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CEN AND ISO EPB STANDARDS ACCEPTED AND READY FOR PUBLICATION

NEW ISO STANDARDS ON FILTERS

PUE INDICATOR FOR DATACENTRES EFFICIENCY

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The implementation of the new EPB-standards will boost product and HVAC system innovation and create new market opportunities for the HVAC industry

January 2017 the series of 17 EN-ISO Energy Performance Buildings (EPB) standards and 29 EPB EN-standards have been accepted. These standards passed the Final Vote last week of January 2017 and will soon be published. At ISO global level the 17 ISO standards and seven accompanied Technical Reports. At CEN level in Europe also the additional set of 31 EN standards and 23 CEN Technical Reports.

This set of EPB standards will be the basis for the Energy Performance Buildings assessment in Europe. It will be more or less obligatory for the EU Member States and EFTA countries to use these standards as a basis for their national regulation on Energy Performance of Buildings. More or less because the EPBD is just directing the EU MS's. However, if the MS's regulators seriously respect the outcome of the vote of the CEN and ISO community, where professionals, industry and other stakeholders gave their opinion and advice, broad implementation seems a question of time. The REHVA member organisations and the many European and national interest groups should combine their forces to convince the national regulators responsible for the regulatory framework to make use of these standards. It is the only way we can develop a strong European market for EPB related technology, systems and products. Making energy efficiency measures for buildings more cost-effective and competitive at the EU and global market.

What will this mean for the future? More harmonisation of the EPB assessment procedures which will have an impact on the harmonisation of the product and system requirements for energy relevant products used for buildings and their HVAC systems.

Under the European Eco-design Directive most relevant energy using products to be applied in buildings are already covered by a product regulation. This regulation requires the product to meet a certain minimum energy performance threshold, which is to be upgraded in the coming years (typically every 5 years). This regulation does not only set the energy performance requirements but also requires the product to have a label (product declaration) where these and other essential requirements have to be reported. Additional the Eco-design regulation refers to European or ISO standards describing the measurement and assessment procedures to obtain the required product data. If no standards available the EU-regulation includes, for the time being, this information. The measurement data which are the basis of these product declarations have to be published in a public data base. These public data are again essential input for the assessment procedures described in the EPB standards mentioned before.

This coupling of two EU directives, the EPBD (Energy Performance Buildings Directive) and the Eco-design Directive connects product declarations to finally Building Energy Performance certificates. It accommodates the holistic building and system approach. Energy saving technologies, systems and products can be can now be awarded at a level playing field. Where transparency, regarding the assumptions and very often needed simplifications of assessment procedures, stimulates innovation. Also, transparency regarding the overall performance parameters (like the levels Indoor Environmental Quality) and other boundary conditions such as the outdoor climate data and the to be used primary energy factors and assessment procedures to reward sustainable energy use. The overarching EPB standard EN-ISO/52000-1 includes all these essential issues to be considered and refers to the total set of EPB standards where these issues are worked out in full detail.

Having these standards available is a first step, implementing them needs dissemination actions at the level of building regulators as well in our professional community. REHVA is involved in supporting this dissemination process in Europe. The EPB-Center where REHVA is a stakeholder and where the current expertise is concentrated is expected to support this process. REHVA member organisations and their members are in a strategic position to implement the assessment procedures nationally and convince their national regulators that using the CEN EPB standards is the most promising way to support reliable building energy performance rating which will stimulate innovation at the same time. ■

JAAP HOGELING
Editor-in-Chief

Analysis of performance metrics for data center efficiency

– should the Power Utilization Effectiveness PUE still be used as the main indicator? (Part 1)




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To halt the ever-increasing energy consumption by data centers it is important to use performance indicators which accurately represent this performance. The strengths and limitations of PUE as the key performance indicator are analyzed and suggestions are made to complement any limitations.

Data centers were responsible for 1.5% of global energy consumption in 2010 and this figure is only expected to double soon. Data centers are becoming more energy efficient, a trend lead by the introduction of PUE (Power Utilization Effectiveness) as a performance metric. PUE's simplicity and focus on infrastructure efficiency was quickly adopted by the industry, but now the question is raised if PUE is still able to lead the quest for improved energy efficiency. PUE does not show performance regarding IT efficiency, water usage, heat recovery, on-site energy generation or carbon impact. This can lead to misuse of PUE by focusing on just improving PUE values instead of real energy use. Improving data center performance assessment is proposed in this paper by broadening the scope beyond PUE.

Key Words: PUE, Performance metrics, Data Center, Energy Efficiency, Indicators

A data center is a building which houses IT hardware, like computational units, network infrastructure and data storage, next to supporting equipment, like cooling and power supply. What all these different types of equipment have in common is that they are all high-energy density systems. This results in great amounts of energy being used, but also major energy savings potential by improving these systems.

Context

The data center industry is growing rapidly and the overall industry is expected to have an annual growth rate of over 10% until 2019 (Technavio, 2015). This is caused by the increase in number of chip driven appliances from 3 billion devices in 2010 to 15 billion devices in 2015 and it is expected to increase to up to 50 billion devices by 2020 (Modoff *et al.,* 2014).

Because of the growth of the data center industry, its energy consumption is rapidly increasing as well. Data center energy consumption accounted for between 1.1% and 1.5% of global energy consumption and up to 2.2% of US energy consumption in 2010 (Koomey, 2011). This meant a 56% increase over the period between 2005 and 2010 after doubling between 2000 and 2005 (*idem,* 2011). The slowing of this trend has partially been caused by increasing energy prices leading to increased operational cost. Giving more incentive to adopt energy efficiency strategies. Another important reason is the economic crisis in 2008. Despite this, energy consumption by data centers is still predicted to double between 2010 and 2020 (Whitney *et al.,* 2014), thus requiring more focus on energy efficiency measures to halt this trend.

Research and Markets (2015) proposes a 30% annual growth rate for green data centers compared to 10% for the whole industry. This predicted demand for energy efficient data centers shows a way forward, but the question is how to accomplish and monitor such progress.

Performance metrics

Over the last years, different performance metrics have been introduced to measure and compare performance and efficiency of data centers. These metrics can be used to assess individual pillars (cooling, IT, power supply) of the data center or the data center as a whole. This can relate to total energy use, water use or carbon emissions, as well as subsystem efficiency like temperature distribution (Wang *et al.,* 2011).

PUE: Power Utilization Effectiveness

The most widely used performance metric is PUE, which shows the ratio between total facility power use and IT equipment power use (Averal *et al.,* 2012):

$$PUE = \frac{Total\ Facility\ Power}{IT\ Equipment\ Power}; 1 \leq PUE$$

Therefore, the optimal value for PUE is 1.0, the maximum value is infinity. PUE has been developed to give data collection standards 'to determine the effectiveness of any changes made within a given data center' (*idem,* 2012). Beyond its intended use, PUE has been adopted by the industry to make comparisons between data centers. The limited scope PUE offers can make it unreliable for comparison as some strategies can improve PUE values without reducing energy consumption. There is also a lack of strict measurement and reporting guidelines, only recommendations exist. This leads to publishing PUE values based on designed nominal values instead of part-load values measured during operation. (Donnely, 2015). A survey by Uptime Institute (2014) found that 'a large majority (75%) of participants said the data center industry needs a new energy efficiency metric'. Which is part of the aim of this study.

The analysis presented in this paper will start by discussing the merits and shortcomings of PUE and continue by presenting other metrics to complement these shortcomings and try to find improved ways for accurately assessing data center energy performance.

Research methodology

To find a solution to the problem described above, the following research question has been formulated:

'Does the broadly accepted PUE metric reflect the real energy performance of a data center?'

This question is answered by performing a literature review on PUE and other available performance indicators.

The first part of this literature review focuses on both the merits of the PUE metric and its limitations. The misuse of the metric resulting from these limitations is also discussed as this helps to illustrate the reason behind the need of complementary performance metrics.

To solve the issues raised in the first part of the literature review, the second part consists of a review of existing metrics which can be used to complement PUE, or in some cases could even replace PUE. An overview of relevant metrics and their intended purpose is provided.

PUE analysis

PUE merits

The total efficiency of a data center comes down to how much useful work is produced per unit of energy. But as different data centers perform different tasks and are often relying on external input, useful work is difficult to determine. Therefore, PUE gained popularity as it shows the efficiency not by quantifying useful work, but by showing the ratio of energy available for useful work and the part that is lost to overhead, also referred to as the infrastructure. This lead to an industry wide adoption of PUE as the main performance metric after PUE's introduction. As in the data center industry energy consumption is one of the major expenses, what all data centers have in common, despite their different specializations, is the requirement to reduce their infrastructure energy consumption to increase efficiency.

When PUE was introduced in 2007 it provided new guidelines for measuring and reporting the internal energy flows in data centers. Industry average PUE values found after PUE's introduction lay between 2.5 and 3.0 in various studies (Foster, 2013). By using the framework provided by PUE average values have decreased to around 1.7 in the last major industry survey by uptime industries (Stansberry, 2015). In this way, PUE has lead the first major industry shift towards energy efficient data centers.

For state-of-the-art large-scale internet data centers the PUE value has always been significantly lower and is close to values of 1.1 now (Google, 2016). Which means further improvement within the boundaries PUE provides is difficult. This underlines the need for other metrics to broaden the scope of energy efficiency assessment beyond PUE to further lower data center energy consumption.

PUE limits and misuse

As said, PUE has been used for comparison since its introduction. As the green grid (2012) states 'the metric is best applied for looking at trends in an individual facility over time and measuring the effects of different design and operational decisions within a specific facility'. Despite the recommendation of applying PUE for internal use it's understandable that it started to be used for comparison. If a facility reports very low PUE values other facilities will be interested in the ways to achieve this efficiency. This also lead to infrastructure designers 'rating' their system with achievable PUE values, but as no strict guidelines apply to the origins of these values it often remains unclear for which conditions they were calculated and if they can be achieved in real life. PUE is supposed to be a tool to decrease the energy consumption of data centers, but decreasing the PUE value has become the goal itself. This leads to strategies where PUE doesn't necessarily reflect real energy performance.

As it can be taken as a fact that PUE will be used for comparison, its reporting parameters should be better regulated. At this moment, there is a lot of flexibility in choosing the measurement point for a data center's energy use (appendix A). As PUE was introduced for internal use it can be decided within a data center which level of monitoring is chosen. For comparison and marketing purposes it is obvious that you would like to choose the best-case scenario. Regulating this reporting parameters can greatly increase the reliability of the PUE metric.

Guidance as to which measurement points and intervals are required and recommended for each PUE measurement level.

Where do I measure? How often do I measure?		Level 1 (L1) Basic	Level 2 (L2) Intermediate	Level 3 (L3) Advanced
IT Equipment Energy	Required	UPS outputs	PDU outputs	IT equipment input
Total Facility Energy	Required	Utility inputs	Utility inputs	Utility inputs
	Additional recommended measurements*		**UPS inputs/outputs** **Mechanical inputs**	**PDU outputs** **UPS inputs/outputs** **Mechanical inputs**
Measurement Intervals	Required	Monthly	Daily	15 minutes
	Additional recommended measurements*	**Weekly**	**Hourly**	**15 minutes or less**

* Recommended measurements are in addition to the required measurements. The additional measurement points are recommended to provide further insight into the energy efficiency of the infrastructure.

The scope of PUE is limited to energy consumption and as stated by The Green Grid (2012) ‘PUE awards no credits or percentage points for on-site energy generation, waste heat recovery, etcetera. While important, these are not the focus of the PUE metric’. Also, the energy source being used isn’t monitored by PUE. Electricity generated by PV-panels is treated the same as electricity from a coal plant. By including the ecological impact of the energy source the total energy impact can be better assessed.

Other forms of resource consumption fall beyond the scope of PUE, like water consumption by evaporative cooling. Especially when treated water is used for this purpose a significant energy impact exists. Broadening the scope of performance assessment to include these effects will increase the complexity, but will help to promote the circular use of resources and the use of low impact energy sources.

Maybe the most important issue with using PUE as the guiding performance metric is its disregard for IT equipment efficiency. As the computational power per watt increases per Moore’s law (Moore, 1965) the useful work produced per watt can double every two years, therefore renewing IT equipment might be one of the best energy efficiency strategies. ‘A typical data center’s PUE is likely to vary with the levels of its IT load’ (Green Grid, 2012). And as illustrated in **Figure 1**, PUE values are better during periods of high relative IT load. **Figure 2** illustrates how the average IT load can drop when more efficient IT equipment is installed, causing a degradation in PUE values. This is obviously not a desirable effect for accuracy of performance evaluation using PUE. When the cooling temperature set, point is increased the PUE value doesn’t accurately reflect real performance. This leads to a decrease of energy consumption by the cooling system, but an increase of IT equipment energy use as the server fans speed up. Also, the electric resistance of the IT equipment increases together with IT energy consumption. It is obvious that the PUE value improves, but total energy consumption might be unchanged or could even increase (Hartfield, 2011). This effect is illustrated in **Figure 3**.

Performance metrics complementing PUE

As made clear in the previous section, to provide a complete assessment of energy efficiency for the data center industry through performance metrics, the scope should be widened from PUE alone. On the other hand, it is important to track the efficiency of separate parts of the data center as well. PUE performs very well if its limits are respected. Therefore, it is proposed to use complementing metrics to PUE addressing the previously presented issues.

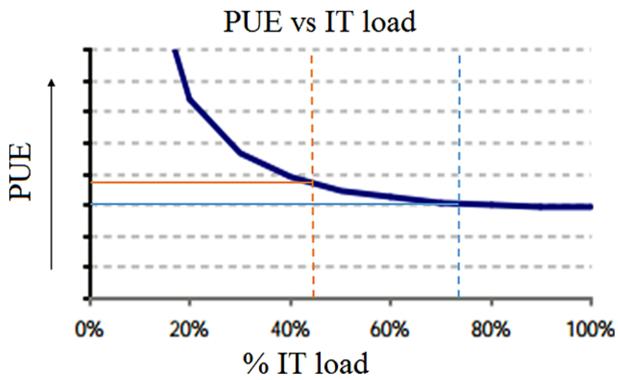

Figure 1. Relationship between PUE and IT Load with example from Figure 2 (adapted from Bisci 2009).

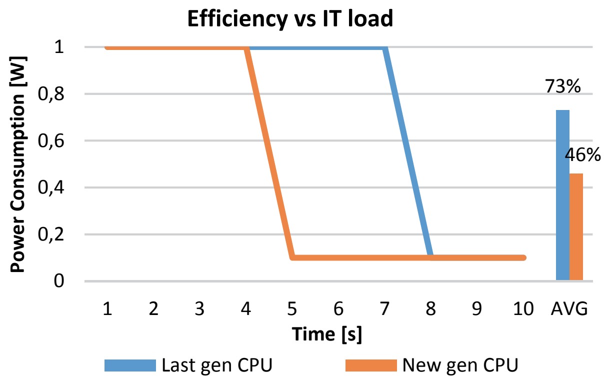

Figure 2. Relationship between efficiency and IT Load (adapted from Wasson 2015).

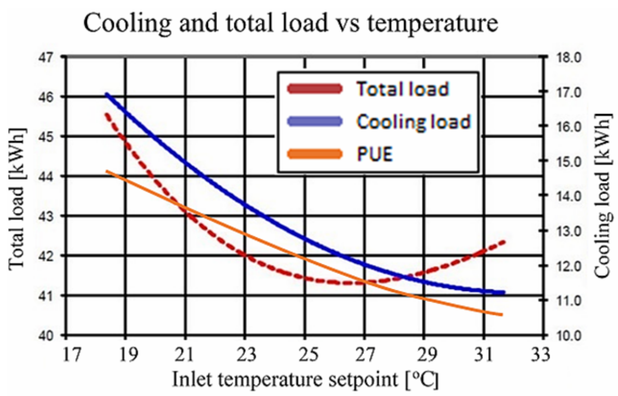

Figure 3. Typical relationship between temperature set point, cooling load, total load and PUE (adapted from Hartfield 2011).

Energy source impact: CUE

To give insight into the primary energy impact of a data center and related carbon emissions the Carbon Usage Effectiveness (CUE) metric has been selected to evaluate this aspect (Belady, 2010). From the same developers of PUE, CUE multiplies the total facility energy with its Carbon Emission Factor (CEF), being the carbon emitted per unit of energy. It is defined as:

$$CUE = \frac{CEF * Total\ energy}{IT\ energy} \left[\frac{kgCO_2}{kWh}\right]$$

$$0 \leq CUE$$

This adds information about the data center's ecological footprint. If the data center has multiple energy sources, like a combination of grid-sourced electricity and on-site renewable sources, the partial contribution of both should be considered. Adopting the CUE metric will incite the industry to choose low impact energy sources, like on-site renewables.

On-site renewables: OEF & OEM

The CUE metric already reflects the positive impact on-site renewables can have on the total energy impact of a data center, but doesn't provide enough insight on the effectiveness of these on-site renewables. To evaluate the energy (mis)matching the On-site Energy Fraction (OEF) and On-site Energy Matching metrics have been chosen. They are defined as:

$$OEF = \frac{\int_{t_1}^{t_2} Min[R(t); L(t)]dt}{\int_{t_1}^{t_2} L(t)dt}; 0 \leq OEF \leq 1$$

$$OEM = \frac{\int_{t_1}^{t_2} Min[R(t); L(t)]dt}{\int_{t_1}^{t_2} R(t)dt}; 0 \leq OEM \leq 1$$

where R(t) is the on-site generated renewable power and L(t) is the load power at time 't'. And 'dt' is the time-step of the calculation (Cao, Hasan and Sirén 2013).

Ideally, the on-site renewable generation is equal to the facility power, this is where the lines in **Figure 4** intersect. Area I is the amount of useable renewable energy, Area II is the surplus generation distributed back to the grid (when OEM < 1) and area III is the energy required from the grid (when OEF < 1).

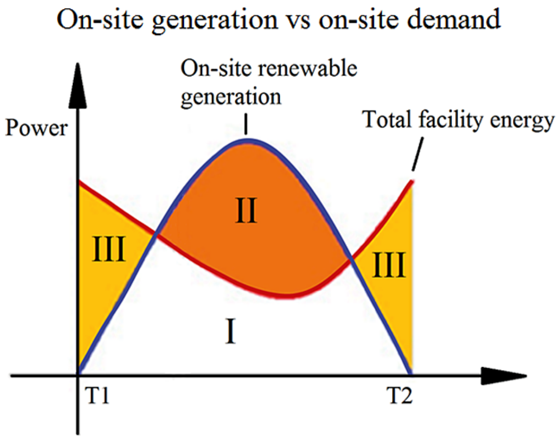

Figure 4. On-site generation vs. demand (adapted from Cao et al. 2013).

Information obtained from the OEF and OEM metrics can be used to track and improve the energy matching. This can be done by adapting generation to the expected demand or adapting demand to supply, i.e. by saving some of the non-essential workload for periods with high on-site energy availability. But also by applying energy storage to conserve surplus generation.

Energy reuse: ERF

Data centers always have a heat surplus resulting from the conversion of electrical energy into heat within the IT equipment. This heat surplus can be reused in different ways depending on local circumstances, like heat demand near the data center. Though it might be difficult to quantify the amount of energy that is efficiently being reused, it does provide opportunities for improving energy efficiency. The metric to track the amount of energy reuse is the Energy Reuse Factor (ERF), defined as (Patterson, 2010):

$$ERF = \frac{Reuse\ energy}{Total\ energy};\ 0 \leq ERF \leq 1$$

Some data centers have already taken measures to efficiently reuse waste heat by providing it to greenhouses or residential and commercial buildings. The best results have been achieved when this is done through an aquifer thermal storage system which helps to mitigate the effect of seasonal demand.

Water usage: WUE

Though PUE doesn't include water use in the total energy consumption, it is estimated that '4% of U.S. electricity demand is for the movement and treatment of water' (EPRI, 2002). To keep track of the impact this has on the ecology the Water Usage Effectiveness (WUE) is available (Green Grid, 2011). It is defined as:

$$WUE = \frac{Water\ usage}{IT\ energy}\ [\frac{L}{kWh}];\ 0 \leq WUE$$

Alternatively, if information concerning the embodied energy of the water source is available it's also conceivable to add this embodied energy from the total water usage to the total facility energy use.

IT efficiency: ITEE & ITEU

The IT efficiency is a very important factor contributing to the total data center facility energy use, but it's also a very complicated contribution. Different data centers have different purposes like storage, calculation and networking, or a combination. This makes a comparison of efficiency difficult. For every type of function the efficiency of all the installed equipment can be compared to a standardized alternative. The average value that is found results in the IT Equipment Efficiency (ITEE) metric (Green IT council, 2012), defined as:

$$ITEE = \frac{W_{DC,rated}\,[units\ of\ useful\ work]}{P_{DC,rated}\,[W]}$$

$$0 \leq ITEE \leq 1$$

With $W_{DC,rated}$ being the capacity of the IT equipment multiplied by the standardized capacity per watt and $P_{DC,rated}$ is the rated power of the IT equipment. The capacity is subdivided in three categories: servers [GTOPS], storage [Gbyte] and networking [Gbps].

Also, important to monitor is the average IT load, as total energy efficiency is better for high IT utilization. This can be done using the IT Equipment Utilization (ITEU) metric (Green IT council, 2012), defined as:

$$ITEU = \frac{E_{IT}}{E_{IT,rated}};\ 0 \leq ITEU \leq 1$$

Some data centers only provide the infrastructure and rent out floor space to customers, meaning the owners have no influence over the efficiency of the IT equipment installed, in this case ITEE and ITEU shouldn't be used to assess the data center's efficiency.

Discussion, conclusion & further research

The literature review has provided sufficient information to answer the research question:

'Does the broadly accepted PUE metric reflect the real energy performance of a data center?'

The merits of PUE for improving data center energy efficiency are clear, but the industry has come to a point where further improvements can only be found by assessing energy performance in a broader sense. It is concluded that the scope of the PUE metric is insufficient to reflect the real energy performance of a data center. Subjects that PUE doesn't touch upon, but should be included in energy performance assessment, are water usage, on-site renewable energy generation, energy recovery, IT equipment efficiency and carbon footprint. For these topics, respectively the WUE, OEF/OEM, ERF, ITEE & ITEU and CUE metrics can be used.

The literature review showed a large energy savings potential by using up-to-date IT equipment, as the IT equipment efficiency doubles each 2 years on average. A very important conclusion is that, at least in some cases, PUE values can be positively influenced by increasing the energy use of IT equipment as it does not track the actual meaningful work that's being done by the data center. This can also be achieved by shifting cooling loads from the HVAC system to the server fans. These practices can be prevented by using complementary metrics as proposed in this paper.

Also, the importance of tracking water usage was shown as, for example, 4% of the U.S. national energy consumption is connected to water treatment and transport. This becomes increasingly important because of the increased use of evaporative cooling systems.

Further research should show to what extent the issues raised in this paper influence the discrepancy between PUE values and real energy performance. This can aid data center designers in their decision-making process on energy efficiency measures and help the data center industry to take another step in reducing its, still increasing, energy impact. ■

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EN-ISO 16890:2016

New global standard links filtration performance to outdoor air pollution

The International Organization for Standardization (ISO) has recently developed and introduced a new standard for the testing and classification of air filters titled "EN-ISO 16890:2016 – Air filters for general ventilation". This standard has been developed under the Vienna-agreement between CEN and ISO, therefore this new standard will replace the current filter test standard EN779:2012 after a few years, and in a longer perspective, it can potentially also replace the present North American test standard ASHRAE 52.2.

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Compared to EN779:2012 and ASHRAE 52.2, EN-ISO 16890 brings several improvements to filter testing and classification, of which the most noticeable is the link between filter performance and outdoor air pollution.

A standard that is air quality-oriented

Until now filtration performance has been determined by a filter's particle removal efficiency on specific particle sizes. This has made sense from a technical and scientific perspective because the particle removal efficiency has given laboratory technicians and engineers detailed and relevant information about the technical performance of air filter products. However, this performance data has provided little guidance to the end user in the process to select filters.

Most filters that are tested, classified and compared with general air filter standards are used in the ventilation systems of public, commercial and residential buildings, including offices, schools, hospitals and multistory apartment complexes. In general, the customers purchasing these filters are not experts in ventilation or filtration, although they usually have a basic level of environmental awareness. Like any person, they are concerned about the surrounding environmental conditions and their potential impact on health and wellbeing. In this respect, air pollution is one of the more important factors.

Today, air pollution is a hot topic anywhere in the world and especially poor air quality in densely populated urban centers. Many people have become familiar with the particle fractions in outdoor air pollution, designated PM_1, $PM_{2.5}$ and PM_{10}, while others have at least heard of these measurements for harmful airborne particulate matter.

On a regular basis around the globe, people are hearing news or reports that the air quality is so poor in their local environment that the limit values for several of these pollution measurements are being exceeded. It is known that traffic and industrial processes are major contributors to air pollution in urban environments and that much of the pollution is in the submicron range and highly respirable. These pollution concerns, which are serious and real, require solutions to mitigate the health risks and exposure.

Ambient air quality is normally improved by addressing the pollution source directly. These measures are usually difficult to implement and require long-term improvements driven by stricter legislation and regulations for controlling emissions from industry and transportation.

In contrast, indoor air quality (IAQ), in relative terms, is easy to take care of and improve when building ventilation systems are equipped with effective air filters. Given that modern-day citizens spend more than 90% of their time indoors, their exposure to air pollution can be considerably reduced by improving IAQ.

Until now, it has been difficult for end users to choose the right filtration solution for a given environmental situation. The new global standard for general filtration can now solve this because ISO 16890 directly links the outdoor air pollution measurements PM_1, $PM_{2.5}$ and PM_{10} to the filtration removal efficiency of air filters for general ventilation. Each filter tested according to ISO 16890 is now assigned a removal efficiency rating for these three particle fractions.

The particle removal efficiency is stated in percent [%] in relation to the PM_x particle fraction that is removed. In simple terms, this means that a filter rated ePM_1[60%] removes 60% or more of the particulates in the PM_1 range. In other words, the filter provides 60% protection against PM_1 air pollution.

With the new classification values, it will now be much easier for air filter customers to decide the level of protection they want in relation to outdoor air pollution levels and their expectations for indoor air quality. Let us now briefly examine how ISO 16890 is built up and how the new standard basically differs from ASHRAE 52.2 and EN779:2012.

EN-ISO 16890:2016 in brief

The ISO 16890 standard consists of four different parts:

1. Technical specifications, requirements and the classification system based upon matter efficiency (ePM).
2. Measurement of fractional efficiency and airflow resistance.
3. Determination of the gravimetric efficiency and airflow resistance versus the mass of the test dust captured.
4. Conditioning method to determine the minimum fractional test efficiency.

If you are interested in the full details, I recommend reading the entire standard. This article only aims to explain ISO 16890's basic differences and its advantages over existing or prior filter standards. Another goal of this article is to shed some light on how ePM efficiencies are calculated and used.

ISO 16890 in practice

In practice, the filter test is performed in five steps:

1. Efficiency and pressure drop measurement
2. Discharging conditioning
3. Post-discharging efficiency measurement
4. Dust holding and arrestance measurements
5. Calculation and ePM classification

Compared to ASHRAE 52.2 and EN779:2012, the main differences of the ISO 16890 testing process are as follows:

Efficiency measurement

When measuring efficiency, the tested particle range is broader than for EN779:2012 – from 0.3 µm to 10 µm, instead of from 0.3 µm to 3 µm – and the entire span is used for classification. This differs from EN779:2012, where the reported removal efficiency is calculated solely on one particle size (0.4 µm). This is like what is used today in ASHRAE 52.2. The advantage of using a wider particle span is that a broader range of filters can be given more relevant classification values.

Electrostatic discharge

The second big difference is the conditioning method for the filter. Conditioning serves to remove the electrostatic filtration effect in the filter. It is known that this filtration effect diminishes with time as the electrostatic charge is neutralized during use. Several methods have proven to be effective to simulate the drop in electrostatic effect.

EN779:2012 uses the method of soaking the filter media in isopropanol and then simply hanging it to dry before testing it again. While this is a very effective discharging method, it has the disadvantage of potentially damaging the fiber structure in the filter and it consequently affects other active filtration mechanisms.

ASHRAE 52.2 uses solid particles of potassium chloride (KCl) to discharge the material. This is a mild form of discharging and it is hard, even after long process times in the laboratory, to achieve full discharge. The advantage of this method is that it does not affect other important filtration mechanisms in the filter.

In the ISO 16890 standard, the isopropanol method has been chosen for its good discharging properties. However, the method has been developed and is now based on saturated gas-phase discharging. Although this method is slower and more complicated to conduct in the laboratory than a wet process, it discharges the filter 100% without affecting the fiber structure of the filter.

Dust loading

Compared to ASHRAE 52.2 and EN779:2012, the test dust in EN-ISO 16890 has been changed from the test dust in ASHRAE 52.2 to a finer test dust designated as L2 in EN-ISO 15957. This finer dust will take longer time to load in the laboratory, but it will simulate real-life conditions more accurately than the currently used method.

Classification and calculation

The main difference between EN-ISO 16890 and EN779:2012 and ASHRAE 52.2 becomes apparent in the final classification and calculation step. Through calculation, the measured test results are converted and related to the known outdoor air pollution measurements PM_1, $PM_{2.5}$ and PM_{10}.

PM is a mass measure expressed in [µg/m³] and the measurements in ISO 16890 are particle counts from an optical particle counter that are stated in numbers [#].

The values from the measurements need to be recalculated to become relevant and indicate their ability to remove outdoor air pollution. This is done with weighted efficiency calculations of the laboratory measurements that are related to a global standardized particle distribution from urban and rural environments. This particle distribution is bimodal, as can be seen in the two illustrations. In **figure** below, the urban curve shows that a larger portion of the particles from an urban environment is submicron, compared to the particle sizes in the rural curve.

As different filters are used for different purposes, the urban curve is used for weighted calculations of PM_1 and $PM_{2.5}$ efficiencies. It is assumed that fine filters will be used in urban areas where submicron particles represent a clear majority of the air pollutants. The rural distribution curve is used for coarse filters that target large particles for removal. This gives the consumer a relevant value for a filter's effectiveness for a specific filtration purpose (please refer to ISO 16890-1 for detailed information on weighting calculations).

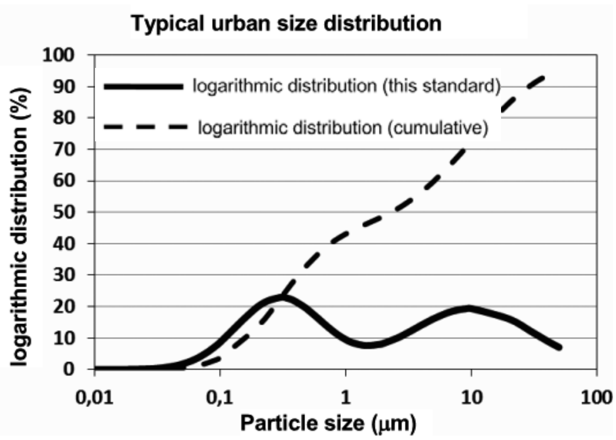
Once the efficiency data is weighted in accordance with the above distribution curves, the average efficiency is calculated. The average is calculated between the virgin filter efficiency and the conditioned discharged efficiency (also called the minimum efficiency of the filter).

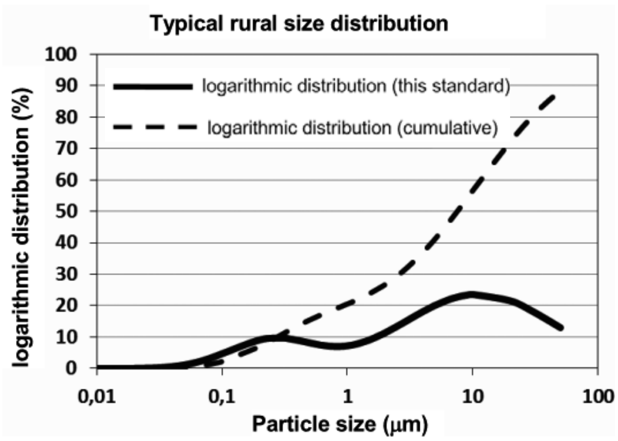
The efficiency calculation is made for three particle spans:

Particle span [µm]	ePM representation	Used particle size distribution
0.3–1.0	ePM_1	Urban
0.3–2.5	$ePM_{2.5}$	Urban
0.3–10	ePM_{10}	Rural

The average and minimum efficiency values are both used to classify a product. To classify a filter as an ePM_1 or $ePM_{2.5}$ product, the minimum efficiency must be above 50%. If the minimum efficiency is above 50%, the reported efficiency value will be the average efficiency value between the minimum and virgin efficiency. For ePM_{10}, there is no threshold demand for minimum efficiency, but the average efficiency has to stay above 50%. If a filter's efficiency drops below 50% on ePM_{10}, it will be classified as a "coarse" filter and only dust arrestance in percent [%] is reported:

Group designation	Requirement			Class reporting value
	$ePM_{1, min}$	$ePM_{2,5, min}$	ePM_{10}	
ISO Coarse	—	—	< 50%	initial grav. arrestance
ISO ePM_{10}	—	—	≥ 50%	ePM_{10}
ISO $ePM_{2,5}$	—	≥ 50%	—	$ePM_{2,5}$
ISO ePM_1	≥ 50%	—	—	ePM_1





Summary

The global applicability of EN-ISO 16890 will be of great significance in the years to come. The new standard marks the first time in history that the air filtration industry has agreed on a global testing and classification standard that makes it easier for customers to select the right filter for the right application. In addition, the standard includes a new efficiency rating for PM_1 – the smallest and most harmful airborne particles – to acknowledge that air filters have a positive influence on air quality and human health.

Although ISO 16890 for general air filters is technically demanding, it brings a wealth of value to end customers. For the first time, filtration efficiency, or filtration protection, can be related directly to common air pollution data.

When choosing the filter solution, the end user should ask a few questions: What is my local air pollution situation? Am I situated in a rural or urban environment? Am I affected by pollution emissions from nearby industries? What level of pollution protection do I want?

The filtration solution may look different, depending on the local situation and the desired minimum indoor air quality. In urban areas, where the majority of the particulate pollution will be submicron, the choice will primarily stand between filters in the PM_1 category. In more rural settings, a higher-grade $PM_{2.5}$ filter may be sufficient as the final filter. PM_{10} and coarse filters will be suitable for dusty environments, or as pre-filters in dual-stage installations.

Whatever the final choice, end users will now have a much clearer idea of what they can expect from the chosen filter solution. ■

Literature

EN-ISO16890:2016 Air filters for general ventilation – Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM).

Part 2: Measurement of fractional efficiency and air flow resistance (ISO 16890-2:2016, IDT)

Part 3: Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured.

Part 4: Conditioning method to determine the minimum fractional test efficiency.

EN 779:2012 Particulate air filters for general ventilation - Determination of the filtration performance.

ANSI-ASHRAE Standard 52.2-2012 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

Definition of filtration performance – from EN 779 to ISO 16890

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A new ISO standard is about to replace the current EN 779 standard used to characterize the filtration efficiency of filters now classified from G1 to F9. This new standard incorporates a different approach from the current standard in terms of classification methodology and will therefore have a significant impact on the market. It is proposed here to present the main changes, to detail the future benefits provided by this standard and to consider the impact on the certification of the filters.

New ISO 16890 - A new way to classify filters

Over the past five years, a new approach has been developed within the ISO standardization working groups to characterize filter filtration efficiency. This new approach is to look at filtration efficiency not only for particles with a diameter of 0.4 µm but to consider the entire spectrum of particle sizes.

The EN779:2012 standard used today in Europe to characterize the filtration efficiency of the filters for the ventilation of buildings defines the filtration classes according to the average filtration efficiency of the particles with a diameter of 0.4 µm (see **Table 1** below).

Table 1. Filter classification according to EN 779:2012.

Group	Class	Average efficiency (Em) at 0,4 µm	Minimum efficiency at 0,4 µm
Medium	M5	40≤ E_m<60	–
	M6	60≤ Em<80	–
Fine	F7	80≤ Em<90	35
	F8	90≤ Em<95	55
	F9	95≤ Em	70

The convention of using only the filtration efficiency of particles with a diameter of 0.4 µm is due to the fact that particles of this size are the most difficult to filter. Indeed, for particles with a smaller diameter, the phenomenon of diffusion predominates, whereas for particles with a larger diameter, the phenomenon of interception is predominant (see **Figure 1** below).

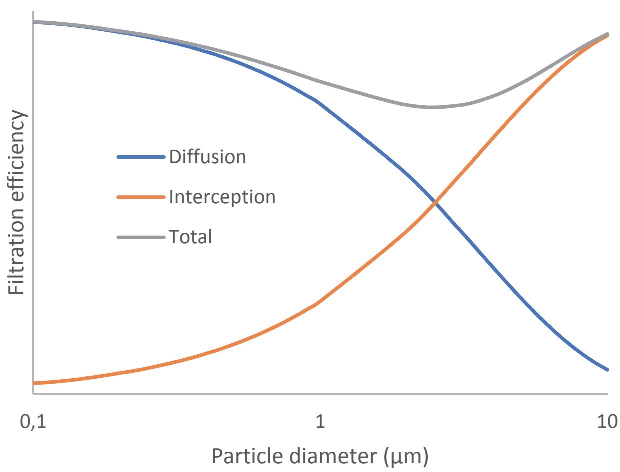

Figure 1. Particle filtration efficiency according to size.

For most media filtering the minimum efficiency is around 0.4 µm.

The current system therefore makes it possible to compare filters between them, but it is not easy to evaluate the effectiveness of a filter with regards to its impact on air quality.

From this observation, it has been suggested to characterize the filters in relation to indicators that have been used for several years in the field of air quality: particulate matter (PM): PM_{10}, $PM_{2.5}$ and PM_1 which respectively define the air concentrations in liquid or solid particles whose diameter is below 10, 2.5 and 1 µm.

These indicators are used in many health and toxicological studies. They make it possible to classify the particles according to their dangerousness:

- Particles with a diameter greater than 10 µm are retained by the upper airway and are not breathed.
- Particles with a diameter of less than 10 µm (PM_{10}) can penetrate the bronchi.
- Particles with a diameter below 2.5 µm ($PM_{2.5}$) can penetrate the pulmonary alveoli.
- Particles with a diameter below 1 µm (PM_1) can penetrate the alveolo-capillary barrier.

The new standard therefore classifies filters relative to their filtration efficiency for these different particle sizes according to **Table 2**.

With respect to PM_1 the efficiency of a filter classified as ePM_1[80%] will be above 80% and below 85%.

a. Other changes from EN 779:2012.

The new ISO 16890 standard will be divided into four parts covering all the chapters currently covered by EN 779:2012 according to **Table 3**.

Table 2. Filter classification according to ISO 16890-1.

Group	Initial efficiency in PM_x	Discharged efficiency PM_x
ePM_{10}	≥ 50% (PM_{10})	≥ 50% (PM_{10})
$ePM_{2.5}$	≥ 50% ($PM_{2.5}$)	≥ 50% ($PM_{2.5}$)
ePM_1	≥ 50% (PM_1)	≥ 50% (PM_1)

Table 3. Filter classification according to ISO 16890-1.

Object	ISO 16890	EN 779:2012
Technical specifications, requirements and classification	Part 1	Chapters 5 - 6
Efficiency measurements	Part 2	Chapters 7, 8 and 9
Definition of the gravimetric efficiency	Part 3	Chapter 10.4
Packaging method to determine the minimum spectral efficiency of the test	Part 4	Chapter 11

Beyond the new approach of classification of the filters certain evolutions are to be noted:

- requirements have been introduced with respect to the test conditions in terms of temperature and relative humidity.
- the conditioning method for determining the minimum efficiency makes it possible to test a complete filter and not only the filter media as with the EN 779:2012.
- “Fine AC” dust is used to determine gravimetric efficiency as a replacement for standardized dust such as “ASHRAE”.

Publication of ISO 16890

The four parts of ISO 16890* have been published in December 2016. It is expected that it will last 18 months before EN 779: 2012 will be withdrawn, this to allow the manufacturers to adapt their current catalogues.

1. Benefits for the end user

a. Towards a universal method?

The adoption of this new standard may perhaps make it possible to harmonize worldwide the method of characterizing the efficiency of filters. Today two systems predominate:

- In Europe, the method EN 779:2012 is the only one
- In North America, the ASHRAE 52.2 method is used exclusively
- In Asia the European and American systems coexist.

* At CEN level in Europe this ISO standard is indicated as EN-ISO 16890 and when published on national level the letters of the National Standard Body are added, like e.g. DIN-EN-ISO 16890

In the future, the new ISO standard is intended to be the universally used method. However, there is no indication that this will be the case, a standard being of a voluntary nature. However, we can say that this standard will be the future reference in Europe as it has already been decided that it will replace the current EN779: 2012. Similarly in Asia there is a good chance that they will become the benchmark except in the markets where US players are predominant.

However, in North America doubts remain about the possible use of this ISO standard. Indeed, the ASHRAE methods have been established for a long time and the United States has shown some reluctance throughout the validation process of this ISO standard.

A clearer link between filter efficiency and indoor air quality

As indicated earlier, concentrations of PM_{10} and to a lesser extent $PM_{2.5}$ and PM_1 are now widely used for assessing air quality. The European "Airbase" project gathers data from more than 8 000 continuous PM_{10} measurement stations in Europe (see **Figure 2** below). WHO defines guidelines for maximum levels of concentrations not to be exceeded for PM_{10} and $PM_{2.5}$.

The use of efficiency referring to these indicators will enable end-users to more easily assess their needs based on outdoor air quality and their objectives in terms of indoor air quality.

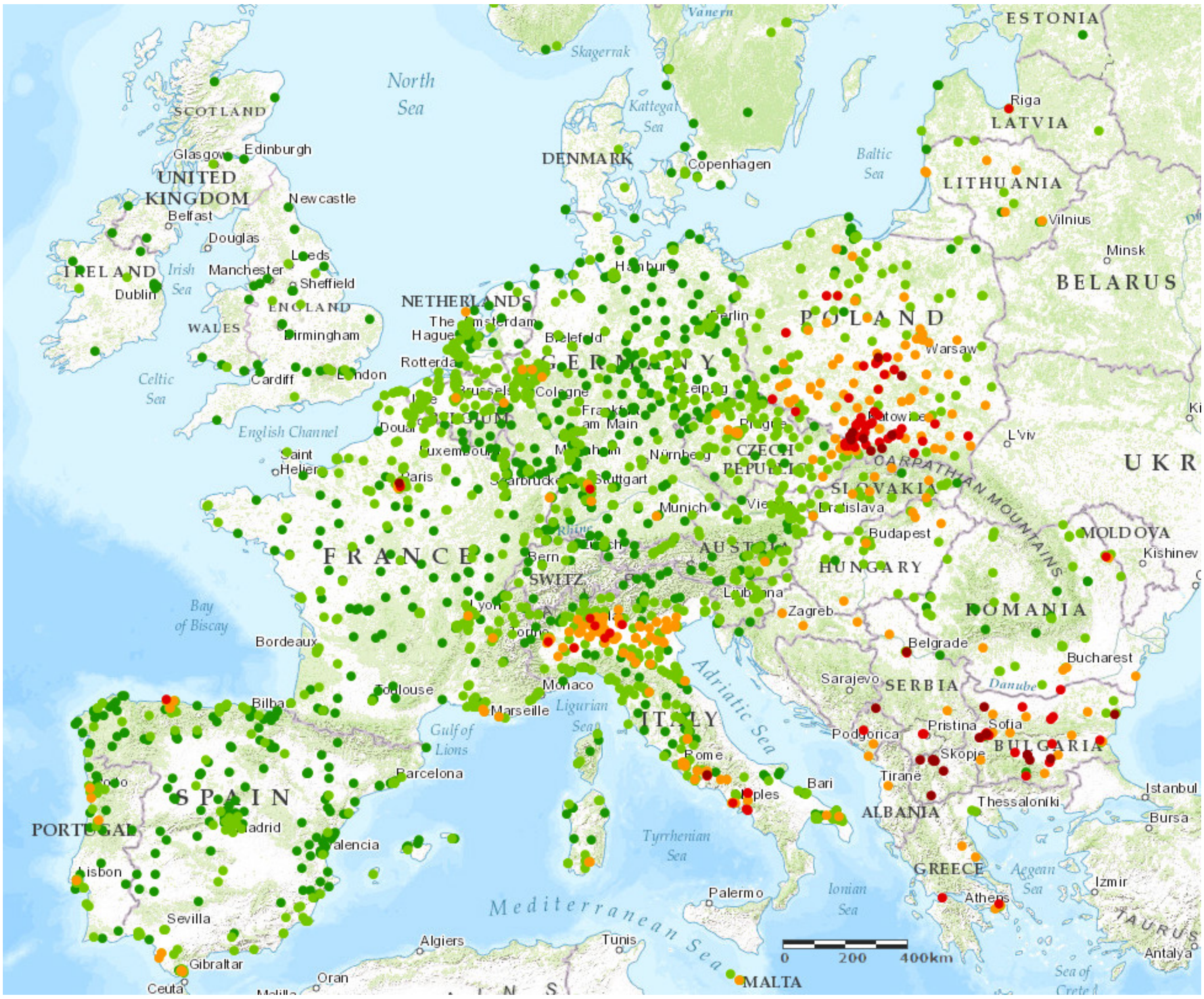

Figure 2. Location of continuous PM_{10} measurements in Europe (Source: Airbase).

2. What impact on the certification of filters for ventilation?

a. The Eurovent certification for filters:

i. The certification programme « Eurovent Certified Performance » for Air Filters M5 – F9 was launched in 2006. This certification is based on tests carried out by independent ISO 17025 laboratories, according to EN 779:2012 (which replaced EN 779:2002). This programme covers the certification of all relevant performances of filters used for general ventilation, namely:

- The filtration class
- The initial pressure drop
- The initial efficiency
- The minimum efficiency

These performances related to the Standard EN 779:2012 add up to the performances related to the energy efficiency as defined in the Standard Eurovent 4/21.

- Annual energy consumption
- Energy efficiency class

All certified data are available on www.eurovent-certification.com.

ii. In 2016 this certification programme covers 25 manufacturers representing 25 brands and more than 2300 references. According to the latest figures from Eurovent Market Intelligence, this programme covers 87% of the French market and 75% of the European market.

Evolution and next steps

The first four parts of the new ISO 16890 standard cover all the chapters covered today by the European standard EN 779. Thus it does not define a method for calculating the average annual energy consumption as defined in document Eurovent 4 / 21. A revision of the latter must therefore be carried out in order to integrate the new provisions of ISO 16890. A Eurovent working group dedicated to this project was recently set up, and met for the first time in December 2015. A first revision project is planned for February 2016.

The Eurovent certification of filters will then be able to evolve towards the new standard once it has replaced the standard EN 779.

Conclusion

The new ISO 16890 Standard will have a significant impact on all the actors of filtration. In the first place manufacturers will have to characterize all their products according to this new method. Knowing that standardized dust will also change this implies a significant effort on their part, the old standardized dust being used for decades.

Secondly, buyers will have to completely revise their current requirements based on the well-known filtration classes M5, M6, F7, F8 and F9. It is expected that a transition period will be required (with dual labeling of products) before the new efficiency classes are integrated by buyers. A major effort will have to be made by all the players (notably the manufacturers) to communicate effectively on these changes. The fact that the vast majority of products available on the market are certified will facilitate this transition by providing clear and controlled information. ■

References

ISO 16890-1, Air filters for general ventilation – Part 1: Technical specifications, requirements and classification system based upon particular matter efficiency (ePM).

ISO 16890-2, Air filters for general ventilation – Part 2: Measurement of fractional efficiency and air flow resistance.

ISO 16890-3, Air filters for general ventilation – Part 3: Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured

ISO 16890-4, Air filters for general ventilation – Part 4: Conditioning method to determine the minimum fractional test efficiency

EN 779:2012, Particulate air filters for general ventilation – Determination of the filtration performance.

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The New Climate Room for transient investigations of thermal comfort

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Criteria of thermal comfort are very important to evaluate different heating and cooling systems for buildings. But the criteria given in ISO 7730 [1] or EN 16798-1 [2] are based on stationary boundary conditions. Real heating and cooling systems operate transient which means we can detect a lot of heating up and cooling down periods during one day. To evaluate these periods in the contents of thermal comfort, a new climate room was built at the Technical University of Dresden. The climate room is the final part to complete the "combined energy lab 2.0" which depends of an electrical test facility to change the parameters of the local electrical grid, the thermal test facility which is a hardware in the loop test rig for different heating and cooling devices and the new climate room. All the different parts of the combined energy lab 2.0 are connected to each other. **Figure 1** shows a principal view of the different test facilities.

With these test facility, it is possible to investigate complex technical systems in the building (generation - distribution - emission) and, also, the connection from the building to the upstream energy supply system.

The climate room consists of a special design. The main focus during the design phase was to create a system with a very low response time. The climate room should also be able to cover a lot of practical applications. Therefore, the test facility consists of 28 different wall elements. Each side wall element is separated in three segments which can be tempered separately. The top and bottom wall elements are each composed of one segment. The construction of the wall elements depends on a metal plate on the inside, a water based capillary system directly on the metal plate and an isolation. Between the capillary tubes temperature sensors are implemented for measuring the surface temperature. Figure 2 shows the construction details of the test facility. The uniform temperature control of the segments ca be demonstrated with

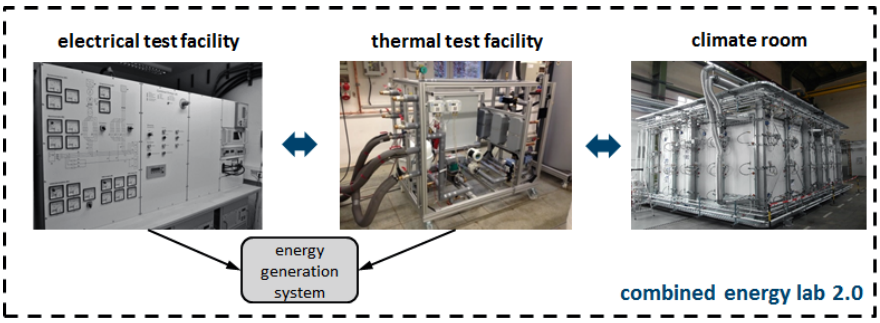

Figure 1. Combined Energy Lab 2.0 at the TU Dresden.

the help of thermography and it is shown in **Figure 2** (right).

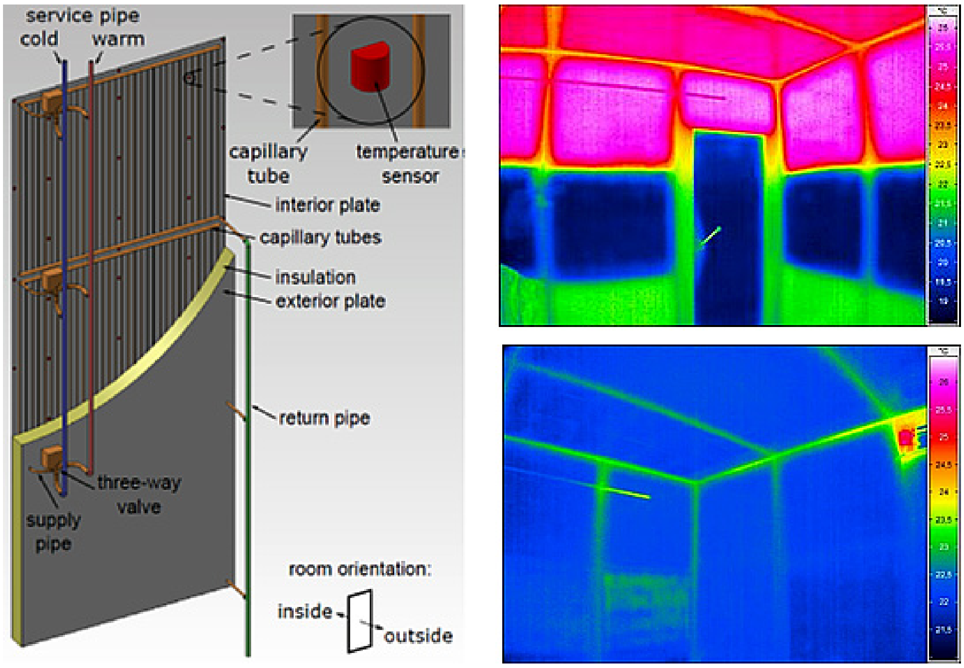

Figure 2. Construction details of the climate room.

The physical behavior of the climate room is extremely flexible. The climate room has an inner dimension of 4m x 5m and a high of x 2,5m. The surface temperatures of the walls, ceiling and floor can be regulated in a range from ϑ=10°C to 50°C. The climate room is connected to a ventilation and air conditioning systems. This is necessary to fulfill the hygienic criteria of the air in the room (e.g. CO_2 -level). Furthermore, the air temperature can be changed in a range of ϑ=10°C to 35 °C and the air humidity from ϕ=20% up to 90%. With this system, a maximum volume flow rate of 600 m^3/h can be generated which results in an air change of n=12 h^{-1}. **Figure 3** shows a view inside the room.

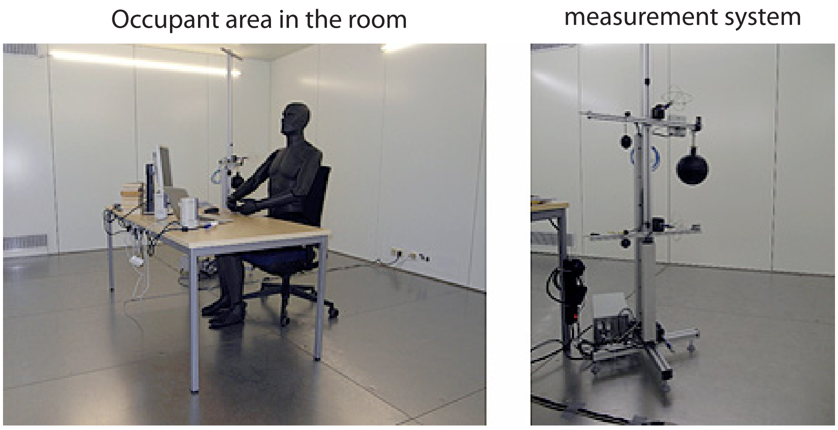

Figure 3. Inside view of the climate room.

In the occupant area, the operative temperature is measured with different sensors. The first one is a classic globe thermometer with a dimension of d=150 mm. For steady state condition this measurement device can be used. For transient conditions a modified globe thermometer is used with a very small diameter of the globe. Additionally, different velocity sensors, combined temperature humidity sensors and CO_2-sensors are used.

The quality of the climate room can be detected with a transient measurement. Therefore, some initialization tests were carried out. Based on a constant operative room temperature the set point of the operative temperature was changed with gradient of 2 K/h. **Figure 4**

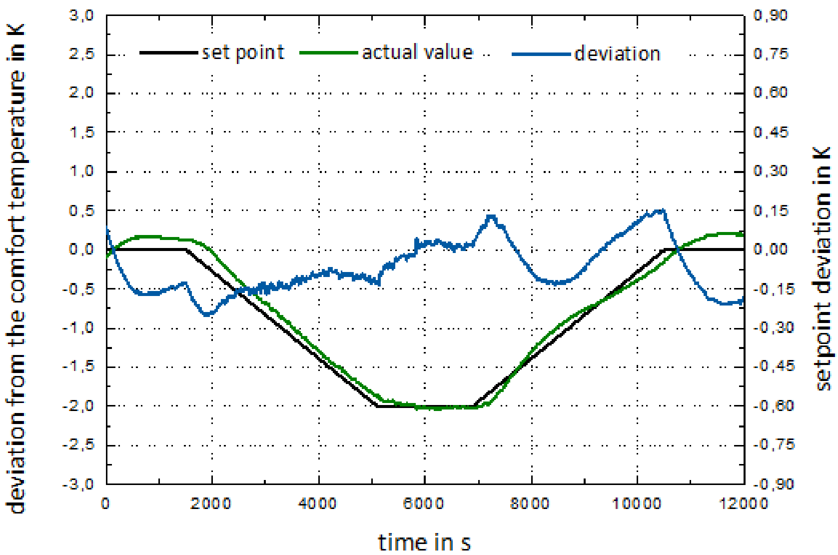

Figure 4. Set point temperature / actual temperature and derivation of the temperatures during the initialization experiment.

shows the results of the initialization test.

Based on documented results it can be determined, that the actual temperature can follow the set point very well. The differences between the set point and the actual values is lower than $\Delta\vartheta$=0,2K. Especially the air temperature fluctuate in a small range. The reason therefor is that the flow pattern in the climate room is like not complete stable.

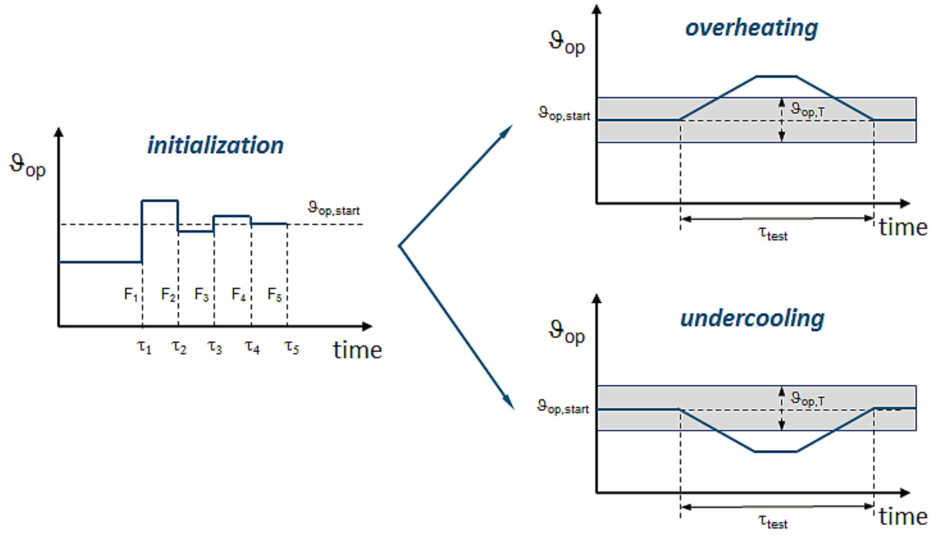

Figure 5. Initialization / overheating and undercooling investigation.

At the moment, the climate room is used to investigate transient thermal comfort aspects. For this purpose, a test program was established, which was carried out with 85 test persons. The investigation procedure begins with an adaption phase. In this adaption period, each test person selects its own comfort temperature. After this period the measurement period closes. Two periods are distinguished. The first one symbolized an overheating of the room and the second one a down cooling. **Figure 5** shows the principle of the analyses.

The results of these investigations were presented in the near future in different papers[1]. This publication should be intended to describe the test facility. But the test facility can not only be used for scientific work in the contents of thermal comfort experiments. Also, product investigations for new heating and cooling systems or control systems can be carried out with the climate room. ■

1 In [3] a complete an detaild describtion of the climat room and the investigations are documented.

Acknowledgment

This research was supported by the German Federal Ministry for Economic Affairs and Energy under the project number 03ET1166A.

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Comfort modelling in semi-outdoor spaces

Indoor comfort modelling is well known and mastered thanks to empirical indices or heat balance equations of the individual. In open buildings, called semi-outdoor spaces, assessing comfort is a considerable effort as rapid variations of ambient conditions require the transient modelling of human metabolism.

Keywords: semi-outdoor spaces, comfort index, transient modelling.

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The widespread comfort index "Predicted Mean Vote" (PMV) by (Fanger 1970) gives a prediction of the average mean thermal sensation depending on the steady-state sensible and latent heat load on the individual in his environment. The predicted percentage of dissatisfied (PPD) is linked to the PMV with a Gaussian-like relationship (see **Figure 1**), depending directly on the heat load that results from the ambient conditions.

This comfort index has been developed for indoor conditions with wall temperatures that do not deviate much from the air's one, and for individuals whose metabolism has reached steady-state, thus implying an exposition time to ambient conditions reaching several hours. The PMV can hence no more be applied to the outdoor or semi-outdoor cases, especially due to the rapid variations of air velocities, mean radiant temperatures and because the average time spent in such places (for instance railway stations) is short compared to the human metabolism reaction time. A detailed, transient simulation of heat and vapour transfer is then necessary for this type of spaces.

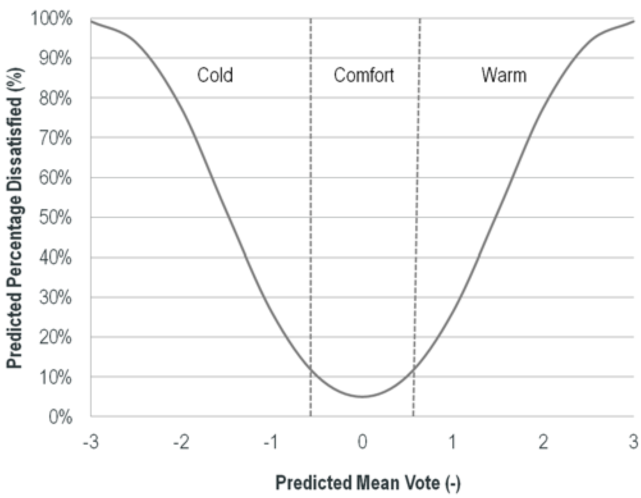

Figure 1. PMV to PPD relationship.

Decades of research in the fields of comfort and applied medical biology have allowed constructing predictive models of the human thermal behaviour. They depend on ambient conditions and human thermal control reactions of the metabolism.

Comfort in semi-outdoor spaces

The "Standard Effective Temperature" (or "SET*") is a comfort index originating from the research of (Nishi et Gagge 1977). It is based on the transient modelling of the human metabolism, including the mechanisms of thermoregulation caused by the ambient conditions or the activity level (perspiration, sweating, shivering, vasoconstriction or dilation). It was adapted to outdoor and semi-outdoor spaces by (Pickup et de Dear 2007) and referred to as "Out_SET*".

The central idea of the SET* is to convert the ambient conditions studied into a single temperature for a reference case: low air velocity (v~0.1 m/s), mean radiant temperature being equal to the air temperature and ambient relative humidity of 50%. In these conditions, the SET* is the operative temperature that leads to the same physiological reactions as the studied ambient conditions, this means: the same skin wetness and skin temperature after a given exposition time (hence SET* or Out_SET* and duration of exposition are inseparable). This little-used approach is however proposed as a reference for the study of thermal comfort by the (ASHRAE 2013).

The inability of steady-state methods to yield a correct prediction of the level of comfort in varying ambient conditions is illustrated on **Figure 2**: the metabolic evolution of an individual suddenly exposed to a hot summer environment is plotted, starting from the set temperatures of the body. In these conditions, one can observe that the core and skin temperatures do not approach their steady-state values before 30 minutes ("steady" on the figure), whereas the dynamics of regulation via skin wetness are slower and take about ~100 minutes to stabilize. Winter conditions produce an even slower response and body temperatures take 3 to 4 hours to stabilize. Using a steady-state approximation for the estimation of thermal comfort leads to an underestimation of discomfort as far as short expositions are concerned (below one hour), as underlined in (Höppe 2002).

These statements are true for the "step response" (as per **Figure 2**), however they remain valid for changing ambient conditions, especially air velocity and solar flux, both having a strong impact on human heat balance. As an illustration, 800 W/m² of incident solar radiation are equivalent to a 27 K increase of the mean radiant temperature.

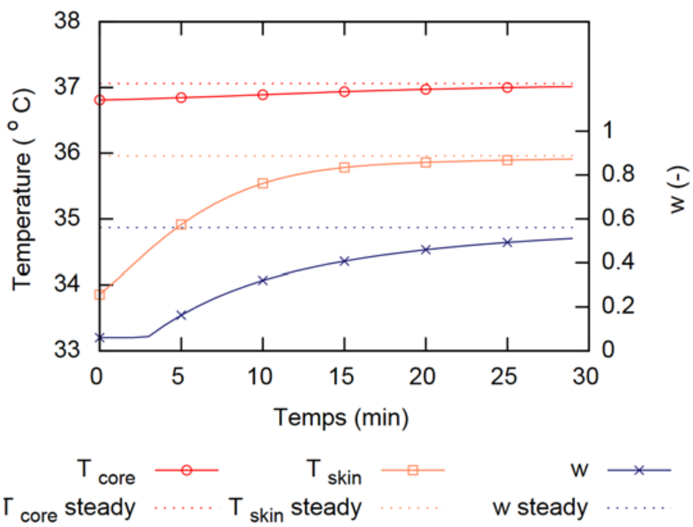

Figure 2. Out_SET* model, comparison between the steady-state and transient physiological values for summer conditions.

However, if the SET*/Out_SET* provides a tool to evaluate an environment, it does not give the designer a comfort scale. The research done by (Int Hout 1990) has allowed to bridge this gap, conciliating the "indoor" PMV and SET* thanks to the reference indoor environment provided in the calculation of the SET*. This allows for a quantitative estimation of the level of comfort equivalent to a given SET* or Out_SET* temperature, using the classical PMV approach, renamed as PMV* in this case.

Influence of air velocities

The influence of air velocity on the comfort zone is shown on **Figure 3**. One can observe the comfort zone position (−0.5<PMV*<+0.5) on the psychrometric diagram for two velocity magnitudes. When air speed increases, the comfort zone shifts towards higher temperatures: the reduction of the temperature difference is compensated by an increase of the convective heat exchange coefficient, allowing for a stable heat balance even at higher temperatures.

The heat and vapour transfer resistance properties of clothing are also dependent on the air velocity. Infiltration and "pumping" due to the individuals' physical activity reduce the insulating properties of cloth in comparison to the still air situation.

A method for evaluating the lessening of heat and vapour transfer resistance properties was provided by (Holmér, et al. 1999) and (Havenith, et al. 1999), which participated in the elaboration of the norm ISO 9920. Based on their study, the influence of air velocity on clothing properties is characterized by a strong reduction of transfer resistance: compared to a still air environment,

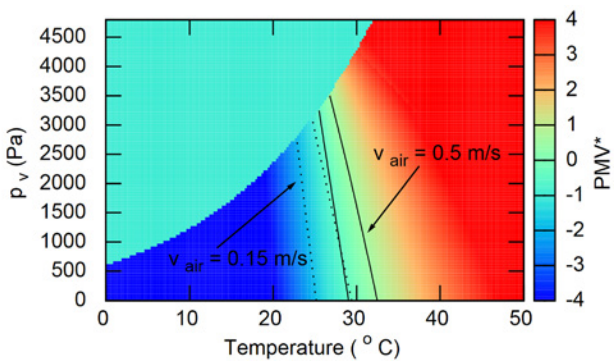

Figure 3. PMV* - Comfort zone position for =0.15 m/s (dotted line) and = 0.5 m/s (solid line).

a 1 m/s air velocity leads to a 40% decrease of convective resistance and a 60% decrease of vapour transfer resistance. **Figure 4** shows the position of the comfort zone on the psychrometric chart with and without the modification of cloth properties depending on air velocities. Such a correction leads to a shift of the comfort zone towards higher temperatures, which is equivalent to wearing clothes that provide less insulation.

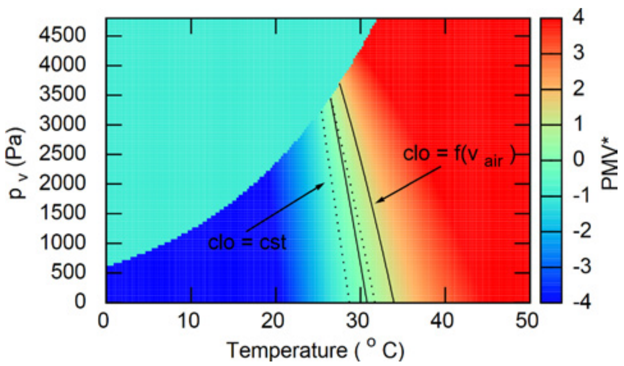

Figure 4. PMV* - Comfort zone position with (solid line) and without (dotted line) correction of cloth insulation.

Conclusion

Given the strong variation of ambient conditions and the short duration of stay, classical indexes are not suited to the estimation of comfort in semi-outdoor spaces, the latter being characterized by highly transient phenomena. It his however possible to qualify comfort rationally, using a refined simulation of the temporal evolution of human metabolism. A detailed knowledge of incident solar fluxes and air velocities is the obvious corollary to such modelling. The calculation of velocity distributions is a challenge in terms of computability, however the rapid evolution of computing capacity and performance, along with the development of affordable on-line 'cloud' services make such approaches possible. The metabolic history also has a sensible effect on comfort perception, as mentioned in (Walther et Barry 2016). ■

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Opening of collection 2017

On 4th of January, Eurovent Market Intelligence (EMI), the European statistics office for the HVAC&R market, launched its new annual data collections for 2017. The aim is to collect sales data from manufacturers in the sector in order to provide them with a reliable and precise market map for HVAC&R in Europe, the Middle East and Africa (EMEA).

YANNICK LU-COTRELLE
Manager
Eurovent Market Intelligence

Last year, more than 300 manufacturers had joined EMI, providing the most comprehensive and reliable ever overview of the market, and thus become the largest collection of data on the HVAC&R market in terms of number of market players.

In 2016, EMI brought also two major innovations to the information provided to its participants.

The first one is the delivery of customised reports. These individual market reports, packed with between 50 and 250 pages, compare market characteristics for each country in the EMEA area (size, segmentation, main players, growth, etc.) and the position of the manufacturer in the market (market share, rank, progress, etc.). The aim is to offer each participant a full overview of his situation so that in a glance he can see his strong points and areas where he needs to improve.

The second one is a new online marketing tool. All the market figures are available – under private access only – on the Eurovent Market Intelligence website, and the new marketing tool allows users to carry out all possible market analyses in a single click, as simple as using a flight comparison tool, and export the results to an Excel file. Participants can see, in detail for each selection – even very accurate – their market share, their rank, the market size and evolution, and the 5 main competitors for this selection.

From January to March 2017, Eurovent Market Intelligence is launching its 24th annual data collections

- Adiabatic coolers
- Air curtains
- Air filters
- Air handling units
- Chilled beams
- Chillers and heat pumps
- Cooling towers
- Fan coil units
- Heat exchangers
- Heat recovery systems
- IT cooling
- Pool dehumidifiers
- Residential air handling units
- Rooftop units

This year, EMI gives priority to the "freshness" of the information and will release all the results during the month of March. As usual, EMI will be attending Acrex in India (Stand C-11) and ISH in Germany (HALL 11.1 – stand B06). ■

For additional information or to receive these reports:
https://www.eurovent-marketintelligence.eu & statistics@eurovent-marketintelligence.eu

Residential Air Handling Units for better indoor air quality and energy efficiency

Eurovent Certita Certification launched in 2014 a new certification programme for residential air handling units in line with existing European standards and regulations focusing on energy efficiency.

In 2017 a new performance index will be introduced for these products allowing to evaluate the efficiency towards Indoor Air Quality.

SYLVAIN COURTEY
Head of Ventilation Department
Eurovent Certita Certification

Background

Back in 2014 Eurovent Certita Certification started a new certification programme for Residential Air Handling Units. This programme is based on state-of-art European testing standard EN 13141-7 and in-line with the European regulations 1253/2014 and 1254/2014 related respectively to Ecodesign and Energy Labelling.

This certification programme concerns only balanced supply and exhaust ventilation units including a heat recovery systems (plate, rotary or heat-pumps). These systems are becoming more and more popular in Europe and not only in Scandinavia due to the stricter requirements regarding energy efficiency in residential buildings. Dwellings are becoming more and more isolated and tight in order to save energy for heating. Infiltration through the building envelope are therefore minimized and mechanical ventilation is therefore necessary to renew the air inside houses.

A good ventilation system should gather the following characteristics:

- insure the renewal of the air according to the needs related to indoor sources of pollutants (occupancy and building materials)
- consume a small amount of energy directly (through the consumption of the fans) or indirectly by discharging warm air from inside to outside while providing cold air from outside to inside
- produce a sufficiently low sound power level so that occupants do not switch off the unit due to noise pollution
- be airtight in order to not recirculate indoor pollutants back in the building
- provide clean air inside even when outdoor air is polluted

A European wide certification programme for Residential Air handling Units

The scope of the Eurovent certification programme includes all balanced supply and exhaust ventilation units with heat recovery systems (plate, rotary or heat-pump) up to 1 000 m^3/h nominal airflow.

The following characteristics are certified:

- Leakage class
- Aeraulic performances (Airflow/pressure curves, Maximum airflow [m^3/h])
- Electrical consumption [W]
- Specific Power Input SPI [$W/(m^3/h)$]
- Temperature efficiency / COP
- Performances at cold climate conditions
- SEC (Specific Energy Consumption) [$kWh/(m^2.year)$]
- A-weighted global sound power levels [dB(A)]

All performances are checked by tests done according to the European standard EN 13141-7:2011 by independent testing laboratories accredited according to ISO 17025.

Aeraulic performances are verified for a certified window as described in **Figure 1**.

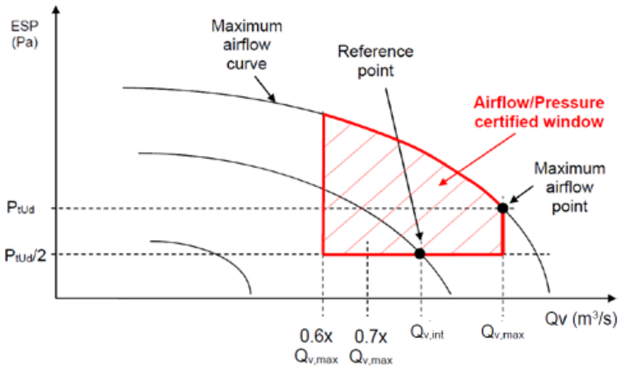

Figure 1. Certified window of airflow/pressure curves according to RS 15/C/001-2015.

Leakage classes are defined based on both internal and external leakages (see **Table 1** for an example).

Heat recovery systems are evaluated according to the conditions given in **Table 2**.

Table 1. Leakage classification for the pressure method according to EN 13141-7:2011.

Class	Pressurization test		
	Internal leakage (at 100 pa)		External leakage (at 250 pa)
A1	≤2%	and	≤2%
A2	≤5%	and	≤5%
A3	≤10%	and	≤10%
Not classified	>10%	and	>10%

This certification programme is based on random selection of units purchased directly on the market thus allowing to assess the real performances of the units provided to end users.

Energy efficient ventilation

Even if this certification programme was introduced in the course of 2014, it already included at this time the characteristics of the European regulations 1253/2014 and 1254/14 which were applied on the European market on the 1st of January 2016. These regulation introduced Ecodesign regulations for residential ventilation systems as well as requirements regarding the way performances shall be displayed, in particular regarding energy efficiency with a dedicated energy efficiency label.

This energy efficiency classification is based on the Specific Energy Consumption (SEC) which accounts for both the direct energy consumption of the fans but also the indirect energy consumption related to the heat recovery efficiency.

The Eurovent certification programme is therefore a good mean to verify the compliance of ventilation units according to these regulations.

Ventilation for a better Indoor Air Quality

Even though energy efficiency is a key element when looking at residential ventilation units, the first performance parameter for such unit is its ability to maintain a good indoor air quality in the building.

As seen before this is related to the ability of the unit to:

- remove indoor pollutants from occupant activities (CO_2, humidity) and from building materials (COVs)
- prevent outdoor pollutants to enter into the building (particulate matter)
- not re-introduce indoor pollutants in the building

Table 2. Testing conditions for heat-recovery efficiency according to EN 13141-7.

Application Mode	Standard test			Cold Climate test
Point number:	1	2	3	4
Heat Exchanger category	I and II (mandatory)	I (mandatory) and II (optional)	I and II (optional)	I and II (optional)
Extract air				
Temperature	20°C	20°C	20°C	20°C
Wet bulb	12°C	15°C	12°C	10°C
Supply air				
Temperature	7°C	2°C	-7°C	-15°C
Wet bulb	-	1°C	-8°C	-

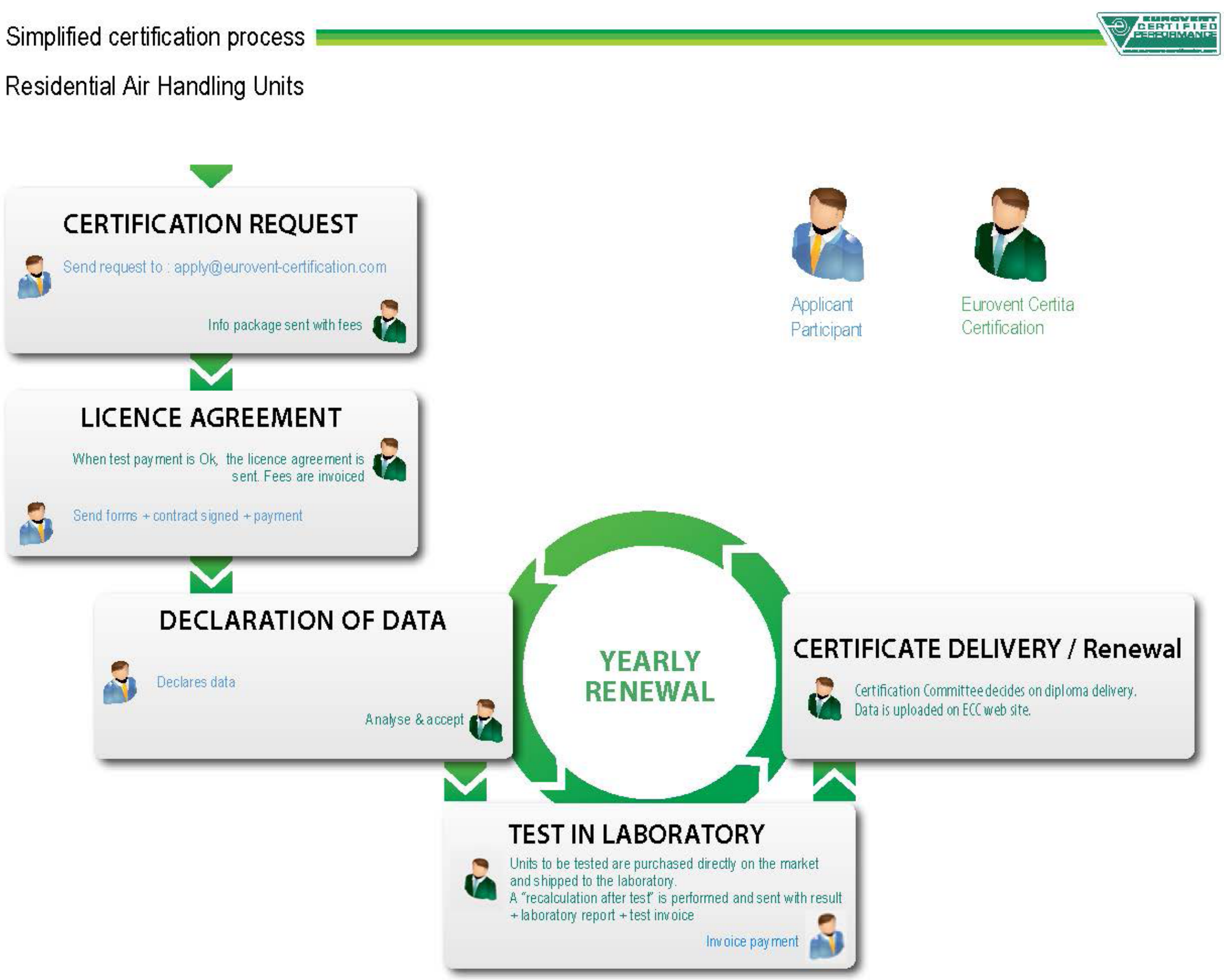

Figure 2. Simplified certification process for the RAHU Eurovent programme.

All of these should be done at the lowest cost possible.

In order to characterize this essential characteristic of these products ECC decided to introduce a new metric allowing to take into account all these parameters: the Clean Air Efficiency (CAE):

$$CAE = \frac{Amount\ of\ clean\ air\ delivered\ to\ the\ building}{Total\ energy\ used}$$

$$\left[\frac{m^3/h}{MWh/year}\right] \qquad \textbf{(Eq. 1)}$$

In order to define what "clean air" is, only the main pollutants are taken into account:

- Indoor pollutants:
- CO_2
- Humidity
- Outdoor pollutants:
- Particulate matter

Other pollutants can also be found such as COVs coming from building materials indoors (formaldehyde) or from outdoors (benzene), allergens from indoors (pets) or outdoors (pollen), micro-organisms etc. It was deliberately decided to focus on the main pollutants in order to achieve a good balance between relevance and simplicity.

As a result the amount of clean air delivered to the building is assumed to be the minimum between the clean air delivered related to indoor pollutants (CO_2 and humidity) and the clean air delivered related to outdoor pollutants:

$$Amount\ of\ clean\ air\ delivered\ to\ the\ building =$$

$$Min\left(q_{clean\ air\ CO_2,H_2O}, q_{clean\ air\ ePM1}\right) \qquad \textbf{(Eq. 2)}$$

The amount of clean air concerning CO_2 and humidity is simply the amount of air removed from the building by ventilation minus the amount of air recirculating from the extract air side to the supply air side due to internal leakages within the ventilation unit:

$$q_{clean\ air\ CO_2,H_2O} = (1 - EATR) \cdot q_{v,int} [m^3/h]$$

(**Eq. 3**)

With:

EATR: the Exhaust Air Transfer Ratio [–] which accounts for internal leakages from the extract side to the supply side

$q_{v,int}$: the airflow rate at the referent point according to EN 13141-7 [m^3/h]

The amount of clean air concerning particulate matter is considered to be related to the efficiency of the air filters towards PM_1 particles. PM_1 particles are the most harmful category of particles which are from various origins (dust, combustion particles, bacteria, viruses). These particles are able to enter into the deepest part of our lungs until the alveoli. Both supply and exhaust air filtration efficiencies have to be considered as indoor particulate matters may be re-introduced indoors through internal leakages (**Eq.4**).

In order to define the total energy used by the unit we propose to introduce the Total Energy Consumption TEC in kWh/m²/year which is analogous to the SEC but which is always positive (**Eq.5–7**).

$$q_{clean\ air\ ePM1} = \left(ePM_{1,supply} \cdot (1 - EATR) + ePM_{1,exhaust} \cdot EATR\right) \cdot q_{v,int} [m^3/h] \quad \textbf{(Eq. 4)}$$

$ePM_{1,supply}$ and $ePM_{1,exhaust}$: efficiencies against PM_1 particles of the supply air and exhaust air filters respectively.

$$TEC_{RAHU} = t_a \cdot pef \cdot q_{net} \cdot MISC \cdot CTRL^x \cdot SPI_{RAHU} + t_h \cdot \Delta T_h \cdot \eta_h^{-1} \cdot c_{air} \cdot q_{net} \cdot CTRL \cdot MISC \cdot (1 - \eta_t) + Q_{defr} \quad \textbf{(Eq. 5)}$$

$$TEC_{RAHU} = SEC_{RAHU} + K \text{ [kWh/m²/year]} \quad \textbf{(Eq. 6)}$$

With:

$K = t_h \cdot \Delta T_h \cdot \eta_h^{-1} \cdot c_{air} \cdot q_{ref}$: constant value [kWh/m²/year]

Finally:

$$CAE = \frac{Min(q_{clean\ air\ ePM1}; q_{clean\ air\ CO_2,H_2O})}{TEC_{RAHU} \cdot \frac{q_{v,int}}{q_{net}}} \left[\frac{m^3/h}{kWh/year}\right] \quad \textbf{(Eq. 7)}$$

With:

q_{net}: net ventilation rate demand per m^2 heated floor area [$m^3/h.m^2$]

Table 3. Typical CAE values.

	Poor	Average	Good
Supply air filter	G3	M5	F7
Exhaust air filter	G3	M5	F7
Leakage class (EATR)	A3 (10%)	A2 (5%)	A1 (2%)
SPI [W/(m³/h]	0.50	0.35	0.25
HRS efficiency	55%	80%	90%
Ventilation control (CTRL)	Clock control (CTRL=0.95)	Central demand control (CTRL=0.85)	Local demand control (CTRL=0.65)
Motor drive (x)	2-speed (x=1.2)	Multi-speed (x=1.5)	Variable speed (x=2=
CAE [(m³/h)/(MWh/year)]	**5**	**20**	**146**

In order to have basic figures in mind, the **Table 3** summarizes typical CAE values for poor, average and good ventilation units.

Conclusion

Recent European regulations have already shaped the market towards better energy efficient products. However, it has to be kept in mind that the primary role of ventilation units is to bring clean air to building occupants. In order to highlight this a new, simple and meaningful metric was developed within the Eurovent Certification programme for Residential Air Handling Units: the Clean Air Efficiency (CAE). This performance will be made available for all Eurovent certified units by the 1st of March 2017. It will allow end-users to compare easily products between each other's regarding their essential characteristic that is its ability to provide good indoor air quality in buildings. ■

Reference documents

OM-16, Operational Manual for the Certification of Residential Air Handling Units, November 2015, wwww.eurovent-certification.com

RS 15/C/001-2015, Rating Standard for the Certification of Residential Air Handling Units, November 2015, wwww.eurovent-certification.com

EN 13141-7 :2011, Performance testing of components/products for residential ventilation. Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings.

COMMISSION REGULATION (EU) No 1253/2014 of 7 July 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for ventilation units, http://eur-lex.europa.eu

COMMISSION DELEGATED REGULATION (EU) No 1254/2014 of 11 July 2014 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of residential ventilation units, http://eur-lex.europa.eu


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Comfort Air Conditioners *	Air Filters Class M5-F9 *	Liquid Chilling Package & Heat Pumps *
Rooftop (RT) *	Residential Air Handling Units (RAHU)	Heat Exchangers *
Fan Coils Units *	Ventilation Ducts (DUCT)	Remote Refrigerated Display Cabinets
Variable Refrigerant Flow (VRF) *	Hygienic Air Handling Units (HAHU)	Heat Recovery Systems with Intermediate Heat Transfer Medium (HRS-coils)

* All models in the production have to be certified

▼ Indoor Climate

European Heat Pumps

Scope of certification

- Electrically driven heat pumps for space heating (incl. cooling function)
- Electrically driven heat pumps used for heating swimming pool water (outdoors or inside)
- Dual-mode heat pumps, i.e. designed for space heating and domestic hot water production,
- Gas absorption heat pumps (incl. cooling function)
- Engine-driven gas heat pumps (incl. cooling function).

Certification requirements

- Qualification campaign: 1 audit/factory + tests depending on products declared
- Repetition campaign: 2 machines/year + 1 audit/year/factory

Main certified characteristics and tolerances

- Heating and/or Cooling capacities *Ph* and/or *Pc* [kW], Electrical Power inputs *Pe* [kW] and Coefficient of performance *COP*
- Design capacity *Pdesignh*, Seasonal Coefficients of Performance *SCOP, SCOP*$_{net}$ and Seasonal efficiency η_s
- Minimum continuous operation Load Ratio *LRcontmin* [%], *COP* at LRcontmin and Performance correction coefficient at LRcontmin *CcpLRcontmin*
- Temperature stabilisation time *th* [hh:mm], Spare capacity *Pes* [W], Energy efficiency for water heating [COP_{DHW} & WH] or Global performance coefficient for a given tapping cycle COP_{global}, Reference hot water temperature θ'_{WH} and Maximum effective hot water volume V_{MAX} [l]
- Daily consumption for the draw-off cycle in question (Qelec)
- Annual consumption (AEC)
- Sound power levels *Lw* [dB(A)]

ECC Reference documents

- Certification manual
- Operational manual OM-17
- Rating standard RS 9/C/010

Main testing standards

Thermal performance:

- Heat pumps with electrically driven compressors
- Space heating & cooling: EN 14511-1 to 4; Seasonal performance: EN 14825
- Domestic hot water: EN 16147
- Direct exchange ground coupled heat pumps: EN 15879-1
- Gas-fired heat pump: EN 12309-1 to 5

Acoustics:

- Heat pumps and dehumidifiers with electrically driven compressors: EN 12102
- ISO 3741: Reverberant rooms or ISO 9614-1: Sound intensity, measurements by points

▼ Indoor Climate

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 procedure (yearly): 3 units are selected from regular production and tested in the independent Laboratory selected by Eurovent Certita Certification.

For the repetition procedures: the number of units selected is limited to 1 unit/range.

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 (for 8°C temperature difference)
- Passive: 6 – 8 – 10°C temperature difference

Tolerance = 12% and +24% for the 3 single values; –6% for the average value.
Water pressure drop: tolerance = maximum (2 kPa; 10%)

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"

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 downgraded (or rerated) as soon as partload efficiency is out of tolerance
- A-weighted sound power level +0 dB (A)
- Auxiliary power +10%

Minimum continuous operation Load Ratio: LRcontmin [%], COP/EER at LRcontmin and Performance correction coefficient at LRcontmin CcpLRcontmin.

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

▼ Indoor Climate

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

Rooftop (RT)

CERTIFY ALL

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

The Eurovent rooftop certification (RT) program covers air-cooled packaged rooftop units below 100 kW in cooling mode, with an option to certify units from 100 kW to 200 kW and water cooled rooftops.

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.

In 2018 the program will evolve towards part load efficiency (SEER, SCOP). Current work done on EN 14825 aims to address rooftops in the calculation hypothesis.

The software certification will be a key item to comply with existing and coming certification of building energy calculations in the EU countries.

Mr Arnaud Lacourt
Head of Thermodynamics Department
Eurovent Certita Certification

Scope of certification

- This certification program applies to air-cooled rooftops rated below 100 kW.

Can be certified as an option:

- Models with cooling or heating capacity ranging from 100 kW to 200 kW
- Rooftops with 3 & 4 dampers
- Water cooled rooftops

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

Indoor Climate

Fan Coils Units

CERTIFY ALL

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 m^3/s and a published external static duct pressure at 40 Pa maximum.
- Ducted units: Fan Coil Units up to 1 m^3/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. Selection tools (software) are checked.

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 17% for Fan Coil Units with a minimum of one test.

Certified characteristics & tolerances

- Sensible capacity* ** : –8%
- Total cooling & heating capacity * ** : –7%
- Water pressure drop* **: +15%
- Fan power input*: +10%
- A-weighted sound power **: +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

(*) At standard and non-standard conditions

(**) Tolerances for capacities are increased by 2% for variable speed units.

ECC Reference documents

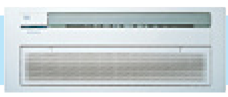
- Certification manual
- Operational Manual OM-1A
- Rating Standard RS 6/C/002
- Rating Standard RS 6/C/002A

Testing standards

- Performance testing: EN 1397:2015
- Acoustic testing: EN 16583:2015

Variable Refrigerant Flow (VRF)

CERTIFY ALL



VRF systems have shown the highest growth amongst cooling systems during the past 10 years and indeed the highest potential for the next 10 years.

Until recently, VRF systems were the only type of direct expansion cooling system that was not covered by a dedicated Certification programme.

The Eurovent Certification scheme was therefore critical.

It was my privilege to Chair the Launching committee from the first meeting to its introduction. Whilst it took 2 years to complete, I believe it was worth the time and effort.

We at Toshiba are pleased as a manufacturer to work with Eurovent Certification Company as they guarantee the consistency of thermal testing and they increase the integrity of the products on the market.

Nick Ball
Toshiba EMEA
Engineer Director

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 ECC shall be tested in an independent laboratory selected by ECC.
- Repetition procedure: units selected from regular production shall be tested on a yearly basis.
- A factory visit is organized every year in order to check the production

Certified characteristics & tolerances

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

ECC Reference documents

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

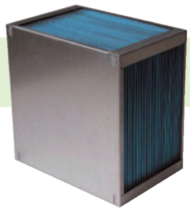
Testing standards

- EN 14511 - EN 12102

▼ Ventilation & Air Quality

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) are also included in the scope of the program.

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
- Temperature efficiency Dry: –3 percentage points
- Temperature efficiency Wet: –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 Regenerative Heat Exchangers

CERTIFY ALL

Scope of certification

This Certification Programme applies to all ranges of Air to Air Regenerative Heat Exchangers (RHE) including sealing systems. Units sold without casing and sealing systems are also included. Participants shall certify all models in the ranges, including:

- all classes: condensation (non hygroscopic, non enthalpy) RHE, hygroscopic enthalpy RHE, hygroscopic sorption RHE
- all RHE geometry (wave height, foil thickness)
- all sizes (rotor diameters and rotor depths and surface areas of Alternating Storage Matrices - ASM)
- 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)
- Outdoor Air Corrrection Factor (OACF): 0.05
- Exhaust Air Transfer Ratio (EATR): +1% point

ECC Reference documents

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

Testing standards

- EN 308
- ARI 1060

▼ Ventilation & Air Quality

Air Handling Units

CERTIFY ALL

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

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 ranges of Air Handling Units that can be selected in a software. Each declared range shall at least present one size with a rated air volume flow below 3 m³/s. For each declared range, all Real Unit Sizes available in the software and up to the maximum stated air flow and all Model Box configurations shall be declared.

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 up to 3 m³/s.

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
- Casing Air Leakage: same class or higher

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”

Ventilation & Air Quality

Air Filters Class M5-F9

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 procedures: 6 units will be selected and tested by an independent Laboratory selected by Eurovent Certification.
  Then each year 4 units will be selected & tested

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 4/21

Ventilation Ducts (DUCT)

Scope of certification

The programme scope covers rigid and semi-rigid ventilation ductwork systems divided into the following sub-programmes:

- Rigid metallic ductwork systems with circular cross-section (DUCT-MC);
- Rigid metallic ductwork systems with rectangular cross-section (DUCT-MR);
- Semi-rigid non-metallic ductwork systems predominantly made of plastics (DUCT-P);

Each sub-programme applies to ductwork systems fitted with integrated sealing solution as described in relevant Rating Standard.

Certification requirements

The certification programme is based on product performance testing by independent testing laboratories as well as production sites auditing.

Certification characteristics & tolerances

The product performance testing will enable the verification of the following ratings accuracy:

- Air tightness class (all sub-programmes)
- Positive and negative pressure limits (all sub-programmes)
- Dimensions (DUCT-MC and DUCT-MR)
- Minimum and maximum service temperatures (DUCT-P)
- Resistance to external pressure (DUCT-P)

ECC reference documents

- OM-19-2016
- RS/2/C/002MC-2016
- RS/2/C/003MR-2016
- RS/2/C/004P-2016

Testing standards

- Air leakage and strength testing:
  – EN 12237:2003 (DUCT-MC and DUCT-P)
  – EN 1507:2006 (DUCT-MR)
- Service temperature and resistance to external pressure (DUCT-P):
  – RS 2/C/004P-2016

Hygienic Air Handling Units (HAHU)

Scope of certification

This programme applies to hygienic ranges of Air Handling Units. As an option of the Certification programme for Air Handling Units, only an already ECP certified range is eligible for the hygienic option. The hygienic aspect of the AHU is certified based on a 3 levels classification, each level declaring an AHU suitable for different application:

- Level 1: Offices, commercial buildings, schools, hotels
- Level 2: Hospitals
- Level 3: Pharmaceutical, food processes, white rooms

The previous list is not exhaustive and must be used as a reference only. Final customer/user who has complete and detailed knowledge of the building application shall decide which Hygienic rating level is appropriate

Certification requirements

Same as in the Air Handling Unit programme.

Certification characteristics & tolerances

Services characteristics:

The following services characteristics are certified:

1. Manufacturing
2. Maintenance
3. Quality Managemement System
4. IOM (Installation and Operational Manual)
5. Shipment

Hygienic characteristics:

The following hygienic characteristics are certified:

1. Materials
2. Casing performance
3. Components arrangement and performances (filters, coils, heat recovery systems, fans, humidifiers, dehumidifiers and silencers)

ECC reference documents

- OM-5-2016-rev1
- RS/6/C/011-2016 Hygienic AHU

Testing standards

- RS 6/C/005-2016
- EN ISO 846:1997
- EN ISO 2896:2001
- EN 10088-3:2014
- EN 1993-1-2:2005
- DIN 1946/4-6.5.1:2008
- EN 779:2012
- EN 1822:2010
- EN ISO 12944-2:1998

Residential Air Handling Units (RAHU)

CERTIFY ALL

The objective of the Eurovent RAHU certification programme is, through tests performed by a third-party, to verify the performance of a unit bought somewhere on the open European market. It is important for the RAHU certification to use a unit out of the serial production – no special samples. For us, as a manufacturer, it pays to develop good products that deliver what we promise. By utilizing certified products, the designers' task is easier as they do not need to make detailed comparisons or perform advanced tests. Consultants, engineers and users can select a product and be assured that the catalogue data is accurate.

Certification is important for a designer/consultant/end user:

- No unnecessary risks – they can only use products that deliver what they promise "Eurovent certified"
- Well-functioning systems – the product delivers the promised capacity and performance
- Safer calculations on energy consumption is expected

Mr. Tobias Sagström
Global Product Manager Residential at Systemair AB

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 [m^3/h]
- Electrical consumption [W]
- Specific Power Input SPI [W/(m^3/h)]
- Temperature efficiency / COP
- Performances at cold climate conditions
- SEC (Specific Energy Consumption) in [kWh/(m^2.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%
- Disbalance ratio 0

ECC Reference documents

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

Testing standards

- European standard EN 13141-7:2010

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 CO_2 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 Certita Certification 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 ongoing 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 the Eurovent Industry Recommendation / Code of Good Practice Eurovent 9/12-2016 and 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: 10°C to 32.2°C (50°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-4-2016
- Rating Standard RS 9/C/001-2014

Testing standards

- CTI STD-201 RS
- ECC OM-4-2016

▼ Process Cooling & Food Cold Chain

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.

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

Scope of certification

The rating standard applies to coils operating:
– with water or with a 0-50% ethylene-glycol mixture, acting as cooling or heating fluid.
– and without fans.

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.
- On-site audits (checking of software)

Certified characteristics & tolerances

- Capacity: –7%
- Air side pressure drop: +20%
- Liquid side pressure drop: +20%

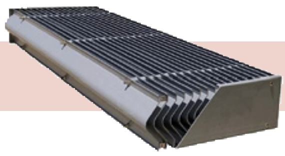
ECC Reference documents

- OM-9-2016
- RS 7/C/005

Testing standards

- EN 1216:1998+A1/2002

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-14-2016
- Rating Standard RS 9/C/003

Testing standards

- CTI ATC-140

Liquid Chilling Package & Heat Pumps

CERTIFY ALL

Certification is a strong way to supply safe information in the right language

Offering guaranteed performances to customers has always been a fundamental benefit thanks to the accredited independency of this certification program. Today the need for certified performances is emphasized by several directives and it is essential for customers to:

- demonstrate the high performance efficiency of their buildings,
- compare safety performances of the products selected with the requirements of the regulations implementing ERP Ecodesign & labelling directives,
- be sure of the return of their investment or energy savings,
- have the ability to compare fairly between chillers, heat pumps or other type of heaters.

In addition to being certified, performances must be seasonal, in line with the new regulations, and assessed according to the new harmonized standards as soon as they apply.

This program is also a great opportunity for fruitful exchanges between independent laboratories, certification body and manufacturers. It also facilitates the understanding and application of new regulations or standards in a regulatory context in perpetual evolution.

A certification is a guarantee of fair competition (for customers/manufacturers). It also helps increase the number of applications using RES, and represents a commitment in the reduction of consumption and emissions.

Didier Perales
Manager of Technical Relations & Concept Projects
CIAT Group France

According to New Regulations for Space heaters Eco Labelling No 811/2013 - ErP No 813/2013.

Seasonal efficiency for heating (η_s) for Chillers & Heatpumps with a design capacity below 70kW is certified since 26 September 2015. (For units above 70kW it is optional).

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 Certita 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%
- Performance SCOP & Seasonal Efficiency for Heating η_s: automatically rerated when Part Load efficiency criteria fails
- Seasonal Efficiency ESEERfor cooling: automatically rerated when Part Load efficiency criteria fails
- A-weighted sound power level: > +3 dB(A) (> +2 dB(A) for units with Pdesignh below 70kW)
- Water pressure drop: +15%

Testing standards

- Performance testing: EN 14511
- Seasonal Performance testing: EN 14825
- Sound testing: EN 12102

ECC Reference documents

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

▼ Process Cooling & Food Cold Chain

Heat Exchangers

CERTIFY ALL

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

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

Air coolers for refrigeration

Dry coolers

Air cooled condensers

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 Certita Certification shall be tested in an Independent Laboratory selected by ECC
- 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

Remote Refrigerated Display Cabinets

CERTIFY ALL

Remote refrigerated display cabinets (RRDC) are the appliances for selling and displaying chilled and/or frozen foodstuff to be maintained within prescribed temperature limits.

Typically, food and beverage retailers are the direct customers of the refrigeration industry while the supermarket's customers are the end users of food and beverage retailers.

Food and beverage retailers ask for food safety and also for appliances with high-energy efficiency, supermarket's customers ask for food safety. Refrigeration industry has to face the hard challenge of satisfying both needs.

How is it possible to assure that the refrigeration appliances perform accurately and consistently to the reference standards? How is it possible to assure that what is rated by the manufacturer is properly rated?

There is only one way: It is necessary to join a globally recognized and industry respected certification program.

Eurovent Certita Certification program for RRDC is the only certification program in Europe that can assure that performance claims have been independently measured and verified. The factory audits and the product's performances tested in an independent and third-party laboratory make the difference!

Since 2011, Eurovent Certita Certification has also launched a voluntary energy label certification scheme, anticipating what only nowadays EC DG Energy is doing in the framework of Ecodesign and Energy Label Regulations. What better way to rate RRDC's energy consumption and to promote their energy efficiency?

What would you trust more: a self-declaration by the Manufacturer or what an independent, globally recognized and forerunner certification program is able to assure? Which one is better?

Maurizio Dell'Eva
Project manager
EPTA S.p.A. – MILANO (ITALY)

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

▼ Process Cooling & Food Cold Chain

Heat Recovery Systems with Intermediate Heat Transfer Medium (HRS-COIL)

Scope of certification

This certification programme covers the heat recovery exchangers with intermediate heat transfer medium corresponding to the category IIa ("without phase change") of the EN 308:1997 standard, that is Run Around Coils systems.

Certification requirements

The certification programme is based on product performance testing by independent testing laboratories according to the European standard EN 308:1997 as well as manufacturing facility auditing and operating software checking.

Certification characteristics & tolerances

When tested in the laboratory the obtained performance data shall not differ from the recalculated values ("test-check") by more than the following tolerance values:

- Dry heat recovery efficiency: –3 percentage points (abs. deviation)
- Air side pressure drop: Maximum [+10%; +15 Pa]
- Fluid side pressure drop: Maximum [+10%; +2 kPa]

ECC reference documents

- OM-18-2016
- RS 7/C/009 – 2016

Testing standards

- EN 308:1997

REHVA GUIDEBOOKS

REHVA Guidebook No. 22 will be available in printed version in March 2017.

Introduction to Building Automation, Controls and Technical Building Management

Andrei Litiu (ed.), Bonnie Brook, Stefano Corgnati, Simona D'Oca, Valentina Fabi, Markus Keel, Hans Kranz, Jarek Kurnitski, Peter Schoenenberger & Roland Ullmann

This guidebook aims to provide an overview on the different aspects of building automation, controls and technical building management and steer the direction to further in depth information on specific issues, thus increasing the readers' awareness and knowledge on this essential piece of the construction sector puzzle. It avoids reinventing the wheel and rather focuses on collecting and complementing existing resources on this topic in the attempt of offering a one-stop guide. The readers will benefit of several compiled lists of standards and other relevant publications and as well a thorough terminology specific for building automation, controls and technical building management.

Among other aspects it captures the existing European product certification and system auditing schemes, the integrated system approach, EU's energy policy framework related to buildings, indoor environment quality, smart buildings and behaviour change related to energy use.

Although this guide can be very useful for several stakeholders (e.g. industry, designers, specifiers, system integrators, installers, building commissioners, facility managers, energy inspectors, energy auditors, students), being an introduction framework to the topic, it is most useful for those interested in fully grasping the 'why, how and what' of building automation, controls and technical building management.

It should be noted that this guidebook is not, nor is it meant to be, an absolutely comprehensive knowledge repository on the topic.

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Certified performances for air cleaners

Air cleaning devices: a growing market polluted by confusing communication

According to an industry study published in March 2016 by the Freedonia Group[1], global demand for consumer air treatment systems is projected to increase to over $10 billion in 2019.

Indeed, the growing public awareness about indoor air pollution coming from furniture, construction materials and sometimes poor quality ventilation has conducted the consumers to care more and more about the effect that these pollutants can have on their health. In some countries, such as Japan, where air cleaning systems are used to capture tobacco smoke when smoking indoor, the air cleaning devices have even become part of "standard" domestic appliances. Besides, the rising diagnosis of asthma and allergic rhinitis, as well as peak pollution incidents in urban areas are contributing to increase the air cleaning devices market demand. This phenomenon has become worldwide and air cleaning devices are appearing everywhere on the market.

In this growing market the manufacturers are all claiming that their product is "efficient against all air pollutants" and will "ensure a purified air in the house where children will be safer and parents happier". Still, few manufacturers quantify their product performance and when they provide figures these are difficult to compare (different units, no information about operating conditions…). The consumer is therefore forced to base his choice on marketing criteria without any clear commitment from the manufacturer.

A need for a harmonized evaluation method

To enable and encourage manufacturers to communicate about quantified performances on a levelled ground, the first step is to provide them a standard to refer to. Indeed, there is no international product standard available for air cleaners except for electrical safety aspects[2]. Several testing methods are coexisting (ANSI/AHAM AC-1:2006[3], JEM 1467:2013[4], GB/T 18801:2015[5]…) and used by some manufacturers to evaluate their products. However, these methods are not recognized on a global scale and the valorisation is limited to the local market.

Among these testing standards exist the NF-B44-200:2016[6] and prEN 16846-1:2015[7], respectively derived from experimental testing standards XP-B44-200:2011[8] and XP-B44-013:2009[9]. These are candidates as testing standards on the international stage. The specificity of NF-B44-200:2016 is the consid-

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1 World Consumer Air Treatment Systems, Industry study 3370, The Freedonia Group Inc., March 2016.

2 IEC 60335-2-65:2002 Household and similar electrical appliances – Safety – Part 2-65: Particular requirements for air-cleaning appliances, International Electrotechnical Commission, 2002.

3 ANSI/AHAM AC-1:2006 Method for measuring performance of portable household electric room air cleaners, Association of Home Appliance Manufacturers, 2006.

4 JEM 1467:2013 Air Cleaners of Household and Similar Use, Japan Electrical Manufacturers' Association, 2013.

5 GB/T 18801:2015 Air Cleaner, Standardization Administration of the People's Republic of China, 2015.

6 NF-B44-200:2016 Independent air purification devices for tertiary sector and residential applications - Test methods - Intrinsic performances, AFNOR, 2016.

7 prEN 16846-1:2015: Photocatalysis - Batch mode test methods - Part 1: measurement of efficiency of photocatalytic devices used for the elimination of VOC and odour in indoor air in active mode, AFNOR, 2015.

8 XP-B44-200:2011 (OBSOLETE) Independent air purification devices for tertiary sector and residential applications-Test methods - Intrinsic performances, AFNOR, 2011.

9 XP-B44-013:2009 Photocatalysis -Test and analysis method for determining the efficiency of photocatalytic systems for eliminating volatile organic compounds/odours in recirculating interior air -Confined chamber test, AFNOR, 2009.

eration of 11 indoor air pollutants[10] divided into 4 categories (Particulate Matters, Volatile Organic Compounds, Micro-organisms and Allergens). Besides, the NF-B44-200:2016 comprises a measurement of reaction intermediates (ozone, carbon monoxide, nitrogen monoxide, nitrogen dioxide) to verify that no dangerous products are emitted by the device.

The NF-Air Cleaners mark

Eurovent Certita Certification has developed a new NF mark certification for Air Cleaners under a mandate from AFNOR Certification. A dedicated working group gathered four times between May and November 2015 to establish the certification requirements and the draft document was approved by AFNOR Certification in January 2016. The NF-Air Cleaners certification scheme[11] entered into force on 2016, March 1st.

This NF mark aims at certifying models of air cleaning devices (i.e. device basically built of a fan and a set of components possessing the ability to capture and/or partially or totally destroy air pollutants[6]) for residential (domestic) and tertiary (stores, offices, classrooms, waiting rooms…) sector applications. This definition covers all types of technology: mechanical filtration, electrostatic filtration, plasma, ionization, UV-A or UV-C lamp, etc.

The Air Cleaners certification scheme enables to verify the accuracy of the performance ratings claimed by manufacturers in terms of effectiveness with respect to several pollutants[10], but also regarding the power consumption and the sound power level of the device.

This verification is performed through product performance testing conducted by independent laboratories selected by Eurovent Certita Certification. As the testing standard NF-B44-200:2016 was chosen as product performance testing method reference, the test enables to verify not only the ratings but also that no dangerous products are emitted. Testing standard XP-B44-013:2009[9] may be used as a supplement in some particular cases identified in the reference document[11].

The purification efficiency is tested at maximum operating speed for one or several pollutants category. It is understood that a manufacturer has to declare ratings for all the pollutants that belong to the category. For example, if the manufacturer wants to claim that his product can remove formaldehyde from the air then he must declare ratings for the 4 remaining gases too[10] and the air cleaner is tested for the whole gas mixture as foreseen in the testing standard[6]. Eurovent Certita Certification will proceed to careful examination of technical and sales documentation (paper and/or website content) to verify the consistency between the declaration and the communications to the public.

The air volume flow rate, the sound power level and the electrical power consumption are tested at the maximum operating speed but also at minimum and intermediate speeds whenever applicable[11]. This enables the end-user to verify the device sound power level at low speed operation ("night mode" for example).

The testing requirements do not stop there. To pass the test, there shall be no generation of reaction/emission by-products and the sound power level at maximum speed shall not exceed 60 dB[A] (when maximum purified air flow rate ≤ 250 m^3/h; 65 dB[A] otherwise[11]).

In addition to product performance testing, the certification scheme comprises factory audits to check that the quality management system in place ensures the manufacturing process reliability and consistency. This guarantees that the tested products, sampled from the manufacturing facility or directly from the market, are representative of the whole production.

If the manufacturer has passed the tests and audits and that he complies with the specified requirements in terms of clarity and transparency of published ratings, then he is granted the right to use the NF-Air Cleaners labelling on the certified air cleaner model(s) and the documentation for a given period mentioned on the certification diploma. Once an air cleaner model is certified, a surveillance procedure is initiated, comprising annual product performance testing and annual factory audits to verify that the requirements continue to be fulfilled throughout the years. This surveillance procedure is mandatory to renew the authorization to use the NF-Air Cleaners labelling.

NF-Air Cleaners certification mark labelling

[10] Particulate matter (PM) in the 0.3 µm to 0.5 µm size range, PM in the 1.0 µm to 2.0 µm size range, PM in the 3.0 µm to 5.0 µm size range, Acetone, Acetaldehyde, Heptane, Toluene, Formaldehyde, Staphylococcus epidermidis (bacteria), Aspergillus Niger (fungi) and Fel D1 (cat allergen).

11 NF-536 Certification rules for NF-Air Cleaners, Eurovent Certita Certification, 2016.

No room for ambiguity in the NF-Air Cleaners mark

The NF-Air Cleaners mark aims at guaranteeing clarity, transparency and comparability of the information related to the product use. Thus, to avoid any ambiguity in relation to the room size where the device use can be recommended, the NF-Air Cleaners reference document[11] establishes a consistency principle between the purified air volume flow rate delivered by the device and the surface area of the room through a minimum ratio criteria. For further details about this consistency principle please refer to the reference document[11] which is available on-line[12].

For example, when a manufacturer claims that the air cleaner can be used to remove VOCs in a room of 50 m², the related purified air volume flow rate measured by the laboratory shall be higher than or equal to 250 m³/h. If this is not the case, the manufacturer shall no longer communicate about 50 m² and update his documentation with the surface area that corresponds to the measured purified air volume flow rate and complies with the minimum ratio defined in the NF-Air Cleaners reference document[11].

Another measure to eliminate any risk of misunderstanding consists in specifying clearly in which measure units the manufacturer has to communicate data. For instance sound pressure levels shall be replaced by sound power levels and the values shall be displayed in dB[A]. Besides whenever the manufacturer displays a performance value the corresponding operation speed must appear.

Foreseen evolutions of the NF-Air Cleaners mark

In the near future, the NF-Air Cleaners mark will most certainly evolve to cover industrial applications and duct mounted installations. A dedicated committee gathering manufacturers, laboratories as well as consumers' associations is in charge of these future developments which will be managed by Eurovent Certita Certification.

As a matter of fact, the first update of the reference document is being reviewed by the NF-Air Cleaners mark committee. This revision aims notably at implementing the minor changes in the testing standard. Indeed, the NF-B44-200:2016[6], which replaces the XP-B44-200:2011[8] standard referred to in the original NF-Air Cleaners document[11], changes the composition of the tested mixture of gaseous pollutants with the introduction of formaldehyde and the decrease of the gases concentration towards more realistic values. The proposal of revision also provides some clarifications regarding product sampling rules and tests to be conducted in the surveillance procedure.

The revision of the reference document is expected to be published in February 2017.

A European certification scheme

As for the Euro-HP certification scheme, which enables participants to the NF-Heat pumps mark to be eligible to the Eurovent Certified Performance (ECP) mark (see dedicated article in REHVA Journal of March 2016[13]), it is foreseen to offer a European-Air Cleaners (Euro-ACL) mark for companies participating to the NF-Air Cleaners scheme.

This ECP certification will rely upon the completion of the NF-Air Cleaners process and the verification that the general requirements of the ECP mark, as detailed in related Certification Manual[14], are fulfilled.

The manufacturer will therefore be able to benefit from the ECP mark notoriety while capitalizing on existing efforts.

The draft documents will be submitted for approval to the Certification Programmes and Policy Commission, independent body in charge of guaranteeing the consistency between ECP programmes. The Euro-ACL mark is expected to enter into force in March 2017.

How to get further information?

Anyone willing to get further information about the NF-Air Cleaners certification can visit the dedicated webpage where the applicable reference document is available in English[12].

For specific questions or to apply for the certification scheme please contact apply@eurovent-certification.com specifying "NF-Air Cleaners" in the e-mail object. There is no deadline as this is a voluntary registration. ■

12 http://www.certita.fr/en/certita-mark/nf-air-cleaners.

13 New challenges for heat pump Certification, Eurovent Certita Certification, REHVA Journal Volume 53 p.31-35, March 2016.

14 Certification Manual of the Eurovent Certified Performance Mark 13th edition, Eurovent Certita Certification, November 2016.

Natural ventilation uncertainties in building energy simulations

With the increase of building envelope's performances, wind effects on natural ventilation represent an increasing share in energy consumption. In classical building energy simulations, those effects are extremely simplified in comparison to reality; however numerical simulations can significantly improve the quality of predictions.

Keywords: natural ventilation, pressure coefficient, building energy simulation.

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Calculation of wind driven natural ventilation in building energy simulations

To illustrate the issue, let us consider the trivial case of a building with wind driven cross-ventilation. The standard Building Energy Simulation (BES) tools compute the transversal cross-ventilation between to openings *a* and *b* at a same height *z* using the Bernoulli equation:

$$Q_v = S_{eq} \times v(z) \times \sqrt{C_p^a - C_p^b}\ .$$

With $v(z)$ is the wind velocity at height *z*, and C_p is the pressure coefficient on each opposite façades. The effective opening area S_{eq} is a weighted average of each individual opening area as well as their respective discharge coefficient, as in the following equation:

$$\frac{1}{{S_{eq}}^2} = \frac{1}{(C_d^a S_a)^2} + \frac{1}{\left(C_d^b S_b\right)^2}\ .$$

S_a and S_b represent the actual surface area of both openings. To overcome Bernoulli hypothesis of non-viscous fluids, their respective discharge coefficients C_d^a and C_d^b are added. They stand for two distinct phenomena reducing the theoretical flow. On one hand, the flow vein is contracting after the opening due to jets inertial effects. The cross-ventilation is thus reduced by a coefficient C_c, equal to the surface ratio between the jet area after the opening and the actual opening area (an illustration presented in **Figure 1**, for two simplified openings). On the other hand, the viscous friction also tends to reduce the airflow. It is usually taken into account through a coefficient C_f, usually taken between 0.95 and 0.99.

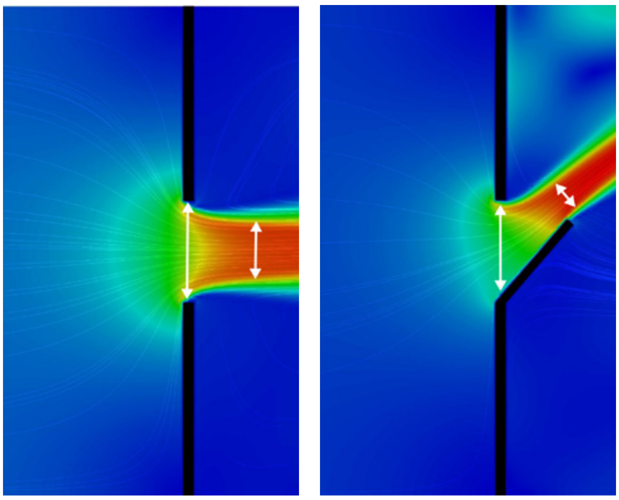

Figure 1. Contraction illustration for two simplified openings.

The discharge coefficient is thus defined by $C_c = C_c \times C_f$. The typical value given in the (ASHRAE 1997) standard and several natural ventilation simulation tools (CONTAM, IES-VE MacroFlo, EnergyPlus) ranges from 0.60 to 0.65.

Since neither the stagnation pressure at the opening height, nor at the actual pressure gap across the two openings *a* and *b* are known in classical BES, a pressure coefficient C_p is introduced for each façade. It represents a fraction of the undisturbed flow's dynamic pressure, and can be either positive or negative, in case of overpressure or depression.

$$C_p = \frac{p_{façade}}{\left(\frac{\rho v_{ref}^2}{2}\right)}$$

$p_{façade}$ represents the stagnation pressure, ρ the air density, and v_{ref} the wind speed at reference height. According to the software accuracy, the C_p coefficient is approximated according the empirical relations, valid only for rectangular buildings, with a shape factor close to one. Sometimes the inflow angle is also taken into account by a corrective factor, as well as the building height influence (Swami et Chandra 1988), (Akins, Peterka et Cermak 1979).

The undisturbed flow velocity v_{ref} is taken equal to closest weather station data. To ascertain the wind speed at the opening height *z*, a logarithmic law describing the atmospheric boundary layer is used:

$$v(z) = v_{ref} \times k_0 \times \ln\left(\frac{z}{z_0}\right)$$

To model the surroundings of the studied building, the profile of the atmospheric boundary layer can be adjusted by the terrain constant, the coefficients k_o and z_o. They represent respectively the apparent terrain's roughness and the roughness' height. k_o usually ranges from 0.14 to 0.25, and z_o from 0.5 mm to 2 m according to the terrain (sea, lake, snow field, desert, or at the opposite a tropical forest or a dense city center).

Modeling critical review

Reality is often very different from the theory presented above due to buildings complex shapes, exact location within an urban context or the actual shapes of openings. In the following paragraphs, we will demonstrate the possible biases on each modelling parameter.

Discharge coefficient: The C_d coefficient is usually misdocumented by the manufacturers since it relies on many variables. (Salliou 2011) and (Regard 2000) noted that it may vary according to the opening ratio, the temperature difference between the inside and outside or the wind speed. In addition, those authors calculated that this variation ranges from C_d = 0.1 to C_d = 2, in other word from 10% to 200% influence on the flow across the opening. However, it is difficult to lift this uncertainty without a wind tunnel experiment or a numerical simulation. According to the building of interest, the hypothesis on the C_d should be conservative at best, and the results should be properly interpreted.

Pressure coefficient: Those coefficients vary strongly per the wind direction, its magnitude close to façades, building shapes and urban surroundings. Even for simple building geometries, the pressure coefficients are not homogeneous throughout façades. **Figure 2** displays a simulation result in terms of C_p, where the values can be contrasted on a unique façade, ranging from slightly negative to positive values in certain areas of a same wall.

Reference air velocity: This parameter is taken from the closest weather station, for which the exact measurement height is usually unknown, nor the precise location. It is hence often difficult to ascertain precisely the actual wind speed near the location of interest. The velocity around buildings also depends on the topography, the close and distant urban settings with their respective roughness's. **Figures 3 & 4** depicts the flows complexity such areas, in plane and sectional view.

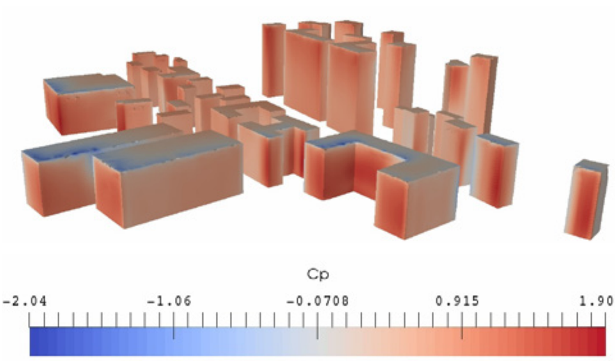

Figure 2. Façade pressure coefficient unevenness – Chambéry train station urban environment.

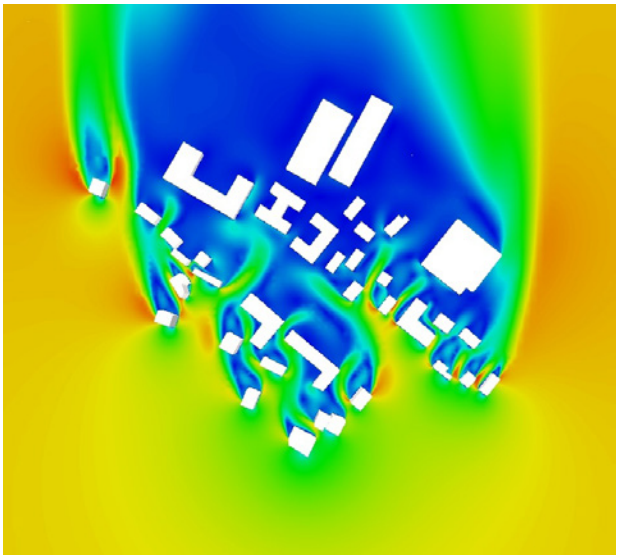

Figure 3. Velocity field fluctuation in urban environments - plane view.

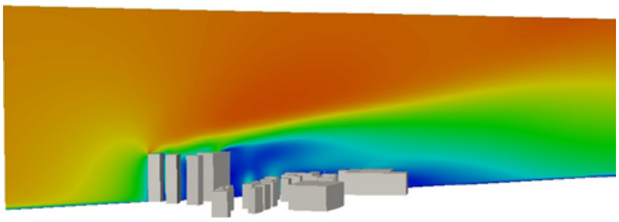

Figure 4. Velocity field fluctuation in urban areas – sectional view.

The uncertain parameters reduction should thus be undertaken using computational fluid dynamics (CFD) simulations. The use of an open-source or purchase-available software that solve the Reynolds-averaged Navier-Stokes equations coupled to a mass-balance model (RANS) is then necessary, using for instance a $k - \varepsilon$ turbulence modelling.

This approach allows the explicit determination the C_p on each façade of interest, according to the annual wind data and urban environment. It reduces the near-building velocities and pressure coefficient uncertainties. Those results are then taken as inputs for the annual hourly BES. It should nevertheless be reminded that this approach only considers wind effects: the buoyancy driven ventilation can be evaluated through a Froude's numbers condition. ■

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Dutch academic Building Services design education:

Integral Design to connect industry and university, essential for nZEB design

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Introduction

In the last 50 years, the world has changed enormously: instead of 3.5 billion people on earth, now there are more than 7 billion with more than 5% living in cities with an enormous increased standard of living. The demands for more comfort in buildings as well as more insight in the relevance of Indoor Air Quality towards health, led to more Building Services installations in buildings. This coupled with higher demands in relation to sustainability led to a development of more effective and efficient Building Services installations. In the past, the Building Services made out less than 10% of the budget and were rather simple systems. Nowadays, the Building Services have become quite complicated systems and form at least 30% up to 50% (hospitals) of the budget. The Architecture, Engineering, Construction (AEC) industry has become a knowledge intensive industry which should create sustained organizational and societal values [1]. It is difficult for different disciplines in the design phase to give adequate answers on the built-environment-questions from society. Inadequate design processes result in a productivity loss in the Dutch building design processes of approximately 10% of the total Construction Costs per year [2]. To reduce these failure costs, collaboration between different design disciplines becomes of considerable importance. One of the complicating aspects in building practice is the different cultural backgrounds of architects and engineers and their different approaches to design [3]. As a result, miscommunication occurs caused by not speaking a common language. Already in 1960, the necessity for improved cooperation between the architect and the engineer was recognized by the famous architect Le Corbusier, see **Figure 1** [4].

Le Corbusier explains the roles of the architect and the engineer [5]: "Under the symbolic composition I have placed two clasped hands, the fingers enlaced horizontally, demonstrating the friendly solidarity of both architect and engineer engaged, on the same level, in building the civilization of the machine age" [4]. The architects and the engineers should work together from the very start of a design project and must aim to reach synergy by combining the knowledge and the experience of all disciplines already in the early stages of the conceptual design. To make this possible, an integral approach is needed which represents a broad view on the world around us that continuously needs to be adapted and developed from sound and documented experiences that emerge out of interaction between practice, research and education.

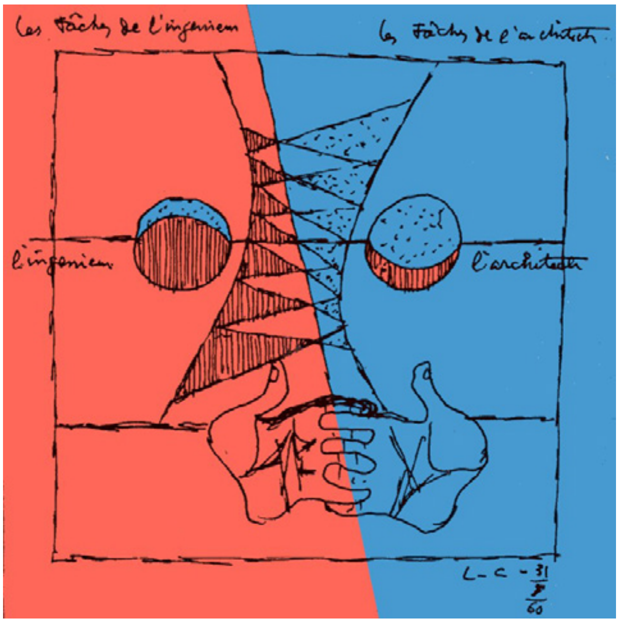

Figure 1. The necessary relation between architect and engineer by Le Corbusier.

Traditionally practitioners in building industry were only educated on a middle level with only a few that have earned a degree of an institute of higher education, but no one on academic level. However, more and more there was a clear need for professionals who are able to solve difficulties on an academic level. Thus, in the late nineties, there was a strong urge from the Dutch industry to the universities, to start with initiatives in order to change the worrying situation of the rather low educational qualified people in the Building Services industry. The MSc Building Services has been established in 2002 as result of a strong initiative from the Dutch Building Services industry, especially the Dutch Society of Building Services Engineers (TVVL), the foundation for stimulating research and education in building services (WOI) and the professional society for building service companies (UNETO-VNI). Both employer and employee have the same professional goals to achieve in the future and have a clear vision of how to share and implement the academic knowledge of the university. In 2011, the MSc Building Services became integrated in the master track Building Physics and Services as part of the MSc Built Environment. The teaching is done by the staff members of the unit Building Physics and Services which exists out of 6 chairs: Building Services, Building Materials, Building Performance Simulation, Building Acoustics, Building Lighting and Building Physics. Through this unique combination of design of systems, simulation and physics, the educational program is broad and technical as well as fundamental oriented.

Methodology

In building design, one should work with ill-defined design problems where the solution and the problem itself develop almost in parallel at the early stages of the design process. In addition, the amount of relationships and dynamic social interactions makes design increasingly complex. Therefore, a method is needed to structure *would-be* design solutions. In the early 1960s, researchers and practitioners began to investigate new design methods to improve the outcome of design processes. Since then, there has been a period of expansion through the 1990s right up to the present day. However, there is still no clear picture of the essence of the design process and many models of designing exist. After studying different design methods, it was decided to use a method derived from the General System theory [6]. This methodical design method has as a distinctive feature the step pattern of activities (generating, synthesizing, selecting and shaping), see **Figure 2**, that occur within the design process.

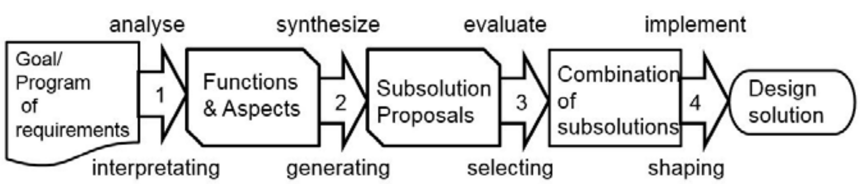

Figure 2. The four-step pattern of Integral Design.

The methodical design method was expanded to a multi-disciplinary design method, Integral Design, through the intensified use of morphological charts developed by Zwicky [7]. This to support design team's activities in the conceptual building design process [8,9] and especially the use of a morphological overview built from the individual design team member's morphological charts. A morphological chart is a kind of matrix with columns and rows which contains the aspects and functions to be fulfilled and the possible solutions connected to them, see **Figure 3**. The functions and aspects derived from the program of demands. An example of a morphological chart created by an architect is depicted in **Figure 4**. In principle, overall solutions can be created by combining various subsolutions to form a complete system solution combination [10], see **Figure 5**.

The most important subfunctions and aspects to be fulfilled ↓		Sub solutions →					
	1	1.1	1.2	1.3	1.4	1.5	1.6
	2	2.1	2.2	2.3	2.4	2.5	
	3	3.1	3.2				
	4	4.1	4.2	4.3	4.4	4.5	
	5	5.1	5.2	5.3	5.4		
	6	6.1	6.2	6.3			

Figure 3. Concept of a morphological chart

The morphological overview of an integral design team process is generated by combining in two steps the different morphological charts made by each discipline. In the first step of the integral design method, the individual designer has to make a list of what he thinks are the most important functions that has to be fulfilled based on the design brief. This is derived from their own specialist perspective. The morphological charts are formed as each designer translates the main goals of the design task, derived from the program of demands, into func-

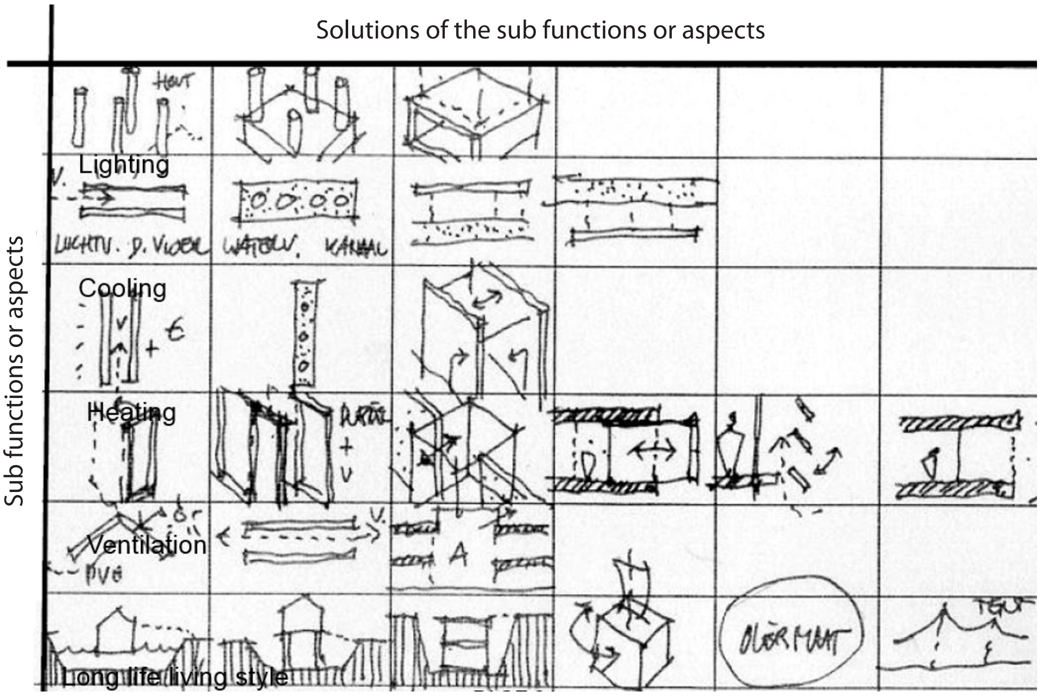

Figure 4. An example of a morphological chart by an architect.

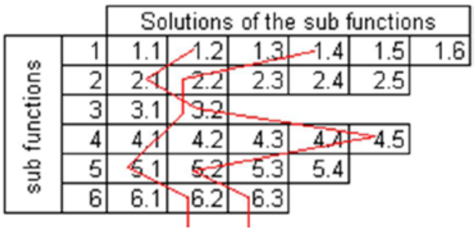

Figure 5. Morphological chart and the possible solutions on the horizontal rows of the chart, with the lines representing 2 possible solution combinations

tions and aspects and is then put into the first column of the morphological chart, see **Figure 6**. In the second step of the process, the designers add the possible part solutions to the related rows of the functions/aspects of the first column. So, functions and aspects are discussed and then the team decides which functions and aspects will be placed in the morphological overview. Then, after this first step, all participants of the design team can contribute their solutions for these functions and aspects by filling in the rows within the morphological overview.

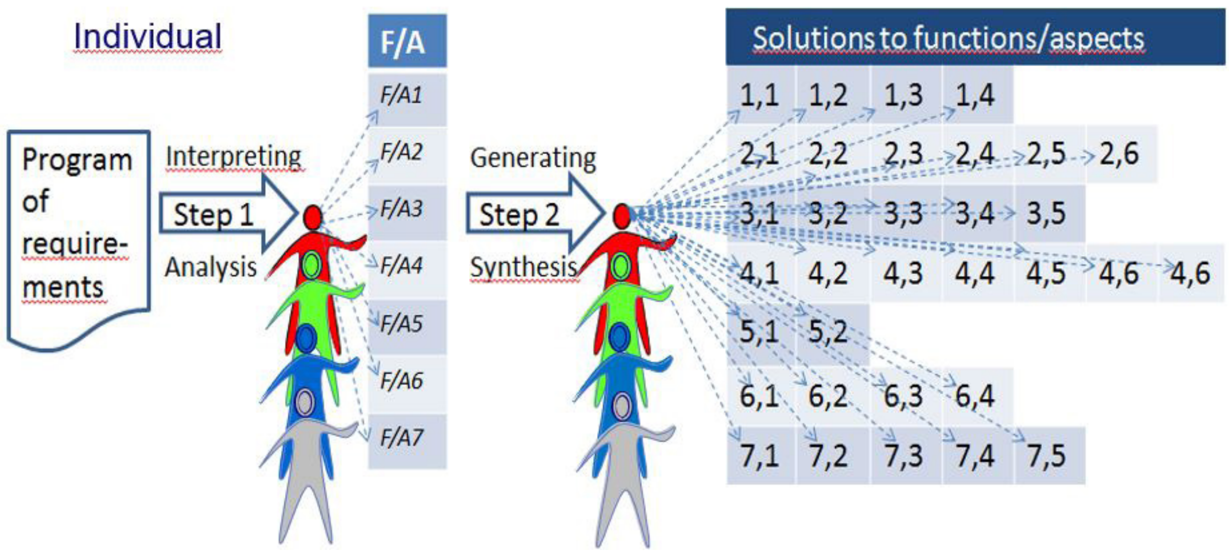

Figure 6. The first two design steps of the design process cycle, interpreting the design brief and list the functions in the first column of the morphological chart and add the related sub solutions [11].

Based on the given design task, each design team member perceives reality due to his/her active perception, memory, knowledge and needs. The morphological charts represent the individual interpretation of reality, leading to active perception, stimulation of memory, activation of knowledge and defining of needs.

These individual morphological charts can be combined by the design team to form one morphological overview, see **Figure 7**. Putting the morphological charts together enables 'the individual perspectives from each discipline to be put on the table', which in turn highlights the implications of design choices for each discipline. This approach supports and stimulates the discussion on and the selection of functions and aspects of importance for the specific design task.

Integral Design: Workshops learning by doing education starting in industry

Since 2000 together with the Dutch Royal society of architects (BNA), the Dutch Association of Consulting Engineers (NLingenieurs), the Dutch Society of Building Services Engineers (TVVL) and different Roofer associations in total 14 series of workshops were organized in which in total more than two hundred experienced professionals, with at least 10 years of experience, from these organizations, voluntarily participated. After extensive experiments with different set ups for implementing the Integral Design approach, in which well over one hundred professionals participated, it was concluded that a good way to test our design approach was a workshop setting for professionals. Therefore, workshops were arranged as part of a training program for architects and consulting engineers (structural engineers, building services engineers and building physics engineers) [8], as well as for architects and contractors [10]. These design exercises were derived from real practice projects and as such were as close to professional practice as possible. The design tasks during the two days are on the same level of complexity and have been used in all workshops. In the workshops, stepwise changes to the traditional building design process type, in which the architect starts the process and the other designers join later in the process, were introduced in the set up of the design sessions. In the final series of the research focussing on the interaction between architects and engineers during the conceptual design phase, three different design set ups of participants were tested in four sessions [8].

In connection with the Integral design research project for professional in the Dutch building industry, we developed an educational project, the master project integral design. Interaction between practice, research and education forms the core of the 'integral approach'. Therefore, the concept of the integral design workshop for professionals was implemented within the start-up workshop of our multidisciplinary masters' project. The basis of this project, which serves as a learning-by-doing start-up workshop for master students, is the Integral Design method with its use of morphological overviews. The different design assignments were related to the design of zero energy buildings. These complex tasks require early collaboration of all design disciplines involved in the conceptual building design. Master students from architecture, building physics, building services, building technology and

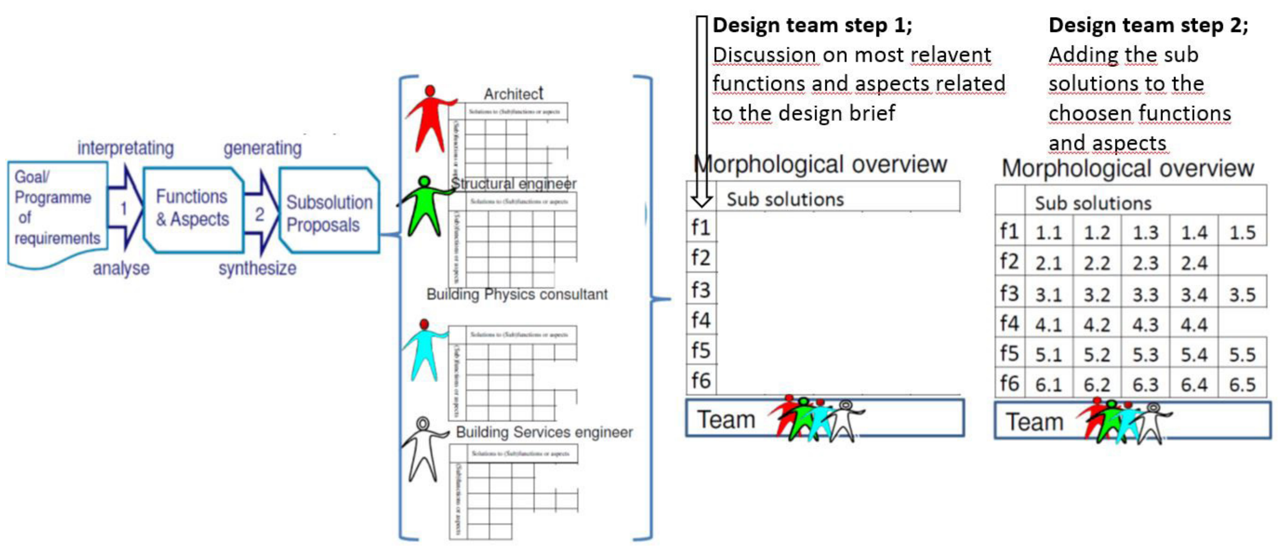

Figure 7. The second phase generating the morphological overview from the individual morphological charts [11].

structural engineering participated in these projects. The master project Integral design was initiated by the chair of Building Services in the 2005/06 academic year and since then, it has been held every year. The master students from architecture, building physics, building services, building technology and structural engineering were offered the opportunity to participate. The specific aspects of the office building design assignments were to realise 'sustainable comfort', a net Zero Energy Solution on different locations. Bearing in mind that in the current situation, 40% of primary energy consumption is due to built environment such a task is highly complex. It requires early collaboration of all design disciplines involved in the conceptual building design. Development of knowledge, skills and the ability to realise this aim are the main tasks of the multidisciplinary masters' project 'Integral design'.

The participants of the workshops were master students of the faculty of architecture, building and planning (architects, structural design, building technology, building physics and building services) and had an average age of 22 and no working experience. Since 2005 around two hundred and fifty students participated in MIO projects. The workshops were developed since they had their final form.

The results of the workshops

Central element of the Integral Design process is the use of morphological charts by individual designers which were combined into one morphological overview by the design team. By making combinations within the morphological overview of possible sub solutions and combining them to overall solutions, the teams generate their solutions. The number of functions and sub solutions mentioned by the designers in their morphological charts were counted and the average numbers of functions and solutions as mentioned by the design teams are represented in **Figure 2**. The same was done for the sub solutions mentioned by the design teams in their morphological overviews. Here only a brief selection is given of all the results of the preliminary professional workshops Integral Design. More results and information were presented by Savanovic [8]. There was a clear increase in the number of mentioned functions (+62%) as well as the number of mentioned sub solutions (+105%) in the workshops for professionals as well as in the workshops for students functions (+30%) and sub solutions (+57%), see **Figure 8**.

Discussion

Given the existing disparities in the construction industry, King [12] stated that, to do something meaningful in terms of moving to low carbon society, there is a need for a consistent framework within which knowledge can be applied as embodied in a design team. By structuring the interactions of designers from different disciplines in the conceptual phase of building design, it is possible to support members of every discipline to handle tasks and to supply information from other disciplines. The Integral Design methodology was tested through workshops with industry professionals from the Royal Institute of Dutch Architects (BNA) and the Dutch Association of Consulting Engineers (NLingenieurs). After this, it was implemented in the educational program of the university.

Putting the morphological charts together makes possible to 'put on the table' the individual perspectives from each discipline about the interpretation of the design brief and its implications for each discipline. This enables, support and stimulates discussion on the

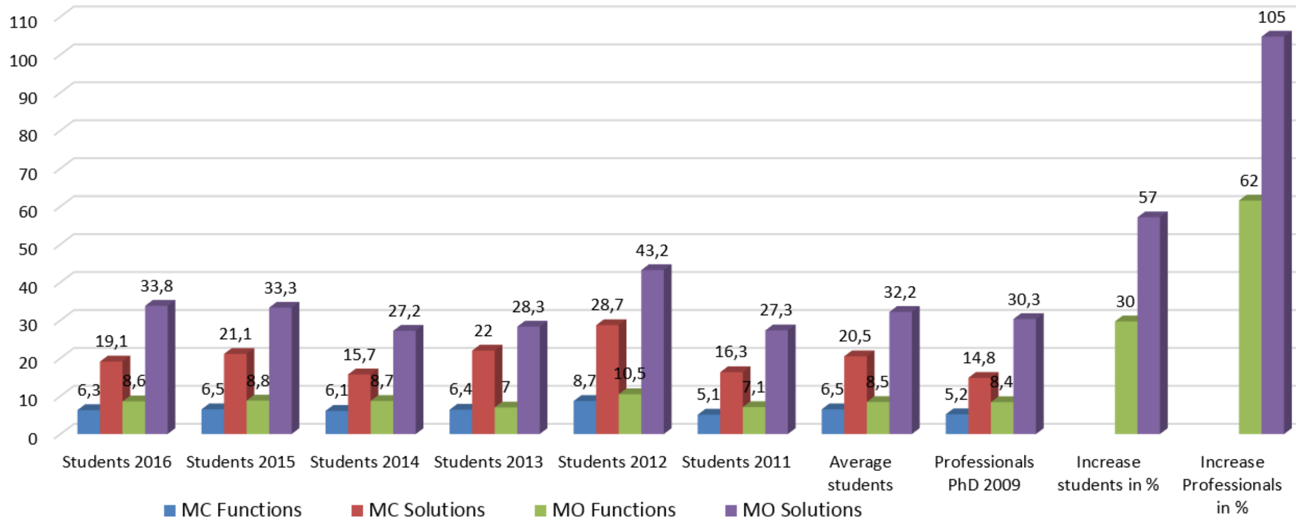

Figure 8. Results workshops Integral Design for professionals and students.

selection of functions and aspects of importance for the specific design. In step two, the functions and aspects are discussed and decisions are placed by the team in the morphological overview. Structuring design (activities) with morphological overviews as the basis for reflection on the design results stimulates the communication between design team members. Thus, integral design helps the understanding within design teams and stimulates collaboration to come forward with new design propositions. Through visualizing the individual contributions within a design team, morphological overviews based on the individual morphological charts stimulate the understanding of different perspectives within design teams.

Workshops are a self-evident way of work for designers that occur both in the practice and during their education. There are a number of advantages that workshops have with regard to standard office work, while at the same time retaining practice-like situation as much as possible: the possibility to gather a large number of designers in a relatively short time, manipulation of design team formation, repetition of the same assignment and comparison of different design teams and their results. The suitability of workshops for integration of design team activities, together with suitability of morphological overviews for structuring knowledge of design team members, forms the basis on which the education design method is built.

Our presented approach of combining research for education for students based on experience with professionals is quite unique. Interaction between the practice, research and education forms the core of our integral approach; we implemented the same workshop pattern and methodology within our multidisciplinary masters' project at the university.

Conclusions

The unique aspect of the academic HVAC educational program at the Technische Universiteit Eindhoven is the context within the Faculty of the Built Environment and the close relation with Building Physics within the master track Building Physics and Services. Furthermore, the close relation with industry and their interaction within the educational structure through the research and education in relation to Integral Design is a strong aspect.

The workshops and the multidisciplinary projects provided us with many insights, some of which were discussed in this paper. Building design processes can be improved through improving process communication understanding, sharing and collaboration. The use of the morphological chart is an excellent way to record information about the solutions for the relevant functions and aid the cognitive process of understanding, sharing and collaboration. ■

Acknowledgments

TVVL, BNA and TU Delft have financial supported the Integral Design project. TU Eindhoven, Kropman, the Foundation WOI and the Foundation 'Stichting Promotie Installatietechniek' (PIT), supported the research focused on introducing the design method from industry back into university.

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The Clean Energy Package of the European Commission – what's new in the revised EPBD?

ANITA DERJANECZ
REHVA Managing Director

The European Commission unveiled on 30 November 2016 the long-awaited "Clean Energy for All Europeans" Package, which is an extensive set of policy measures and documents including the legislative proposal on the revised Energy Performance of Buildings Directive (EPBD), a binding 30% energy efficiency target, clarified Ecodesign framework and measures, policies to improve skills in the construction sector and smarter finance to help Europe grow while meeting its climate goals.

Revised Energy Performance of Buildings Directive (EPBD)

The European Commission has proposed a revised Energy Performance of Buildings Directive (EPBD) and relevant articles of the Energy Efficiency Directive (EED). The proposal sets renovation targets, and minimum performance requirements for existing and new buildings. It furthermore adds provisions on energy performance certificates on inspections. A Staff Working Document linked to the proposal shows best practices of improved energy performance in buildings.

New elements of the legislative proposal:

- Incorporation of the provisions on **long-term renovation strategies** (Article 4 of the EED) in the EPBD
- Article 10 is updated to include two **new provisions on EPCs** to assess savings from renovations financed with public support are to be assessed by comparing EPCs **before and after renovation**
- Improved provisions on inspections of heating and air-conditioning systems (Articles 14, 15, 16), reinforcing the use of continuous electronic monitoring and building automation and control (BAC). Inspections of the H/C systems shall assess also the sizing compared to heating and cooling the requirements
- Annex I is updated to improve transparency and consistency of energy performance definitions at national or regional level and to take into account the importance of the indoor environment
- Commission is empowered to adopt delegated acts on "**smartness indicator**" (Article 23).

REHVA experts and TRC members have started to exchange opinions about the proposed changes and define key elements of a REHVA position.

Indoor environment quality in the revised EPBD

REHVA has been advocating for minimum indoor environment quality (IEQ) requirements and for strengthening IEQ related aspects in EPBD during the whole review process. We can see some positive move in this direction in the published proposal. Annex I includes a binding requirement of ensuring minimum environment levels, without defining European level requirements though. It is left to the Member States to define them at national or regional level. To make sure that good IEQ is provided and maintained, there is a need to further strengthen IEQ in the EPBD. REHVA will further advocate for strengthening indoor environment and comforts aspects in the legislation, for instance that IEQ criteria should be part of the inspection of heating and cooling systems.

Inspection, continuous monitoring of heating and air conditioning systems and BAC

It is certainly a good news that the articles 14-15 on the inspection of heating and of air conditioning system remained in the EPBD proposal, after they were deleted from the leaked version circulated in August 2016. Even though the previous requirements were not implemented by the countries, it is

important to have a scheme ensuring the proper operation and maintenance of the systems. Member States poorly implemented the original requirements partly because it was not clear how the outcomes should be enforced. The new articles contain binding requirements on setting up schemes that enforce regular inspection, including the assessment of system efficiency and sizing. However, the article focuses only on thermal energy and this should be widened to tackle measures for power load reduction and management.

Member States can choose requiring continuous monitoring and mandate the integration of building automation and control systems as an alternative to regular inspection. However, the requirements in the current proposal seem to be technically too complex, demanding at the same time the ability of:

- continuous monitoring, analysing and adjusting energy usage
- benchmarking, detecting of losses and informing the facility managers about energy saving opportunities
- communication with connected technical building systems and other appliances, and interoperability across the different types of systems and devices.

If the requirements are too complex, the risk that Member States won't implement the non-binding alternative measures is high. The requirements mix what can be implemented by a third-party service provider/inspector, by the building operator, or can be automated using BAC. For instance, benchmarking and the definition of energy saving opportunities can be an external service. The adjustment of the energy usage is mostly being done by the building and system operator. The requirement on connectivity and interoperability is not closely linked to inspection, goes beyond the scope of these articles.

To ensure cost effective inspection, instead of in-situ analysis, regular inspections can be carried out by analysing operational data provided by the BAC. However, the target values should be defined for individual components and systems, and measured appropriately. An important aspect is missing from the requirements: quality management must be ensured and the application of the BAC should be verified in a transparent way. This can be guaranteed by third party testing that is independent from owner, operator, or the BAC system itself.

What is the smartness indicator?

The EPBD gives the mandate to develop a smartness indicator to assess the technological readiness of the building to adapt in response to the need of the occupants' demand, to interact with the grid and to facilitate maintenance and efficient operation. DG Energy has launched a service tender for the preparatory work, which is under contracting now. The technical specification of the tender describes the requirements that DG energy has in mind regarding he indicator. Beside the elaboration of a thorough market study and an impact assessment, the aim of the contract is to define and characterise a smartness indicator applicable for all building types and to develop a robust methodology for the calculation of such an indicator. The technical specification specifies to respect the EPBD, the related international and European standards. The impact assessment and the technical analysis should consider the wider benefits, including indoor environment and comfort aspects. At this stage, it is not clear yet how the characteristics and calculation methodology will consider IEQ requirements. REHVA will closely follow the process and provide inputs to the work of the consortium developing the indicator.

Ecodesign Working Plan for 2016-2019

The Clean Energy Package contains also the new Ecodesign Working Plan for the 2016-2019 period defining new product groups including building automation and control systems, refrigerated containers, Solar panels and inverters and how Ecodesign will contribute to circular economy objectives.

Beside the new work plan the work is ongoing related to minimum energy efficiency requirements for air heating and cooling products and standardisation requests in support of Ecodesign measures for solid fuel boilers and local space heaters.

Accelerating clean energy in buildings – construction initiative

The Commission reinforces its action to support the competitiveness of the construction sector and the benefits of the Energy Efficiency legislation by launching a construction initiative to accelerate the modernisation of the construction sector boosting growth and jobs. This initiative entails the speeding of the digitisation of the sector, the further upskilling of workers, a functioning internal market, and the development of the circular economy.

Smart Finance for Smart Buildings Initiative

The initiative includes specific measures to further unlock private financing and enable market actors to realise their projects through attractive and appropriate financing solutions. This initiative can unlock an additional EUR 10 billion of public and private funds until 2020 for energy efficiency and renewables. The 3 pillars of the imitative are:

- More effective use of public funding
- Aggregation and assistance with project development
- De-risking investments

Next steps

The European Parliament and the Council of the European Union will discuss and agree on equal terms with the proposal of the European Commission. REHVA is developing its position on the EC proposal and will closely follow the Parliament reading communicating its position to the policy makers. ■

More information

- Communication from the Commission Ecodesign Working Plan 2016-2019, COM(2016) 773 final.
- Directive of the European Parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings, COM(2016) 765 final 2016/0381 (COD).
- European Commission - Fact Sheet: Putting energy efficiency first: consuming better, getting cleaner, 30 November 2016.
- Commission Staff Working Document: Good practice in energy efficiency, SWD(2016) 404 final.

REHVA Annual Meeting 2017

REHVA is pleased to invite its Members and Supporters to the 2017 REHVA Annual Meeting hosted by CISBE in London, United Kingdom. The 2017 Annual Meeting is held on Sunday April 2nd to Tuesday April 4th, 2017 with some major changes in the agenda compared to previous years. The REHVA Board would like to present and discuss a new strategy of cooperation with Member and Supporters, so the schedule of this year's Annual Meeting was planned to provide fora for more interactive discussions.

REHVA strategic meetings and General Assembly (2-3 April, CIBSE Headquarters)

The first day (2nd April) will be dedicated to committee meetings, a REHVA Members Plenary meeting and an Advisory meeting between REHVA Board and past REHVA Presidents, closed by the usual welcome cocktail. The 61st REHVA General Assembly will be held after these strategic discussions in the afternoon on the 2nd day (3rd April). In the morning, our sister organizations SCANVAC and BALTVAC will have a meeting. The General Assembly will be followed by the usual REHVA Gala Dinner and Awards Ceremony. The venue of the first 2 days will be the CIBSE Headquarter, 222 Balham High Road, London SW12 9BS.

REHVA Supporters Day with REHVA seminar and the Student Competition (April 4th, University College London)

The 3rd Day will be dedicated to REHVA supporters and features the Supporters Committee discussing about the new REHVA strategy for Supporters, a REHVA Seminar on future HVAC sector challenges and the REHVA Student Competition. The REHVA Seminar will give updates on the EPBD review and upcoming key policy changes and presentations from industry representatives about technology challenges of the near future followed by a moderated interactive discussion between speakers and participants. REHA would like to provide forum to exchange knowledge and experience between their members and supporters, practitioners, engineers, and HVAC manufacturers.

Schedule

Sunday 2 April 2017

Venue: CIBSE Headquarter, 222 Balham High Road, London SW12 9BS, UNITED KINGDOM

09.00 – 10.15	Education and Training Committee Meeting	Publishing and Marketing Committee Meeting and REHVA Journal Editorial Board Meeting
10.15 – 10.30	*Coffee break*	
10.30 – 12.00	External Relations Committee Meeting	Publishing and Marketing Committee Meeting and REHVA Journal Editorial Board Meeting
12.00 – 13.00	*Lunch*	
13.00 – 14.00	Technology and Research Committee Meeting	Awards Committee Meeting
14.00 – 15.00		
15.00 – 15.30	*Coffee break*	
15.30 – 17.30	REHVA and Member Associations Plenary Meeting (Presidents, Directors and delegates)	
17.30 – 18.30	Advisory meeting between Board of Directors and Past Presidents	
19.30	*REHVA Welcome Cocktail (location in Balham - TBC)*	

Monday 3 April 2017

Venue: CIBSE Headquarter,222 Balham High Road, London SW12 9BS, UNITED KINGDOM

09.00 – 10.45	REHVA Board Meeting	COP Meeting	SCANVAC/BALTVAC meeting
11.00 – 12.00			
12.00 – 13.00	*Lunch*		
13.00 – 15.30	General Assembly		
15.30 – 16.00	*Coffee break*		
16.00 – 18.00	General Assembly		
19.30	*REHVA Dinner and professional awards (location in Balham - TBC)*		

Tuesday 4 April 2017 - REHVA SUPPORTERS DAY

Venue: University College London (UCL), Gower St, Kings Cross, London WC1E 6BT, UNITED KINGDOM

9.00 – 10.00		REHVA Student Competition
9.30 – 11.30	Supporters Committee Meeting – Strategic Plan	
11.30 – 13.00	*Supporters' Lunch (upon invitation)*	
13.00 – 17.00	REHVA Seminar - HVAC sector challenges ahead us	

The sessions of the last day are held at the University College London, (UCL), Gower St, Kings Cross, London WC1E 6BT in Central London. The UCL is close to the St. Pancras train station, so participants have easy connections to continue to the CIBSE-ASHRAE Technical Symposium "Delivering Resilient High Performance Buildings" held on April 5th and 6th, 2017 at the Loughborough University.

REHVA looks forward to meeting you in London in April!

ASHRAE Recognizes Outstanding Industry Achievements

Zoltan Magyar, Ph.D., head of the Department of Building Energetics and Building Service Engineering, Budapest University of Technology and Economics and former REHVA Vice President and Treasurer was elevated to the grade of ASHRAE Fellow.

On January 28th, 2017, in Las Vegas, Nevada, ASHRAE recognized fifty-five people for outstanding industry and society achievements, for their contributions to ASHRAE and the industry at the Society's 2017 Winter Conference.

Fellow ASHRAE is a membership grade that recognizes members who have attained distinction and made substantial contributions in HVAC&R such as education, research, engineering design and consultation, publications and mentoring.

ASHRAE president Tim Wentz congratulates Zoltan Magyar.

TESKON + SODEX: Exhibition and Congress Altogether!

TESKON + SODEX – April 19th–22nd, 2017 – IZMIR

Set to be held in Izmir Tepekule Congress and Exhibition Center on April 19th – 22nd, 2017, TESKON+SODEX is housing the National Sanitary Engineering Congress (TESKON) which will be held by UCTEA (TMMOB) Chamber of Mechanical Engineers. Organized for the first time in 1993 and executed by the Izmir Branch on behalf of UCTEA Chamber of Mechanical Engineers and continued simultaneously with SODEX for 10 years, the congress brings together many prominent academicians, architects, engineers, project company officials and professionals in the industry under TESKON+SODEX and allows them to share notable knowledge.

Held in Izmir biennially, the show took place on April 8th – 11th, 2015 last and the main topic for the congress in 2015 was "Thermal Comfort and Indoor Air Quality for Health". Offering theoretical and applied scientific and technological developments in both sanitary engineering and in other disciplines, TESKON Congress will feature "Integrated Performance" in 2017.

SODEX Exhibitions are organized by Hannover Messe Sodeks Fuarcılık, the Turkish subsidiary of Deutsche Messe which is among the world's top 10 exhibition companies. Attended by the leading companies of the industry as exhibitors, the events host not only local visitors but also many buyers from Europe and Middle East under the International Hosted Buyer Programs. This way it makes major contribution to the HVAC industry with its business volume. The sales that began last month for 2017 for the two exhibitions continue at full speed. Companies who'd like to attend need to be quick, considering the limited available place.

Russian HVAC market speeds up!

Economic challenges are considered to be the drivers for new solutions in each sphere. That was what had happened with the Russian HVAC industry: the country whose market is considered as one of the most attractive with its 143.5 mln active consumers and 6th largest volume of economy in the world, experienced need in the new products that could be more efficient both for new and existing residential and industrial projects.

Among the factors that still influence the market potential are: stable level of construction (622.8 mln sqm of residential and non-residential buildings' space were placed in service during 2015), growth of per capita housing (25–35 sqm to be reached by 2020 according to federal residential construction housing support programme), high level of HVAC products' import despite localization of major market players' production.

Nowadays, the size of Russian heating market is estimated at 2 bn euro, with a forecast of nominal year-on-year increase by 10%*, while developers continue to work on big amount projects launched in 2013 – 2014 and refurbishment of old buildings.

All these facts make Russia one of the most attractive markets for international companies that can provide both cost and resources efficient products to customers.

Aquatherm exhibitions are the leading B2B platforms for developing HVAC & Pool business in Russia and the CIS countries that show constant success. In 2016, 651 exhibitors from 300 countries presented 830 product solutions at over 30 000 sqm of exhibition space of the central show in Moscow. The exhibitions annually gather world market leaders and industry newcomers to have negotiations with 27 thousand of professionals.

In February, before the start of construction season in Russia the expositions in Moscow and Novosibirsk will deliver strong and most efficient opportunities for international companies to enter one of the largest European HVAC markets and improve sales network with thousands of distributors, wholesalers, retailers, construction and engineering companies. A really high business activity in the market and booming interest in the new products are approved by 5% growth of visitor registration to the show vs 2016 edition.

Over 750 global leaders from Austria, Belarus, Belgium, China, Czech Republic, Egypt, Finland, France, Germany, Hong Kong, Israel, Italy, Latvia, Poland, Kazakhstan, Republic of Korea, Russia, Serbia, Slovakia, Spain, Sweden, Switzerland, Taiwan, Turkey and the UAE will present their products at Aquatherm Moscow (7–10 February 2017), Novosibirsk (14–17 February 2017) and St. Petersburg (19–21 April 2017).

Ariston Thermo, Baxi, Bugatti, BWT, Caleo, Comisa, Danfoss, De Dietrich, Dizayn, Espa, Fondital, FV-Plast, Genebre, Grando, Gruenbeck, Giacomini Spa, Evan, Heisskraft, Henco, Herz Armaturen, Hogart, Honeywell, Kalde, Kessel, Kiturami, KSB, Meibes, Minib, Navien, Oventrop, OSPA, Pahlen, Polykraft, Reflex, REMS, Rinnai, Rothenberger, Sahna, Sermeta, Sit, Uponor, Valtec, Vernet, Vesbo, Viega, Wavin, Wirbel, Xylem, Wirquin, Unipump, Viessmann, Wavin, Zehnder and many others are among the brands that have chosen Aquatherms to grow sales this year.

International recognition of Aquatherm Moscow, the major show of the brand, is reinforced by traditional support of government agencies of Germany, Italy, Spain, China and Turkey.

New opportunities for trend sectors

The show includes specialized section of pool and sauna equipment products – World of Water & Spa, which represents a meeting point of pools and spa construction professionals, architects, designers and trade companies. Being approx. 90% imported, the section related products match the market demand for the best world technologies and quality. The section is considered to be the only specialized B2B platform for this industry in Russia.

Special project New Energy corresponds with the current state trend for renewable and energy-efficient products specially highlighted during the Year of Ecology in Russia. "We've chosen Novosibirsk show this year and focus on the need of local market: highly efficient equipment with condensing technologies and natural gas which is still very rare here in Siberia. Maximum energy efficiency is our target this time, besides the interest to energy efficient equipment has always been in Russia and it will develop further year by year!" (A. Loskutov, Head of Viesmann LLC, Novosibirsk)

Get new business solutions, find distributors, investigate competitors, announce and promote products – take a chance to grow your business at Aqutherms in Russia!

* PMR research

VDI award to Jan Aufderheijde

The President of the VDI, Prof. Dr.-Ing. Udo Ungeheuer, awarded Mr. Dipl.-Ing. Jan Aufderheijde (1947) as Corresponding Member of VDI, a presidential title of honour of VDI. Aufderheijde was awarded by the VDI-Fachbereich Technische Gebäudeausrüstung (VDI-TGA) based on his great services towards European collaboration and understanding.

Jan Aufderheijde was from 2000–2012 director of the Dutch TVVL and developed already in this position a close relation with VDI-TGA. From 2015 onwards Jan Aufderheijde developed, in close cooperation with VDI-TGA, plans to strengthen the position of REHVA in Europe. From 2012 till 2016 Aufderheijde held the position of Secretary General of REHVA where he was in the position to successfully work out these plans.

Jan Aufderheijde proved his worth in the fields of European cooperation in the area of HVAC. The VDI-TGA congratulates Jan Aufderheijde with this award.

Contact: Thomas Terhorst
VDI-Gesellschaft Bauen und Gebäudetechnik
E-Mail: terhorst@vdi.de
Relevante Links: www.vdi.de/gbg

Prof. Michael Schmidt (left), Chair person of the VDI-GBG and Jan Aufderheijde (Photo: Terhorst /VDI 22.11.2016)

IEA Heat Pump Conference 2017

The triennial 12th IEA Heat Pump Conference 2017 will be held at the World Trade Centre in Rotterdam from 15th – 18th May.

Conference theme:
Rethink Energy, Act NOW!

The Conference starts on the first day with six workshops and will continue after a plenary opening with three days of presentations. More than 250 high quality full papers were received, resulting in four main conference tracks. Keynote presentations of high level experts will open each morning and afternoon session. With participants from over 30 countries, the event is a key event for policymakers, executives and representatives from industry, utilities and the public sector, R&D managers and technology supporters, energy managers, planners, consultants.

ISH

ISH 2017 – the trade fair for planners and engineers

The ISH is the sector's number one event and its significance as a leading world trade fair is now underlined by impressive figures already released. From 14 to 18 March 2017 the ISH will gain host over 2,400 exhibitors including all the principal market players from Germany and abroad. These leading tech companies come to the ISH to stage the world launch of their new product innovations. The ISH has, therefore, a leading role worldwide as the occasion per se when the sector comes together – in 2015 61 percent of the exhibitors and 39 percent of the visitors came from outside Germany.

The ISH 2017's motto is 'Water. Energy. Life', a clear statement of where the focus lies for what is the world's biggest demonstration of the combined potential of water and energy, themes which, ultimately, have always been the cornerstones of the ISH. Held every two years, this leading world trade fair offers a wide range of cutting edge, building technology solutions in response to the political and economic themes of the day.

The 'Water' section of the ISH focuses on sustainable sanitary solutions and innovative bathroom design. In 2017 it takes 'bathrooms for people' and 'technology for people' as its main themes and includes many different aspects such as design, health, wellness, convenience, but also the protection of resources and drinking water hygiene. A further focus is also on the topics sustainable systems for domestic hot water heating and networked water management systems for a comfortable and safe environment.

The ISH Energy and Aircontec section is all about having energy-efficient and convenience-driven buildings. Key trends include the field of efficient futuristic technologies and intelligent building services technology. Essentially, the idea is to demonstrate the synergistic combination of heat and renewable energy. However, it will also address the issue of digital heating and the increasing integration of IT in innovative heating technologies that this involves. It is all brought together under the overarching theme of 'Energy Turnaround and the future – we have the solutions', which introduces visitors to the total spectrum of innovative building services technology.

Modern residential ventilation units will be one of the key themes in the Aircontec section to include the themes of energy efficiency and home comfort along with centralised and decentralised solutions for new buildings and renovation projects. Another theme will also be technical challenges for environmentally friendly air-conditioning and ventilation technology. Therefore, in the Aircontec segment, there has been an increase in interest and greater demand from new domestic ventilation systems companies.

At ISH, planners and engineers can see the entire spectrum of innovative and energy-efficient building-system technology together with concepts and solutions not only for modernising existing buildings but also for new buildings in the residential and non-residential sectors. In this connection, Messe Frankfurt offers free guided tours of the fair especially for planners and engineers, which give them a good opportunity to orientate themselves and to make contact with colleagues. All this is rounded off by the complementary programme of events, which includes the ISH Technology and Energy Forum, the Air-conditioning Forum and the Building and Real Estate Forum.

Additionally, there will be a special REHVA Day on 15 March 2017, the main part of which will be a guided tour and happy hour for networking. On the following day, REHVA will hold a seminar consisting of lectures and a concluding discussion on the subject of 'Controlled Home Ventilation'. For seminar participants, ISH offers the associated range of products and, therefore, represents the perfect conclusion to the seminar. Accordingly, Messe Frankfurt is delighted with the productive collaboration and looking forward to intensifying the working relationship with REHVA.

More information: www.ish.messefrankfurt.com.


NFC

BELIMO

BELIMO ZoneTight™

Product news

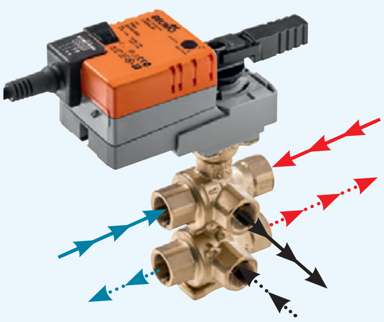
The original: 6-way zone valves from Belimo

From the invention to the “all-in-one” solution

Controlling combined heating/cooling elements in 4-pipe systems has long been an elaborate, bulky and complicated process. But since 2008 there has been an impressive alternative: the 6-way zone valve invented by Belimo. The world market leader has now further developed this revolutionary concept into an electronic, pressure-independent «all-in-one» control unit and therefore taken another further pioneering step towards simplification.

The 6-way zone valve invented by Belimo makes control of combined heating/cooling elements simpler, more cost-effective and safer.

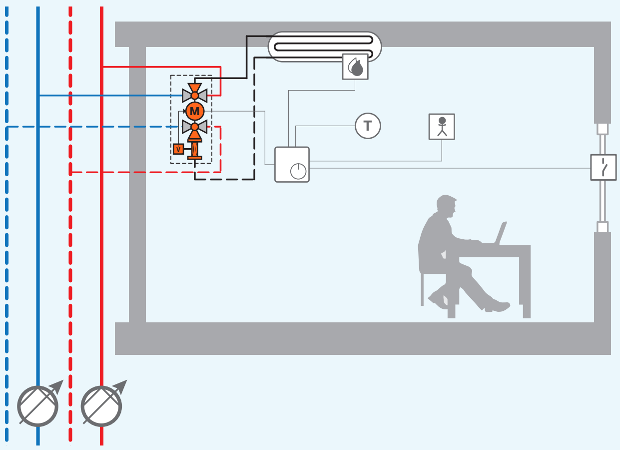
The ingenious functional principle of the 6-way zone valve means that more can be achieved with less these days. Only one valve is required instead of four, one actuator instead of four and one data point instead of four. This reduces planning work and procurement costs, installation requires less space and there is less probability of mistakes during mounting.



The revolutionary functional principle of the 6-way zone valve from Belimo.

The tried and tested 6-way zone valve

The numerous advantages of the pressure-dependent 6-way zone valve have been proven time and time again in practical applications. Customers and installers value this solution because they need less material and mounting in tight spaces in false ceilings is much simpler and faster. Plant operators achieve greater efficiency because the different k_{vs} values which can be selected for heating and cooling permit precise and effective control of both circuits with one valve. Reliably decoupling the cooling and heating circuit ensures high operating safety and the integrated pressure relief function ensures maximum protection for the plant. Because the valve closes completely air bubble-tight when closed, energy consumption and life cycle costs fall significantly.



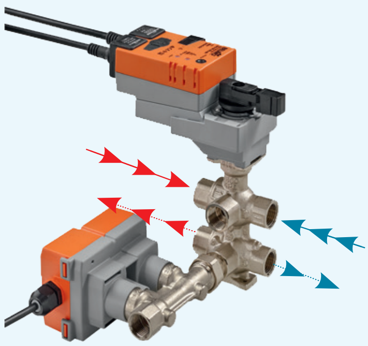
Example: Functional diagram showing integrated use of the 6-way zone valve with decoupled heating and cooling circuit.

Further development towards electronic pressure independence

The age of digitalisation has entered building technology. In the interests of optimum transparency and efficiency, it makes sense to make use of the possibilities of modern electronics at the level of individual control components.

By further developing the 6-way zone valve into an intelligent «all-in-one» control unit, Belimo is now enabling it to be used to control combined heating/cooling elements too.

As well as the described benefits of the mechanical version, the electronically controlled 6-way zone valve can do even more. The integrated flow measurement and control automatically ensures permanent dynamic balancing and, if there are changes in differential pressure during partial load operations, ensures that the amount of water is correct at all times. This allows plant operators to save on elaborate, manual hydronic balancing and any adjustments needed. They also have peace of mind that the plant is running perfectly at all times.



The functional principle of the further developed electronic, pressure-independent 6-way zone valve from Belimo.

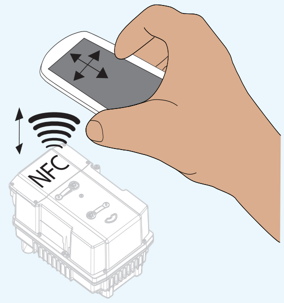
Flexible and transparent communication

The integral control and monitoring of heating and cooling requires components, which orientate themselves towards the bus systems used – and not the other way round. This applies particularly in complex, large-sized buildings, but also in the "Smart Homes" of the near future.

The complete product range of the 6-way zone valves from Belimo communicate with MP-Bus® and Modbus. Depending on the application a communication is also possible with LonWorks®, BACnet® or KNX®. The MP-Bus® actuators can also be used to bring together up to eight valves in lines. This permits maximum flexibility in plant planning and when integrating the 6-way zone valves into the overall HVAC system of each house.

The central element in an optimised operating concept is transparent communication between technicians and system. This helps with commissioning and provides data for the analysis and evaluation of valve settings.

To make the whole process simpler and faster, the bus actuators of the pressure-independent 6-way zone valves from Belimo have an NFC interface (Near Field Communication). This allows wireless on-site communication with the actuator via a smartphone app. Data can be accessed and the setting configured if necessary.



The built-in NFC interface permits wireless communication with the bus actuators of the 6-way zone valves from Belimo.

Optimised economic efficiency

Economic efficiency is not defined solely by price. It is far more the case that it is dependent on whether each plant is equipped with the exact-fitting and optimally coordinated components. By offering the biggest choice of 6-way zone valves, Belimo makes this possible. Whether the customer is looking for pressure-dependent or pressure-independent – the wide product range is unique and includes various k_{vs} combinations and a huge number of motor variants. Because very particular special requirements also sometimes have to be met, further customised solutions can be implemented with various combinations of zone valves from the Belimo ZoneTight™ family.

Consulting engineers, plant manufacturers, system integrators and operators can rely on the world market leader's sound technical application knowledge both when selecting and using the 6-way zone valves. This gives them additional peace of mind during planning and the operating phase. ■

More information: **www.belimo.eu**

The Belimo Group is a leading global manufacturer of innovative electrical actuator and valve solutions for heating, ventilation and air conditioning technology. The Group achieved sales of CHF 493 million in 2015 and employs around 1,470 people. For information on the company and its products, visit www.belimo.com/investorrelations.

The shares of BELIMO Holding AG have been traded on the SIX Swiss Exchange since 1995 (BEAN).

VDI-Standards 2017

January:

VDI 2083 Part 9.2 "Cleanroom technology; Consumables in the cleanroom"

This standard applies to all consumables used in contamination-controlled areas; examples are gloves, garments, shoes/over-shoes, packaging materials, wipers, masks, paper. The standard describes the generic characteristics of these types of products as well as cleanliness-related properties and testing. The focus is on particulate and airborne chemical contamination. In addition, this standard contains guidance on the selection of products with branch- and process-specific requirements and logistics in mind.

D VDI 2552 Part 3 "Building Information Modeling; Quantities and controlling"

Buildings are getting technically more complex and the available computer technology more efficient. The building-information-modeling (BIM), including the linking of resources and schedules, provides available methods that can limit potential risks to quality, costs and scheduled deadlines for construction projects. The standard describes methods that allow to take advantage of these benefits in the relationship between clients and contractors and other construction parties based on shared information.

D VDI/GEFMA 3810 Part 5 "Operation of buildings and maintenance of building installations; Building automation and control systems"

Building automation and control systems (BACSs) are a tool for operating, setting, switching, controlling, regulating, monitoring, evaluation and optimisation of building services. BACSs provide information technology support in the context of the processes of operation and maintenance of building services and is thus part of the computer-aided facility management (CAFM). However, BACSs themselves need the maintenance of their hardware and software. The standard gives instructions for operation of buildings by means of a BACS and the maintenance of the BACS itself.

C D VDI 6022 Part 1 "Ventilation and indoor-air quality; Hygiene requirements for ventilation and air-conditioning systems and units"

This standard deals with the hygiene in air conditioning systems and equipment, with the aim of adjusting the air without any negative impact. The standard describes requirements for the design, construction and operation of air handling systems and air handling equipment and their components.

D VDI 6022 Part 6 "Ventilation and indoor-air quality; Air humidification by decentralised devices; Hygiene in planning, construction, operation, and maintenance"

This standard applies to stand-alone 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. The standard factors the particular hazards incurring from such units arising from, e.g., the supply of unfiltered microbiologically contaminated breathing air and insufficient maintenance.

February:

D VDI 2077 part 4 "Energy consumption accounting for the building services; A/C installations"

This standard deals with the allocation of costs for energy and media consumption of A/C installations. The application of the standard helps to account and allocate the costs for a fair consumption-based energy and media usage in order to promote a resource and environmental friendly energy and media use.

VDI 3805 Part 20 "Product data exchange in the building services; Storage tanks and instantaneous water heater"

Based on VDI 3805 Part 1, the standard describes a manufacturer and IT system independent and unified data format for the exchange of product data for storage tanks and instantaneous water heaters.

D VDI 3805 Part 24 "Product data exchange in the building services; Actuators used in building services"

Based on VDI 3805 Part 1, the standard describes a manufacturer and IT system independent and unified data format for the exchange of product data for actuators used in building services.

D = *Draft*

C = *VDI Ventilation Code of Practice*

Send information of your event to Ms Chiara Girardi cg@rehva.eu

Events in 2016 - 2017

Conferences and seminars 2017

March 1-3	World Sustainable Energy Days 2017	Wels, Austria	https://goo.gl/o9ErPg
March 14-15	Is ventilation the answer to indoor air quality control in buildings? Do we need performance-based approaches?	Brussels, Belgium	https://goo.gl/TG0loL
March 29-31	5th International Congress Mechanical Engineers Days	Vodice, Croatia	http://www.hkis.hr/
April 2-4	REHVA Annual Meeting	London, UK	https://goo.gl/frmniD
April 5-6	'Delivering Resilient High Performance Buildings' Engineering and maintaining buildings and systems to provide resilient lifetime performance	Loughborough University, UK	https://goo.gl/3ulJxe
April 19-22	Teskon+Sodex	Izmir, Turkey	http://www.teskonsodex.com/
April 19-21	Aquatherm St. Petersburg	St. Petersburg, Russia	https://goo.gl/WhX1Zx
May 10-11	50th International Congress "Beyond NZEB retrofit of existing buildings"	Matera, Italy	https://goo.gl/K3Kk9j
May 10-12	1st Buildings India 2017 Exhibition and Conference	New Delhi, India	http://www.smartcitiesindia.com/
May 10-13	Sodex Ankara	Ankara, Turkey	http://www.sodexankara.com/
May 12-13	Climamed 2017 Conference "Historical buildings retrofit in the Mediterranean area"	Matera, Italy	http://www.climamed17.eu/
May 14-17	38th Euroheat & Power Congress	Glasgow, United Kingdom	www.ehpcongress.org
May 15-18	12th IEA Heat Pump Conference	Rotterdam, the Netherlands	www.hpc2017.org
August 7-9	Building Simulation 2017	San Francisco, California, USA	www.buildingsimulation2017.org
August 23-25	43rd International Symposium of CIB W062 Water Supply and Drainage for Buildings 2017	Haarlem, The Netherlands	http://www.tvvl.nl/cib-w062-2017
September 5-7	ISH Shanghai & CIHE 2017	Shanghai, China	www.ishs-cihe.hk.messefrankfurt.com
September 13-14	Ventilating healthy low-energy buildings	Nottingham, United Kingdom	http://www.aivc2017conference.org/
September 28-29	7th International Conference on Solar Air-Conditioning - PV Driven/Solar Thermal	Tarragona, Spain	http://www.solaircon.com/
November 10-11	Second ASHRAE Developing Economies Conference	Delhi, India	https://goo.gl/EWocKu

Conferences and seminars 2018

March 12-15	Cold Climate HVAC Conference 2018	Kiruna, Sweden	http://www.cchvac2018.se

Exhibitions 2017

February 23-25	ACREX 2017	Delhi, India	www.acrex.in
March 14-18	ISH	Frankfurt am Main, Germany	http://www.ish2017.com/
May 18-20	ISH China & CIHE 2017	Beijing, China	www.ishc-cihe.hk.messefrankfurt.com
September 5-7	ISH Shanghai & CIHE 2017	Shanghai, China	www.ishs-cihe.hk.messefrankfurt.com
September 19-23	FOR ARCH	Prague, Czech Republic	www.forarch.cz/en/

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REHVA GUIDEBOOKS

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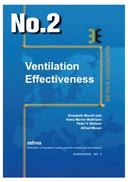
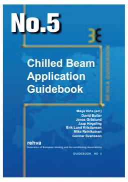
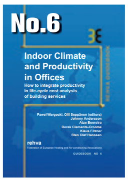


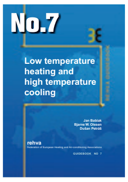
Ventilation Effectiveness. Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook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



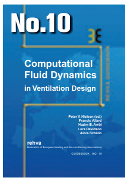
Chilled Beam Cooling. Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature 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.



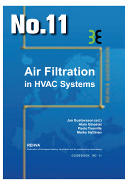
Indoor Climate and Productivity in Offices. This Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available.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



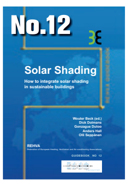
Low Temperature Heating And High Temperature Cooling. This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in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



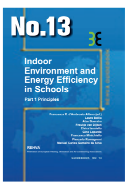
Computational Fluid Dynamics in Ventilation Design. CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary 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.



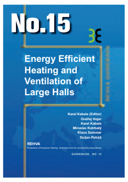
Air Filtration in HVAC Systems. This Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on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



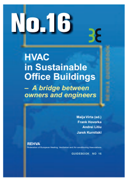
Solar Shading – ***How to integrate solar shading in sustainable buildings.*** Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy 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.



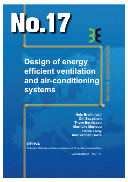
Indoor Environment and Energy Efficiency in Schools – ***Part 1 Principles.*** School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with respect to low energy cost and performance of the students. It focuses particularly on energy efficient systems for a healthy indoor environment.



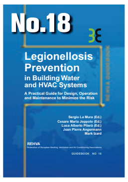
Energy Efficient Heating and Ventilation of Large Halls. This Guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating,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



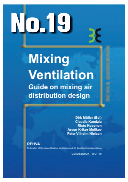
HVAC in Sustainable Office Buildings – ***A bridge between owners and engineers.*** This Guidebook discusses the interaction of sustainability and heating, ventilation and air–conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be asked in various phrases of building's life time. Different case studies of sustainable office buildings are presented.



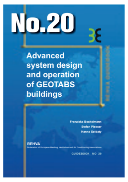
Design of energy efficient ventilation and air-conditioning systems. This Guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked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



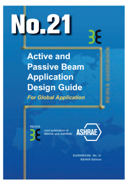
Legionellosis Prevention in Building Water and HVAC Systems. This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionellosis in building water and HVAC systems. It is divided into several themes such as: Air conditioning of the air (by water – humidification),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



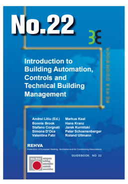
Mixing Ventilation. In this Guidebook most of the known and used in practice methods for achieving mixing air distribution are discussed. Mixing ventilation has been applied to many different spaces providing fresh air and thermal comfort to the occupants. Today, a design engineer can choose from large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



Advanced system design and operation of GEOTABS buildings. 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.



Active and Passive Beam Application Design Guide is the result of collaboration by worldwide experts. It provides energy-efficient methods of cooling, heating, and ventilating indoor areas, especially spaces that require individual zone control and where internal moisture loads are moderate. The systems are simple to operate and maintain. This new guide provides up-to-date tools and advice for designing, commissioning, and operating chilled-beam systems to achieve a determined indoor climate and includes examples of active and passive beam calculations and selections.



Introduction to Building Automation, Controls and Technical Building Management. This guidebook aims to provide an overview on the different aspects of building automation, controls and technical building management and steer the direction to further in depth information on specific issues, thus increasing the readers' awareness and knowledge on this essential piece of the construction sector puzzle. It avoids reinventing the wheel and rather focuses on collecting and complementing existing resources on this topic in the attempt of offering a one-stop guide.

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