INTERNATIONAL STANDARD

ISO
21573-2

First edition
2008-06-15

Building construction machinery and equipment — Concrete pumps —

Part 2:
Procedure for examination of technical parameters

Machines et matériels pour la construction des bâtiments — Pompes à béton —

Partie 2: Procédure pour la détermination des paramètres techniques

COPYRIGHT PROTECTED DOCUMENT

Contents

Page

iii

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 21573-2 was prepared by Technical Committee ISO/TC 195, *Building construction machinery and equipment*, Subcommittee SC 1, *Machinery and equipment for concrete work*.

ISO 21573 consists of the following parts, under the general title *Building construction machinery and equipment — Concrete pumps*:

— *Part 1: Terminology and commercial specifications*

— *Part 2: Procedure for examination of technical parameters*

Building construction machinery and equipment — Concrete pumps —

Part 2:
Procedure for examination of technical parameters

1 Scope

This part of ISO 21573 specifies the procedure and requirements for examining the technical commercial specifications of concrete pumps as defined in ISO 21573-1.

It applies to mobile (with or without boom) and stationary concrete pumps.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 21573-1, *Building construction machinery and equipment — Concrete pumps — Part 1: Terminology and commercial specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21573-1 and the following apply.

3.1
single-roller rotary pump
concrete pump that discharges fresh concrete by squeezing an elastic tube by one rotating roller

3.2
double-roller rotary pump
concrete pump that discharges fresh concrete by squeezing an elastic tube between double rotating rollers

4 Test items of performances

The following performances are tested in this examination:

a) pumping performance;

b) hopper and mixing performance of the agitator;

c) performance of the cleaning water pump;

d) performance of the distributing boom;

e) performance of the outrigger.

5 Pumping performance test (see Tables 1 to 3)

5.1 Piston pump

5.1.1 Pumping output

The volumetric output of the concrete pump is indicated by the theoretical delivery volume.

The theoretical delivery volume is calculated by the following formula.

$$Q_{th} = \left(D^2 \times \frac{\pi}{4} \right) \times S_t \times N \times 6 \times 10^{-8}$$

where

   Q_{th} is the theoretical output volume (m^3/h);

   D is the diameter of concrete cylinder (mm);

   S_t is the stroke length of concrete piston (mm);

   N is the number of strokes per minute (min^{-1}).

5.1.2 Delivery pressure

The delivery pressure is indicated by the maximum theoretical pressure.

The maximum theoretical pressure is calculated by one of the following formulas.

$$p_{th,max} = p_L \times \left(\frac{d_1^2}{D^2} \right) \qquad \text{: head-side operation}$$

$$p_{th,max} = p_L \times \left[\frac{\left(d_1^2 - d_2^2 \right)}{D^2} \right] \qquad \text{: rod-side operation}$$

where

   $p_{th,max}$ is the maximum theoretical delivery pressure;

   p_L is the setting of the lowest pressure limiting device;

   d_1 is the diameter of main hydraulic cylinder;

   D is the diameter of concrete cylinder;

   d_2 is the rod diameter.

5.2 Rotary pump

5.2.1 Single-roller rotary pump (see A.1)

5.2.1.1 Pumping output

$$V_1 = r_5 \times 2 \times \alpha \times \pi \times \frac{\phi^2}{4} \qquad \text{(mm}^3)$$

$$r_5 = r_2 + \frac{\phi}{2} \qquad \text{(mm)}$$

$$\alpha = \cos^{-1}\left[\frac{\left(r_1^2 + r_5^2 - r_3^2\right)}{\left(2 \times r_1 \times r_5\right)}\right] \times \frac{\pi}{180} \qquad \text{(rad)}$$

$$q = \frac{\left(2 \times \pi \times r_5 \times \pi \times \phi^2\right)}{4} - \left(2 \times V_1\right) \qquad \text{(mm}^3\text{/r)}$$

$$Q_{\text{th,max}} = N \times 60 \times q \times 10^{-9} \qquad \text{(m}^3\text{/h)}$$

5.2.1.2 Delivery pressure

$$p_{\text{th,max}} = \frac{p_1}{S} \qquad \text{(MPa)}$$

$$p_1 = \frac{T}{\sin\beta_1 \times \dfrac{r_1}{10^3}} \qquad \text{(N)}$$

$$\beta_1 = \frac{\left(2\pi \times X_G\right)}{\left(2\pi \times r_3\right)} \qquad \text{(rad)}$$

$$X_G = \frac{\left(4 \times a\right)}{3\pi} \qquad \text{(mm)}$$

$$a = \left[r_4^2 + \left(r_3 \times \cos\theta\right)^2\right]^{1/2} \qquad \text{(mm)}$$

$$r_4 = r_3 \times \left(1 - \sin\theta\right) \qquad \text{(mm)}$$

$$\theta = \cos^{-1}\left[\frac{\left(r_1^2 + r_3^2 - r_2^2\right)}{\left(2 \times r_1 \times r_3\right)}\right] \times \frac{\pi}{180} - \frac{\pi}{2} \qquad \text{(rad)}$$

$$r_2 = r_p - \phi - t \qquad \text{(mm)}$$

$$r_3 = r_0 + t \qquad \text{(mm)}$$

$$S = \left(\frac{\pi}{2}\right) \times a \times b \qquad \text{(mm}^2\text{)}$$

$$a = \left[r_4{}^2 + \left(r_3 \times \cos\theta\right)^2 \right]^{\frac{1}{2}} \qquad \text{(mm)}$$

$$b = \frac{1}{4} \times \left(\pi \times \phi\right) \qquad \text{(mm)}$$

where

a is the long radius of semi-ellipse contact zone (mm);

b is the short radius of semi-ellipse contact zone (mm);

N is the rotating speed of rotor (min^{-1});

p_1 is the load by inside pressure (N);

$p_{th,max}$ is the output pressure (MPa);

$Q_{th,max}$ is the output volume per one hour (m^3/h);

q is the output volume by one rotation of rotor (mm^3/r);

r_0 is the radius of roller (mm);

r_1 is the distance between pump centre to roller centre (mm);

r_2 is the distance between pump centre and inside contact point between rotor and tube (mm);

r_3 is the distance between inside contact point of roller and tube and roller centre (mm);

r_4 is the perpendicular distance from inside contact point of roller and tube to pump centre line (mm);

r_5 is the distance between pump centre and tube centre line (mm);

r_p is the radius of pump centre to surface of pad (mm);

S is the projected area of contact zone of tube and roller (mm^2);

T is the rotor drive torque (N·m);

t is the thickness of pumping tube (mm);

V_1 is the inside volume of tube depressed by roller (mm^3);

X_G is the centre of gravity of semi-square contact zone of tube and roller (mm);

α is the centre angle occupied by roller used for calculation of V_1 (rad);

β_1 is the angle between p_1 and p_0 (rad);

ϕ is the inside diameter of pumping tube (mm);

θ is the angle between r_3 and r_4 (rad).

See Figure A.1.

5.2.2 Double-roller rotary pump (see A.2)

5.2.2.1 Pumping output

$$V_1 = r_3 \times 2 \times \theta \times \pi \times \frac{\phi^2}{4}$$ (mm³)

$$r_3 = r_0 + t$$ (mm)

$$\theta = \cos^{-1}\left[\frac{(r_3 - \phi)}{r_3}\right] \times \frac{\pi}{180}$$ (rad)

$$q = \frac{\left(2 \times \pi \times r_5 \times \pi \times \phi^2\right)}{4} - \left(2 \times V_1\right)$$ (mm³/r)

$$Q_{\text{th,max}} = N \times 60 \times q \times 10^{-9}$$ (m³/h)

5.2.2.2 Delivery pressure

$$p_{\text{th,max}} = \frac{p_1}{S}$$ (MPa)

$$p_1 = \frac{T}{2 \times \sin\beta_1 \times \left(\frac{r_1}{10^3}\right)}$$ (N)

$$\beta_1 = \frac{(2\pi \times X_G)}{(2\pi \times r_3)}$$ (rad)

$$X_G = \frac{(4 \times a)}{3\pi}$$ (mm)

$$a = \left[2 \times r_3^2 \times (1 - \cos\theta)\right]^{1/2}$$ (mm)

$$\theta = \cos^{-1}\left[\frac{(r_3 - \phi)}{r_3}\right] \times \frac{\pi}{180}$$ (rad)

$$r_3 = r_0 + t$$ (mm)

$$S = \left(\frac{\pi}{2}\right) \times a \times b$$ (mm²)

$$b = \left(\frac{1}{4}\right) \times (\pi \times \phi)$$ (mm)

where

a is the long radius of semi-ellipse contact zone (mm);

b is the short radius of semi-ellipse contact zone (mm);

N is the rotating speed of rotor (min^{-1});

p_1 is the load by inside pressure (N);

$p_{th,max}$ is the maximum theoretical delivery pressure (MPa);

$Q_{th,max}$ is the maximum theoretical pumping output (m^3/h);

q is the output volume per rotation of rotor (mm^3/r);

r_0 is the radius of roller (mm);

r_1 is the distance between pump casing centre and tube centre circle (mm);

r_3 is the distance between inside contact point of roller and roller centre (mm);

r_5 is the distance between pump centre and tube centre line (mm);

S is the projected area of contact zone of tube and roller (mm^2);

T is the rotor drive torque (N·m);

t is the thickness of pumping tube (mm);

V_1 is the inside volume of tube depressed by roller (mm^3);

X_G is the centre of gravity of semi-ellipse contact zone of tube and roller (mm);

β_1 is the angle between p_1 and p_0 (rad);

ϕ is the inside diameter of pumping tube (mm);

θ is the angle between r_3 and p_0 (rad).

See Figure A.2.

6 Performance of hopper and agitator (see Table 4)

6.1 Height of hopper

Set the concrete pump in the operating position by extending the outrigger. Measure the height of hopper edge above the ground.

6.2 Agitator performance

Measure the data on the performance of the agitator without concrete.

a) Agitator revolution speed

The agitator revolution speed shall be measured by using a stopwatch or tachometer.

b) Agitator pressure

The operation hydraulic pressure of the agitator drive shall be measured under the following conditions:

— no load operation without concrete in the hopper;

— relief valve pressure.

7 Performance of cleaning water pump (see Table 4)

7.1 General

The water pump installed on concrete pump for cleaning after concrete pumping is tested by measuring the following items (see 7.2 and 7.3).

7.2 Shut-off pressure

Shut off the delivery pipe line of the water pump by closing the throttle valve completely provided on the delivery line. Measure the water pressure and the hydraulic pressure.

7.3 Discharge volume in case of no load operation

Open the throttle valve fully, then measure the discharged volume, pressure of water and the hydraulic pressure.

8 Performance of concrete distributor boom (see Table 5)

This test is applied to the concrete distributor boom installed on mobile concrete pump.

The following items shall be measured.

a) Maximum length of the boom

Keeping the booms extended horizontally, measure the horizontal distance between the centre of slewing and the centre of tip hose, which is vertically suspended at the end of hose guide or elbow attached on the highest boom.

b) Maximum height of the boom

Keeping the booms totally extended and raised upright, measure the vertical height of boom above ground.

This height may be calculated by using the measured data of maximum length of boom, raised angle of booms and height of the support point of lower boom.

c) Boom operation zone

Draw the chart of the boom operation zone by measuring the length of each stage boom, folding angle of each boom, etc.

d) Speed of the boom operation on each boom section

e) Slewing angle

f) Slewing zone

g) Slewing speed

9 Performance of outrigger (see Table 6)

The following items shall be measured:

a) span of outrigger pedestal at the set up position;

b) maximum load on each outrigger.

Table 1 — Test report — Concrete pump (piston pump)

Date of test			Place			
Model of concrete pump				Serial number		
	Characteristics		Measured data	Unit	Remarks	
Concrete pump	Revolution speed of hydraulic pump			min^{-1}		
	No load operation hydraulic pressure			MPa	p_n	
	Maximum hydraulic pressure (relief valve)			MPa	p_r	
	Number of strokes of concrete piston			min^{-1}	N	
	Diameter of concrete cylinder			mm	D	
	Diameter of hydraulic cylinder			mm	d_1	
	Rod diameter			mm	d_2	
	Piston stroke			mm	S_t	
	Stroke volume			m^3	$q = \pi D^2 / 4 \times S_t / 10^9$	
	Rate of section area of hydraulic cylinder and concrete cylinder				$R_1 = (d_1/D)^2$: head side pressurized $R_2 = (d_1^2 - d_2^2)/D^2$: rod side pressurized	
	Maximum theoretical delivery pressure			MPa	$p_{th,max} = (p_r - p_n) \times R_1$ or R_2	
	Maximum theoretical pumping output			m^3/h	$Q_{th,max} = q \times N \times 60$	
	Hydraulic system power setting			kW		

Table 2 — Test report — Concrete pump (single-roller rotary pump)

Date of test			Place			
Model of concrete pump				Serial number		
	Characteristics		Measured data	Unit	Remarks	
Concrete pump	Revolution speed of hydraulic pump			min⁻¹		
	No load operation hydraulic pressure			MPa	p_n	
	Maximum hydraulic pressure (relief valve)			MPa	p_r	
	Rotating speed of rotor			min⁻¹	N	
	Distance between pump centre and tube centre line			mm	r_5	
	Inside diameter of pumping tube			mm	ϕ	
	Inside volume of tube depressed by roller			mm³	V_1	
	Output volume per rotation of rotor			m³	$q = \left[\dfrac{\left(2 \times \pi \times r_5 \times \pi \times \phi^2\right)}{4} \right] - \left(2 \times V_1\right)$	
	Load by inside pressure			N	p_1	
	Projected area of contact zone of tube and roller			mm²	S	
	Maximum theoretical delivery pressure			MPa	$p_{th,max} = \dfrac{p_1}{S}$	
	Maximum theoretical pumping output			m³/h	$Q_{th,max} = q \times N \times 60 \times 10^{-9}$	

Table 3 — Test report — Concrete pump (double-roller rotary pump)

	Date of test			Place			
	Model of concrete pump				Serial number		
	Characteristics		Measured data	Unit	Remarks		
Concrete pump	Revolution speed of hydraulic pump			min^{-1}			
	No load operation hydraulic pressure			MPa	p_n		
	Maximum hydraulic pressure (relief valve)			MPa	p_r		
	Rotating speed of rotor			min^{-1}	N		
	Distance between casing centre and tube centre line			mm	r_1		
	Inside diameter of pumping tube			mm	ϕ		
	Inside volume of tube depressed by roller			mm^3	V_1		
	Output volume per rotation of rotor			m^3	$q = \left[\dfrac{\left(2 \times \pi \times r_5 \times \pi \times \phi^2 \right)}{4} \right] - \left(2 \times V_1 \right)$		
	Load by inside pressure			N	p_1		
	Projected area of contact zone of tube and roller			mm^2	S		
	Maximum theoretical delivery pressure			MPa	$p_{th,max} = \dfrac{p_1}{S}$		
	Maximum theoretical pumping output			m^3/h	$Q_{th,max} = q \times N \times 60 \times 10^{-9}$		

Table 4 — Test report — Hopper and agitator

	Date of test		Place				
	Model of concrete pump			Serial number			
	Characteristics		Measured data			Unit	Remarks
	Concrete used (slump)	without concrete				cm	
Hopper and agitator	Hopper height (no charge)					mm	
	Agitator revolution speed					min^{-1}	
	Hydraulic pressure (no load)					MPa	
	Hydraulic pressure (relief)					MPa	
Water pump for cleaning	Shut off	Oil pressure				MPa	
	No load	Water pressure				MPa	
		Discharged volume				dm^3 (l)	
		Oil pressure				MPa	

Table 5 — Test report — Distributor boom

Date of test			Place			
Model of concrete pump			Serial number			
	Characteristics		Measured data	Unit	Remarks	
Distributing boom	Maximum reach			mm		
	Maximum height			mm		
	Boom length	1st section		mm		
		2nd section		mm		
		3rd section		mm		
		4th section		mm		
		5th section		mm		
		6th section		mm		
	Folding angle	1st section		deg (°)		
		2nd section		deg (°)		
		3rd section		deg (°)		
		4th section		deg (°)		
		5th section		deg (°)		
		6th section		deg (°)		
	Boom speed (time of full fold or unfold)	1st section		min^{-1}(s)		
		2nd section		min^{-1}(s)		
		3rd section		min^{-1}(s)		
		4th section		min^{-1}(s)		
		5th section		min^{-1}(s)		
		6th section		min^{-1}(s)		
	Slewing angle			deg (°)	Measure in case of limited angle	
	Slewing ability (minimum inclination)			deg (°)		
	Slewing ability (maximum inclination)			deg (°)		
	Slewing speed (time for one turn or full angle)			min^{-1}(s)		

Table 6 — Test report — Outrigger

Date of test			Place			
Model of concrete pump			Serial number			
	Characteristics		Measured data	Unit	Remarks	
Outrigger	Span	Outrigger width, front		mm		
		Outrigger width, rear		mm		
		Right side outrigger (longitudinal)		mm		
		Left side outrigger (longitudinal)		mm		

Annex A
(informative)

Theoretical pumping output and delivery pressure for rotary pump

A.1 Single-roller rotary pump
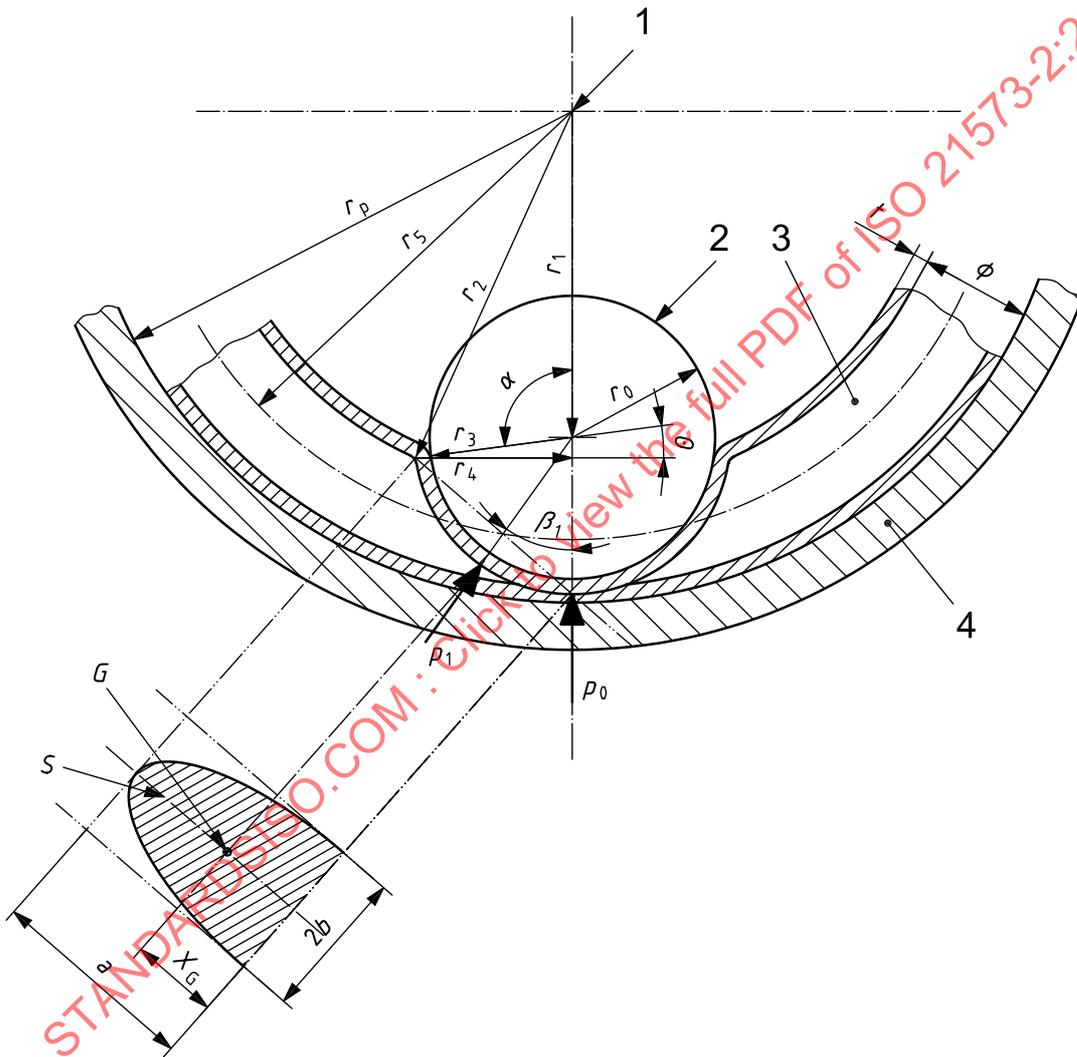
Figure A.1 — Rotary pump — Single-roller rotary pump

Key

1 centre of pump casing
2 roller
3 pumping tube
4 pad

G centre of gravity
a long radius of semi-ellipse contact zone (mm)
b short radius of semi-ellipse contact zone (mm)
p_0 initial depressing force on pumping tube (N)
p_1 load by inside pressure (N)
r_0 radius of roller (mm)
r_1 distance between pump centre and roller centre (mm)
r_2 distance between pump centre and inside contact point between rotor and tube (mm)
r_3 distance between inside contact point of roller and tube and roller centre (mm)
r_4 perpendicular distance from inside contact point of roller and tube to pump centre line (mm)
r_5 distance between pump centre and tube centre line (mm)
r_p radius of pump centre to surface of pad (mm)
S projected area of contact zone of tube and roller (mm^2)
t thickness of pumping tube (mm)
X_G centre of gravity of semi-square contact zone of tube and roller (mm)
α centre angle occupied by roller used for calculation of V_1 (rad)
β_1 angle between p_1 and p_0 (rad)
θ angle between r_3 and r_4 (rad)
ϕ inside diameter of pumping tube (mm)

Figure A.1 (*continued*)

Calculation example

T	rotor drive torque	8 840 N·m
r_0	radius of roller	150 mm
r_1	distance between pump centre and roller centre	345 mm
t	thickness of pumping tube	16 mm
ϕ	inside diameter of pumping tube	101,6 mm
N	rotating speed of rotor	38,3 min^{-1}
r_p	radius of pump centre to surface of pad	520 mm