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Centrifugal pump — Test methods

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Rwanda Standards Board

P.O Box 7099 Kigali-Rwanda

KK 15 Rd, 49

Tel. +250 788303492

Toll Free: 3250

E-mail: info@rsb.gov.rw

Website: www.rsb.gov.rw

ePortal: www.portal.rsb.gov.rw

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Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

DRS 249 was prepared by Technical Committee RSB/TC 23, *Road vehicles.*

This second edition cancels and replaces the first edition (RS 249: 2014), clause 3.6 (formula) / which has been technically revised.

Committee membership

The following organizations were represented on the Technical Committee on *Road vehicles* (RSB/TC 23) in the preparation of this standard.

Ministry of Infrastructure (MININFRA)

OX Delivers

Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA)

University of Rwanda College of Science and Technology (UR-CST).

Volkswagen Rwanda

Rwanda Standards Board (RSB) – Secretariat

Centrifugal pump — Test methods

1 Scope

This Draft Rwanda Standard specifies the methods for centrifugal, mixed flow and axial flow water pumps.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

RS 241, *Agricultural machinery — Method of sampling*

3 Terms and definitions

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

3.1

axial flow pump

type of pump which develop most of the suction and discharge head by propelling or lifting action of the impeller vanes on the water

3.2

base plane datum elevation

for horizontal shaft pumps, the distance from the level of water source to the centerline of the pump shaft; for vertical single suction pumps (volute and diffusion vane type), the distance from the entrance eye to the first stage impeller; for vertical double suction pumps, the distance from the level of water source to the impeller discharge horizontal centerline

3.3

cavitation

formation of cavities filled with water vapour due to local pressure drop and collapse as soon as the vapour bubbles reach regions of high pressure

3.4

centrifugal pump

type of pump with vanes or impellers rotating inside a close housing which draws water into the pump through a central inlet opening and forces water out through a discharge outlet at the periphery of the housing by means of centrifugal force

3.5

discharge

volume of water pumped per unit time

3.6

friction head, h_f

equivalent head required to overcome the friction caused by the flow through the pipe and pipe fittings

$$hf = f\left(\frac{L}{D}\right) * \frac{v^2}{2g} \text{ or } hf = f\,\frac{8LQ^2}{\pi^2 D^5 g}$$

where

L is the length of the pipe, m

Q is the discharge, m3/s

D is the internal diameter of pipe, m

f friction factor

v is velocity of liquid through the pipes.

g is acceleration due to gravity

3.7

head

quantity used to express a form (or combination of forms) of the energy content of the liquid per unit weight of the liquid referred to any arbitrary datum

3.8

mixed flow pump

type of pump which combines some of the features of both centrifugal and the axial flow pump and in which head is developed partly by the centrifugal force and partly by the lift of the vanes on the water

3.9

net positive suction head-NPSH

total suction head determined at the suction nozzle (corrected to pump centre line) minus the vapour pressure of water at the pumping temperature

3.10

net positive suction head available (NPSHA)

NPSHA as determined from the actual suction piping conditions

$$\text{NPSHA}=\left(\frac{P_a-P_{vp}}{y}\right)=H_s$$

where

Pa is the atmospheric pressure, kg/m^2

Pvp is the vapour pressure, kg/m^2

y is the specific weight of water, kg/m^3

Hs is the total suction lift/head, m

3.11

net positive suction head required (NPSHR)

performance characteristic required of the pump and is the NPSH at the pump inlet

3.12

performance curve

curve which represents the interrelationship between capacity, head, power, NPSH and efficiency of the pump

3.13

pump

device that is used to lift or transfer water from one source to another

3.14

priming

filling up the pump with water to displace or evacuate the entrapped air through a vent and create a liquid seal inside the casing

3.15

pump efficiency (ηp)

ratio of the power output to the power input of the pump

3.16

shaft power

power required at the pump shaft

3.17

static discharge head (hd)

vertical distance from the centre line of the pump to the discharge water level

3.18

static suction head (hs)

vertical distance from the free suction water level to the centre line of the pump

Note 1 to entry: It exists when the source of water supply is above the centre line of the pump.

3.19

static suction lift (hs)

vertical distance from the free suction water level to the centre line of the pump

Note 1 to entry: It exists when the source of water supply is below the centre line of the pump.

3.20

total discharge head (Hd)

sum of static discharge head, friction, and exit losses in the discharge piping plus the velocity head and pressure head at the point of discharge

Note 1 to entry: As determined on test, it is the reading of a pressure gauge at the discharge pipe of the pump referred to datum plus velocity head at the point of gauge attachment.

3.21

total head (TH)

measure of energy increase imparted to the water by the pump and the algebraic difference between the total discharge head and total suction head

Note 1 to entry: Total head, as determined on test where suction lift exists, is the sum of the total discharge head and total suction lift. Where positive suction head exists, the total head is the total discharge head minus the total suction head.

3.22

total suction head (Hs)

vertical distance from the centre line of the pump to the free level of the water to be pumped minus all friction losses in suction pipe and fittings, plus any pressure head existing on the suction supply

Note 1 to entry: As determined on tests, it is the reading of a gauge at the suction of the pump referred to datum plus the velocity head at the point of gauge attachment. Suction head exists when the total suction head is above atmospheric pressure.

3.23

total suction lift (Hs)

sum of static suction lift, friction and entrance losses in the suction piping

3.24

velocity head (hv)

pressure expressed in meters required to create the velocity of flow, it is specifically defined by the expression:

$$H_V = \frac{V_2}{2g}$$

where

V_2 is the velocity in the pipe and is obtained by dividing the discharge by the actual area of the pipe cross-section and determined at the point of gauge connection, m/s

g is the acceleration due to gravity, m/s^2

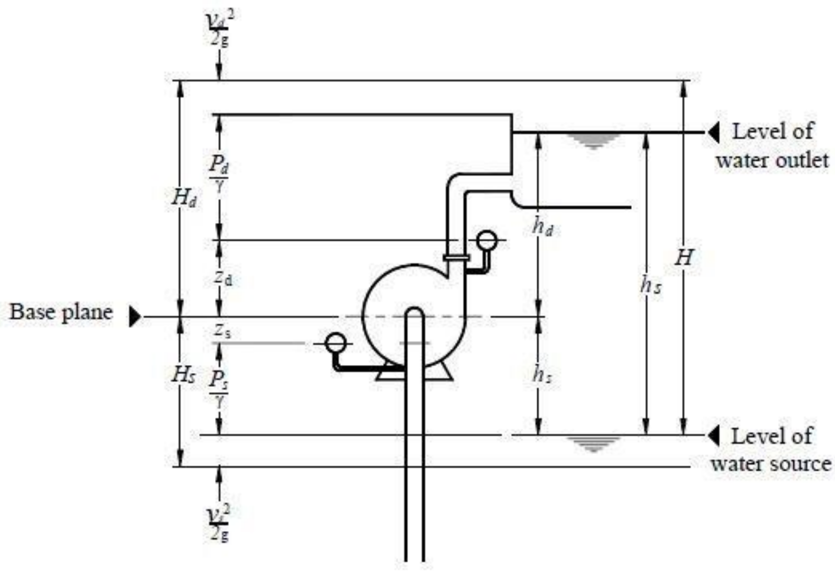

Figure 1 — Measurement of head

3.25

water power

theoretical power required for pumping

4 General conditions for test and inspection

4.1 Pump on test

The pump on test shall be commercially produced or prototype unit of pumps depending upon the test objective. In the case of testing for commercially manufactured pumps, the pump submitted for test shall be sampled in accordance with RS 241.

4.2 Site of test

The pump shall be tested in a laboratory using a test rig. In the case of pump permanently installed, it shall be tested at the site where it is installed.

4.3 Materials and equipment

4.3.1 Water

The water to be used during the test shall be clean with a temperature range of 10 ºC – 40 ºC.

4.3.2 Measuring instruments

4.4.2.1 The gauges to be used for head measurements shall be water columns or manometers. For a relatively high pressure, mercury manometer, bourdon gauges, electrical pressure transducers or dead weight gauge testers shall be used. Pressure gauges shall be attached as specified in Annex A.

4.4.2.2 For measuring discharge, the equipment to be used for relatively small flow rates shall be weighing tank. For relatively large flow rates, the weir, venturi, nozzle, orifice plate and pitot tube shall be used.

4.4.2.3 For measuring pump input power, a dynamometer or a calibrated prime mover shall be used.

4.4.2.4 All instruments to be used for test shall be calibrated.

4.3.3 Suction lift / head

The testing of pump shall be conducted on the smallest attainable suction head/lift to attain the basic performance curve of the pump.

4.3.4 Ambient conditions

The ambient conditions such as atmospheric pressure, temperatures (dry bulb and wet bulb) and relative humidity shall be recorded at equal interval during the test.

4.3.5 Suspension of test

If during the test run, the pump stops due to breakdown or malfunction so as to affect the pump's performance, the test shall be suspended at the discretion of the test engineer and concurred by the company representative.

5 Tests and inspection

5.1 Verification of manufacturer's technical data and information

5.1.1 This inspection is carried out to verify the mechanism, main dimensions and materials and accessories of the pump in comparison with the list of manufacturer's technical data and information.

5.1.2 A plain and level surface shall be used as reference plane for verification of dimensional pump specifications.

5.2 Performance test

5.2.1 This is carried out to determine/establish the performance characteristics of the pump.

5.2.2 The test shall be conducted by operating the pump at manufacturer's recommended speed. The discharge and total head shall be varied by regulating the valve on the discharge side. In the case of pump to be tested in actual site, the actual measurements of the following shall be obtained:

a) static suction lift;

b) static discharge head;

c) size and length of the pipes from coupling; and

d) number of bends of piping.

5.2.3 Data measurements shall be obtained at the following specified measuring points:

a) in the testing of a centrifugal pump, measurements shall be taken on not less than ten different discharge values starting from no-discharge state to the maximum flow rate possible, and at least of one these shall be measured at a head lower than the specified head.

b) in the testing of a mixed flow pump, measurements shall be taken on not less than ten different discharge values extending from the lower to the maximum flow rate possible within a range of over and below the specified head.

c) in the testing of an axial flow pump, measurements shall be taken on not less than ten different discharge values extending from full maximum to the minimum discharge values possible, and at least one of these shall be measured at a head higher than the specified head.

5.2.4 During the test, the following shall be taken:

a) reading of vacuum gauge on the suction side;

b) reading of pressure gauge on the discharge side;

c) discharge (refer to Annex B); and

d) input power to pump

5.2.5 Magnitude of vibrations and presence of extra-ordinary noises shall be determined during operations.

5.2.6 Results shall be presented in tabular and graphical forms. The following curves shall be presented:

a) total head vs. Discharge;

b) pump input power vs. Discharge;

c) efficiency vs. Discharge;

d) pump Speed vs. Discharge; and

e) NPSH vs. Discharge

5.3 Cavitation test

5.3.1 This is carried out to determine the suction conditions of the pumps.

5.3.2 The conditions for testing shall be the following:

a) pump shall be tested using the same set-up as in performance testing.

water to be used during the test shall be clean with a temperature range of 10 ºC – 40 ºC.

5.3.3 The test shall be conducted by operating the pump at constant discharge and recommended speed. The suction pressure shall be varied starting from low to maximum suction pressure. Data on discharge, suction and discharge pressure, and power shall be recorded on every suction pressure setting.

5.3.4 Magnitude of vibrations and presence of extraordinary noises shall be determined.

5.3.5 Results shall be presented in tabular and graphical forms.

5.4 Priming test

5.4.1 This is carried out to determine the priming time of a self-priming pump.

5.4.2 The pump shall be mounted on a test set-up with a static lift between the eye of the impeller and the water level of at least 3 m.

5.4.3 No check or foot valves shall be installed in the suction piping.

5.4.4 Before operation, fill the priming chamber with water at a temperature range of 10 ºC – 40 ºC.

5.4.5 Operate the pump. The time elapsed between starting the unit and the time required to obtain a steady discharge gauge reading or full flow through the discharge nozzle shall be obtained and recorded as pump priming time.

6 Data analysis

Measurements of heads and the formulas to be used during calculations and testing are given in Annex C.

6.1 Test report format

The test report must include the following information in the order given:

a) name of testing agency;

b) test report number;

c) title;

d) purpose and scope of test;

e) methods of test;

f) description of the pump;

g) table 1 – Centrifugal pump specifications;

h) table 2 – Results of performance test;

i) table 3 – Results of cavitation test;

j) results of priming test;

k) observations; and

l) name and signature of test engineers.

Annex A
(normative)

Pressure gauges attachment

A.1 The suction and discharge side of the pump shall be connected to a straight pipe with a length of 4 times the diameter of each bore and one pressure tapping shall be provided at a distance twice the diameter from each flange surface of the pump. Its position shall be at right angle to the plane of the bend or of the curve of spiral of the pump (see Fig.A.1).

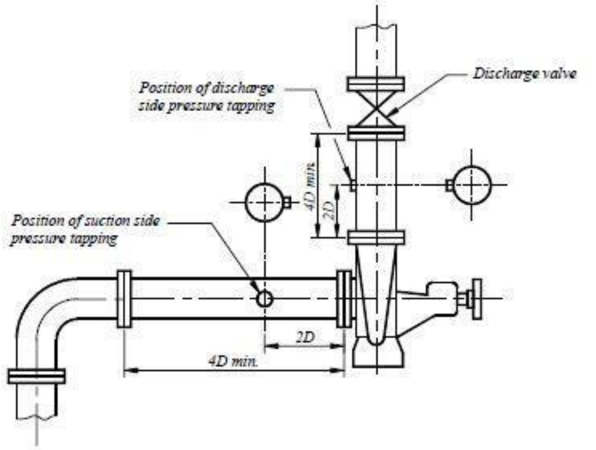

Figure A.1 — Position of discharge side and suction side pressure tappings

A.2 The diameter of pressure tapping shall be 2 mm - 6 mm or 1/10 of pipe inner diameter, whichever has the less value, and the bore shall be normal (perpendicular) to the inner wall of the pipe and shall have length of not less than twice of its diameter (see Figure.A.2). Inner wall of the pipe at this part shall be sufficiently smooth and inner rim of the bore shall be made free from any burrs.

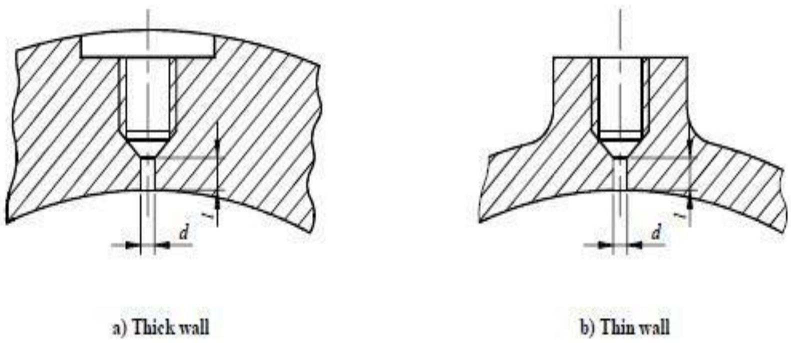

Figure A.2 — Pressure tappings with thick or thin inner wall

Annex B
(informative)

Different methods of discharge measurement

B.1 Container method

Measurement of discharge by container method is primarily suitable for the measurement of relatively small flow rate. The two ways of discharge measurement by means of a container are the weight and volume methods:

a) weight method: This method is preferably used when a liquid's bubbles are hard to break. The container shall have a sufficient capacity to prevent the liquid from overflowing during measurement. The weight of the liquid in the container shall be obtained using a suitable scale at a definite time usually one minute. The discharge shall be computed using the formula:

$$Q = \frac{0.6W}{P^t}$$

where

Q is the discharge, m^3/h;

W is the weight of liquid introduced into the container in t seconds, kg;

t is the time required to introduce liquid of W, s;

p is the weight per unit volume of liquid at the temperature during measurement, kg/L.

b) volume method: The container shall have sufficient capacity to prevent the liquid from overflowing during measurement, and it shall be sufficiently rigid to prevent deformation when it is filled with liquid. The liquid shall be obtained in a container of known volume for a definite time usually one minute. The discharge shall be computed using the formula:

$$Q = \frac{60V}{t}$$

where

Q is the discharge, m^3/h;

V is the volume of liquid introduced into container in t seconds, m^3;

t is the time required to introduce liquid of V, s.

B.2 Using weir

For the measurement of flow by means of a weir (sharp crested triangular or rectangular weir) shall preferably be used. The flow shall be calculated according to the following equation:

a) for 90° triangular weir,

$$Q = 0.138H\ 5^{5/2}$$

where

Q is the discharge, L/s;

H is the head, cm;

b) for rectangular weir,

$$Q = 0.0184\ H^{3/4}$$

where

Q is the discharge, L/s

H is the head over the crest, cm

Annex C
(normative)

Different methods of discharge measurement

C.1 Total Head, TH

$$\mathrm{TH} = H_d + H_s$$

$$H_d = \frac{\mathrm{Pd}}{\mathrm{y}} + \frac{v_d^2}{\mathrm{y}} + z_d + h_f$$

$$H_s = \frac{P_s}{y} + \frac{v_s^2}{2g} + z_s + h_f$$

where

TH is the total head, m

H_d is the total discharge head, m

H_s is the total suction head, m

P_d is the pressure gauge reading on the discharge pipe at gauge connection, in meters of H_2O

$\frac{P_S}{y}$ is the vacuum gauge reading on the suction pipe at the point of gauge connection, in meters of H_2O

$\frac{v_d^2}{2g}$ is the velocity head at the point of gauge attachment on the discharge side, m

$\frac{v_s^2}{2g}$ is the velocity head at the point of gauge attachment on the suction side, m

z_d is the elevation of the pressure gauge, m

z_s is the elevation of the vacuum gauge, m

NOTE Friction loss the part between pressure tapping and the pump flanges is be computed.

C.2 Water power, WP (kW)

$$WP = \frac{THXQ}{102}$$

where

TH is the total head, m

Q is the discharge, L/s

C.3 Input Power of the pump, IP_P

$$IP_P = \frac{T_S XN}{974}$$

where

Ts is the input shaft torque, kg-m

N is the input shaft angular speed, rpm

C.4 Efficiencies

C.4.1 Pump efficiencies, nP, (%)

$$n_p = \frac{WP}{IP_P} X100$$

where

WP is water power, kW

IP_p is input power of the pump, kW

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