C/005

Testing standards

- EN 1886: "Ventilation for buildings – Air handling units – Mechanical performance"
- EN 13053: "Ventilation for buildings – Air handling units – Rating & performance for units components and sections"

Air to Air Plate Heat Exchangers

CERTIFY ALL

Scope of certification

This Certification programme applies to selected ranges of Air to Air Plate Heat Exchangers. Participants shall certify all models in the selected range, including:

- cross flow, counter-flow and parallel flow units
- all sizes
- all materials
- all airflow rates
- all edge lengths
- plate heat exchanger with humidity transfer

Heat Exchangers with accessories such as bypass and dampers shall not be included.

Manufacturers shall declare production places and provenance of products is randomly chosen. The programme does not cover other types of Air to Air Heat Exchangers like Rotary Heat Exchangers or Heat Pipes. Combination of units (twin exchangers) shall not be included.

Certification requirements

For each range to be certified, 3 units for qualification and 1 for yearly repetition will be selected by Eurovent Certita Certification and tested in an independent Laboratory.

Certified characteristics & tolerances

- Dimensions: ± 2 mm
- Plate spacing: ± 1% or ± 1 plate
- Dry efficiency: –3 percentage points
- Wet efficiency: –5 percentage points
- Humidity efficiency: -5%
- Pressure drop: +10%, minimum 15 Pa

ECC Reference documents

- Certification manual
- Operational Manual OM-8
- Rating Standard RS 8/C/001

Testing standards

- EN 308

Air to Air Rotary Heat Exchangers

CERTIFY ALL

Scope of certification

This Certification Programme applies to all Rotary Heat Exchangers in-cluding casing. Participants shall certify all models, if available, including:

- all classes: condensation rotor / non hygroscopic rotor / enthalpy rotor ; hygroscopic rotor / sorption rotor
- all rotor geometry (wave height, foil thickness)
- all sizes (rotor diameters and rotor depths)
- all materials
- all airflow rates
- all different types of sealing (if available)

Certification requirements

For the qualification procedures 1 unit per class of rotor will be selected and tested by an independent laboratory. For yearly repetition, 1 unit will be selected.

Certified characteristics & tolerances

- Temperature Efficiency: –3% points
- Humidity Efficiency: –5% points (min. tolerance 0.2 g/kg in absolute humidity of leaving supply air
- Pressure Drop: +10% (min 10 Pa)

ECC Reference documents

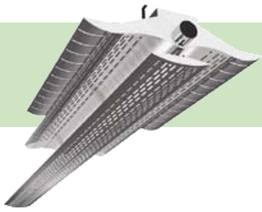
- Certification manual
- Operational Manual OM-10
- Rating Standard RS 8/C/002

Testing standards

- EN 308
- ARI 1060

Chilled Beams

CERTIFY ALL



Scope of certification

This Certification Programme applies to all Active and Passive Chilled Beams.

Chilled Beams are presented by ranges but all ranges must be certified. This applies to all product ranges which have either catalogue leaflets with product details including technical data or similar product information in electronic format.

Certification requirements

For the qualification & repetition procedures (yearly): 3 units are selected from regular production and tested in the independent Laboratory selected by Eurovent Certification.

Obtained performances shall be compared with the values presented in the catalogues or electronic selection from manufacturer's website.

Certified characteristics & tolerances

Cooling capacity: 3 conditions are required.

- Active: 80 – 100 – 120% of the nominal air flow rate.
- Passive: 6 – 8 – 10°C temperature difference.

ECC Reference documents

- Certification manual
- Operational Manual OM-12
- Rating Standard RS 2/C/007

Testing standards

- EN 14518: "Testing and rating of Passive Chilled Beams"
- EN 15116: "Testing and rating of Active Chilled Beams"

Close Control Air Conditioners

CERTIFY ALL

Scope of certification

This Certification Programme applies to factory-made units intended for Close Control Air Conditioning. This programme includes units with cooling capacities up to 100 kW under the specified test conditions.

Participating companies must certify all production models within the scope of the programme.

Certification requirements

For the qualification & repetition procedures: 10% of the units declared will be selected and tested by an independent laboratory.

Certified characteristics & tolerances

Air-Cooled and Water-Cooled Close Control Air Conditioners

- Total cooling capacity : –8%
- Sensible cooling capacity :–8%
- EER : –8%
- A-weighted sound power level : +0 dB

Chilled-Water Close Controls Air Conditioners

- Total cooling capacity : –8%
- Sensible cooling capacity : –8%
- Effective power input : +8%
- A weighted sound power level : +0 dB
- Water pressure drop :+10%

ECC Reference documents

- Certification manual
- Operational Manual OM-1
- Rating Standard RS 6/C/001
- Rating Standard RS 6/C/004
- Rating Standard RS 6/C/006

Testing standards

- EN 14511
- EN 12102 - EUROVENT 8/1

Comfort Air Conditioners

CERTIFY ALL

Scope of certification

This certification programme includes:

- AC1: comfort air cooled AC and air to air HP with cooling capacity up to 12 kW, except double duct and single duct units.
- AC2: comfort units with cooling capacity from 12 to 45 kW
- AC3: comfort units with cooling capacity from 45 to 100 kW

This programme applies to factory-made units intended to produce cooled air for comfort air conditioning (AC1, AC2, AC3). It also applies to units intended for both cooling and heating by reversing the cycle. For the AC1 programme units out of Regulation 206/2012 are excluded.

Participating Companies must certify all production models within the scope of the programme they enter. However concerning multi-split air conditioners, only systems with maximum two indoor units are included, same mounting type, capacity ratio 1+/- 0.05.

Certification requirements

For the qualification & yearly repetition procedures: AC1 : 8% of the units declared are selected and tested by an independent laboratory, and 30% of the selected units are tested at part load conditions. AC2 & AC3 : 10% of the units declared are selected and tested by an independent laboratory.

Certified characteristics & tolerances

- Capacity (cooling and heating) –5%
- Efficiency (EER and COP) –8%
- Seasonal Efficiency (SEER and SCOP): –0% (the product is automatically downgraded (or rerated) if partload efficiency criteria fails)
- A-weighted sound power level +0 dB
- Auxialiary power +10%

ECC Reference documents

- Certification manual
- Operational Manual OM-1
- Rating Standard RS 6/C/001 - RS 6/C/001A - RS 6/C/006

Testing standards

- EN 14511 • EN 14825 • EN 12102

Fan Coils Units

CERTIFY ALL

EUROVENT CERTIFIED PERFORMANCE ENERGY EFFICIENCY CHECK ENERGY CLASS ON www.eurovent-certification.com

Scope of certification

This Certification Programme applies to Fan Coil Units using hot or chilled water. It concerns both non ducted and ducted fan coils:

- Non ducted units: Fan Coil Units with air flow less than 0.7 m³/s and a published external static duct pressure at 40 Pa maximum.
- Ducted units: Fan Coil Units up to 1 m³/s airflow and 300 Pa available pressure.
- District cooling units and 60 Hz units can be certified as an option

Participating companies must certify all production models within the scope of the programme.

Certification requirements

Repetition procedure: the number of units to be tested each year will be proportional to the number of his basic models listed in the Directory, in an amount equal to 20% for Fan Coil Units with a minimum of one test.

Certified characteristics & tolerances

- Capacity (cooling, sensible, heating): –5%
- Water pressure drop: +10%
- Fan power input: +10%
- A-weighted sound power: +1 / +2 dB(A)
- Air flow rate: –10%
- Available static pressure 0 Pa for medium speed and –5 Pa for other speeds
- FCEER & FCCOP
- Eurovent energy efficiency class

ECC Reference documents

- Certification manual
- Operational Manual OM-1A
- Rating Standard RS 6/C/002
- Rating Standard RS 6/C/002A

Testing standards

- Performance testing: Eurovent 6/3, 6/11, 6/10
- Acoustic testing: Eurovent 8/2, 8/12

Cooling Towers

The importance of air conditioning and industrial cooling is constantly increasing in modern architecture and industrial process cooling. The human perception of comfort and the new challenges to reduce the electrical power consumption and CO2 footprint have designers striving for optimal system performances with the highest possible efficiencies. Reliable thermal performances are crucial to ensure these best efficiencies which are typical for cooling circuits driven by evaporative cooling equipment. On a yearly basis, one random picked cooling tower of each Eurovent-CTI certified product line will be full scale thermal tested by applying the CTI standard 201.

Eurovent Certification Company guarantees the consistency of thermal testing and manufacturing of European and non-European companies that subscribe to the program.

Committee chair:
Mr Rob Vandenboer
Product Manager, Quality Manager
Evapco Europe, BVBA

The first ECC / CTI collaborative certification program for Cooling Towers

The Eurovent Certification Company (ECC, Brussels, Belgium) is pleased to announce the Certification programme for cooling tower thermal performance developed in cooperation with the Cooling Technology Institute Est.1950 (CTI, Houston, Texas, USA). The scope of the program includes standardized model lines for open circuit cooling towers, typically factory assembled. Standardized model lines are composed of individual models that are required to have published thermal rating capacities at corresponding input fan power levels.

Thermal performance certification via this program offers a tower buyer assurance that the capacity published for the product has been confirmed by the initial and on-going performance testing per the requirements of the program using CTI STD-201. It also offers for regulators of energy consumption related to cooling towers, that the capacity of the towers has been validated. Minimum energy efficiency standards such as ASHRAE 90.1, which requires cooling tower energy efficiency validation by the CTI certification process, are used by governments and by green building certification programs such as LEED™.

Scope of certification

This Certification Programme for Cooling Towers applies to product ranges (or product lines) of Open-Circuit series and Closed Circuit Cooling Towers that:

- Are manufactured by a company whose headquarter or main facility are located in Europe, Middle-East, Africa or India. After getting the Eurovent Certification, the CTI certificate could be requested.
- Have already achieved and hold current certification by the Cooling Technology Institute (CTI) according to CTI STD-201.

Certification requirements

For the qualification & yearly repetition procedures our internal auditor visits the production place and reviews the conformity of Data of Records. One unit per range is selected and tested by an independent test agency.

Certified characteristics & tolerances

- Certified characteristic shall be per CTI STD-201
- Entering wet bulb temperature: –12.8°C to 32.2°C (55°F to 90°F)
- Cooling range > 2.2°C (4°F)
- Cooling approach > 2.8°C (5°F)
- Process fluid temperature < 51.7°C (125°F)
- Barometric pressure: –91.4 to 105.0 kPa (27" to 31" Hg)

ECC Reference documents

- Certification manual
- Operational Manual OM-4-2013
- Rating Standard RS 9/C/001-2010

Testing standards

- CTI STD-201 RS
- ECC OM-4-2013

Cooling & Heating Coils

Heating Cooling Coils (HCCs) which enable the conditioning of different zones and flexibility in application in buildings are generally employed in compact and central station AHU. To meet the required extra capacity in various processes, they are also used as heating or cooling devices.

With the application of these coils to high energy efficient heat recovery systems, the entire system becomes more compact as well as it avoids occupation of large spaces. Besides, they can be applied to Variable Air Volume (VAV) systems used for conditioning of hospitals, shopping centers and convention facilities.

The Certification programme for the HCCs has increased integrity and accuracy of the industrial performance ratings which provides clear benefits for end users who can be confident that the product will operate in accordance with design specifications. Also, by means of this certification programme users can collect reference data on the fundamental characteristics of the HCCs, such as capacity, pressure drop, mass flow complying with the standard of EN 1216.

Committee chair:
Engin Söylemez
R&D Test Engineer, Friterm A.Ş

Scope of certification

The rating standard applies to ranges of forced circulation air cooling and air heating coils as defined in ENV1216.

Certification requirements

- Qualification and repetition procedures: units declared will be selected and tested by an independent laboratory.
- The number of units will depend on the variety of coil material configurations and their applications for the applied range.
- The selection software will be verified in comparison with the test results.

Certified characteristics & tolerances

- Capacity: –15%
- Air side pressure drop: +20%
- Liquid side pressure drop: +20%

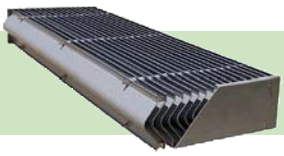
ECC Reference documents

- OM-9
- RS 7/C/005

Testing standards

- ENV 1216

Drift Eliminators



Scope of certification

The Certification Programme for Drift Eliminators applies to Drift Eliminators used for evaporative water-cooling equipment.

Certified characteristics & tolerances

The following characteristics shall be certified by tests:

- For counter-flow and cross-flow film fill, the average drift losses of the two tests at 3.5 m/s are less than 0.007% of circulating water flow rate.
- For cross-flow splash fill, the average drift losses of the two tests at 3 m/s are less than 0.007% of circulating water flow rate.

No tolerance will be applied on the average drift losses.

ECC Reference documents

- Certification manual
- Operational Manual OM-14
- Rating Standard RS 9/C/003

Testing standards

- CTI ATC-140

Air Filters Class M5-F9

CERTIFY ALL

Today, people spend most of the time inside of buildings. Hence, indoor air quality is a key factor to human health. Air filters removing fine dust from the air stream are the key component in building heating, ventilation and air conditioning systems to supply air of the required cleanliness and to ensure a high level of indoor air quality. With the air filter certification program, reliable and transparent filter data are ensured to customers. On a yearly base, four different filters are selected out of the product range of each participant for testing at independent laboratories according to EN 779:2012, verifying the initial pressure drop, the filter class and the initial and minimum efficiency, as well as the energy efficiency class to Eurovent document 4/11. Additionally, with the new energy efficiency label, Eurovent provides valuable data to enable users to select the most energy efficient air filters.

Committee chair:
Dr. Thomas Caesar
Head of Filter Engineering Industrial Filtration Europe
Freudenberg Filtration Technologies SE & Co. KG

Scope of certification

- This Certification Programme applies to air filters elements rated and sold as "Medium or Fine Air Filters M5-F9" as defined in EN 779:2012 and with a front frame size of 592 x 592 mm according to standard EN 15805.
- When a company joins the programme, all relevant air filter elements shall be certified.

Certification requirements

- For the qualification & repetition procedures: 4 units will be selected and tested by an independent Laboratory selected by Eurovent Certification.

Certified characteristics & tolerances

- Filter class: no tolerance.
- Initial pressure drop: +10% + 5 Pa (minimum 15 Pa)
- Initial efficiency for F7 to F9: 10% – point
- Discharge efficiency for F7 to F9: 10% – point
- Annual energy consumption +10% +60 kWh/a

ECC Reference documents

- Certification manual
- Operational Manual OM-11
- Rating Standard RS 4/C/001

Testing standards

- EN 779:2012
- Eurovent 4/11

Residential Air Handling Units (RAHU)

Scope of certification

This programme applies to balanced residential AHUs (supply and exhaust) with heat recovery systems such as:

- Air-to-air **plate** heat exchangers
- Air-to-air **rotary** heat exchangers
- **Heat-pumps**

with a nominal airflow below 1 000 m³/h.

Certification requirement

- Qualification test campaign: 1 test per heat recovery type.
- Repetition test campaign: 1 test every 2 years for each heat recovery type.
- Units are sampled directly from selling points.

Certified performances

- Leakage class
- Aeraulic performances:
- Airflow/pressure curves
- Maximum airflow [m³/h]
- Electrical consumption [W]
- Specific Power Input SPI [W/(m³/h)]
- Temperature efficiency / COP
- Performances at cold climate conditions
- SEC (Specific Energy Consumption) in [kWh/(m².an)]
- A-weighted global sound power levels [dB(A)]

Tolerances

- Leakage class 0
- Airflow +/-10%
- Temperature efficiency –3%-point
- Temperature efficiency at cold climate –6%-point
- COP / EER –8%
- A-weighted global sound power levels +2dB(A)
- Electrical consumption +7%
- Specific Power Input SPI +7%

ECC Reference documents

- Certification manual
- Operation manual OM-16
- Rating standard RS 15/C/001

Testing standards:

- European standard EN 13141-7:2010

Heat Exchangers

Air coolers for refrigeration

Dry coolers

Air cooled condensers

The purpose of the Eurovent "Certify-All" certification programme for heat exchangers is to encourage honest competition and to assure customers that equipment is correctly rated.

The programme covers 3 product groups:

- Unit Air Coolers
- Air Cooled Condensers
- Dry Coolers

The "Certify-All" principle ensures that, for heat exchangers, all models in the three product categories are submitted for certification, not just some models chosen by the manufacturer.

A product energy class scheme has been incorporated into the certification programme, based on 7 classes from "A++" to "E" in order to provide a guide to the best choice of product: this enables the user to minimize life-cycle costs, including running costs which account for a much superior sum than the initial investment cost.

Committee chair:
Stefano Filippini
Technicalmanager - LUVE

Scope of certification

The Eurovent Certification Programme for Heat Exchangers applies to products using axial flow fans. The following products are excluded from the Eurovent Certification Programme for Heat Exchangers:

- Products units using centrifugal type fans.
- Units working at 60 Hz

In particular, the following products are also excluded from the Eurovent Certification programme for Dx Air Coolers and Air Cooled Condensers:

- Products using R717 refrigerant (ammonia), CO_2, and refrigerants with high glide like R407C or without correction factors
- Product ranges of Dx Air Coolers where maximum standard SC2 is below 1.5 kW.
- Product ranges of Air Cooled Condensers where maximum standard capacity under DT1 15K is below 2.0 kW

Certification requirements

- Qualification: units selected by Eurovent Certification shall be tested in an Independent Laboratory selected by Eurovent Certification.
- Repetition procedure: units selected from regular production shall be tested on a yearly basis.

Certified characteristics & tolerances

- Standard capacity –8%
- Fan power input +10%
- Air volume flow ±10%
- External surface area ±4%
- Energy ratio R
- Energy class

For Dry Coolers:

- Liquid side pressure drop +20%

For Air Cooled Condensers and Dry Coolers:

- A-weighted sound pressure level: +2 dB(A)
- A-weighted sound power level: +2 dB(A)

ECC Reference documents

- Certification manual
- Operational Manual OM-2
- Rating Standard RS 7/C/005

Testing standards

- Thermal Performance EN 328
- Thermal Performance EN 327
- Thermal Performance EN1048
- Acoustics EN 13487

Liquid Chilling Package & Heat Pumps

CERTIFY ALL

Scope of certification

- This programme applies to standard chillers and hydronic heat pumps used for heating, air conditioning and refrigeration.
- They may operate with any type of compressor (hermetic, semi-hermetic and open) but only electrically driven chillers are included.
- Only refrigerants authorised in EU are considered. Chillers may be air cooled, liquid cooled or evaporative cooled.
- Heating-only hydronic heat pumps, 60 Hz units and Higher capacities (between 600 kW and 1500 kW) units can be certified as an option.

Certification requirements

Qualification and repetition: a certain number of units will be selected by Eurovent Certification and tested every year, based on the number of ranges and products declared.

Certified characteristics & tolerances

- Cooling & heating capacity and EER & COP at full load: < –5%
- Seasonal Efficiency ESEER: automatically rerated when Part Load efficiency criteria fails
- A-weighted sound power level: > +3 dB(A)
- Water pressure drop: +15%

ECC Reference documents

- Certification manual
- Operational Manual OM-3
- Rating Standard RS 6/C003 - RS 6/C/003A

Testing standards

- Performance testing: EN 14511
- Sound testing: EN 12102

Remote Refrigerated Display Cabinets

CERTIFY ALL

EUROVENT CERTIFIED PERFORMANCE ENERGY EFFICIENCY CHECK ENERGY CLASS ON www.eurovent-certification.com

Why do we need transparent information on refrigeration equipment?

Refrigeration in the supermarkets represents between 30 to 60% of the electrical consumption of the store. For design offices, consultants and end-users, the difference in energy efficiency of the products shall be accurate and visible, so that it is possible to make the right choice.

Furthermore the Europe targets an energy saving by 2020 and put in place an Energy Related Product Directive. The less efficient products will be banned from the market.

Only a Certification program via its independent controls guarantees the required transparency and it allows a fair market.

Committee chair: ***Stéphane Mousset***
Product Manager – Marketing, EPTA Group

Scope of certification

- 100 basic model groups divided in 5 categories of remote units : semi-verticals and verticals (with doors); multi-deckers; islands; service counters; combi freezers.
- At least two references per basic model group representing 80% of sales shall be declared.
- One Bill of Material for each declared reference.

Certification requirements

- Qualification: sampling and test of one unit & Audit of one factory.
- Repetition test of one unit per brand every 6 months & Annual audit of each factory.

Certified characteristics & tolerances

- Warmest and coldest product temp. ±0.5°C
- Refrigeration duty (kW) 10%
- Evaporating temperature –1°C
- Direct elec. Energy Consumption (DEC) +5%
- Refrigeration elec. Energy Cons (REC) +10%
- M-Package Tclass : ±0.5°C
- Total Display Area (TDA) –3%

ECC Reference documents

- Certification manual
- Operational Manual OM-7
- Rating Standard RS 14/C/001

Testing standards

- EN ISO 29953 and amendments

Rooftop (RT)

CERTIFY ALL

The Eurovent rooftop certification (RT) program covers air-cooled and watercooled packaged rooftop units below 100 kW in cooling mode, with an option to certify units from 100 kW to 200 kW. The Rooftop program participants represent the five main European rooftop manufacturers.

Eurovent certifies indoor and outdoor sound levels, cooling and heating capacity and efficiency. Certified performances provide transparency and fair comparison between manufacturers. It is also the basis for the reliable study of HVAC system energy performance.

Currently the program evolves towards part load efficiency (SEER, SCOP) and certification of performance simulation tool data. Current work done on EN 14825 aims to address rooftops in the calculation hypothesis. The software certification is a key item to comply with existing and coming certification of building energy calculations in the EU countries.

Committee chair:

Mr Philippe Tisserand

Product Manager for rooftop & commercial unitary for Trane EMEIA – Chairman of Eurovent Rooftop program compliance committee

Scope of certification

- This Certification Program applies to air-cooled and water cooled rooftops rated below 100 kW.
- Models with cooling or heating capacity ranging from 100 kW to 200 kW can be certified as an option.
- Models of rooftops using gas burners for heating shall be only certified for cooling.

Certification requirements

- For the qualification and repetition procedures (yearly) between 1 & 3 units are selected and tested by Eurovent Certification, depending on the number of products declared.

Certified characteristics & tolerances

- Capacity (Cooling or Heating): –5%
- EER or COP: -8%
- Condenser water pressure drop: +15%
- A-weighted Sound Power Level: +3 dBA.
- Eurovent Energy Efficiency class (cooling and heating)

ECC Reference documents

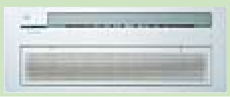
- Certification manual
- Operational Manual OM -13
- Rating Standard RS 6/C/007

Testing standards

- EN 14511 for Performance Testing
- EN 12102 for Acoustical Testing

Variable Refrigerant Flow (VRF)

CERTIFY ALL



Scope of certification

The certification programme for Variable Refrigerant Flow (VRF) applies to:

- Outdoor units used in Variable Refrigerant Flow systems with the following characteristics:
- Air or water source, reversible, heating-only and cooling-only.

VRF systems with data declared and published as combinations are excluded from the scope.
Heat recovery units are included in the scope but the heat recovery function is not certified.
High ambient systems are included in the scope but tested under standard conditions as specified in RS 6/C/008.

Certification requirements

- Qualification: units selected by Eurovent Certification shall be tested in an independent laboratory selected by Eurovent Certification.
- Repetition procedure: units selected from regular production shall be tested on a yearly basis.

Certified characteristics & tolerances

- Outdoor Capacity (cooling and heating): –8%
- Outdoor Efficiency (EER, COP): –10%
- A-weighted sound power level: 2 dB in 2014 –0 dB in 2015.

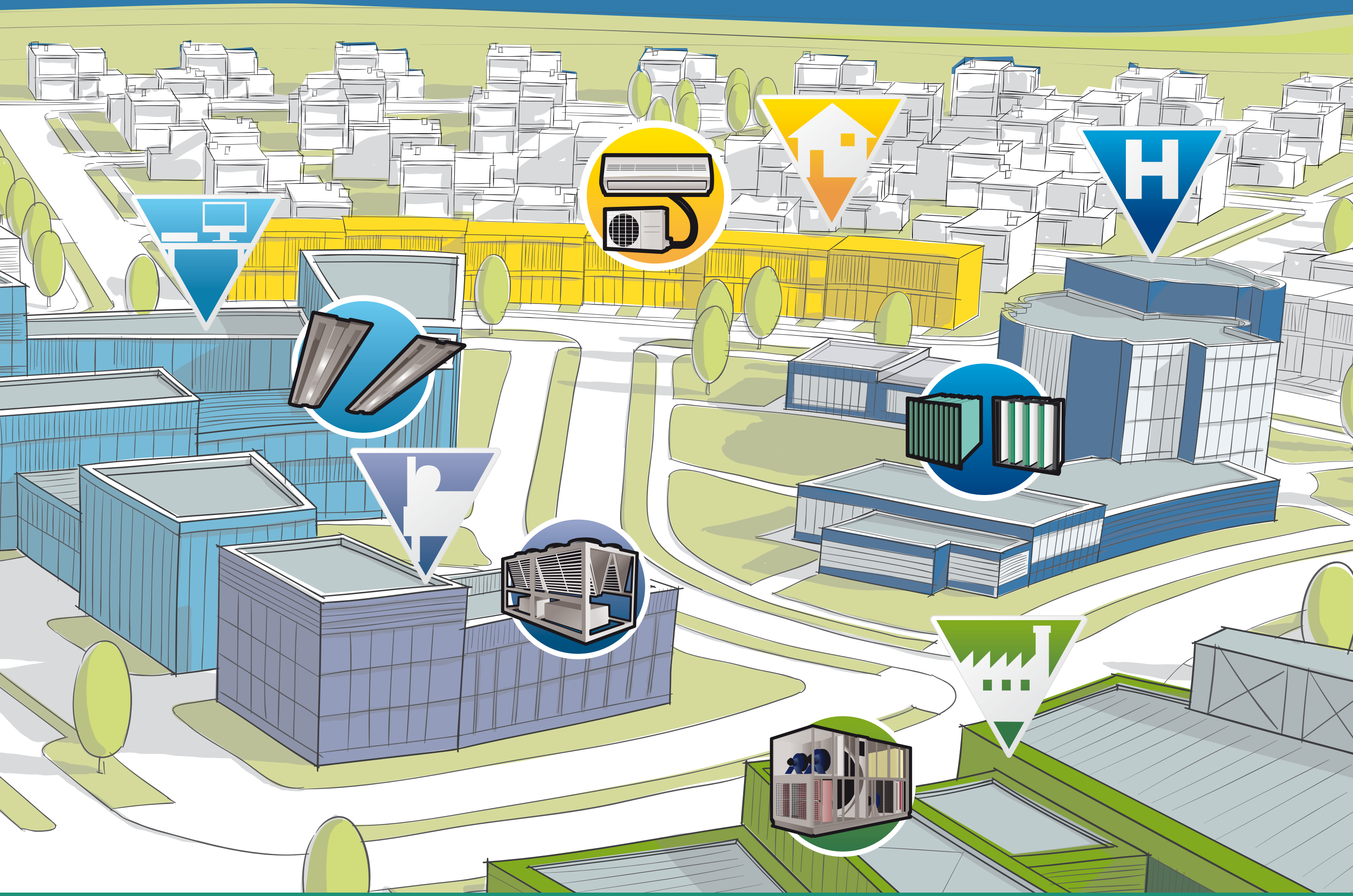
ECC Reference documents

- Certification manual
- Operation manual OM-15
- Rating Standard RS 6/C/008

Testing standards

- EN 14511
- EN 12102

LOOKING FOR **HVAC-R PRODUCTS**
FOR YOUR BUILDING ?



WE CONTRIBUTE TO
HIGHER ENERGY EFFICIENT PROJECTS

SELECT EUROVENT CERTIFIED PRODUCTS AND **CHECK PERFORMANCE ON LINE**

The Eurovent Certification label is a guarantee that the energy level indicated is based on certified performances. Eurovent Certification certifies the thermal and acoustic performance of air conditioning, ventilation, heating and refrigeration equipment tested at independent ISO 17025 accredited laboratories. The certification protocol includes sampling of the units to be tested, annual test campaigns, downgrading of indicated performance levels in the event of test failure and subsequent publication of data.

www.eurovent-certification.com

EUROVENT CERTIFIED PERFORMANCE

**Accreditation # 5-0517 Products and Services Certification - According to EN 45011:1998 - Scope and validity at www.cofrac.fr - International recognition EA/IAF*

REHVA Task Forces

– backbone of the REHVA Technical activities

JORMA RAILIO
Chair of the REHVA
Technical and Research Committee

JAREK KURNITSKI
Vice-chair of the REHVA
Technical and Research Committee

LIVIO MAZZARELLA
Vice-chair of the REHVA
Technical and Research Committee

REHVA Task Forces

The objective of REHVA Technology and Research Committee is to develop and disseminate technical information for the benefit of REHVA members and supporters, enhance development of standards and research on European level, and increase the REHVA participation and visibility at European level activities.

To achieve these objectives, REHVA has established Task Forces, each with a specific topic. Each Task Force will prepare a REHVA publication, and REHVA Guidebooks are the main outcome of Task Forces. In some cases, a Technical Report is a more suitable outcome, especially in rapidly changing or developing issues.

The tradition of REHVA Task Forces and Guidebooks is rather young. The idea of Guidebooks matured at the end of last Millennium, after several discussions about the needs of practical and reliable documentation of European good HVAC practices, targeted directly to designers and other HVAC practitioners and also to other stakeholders. Finally, in spring 2000, the first action towards a REHVA Guidebook started, with the topic of **Displacement Ventilation**. This topic had been dealt with in numerous research reports, articles in professional journals, commercial brochures etc., but the information there was either fragmented, unpractical or commercially biased.

The format of Guidebooks, and also working practices of Task Forces, developed during the first project and still are much the same: first make a clear working plan and establish a working team, prepare a manuscript within a realistic schedule, and also make sure that the publication will sell.

In late 2002 the first Guidebook was published, and it still is one of the bestsellers. The principles of displacement ventilation are still the same, but technologies have developed and new applications have been commercialized, so the Guidebook No. 1 will be subject to revision which is currently about to start.

Since year 2002, teams of experts from all parts of Europe have participated in the work of Task Forces, often on a voluntary basis. A typical team consists of 4-6 experts, but in a few guidebooks or reports the number of contributors has been up to 20 or even more. All manuscripts are reviewed independently by well recognized experts.

The number of printed Guidebooks reached 20 in June 2013, when three new books were published and on display at Clima 2013 in Prague. At the same time, a Technical Report containing a proposed all-European framework definition of **nearly zero energy building** was published, this is TR 4 but actually the first one resulted from an "ordinary" Task Force – the first three were the collections of Workshop summaries from Clima conferences in 2005, 2007 and 2010. The decision to make a Technical Report was relatively easy: the need to disseminate the TF results was urgent, but the outcome is subject to change very soon, due to many changes "around".

The most successful Guidebooks have one common feature: strong "push" and commitment from the industry.

The working language in the Task Forces is English, as well the official original version of the Guidebook. But as a European organization over 20 languages are spoken within REHVA member associations. To reach better the national professionals the Guidebooks can be translated to national languages. REHVA offers this opportunity as a membership benefit to its members. More than 50 translations (see table below) are available through REHVA National members (contact information at www.rehva.eu).

Translations of REHVA Guidebooks

GB no.	Title	Language
1	Displacement Ventilation	Dutch Finnish German Italian Japanese Latvian Norwegian Portuguese Russian Slovenian Spanish Turkish
2	Ventilation effectiveness	Japanese Latvian Portuguese Slovenian/Serbian
4	Ventilation and Smoking	Portuguese Spanish
5	Chilled Beam Application	French Hungarian Italian Polish Portuguese Slovenian Spanish Turkish
6	Indoor Climate & Productivity in offices	Dutch Italian Japanese
7	Low Temperature Heating and High Temperature Cooling	Portuguese Finnish Hungarian Slovenian Italian Turkish Chinese

GB no.	Title	Language
8	Cleanliness of ventilation system	German Portuguese Italian
9	Hygiene Requirement for ventilation and air conditioning	Italian Portuguese
10	COMPUTATIONAL FLUID DYNAMICS (CFD) CALCULATIONS in Ventilation Design	Japanese Italian
11	AIR FILTRATION IN HVAC SYSTEMS	Portuguese Italian
12	Solar Shading	Finnish French Swedish Portuguese
13	INDOOR ENVIRONMENT AND ENERGY EFFICIENCY IN SCHOOLS - Part 1 Principles	Portuguese Italian
14	INDOOR CLIMATE QUALITY ASSESSMENT - Evaluation of indoor thermal and indoor air quality	Italian French
16	HVAC IN SUSTAINABLE OFFICE BUILDINGS - A BRIDGE BETWEEN OWNERS AND ENGINEERS	French
17	DESIGN OF ENERGY EFFICIENT VENTILATION AND AIR-CONDITIONING SYSTEMS	Portuguese Turkish

Active REHVA Task Forces (TF) August 2013

Name of the Task Force, Schedule and Chair/contact person	Descriptive objective of the Task Force
Air Conditioning inspections - Technical Guideline, 2012-2015 Chair: Vincenc Butala University of Ljubljana Slovenia vincenc.butala@fs.uni-lj.si	This TF aims to prepare a technical guideline for inspections of air conditioning systems, to support the implementation of Article 15 of the EPBD recast.
Reference Buildings for Energy Performance and Cost-Optimal Analysis, 2012-2014 Chair: Stefano P. Corgnati, Politecnico di Torino, taly stefano.corgnati@polito.it	This TF aims to develop, on the bases of the national experiences, a set of European Reference Buildings/benchmark buildings in order to suggest European wide harmonized database of building types which could be used for cost optimal calculations according to EPBD recast at European level by technicians and researchers. So far ongoing activities on the definition of national approved RBs are being developed and they are still far from being closed. Due to this fact, TF is now focusing in conducting cost optimal analyses and comparing the results of these between different MS in order to give some useful information to policy makers and investors.
Environmental-friendly Refrigerants in HVAC Applications, 2012-2014 Chair: Attila Zoltán Hungarian Coordination Association of Building Engineering attila.zoltan@t-online.hu	This TF aims to prepare a Refrigerant Guidebook which will help to define the optimal system-equipment-refrigerant couple for dedicated applications. The guidebook will introduce how to reduce, optimise the cooling power needed, the environmental impacts and energy efficiency of the equipment, including global parameters of refrigerants (ODP, GWP), energy efficiency (EER, ESEER, COP, SCOP), direct-indirect environmental impacts of equipment, systems, the TEWI (CO_2eq) and TEEI (inversed TEWI, kWheq) comparison methods.
HVAC systems long term impact in buildings valuation, 2013-2015 Chair: Frank Hovorka Caisse des Depots, France frank.hovorka@caissedesdepots.fr	HVAC related building performance is often insignificant in the context of an overall building evaluation made by potential investors. The TF thus aims at bridging the gap between HVAC engineers and building investors by translating typical HVAC system benefits into tangible financial benefits for the overall valuation of real estate. "Global costs" considering functionalities, investments costs and operation & maintenance issues are taken into account and the methodologies for translating the HVAC benefits to real-estate valuation will be presented and demonstrated with real life examples.
Energy refurbishment, 2013-2015 Chair: Marija S. Todorovic Academy of Engineering Sciences of Serbia deresmt@eunet.rs	EnRef TF aim is to prepare guidebook/s on the topic of the energy refurbishment encompassing holistic approach to the deep energy renovation of existing buildings, to the level of energy efficiency and renewable energy sources (RES) integration that ensures clear "zero" or "net zero" energy quality of the refurbished buildings status. TF promotes large-scale RES integrated buildings structure/ HVAC refurbishment technologies development, as well as necessary R&D to commercialize "RES Integrated Energy Refurbishment Construction/HVAC - Industry" as a whole integrated engineering process.
nZEB Nearly Zero Energy Buildings, 2012-2015 Chair: Jarek Kurnitski Tallinn University of Technology, jarek.kurnitski@ttu.ee	nZEB TF revised REHVA nZEB technical definition during 2012-2013, with the aim to help the experts in the Member States to define the nearly zero energy buildings in a uniform way. The revision, coordinated with CEN project group preparing 2nd generation EPBD standards, was published in June 2013 (REHVA REPORT NO 4, 2013). The work will continue as a new task force focusing on nZEB case studies/ technology with on site and nearby production and trying to find assessment method/indicator for "real addition" of RE energy and optimal performance on energy system level.

Name of the Task Force, Schedule and Chair/contact person	Descriptive objective of the Task Force
Combined Heat and Power (CHP) for buildings, 2012-2015 Chair: Klaus Sommer Cologne University of Applied Sciences Germany klaus.sommer@fh-koeln.de	In order to achieve the EU targets on energy savings and on reduction of greenhouse gas emissions the decentralized cogeneration (CHP) on individual building level can play an important role. This TF will produce a REHVA guidebook that covers different technologies of small and middle size CHP for different applications. Key aspects are system engineering and control, system operation and economic feasibility that will be derived from field tests and practical applications.
Fire safety in buildings: Smoke management guidelines, 2012-2014 Chair: Othmar Braendli Belimo Switzerland othmar.braendli@belimo.ch	This TF aims to prepare state of the art guidebook on fire & smoke solutions. It will provide approved fire & smoke solutions and show latest status of European fire & smoke standards and regulations.
Heat pump applications in refurbishment, 2012-2014 Chair: Branimir Pavkovic Croatia branimir.pavkovic@riteh.hr	This TF will produce a new guidebook on heat pump applications for new buildings and for refurbishment. Heat pumps can in some cases efficiently be implemented in existing systems of heating and cooling, providing cost effective solution in refurbishment. Limits of such application and proper system design will be discussed. General information suitable for target groups will be provided.
Cold climate design guide (ASHRAE/REHVA), 2012-2015 Chair: Bjarne Olesen, Technical University of Denmark bwo@byg.dtu.dk	This TF aims to prepare a cold climate design guidebook in cooperation with ASHRAE.
Weather Data Directory, 2012-2014 Chair: Livio Mazzarella, Italy Livio.mazzarella@polimi.it	The aim of this task force is to develop, on the bases of the worldwide available information, a weather data directory for HVAC design and performance simulation, which collects in a simple and concise way all references to national and/or regional weather data, their availability, statistical validity and application purposes.
Commissioning process Reactivation of the old TF, contact person: Ole Teisen, Ole.Teisen@grontmij.dk	In spite of the many standards there are different approaches to the commissioning process, and a lot of work is done in the name of Commissioning that is not adding any value to the buildings. We need more stringent requirements for verification of buildings and systems in order to verify planned energy savings and achieve sustainability certification. To achieve these aims, this TF will prepare guidelines and guidance on the Commissioning process. Besides supporting the Commissioning requirements of various sustainability certification programmes, the guidebook shall serve as a tool when doing a commissioning process on refurbishments.
Indoor environment in the implementation of policies and technologies for energy efficient buildings New proposal by FINVAC	There is a need a position paper on indoor environmental issues aimed at policy makers and authorities to point out the potential conflict between energy efficiency and indoor environment and to develop protocols and criteria for design and construction and operation practice.
Displacement ventilation New proposal by TRC	Existing displacement ventilation guidebook is sold out and already so old that needs to be updated. TRC will initiate new TF with the aim to revise and publish new displacement ventilation guidebook.

Eurovent Market Intelligence celebrates its 20th anniversary

In 2013, Eurovent Market Intelligence celebrates 20 years of service to businesses in the field of market intelligence. The following the evolution of market intelligence during last two decades is

1993-2007: CECOMAF/Eurovent Association

The statistical activity came about through two men, Sule Becirspahic, consultant for Eurovent, and Jean-Pierre Hughet, Chairman of the chillers working group and Head of Marketing at Carrier. At the time, there was a real need for statistics that were both reliable and standardised for all European countries. The questionnaires would be sent by post to the manufacturers, who would fill in their tables with their sales figures and would send them to a notary, who would then forward them to Eurovent in such a way as to ensure the anonymity of the participant. The first data collections were initially done "by hand", i.e. calculations were done on a sheet of paper with the help of a calculator, and the results were handwritten in a blank table. They soon moved on to being processed by computer but, as the files arrived by post, a significant amount of manual input work was carried out until 2008.

2007-2009: the emergence of EMI

The next turning point occurred in 2007, when Mr Becirspahic retired and a department dedicated to Market Intelligence was created. Since then, Eurovent Market Intelligence has formed an integral part of Eurovent Certification. The first managers, Andrea Bencelova and Emilie Behnert successively, laid down the legal foundations of the new entity, created a website and consolidated the statistical processing and validation stages. At the same time they put in place an ambitious project running over a three-year period: transferring the programmes onto an Extranet, whose contents are reserved for those participating in data collections. There, they are able to upload their sales file, download the results of the data collections and also carry out additional analyses, such as cross-checking data, measuring development against a constant panel and especially checking their position within each type of market or sub-market. It was in 2010, under the leadership of the current manager, Mr Yannick Lu-Cotrelle, who arrived in June 2009, when this project was finally completed.

Eurovent Market Intelligence (EMI) is the **European Statistics Office on the HVAC&R market**, and provides key market data like :

- **Annual** and **Quarterly** analyses
- Market **Trends and Forecasts** (annually and quarterly)
- **Detailed information** on the equipments sold (technology, capacity...)
- Analyses **by country** (in Europe, Middle-East and Africa)

Detailed information on statistic program & database can be found at www.eurovent-marketintelligence.eu

2009 – 2013: a period of expansion

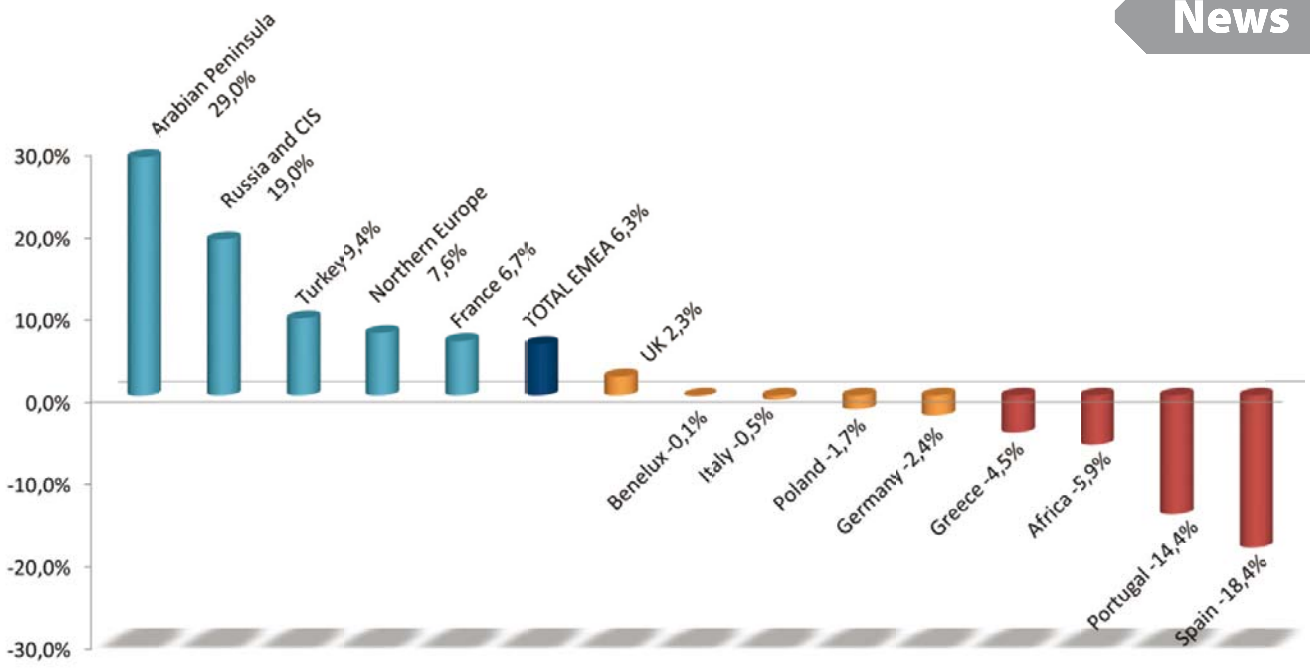
In June 2009, the simultaneous arrival of Erick Melquiond, at the head of Eurovent Certification, and Yannick Lu-Cotrelle, at the head of Eurovent Market Intelligence, led to the activities of EMI entering a new age of expansion. Erick Melquiond, the new Director of ECC, wanted to give EMI the means to fulfil its ambitions and to make it the European reference body for HVAC&R market data, thus supplying the quantified data needed for the European Union's Action Plans. As for Yannick Lu-Cotrelle, he injected a less institutional and more customer service-focused approach.

Yannick Lu-Cotrelle's first project was to break the downward trend in the overall number of participants that had been observed for several years. The department's new objectives were:

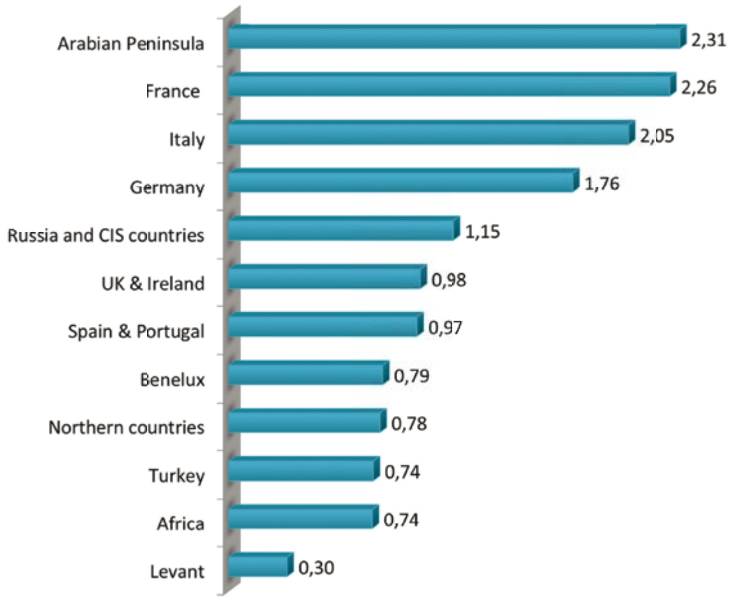
- To re-stimulate the appeal of the various statistical programmes, particularly through adding better quality or higher added value information;
- To implement rigorous follow-up of marketing to manufacturers, in order to optimise the canvassing that is carried out during the collection of data;
- To rationalise the existing offering, by abandoning the least promising and most time-consuming programmes and by focusing on those with greater potential;
- To regularly release new statistical programmes in order to ensure the continuous development and the durability of the activity.

Quarterly Forecasts for HVAC-R Market in Europe for the 3rd Quarter 2013 by the Eurovent Market Intelligence.

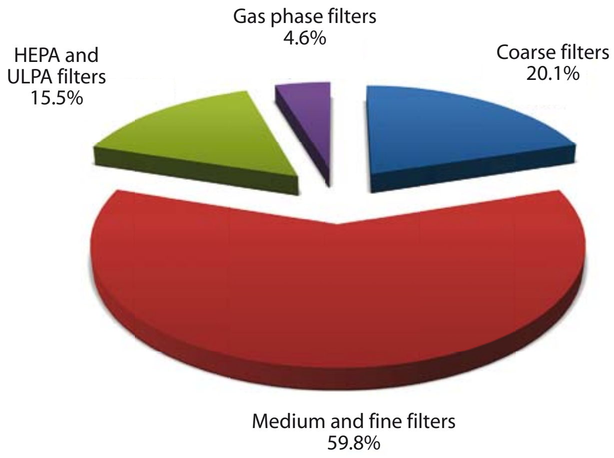
Product*	Quarter 2013Q3 Market trend (vs 2012Q3)	Trend 2013 vs 2012
AHU	+3,4%	+1,6%
Fan Coils	–1,2%	–4,3%
Chillers	–5,2%	–2,1%
Rooftops	+8,4%	+6,9%



Market trends of air handling units in 2011-12 based on sales in Euro in Europe, Middle East and Africa (EMEA).



Chiller market in 2012 based on sold cooling power in Gigawatts (millions of kW).



Air filter market in Europe based on sales in Euro.

It has been a success because, in 3 years, the number of manufacturers participating in EMI programmes has doubled, going from 78 in 2009 to 156 in 2012.

The second project was to raise EMI's profile around the world. From 2009, EMI started regularly communicating in trade journals regarding both the beginning of data collection campaigns and on market data. It also participated in conferences at the majority of trade shows, such as the Mostra Convegno Expocomfort in Milan, Chillventa in Nuremberg, the BIG5 in Dubai and in 2013, the ISH in Frankfurt and Climate World in Moscow are on the agenda.

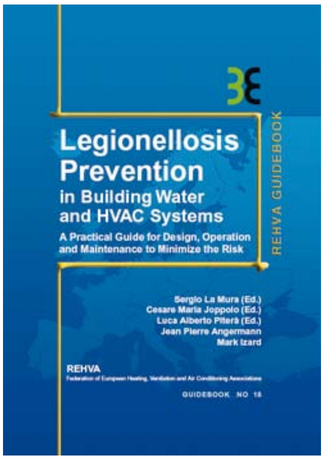
2013: a year of transition towards a new dimension

Two new developments are expected in the summer of 2013. Firstly, the planned merger of Eurovent Certification and Certita, 2 leading certification companies operating in the field of Heating, Ventilation, Air conditioning and Refrigeration (HVAC&R) products. This association of activities will open the doors of the heating and green energy sectors to EMI.

Finally, the arrival of a new statistician within the department will enable the increased flow of activity that has occurred over the last three years to be better managed, in addition to broadening EMI's service offering. These two factors together have already enabled a significant expansion of EMI's activities to be planned up to 2015. ■

Sergio la Mura, Cesare Maria Joppolo, Luca Alberto Pitera, Jean Pierre Angermann & Mark Izard:

Legionellosis Prevention in Building Water and HVAC Systems – New REHVA Guidebook no 18



The Guidebook has been prepared by an European Working Group (leaded by AICARR, the Italian Air Conditioning Heating Refrigeration Association) and has been published by REHVA the European Federation of Heating, Ventilation and Air-conditioning Associations.

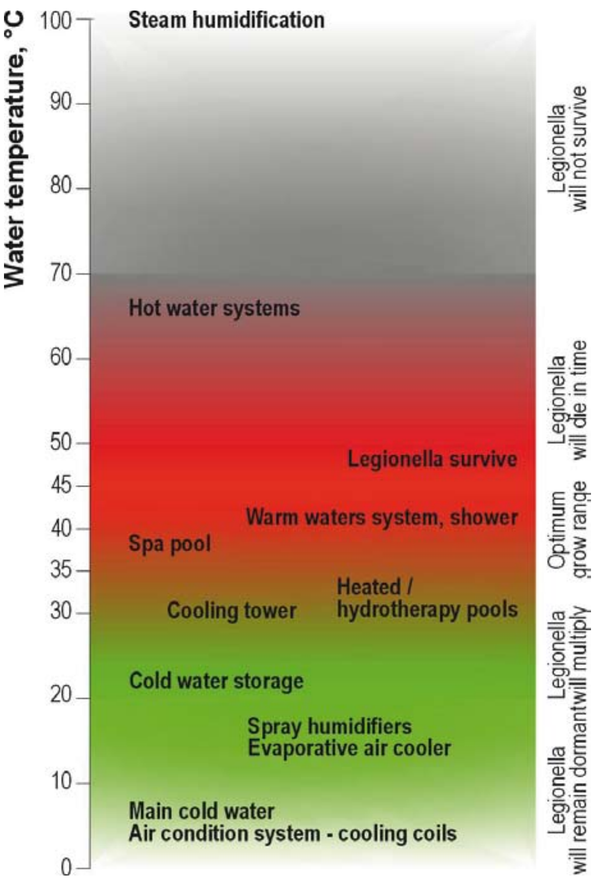
The Guidebook adopts an articulated structure for each of all building services sectors covering four aspects (i.e. introduction; how to design a new installation; how to evaluate an existing installation; how to effect corrective modifications to an existing installation. Special concern and a separate section of the book have been devoted to Operation & Maintenance (O&M) in consideration of their relevance both from a technical point of view and from a "procedure" approach. The following snapshots illustrate the technical contents of the Guidebook.

Growing conditions of *Legionella*

Presence of the bacterium *Legionella* is present in natural and artificial aquatic environments: it is to be found in springs, including hot springs, in rivers, lakes, mists/vapors, and in the soil. From these environments it reaches man-made environments such as city mains conduits and building service water installations, such as tanks, pipes, fountains and swimming pools. Legionella bacteria have been detected also in river or torrent mud, or in clay for terracotta pottery articles.

The conditions favorable to the proliferation and to the presence of the bacterium are:

- a water temperature between 20°C and 45°C, where growth of Legionellae is possible;
- service water systems with a temperature not greater than 60°C;
- acid and alkaline environments, with pH values between 2.7 and 8.3.
- stagnation conditions of the water in distribution piping networks and in storage systems;
- presence of scaling and/or sediments inside piping networks;
- presence of nutrients and shields, giving eg. by amoeba and biofilm.



Effects of temperature upon the reproductive mechanisms of the ***Legionella*** bacteria and operating ranges in some applications.

Air conditioning humidification

The influence that humidity has on human comfort has still not been precisely established. Conditions of comfort for people are to be found for humidity values between 30 and 60%.

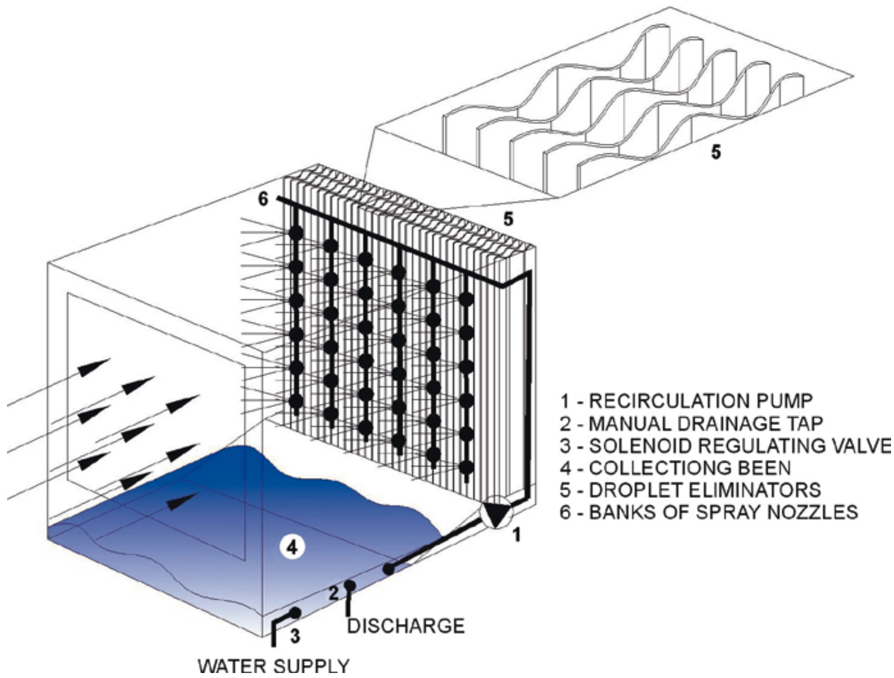
Illustration and specification of health and hygiene aspects of humidification system for:

- Adiabatic humidifier
- Steam humidifiers

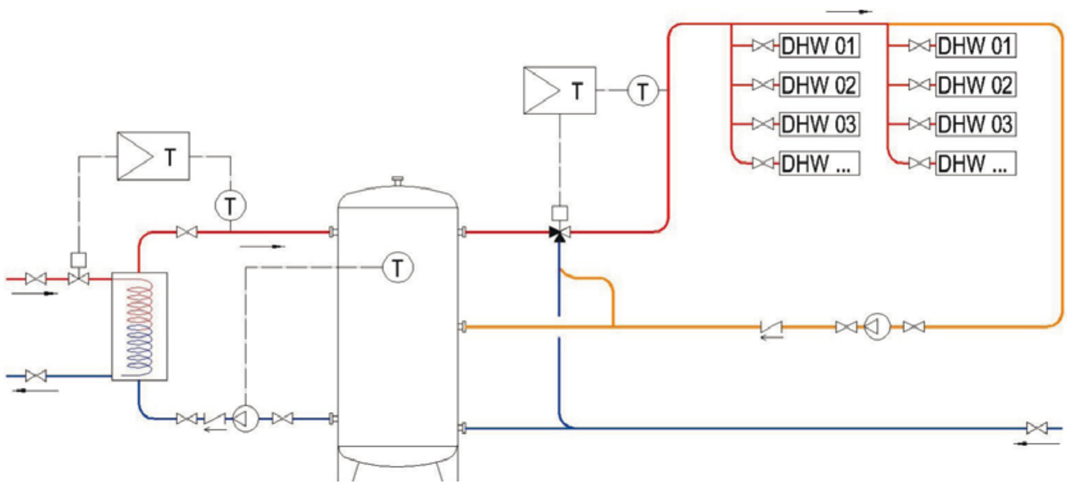
Hot and cold potable water hydraulic networks and installations

Situation with risk of proliferation occurs when water remains at rest for a long time (stagnation) at temperatures between 20° and 50°C, and particularly between 32° and 40°C.

These conditions are normally to be found in service Hot Water Systems for hygienic and washing purposes; the hot water can also become warm / lukewarm (32 – 40°C) by choice of design (mixing valve control) or through running or malfunctioning. Temperature range above 20°C can, on the other hand, also occur in Cold Water Piping Networks, which are considered to be at



Schematic drawing of an adiabatic washer inserted in an air handling unit.



Schematic drawing of sanitary hot water network with semi-instantaneous production.

temperatures below those of proliferation because they are fed by mains water or well-water (at temperatures which are usually below 15°C).

FOCUS on:

- Production of sanitary
- Hot water with storage
- Tank

And for the sanitary hot water

- Instantaneous production of sanitary hot water
- Semi-instantaneous production
- Design Expedients
- Description of water treatment techniques

Evaporative cooling towers

Evaporative cooling combines high thermal performance and good cost efficiency through low cooling temperatures which mean containment of energy and water usage. The evaporative cooling tower is an energy-efficient device of relatively simple design and operation, with many applications both for buildings HVAC systems and for industrial processes. But, errors in design or construction, or poor maintenance procedures, particularly in those installations with seasonal usage (e.g. summer air conditioning installations), can generate the conditions for proliferation and diffusion of the bacterium.

FOCUS on:

– Evaporative cooling tower operation;
– Cooling Tower Geometrical Forms and Construction Types:

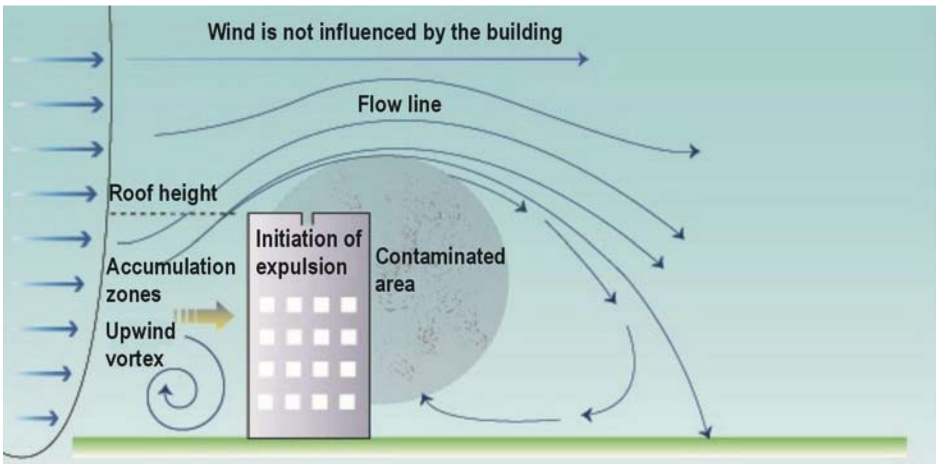
- Design evaporative cooling towers systems;
- Evaluation existing evaporative cooling towers systems
- Corrective modifications to existing installations;
- Chemical treatment of the water

Management of operation and maintenance

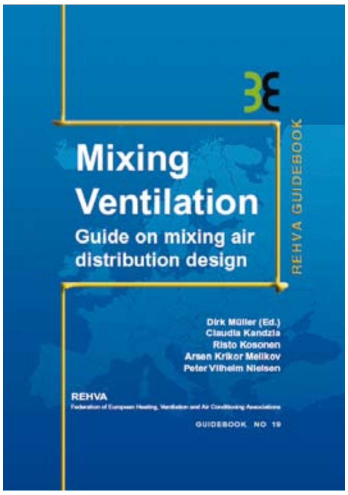
Good operation and maintenance are the in key role in the prevention of Legionella growth. In the end of the guidebook 25 pages is focused on principles and details for goof O&M. In order to organize successfully Operation and Maintenance management following principles are proposed and several check lists are given for each action:

- Conduct a hazard analysis;
- Identify critical control points.
- Establish critical limits for each critical control point;
- Establish a monitoring plan for critical limits at critical control points;
- Establish corrective action for each critical limit;
- Establish procedures to document all activities and results;

Establish procedures to confirm that the plan actually works under operating conditions (validation), is being implemented properly (verification) and is periodically reassessed and reviewed if necessary after a critical dysfunction. ■



Entrainment risk through windows in the downwind (negative pressure) side of a building with cooling tower over the roof.



Risto Kosonen, Halton Oy and Aalto University, Finland
Dirk Müller, Claudia Kandzia, RWTH Aachen University, Germany
Arsen K. Melikov, DTU, Department of Civil Engineering, Demark
Peter V. Nielsen, Aalborg University, Denmark

Mixing Ventilation

– New REHVA Guidebook No 19

At present mixing ventilation is mostly used in practice. Although it has been applied for many years the conditions for its optimal performance in practice are not widely understood. A new REHVA design guide book is giving an overview of the nature of mixing ventilation, design methods and its evaluation under laboratory conditions and in practice.

Objectives of the guidebook

The motivation for the mixing ventilation (more correct is mixing air distribution) guide book was that existing knowledge was not structured in a simple, short and understandable way for the majority members of the HVAC community.

Although mixing ventilation has been applied for many years the conditions for its optimal performance in practice are not widely understood. The aim of the guidebook is:

- to introduce the main factors important for achieving different air distribution patterns in rooms, the airflows generated by jets or convection flows in spaces and their interaction is presented;
- to summarise human response to air movement and its importance for occupants comfort;
- to systemize the main principles and considerations used today for design of comfortable and efficient mixing air distribution;
- to outline the methods for prediction and assessment of the environment obtained with mixing ventilation.

The guidebook is addressed to a large audience of consulting engineers, contractors, facility owners, engineers who enter the field of ventilation.

Nature of mixing air distribution

The air distribution strategies in spaces can be divided into two groups, namely total volume air distribution and localized air distribution. The total volume air distribution aims to achieve uniform velocity and temperature field in the occupied zone, i.e. occupants are exposed more or less to uniform environment. The total volume air distribution principles applied in practice are: mixing air distribution and displacement air distribution.

Several boundary conditions including geometry, supply and return air openings, different sources and sinks of heat load including their strength and location, enclosure surface temperature, etc. have influence on the air distribution in spaces.

The most critical factors that effect on air distribution are defined as:

- Cooling or heating mode
- Archimedes ratio $\Delta T_o/q_o^2$ based on flow rate of air supplied to the room, q_o and temperature difference between return and supply air, ΔT_o
- The ratio between the total area of the supply openings and the wall/ceiling/floor area where the openings are located, a_o/A
- Location, high or low, of the air supply opening(s)

Both, the air distribution with mixing and the air distribution with displacement can be can be driven by either buoyancy or momentum. In **Figure 1** examples of mixing and displacement air distribution patterns resulting due to buoyancy effect and momentum effect are shown. Diffuse ceiling/floor inlet, i.e. when the air

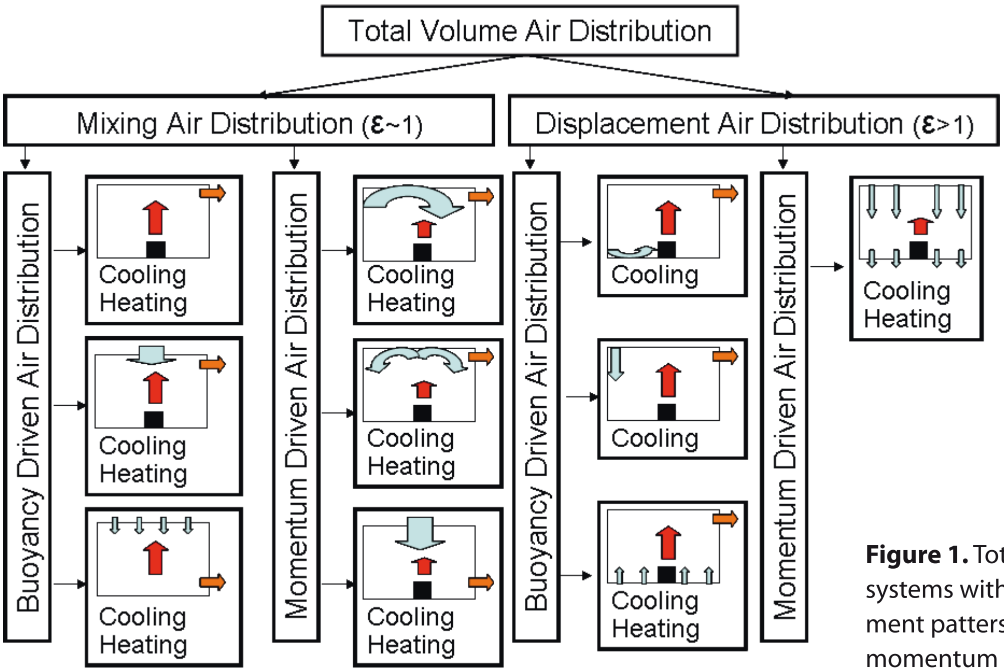


Figure 1. Total volume air distribution systems with mixing and displacement patters based on buoyancy or momentum driving forces.

is supplied over the whole area of the ceiling/floor (a_o/A = 1.0), have been rarely used for comfort ventilation in occupied public buildings, such as office rooms, etc. For typical practical applications ventilation air is supplied from air terminal devices installed either on the ceiling or the wall or the floor (a_o/A <1.0), In this case the general rule is that air distribution with mixing effect is used for cooling and heating while the air distribution with displacement effect is used mainly for cooling.

Design and evaluation of the indoor conditions

Ventilation air supplied to spaces aims to generate healthy, comfortable and work stimulating environment for occupants. Airflow with different characteristics, including air temperature, mean velocity, turbulence intensity, frequency of velocity fluctuations, flow direction, etc., can be generated which affect occupants' thermal comfort and inhaled air quality.

Selection of air distribution schemes is critical for the whole system performance with regard to its ventilation efficiency and occupants' comfort. Air distribution methods for high and low ceiling applications are presented in the guide.

Several models are available for the study of the room air distribution at different stages of the design process. Simplified models such as flow elements are easy to use at the early stage. Flow element models often describe steady state and they may form the basis of zonal models. In practice, isothermal throw length method, pen-

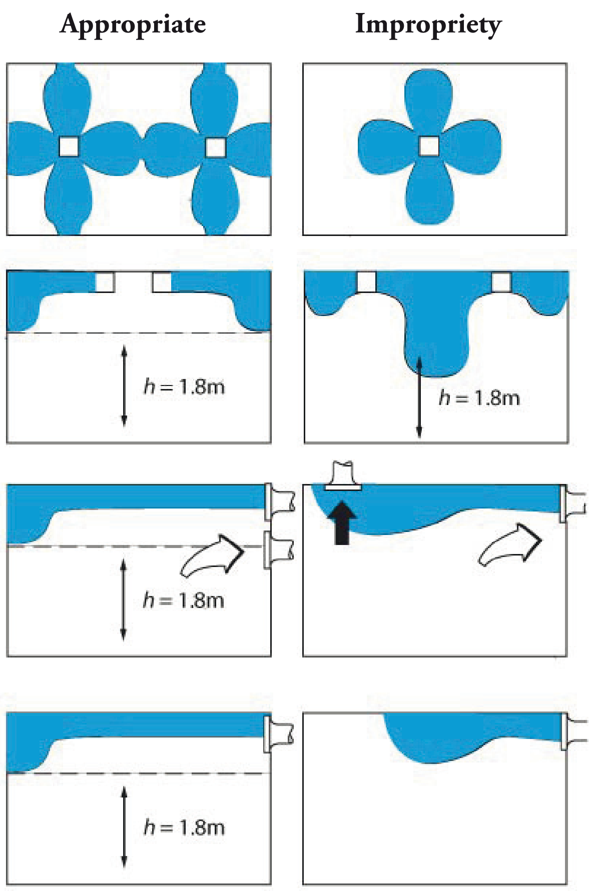


Figure 2. Air distribution should be designed to get high ventilation efficiency without draught (left) and to avoid short cirtuiting and low ventilation efficiency (right).

etration length of jet or manufactures product data of non-isothermal jets are used when air distribution is designed. At present there is no standardized method to present air velocities on the boundaries of the occupied zone.

The air movement generated in rooms has a major impact on occupants' thermal comfort and inhaled air quality. Special attention should be taken to analyse ventilation efficiency and air velocities in the occupied zone in all typical load conditions. Therefore one of the stages of indoor environment design improvement includes identification of the air distribution in room, its assessment by measurements and evaluation of its impact on occupants comfort. Typically the evaluation is performed in two stages: first, assessment is performed based on full-scale laboratory mock-ups together with Computational Fluid Dynamics (CFD) in order to describe the complex interaction of the room flows and then a field survey of air distribution and its impact on occupants is performed when the building is accomplished and occupied. During the first stage proper simulation of the strength and location of the heat sources, such as occupants, office equipment, solar radiation, etc. is important.

The importance of proper simulation of the heat source for the air distribution in rooms is demonstrated in **Figure 3**. Ventilation air is supplied at rate of 1.5 L/s/m² from chilled beam installed in a room with heat load of 50 W/m² generated by two occupants and heated window (on the left side of the section of the room shown in the figure. The importance of the airflow interaction for the room air distribution can be clearly seen. The air

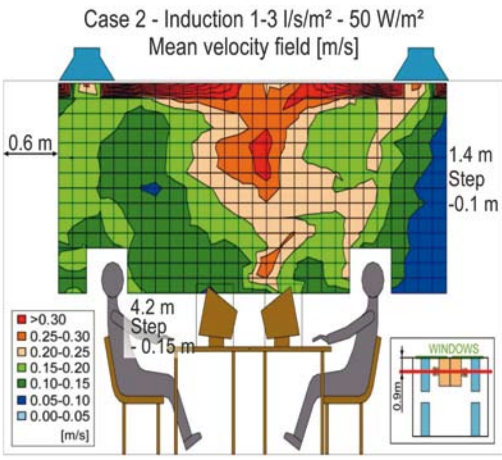


Figure 3. Contours of constant mean velocity measured in a full-scale room ventilated by chilled beams.

supplied from the chilled beams on the side of the window is deflected by the strong thermal plum toward the second occupant generating velocity as high as 0.25 m/s at his head region.

In mixing ventilation design guide, case studies on mixing air distribution in rooms are presented and discussed. Special attention is on the examples that depict the complex interaction between air jets and thermal plumes.

Conclusions

The new REHVA design guide gives an overview of nature of mixing ventilation and methods for its design and evaluation. Various case-studies are included as practical examples. ■

REHVA Report No 4

Definition and system boundaries for nearly zero energy buildings

Jarek Kurnitski (Ed.), Francis Allard, Derrick Braham, Dick van Dijk, Christian Feldmann, Jacquelyn Fox, Jonas Gräslund, Per Heiselberg, Frank Hovorka, Risto Kosonen, Jean Lebrun, Zoltán Magyar, Livio Mazzarella, Ivo Martinac, Vojislav Novakovic, Jorma Railio, Olli Seppänen, Igor Sartori, Johann Zirngibl, Michael Schmidt, Maija Virta, Karsten Voss, Åsa Wahlström

This REHVA Task Force, in cooperation with CEN, prepared technical definitions and energy calculation principles for nearly zero energy buildings required in the implementation of the Energy performance of buildings directive recast. This 2013 revision replaces 2011 version. These technical definitions and specifications were prepared in the level of detail to be suitable for the implementation in national building codes. The intention of the Task Force is to help the experts in the Member States to define the nearly zero energy buildings in a uniform way in national regulation.

HVAC publications from British Engineering Association CIBSE in 2013

CIBSE Chartered Institution of Building Services Engineers, UK

AM12 Combined Heat and Power for Buildings

First published in 1999, this new edition takes the growing concerns over global warming and the recognition of the role that chp can play in delivering low carbon buildings into consideration. Revised and updated it contains new sections including:

- a new chapter on district heating applications
- more information on assessing environmental benefits
- more detail on tri-generation and thermal storage

TM51 Ground Source Heat Pumps

The purpose of this Technical Memorandum is to provide information for practitioners to enable ground source heat pumps to be properly applied, and their environmental and economic potential to be realised. Specifically it aims to provide:

- understanding of the technology and its application
- information on the availability and comparability of systems
- clarity on how gshps comply with building regulations, SBEM and Environment Agency regulations
- understanding of the design, integration and procurement process
- information on maintenance, training and resources
- information on real performance with case studies

TM13 Minimising the Risk of Legionnaires' Disease

These Technical Memoranda set out to give guidance on the appropriate design, installation, commissioning, operation and maintenance procedures necessary to minimise the risk of infection by Legionella from water systems within a building. Principles are highlighted, and practitioners in these fields are encouraged to apply them to their own particular building services applications.

TM52 The Limits of Thermal Comfort: Avoiding Overheating in European Buildings

This Technical Memorandum (TM) is about predicting overheating in buildings. It is intended to inform designers, developers and others responsible for defining the indoor environment in buildings. It includes the recommendations of the Overheating Task Force, which has sponsored and published this document.

TM54 Evaluating Operational Energy Performance of Buildings at the Design Stage

This guidance will help to turn low energy designs into low energy buildings that achieve the design energy targets. It is one of several CIBSE actions to promote more effective assessment of energy performance.

CIBSE Briefing 04 The Enhanced Capital Allowance Scheme for Energy Saving Plant and Machinery

The Enhanced Capital Allowance (ECA) scheme was introduced by the Finance Bill in 2001 to encourage businesses to invest in energy-saving equipment. It is an integral part of the climate change levy package. The scheme provides an incentive for your clients to make energy saving investments in specific technologies and products approved by the Department for Energy and Climate Change (DECC). The ECA scheme is an extension of the Integral Features (8% SRP) regime in that the benefit of the capital allowances are accelerated into one year and not over 15 to 22 years as with the SRP. This totally revised edition of CIBSE Briefing 4 updates the information in the previous 2002 edition.

TM53 Refurbishment of Non-domestic Buildings

TM53 aims to assist the understanding of the buildings and systems we may encounter and produce a common strategy in the analysis of options and solutions. Its aim is to maximise the opportunities presented when refurbishing non-domestic buildings.

Guidelines for the Design and Application of Green Roof Systems

These guidelines highlight the important considerations for green roof planning, design, installation and maintenance, and provide guidance as to how they can be accommodated in the final green roof scheme. They aim to promote awareness of green roofs, facilitate effective planning, design and implementation of sustainable green roof projects and stimulate an increase in the uptake of green roofs on new developments and existing buildings.

Guide G: Public Health Engineering

This comprehensive guide examines the broad scope of public health engineering, and written with the latest legislation and British Standards in mind. It provides a comprehensive source of reference for all those involved in the design, specification, installation and maintenance of water systems or other piped services. It covers water services and utilities, waste management systems, water treatment, irrigation, and more. ■

All CIBSE titles are available in hard copy or in PDF at
https://www.cibseknowledgeportal.co.uk/

HVAC Guidelines published by German Engineering Association VDI in September –December 2013

VDI 2067/10 "Economic efficiency of building installations; Energy demand for heating, cooling, humidification and dehumidification"

This standard describes the calculation of the energy demand of buildings and rooms whose conditions should be met and which therefore must be supplied with or dissipated of energy and materials. The material demands will be treated similarly to energy demands. The standard takes into account both radiation, transmission and ventilation processes. Influences of energy transfers to the room, technical equipment, energy supply and conversion are not subject of the standard. The calculation basis is a defined set of weather data.

VDI 2050/1 "Requirements for technical equipment rooms; Technical bases for planning and execution"

Technique areas are cost-relevant factors which are often minimised by optimising utilisation areas at the expense of the subsequent costs of operation and maintenance. The persons responsible are often not the ultimate operators or users of the systems, and the balancing influence of the operating costs is therefore lacking. Early decisions about the amount of space needed for the individual technique rooms and service shafts are essential, particularly with a view to economical operation and maintenance

The series of standards VDI 2050 serves as a basis for the planning and integral consideration of building and their Building Services (BS). Here, the focus is on determining the space requirement for technique centres of a building.

VDI 2067/40 "Economic efficiency of building services installations; Energy effort for generation"

This standard describes the calculation of the energy effort for heat and cold generation. Input energy may originate in the environment or fuels (solid, liquid, gaseous) or may be electrical. The standard allows to evaluate the energy efficiency of generators to be installed or existing ones already in use. The numerical reference values given in the standard, however, refer to current aggregates only. This standard and the other parts of the series of standards VDI 2067 represent an overall system, which means that the standard is to be applied in conjunction with these parts. Fundamentals and the calculation process are illustrated for an exemplary vessel with continuous fuel supply.

D VDI 2083/7 "Cleanroom technology; Ultrapure media; Quality, supply, distribution"

The standard deals with the specification of ultrapure media (steam, gases, chemicals) for contamination-controlled processes and with the distribution systems for such media. The standard provides a summary of knowledge regarding the design, construction, operation and monitoring of high purity supply systems, and supports planners, system suppliers and operators in their work. It is intended to supersede and replace VDI 2083 Part 7 and Part 10.

VDI 3805/18 "Product data exchange in the building services; Panel heating/cooling"

The standard describes the rules for the exchange of product data in the computer-aided process of planning technical building services for panel heating/-cooling components. It is based on the standard VDI 3805 Part 1.

VDI 3805/32 "Product data exchange in the building services; Distributors/collectors"

The objective of this standard is to provide a set of rules for the exchange of product data in computer-aided planning processes for the building services product range of distributors and collectors on the basis of the standard VDI 3805 Part 1.

D = Draft Guideline

VDI 3810/4 "Operating and maintenance of buildings and building installations; Ventilating and air-conditioning installations"

The standard applies to the operation and maintenance of ventilating and air-conditioning (VAC) installations and VAC equipment (centralised as well as decentralised). It targets in particular cost groups 430 through 434 and 439 as per DIN 276. It does not apply to household equipment as specified in the German Product Safety Act (ProdSG). The standard offers the owner and operator of installations recommendations for the safe, specified and economic operation of VAC installations. It specifies the basis of maintenance and describes the maintenance activities and defines terms which, together with the terms defined in DIN EN 13306, are necessary for understanding the interactions.

D VDI 4700/1 "Terminology of civil engineering and building services"

This guideline deals with the application of filters in air-conditioning systems (A/C systems) in, e.g., residences and offices, in medical facilities, in pharmaceutical and food productions and in public buildings, service centers and commercial enterprises, schools and sports facilities.

This guideline adopts the technical specifications of the guideline SWKI VA101-01:2007-11.

D VDI 4700/3 "Terminology of civil engineering and building services; Symbols (mainly ventilation and air conditioning)"

In national and European standards, a multitude of symbols are used, which have identical meanings but different notations. On the one hand, this is due to internationalisation in standardisation (e.g. DIN EN, DIN EN ISO), on the other hand, to technical rules being drafted by different bodies and the symbols being used in various branches of industry. This standard specifies the preferred usage of symbols in standards. Also symbols are preserved in spite of being outdated, because of their origin in the principles of thermodynamics.

D VDI 4703 "Facility Management; Lifecycle-cost-based tender"

This standard serves as guidance for the lifecycle-based tender. It aims at creating conditions under which offers can be compared over their entire lifecycle. The specifications and information required to creating comparability are defined and structured in this standard. The standard is intended for use by persons planning an investment. The lifecycle cost calculation in accordance with VDI 4703 is based on the calculation procedure of VDI 2067 Part 1.

D VDI 6010/3 "Technical safety installations for buildings; Integrated system test"

The series of standards VDI 6010 applies to safety devices in buildings. Part 3 gives information about the organization, implementation and documentation of black building tests in buildings. The standard is intended in particular to prove the public requirements in initial tests, periodical tests and tests after an important modification. It can also be used to verify the fulfillment of private agreements.

VDI 6028/1.1 "Assessment criteria for Building Services; Technical quality for sustainable buildings"

In this standard, evaluation criteria for the sustainability of building services are provided. The criteria are applicable to all trades of building services. Evaluating the technical quality of the TGA will be treated separately from usage requirements. It's only about the valuation of the plant itself, not to evaluate the impact on the use and operation of the facilities. Compliance with the usage requirements is provided in the evaluation.

VDI 6022/6 "Ventilation and indoor-air quality; Air humidification on decentralised devices; Planning, construction, operation, maintenance"

This standard applies to standalone units for the intended and local humidification of air as well as for decorative water-carrying devices (such as fountains, cascades and water walls) which affect the air humidity in a room. Units originally intended for residential use, which are used in workplaces are also subject to the requirements specified by this standard. The standard factors the particular hazards incuring from such units arising from, e.g., the supply of unfiltered microbiologically contaminated breathing air and insufficient maintenance. ■

More information:
www.vdi.eu/
www.beuth.de/en/

Mostra Convegno Expocomfort 2014

March 18 – 21, 2014
Flera Milano, Italy

"Smart plants – Smart cities" – The highly topical theme of MCE

MCE – Mostra Convegno Expocomfort – the biennial international exhibition dedicated to residential and industrial installations, air-conditioning and renewable energy, scheduled for 18th – 21st March 2014 at Fiera Milano, will offer a rich programme of conferences to put a spotlight on one of the most important issues facing the future of our cities, where "Smart" buildings are the cornerstones of a new way of living under the banner of energy efficiency and conservation to increase positive impacts on the territory and people's life. An opportunity not to be missed by professionals (over 155 000 in 2012). So far more than 1 500 exhibiting companies have signed up, 37% of rebooking made by foreign exhibitors from 52 countries.

MCE – Mostra Convegno Expocomfort with the support of the Scientific Committee – made up of experts from the most authoritative trade associations and federations in the reference sector, and chaired by a representative of the Polytechnic of Milan, Department of Architecture, Built Environment and Construction Engineering – providing topical issues that will act synergistically with a wide exhibition area.

Three institutional conference sessions to thoroughly investigate the future of sustainable planning, ranging from installation technologies through relevant case histories to the future of the market:

1. The First Conference Session "Comfort Technology – Designing and Installing integrated systems for energy efficiency", Wednesday 19 March 2014, will deeply illustrate Italy scenarios with a special focus on technical and regulatory aspects of the next generation of buildings, where the installation technology provides a wide range of functions incorporated into innovative control systems.

2. The Second Conference Session held on Thursday, 20 March 2014, – in collaboration with Associations, Universities, Bodies, and Institutions – will also meet a positive response on an international level, providing an invaluable occasion to examine some of the most relevant International case studies offering an overview of cutting-edge designs to improve the energy performance, reduce energy consumption, combine functionality and advanced building management control systems.

3. The Third Conference Session and last day of the conference, scheduled for Friday, 21 March 2014, will focus on the market potential to highlight the most promising advanced technology, namely heat pumps, high efficiency boilers, energy storage, as well as the new regulatory framework, and to interpret business opportunities in favour of all professionals in the industry.

The conference calendar will integrate with a list of training meetings and workshops promoting cutting-edge technology, organized by the main trade associations, such as AICARR, REHVA, ASHRAE and many others, and those set up by the exhibiting companies. An important role at MCE will be played by the synergy between "Percorso Efficienza & Innovazione" (Efficiency & Innovation Path), an initiative aimed to show off a selection of the most innovative and highly efficient products and solutions on display, and "Oltre la Classe A" (Beyond Class A), an overall showcase to highlight the highest excellence in energy efficiency.

www.mcexpocomfort.it is the reference point for professionals who surf the web and want to be updated on MCE – Mostra Convegno Expocomfort. A virtual showcase constantly providing a full panorama of news about the exhibition, initiatives promoted by exhibiting companies and all the information for planning a visit to MCE.

REHVA and AICARR seminar at MCE

Towards nearly zero retrofitted buildings
Wednesday 19 March 2014 at 14.30 – 17.30
Milan, Italy

ISH China & CIHE launches Building Water Supply and Drainage section at the 2014 edition

May 13 – 15, 2014
Beijing, China

Noted as one of Asia's largest HVAC and sanitation exhibitions, ISH China & CIHE – the China International Trade Fair for Sanitation, Heating, Ventilation & Air-Conditioning, is adding a new and highly in-demand section on Building Water Supply and Drainage to its 2014 edition. Scheduled to take place from 13–15 May 2014 at Beijing's New China International Exhibition, the show will once again be organised by Messe Frankfurt (Shanghai) Co Ltd and Beijing B&D Tiger Exhibition Co Ltd. The three-day event expects to welcome over 950 exhibitors and is estimated to cover more than 85,000 sqm of exhibition space across six halls with the latest innovations and practical solutions in HVAC and sanitation technology.

Mr Li Hongbo, General Manager, Beijing B&D Tiger Exhibition Co Ltd shared: "Based on the Chinese government's recent energy policy initiatives, demand for green and intelligent HVAC solutions is growing quickly. End-users as well as property and infrastructure developers are looking for the best HVAC solutions offered by suppliers. And ISH China & CIHE will highlight recent solutions and products that can meet government regulations while maintaining a comfortable living environment."

Mr Richard Li, General Manager of Messe Frankfurt (Shanghai) Co Ltd said: "ISH China & CIHE's sanitation section has proven to be more and more popular among buyers and industry professionals each year. Focused on water-saving technology, the fair provides an unmatched platform for professionals and suppliers to discuss various solutions as well as installation methods while also discover new business opportunities. To add on to this already popular area, I am excited to announce that we will be launching a new section on building water supply and drainage for the 2014 show. This new section will aim to provide a one-stop destination for construction purchasing."

With the rapid development of China's building industry has come the increased integration of water supply and drainage systems into buildings. The concept of building water supply and drainage is quickly growing from just an individual user focus, to a building-wide necessity across the country. Building water supply includes domestic, recycled and fire water supply systems, while drainage encompasses sewage, waste and rainwater systems.

As China's living standards continue to rise, efficient water supply and drainage systems are being integrated not only into residential properties but also commercial buildings such as hotels, office spaces, entertainment venues and much more. The fast-growing market presents a wealth of opportunities to suppliers able to cater to property developers, project-based business professionals and many others.

Working with this information, ISH China & CIHE will launch its latest specialty area "Building Water Supply and Drainage" at the 2014 show. The section will showcase advance products, technologies and solutions for this important market.

As China's leading HVAC and sanitation fair, ISH China & CIHE aims to provide global manufacturers, buyers and retailers a professional trading and purchasing platform for brand building, product procurement and technical exchange.

ISH China & CIHE is headed by the biennial ISH event in Frankfurt, the world's leading trade fair for the Bathroom Experience, Building, Energy, Air-conditioning Technology and Renewable Energies, taking place 10–14 March 2015. Furthermore, the next edition of ISH Shanghai & CIHE is scheduled to take place from 3–5 September 2014 at the Shanghai New International Expo Center.

More information:
www.ishc-cihe.com or email info@ishc-cihe.com

São Paulo with more than 11 million inhabitants, stands out as a city that lives intensely and "doesn't stop." Having more than 150 000 seats for shows and concerts, 124 museums and more than 15 000 theater and cinema seats. A great party! A great opportunity to explore such alternative culture, discovering the city, its architecture and its inhabitants.

RoomVent 2014

October 19–22, 2014
Sao Paulo, Brazil

The 13th SCANVAC Conference RoomVent 2014 will be held in Sao Paulo, Brazil, on October 19–22, 2014. The main theme of the next RoomVent is "New ventilation strategies with base in active and passive technology in building and for comfort in airplane".

The topics of the scientific and technical sessions cover:

- Indoor Air Quality and Human Comfort
- Ventilation and Air Conditioning in Green Buildings
- Innovative strategies and components for ventilation and air conditioning systems
- Computer based design methods applied to Room Ventilation
- Airflow inside buildings and case studies
- Smoke and Contaminant Movement
- IAQ in Vehicles

Organisers:

IPT – Institute for Technological Research
USP – São Paulo University
State University of North Fluminense – Rio de Janeiro
Federal University of Minas Gerais – Belo Horizonte

Technical visits will be arranged during the Conference.

Important dates: Abstract submission will open on 16 February 2014 and close on 16 March 2014. Deadline for full paper submission is 20 April 2014. Registration will open 27 April 2014.

More information: www.roomvent2014.com

Indoor Air 2014

The 13th International Conference on Indoor Air Quality and Climate

July 7–12, 2014
Hong Kong

A conference for both developed and developing countries

As a developed economy, Hong Kong is unique as a part of the largest developing country in the world. Hong Kong provides easy access to the other major developing countries in the region while also sharing many of the indoor air challenges of developed countries.

- Paper submission deadline: January 31, 2014
- Final paper submission: April 1, 2014
- Registration open: January 1, 2014

Grand hall of the conference venue, University of Hong Kong.

ISIAQ

Indoor Air 2014 is the official conference of the International Society for Indoor Air Quality and Climate, ISIAQ.

More information:
www.indoorair2014.org | info@indoorair2014.org

ebtc

European Business and Technology Centre

A Platform for EU-India cleantech collaborations

The **European Business and Technology Centre (EBTC)** supports EU-India cleantech business and research collaborations in four key focus sectors – **Biotechnology, Energy, Environment** and **Transport,** with a presence pan India in the cities of **New Delhi, Mumbai, Bengaluru and Kolkata.**

A prime toolbox for EU and Indian businesses, researchers, clusters, and policy makers, EBTC has a portfolio of services to support cross-border collaboration at all levels – from comprehensive market information to help overcome market access issues including an IPR Helpdesk, to project and partner identification, strategic advisory services, business and technology incubation at the **European Technology Experience Centre (ETEC)**, and more. EBTC is also the lead consortium partner for the **Enterprise Europe Network India**.

Energy opportunities in India:

- India has set an ambitious target to reduce the energy intensity of its GDP by 20 to 25 % by 2020 through the National Mission on Enhanced Energy Efficiency (NMEEE).
- The Ministry of Power (MoP) estimates 23% is the potential to improve energy efficiency in the industrial & agricultural sectors.
- Trade Energy Savings Certificates (ESCerts) through the Perform-Achieve-Trade (PAT) Scheme covers 563 designated consumers across 8 industry sectors that consume 60% of the total energy, thus boosting energy efficiency measures.

EU technology collaborations facilitated by EBTC in India:

- **Aqua-Q AB (Sweden):** *A real time water quality monitoring device.*
- **Rafako (Poland):** *Circulating Fluidised Bed Boilers.*
- **NewEn (Italy):** *A software tool for energy efficiency applications.*
- **Ciel et Terre (France):** *A patented floating solar PV platform: The Hydrelio System.*
- **A series of EU-India Livestream events with CleanTuesday (France):** *A platform for technology pitches to audiences in Europe and India.*

Interested in energy opportunities in India? Connect with EBTC:

www.ebtc.eu | *info@ebtc.eu* | *@EBTC_EU*

EBTC.EU | *EBTCIndia* | *European Business and Technology Centre (EBTC)*

EBTC is a programme co-funded by the European Union and coordinated by EUROCHAMBRES

Send information of your event to Ms Cynthia Despradel cd@rehva.eu

Events in 2014 - 2015

Conferences and seminars 2014

January 18–22	ASHRAE 2014 Winter Conference	New York, NY, USA	www.ashrae.org/membership--conferences/conferences
February 13	REHVA-iSERV Technical Seminar	Brussels, Belgium	www.rehva.eu
February 24–26	First International Conference on Energy and Indoor Environment for Hot Climates	Doha, Qatar	www.ashrae.org/HotClimates
February 26–28	World Sustainable Energy Days 2014	Wels, Austria	www.wsed.at
February 26–28	49th AiCARR International Conference	Rome, Italy	www.aicarr.org
March 18–19	International Workshop Quality of Methods for Measuring Ventilation and Air Infiltration in Buildings	Brussels, Belgium	www.aivc.org/News/Newsflash_20131009.html
March 19	REHVA - AiCARR Seminar - Towards nearly zero retrofitted buildings	Milan, Italy	www.rehva.eu
March 31	REHVA Seminar - Building Management Systems and Energy Efficiency	Frankfurt, Germany	http://light-building.messefrankfurt.com/frankfurt/en/aussteller/willkommen.html
April 2–3	8th International Conference Improving Energy Efficiency in Commercial Buildings (IEECB'14)	Frankfurt, Germany	http://iet.jrc.ec.europa.eu/energyefficiency/conference/8th-international-conference-improving-energy-efficiency-commercial-buildings-ieecb%E2%80%9914
April 3–4	4th CIBSE ASHRAE Technical Symposium 2014 - "Moving to a New World of Building Systems Performance"	Dublin, Ireland	www.cibse.org/symposium2014
April 7–8	ASHRAE High Performance Buildings Conference	San Francisco, California	www.hpbmagazine.org/hpb2014
April 10–13	2014 Windsor conference-Counting the Cost of Comfort in a Changing World	Windsor, United Kingdom	http://nceub.org.uk
April 28–29	2014 Euroheat & Power Annual Conference and 60th anniversary	Brussels, Belgium	www.buildup.eu/fr/events/38110
April 30	REHVA Annual Conference	Dusseldorf, Germany	www.rehva.eu
May 8–10	TTMD XI. International HVAC+R Technology Symposium 2014	İstanbul, Turkey	www.ttmd.org.tr/sempozyum2014
May 13–15	11th IEA Heat Pump Conference 2014	Montreal, Canada	www.geo-exchange.ca/en/canada_to_host_the_11th_international_energy_agenc_nw211.php
June 23–27	"Sustainable Energy Week EU Sustainable Energy Week"	Brussels, Belgium	www.eusew.eu
June 28–July 2	ASHRAE 2014 Annual Conference	Seattle, WA, USA	http://ashraem.confex.com/ashraem/s14/cfp.cgi
July 7–12	Indoor Air 2014	University of Hong Kong	www.indoorair2014.org
August 31–Sep 2	11th IIR-Gustav Lorentzen Conference on Natural Refrigerants - GL2014	Hangzhou, China	
September 10–12	ASHRAE/IBPSA-USA Building Simulation Conference	Atlanta, GA, USA	http://ashraem.confex.com/ashraem/emc14/cfp.cgi
September 21–24	Licht 2014 - Den Haag Holland	Haag, The Netherlands	www.licht2014.nl
September 24–25	35th AIVC Conference - 4th TightVent Conference - 2nd venticool Conference	Poznań, Poland	www.aivc.org
October 18–19	CCHVAC Congress	China	
October 19–22	Roomvent 2014	Sao Paulo, Brazil	www.roomvent2014.com.br

Exhibitions 2014

January 21–23	AHR Expo	New York, NY, USA	www.ahrexpo.com
February 4–7	Aqua-Therm Moscow	Moscow, Russia	www.aquatherm-moscow.ru/en/
Feburary 27–March 1	ACREX 2014	New Delhi, India	http://acrex.in/
March 4–7	Aqua-Therm Prague	Prague, Czech Republic	www.aquatherm-praha.com/en/
March 18–21	MCE - Mostra Convegno Expocomfort 2014	Fiera Milano, Italy	www.mcexpocomfort.it
March 30–Apr 4	Light + Building	Frankfurt, Germany	www.light-building.messefrankfurt.com
April 1–4	NORDBYGG 2014	Stockholm, Sweden	www.nordbygg.se
May 7–10	ISK - SODEX 2014	Istanbul, Turkey	www.hmsf.com
May 13–15	ISH China & CIHE	Beijing, China	www.ishc-cihe.com
October 1–3	Finnbuild 2014	Helsinki, Finland	www.finnbuild.fi
October 14–16	Chillventa 2014	Nuremberg, Germany	www.chillventa.de/en/

Conferences and seminars 2015

January 24–28	ASHRAE 2015 Winter Conference	Chicago, Il, USA	
April 16–18	International Conference Ammonia and CO2 Refrigeration Technologies	Ohrid, Republic of Macedonia	
May 6–8	Advanced HVAC and Natural Gas Technologies	Riga, Latvia	
May 7–9	REHVA Annual Conference	Riga, Latvia	
October 20–23	Cold Climate HVAC	Dalian, China	www.coldclimate2015.org

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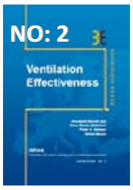
REHVA

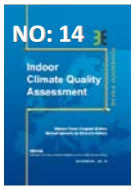
Federation of European Heating Ventilation and Air-conditioning Associations

REHVA GUIDEBOOKS

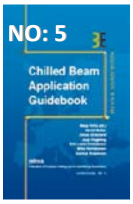
REHVA Guidebooks are written by teams of European experts



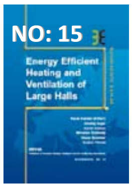
Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook provides easy-to-understand descriptions of the indices used to mesure the performance of a ventilation system and which indices to use in different cases.



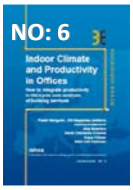
This new REHVA Guidebook gives building professionals a useful support in the practical measurements and monitoring of the indoor climate in buildings. Wireless technologies for measurement and monitoring has allowed enlarging significantly number of possible applications, especially in existing buildings. The Guidebook illustrates with several cases the instrumentation



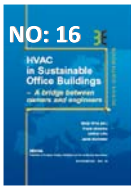
Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature hot water system. Primary air supply induces room air to be recirculated through the heat exchanger of the chilled beam. In order to cool or heat the room either cold or warm water is cycled through the heat exchanger.



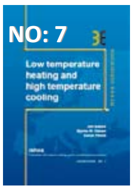
This guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating, floor heating and industrial air heating systems. Various heating systems are illustrated with case studies. Design principles, methods and modeling tools are presented for various systems.



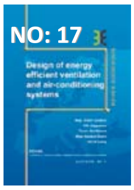
Indoor Climate and Productivity in Offices Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available. The quantitative relationships presented in this Guidebook can be used to calculate the costs and benefits of running and operating the building.



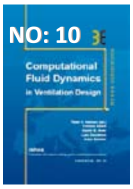
This guidebook talks about the interaction of sustainability and heating, ventilation and air–conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be asked in various phrases of building's life time. Different case studies of sustainable office buildings are presented.



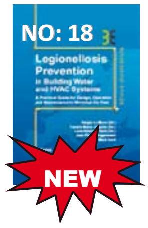
This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in all types of buildings and work with heat carriers at low temperatures for heating and relatively high temperature for cooling.



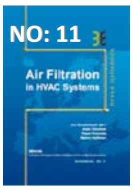
This guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked in the daily design practice, resulting in poor performance of high quality products once they are installed in the building system.



CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary conditions. Computational Fluid Dynamics (CFD) – in Ventilation Design models is written by a working group of highly qualified international experts representing research, consulting and design.

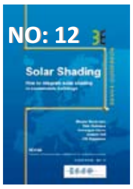


This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionellosis in building water and HVAC systmes. It is devided into several themes such as: Air conditioning of the air (by water – humidification), Production of hot water for washing (fundamentally but not only hot water for washing) and Evaporative cooling tower.

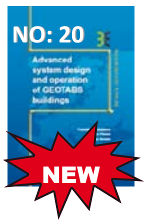


Air filtration Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on external conditions such as levels of existing pollutants, indoor air quality and energy efficiency requirements.

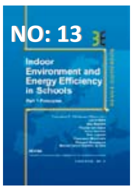
In this guidebook most of the known and used in practice methods for achieving mixing air distribution are discussed. Mixing ventilation has been applied to many different spaces providing fresh air and thermal comfort to the occupants. Today, a design engineer can choose from large selection of air diffusers and exhaust openings.



Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy for cooling, heating and lighting. The book gives also practical guidance for selection, installation and operation of solar shading as well as future trends in integration of HVAC-systems with solar control.



This guidebook provides comprehensive information on GEOTABS systems. It is intended to support building owners, architects and engineers in an early design stage showing how GEOTABS can be integrated into their building concepts. It also gives many helpful advices from experienced engineers that have designed, built and run GEOTABS systems.



School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with respect to low energy cost and performance of the students. It focuses particularly on energy efficient systems for a healthy indoor environment.

In this REHVA Report in cooperation with CEN, technical definitions and energy calculation principles for nearly zero energy buildings required in the implementation of the Energy performance of buildings directive recast are presented. This 2013 revision replaces 2011 version. These technical definitions and specifications were prepared in the level of detail to be suitable for the implementation in national building codes.

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