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# Centrifugal pumps — Test procedure for seal packings

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A list of organizations represented on this committee can be obtained on request to its secretary.

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EUROPEAN STANDARD

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# EN 16752

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English Version

# Centrifugal pumps - Test procedure for seal packings

Pompes centrifuges - Procédure d'essai pour garnitures tressées

Kreiselpumpen - Abnahmeprüfung für Packungen

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## European foreword

This document (EN 16752:2015) 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of an identical text or by endorsement, at the latest by March 2016, and conflicting national standards shall be withdrawn at the latest by March 2016.

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# 1 Scope

This European Standard gives details of a test procedure for packings to be used to seal the stuffing boxes of centrifugal pumps. It gives provisions on the design of test equipment, standard test parameters and reporting criteria. It does not specify performance criteria which should be agreed between supplier and customer, but does define 3 tightness classes.

When necessary, this European Standard is also applicable to packings used on other rotary equipment such as mixers and agitators.

# 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 286-2, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts (ISO 286-2)*

# 3 Terms and definitions

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

**3.1**
**stuffing box**
space into which compression packing is inserted

Note 1 to entry: Stuffing box is also known as packing gland.

**3.2**
**gland follower**
part that provides into a stuffing box to compress a packing set or a packing ring

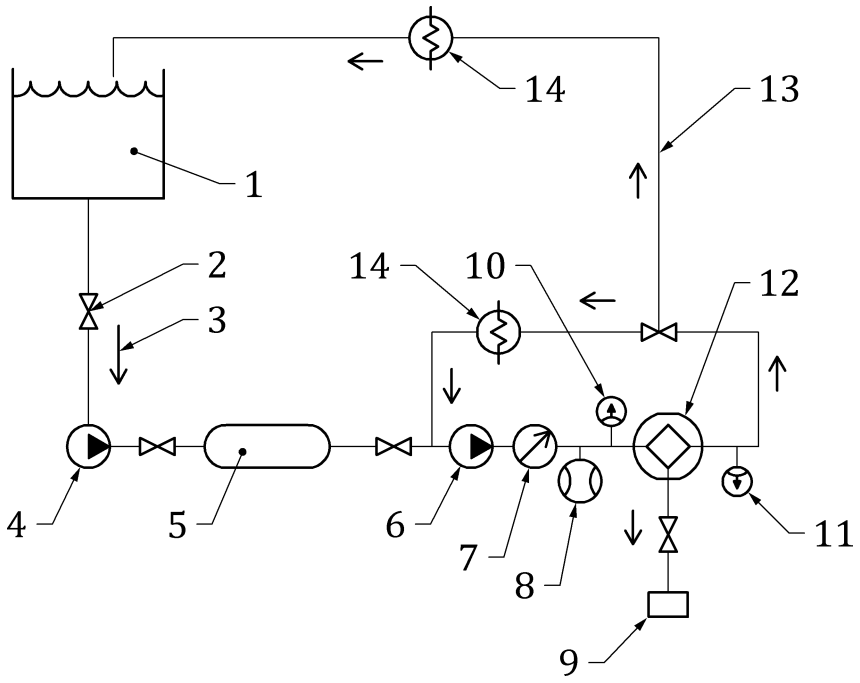
**3.3**
**shaft**
metal rod connecting the impeller of a pump to the motor

**3.4**
**leakage**
flow of liquid permitted to pass the packing

**3.5**
**housing bore**
dimension of the annular space that packing is inserted into

# 4 Test facility, testing apparatus

The test facility shall be arranged as described in Figure 1.

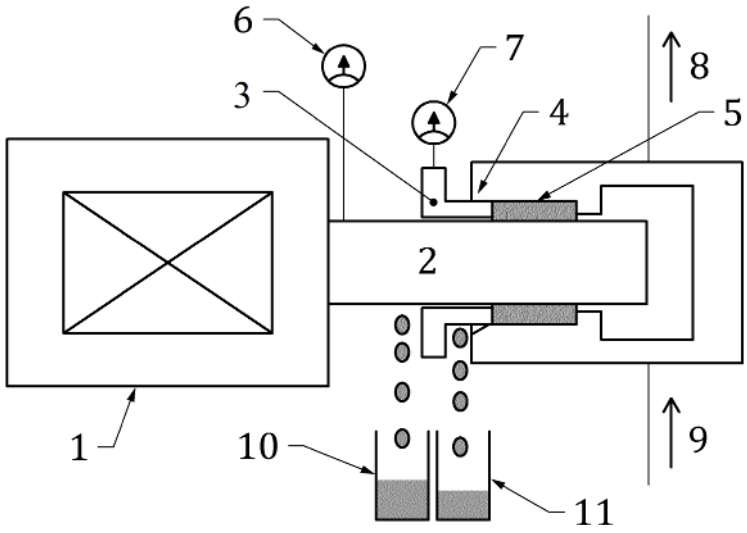



**Key**

1 tank
2 valve
3 direction of flow
4 pump
5 pressure container
6 water circulation pump
7 pressure gauge
8 flow measurement
9 drain
10 inlet temperature gauge
11 outlet temperature gauge
12 testing apparatus
13 alternate return line
14 heat exchanger

**Figure 1 — Test arrangement**

The testing apparatus shall be compliant with the description given in Figure 2. In particular, it shall consist of a suitable housing for retaining the test fluid and either one or more stuffing boxes to house the test packing. Each stuffing box shall be fitted with a gland follower and suitable retaining plate capable of controlled axial adjustment. There shall be a test shaft mounted on suitable bearings and attached to a suitable drive mechanism.




**Key**

1 motor
2 test shaft
3 gland follower
4 stuffing box
5 test packing
6 torque measurement
7 gland follower temperature
8 water in
9 water out
10 shaft leakage measurement
11 gland leakage measurement

**Figure 2 — Testing apparatus details**

The testing apparatus shall also conform to the following additional requirements:

a) the shaft speed shall be controlled within a maximum variation of ± 5 %;

b) the test head shall be designed and constructed so as to maintain stuffing box bore alignment relative to the shaft axis within 0,10 mm;

c) the design of the test head and support shall ensure minimum vibration;

d) the surface roughness of the stuffing box bore shall be no worse than 1,6 µm Ra. The surface roughness of the shaft shall be no worse than 0,4 µm Ra and the shaft shall be free of helical machine marks;

e) shaft and housing shall be manufactured from corrosion resistant stainless steel (e.g. 1.4016 or 1.4404 in accordance with EN 10088-1) without surface coating and shaft hardness shall be 40 HRC minimum;

f) the tolerances on shaft and stuffing box bore shall be h10 and H10 respectively in accordance with EN ISO 286-2;

g) the test fluid shall be circulated through the test housing at a rate such that the temperature of the test medium entering the housing remains constant within ± 5 °C and the outlet temperature is no more than 10 °C higher than the inlet temperature;

h) means shall be provided for collecting and measuring the volume of fluid leakage during the test, the leakage from the shaft and stuffing box bore sides shall be measured separately;

i) means shall be provided to measure the temperature of the fluid as it enters and leaves the test housing and the temperature of the gland follower within (3 ± 0,5) mm of the outer packing ring (i.e. packing temperature). In particular, a probe shall be positioned in a blind hole drilled axially into the gland follower;

j) means shall be provided to measure frictional power consumption of the packing. This shall be achieved by continuous torque measurement. The following value, called hereafter Normalized Power Consumption, shall be then calculated by taking the power in Watts divided by the packing contact area in square metres divided by the speed in metres per second – rationalised to $Ws/m^3$.

$$\text{Normalized Power Consumption } (W.s/m^3) = \frac{P(W)}{Sc\left(m^2\right) \times linear\ rotation\ speed\left(m/s\right)}$$

With dissipated power $P(W) = T(N \cdot m) \times \omega(rad/s)$ where $T$ is the measured torque

With $\omega(rad/s) = \frac{2\pi}{60} \times rotation\ speed(rpm)$

With Surface contact **Sc ($m^2$) = π x D (m) x L (m)** where $D$ is shaft diameter and L is packing height

With linear rotation speed (m:s) = $\frac{rotation\ speed(rpm) \times \pi \times D(m)}{60}$ where $D$ is shaft diameter

The test packing shall be made of 4 pre-formed rings or 4 rings of packing cut from length form material to size, cut with a 'skive' (diagonal) cut in accordance with installation good practice.

NOTE FSA/ESA gives guidelines for good practice in the document Compression Packing Technical Manual (3rd Edition).

## 5 Pre-test procedure

Prior to the installation of rings in the stuffing box, the following steps shall be undertaken:

1) Inspect the packing for conformity to its specification and measure and record its cross-section dimensions: measure the radial cross-section of each ring at two diametrically opposite positions and record the average section of the whole set and the overall set depth.

2) Measure and record the shaft and housing bore diameters and their surface roughness.

3) Weigh each ring and record the weight of the set.

## 6 Installation

The 4 rings of packing in each stuffing box shall be installed as follows:

— Install one ring at a time. Make sure it is clean and has not picked up any dirt in handling.

— Seat rings firmly (except PTFE filament and graphite yarn packings to which only sufficient pre-load should be applied to ensure full axial contact and then tightened gradually after start up).

— Joints of successive rings should be staggered and kept at least 90 degrees apart. Each individual ring should be firmly seated (no axial gaps between the rings) with a tamping tool, or suitable split bushing fitted to the stuffing box bore. When enough rings have been fitted so that the nose of the gland will reach them, individual tamping should be supplemented by the gland.

— After the 4th ring is installed, take up gland bolts finger tight. Do not jam the packing into place by excessive gland loading.

— Lantern or spacer rings shall not be fitted between packing rings.

# 7 Test conditions

## 7.1 General

Any additional tests carried out under different conditions than specified (e.g. other media, pressure, speed, etc.) should be reported.

All tests shall be carried out at ambient temperature, i.e. the fluid shall enter the test housing at 20 °C with a possible deviation of +10/-5 °C.

## 7.2 Test medium

The test medium shall be clean water.

## 7.3 Shaft diameter

The shaft diameter shall be between 40 mm and 65 mm inclusive.

## 7.4 Packing cross section

The nominal packing cross-section shall be between 9,5 mm and 12,7 mm inclusive.

## 7.5 Surface speed

Packings shall be tested at one steady speed rating, chosen between 8 m/s and 9 m/s inclusive.

## 7.6 Pressure

Packings shall be tested at the steady pressure rating of 0,6 MPa with a possible deviation of ± 0,1 MPa, and the pressure shall be monitored within the test housing.

## 7.7 Tightness-classes

Test shall be performed in order to achieve one of the three following Tightness classes T1, T2 or T3 during the 100 h test period (that is, excluding the break-in period), corresponding to the following total leakage levels:

T1 = less than or equal to 5 ml/min

T2 = less than or equal to 15 ml/min

T3 = less than or equal to 30 ml/min

# 8 Test Procedure

## 8.1 Break-in period

The following steps critical to get optimum packing performance during test shall be undertaken:

— Pressurize the test housing and rotate the shaft at the selected test speed.

— Adjust the compression on the packing to allow liberal leakage (around 15 ml/min to 30 ml/min) as it beds in and then adjust compression to give the desired leakage class, without causing excessive or fluctuating packing temperature.

— Record the total number of any adjustments to compression and the total compression applied during the break-in period. Record the leakage rate at the end of the break-in period (measure the leakage over a 5 min period and record the average).

The actual duration of the breaking period shall be recorded.

NOTE Typically the total break-in period will be of less than 1 h duration but this is sometimes extended in order to achieve stable performance.

### 8.2 Test duration

At time zero, that is, after the end of the break-in period (i.e. once the packing is exhibiting stable leak rate and temperature) the power consumption and temperatures shall be recorded (see Clause 4 for details on provisions).

The packing shall then be tested continuously for a minimum duration period of 100 h

### 8.3 Result recording

The following data shall be recorded: the accumulative leakage, power consumption and gland temperature at least four times per 24 h period and at the end of the test period (plus, prior to, and after, gland adjustments, see 8.4 below).

### 8.4 Gland adjustments

Excluding the break-in period, a maximum of 3 gland adjustments may be made during the test period itself and the accumulative leakage, power consumption and gland temperature shall be recorded immediately prior to each adjustment and 30 min thereafter. No gland adjustment shall be made less than one hour before completion of the total test period.

### 8.5 Number of tests

A minimum of 2 complete tests shall be carried out for each packing type.

### 8.6 Test completion

At the end of the test period the packing, including any packing residue adhering to the shaft or housing shall be removed. The packing and residue shall be dried for a minimum of 4 h at 80 °C and then allowed to cool naturally to room temperature and reweighed. The condition of the packing shall be reported including weight loss/increase and compression. The condition of the shaft shall also be recorded.

## 9 Reporting

For each test, the data shall be collected and combined on a seal test report and graphically represented, see Annexes A and B for examples.

The graphical representation shall include the following data plotted against time:

— inlet temperature;

— outlet temperature;

— gland temperature;

— pressure;

— shaft leak rate;

— gland leak rate;

— Normalized Power Consumption.

The time which any adjustment is made shall be indicated.

When publishing results for consumption by potential users the results for a minimum of two tests shall be reported and the following data shall be included:

— current standard number;

— packing type including sufficient information for traceability (e.g. batch number, etc.);

— test duration - the actual duration shall be quoted;

— test speed - the actual speed shall be quoted;

— test pressure - the actual pressure shall be quoted;

— average power consumption (excluding the break-in period);

— tightness class achieved;

— average gland temperature during test duration (excluding the break-in period).

The complete report shall be made available to the users on request.

# Annex A
(normative)

# Packing test report template

**Company:**_____ **Test Date:** / /

***Set Information*** ***Test Ref:*** _____

Packing Name _____

Identification reference _____

Length form or Die-form Rings_____

Set dimensions (mm) I/D _____ O/D_____ Depth_____

Set weight (g) _____

Shaft and housing inspected and cleaned ☐

Shaft surface roughness (µm) _____ Bore surface roughness (µm) _____

Actual shaft diameter (mm) _____ Actual bore diameter (mm) _____

***Shaft speed***

**8–9 m/s**; precisely _____m/s

***Test Pressure***

**0,6 MPa;** precisely _____ MPa

***Test Duration***

**100 h** precisely _____ h

***Break-in period results***

| Total duration (min) | Total number of adjustments | Total compression applied (mm) | Leakage rate at end (ml/min) |
|---|---|---|---|
| | | | |

Record leakage rate at end over a 5-minute period and report the average figure.

***Test period results***

Results to be registered in the following table if continuous monitoring is not taking place. All the results of

| Time (h) | Accumulative compression (mm) after break-in | Accumulative leakage (ml) | | Torque (Nm) | Temperature (°C) | | | Adjustment (**X** here if the reading is associated with a gland adjustment) |
|---|---|---|---|---|---|---|---|---|
| | | Shaft | Gland | | Gland | Inlet | Outlet | |
| Start | 0 | 0 | 0 | | | | | |
| | | | | | | | | |
| | | | | | | | | |
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| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| End | | | | | | | | |

Set weight dry (g): _____ % weight loss: _____

Set height after (mm): _____ % height loss: _____

Average leakage rate (ml/min): ___Shaft leakage (ml/min): ___Gland leakage (ml/min):___

Average gland temperature (°C): _____

Normalized average power consumption (Ws/m$^3$): _____

***Packing condition at end of test:*** (please **X**)

| **Condition** | **None** | **Slight** | **Heavy** |
|---|---|---|---|
| Surface hardening/glazing | | | |
| Extrusion | | | |
| Fraying | | | |

***Shaft condition at end of test:*** (please **X**)

| **Condition** | **None** | **Slight** | **Heavy** | **Rough** |
|---|---|---|---|---|
| Visible wear | | | | |
| Thermal Colour change | | | | |

***Comments:***

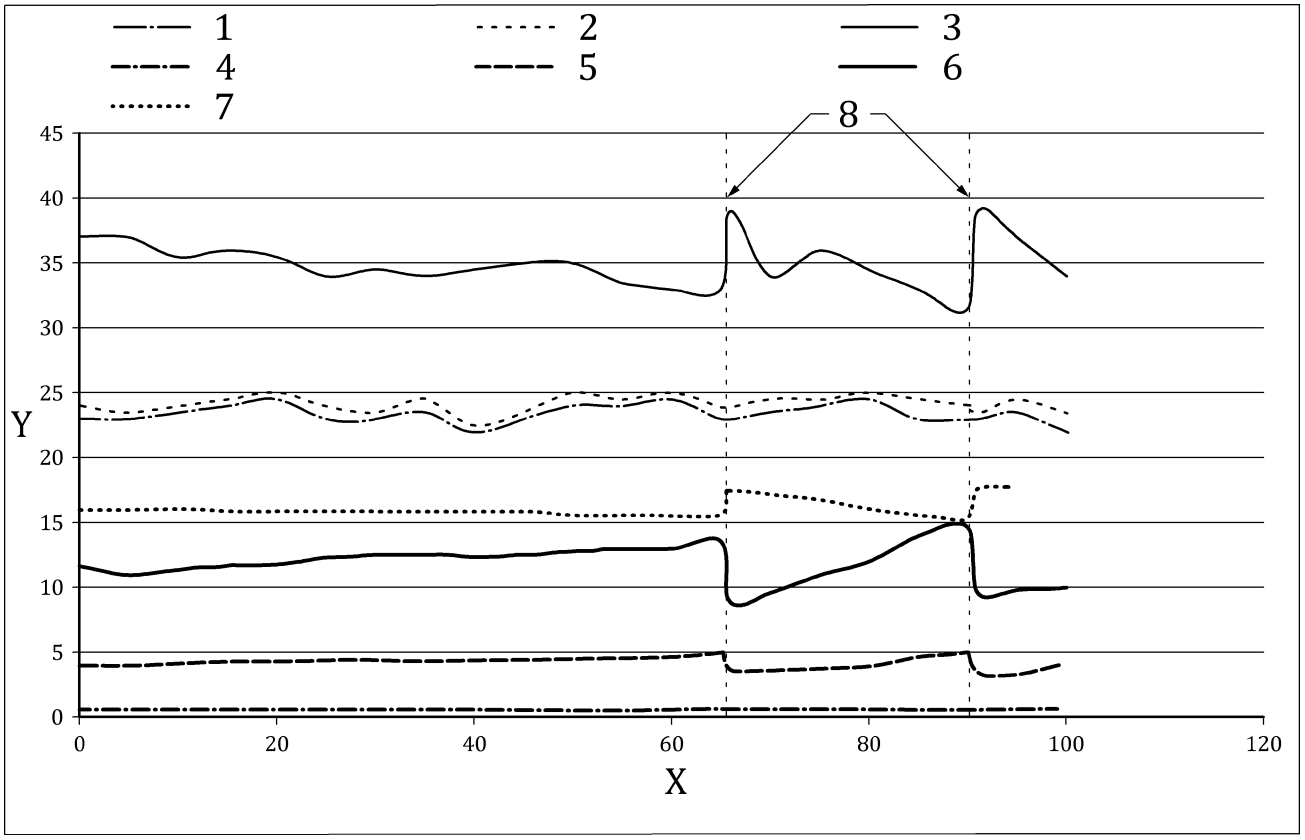
_____
_____
_____

**Signature: _____**

# Annex B
(informative)

# Typical graphical representation of results

Figure B.1 gives an example of representation of results.




**Key**

X test time (hours)
1 inlet temperature °C
2 outlet temperature °C
3 gland temperature °C
4 pressure MPa
5 shaft leak rate ml/min
6 gland leak rate ml/min
7 normalized power consumption $Ws/m^3$
8 adjustment

**Figure B.1 — Example of representation of results**

# Bibliography

EN 10088-1, *Stainless steels — Part 1: List of stainless steels*

ESA Publication N°PD001/2010, *Specification for a test procedure for packings for rotary applications*

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