BRITISH STANDARD

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Rotary positive displacement pumps — Performance tests for acceptance

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ICS 23.080

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National foreword

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English Version

Rotary positive displacement pumps - Performance tests for acceptance

Pompes volumétriques rotatives - Essais de performances pour la réception

Rotierende Verdrängerpumpen - Leistungsprüfung zur Abnahme

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This European Standard (EN 14343:2005) has been prepared by Technical Committee CEN/TC 197 “Pumps”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2006, and conflicting national standards shall be withdrawn at the latest by June 2006.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard describes specified types of acceptance tests for rotary positive displacement pumps for applications other than fluid power, excluding progressing cavity and peristaltic type pumps.

This European Standard applies to the testing of pumps with and without drivers.

This European Standard covers a selection of tests to establish a uniform demonstration of the pump's ability to perform satisfactorily. It does not, however, cover all tests that may be needed for particular pump types or applications, e.g. tests for hazardous liquids or single shaft multiple pump units. Furthermore, it does not cover any noise and vibration tests, priming tests nor any hydrostatic pressure tests. Some pump types with integral relief valves may require more extensive relief valve tests than described in this European Standard. For dosing and metering applications, further tests to demonstrate the dosing and metering abilities of the pumps may be necessary.

NOTE Extrapolation of test results to non-tested pumps is not described in this European Standard. Such extrapolation could be made for mass-produced pumps with reference to pertinent quality assurance methods and standards.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10204, *Metallic products — Types of inspection documents*

EN 12723:2000, *Liquid pumps — General terms for pumps and installations — Definitions, quantities, letter symbols and units*

EN ISO 10012, *Measurement management systems — Requirements for measurement processes and measuring equipment (ISO 10012:2003)*

3 Terms and definitions

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

3.1 General

For the purposes of this European Standard, the terminology, symbols and abbreviations as given in EN 12723:2000 apply.

3.2 Types of test

3.2.1 T1 flow test

test to verify that the pump flow is within a specified tolerance

3.2.2 T2 power test

test to verify that the input power is within specified tolerances

3.2.3 T3 inlet pressure test
test to verify that the pump operates satisfactorily without cavitation at specified inlet pressure conditions

NOTE The inlet pressure test T3 is not designed to establish the limit for cavitation, nor is it intended to establish the priming characteristics of the pump. Some guidance for priming tests is given in Annex B. Such a test, when required, may be made part of the test programme, but will require separate description of the test procedure and acceptance criteria, adapted to the subject type of pump.

3.2.4 T4 relief valve test
test to verify the pressure accumulation of a relief valve and its ability to reseat/close when the pressure is returned to normal

3.3 Test levels

3.3.1 L1 works test
manufacturers' internal quality assurance test. This test level is a pass/fail test without any formal recording requirements

3.3.2 L2 standard test
manufacturers' internal quality assurance test, with traceable records of pertinent test data

3.3.3 L3 order specified test
test to verify the performance of a pump or pump unit at specified conditions. Test data are recorded

3.3.4 L4 observed test
test to verify the pump or pump unit performance at specified conditions. The purchaser is given an opportunity to have a representative present at test. Test data are recorded

3.3.5 L5 witness test
test to verify the pump or pump unit performance at specified conditions. The purchaser needs a representative present at test (shall be a hold point). Test data are recorded

3.4 Other terms

3.4.1 test condition variables (TCV)
those variables, such as pressure, speed and viscosity, that are directly controlled by the test arrangement and its operation

3.4.2 test result variables (TRV)
those variables, such as flow and power consumption, that are obtained as a result of TCV and reflect the performance of the object under test

3.4.3 accuracy grade
set of instrumentation and test equipment accuracy requirements

3.4.4 tolerance class
set of tolerance requirements for TRV

3.4.5 pressure accumulation
for the purpose of this European Standard, pressure accumulation is considered as the difference between the maximum pressure observed during relief valve opening and the specified operating pressure. This value includes the margin between operating pressure and valve setting and the pressure increase by relief valve characteristic

4 Performance requirements

The supplier shall identify and specify in writing, prior to the test, the TCV values (test conditions) together with the corresponding requirement values of TRV (performance results) for each set. He shall also specify test level, accuracy grade and tolerance class relevant to the purpose of the test.

NOTE For test levels L3, L4 and L5 the TCV (test condition variables) values should be selected to conform as far as practical to the conditions of the order and agreed upon by manufacturer and purchaser.

Unless otherwise specified and agreed between purchaser and supplier, the following default values shall apply:

— test type: T1 Flow test
and, for pumps with integral valve or a valve directly attached to the pump body,
T4 Relief valve test

— test level: L2 Standard test

— accuracy: Grade 2

— tolerance: Class 2

5 Organisation

5.1 Responsibility for test

The supplier shall be responsible for the appointment of a competent and experienced person to be in charge of the tests. The supplier shall also be responsible for ensuring compliance with all relevant safety regulations and standards, unless testing is performed at an independent laboratory or at site, when conformity to safety regulations shall be ensured by the party responsible for the test location.

5.2 Test location

Unless otherwise specified, testing shall be carried out at the supplier's works. If so agreed between purchaser and supplier, the testing may be carried out either at an independent test facility or at site.

5.3 Test date

The supplier shall determine the date of test. For observed or witness test (level L4 and L5), a minimum of 10 calendar days notice shall be provided to the purchaser unless otherwise agreed in advance.

5.4 Test programme

The test procedure shall be described in a test programme prior to test. For observed test L4 or witness test L5, the test programme shall be made available to the purchaser prior to test.

The test programme shall include details on scheduling and responsibility for test, test methods and arrangements, performance requirements as per Clause 4 above, verification levels for inlet pressure tests T3, when applicable (see 9.4.2), sequence and timing of actions and observations, recording of test data, methods for data corrections (see 7.1), presentation of results etc.

6 Equipment

6.1 Test equipment

6.1.1 General

The pump under test shall be connected to a suitably dimensioned and rated test loop. Example of a test loop is given in Annex A. The test loop shall conform to the installation instruction given for the test pump. Special attention should be given to the alignment between pump and driver, possibilities to fill and drain the pump and to access for observation of leakage, vibration or other indications of malfunction.

When necessary, an auxiliary loop for conditioning of the liquid, i.e. heating, cooling and/or filtering, shall be provided, see 6.1.3 and 6.1.4.

6.1.2 Test liquid

The test liquid shall be a Newtonian liquid of known characteristics selected by the manufacturer. Necessary liquid data, such as viscosity-temperature relationship, shall be available at the test stand, either in tabulated or graphical form, indicating the liquid designation and the date of issue and latest revision.

The amount of test liquid shall be sufficient to allow it to settle in the tank and for this purpose the ratio of liquid volume to pump flow shall exceed 150 s, unless the purpose can be ascertained by other means, like highly efficient filtration and cooling.

6.1.3 Liquid temperature

Means shall be provided to maintain an inlet temperature to the pump during test, constant within ± 1,5 °C.

6.1.4 Liquid cleanliness

If necessary, adequate filtration in order to maintain the cleanliness of the liquid within the limits specified for the pump under test shall be provided.

6.1.5 Entrained air

For viscous test liquids and when otherwise so required, means shall be provided for separating un-dissolved air and gas from the test liquid in order to minimise the risk of air and other gases entering the pump. Such means may include for instance a sloping mesh in the tank or suitably arranged bleeder valves.

6.1.6 Driver

For tests on bare-shaft pumps, a suitable driver shall be selected, capable of maintaining constant speed at any given test point within ± 5 rpm.

6.1.7 Inlet pressure control device

When so required, a suitably dimensioned valve to control the inlet pressure shall be fitted in the inlet line. In fully open position it shall not cause any significant pressure drop. The type of such a valve and its position in the test loop shall be selected in such a way that cavitation in the valve is minimised and possible cavitation or release of dissolved gases in the valve does not influence the test. It shall generally be fitted as far from the pump as possible and as far below the pump inlet level as possible.

Any other relevant means to decrease inlet pressure, such as a pressure-controlled tank or changing the geodetic suction height, is acceptable.

6.1.8 Flow measurement

The flow meter shall be installed according to the relevant standards and instructions, and in a way to provide flow values referred to atmospheric conditions, unless otherwise agreed between manufacturer and supplier. This implies in most cases installation downstream of the loading valve and with an adequate back-pressure.

Any other relevant means to determine flow, such as volumetric or gravitational tanks, is acceptable.

6.1.9 Pressure measurement

Pressure gauges/transducers shall be fitted on inlet and outlet sides of the pump, as close to the pump as practically possible. Pressure tappings shall be external to the pump and preferably arranged on a straight pipe section.

6.2 Measurement equipment

6.2.1 General

To monitor and record the values to be measured, adequate instrumentation shall be used in accordance with EN ISO 10012. The type of instrumentation shall be selected by the pump supplier unless testing is performed at an independent laboratory or at site, when it is selected by the party responsible for the test location. The instrumentation shall meet the accuracy requirements below. Unless otherwise agreed with the purchaser, Grade 2 shall be selected.

6.2.2 Systematic uncertainties

The instrumentation for the measurement of each quantity shall have a sufficient accuracy to permit an overall systematic measurement uncertainty as per Table 1, referred to the entire measurement chain for each quantity, up to and including read-out and/or recording devices. The accuracy values shall be valid with reference to the actual observation.

Table 1 — Maximum measurement uncertainty

Quantity	Grade 1	Grade 2
Flow	± 2,0 %	± 4,0 %
Pressure	± 2,0 %	± 5,0 %
Torque	± 1,5 %	± 3,0 %
Temperature	± 2,0 °C	± 3,0 °C
Speed	± 0,35 %	± 1,4 %
Electrical power	± 1,5 %	± 3,5 %
Mechanical power (e.g. when using a calibrated driver)	± 2,0 %	± 5,0 %

6.2.3 Random uncertainties

Random uncertainties shall be eliminated by averaging, following the provisions of 7.2 and shall for the purpose of this European Standard be neglected.

6.2.4 Calibration of instruments

To verify the accuracy, a valid calibration certificate shall be available for each instrument. As a minimum, the certificate shall state requirement and result of the calibration, the calibration date, calibration method and tracability to national standards. The expiry date shall be shown on the calibration certificate, unless valid calibration intervals are available from a Quality Assurance Manual or similar document.

7 Test conditions

7.1 Test condition variables (TCV)

The pump shall be operated as close to the specified TCV-values as practically possible and preferably within the limits as per Table 2.

Table 2 — Maximum deviation from specified TCV (Test Condition Variables)

Quantity	Min.	Max.	
Discharge pressure	98 %	104 %	of TCV > 5 bars
Discharge pressure	0,1 bar below	0,2 bar above	TCV ≤ 5 bars
Inlet pressure	0,04 bar below	0,04 bar above	TCV ≤ 2 bars
Inlet pressure	98 %	102 %	TCV > 2 bars
Temperature	3,0 °C below	3,0 °C above	TCV
Speed	99 %	101 %	of TCV
Viscosity	95 %	105 %	of TCV

However, due to available mains frequency, required time for heating and cooling or other relevant factors, deviations from specified TCV (test condition variable)-values within the ranges specified in Table 3 shall be accepted, provided correction methods and formulas are stated in the written test programme and applied as per 9.1.3.

Table 3 — Maximum deviation from specified TCV (correction required)

Quantity	Min.	Max.	
Discharge pressure	95 %	150 %	of TCV
Inlet pressure	Above cavitation limit	0,2 bar above	TCV ≤ 2 bars
Inlet pressure	Above cavitation limit	110 %	TCV > 2 bars
Temperature	10 °C below	15 °C above	TCV
Speed	80 %	125 %	of TCV
Viscosity	60 %	200 %	of TCV

7.2 Fluctuations

Prior to taking observations for each measuring point, constant conditions shall prevail. Should fluctuations of the observed values remain, adequate measures to create average values shall be utilised in a manner described in the test programme. All values for one test point shall reflect the average over the same time span, not less than the time needed for 10 shaft revolutions.

For manual readings the display fluctuations shall not exceed ± 5 % of the observed value.

8 Test procedure

8.1 Pre-run data

Prior to test, except at work test level (L1), relevant general data shall be recorded, as a minimum:

— test date and test operator signature;

— pump nameplate information (e.g. designation and serial number);

— name of other test attendees;

— driver data and other relevant test arrangement information;

— references to the test programme;

— references to a list of the specific instrumentation used at test.

8.2 Operating the pump

8.2.1 General

Installation in the test stand and start-up of the pump shall be performed as per the relevant instruction manual. Adequate time to adjust and stabilise pump body temperature shall be allowed as well as time for stabilising liquid flow in tank and pipework. When this is satisfied, the test stand controls shall be operated to reach each pre-specified set of test condition variable (TCV)-values. Again the flow and temperature shall be given adequate time to stabilise before readings are taken.

Should indications of pump malfunction be observed, the test shall be discontinued and the fault corrected prior to rerunning the test from the beginning.

NOTE Different test types requires slightly different equipment and readings, but basically the test methods will be the same and as described in Clauses 8 and 9.

8.2.2 Special considerations for Inlet pressure test

Due to difficulties to detect cavitation on a PD pump, test method will vary with selected measurement accuracy grade as follows:

8.2.2.1 Method when accuracy Grade 1 is specified in the test programme:

Detection of cavitation shall be made with high frequency (> 20 kHz) noise monitor equipment at an inlet pressure of 0,05 bar below the specified TCV (test condition value).

8.2.2.2 Method when accuracy Grade 2 applies:

Detection of cavitation shall be made as per 8.2.2.1 above or the satisfactory operation verified visually as follows:

The inlet pressure shall be regulated from a value higher than the specified test value downwards until cavitation is indicated or inlet pressure is at least 0,2 bar lower than the specified test condition variable (TCV)-values. During the test, speed and differential pressure shall be kept constant.

The onset of cavitation shall be indicated by the first occurrence of the following observations:

— a change in flow of more than 3 % at constant speed and constant differential pressure;

— a disproportionate noise change;

— a disproportionate change of vibrations;

— a disproportionate change of pressure pulsation;

— any other disproportionate change in the pump comportment.

8.2.3 Special considerations for relief valve test

When so required, a relief valve test shall be made after the flow test, with the observed flow value used for reference. The pressure is monitored as the discharge control device is fully closed and immediately reopened to the pressure level defined by TCV (test condition variables). The maximum pressure during the process is to be recorded and the process is to be repeated 4 times. After each cycle a flow reading is to be taken to establish that the valve reseats properly.

8.3 Collection of test data

8.3.1 General

Observations shall include test condition variable (TCV)-values and test result variable (TRV)-values for each test point as specified in the test programme. The values shall be read and recorded without rounding and for manual analogue readings normally with an estimated fraction between scale divisions. All values for one test point shall reflect the average over the same time span, see also 7.2.

8.3.2 Unexpected events

The observations shall include notes of unexpected events and possible malfunction as observed by the test operator, e.g. external leakage or excessive vibrations or noise.

8.3.3 Inlet pressure test (T3)

The inlet pressure value at the onset of cavitation shall be recorded (see 8.2.2).

8.3.4 Relief valve test (T4)

Observations shall include at least 4 readings of maximum differential (discharge and inlet) pressure values when slowly throttling the discharge until fully blocked and then reopening it to initial position, see 8.2.3. If the valve has a separate return line, the return line pressure shall be used instead of the pump inlet pressure. After each cycle, the flow value at TCV (test condition variables) shall be recorded.

8.4 After test

The body and the moving parts of the pump shall not be disassembled after test, unless so agreed between supplier and purchaser.

If so specified in the test programme, adequate markings shall be stamped on the pump body and/or other vital components.

9 Evaluation and test report

9.1 Readings and primary data

9.1.1 Conversions

Where applicable, recorded data shall be converted to primary test data, expressed in predetermined units, by using instrument factors and constants as directed in relevant instructions.

EXAMPLE A reading of 4,3 mV shall be converted to 21,93 bars, assuming the instrument factor is 5,1 bar/mV.

No rounding shall be performed at this stage.

9.1.2 Corrections for pressure readings

Correction of pressure readings for gauge level deviations from the horizontal datum plane through the centre of the pump pipe connection, for flow velocity at gauge tapping and for pressure drop between tapping and pump connection is allowed, if required to maintain the over-all accuracy stated in 6.2.2.

9.1.3 Test condition corrections

When specified in the test programme, all TRV (test condition variable)-values shall be recalculated from observed TCV (test condition variable) conditions to specified TCV conditions, see 7.1.

9.1.4 Derived results

From primary data, derived results may be obtained, by combination of primary data or by retrieving dependent tabulated data.

EXAMPLE 1 Input mechanical power is derived from the product of shaft speed and torque.

EXAMPLE 2 Viscosity is derived from temperature by retrieving data from a tabulated or graphical representation of the temperature viscosity relationship.

9.1.5 Relief valve test result

The pressure accumulation shall be considered the difference between the average of the 4 discharge pressure readings per 8.3.4 and the observed differential pressure at TCV (Test Condition Variables). The relief valve closing capability shall be represented by the difference between the lowest of the flow values after each test cycle and the reference flow value at TCV as mentioned in 8.2.3, divided by the reference flow value.

EXAMPLE Reference flow value 100 l/min at differential pressure 3 bar.
Observed maximum differential pressures at relief valve test 4,5 bar; 4,7 bar; 4,6 bar and 4,6 bar
Observed flow values 101 l/min, 99 l/min, 100 l/min, 101 l/min

Maximum differential pressure result: 4,6 bar, pressure accumulation is 1,6 bar (= 4,6 – 3,0)
Closing capability: (99 – 100)/100 = - 1 %

9.1.6 Other corrections

No corrections of recorded values are allowed beyond those described in 9.1.1 to 9.1.3.

9.2 Accuracy

After correction the observed performance values (TRV, test result variables) shall be rounded to 3 significant digits.

9.3 Acceptance limits

The acceptance limits shown in Table 4 shall be applied on each value of the TRV (test result variables) requirements per Clause 4, yielding an upper limit L_u and a lower limit L_l. These limits shall be rounded to 3 significant digits. Where N/A is stated, L_l shall be 0 and L_u shall be infinity.

Unless otherwise agreed, Class 2 shall apply.

Table 4 — Acceptance limits relative to specified values

	Class 1		Class 2	
TRV (test result variable) quantity	**low**	**high**	**low**	**High**
Flow	- 0 %	+ 10 %	- 0 %	N/A
Mechanical power	N/A	+ 0 %	N/A	+ 0 %
Torque	N/A	+ 0 %	N/A	+ 0 %
Electrical power	N/A	+ 0 %	N/A	+ 0 %
Relief valve accumulation	N/A	+ 0 bar	N/A	+ 2 bar
Relief valve closing	- 2 %	+ 2 %	- 5 %	+ 2 %

9.4 Evaluation

9.4.1 General pass/fail criteria

For each specified test type and each specified TRV (test result variable)-value the following relation shall apply:

$L_l \leq$ respective TRV-value $\leq L_u$

If this relation holds true for all TRV-values at all specified TCV-points, the pump or pump unit has passed the test, otherwise it has failed.

EXAMPLE A flow requirement is 100 l/min and the corresponding power requirement is 7,2 kW. Class 2 tolerance is specified. Observed values, after correction and rounding is 102 l/min and 7,20 kW.

Evaluating the above relation will give:

— for flow: $L_l = 100$, $L_u = \infty$ ==> $100 \leq 102 \leq \infty$ TRUE

— for power: $L_l = 0$, $L_u = 7{,}20$ ==> $0 \leq 7{,}20 \leq 7{,}20$ TRUE

As the test relation yields TRUE on both the observed values, the pump has passed the test.

9.4.2 Criteria for Inlet pressure test

When the inlet pressure at the onset of cavitation as per 8.3.3 is lower than the specified value for inlet pressure, the pump has passed this test. With equal values or recorded value higher than specified, the pump has failed this test.

9.4.3 Criteria for relief valve test

Evaluation of pressure accumulation is based on the stated value according to TRV (test result variables) and the acceptance limits as per Table 4 above.

NOTE Specified TRV for closing capability should be 0%, unless otherwise contractually agreed.

EXAMPLE Reference flow value 100 l/min at differential pressure 3 bar
Observed maximum differential pressures at relief valve test 4,5 bar; 4,5 bar; 4,6 bar and 4,6 bar
Observed flow values 101 l/min, 99 l/min, 100 l/min, 101 l/min

Stated pressure accumulation requirement: + 1,7 bar Stated relief valve closing 0 %

Maximum differential pressure result: 4.6 bar, pressure accumulation is 1,6 bar (= 4,6 – 3,0)
Closing capability: (99 – 100)/100 = - 1 %

Evaluating the above relation by class 2 tolerances will give:

— for accumulation: $L_l = -\infty$, $L_u = 1{,}7$ ==> $-\infty \leq 1{,}6 \leq 1{,}7$ TRUE

— for closing: $L_l = -5\ \%$, $L_u = +2\ \%$ ==> $-5\ \% \leq -1\ \% \leq 2\ \%$ TRUE

9.5 Test report

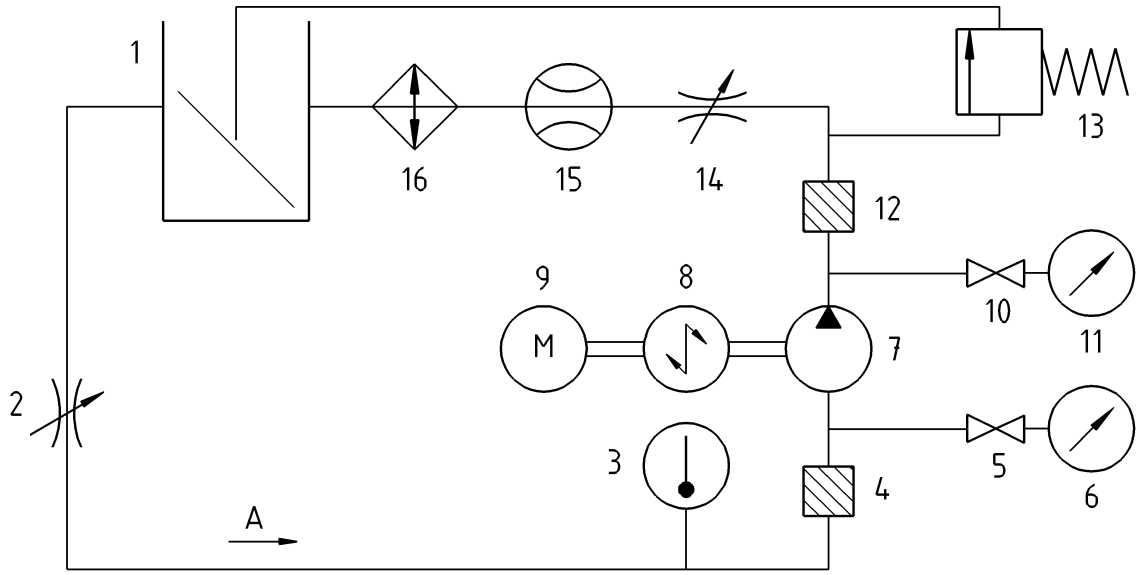
For test levels L3, L4 and L5 and otherwise when so required per the test programme, an inspection document conforming to EN 10204 shall be issued. The report shall refer to this European Standard and identify the pump/pump unit and state the types, levels, accuracy grade and tolerance class of the tests performed, including the data as per 8.1. It shall further show test result details and state the outcome of the test evaluation. If so agreed, it shall also contain specific test accuracy analysis results, relevant to the test results obtained.

For inspection documents per EN 10204, the following types shall be preferred:

Test level	Inspection document designation	
L1	2.2	Declaration of compliance with the order
L2	2.3	Test report
L3	3.1B	Inspection certificate 3.1
L4	3.1B	Inspection certificate 3.1
L5	3.2	Inspection certificate 3.2

Annex A
(informative)

Example of rotary displacement pump test loop



Key

1 Test tank with baffle
2 Inlet throttling device
3 Thermometer
4 Optional inlet stabilizer
5 Gate valve
6 Pressure gauge
7 Test pump
8 Torque transducer (if necessary)
9 Driver
10 Gate valve
11 Pressure gauge with optional dampening device
12 Optional output stabilizer
13 Safety relief valve
14 Discharge control device
15 Flowmeter
16 Optional heat exchanger
A Flow

Figure A1 – Example of a PD pump test loop

Annex B
(informative)

Priming test

B.1 Priming test

For many positive displacement pumps, the priming ability (the ability to fill its own suction line at start-up) is a major performance feature. Many manufacturers have a company specific test procedure to determine the priming ability of their pumps.

The priming ability depends on many factors and the vast and varying fields of application has made it impossible to generate and agree upon a general test code. Some of these factors are related to the pump, its type, clearances, shaft seal, wear status; others of the installation, for example suction height, volume of suction line, vapour pressure and others again on the process, like pump speed, if the pump is wet or not and the counter pressure during priming. So, the supplier is recommended to describe the testing procedure and acceptance criteria in the Quality Assurance Manual.

The following procedure is commonly used and is given as an example. The pump is pumping on the test rig with its discharge valve fully open. By turning a 2-way 3-port valve on the suction line close to the pump, the pump draws air for 10 s, then the suction line is closed for 5 s, reopened for 10 s etc. This process is repeated until the pump has drawn air 3 times and the maximum vacuum generated by the pump is recorded.

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