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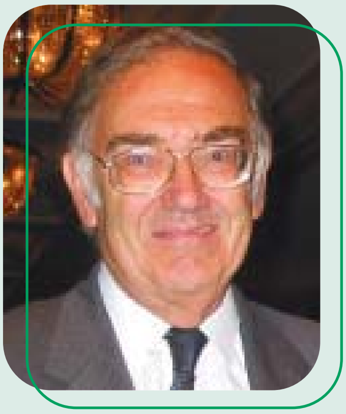

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Effect of the Certification on Chillers Energy Efficiency

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Abstract:

Energy efficiency has become one of the most important issues for HVAC industry. Indeed, the implementation of Kyoto Protocol has now a high priority for the European Union and strong measures should be applied to achieve its targets, like an 8% reduction of equivalent CO_2 emission between 2008 and 2012. For our industry, the best way to meet this important challenge is to be proactive and propose relevant actions in advance instead of waiting for some mandatory measures decided by the European Commission or the National Authorities.

Within this framework, two important measures have been decided by Eurovent Chillers Manufacturers. The first action, February 2005, was the implementation on a voluntary basis, of the classification for chillers. The objective of the classification is double:

1. Promote the more efficient chillers
2. Facilitate the elimination, in the near future of the low efficient ones.

Based on existing chillers presented to Eurovent certification, the limits between classes have been defined, for gross EER, for each type of chillers. It is now easier for consultants, engineers and technical specialists to select efficient chillers from Eurovent directories, www.eurovent-certification.com.

The second issue was the use of the chillers and the real annual energy consumption. As the part load efficiency has a very strong impact on energy consumption, Eurovent has initiated the SAVE study, EECCAC-Energy Efficiency and Certification of Central Air Conditioners. An integrated energy efficiency index called ESEER, European Seasonal Energy Efficiency Ratio, equivalent to IPLV, Integrated Part Load Value, developed in the US and used by ARI, was established for the European conditions. The study was finalised in 2004, the experimental application started in 2005 and the mandatory implementation for Eurovent manufactures is scheduled for June 2006. From the certified part load table, Eurovent will compute ESEER allowing the comparison of chillers performances in the cooling mode. This global single figure shall be published in Eurovent directory together with cooling capacity and power input for standard conditions at full load.

This paper presents the evolution of chillers efficiency, analyses Eurovent chillers classification after one year of implementation, describes Eurovent certification for European Seasonal Energy Efficiency Ratio for chillers and gives an overview of next steps for chillers certification.

Introduction

According to EECCAC-Energy Efficiency and Certification of Central Air Conditioners-project (1), the cooled area in 2010 in Europe will be 2200Mm^2. These expectations are confirmed by the ever growing number of chillers sold in Europe every year, as shown in Figure 1. As a consequence of the increasing of the installed units, the electrical end-use and the efficiency of central air conditioning systems are becoming an important issue for the European Commission and the National Authorities.

At present, the Energy Labelling Directive is restricted to household appliances. Indeed, the label is mandatory only for Room Air Conditioners with capacity equal to or lower than 12 kW. However, Eurovent established classification for full load Energy Efficiency Ratio of each type of chillers. The classification follows the A to G approach used in the European Energy Label for household appliances but the limits between classes have been defined for the existing chillers as listed in Eurovent directory, see Table1 for cooling mode.

Table 1: Chillers Energy Classification in Cooling Mode

EER Class	Air Cooled	Water cooled	Remote condenser
A	EER ≥ 3.1	EER ≥ 5.05	> = 3,55
B	2,9 ≤ EER< 3,1	4,65 ≤ EER < 5,05	3,4 ≤ EER < 3,55
C	2,7 ≤ EER< 2,9	4,25 ≤ EER < 4,65	3,25 ≤ EER < 3,4
D	2,5 ≤ EER< 2,7	3,85 ≤ EER < 4,25	3,1 ≤ EER < 3,25
E	2,3 ≤ EER< 2,5	3,45 ≤ EER < 3,85	2,95 ≤ EER < 3,1
F	2,1 ≤ EER< 2,3	3,05 ≤ EER < 3,45	2,8 ≤ EER < 2,95
G	< 2,1	< 3,05	< 2,8

The Energy Performance Building Directive requires calculation of building energy performance and regular inspection of central air conditioners and chillers with more than 12 kW cooling capacity. On the basis of this inspection, which shall include an assessment of the efficiency of the system and the sizing compared to the cooling requirements of the building, the competent authorities will ask the users to improve or replace the installed system by more efficient one. The transposition of this Directive in Member States shall oblige the National Authorities to develop policy measures for energy savings.

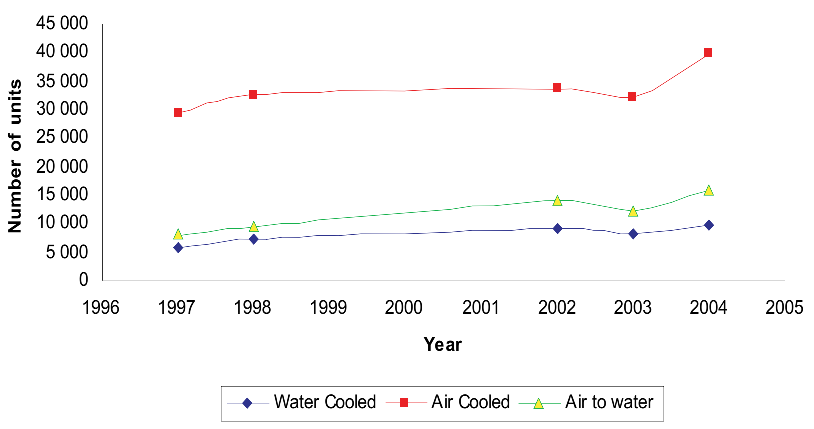
However, these measures only address the efficiency of the end-use equipment as determined under standard conditions at full load and will not realise many of the potential energy savings which are related to operating conditions at part load. To be really effective, energy efficiency options have to be defined not on the basis of nominal operating conditions but on a variety of part load conditions, which better reflect the central air conditioners operating modes that occur in real use. For this reason, Eurovent developed a European Seasonal Energy Efficiency Ratio, ESEER, index based on ARI approach to determine the Integrated Part Load Value, IPLV.

The manufacturers will provide their customers with a map of performance, not only at the four arbitrary percentages and temperatures. The customer can rely on ESEER computed from this map or compute its specific ESEER for its specific demand.

As there is no European or ISO standard for part load testing conditions, Eurovent standard, 6-C003-2006 has been amended including testing procedure for part load conditions.

The implementation of ESEER certification is scheduled for 2006 and the classification of chillers will be reviewed for translation into part load classes.

Figure 1: Chillers sales evolution in EU



Energy Efficiency Classification Analysis

Starting with 1994, Eurovent is issuing a directory of certified products sold on the European market, giving information on certified performances.
At the beginning, the information was limited to cooling capacity and electrical power absorbed; then in 2002, it was extended to Energy Efficiency in cooling and heating mode. The last improvement was in 2005 with the publication of the classification of the chillers according to Table 1.

Using data published in the Eurovent directories since 2003 (2), we can see the evolution of EER for air cooled, Figure 2, and water cooled chillers, Figure 3.

Based on the standard test conditions, the mean EER for air cooled units is 2.56 while the average EER for water cooled units is 4.05. This difference is not inherent to chillers, but rather represents the temperature regime found in cooling towers. Nevertheless, water cooled systems are expensive because of the additional cost of using either a cooling tower or of accessing a natural water supply. Therefore, they are used only for large systems.

Figure 2: EER Evolution for Air Cooled Chillers

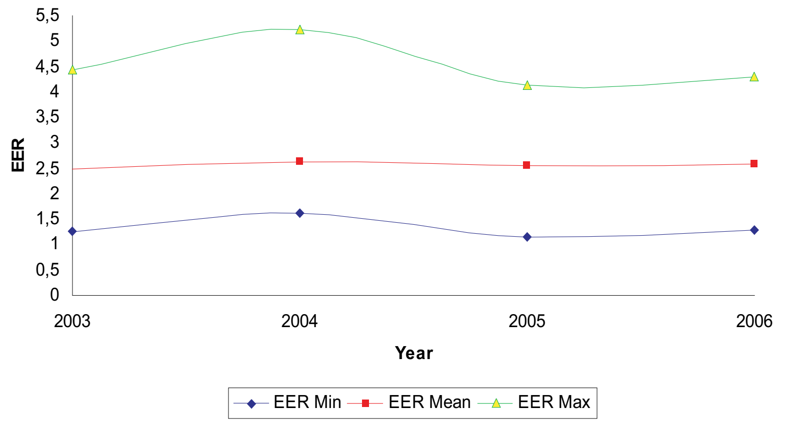
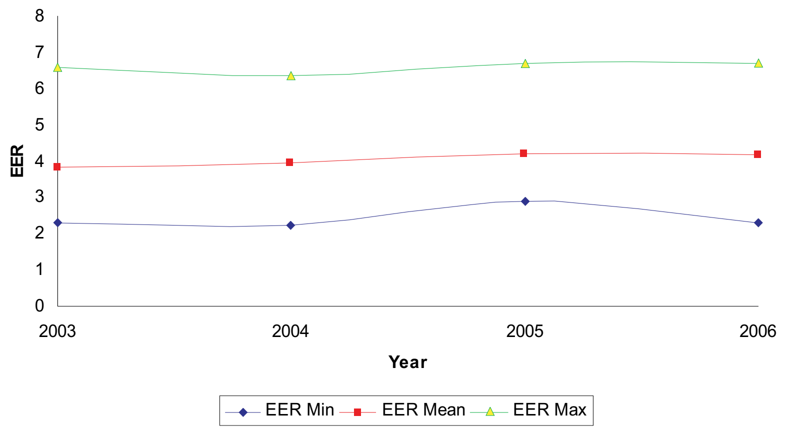


Figure 3: EER Evolution for Water Cooled Chillers



On a voluntary basis, Eurovent implemented a classification according to energy efficiency. The purpose of this measure is double fold:

1. For high efficient chillers, the energy efficiency will be highlighted as the best units for each type being in Class A could be strongly promoted.
2. Minimum energy efficiency could easily be implemented, either on voluntary basis or decided by the European Commission.

The proposed classification is not "labelling", as no label will be used. Energy efficiency of chillers expressed by classes is indicated as "Eurovent Class A" or "Eurovent Class B" in manufacturers catalogues and Eurovent Directory of Certified products.

Based on existing chillers list published in Eurovent directory, limits between classes have been decided; see Table 1 for cooling mode, taken into account the following considerations:

1. Classification concerns gross EER at full load operation. When part load characteristics will be implemented, classes will be defined with equivalent ESEER.
2. To avoid confusion and possible use of classification by non-certified manufacturers, the designation "Eurovent Class A" or "Eurovent Class B" will be used and legally protected.
3. For "low noise" chillers, the class will correspond to full load operation with maximum fan speed. The same class will be used for lower fan speeds.

The classification has been implemented in February 2005; the distribution of number of units in each class is shown in Table 2.

It is too early to see the influence of this classification on energy efficiency. However, the distribution shows that 7% of certified chillers are in Eurovent Class A and in total only 5% of the certified chillers are in Eurovent Class G.

Table 2: Distribution of units in each class

Class/ kW	0-50	50-100	100-150	150-200	200-500	500-1 000	>1000	Total
A	85	12	4	7	72	85	115	380
B	114	51	46	21	142	179	112	665
C	203	75	76	40	206	229	137	966
D	244	143	106	80	295	213	80	1 161
E	383	131	121	84	432	246	98	1 495
F	287	62	54	52	125	68	29	677
G	152	14	10	8	41	31	19	275
Total	1 468	488	417	292	1 313	1 051	590	5 619

European Seasonal Energy Efficiency Ratio

1. Definition

Until now, the chillers are tested according to EN 14511 at full load conditions only while energy consumption is not covered by full load EER given in such a standard but by the average part load EER, often called Seasonal EER. This is largely used in the US market and called IPLV, Integrated Part Load Value.

The percentage of operating hours assigned to each part load condition in IPLV is corresponds to the US climate and buildings but could not be applied to the European ones. Eurovent established ESEER which represents the universe of EU buildings and climates.

The European Seasonal Energy Efficiency Ratio, ESEER, is a weighed formula enabling to take into account the variation of EER with the load rate and the variation of air or water inlet condenser temperature.

$ESEER = A.EER_A + B.EER_B + C.EER_C + D.EER_D$

With the following weighing coefficients:

A = 0.03
B = 0.33
C = 0.41
D = 0.23

For the following part-load ratings

Air cooled chillers:

Load Ratio (%)	Air temperature at condenser inlet (°C)
100	35
75	30
50	25
25	20

Water cooled chillers

Load Ratio (%)	Water temperature at condenser inlet (°C)
100	30
75	26
50	22
25	18

2. ESEER Certification Procedure

ESEER enables to calculate the seasonal efficiency for all the European chillers. The constraint was to minimise the testing time while ensuring maximum precision. Contrary to ARI certification where one full load condition and three part load conditions are tested, in Eurovent certification, the ESEER procedure will be added to the existing one. That means, we will test one standard rating, one application rating selected by Eurovent and in addition one part load condition also selected by

Eurovent. The manufacturer has to fill in Table 3 by giving first the number of stages of the chillers. Once notified, the table corresponding to the number of stages is built automatically. Then the manufacturer has to fill in the cooling capacity and absorbed electrical power for each condition and each stage.

ESEER procedure will calculate EER for each part load condition, and then compute ESEER value using the red cells shown in the Table 3. It also shows the intermediary points that have been calculated at 25, 50 and 75% load points in order to use the weighed coefficients derived for the ESEER.

Table 3: : ESEER Calculation

Capacity stage number	4	Temperatures		FULL LOAD	STAGE 2	STAGE 3	STAGE 4
Cycling coefficient	0,9	35	Cooling Capacity	153,7	116,8	81,5	38,4
			Electrical Power	60	43,8	26,9	14,2
Weighting coefficients		30	Cooling Capacity	166,3	126,4	88,1	41,6
25% - 50% - 75% - 100%			Electrical Power	53,9	39,4	24,2	12,7
0.23 - 0.41 - 0.33 - 0 .03		25	Cooling Capacity	176,3	134,0	93,4	42,9
			Electrical Power	48,9	35,8	22,0	11,9
		20	Cooling Capacity	185,0	137,0	93,0	50
ESEER	3,87		Electrical Power	43,8	32,8	20,7	10,9
			Part load EER	100%	75%	50%	25%
				2,56	3,29	4,11	4,45

The cycling coefficient is defined as fellow:

Cc = 1- "Measured sleep power" / (Pe (c)) (electric power of the cycling stage for given source temperatures)

For 2006 test campaign, a default value of 0,9 will be used for the cycling coefficient for all chiller. The laboratory will measure, when the chiller is OFF, the "sleep power" and calculate the cycling coefficient for each tested unit. According to these calculations the default value will be revised by category of chiller for the next year test campaign.

3. Part load Testing Procedure:

The following rating conditions are used to test chillers at part load conditions:

- For air cooled chillers:
  1. The leaving water temperature is set at 7°C
  2. The evaporator water-flow rate is equal to the standard rating water-flow rate
  3. The air-flow rate is controlled by the chillers
- For water cooled chillers:
  1. The leaving water temperature is set at 7°C
  2. The evaporator water-flow rates are equal to the standard rating water-flow rates
  3. The condenser water flow rate is controlled by the chillers. If the chillers don't control it, the condenser water flow rate will be equal to the standard rating water flow rate.

For air cooled chillers, the condenser fan(s) should be operated by the control of the chillers. Whenever cycling of the condenser fan(s) occurs, the test should be led as follows:

- An acquisition time period of 1 hour is required.
- Tolerance on leaving water temperature can exceed the maximum permissible deviation.
- If cycles exceed 1 minute, an entire number of periods shall be acquired.

Conclusion:

Eurovent has done and is still doing a lot for improving energy efficiency of HVAC products, all on a voluntary basis. This paper has presented the work in the field of chillers, namely certification of EER, classification of chillers and certification at part load conditions.

Next steps will be the elimination of Class G chillers (poorly efficient) and reviewing the classification of chillers according to ESEER instead of EER.

References:

(1): Energy Efficiency and Certification of Central Air Conditioners (EECCAC), Final report, April 2003. Co-ordinator: Jérôme ADNOT, assisted by Paul WAIDE

(2): Eurovent Directory 2003, 2004, 2005 and 2006

(3): Performances saisonnières des groupes de production d'eau glacée, PhD Thesis, presented at Ecole des Mines de Paris, May 2004 by Philippe RIVIERE

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