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Pumps — Testing — Submersible mixers for wastewater and similar applications

Pompes — Essais — Mélangeurs immergés pour eaux usées et applications similaires

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21630 was prepared by Technical Committee ISO/TC 115, *Pumps*, Subcommittee SC 2, *Methods of measurement and testing*.

Introduction

This International Standard prescribes acceptance test methods for submersible mixers for wastewater and other applications. It is intended for performance measurements relevant to submersible mixers bearing in mind the similarities to, and crucial differences from, submersible pumps. Hence head (pressure) and flow rate measurements are not included. The basic output performance parameter is the thrust. As continuous operation is commonplace, electric power consumption is important for the Life Cycle Cost, and is put forward as an important parameter. It is acknowledged that the present International Standard draws heavily on ISO 9906:1999 in the generalities.

The major objectives of this International Standard are to

- increase uniformity/compatibility in equipment performance characterization, enabling a comparison of mixers,
- simplify communication between customer and supplier and protect customers,
- reduce the need for documentation,
- increase quality and efficiency in both machinery and process.

Pumps — Testing — Submersible mixers for wastewater and similar applications

1 Scope

This International Standard prescribes acceptance test methods for submersible mixers (hereafter “SM” or “mixer”) used for mixing in wastewater and other applications where at least one system component is a liquid.

“Submersible mixer” is taken to mean a fully submersible aggregate consisting of a drive unit and an axial flow type impeller, and optional parts, such as shrouds, supporting the basic functions.

“Liquid” is taken to mean a body without capacity to accommodate shear stresses when at rest. This includes suspensions and dispersions (liquid/solid, gas/liquid and gas/liquid/solid), and non-Newtonian liquids, provided that a possible small yield stress does not prevent the liquid from flowing when agitated.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
thrust-to-power ratio
ratio of mixer thrust force to mixer power consumption

$$R_{FP} = F / P_1$$

NOTE 1 The ratio of minimum required mixing system power dissipation to mixer power consumption is an (end-user oriented) system efficiency. To understand the importance of the thrust-to-power ratio, consider the case of an SM generating a longitudinal flow velocity u in a recirculation channel such as a wastewater oxidation ditch. This is in fact a common application of the SM, and the following argument is in principle possible to generalize to other applications.

The momentum loss of the flow over one circulation equals the rate of momentum provided by the SM at quasi-steady state. This is given by the mixer thrust F. The power dissipated as a result of this momentum loss is $P = F\,u$, and this is the minimum required mixing system power to maintain the velocity u. Hence, the system efficiency is $P / P_1 = F\,u / P_1$.

It is possible to isolate the mixer properties from the system requirement in this expression, and this leads to the thrust-to-power ratio, R_{FP}, as the most relevant efficiency-related parameter of the SM. It should be noted that it is dimensional, and hence it depends on the impeller diameter and speed, not only on the impeller geometry. Other considerations than energetic efficiency of generation of longitudinal flow provide for the multitude of impeller diameters and speeds available in practice.

NOTE 2 An impeller efficiency, defined as the ratio of power of axial motion of the impeller discharge to the electric power uptake of the mixer, can be defined. The definition draws on the assumption that the approaching velocity, u, is small enough to have negligible influence on the mixer impeller characteristics. The hydraulic discharge power $P_\mathrm{h} = p\,Q$ can be expressed in thrust using the relations

$$p = F / A \text{ and } F = 2\,\rho Q^2 / A$$

which are approximately valid for the mixer test established herein. The conventional area of the *vena contracta* $A / 2$ is used, as this discharge section best fulfils the flat velocity profile requirement. With $A = \pi\,D^2 / 4$, one obtains

$$P_\mathrm{h} = (F / A)\,(A\,F / 2\,\rho)^{1/2} = F^{3/2} / [D\,(\pi\,\rho / 2)^{1/2}]$$

Hence the impeller efficiency can be written

$$\eta = F^{3/2} / [(\pi \rho / 2)^{1/2} D P_1]$$

It can be noted that, often correct to within 1 %, the efficiency is conventionally given as (assuming SI units $[F]$ = Newton, $[P_1]$ = Watt, $[D]$ = meter, and clean cold water as defined in 5.4.5.2)

$$\eta = F^{3/2} / (40 D P_1)$$

Although the derivation given here is not based on completely correct assumptions, the approximate expression for the efficiency may be derived in more rigorous ways.

The value of the impeller efficiency alone is not deemed to be of primary interest because of the dependency of mixer-system efficiency on the impeller diameter and speed.

2.2

advance ratio

ratio of propeller traversing speed or mean liquid ambient speed to (essentially) tip speed

$$J = u / nD$$

2.3

impeller Reynolds number

ratio between inertial and viscous forces prevailing at impeller

$$Re = (F / \rho)^{1/2} / \nu$$

NOTE F is the thrust for the same mixer running at the same speed in clean cold water as defined in 5.4.5.2. Also note that this is not the same as the blade Reynolds number, nor is it identical, but akin to the impeller Reynolds number used for dry-installed agitators in the process industries.

3 Symbols and abbreviated terms

Table 1 summarizes the symbols in alphabetical order and SI units used.

Table 1 — Alphabetical list of letters used as symbols

Symbol	Quantity	Unit
A	Area swept by impeller	m^2
D	Diameter of impeller	m
e	Uncertainty, relative	(pure number), %
f	Frequency	s^{-1}, Hz
F	Thrust	N
J	Propeller advance ratio	(pure number)
L	Length of lever	m
n	Speed of rotation	s^{-1}, Hz
p	Pressure	Pa
P	Power	W
Q	Flow rate	m^3/s
R_{FP}	Thrust-to-power ratio	N/W
Re	Impeller Reynolds number	(pure number)
t	Tolerance	(pure number), %
T	Time	s
u	Mean velocity in the axial or longitudinal direction	m/s
U	Voltage	V
x	Generic measured entity	
$<x>$	Time average of x	
η	Efficiency	(pure number), %
ν	Kinematic viscosity	m^2/s
ρ	Density	kg/m^3
σ	Standard deviation	

Table 2 summarizes the subscripts used for the symbols.

Table 2 — Alphabetical list of letters and figures other than above used as subscript

Subscript	Meaning
1	electric (power)
G	guaranteed
L/L	length ratio
h	hydraulic (power)
LC	load cell related
m	measured
M	mixer related
FP	see R_{FP}
sp	specified
Tr	translated
TS	time series

4 Guarantees

4.1 Subjects of guarantees

4.1.1 General

Terms used herein such as “guarantee” or “acceptance” should be understood in a technical but not in a legal sense. The term “guarantee” therefore specifies values for checking purposes determined in the contract, but does not say anything about the rights or duties arising if these values are not reached or fulfilled. The term “acceptance” does not have any legal meaning here, either. Therefore, an acceptance test carried out successfully alone does not represent an “acceptance” in the legal sense.

A procedure for verifying the guarantees is given in 6.4.

4.1.2 Thrust guarantee

One guarantee point shall be defined by a guarantee thrust F_{G}.

The manufacturer/supplier guarantees that under the standard test conditions established in this document, the measured thrust will fall in a specified interval surrounding F_{G}. Unless otherwise stated, the interval is given by the tolerances stated in Table 6.

4.1.3 Electric power uptake guarantee

One guarantee point shall be defined by a guarantee electric power uptake $P_{1\mathrm{G}}$.

The manufacturer/supplier guarantees that under the standard test conditions established in this document, the measured electric power uptake will fall in a specified interval surrounding $P_{1\mathrm{G}}$. Unless otherwise stated, the interval is given by the tolerances stated in Table 6.

4.1.4 Thrust-to-power ratio guarantee

One guarantee point shall be defined by a guarantee thrust-to-power ratio $R_{FP,\mathrm{G}}$. This shall be given by $R_{FP,\mathrm{G}} = F_\mathrm{G} / P_{1\mathrm{G}}$.

The manufacturer/supplier guarantees that under the standard test conditions established in this document, the measured and calculated thrust-to-power ratio will fall in a specified interval surrounding $R_{FP,\mathrm{G}}$. Unless otherwise stated, the interval is given by the tolerances stated in Table 6.

4.2 Conditions of guarantees

Unless otherwise agreed, the following conditions shall apply to the guaranteed value.

a) The guarantee point shall apply to clean cold water (see 5.4.5.2).

b) The relationship between the guarantee values under clean cold water conditions and the likely performance under other liquid conditions shall be agreed in the contract.

c) Guarantees shall apply only to the mixer as tested by the methods and in the test arrangements specified herein.

d) The relationship between the guarantee values under the conditions of the methods and test arrangements specified herein and the likely performance under other operating conditions shall be agreed in the contract.

5 Execution of tests

5.1 Subjects of tests

5.1.1 General

If not otherwise agreed between the manufacturer/supplier and the purchaser, the following shall apply:

- accuracy according to 6.2; and
- tests shall be carried out on the test stand of the manufacturer's works, or on a test stand engaged by the manufacturer/supplier.

Any deviations from this shall be agreed between the purchaser and manufacturer/supplier. This should be done as soon as possible, and should preferably form part of the contract.

Among others, such deviations may be

a) accuracy other than that given in 6.2,

b) tolerance factors other than those given in 6.3,

c) tests in a neutral laboratory.

Annex A shows a checklist of items where agreement between the purchaser and manufacturer/supplier is recommended.