Product Fact Sheet — Motors, pumps and fans: Motors

Table 33. Overview of Motors

Country	MEPS	High Label	S&L metric	Test procedure	Reference test procedure & metric	Test Procedure (*)	Energy Performance Metric (*)	Notes
China	IE2 (Grade 3)	IE4	Efficiency (%)	GB/T series	**IEC60034-2-1**	1	1	
Europe	IE2 0.75 - 375kW		Efficiency (%)		IEC60034-2-1	1	1	
Mexico	IE3	IE4	Efficiency (%)	NOM 014/16	IEC60034-2-1	1	1	
US	1 - 200hp NEMA Premium Efficiency (Equivalent to IE3) & 201 - 500hp IE2		Efficiency (%)	IEEE Std112	IEC60034-2-1	1	1	
India	IE3	IE4	Efficiency (%)		IEC60034-2-1	1	1	
Australia	N/A	IE4	Efficiency (%)	AS/NZS 1359.5	IEC60034-2-1	1	1	

(*) Conversion factors

Product

1. Electric motors convert electrical energy to rotating mechanical energy. When operating, the electrical energy is transferred as useful mechanical energy to some driven device such as a fan, pump, blower, compressor, or conveyor.

Overview of international situation with regards to S&L for this product category

1. In summary, all motor test methods give results that for the purposes of this exercise (which is intended to be used at a macro-level and not for individual conversion) are very similar indeed and any differences can be neglected. The same is not necessarily the case on an individual motor basis.

2. There have been great efforts by the IEC to harmonize global motor test methods, culminating in the 2007 revision of the key standard IEC 60034-2-1. This was long overdue, as different global regions have, in the past, used significantly different test methods, not allowing comparison between motors tested to different standards. The US and Canada have always used the direct torque output;input method, Europe and many other IEC Countries have used the Summation of losses method. Japan used another method that gave yet different results, but no longer do so. This led to the IEC60034-2-1 2007 standard, which actually presents and in some cases updates a total of 10 methods that are in use. However, only 3 of these are used for regulatory work, one of which (summation of losses with assigned losses) is now effectively obsolete. Others are either of academic interest, or are too expensive for regular use (the calorimetric method). Critically it pronounces the uncertainty associated with each method (low to high), and states which is the preferred method for different motors. For the induction motors that are of most concern to

regulators, there are two methods, according to size. The current situation is that North America is still not ready to align with the IEC preferred methods, instead using the direct torque method for some sizes. The method for achieving this as stated in IEC60034 is very similar to that used in US IEEE112B, with just a minor correlation factor difference (ref Electrical Energy Efficiency, 2012, Sumper and Baggini).

3. The practical implications of this are that a manufacturer can use whatever method they like, but the regulator will specify what they will assess the motor by, and so it makes sense for the manufacturer to follow this specification. Meanwhile, Australia (alone) has MEPS listed for both standards.

4. The focus of efforts is on the induction motor, where the summation of losses method is preferred for all 3-phase motors above 1kW, and which use the bulk of energy

5. This is reflected in the fact that to date it is only these motors that have applicable MEPS. But smaller motors, such as used in appliances, will rarely be this type, and so should be tested by the output:input method for two reasons: This method is accurate in small sizes, and the alternative summation of loss method will anyway not work with anything other than three phase induction motors. This means that while the summation of losses method is more accurate in larger sizes, the output:input method will always be needed, and so cannot be abolished in pursuit of harmonization.

6. This essential co-existence is making it easier for the output:input method to still be used in size regions where is not the preferred method. From the User's perspective it does not matter in that either method will give a low uncertainty, but for the manufacturer it means testing to both standards, and each Regulator has to nominate the test method to be used. Efforts to gain a single global approach are ongoing in medium to large induction motors, but for other motors it is still early days and so no consensus has yet emerged.

General description of conversion for test procedures and metrics/ efficiency metrics and standards

1. As mentioned above, in summary, all motor test methods give results that for the purposes of this exercise are very similar indeed, and for most purposes any differences are not significant. All regulations are based solely on the full load performance.

2. For induction motors, the IEC 60034-2-1:2007 Summation of Losses Method is used in most countries, and is becoming increasingly popular. The other method used almost exclusively in the US is standard 10CFR part 431, which gives very similar results.

3. For new types of motor (non-induction motors) these methods can not be used, and so output:input methods are used instead. Again, IEC 60034-2-1:2007 is the most popular standard, with the output:input method being specified. Similarly the US uses a different standard IEEE112B:C Method A, which gives very similar results to the IEC standard.

4. Note that it is not mathematically possible to convert the efficiency measured with one method to give its equivalent value measured with a different method. Though the results obtained will be very similar.

5. Looking ahead, it is expected that part load efficiency of motors will also be recorded, and might possibly be used for regulatory purposes. In addition, methods for assessing the losses of motors under variable speed drive control are being developed, and so should also be considered as a possible future information requirement.

6. There are two labeling schemes in existence, with the IE scheme created by IEC, and the other scheme a US only NEMA scheme. These are now harmonized to have the same levels of efficiency.

IEC Designation	Similar to NEMA class
IE1	Standard efficient
IE2	Energy efficient
IE3	Premium
IE4	Above premium

Notes and assumptions

None other than as described above.

List of sources

Relevant IEC standards http://www.motorsystems.org/iec-standards
Review of test methods and MEPS:
http://www.eemods2013.org/paper/Oct30/Session%208.c/Papers/045_Angers_finalpaper_EEMODS13.pdf
http://www.motorsummit.ch/data/files/MS_2012/presentation/ms12_yuejin_update.pdf
IEA Motor Policy publication:
http://www.motorsystems.org/files/otherfiles/0000/0101/iea_falkner_holt_2011.pdf

Product Fact Sheet — Motors, pumps and fans: Pumps

Table 34. Overview of Pumps

Country	MEPS	High Label	S&L metric	Test procedure	Reference test procedure & metric	Test Procedure (*)	Energy Performance Metric (*)	Notes
				Pumps				
China	N/A	N/A	GB 19762-2007 GB/T 3216 GB/T 5657 GB/T 7021 GB/T 13006	ISO9906	**ISO9906**	1	1	China and Europe metrics based on similar principles but the conversion varies with type and size of pump
Europe	MEI = 0.1		EUP Directive (MEI)	ISO9906	ISO9906	1	1	
US	N/A			ANSI 14.6-2011	ISO9906	1	1	
				Pump + Motor combinations				
Mexico	N/A	N/A	NOM-00X-ENER	ISO9906	**ISO9906**	1	1	
India		N/A	IS 11346:2004	ISO9906	ISO9906	1	1	
US			ANSI 14.6-2011	ISO9906	ISO9906	1	1	
				Circulators				
Europe	0.27		EUP Directive	ISO9906	**ISO9906**	1	1	

(*) Conversion factors

Product

1. Pumps are used in agriculture, oil and gas production, water and wastewater, manufacturing, mining, and commercial building systems. The primary functional parameters of pumps are: rated flow, head, and fluid properties.

2. Pumps contain motors. The boundaries of a system can be defined depending on how the pump and motor are manufactured. Where the motor can be removed and tested separately, the pump and motor are considered separate products. Where they cannot be easily separated they can be considered as an integral product.

Overview of international situation with regards to S&L for this product category

1. Pumps are all tested to ISO9906, and only the Best Efficiency Point performance is included. The derivation of target efficiencies for a particular head:flow duty is complicated, but the different methods give similar values.

2. Where pumps are tested with their driving motor, then the target efficiency values will be shaped by the combination of pump efficiency and motor efficiency, both of which vary with size but in different ways. The results of pumps tested with and without their motors cannot be compared.

3. The central heating Circulator is used mainly in Western Europe, and uses an Extended Product Approach based on the Blue Angel time flow distribution. The regulation includes the complete pump+motor+control. There are currently no other test standards for these products.

4. The EU or China methods alone are probably the most appropriate for pump alone efficiencies.

General description of conversion for test procedures and metrics/ efficiency metrics and standards

1. The under-lying test methods for the hydraulic (wet end) are effectively identical. ISO9906 is used widely, with the exception of US that uses ANSI/HI 14.6 – 2011. This is functionally equivalent, and was just published due to delays in the ISO standard being published. ISO9906 is the method for measuring the pump efficiency only. Please note that ISO9906 was revised in 2012, not all regulations may have caught up with this yet.

2. There are several metrics that can be, and are, used with pumps:

- Pump (hydraulics only). This method is used by EU and China, and allows for more accurate setting of MEPS values, as it can separate the motor MEPS and pump MEPS. This is important because the same kW rating of pump will have different MEPS rating according to the duty (head and flow). Note that the same pump will have a different MEPS value according to the speed, as specific speed considerations will mean that it is inherently better at some speeds than others. Even taking this into account, the China standard GB 19762-2007 gives MEPS efficiency levels typically >5% higher efficiency than for the EU MEPS for the same pump. This also means that pump-set (motor + pump) efficiency values do not have to be altered should the motor efficiency regulations change. There are different ways of defining metrics, and so they will not be compatible, although in theory they could possibly be converted by an expert.
- The counter-argument is that most pumps are sold to the end user with a motor, and so it makes sense to reflect this in the information given. However, this then shifts responsibility for compliance to the systems integrator, who may not have the will or knowledge to apply any regulations properly.
- The most advanced methodology is based on what Europump call the "Extended Product Approach", and this considers the performance of the pump + motor + controls over a representative load profile. This hinges on being able to define an agreed standardized load profile that is typical of real life operation, but this has already been achieved by the European Circulator regulations. It is not possible to simply add the load profile factor to the motor+pump performance, as this neglects any controller losses and critically the performance at part load. Europump is currently working on a methodology (SAM = Semi Analytical Method) that will allow the prediction of part load performance, but this is still under development.

3. All countries appear to use ISO9906 for testing of the pump efficiency. However, there are various "acceptance grades" (tolerances) specified in here, and it is for the local regulator to specify which shall be applied.

4. The current situation is therefore that these metrics do not allow for simple conversion between them, but can be "unpicked" by anybody with an in depth knowledge.

5. US (DOE) and Europe have diverging approaches on the Extended Product Approach, but it would seem sensible to let both methods develop in order to identify which is best.

6. There is a clear opportunity to unify EU and Australian swimming pool pump standards.

Notes and assumptions

None other than as described above.

List of sources

Test procedures from each country, as listed in CLASP's Global S&L Database
http://www.clasponline.org/en/Tools/Tools/SL_Search.aspx

EUP LOT11 Preparatory study on Pumps

Product Fact Sheet — Motors, pumps and fans: Fans

Table 35. Overview of Fans

Country	MEPS	High Label	S&L metric	Test procedure	Reference test procedure & metric	Test Procedure (*)	Energy Performance Metric (*)	Notes
Ceiling Fans								
China	N/A	N/A		CGC6101	**IEC 60879-1986 Ed.2**	1	1	
US	N/A	N/A		10CFR Part 430	IEC 60879-1986 Ed.2	1	N/A	MEPS uses an ENERGY STAR method.
India		N/A		IS374	IEC 60879-1986 Ed.2	1	1	
Portable Fans								
Indonesia	N/A	N/A		SNI 04-6292.80-203		N/A	N/A	Insufficient data
China		N/A		Insufficient data	Insufficient data - probably ISO5801	N/A	N/A	Insufficient data
Industrial Blower								
China	N/A	N/A		GBT 19761-2009 series	**ISO5801**	1	N/A	
US	N/A				ISO5801	1	N/A	
EU			ISO12759	327/2011	ISO5801	1	N/A	
Fume Hood/Cooktop								
China		N/A		CQC 6101-2009 GB 4706.28	**IEC 60665: 1980**	N/A	N/A	
EU					IEC 60665: 1980	1	1	
US	N/A				ISO5801?	N/A	N/A	
Furnace/duct Fan								
US	N/A				**ISO5801**	1	1	

(*) Conversion factors

Products

1. Fans have rotating blades that create a current of air for cooling or ventilation. This product group includes ceiling fans, portable fans, industrial blowers, fume hoods, cooktop/cookers and furnace/duct fans.

Overview of international situation with regards to S&L for this product category

1. For commercial fans, ISO5801 is the universally accepted global test standard, and ISO12759 has been developed to give the technical basis for efficiency metrics of a MEPS scheme.

2. No country regulates the fan (blades and hub) alone, with the reasoning being that fans invariably come attached to a motor.

3. It would be possible, but there are some practical points behind that need to be taken account of:

- The introduction of highly integrated brushless DC fans that are non separable means that for this important group it would be practically impossible to regulate the fan without the motor.
- For axial direct drive fans the fan itself cools the motor, reducing its losses, an effect which is currently only practical to measure with the motor and fan tested as an assembly.

4. Instead regulations are based on the whole assembly. This reflects the packaged product as bought "off the shelf". (The exception may be China for larger fans)

5. The EU approach is interesting in that it also gives an energy efficiency "multiplier" value to ascribe benefit to the use of variable speed control. The methodologies for defining the “Fan Efficiency Grades” are now included within ISO12759, and includes tables of efficiency grades for the combined assembly of motor + fan + controls.

6. This is though simplistic in that it does not consider actual part load performance in the way that the Extended Product Approach (EPA) does. It is therefore suggested that any new regulations should first look to the EPA, which is still under development. The US is most advanced in this regard.

7. For small fans, including ceiling, cooker hood and small domestic bathroom/kitchen extract fans, there is considerable diversity on the metrics to be used. This means that in practice, close inspection of the different standards will be needed in order to select the one most appropriate for a particular technology / usage pattern.

8. For ceiling fans the approach is to measure the energy consumption at rated flow only. But in addition the standby consumption may be taken account of (US and China) or there may be separate requirements for the speed regulator (India).

General description of conversion for test procedures and metrics/ efficiency metrics and standards

Fans can only be compared with others in the same category. For each category, the underpinning measurement standard references an agreed international standard. However, there will be some differences which mean that a precise comparison is not possible. Therefore a medium reliability is appropriate for most comparisons.

Notes and assumptions

None other than as described above.

List of sources

Test procedures from each country, as listed in CLASP's Global S&L Database
http://www.clasponline.org/en/Tools/Tools/SL_Search.aspx

Potential Global Benefits of Improved Ceiling Fan Energy Efficiency. Nakul Sathaye, Amol Phadke**, Nihar Shah, Virginie Letschert & Mia Forbes-Pirie, LBNL, Oct 2012

EUP LOT11 Fans Preparatory Study, European Commission.

US Ceiling Fans:
http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/25

US Commercial and Industrial Fans and Blowers:
http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/65