Understanding IEC standards and wastewater pump motor efficiencies
Grundfos offers approach to missing IE3 classification

A technical analysis of IEC motor efficiency standards in wastewater applications

By Bryan Orchard

Today pumps account for no less than 10% of the world's consumption of electricity, and two-thirds of all pumps use up to 60% too much electricity. If every business switched to high efficiency pump systems there could be global savings of 4% of the total electricity consumption, or to put it another way, comparable with the residential electricity consumption of 1 billion people according to global pump manufacturer Grundfos. Therefore, reducing energy costs through the development of more energy efficient electric motors has become a priority for end-users, environmental legislators, governments and manufacturers.

Over the past decade, a substantial effort has been put into harmonizing the different test and classification standards around the globe, and the subsequent labelling schemes in use.

Image: Grundfos SL pumps in a PUST pumping station

The International Electrotechnical Commission (IEC) has worked together with NEMA, CEMEP, IEEE and other international organizations and this work resulted in the publication of two major standards:

- IEC 60034-2-1 (Ed. 1.0): Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles, 2007), which describes methods used to determine motor efficiency.
- IEC 60034-30: Rotating electrical machines – Part 30 (Ed.1.0): Efficiency classes of single-speed, three-phase cage-induction motors (IE-code), which defines energy classes for induction motors.

"There are two ways of determining the efficiency of an electric motor," says Mikael Nedergaard, Global Product Manager, Grundfos. "One is a direct test that relies on measuring the input power on the basis of the voltage and current supplied and the output power based on the rotational speed and torque. The other indirect method involves measuring the input power and calculating the total losses by measuring and adding individual loss components. This indirect test can only be used for three-phase motors."

The present classification standard – IEC60034-30 for single-speed, three-phase cage and induction motors defines three levels of energy efficiency:

- IE3 – Premium efficiency (equivalent to NEMA Premium)
- IE2 – High efficiency (equivalent to NEMA Energy Efficient)
- IE1 – Standard efficiency (equivalent to former CEMEP EFF2)

Photo: Grundfos MG standard norm motors.

In 2014, a new IEC60034-30-1 will define the fourth efficiency level – IE4 Super Premium efficiency standard, replacing the current IEC 60034-30 standard.

"The IE2 efficiency level was forced into action by the EcoDesign Directive in June 2011, and from January 2015 all motors with a rated output of 7.5-375 kW shall not be less efficient than IE3, or meet the IE2 efficiency level if equipped with a variable speed drive," explains Robert Bork Hansen, Global Product Specialist, Grundfos. "These requirements apply to 2-, 4- and 6-pole, single speed, three-phase, induction motors rated up to 1000 V and on the basis of continuous duty operation. Significantly, motors designed to operate wholly submerged in a liquid and/or motors completely integrated into a product where the motor's energy performance cannot be tested independently from the product were not included."

The question that has to be raised is whether a pump with an integrated motor designed for submergence in water, such as a wastewater pump, can be described as being IE2 or IE3 efficient. As the motor cannot be tested independently of the pump, largely because there is no standardised connection, no defined cooling system nor an established test method, the answer has to be "No".

"Theoretically, testing a motor on a wastewater pump should be relatively straightforward as the motor contains a shaft which could be tested for torque and power," says Leo Andersen, Regional Program Manager, Grundfos. "However, it is issues such as cooling and venting, together with the power used for keeping the motor cooled, that any test procedure would have to address. Two other elements that can contribute to the motor shaft power requirement are mechanical seal friction losses and bearing friction losses, which result from the use of angular contact bearings. Wastewater pumps will typically use a double mechanical seal arrangement to prevent leakage of the pumped liquid into the motor."

Leo Andersen continues: "There is also the matter of the installation to consider. For example, in wet and dry installations where the same motor is used, the efficiencies will differ. To sum up, it is all the losses in the system that requires a clearly defined method of testing, but to do so would involve establishing a facility which replicates the installation."

Anecdotal evidence from Grundfos customers in the wastewater industry reveals that operating reliability and greater efficiency are the issues that are the most important concerns. Once the pump is installed users do not want to touch it again; but equally are prepared to sacrifice some degree of energy efficiency if there are fewer breakdowns. Efficiency is an issue that affects all pump users in the wastewater industry and it becomes even more important when the pump motor increases in size. Providing the highest levels of total energy efficiency across all its wastewater pumps is the Grundfos objective.

Grundfos solution

As it is impossible to claim that a wastewater pump which contains an integral motor is IE2 or IE3 compliant, Grundfos offers a solution which they consider addresses the subject of pump and motor efficiency. Grundfos SE1/SEV and SL1/SLV wastewater pumps now incorporate the electrical internals, i.e. the rotor and stator, of the IE3 motor in the pump housing.

Photo: Grundfos SE pump mounted on auto-coupling assembly.

"What make the wastewater pump motor differ from the conventional IE3 motor are the bearings, mechanical seals and the absence of fan cooling as described above," explains Robert Bork Hansen. "In wet installations, cooling is provided by the fluid in which the pump is submerged. The rotors and the stators from the Grundfos IE3 motor are type test certified in accordance with the TEFC motor standard and supported by measurement reports, so to all intents and purposes it is an IE3 compliant motor. However, by changing the bearings, adding a mechanical shaft seal and method of cooling, IE3 motor compliancy is negated."

The main reason why an efficiency standard has not been introduced to date for wastewater pumps could be due to the fact that manufacturers, legislation and standard makers see wastewater pump motors as a separate unit and not as a unit integrated in the pump, and therefore they are having difficulties in defining the motor friction losses and efficiency.

Pump manufacturers who claim that their wastewater pumps are IE3 compliant are guilty of misleading consultants and end users. If a tender document specifies that wastewater pumps must comply with IE3, then it is impossible for any manufacturer to supply such a pump since there is no applicable standard available regarding the efficiency definitions for wastewater pumps with integrated motors.

Using the electrical components from an IE3 motor and installing them in a wastewater pump does provide some information about the efficiency level of the entire motor unit. What it does not provide is any specific value because the friction losses in a wastewater pump are different from those present in a standard pump and these losses are not taken into account. Nor does it tell anything about the hydraulics side, which is where the greater possibilities for efficiency gains exist.

"To attain the highest level of efficiency in the pump system, the pump selected must have a BEP (Best Efficiency Point) that best matches the duty point," says Mikael Nedergaard. "The BEP is largely dependent on the characteristics of the pump, these being power, flow and head and it is the point on the pump curve that gives the most efficient operation. It must be remembered that pump efficiency will decline substantially if the pump operates away from the designed BEP."

Grundfos believes that rather than concentrating exclusively on motor efficiency, manufacturers, consultants and end users need to address total pump efficiency defined in the ISO 9906:2012 'Performance acceptance test for rotodynamic pumps' standard, or ANSI/HI 11.6.2012 'Performance acceptance test for rotodynamic submersible pumps' standard when discussing wastewater and submersible motor pumps.

Photo: Grundfos SL submersible pump, 22 kW, Medium Head, with integrated motor.

Of equal importance to motor efficiency are pump hydraulics, as the possibilities for improving pump efficiency are far greater. In the absence of an appropriate energy efficiency standard for the pump, it is inevitable the manufacturers and vendors are going to highlight the IE3 connection. This situation is starting to change and Europump is discussing proposals for an appropriate pump standard. The drive towards establishing a suitable standard cannot come exclusively from pump manufacturers, but has also to be driven by politicians and regulatory bodies.

"In recent years an energy standard has been produced for small circulator pumps where, like wastewater and submersible pumps, the motor and shaft are contained in a single housing and cannot be tested separately," comments Mikael Nedergaard. "Endorsed by the EU, the standard drawn up by Europump, the pump manufacturers' trade association and pump manufacturers, consists of seven classifications of energy-saving. The energy efficiency index (EEI) of the pump is calculated according to an annual load profile and the pump is labelled according to its energy efficiency. By introducing energy labelling, the end user can compare products and specify the most appropriate pump, or pumps, for the installation."

If this can be achieved for circulator pumps, then it follows that an internationally recognised energy standard can also be produced for wastewater pumps. As the wastewater treatment industry is gradually moving to larger and more efficient treatment plants that require larger pumps, energy costs are going to become far more important. The pump industry and regulatory bodies will have to respond accordingly and invest in a testing regime that gives the end users the information that they require.

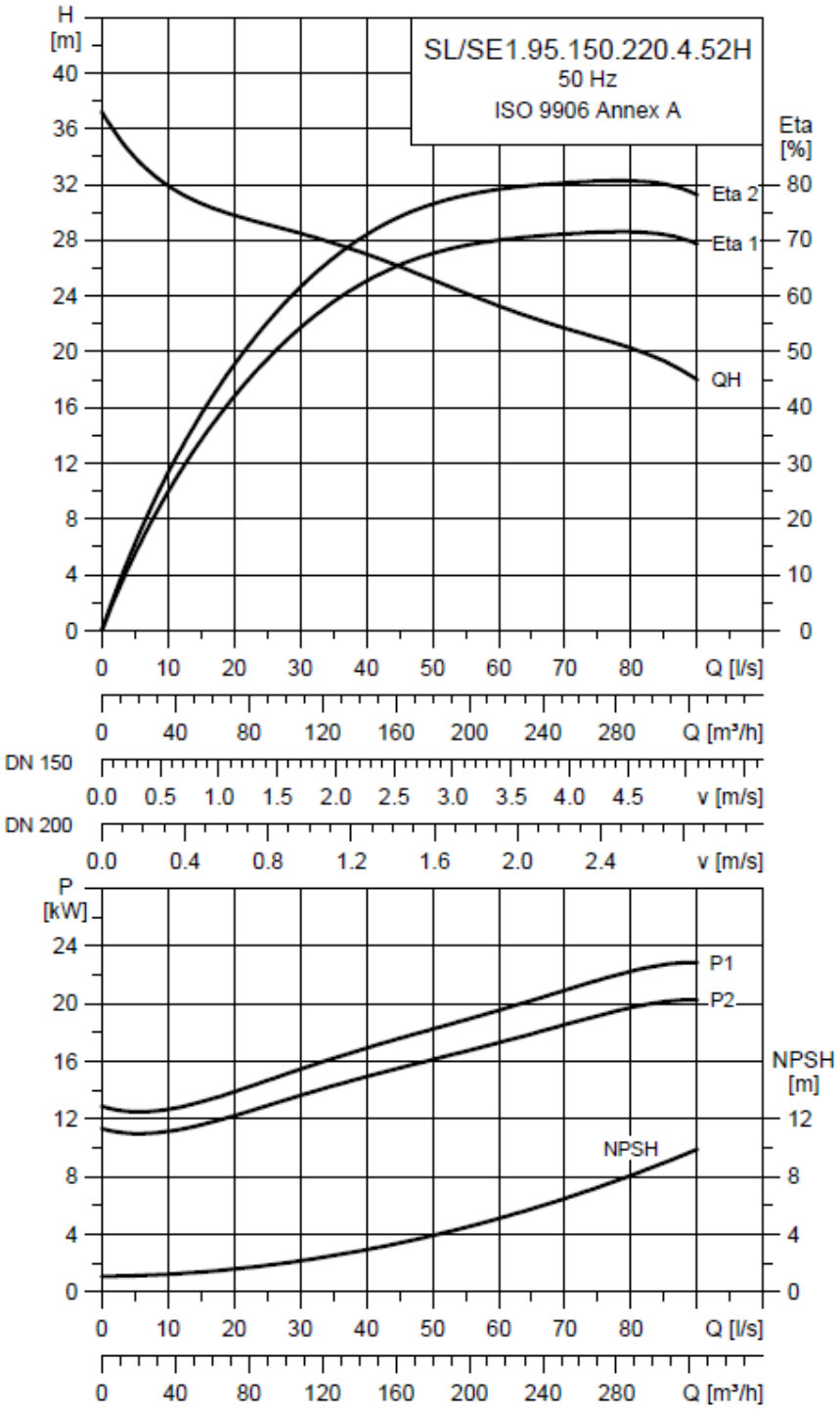

Figure: The performance curves of the Grundfos SL/SE1.95.150.220.4.52H wastewater pump, including the total efficiency curve (Eta 1). The Eta 2 curve shows the hydraulic efficiency.

References

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