Discussion of evidence behind proposed eco-design measures for high temperature chillers, and any consultation queries

Meeting notes for Tuesday 12 March 2013

Venue: DG Enterprise, Avenue d'Auderghem, Brussels, 1049

Timing: Delayed start at 10.30 due to snow, meeting closed 12.45.

Attendees: At meeting room: Ugo Miretti, Laure Baillargeon, Davide Polverini (DG ENTR); Jeremy Tait (Tait Consulting / study contractor for CLASP Europe); Paul de Larminat (JCI); Denis Bonvillain (EPEE). Dieter Mosemann (GEA Group) joined 11.30.

By telephone: Philippe Rivière (ARMINES / study contractor for CLASP Europe); Hermann Renz (Bitzer, had to leave the call at 12:00); Els Baert (Daikin); Pierre Crevat (Carrier, also had to leave the call at 12:00).

1. Summary of the proposals, information sources and questionnaire

Jeremy Tait summarised the current status in the process of developing proposed ecodesign requirements for high temperature industrial process chillers, as explained in the document Annex 3 that accompanied the consultation questionnaire:

i. The main principles of setting minimum requirements for high-temperature industrial process chillers were established during 2012 including a full consultation, although the commission lacked the detailed data to set specific requirements at that stage.
ii. The meeting with the JIEG on 14th of December 2012 initiated a process of data gathering and analysis to develop possible specific requirements.
iii. Data was received from eight different suppliers covering 53 high-temperature chillers (22 air cooled and 31 water cooled). Available data allowed SEPR to be calculated for 47 of those chillers. Jeremy thanked on behalf of the Commission those companies who had been able to provide product performance data to enable the analysis.
iv. A review of the products in the dataset compared to the wider market availability concluded that the dataset was broadly representative of the available technologies, refrigerants and performance ranges with the exception of low data availability for large water-cooled chillers.
v. The Eurovent dataset of several thousand air conditioning chillers was used to develop indicative market average and best practice performance levels in terms of SEPR for cross comparison with the averages indicated by the specific product data submitted. The 47 chillers for which good EER and SEPR data were available were used to develop indicative EER/SEPR ratios for the different technology types and capacity ranges. These rules of thumb were used to convert market average (in fact a median value was used) and best practice EER levels for each technology type and capacity range into SEPR values.
vi. Based on combined knowledge gained from the specific product data, in the context of indicative market spread from the Eurovent data and also informed by expert knowledge of

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the technologies and improvement options, best practice and market average SEPR figures were derived for each target type and capacity of high-temperature chiller. These figures are given in the consultation document and in Annex 3.

vii. Proposed performance thresholds were developed aimed at removing around one third of the poorest performing chillers on the 2012 market at Tier 1; with Tier 2 aimed at removing the poorest performing two thirds of the 2012 market.

viii. The proposed requirements for high temperature chillers are significantly more stringent than those proposed for low temperature and medium temperature chillers. This situation may be acceptable to the Commission, given that over 70% of the energy savings should accrue from high-temperature chillers, and the economic and technical burden on manufacturers is more manageable if the pressure to develop product ranges could be spread over a longer period, but with initial focus on the most important products. Increased stringency for low and medium temperature products could be considered at the first regulatory review.

ix. Further details on this are available in the Annex 3 document.

x. Jeremy drew the attendees attention to the questionnaire document, summarising the main topics on which feedback is sought **by 18 March please**.

Philippe Rivière was invited to explain more of the technical background to the analysis and to answer questions from the attendees.

2. Summary of the evidence and analysis behind the proposals (Philippe Rivière)

Philippe Rivière provided for attendees a document containing tables and graphs drawn from the more detailed analysis that was undertaken on the data to derive the proposed thresholds. This document shows the technical characteristics of each of the products for which data was made available, split into air cooled and water cooled and further divided by capacity range. It detailed the rules of thumb for SEPR/EER for each type, with further analysis of how EER varies with load ratio for each product. Tables were also included showing the median and best practice SEPR indicated by the available data for each technology type and capacity range.

Discussion and questions on some aspects of the analysis followed.

i. Attendees queried what was meant by the term ‘Rotary’ compressor type in this document - this was clarified as meaning rolling piston compressor (and not a rotary vane compressor which would have different characteristics). Similarly, the ‘double stage rotary’ mentioned refers to a design favoured by several Japanese suppliers to provide improved efficiency over standard rolling piston compressor for split air conditioners and VRF of limited (up to 10 to 20 kW) cooling power.

ii. Several attendees remarked on the very high EER levels mentioned during some of the explanation of analysis (e.g. exceptionally at EER 18). This was discussed at some length, concluding that these levels of efficiency are all feasible thermodynamically under the conditions stated in the analysis but lower levels are typical of most product types. For example, very high efficiencies at low condensing temperature are feasible for centrifugal compressors that would not be possible for positive displacement types. No specific flaws in the analysis as presented were noted but further cross-examination is invited.

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iii. It was noted that high-performance of rotary compressors at low outdoor temperature should be considered with caution in terms of their wider deployment at larger sizes as this may lead to relatively low ambition of SEPR requirements on the small capacity segment for air cooled chillers.

iv. It was also discussed the very good performance of ammonia chillers using reciprocating compressors (SEPR close to 12). If reciprocating compressors may lead to very good performance at low condensing temperature, manufacturers reminded they could not be used with all refrigerant fluids (especially their design with refrigerant mixtures may be problematic) because of reliability issue. Historically, their poorer reliability for long term and high utilisation applications is the reason why these compressors have been progressively replaced by screw or scroll compressors (higher mechanical vibration leads to needing more regular downtime for maintenance). However, the proposed levels of performance do not impose this technology and so this does not appear as an issue.

v. Another technology constraint was noted, that magnetic bearing centrifugal compressors are only available from one manufacturer as the capacity range up to 800 kW: setting a requirement in this capacity range that would effectively exclude other less efficient technologies could cause a monopoly. Such a monopoly could fall foul of the intent of the eco-design framework directive. However, the proposed levels of performance for chillers below 1000 kW does not trigger this constraint and so this is not a problem.

A more detailed document explaining the analysis process will be made available in due course with the final report from CLASP / Tait Consulting / ARMINES, and any further questions are invited.

3. Priority topics agreed for discussion:

The suggested points a) to e) from the agenda were agreed as being of highest priority for discussion in the meeting; others to be considered in less detail if time allowed. No additional points were suggested.

a. Definition of high temperature industrial process chillers for purposes of regulation, in particular distinction from air conditioning chillers. *Is year-round operation at below +10°C the correct temperature threshold?*

i. Noted that some air conditioning chillers do have to operate all year round, e.g. for hospitals. However, such applications would experience high variation in loading as is expected for air conditioning (lot 6) applications. Hence it would be appropriate to combine the 'all year operation' with 'over 80% typical loading' in the definition to distinguish process chillers.

ii. The threshold temperature that might distinguish equipment capable of offering year round operation was drafted as +10°C in the notes from meeting of 14 December 2012. The possibility of using the threshold figure from EN 14825 of 16°C was discussed, but deemed too high because some buildings would have to operate cooling at below 16°C. "Approximately 10°C" was agreed as an appropriate phrase to use.

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iii. Also accepted that there will be mixed-use applications serving both air conditioning and process loads. Many exceptions and niche grey areas would be found for chiller applications and this should be allowed for in the regulation.

iv. Therefore, it seems inevitable that some reliance would have to be made on a 'declaration of intended purpose', but this could be qualified using the attributes that apply to the majority of applications.

v. Daikin observed that the definition suggested in the consultation document is clear enough for manufacturers to decide the category in which to place products. This suggests that significant development may not be required.

vi. One possible approach discussed was that all chillers could be deemed within the scope of Lot 6 in which case Lot 6 may not use an 'intended purpose' clause; and that a separate and more specific process chiller regulation would take precedence for those products. Such an approach appears acceptable according to the definitions within the Commission's 'Blue Guide'. A consequence of this is an increased testing cost for products that could be used under both regulations, and this should be minimised if possible. For example, having at least one common rating point (expected to be the full load condition) that would mean seven tests to cover both requirements, rather than eight. It was also noted that a test lab may not be able to perform both process and air conditioning tests at the same time if outdoor ambient conditions were not favourable to achieve this (problematic particularly for larger chillers).

vii. Note: Specific draft text to consolidate the discussion was developed after the meeting: *"Chillers intended for process cooling applications, being those that are generally designed to operate all year round, including in ambient temperatures below approximately +10°C, and optimised for efficient operation at 80% loading and above* [option: *and for which the load is generally independent of ambient conditions]"*

b. How confident can we be in the accuracy of the stated market average performance levels of HT chillers (in Annex 3 document)?

i. Manufacturers would require some more time to review product performance against these benchmarks.

c. Is it necessary to specifically exclude evaporative chillers from the regulation (as was done in the January 2012 working document)? Can we not make them subject to the same requirements?

(This point follows possible inclusion of evaporative condensers within the scope of Lot 6 requirements)

i. Evaporative condensers would have to be remote condensers and that the testing of systems with these would be particularly challenging due to control of humidity levels. And indeed such testing is not covered by EN14825. Inclusion of evaporative condensers for air conditioning applications which operate predominantly in higher ambient temperatures makes particular sense, but it may be found that this would be challenging to include within the scope also of the Lot 6 regulation.

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ii. The consensus was that this exclusion of evaporative condensers remains appropriate.

d. Timing of Tiers – issues to take into account

i. Daikin suggested that having a start date of requirements in January or December would be most favourable to fit with production of catalogues and marketing materials, rather than mid-year. This was particularly relevant to smaller capacity units; less critical for the very large units that are not sold from catalogues.

i. **ACTION: EPEE** undertook to ask members about the starting date of the tiers (is it better to start in December or January (from a marketing / catalogue point of view)?); Also EPEE members to evaluate the 2 years' time between the two tiers and suggest views on the link with Tiers of ENTR Lot 6; assess synchronisation of Tiers ENTR Lot 1 / ENTR Lot 6 - **by end of March / early April.**

ii. The consensus of those present appeared to be that the timing suggested for Tier 1 (two years after coming into force) was generally acceptable. However, meeting Tier 2 would pose challenges when considered alongside the responses necessary also for Lot 6 chillers.

iii. Manufacturers present agreed that synchronising requirements between Lot 1 and Lot 6 was a preferred option (i.e. requirements come into force at the same time for both regulations).

iv. **ACTION: The Commission** undertook to consult with DG ENER regarding timing options for Lot 6.

e. Grouping of HT chillers under Lot 1 or separate Lot 6 regulation: Any factors to take into account in the Commission's decision on how to group them? (HT IPC with Aircon chillers under Lot 6; HT with MT & LT IPC under Lot 1; all chillers together. Note: grouping together does NOT mean identical thresholds – only under which umbrella the requirements appear).

i. JCI suggested that low temperature and medium temperature chillers do not include the same technology and product platforms as high-temperature chillers. There is therefore no practical logic (from an engineering/design point of view) to having low and medium grouped with high temperature chillers.

ii. The Commission observed that if high temperature process chillers were to be combined with air conditioning chillers then this would represent a very large total energy consumption and savings potential and therefore pressure would be intense to get that group moving quickly through the regulatory process. It was noted that regulations for all types of process chiller could probably be ready for interservice consultation during 2013, whereas the air conditioning chiller regulation may require longer in preparation. This would be discussed with DG ENER.

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f. **Any impact of F-Gas regulations on requirements (any feedback from discussions at ASERCOM meeting in January).**

   i. This issue caused considerable concern due to recent developments in the European Parliament. It appears that the F-Gas caveat that refrigerants should not be banned if it is shown that TEWI analysis (i.e. including energy implications) proves favourable, may be removed from the regulation. In addition, HFC (even with GWP lower than 150) in stationary air conditioning products could be banned from 2020 already (instead of being included in the cap and trade approach with progressive HFC production decrease up to 2025 or 2030). If the remaining HFC refrigerants were to be banned as a result, the performance levels required under this draft regulation for chillers could become much more difficult to reach (ie more costly). The present uncertainty about which refrigerants would be available and which compressor technologies could be applied with them makes it difficult to evaluate it however.

   ii. It was accepted that the implications of this are beyond the scope of the current analysis sponsored by CLASP, but Tait Consulting agreed to note the issues raised in its report to the commission.

g. **Organising update of Condensing units and chiller SEPR guidance documents; then transfer of the SEPR explanatory material to Commission web site.**

   i. The JIEG was kindly requested by the Commission to organise update and completion of the SEPR guidance documents, taking on board comments raised by JCI, Bitzer and GEA.

   ii. These documents are declared as 'transitional'; it would be useful to set in train the production of a harmonised standard to settle the requirements robustly as soon as possible. This would involve a mandate from the Commission. It was noted that there was no technical need for the documents describing SEPR for process chillers to be linked with the documents describing ESEER for air conditioning.

h. **AOB:** none presented.

4. Conclusions and next steps (Jeremy Tait & Ugo Miretti)

Detailed comments were invited from all stakeholders in response to the consultation by 18th of March if at all possible. The commission have requested a report from Tait Consulting by the end of March to enable drafting of further regulatory documents.

The meeting closed at 12.45, after which GEA, JCI and Tait Consulting further discussed some feedback on the SEPR explanatory documents, concluding that JIEG would manage the completion.

Jeremy Tait

14 March 2013 (V2 minor updates 27 March)

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Discussion of evidence behind proposed eco-design measures for high temperature chillers, and any consultation queries

Agenda for Tuesday 12 March 2013

Venue: DG Enterprise, Avenue d'Auderghem, Brussels, 1049
Metro station: Schuman.

Timing: **Start at 10 AM**; close by 3 PM (latest). There will be a break for lunch.

Agenda:

1. Summary of the proposals and information sources; reminder of the consultation questionnaire topics (Jeremy Tait)
2. Summary of the evidence and analysis behind the proposals (Philippe Rivière)
3. Any questions to clarify on analysis and evidence (all)
4. Review and agree the priority topics for discussion today (first draft list below). Decide which to deal with later by email.
5. Discussion of priority topics. Draft list:
   - *a.* Definition of high temperature industrial process chillers for purposes of regulation, in particular distinction from air conditioning chillers. *Is year-round operation at below +10°C the correct temperature threshold?*
   - b. How confident can we be in the accuracy of the stated market average performance levels of HT chillers (in Annex 3 document)?
   - c. Is it necessary to specifically exclude evaporative chillers from the regulation (as was done in the January 2012 working document)? Can we not make them subject to the same requirements?
   - d. Timing of Tiers – issues to take into account
   - e. Grouping of HT chillers under Lot 1 or separate Lot 6 regulation: Any factors to take into account in the Commission's decision on how to group them? (HT IPC with Aircon chillers under Lot 6; HT with MT & LT IPC under Lot 1; all chillers together. Note: grouping together does **NOT** mean identical thresholds – only under which umbrella the requirements appear).
   - f. It is being considered to add 'chillers using ground as a heat sink' to the scope, but only with information requirements (no specific performance requirements at this stage). Any issues associated with this?
   - g. The Commission's Blue Guide allows for the possibility of a product to be subject to 2 regulations – where the one with the more focused scope would take precedence. If all

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chillers were subject to Lot 6 regulation (including air conditioning chillers and industrial process chillers) and Lot 1 Regulation applied to high temperature industrial process chillers (however these are separately defined), would this cause any particular adverse consequences?

h. Any impact of F-Gas regulations on requirements (any feedback from discussions at ASERCOM meeting in January).

i. Organising update of Condensing units SEPR guidance document (as was done for chillers document): then transfer of the SEPR explanatory material to Commission web site.

j. AOB

6. Conclusions and next steps (Jeremy Tait & Ugo Miretti)

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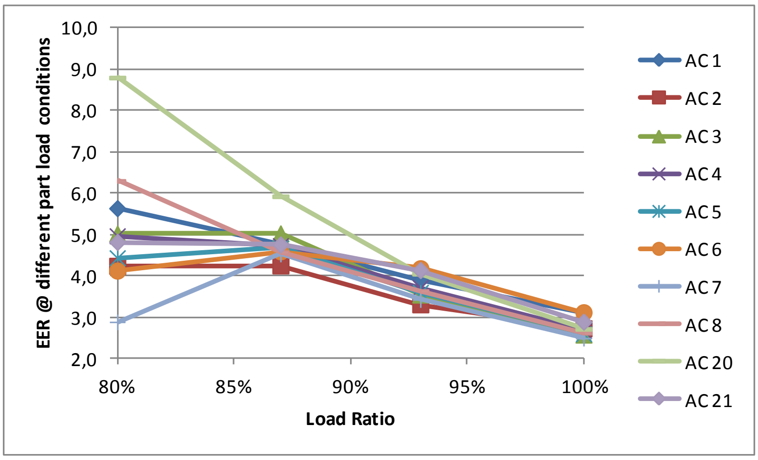
1.1 Air cooled chillers

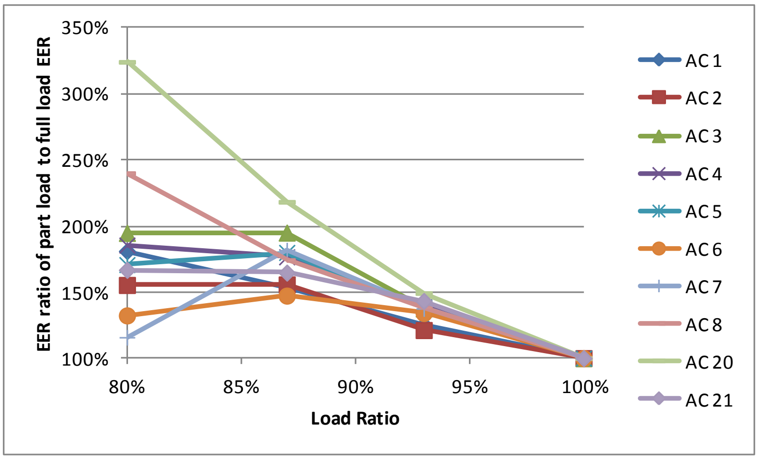
1.1.1 Air-cooled chillers <400 kW

Tab. 1 Design characteristics and performance of AC chillers below 400 kW

	Part load	Net cap kW	EER net	ESEER	SEPR	SEPR / EER	fluid	Evap	Cond	Comp	*range min cap (kW)*	*range max cap (kW)*
AC 1	On off	21	3,11	3,47	4,94	159%	R410A	BPHE	RTPF	Scroll	17	33
AC 2	Cap Step	21	2,73	4,18	4,71	173%	R410A	BPHE	RTPF	scroll		
AC 3	On off	23	2,58	3,02	4,1	159%	R407C	BPHE	RTPF	scroll	10	200
AC 4	Cap Step	134	2,68	3,88	4,62	172%	R410A	BPHE	RTPF	Scroll	39	160
AC 5	Cap Step	156	2,6	3,7	4,3	165%	R410A	DX plate	RTPF	Scroll	56	450
AC 6	Cap Step	194	3,12	4,08	4,29	138%	R134a	DX plate	RTPF	Scroll	178	672
AC 7	Var Cap	341	2,49	3,51	3,5	141%	R134a	DX S&T	RTPF	Screw	273	646
AC 8	Var Cap	370	2,62		5	191%	NH3	FX plate	RTPF	Screw	200	1000
AC 21	Var Cap	385	2,9	4,01	4,65	160%	R134a	DX S&T	RTPF	Screw	300	1800
AC 20	Var Cap	250	2,71	3,81	6,74	249%	R134a	DX S&T	RTPF	Cent. VFD, MB	250	1650

Fig. 1 Part load data of AC chillers below 400 kW



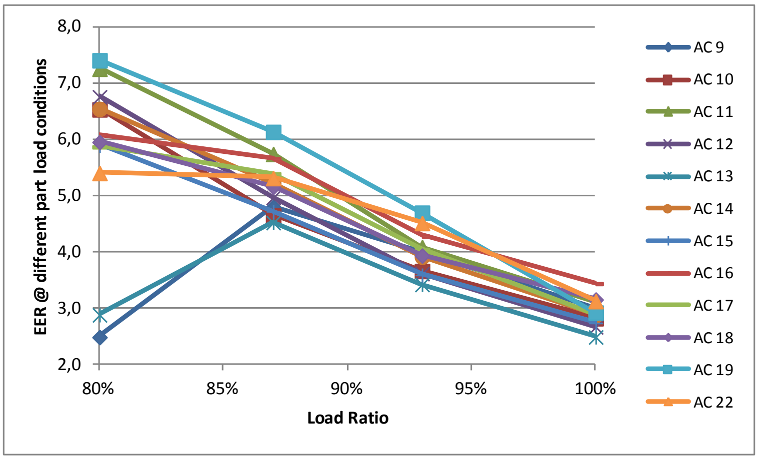


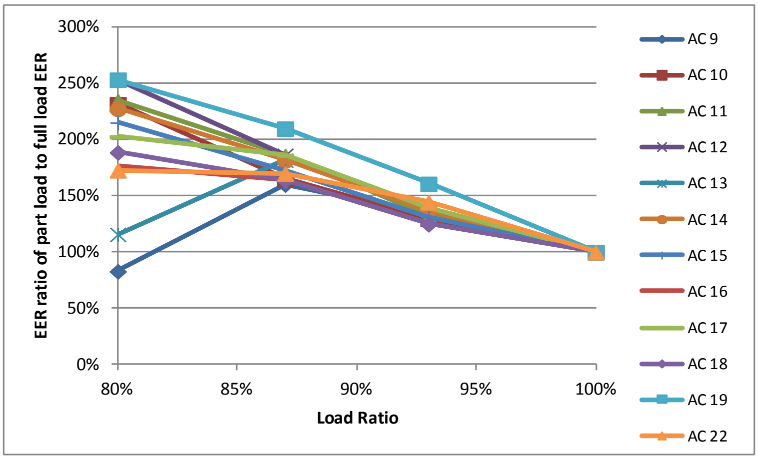
1.1.2 Air-cooled chillers >400 kW

Table 2. Design characteristics and performance of AC chillers above 400 kW

	Part load	Net cap kW	EER net	ESEER	SEPR	SEPR / EER	fluid	Evap	Cond	Comp	*range min cap (kW)*	*range max cap (kW)*
AC 9	Var Cap	449	2,8	3,79	3,39	121%	R134a	Flooded S&T	Ct, Al F	Screw	404	1511
AC 10	Var Cap	483	2,82		5,13	182%	NH3	FX plate	Al T, Al F	Screw	200	1000
AC 11	Var Cap	522	3,1	3,4	5,95	192%	R134a	DX S&T	Ct, Al F	Screw	388	575
AC 12	Var Cap	553	2,67	3,4	5,32	199%	R134a	DX S&T	Ct, Al F	Screw	388	575
AC 13	Var Cap	616	3	3,14	3,5	117%	R134a	DX S&T	Ct, Al F	Screw	273	646
AC 14	Var Cap	760	2,88	4,06	5,44	189%	R134a	Flooded	Micro Channel	Screw	252	1 702
AC 15	Var Cap	829	2,74	3,72	4,93	180%	R134a	DX S&T	Ct, Al F	Screw	645	1917
AC 16	Var Cap	1153	3,16	4,14	5,22	165%	R134a	DX S&T	Ct, Al F	Screw	645	1917
AC 17	Var Cap	1202	2,9	5,24	5,3	183%	R134a	Flooded S&T	Ct, Al F	Screw	404	1511
AC 18	Var Cap	1276	3,44	3,86	5,55	161%	R134a	DX S&T	Ct, Al F	Screw	645	1917
AC 19	Var Cap	1444	2,93	4,73	6,31	215%	R134a	DX S&T	Ct, Al F	Screw VFD	645	1917
AC 22	Var Cap	1180	3,13	4,92	5,19	166%	R134a	Flooded S&T	Ct, Al F	Cent. VFD, MB	200	1300

Figure 2. EER at the different SEPR points, AC chillers above 400 kW, Absolute and relative to standard full load EER values





1.1.3 SEPR average and upper values

Table 3. Median EER values by caapcity range for air cooled chillers (Eurovent 2013 data)

AC chillers categories	All	< 100	100-400	> 400
Median EER	2,75	2,73	2,71	2,87

Table 4. Estimates of average and high SEPR values bu product category

AC < 400 kW						
	EER ave	EER max	SEPR / EER ave	SEPR / EER high	SEPR ave	SEPR high
On-off scroll	2,7	3,4	160%		4,32	5,44
On-off scroll with extended HP range	2,7	3,4		190%	5,13	6,46
Capacity stage or VFD scroll	2,7	3,4	166%		4,48	5,64
VFD scroll / rotary with extended HP range	2,7	3,4	197%		5,32	6,70
Cap stage or var cap screw	2,7	3,4	166%	190%	4,48	6,46
Ammonia screw chiller	2,7	2,9	180%	190%	4,86	5,51
VFD screw	2,7	3,4	215%		5,81	7,31
Centrifugal VFD (MB)	2,7	3,4	203%	240%	5,48	8,16
AC > 400 kW						
	EER ave	EER max	SEPR / EER ave	SEPR / EER high	SEPR ave	SEPR high
Capacity stage or VFD scroll	2,87	3,4	166%		4,76	5,64
VFD scroll with extended HP range	2,87	3,4	197%		5,66	6,70
Cap stage or var cap screw	2,87	3,4	166%	190%	4,76	6,46
Ammonia screw chiller	2,87	2,9	180%	190%	5,17	5,51
VFD screw	2,87	3,4	215%		6,17	7,31
Centrifugal VFD (MB)	2,87	3,4	203%	240%	5,83	8,16

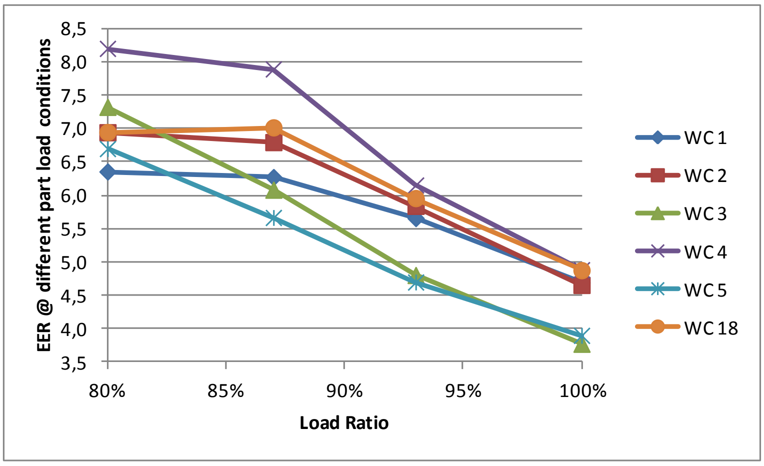
1.2 Water cooled chillers

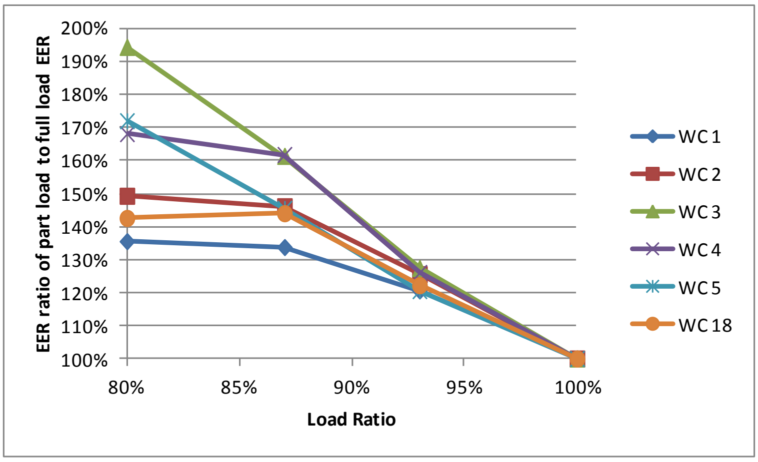
1.2.1 Water-cooled chillers <400 kW

Table 5. Design characteristics and performance of WC chillers below 400 kW

	Part load	Net cap kW	EER net	ESEER	SEPR	SEPR / EER	fluid	Evap	Cond	Comp	*range min cap (kW)*	*range max cap (kW)*
WC 1	On off	42	4,69	5,03	6,18	132%	R410A	BPHE	BPHE	Scroll	20	90
WC 2	Cap Step	88	4,65	5,99	6,66	143%	R410A	BPHE	BPHE	Scroll	20	90
WC 3	Var Cap	165	3,77	4,46	6,22	165%	NH3	DX S&T	DX S&T	Screw	165	554
WC 4	Var Cap	317	4,88	5,76	7,76	159%	R134a	Falling film	DX S&T	2 screw	230	840
WC 5	Var Cap	327	3,89		5,88	151%	NH3	FX plate	plate	Screw	200	8000
WC 18	Var Cap	350	4,87	5,46	6,77	139%	R134a	DX S&T	DX S&T	Screw	300	2400
WC 24	Var Cap	210	4,9		11,7	239%	NH3	BPHE	Plate	Recip VFD	200	1350
WC 31	Var Cap	195	3,4		7,1	209%	NH3	FX plate	Plate	Screw VFD Eco	200	3000

Figure 3. EER at the different SEPR points, WC chillers below 400 kW, Absolute and relative to standard full load EER values



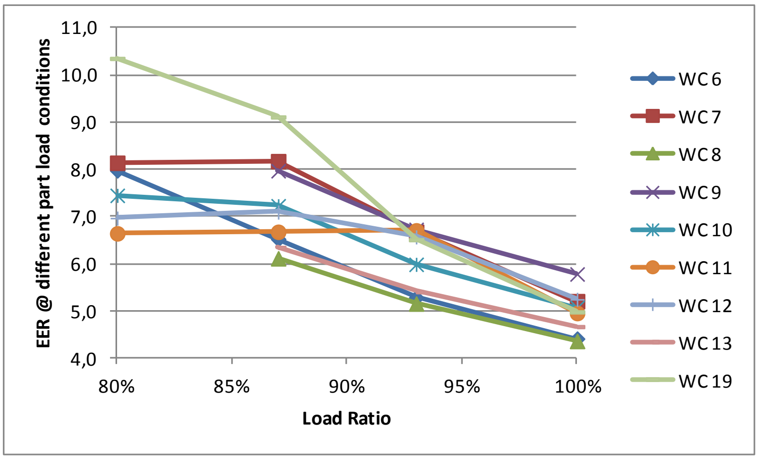


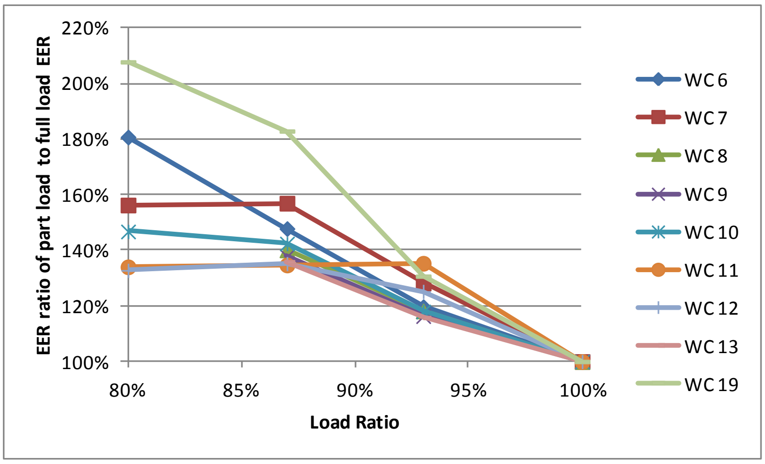
1.2.2 Water-cooled chillers >400 <1000 kW

Table 6. Design characteristics and performance of WC chillers between 400 kW and 1000 kW

	Part load	Net cap kW	EER net	ESEER	SEPR	SEPR / EER	fluid	Evap	Cond	Comp	*range min cap (kW)*	*range max cap (kW)*
WC 6	Var Cap	459	4,41		6,84	155%	NH3	FX plate	plate	Screw	200	8000
WC 7	Var Cap	460	5,21	5,75	7,86	151%	R134a	Flooded S&T	Flooded S&T	Screw	252	1762
WC 8	Var Cap	637	4,36	5,04			R134a	DX S&T	DX S&T	Screw	332	1503
WC 9	Var Cap	746	4,67	6,76			R134a	Flooded S&T	Flooded S&T	Screw	368	1212
WC 10	Var Cap	860	5,07	7,76	7,94	157%	R134a	Flooded S&T	Flooded S&T	Screw VFD	580	1710
WC 11	Var Cap	887	5,78	8,52	6,59	114%	R134a	Flooded S&T	Flooded S&T	Cent	316	1054
WC 12	Var Cap	897	5,25	5,83	6,93	132%	R134a	Falling film	DX S&T	1 screw	550	1460
WC 13	Var Cap	971	4,96	5,18			R134a	DX S&T	DX S&T	Screw	332	1503
WC 19	Var Cap	810	4,98	8,04	9,03	181%	R134a	Flooded S&T	DX S&T	Cent VFD, MB	240	1950
WC 22	Var Cap	800	6,1	8	12	197%	R134a	Falling Film	Flooded S&T	Cent VFD, MB	800	1300
WC 23	Var Cap	850	5,3	6,5	8	151%	R134a	Falling Film	Flooded S&T	Screw VFD Eco	700	1000
WC 29	Var Cap	464	4,9		11,7	239%	NH3	BPHE	Plate	Recip VFD	200	1350

Figure 4. EER at the different SEPR points, WC chillers above 400 kW and below 1000 kW, Absolute and relative to standard full load EER values



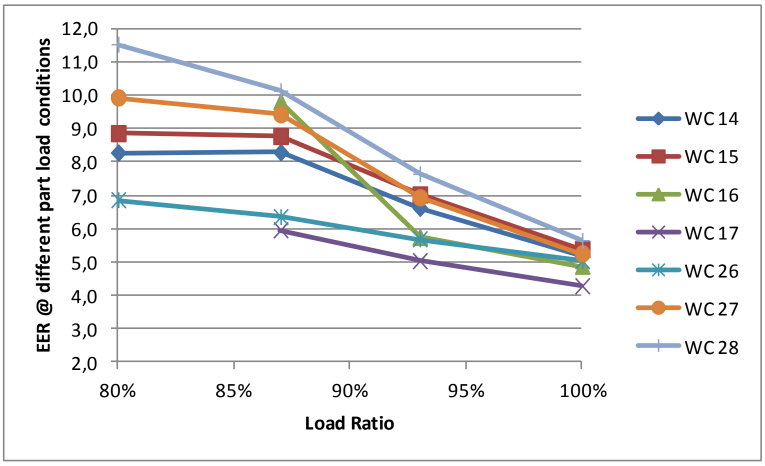


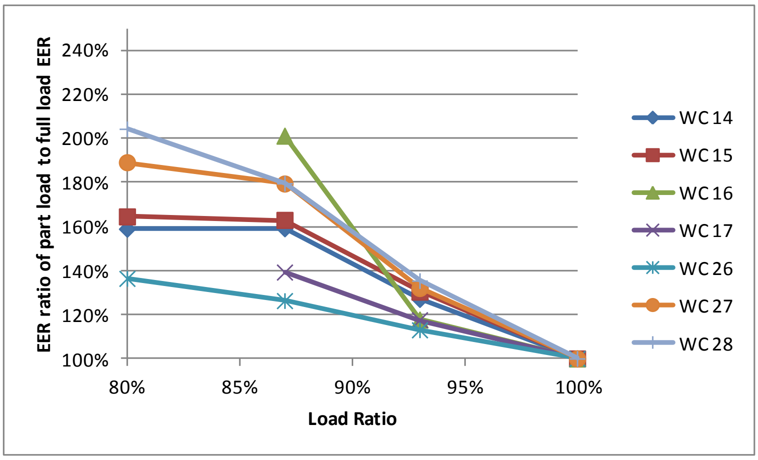
1.2.3 Water-cooled chillers >1000 kW

Table 7. Design characteristics and performance of WC chillers above 1000 kW

	Part load	Net cap kW	EER net	ESEER	SEPR	SEPR / EER	fluid	Evap	Cond	Comp	*range min cap (kW)*	*range max cap (kW)*
WC 20	Var Cap	1000	6	5,9	8	133%	R134a	Flooded S&T	Flooded S&T	Centrifugal	1000	3000
WC 21	Var Cap	1000	6	7,1	11	183%	R134a	Flooded S&T	Flooded S&T	Centrifugal, VFD	1000	3000
WC 14	Var Cap	1060	5,2	6,34	7,04	135%	R134a	Flooded S&T	Flooded S&T	Screw	252	1762
WC 30	Var Cap	1066	5,1		11,8	231%	NH3	Plate	Plate	Recip VFD	200	1350
WC 25	Var Cap	1000	4,5		8	178%	NH3	Flood. Plate	Plate	Screw VFD Eco	200	3000
WC 15	Var Cap	1460	5,38	7,3	7,08	132%	R134a	Flooded S&T	Flooded S&T	Screw VFD	580	1710
WC 16	Var Cap	1580	4,28	5,26			R410A	DX S&T	DX S&T	Screw	379	2156
WC 26	Var Cap	1583	5,03		6,44	128%	R134a	Flooded S&T	Flooded S&T	Centrifugal		
WC 27	Var Cap	1583	5,25		9,1	173%	R134a	Flooded S&T	Flooded S&T	Cent VFD		
WC 28	Var Cap	1583	5,64		10,1	179%	R134a	Flooded S&T	Flooded S&T	Tri screw VFD		
WC 17	Var Cap	1595	4,88	4,76			R410A	DX S&T	DX S&T	Screw	379	2156

Figure 5. EER at the different SEPR points, WC chillers above 1000 kW, Absolute and relative to standard full load EER values





1.2.4 SEPR average and upper values

Table 8. Median EER values by caapcity range for water cooled chillers (Eurovent 2013 data)

	All	<100	100-400	< 400	400-1000	> 1000
Median EER	4,51	4,29	4,41	4,37	4,82	4,92
Max EER	6,09	4,95	5,61	5,61	5,94	6,09

Table 9. Estimates of average and high SEPR values by product category

WC < 400 kW						
	EER med	**EER max**	**SEPR / EER ave**	**SEPR / EER high**	**SEPR med**	**SEPR high**
On-off scroll	4,3	4,95	132%		5,68	6,53
On-off scroll / extended HP range	4,3	4,95	152%	158%	6,81	7,84
Capacity stage or VFD scroll / rotary	4,3	4,95	142%		6,11	7,03
VFD scroll / extended HP range	4,3	4,95	170%		7,33	8,43
Cap stage or var cap screw	4,4	5,6	130%	160%	5,72	8,96
Ammonia screw chiller	3,8	4,4	150%	165%	5,70	7,26
Ammonia screw chiller with VFD	3,4	4,5	210%	180%	7,14	8,10
Ammonia reciprocating VFD	4,9	5,1	240%	230%	11,73	11,76
Centrifugal VFD (MB)	4,4	5,6	180%	200%	7,92	11,20
WC > 400 kW and < 1000 kW						
	EER med	**EER max**	**SEPR / EER ave**	**SEPR / EER high**	**SEPR med**	**SEPR high**
Capacity stage or VFD scroll / rotary	4,3	4,95	142%		6,11	7,03
VFD scroll / extended HP range	4,3	4,95	170%		7,31	8,41
Cap stage or var cap screw	4,8	5,6	130%	160%	6,24	8,96
Screw VFD	4,8	5,6	160%	135%	7,68	8,96
Ammonia screw chiller	3,8	4,4	150%	165%	5,70	7,26
Ammonia screw chiller with VFD	3,4	4,5	210%	180%	7,14	8,10
Ammonia reciprocating VFD	4,9	5,1	240%	230%	11,73	11,76
Centrifugal VFD (MB)	4,8	6	180%	200%	8,64	12,00
WC > 1000 kW						
	EER med	**EER max**	**SEPR / EER ave**	**SEPR / EER high**	**SEPR med**	**SEPR high**
Capacity stage or VFD scroll / rotary	4,3	4,95	142%		6,11	7,03
VFD scroll / extended HP range	4,3	4,95	170%		7,31	8,41
Cap stage or var cap screw	4,92	5,6	130%	160%	6,40	8,96
Screw VFD	4,92	6,1	160%	135%	7,87	9
Ammonia screw chiller	3,8	4,4	150%	165%	5,70	7,26
Ammonia screw chiller with VFD	3,4	4,5	210%	180%	7,14	8,10
Ammonia reciprocating VFD	4,9	5,1	240%	230%	11,73	11,76
Centrifugal	5	6,3	115%	130%	5,75	8,19
Centrifugal VFD (incl. MB) and Tri-screw	5	6,3	180%	200%	9,00	12,60