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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

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Foreword

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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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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);

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

$Q_{\text{th,max}}$ 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

$$V_1 = r_3 \times 2 \times \theta \times \pi \times \frac{\phi^2}{4} \qquad (\text{mm}^3)$$

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

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

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

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

5.2.2.2 Delivery pressure

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

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

$$\beta_1 = \frac{(2\pi \times X_{\text{G}})}{(2\pi \times r_3)} \qquad (\text{rad})$$

$$X_{\text{G}} = \frac{(4 \times a)}{3\pi} \qquad (\text{mm})$$

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

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

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

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

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

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);
$p_{\text{th,max}}$	is the maximum theoretical delivery pressure (MPa);
$Q_{\text{th,max}}$	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		mm^3	V_1
	Output volume per rotation of rotor		m^3	$q = \left[\frac{\left(2 \times \pi \times r_5 \times \pi \times \phi^2 \right)}{4} \right] - \left(2 \times V_1 \right)$
	Load by inside pressure		N	p_1
	Projected area of contact zone of tube and roller		mm^2	S
	Maximum theoretical delivery pressure		MPa	$p_\text{th,max} = \frac{p_1}{S}$
	Maximum theoretical pumping output		m^3/h	$Q_\text{th,max} = q \times N \times 60 \times 10^{-9}$

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	$q = \left[\frac{\left(2 \times \pi \times r_5 \times \pi \times \phi^2\right)}{4} \right] - \left(2 \times V_1\right)$
	Load by inside pressure		N	p_1
	Projected area of contact zone of tube and roller		mm^2	S
	Maximum theoretical delivery pressure		MPa	$p_{\text{th,max}} = \frac{p_1}{S}$
	Maximum theoretical pumping output		m^3/h	$Q_{\text{th,max}} = q \times N \times 60 \times 10^{-9}$

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

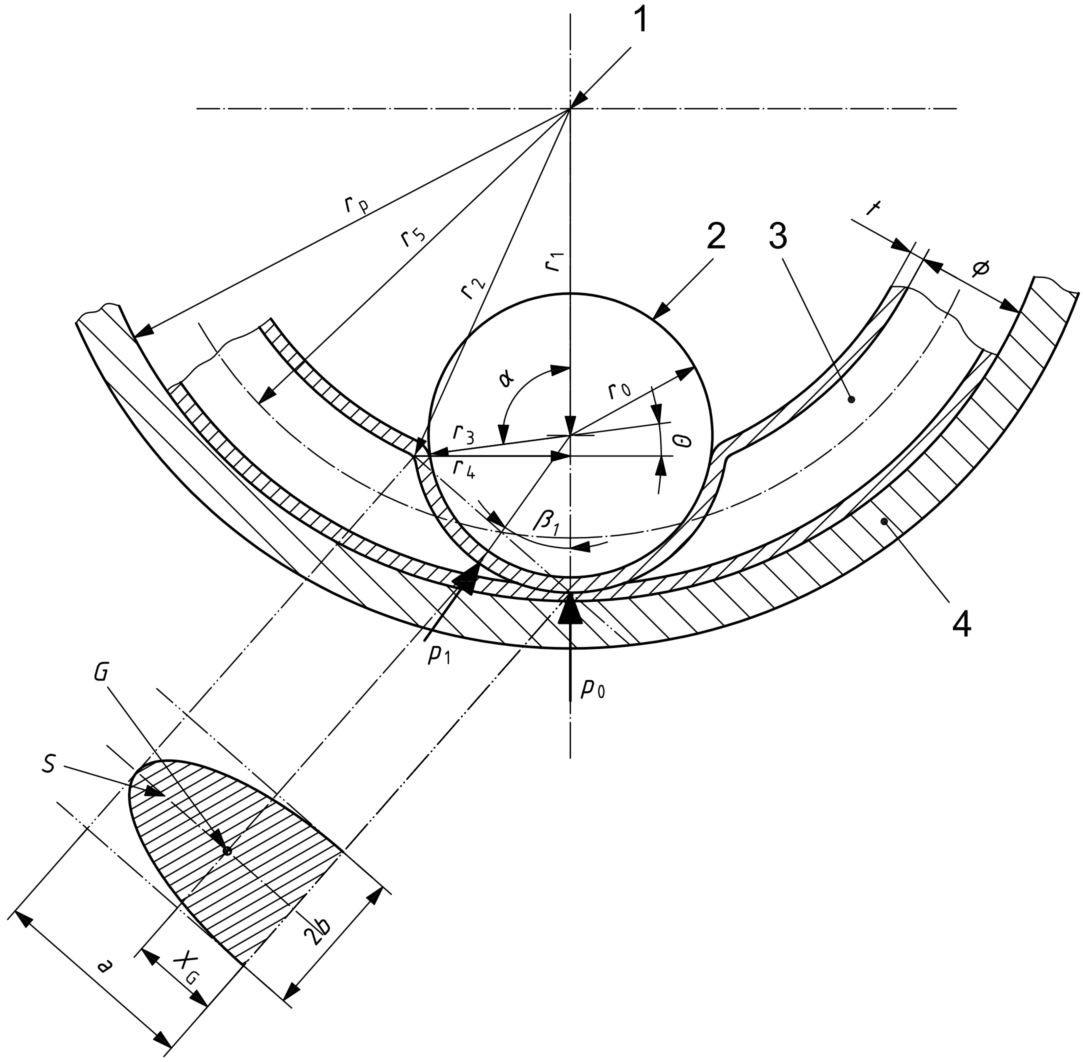


Figure A.1 — Rotary pump — Single-roller rotary pump

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

$$p_{\text{th,max}} = \frac{p_1}{S}$$ 1,756 MPa

$$p_1 = \frac{T}{\sin\beta_1 \times \left(\frac{r_1}{10^3}\right)}$$ 48 347 N

$$\beta_1 = 2 \times \pi \times \frac{X_\text{G}}{(2\pi \times r_3)}$$ 0,559 rad

$$X_\text{G} = \frac{(4 \times a)}{3\pi}$$ 92,7 mm

$$a = \left[{r_4}^2 + (r_3 \times \cos\theta)^2\right]^{1/2}$$ 218,5 mm

$$r_4 = r_3 \times (1 - \sin\theta)$$ 143,8 mm

$$\theta = \cos^{-1}\left[\frac{\left({r_1}^2 + {r_3}^2 - {r_2}^2\right)}{2 \times r_1 \times r_3}\right] \times \frac{\pi}{180} - \frac{\pi}{2}$$ 0,134 rad

$$r_2 = r_\text{p} - \phi - t$$ 402,4 mm

$$r_3 = r_0 + t$$ 166,0 mm

$$S = \left(\frac{\pi}{2}\right) \times a \times b$$ 27 525 mm^2

$$a = \left[{r_4}^2 + (r_3 \times \cos\theta)^2\right]^{1/2}$$ 219,6 mm

$$b = \left(1/4\right) \times (\pi \times \phi)$$ 79,8 mm

$$V_1 = r_5 \times 2 \times \alpha \times \pi \times \frac{\phi^2}{4}$$ 2 349 589 mm^3

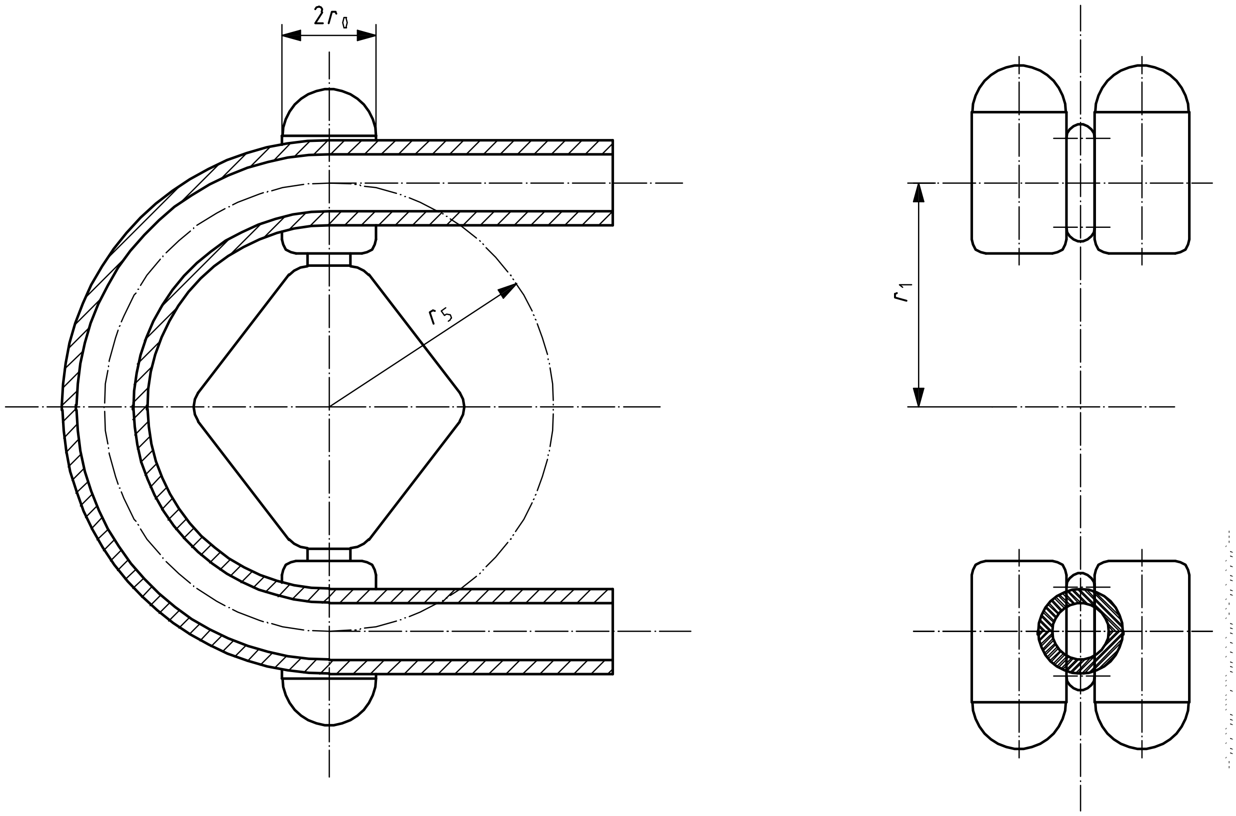
$$r_5 = r_2 + \frac{\phi}{2}$$ 453,2 mm

$$\alpha = \cos^{-1}\left[\frac{\left({r_1}^2 + {r_5}^2 - {r_3}^2\right)}{(2 \times r_1 \times r_5)}\right] \times \frac{\pi}{180}$$ 0,320 rad

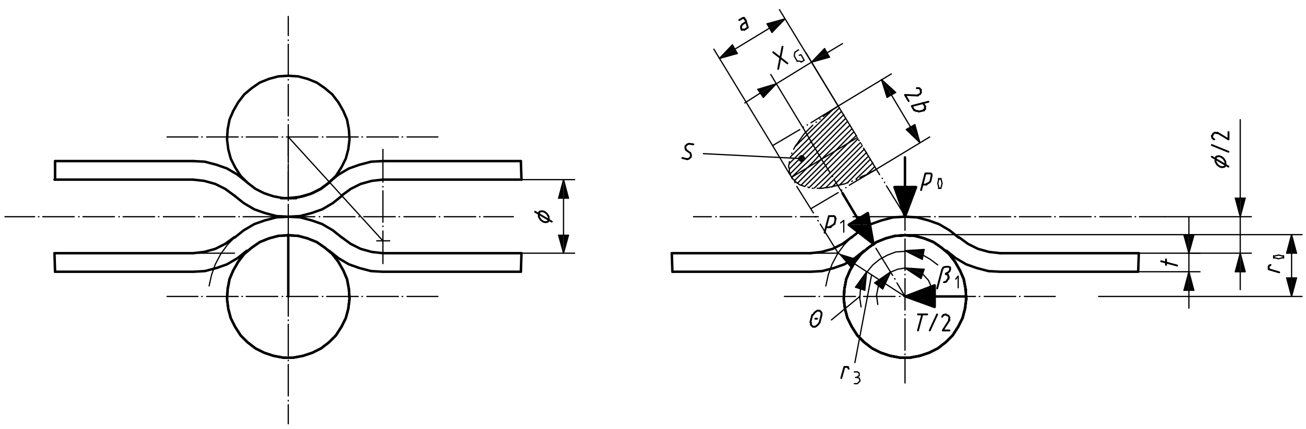
$$q = \left[\frac{\left(2 \times \pi \times r_5 \times \pi \times \phi^2\right)}{4}\right] - (2 \times V_1)$$ 18 386 736 mm^3/r

$$Q_{\text{th,max}} = N \times 60 \times q \times 10^{-9}$$ 42,3 m^3/h

A.2 Double-roller rotary pump



a) Double-roller rotary pump



b) Model of depressed area

Figure A.2 — Rotary pump — Double-roller rotary pump

Key

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 casing centre and tube centre circle (mm)
r_3 distance between inside contact point of roller and tube and roller centre (mm)
r_5 distance between pump centre and tube centre line (mm)
S projected area of contact zone of tube and roller (mm^2)
T rotor drive torque (N·m)
t thickness of pumping tube (mm)
X_G centre of gravity of semi-square contact zone of tube and roller (mm)
β_1 angle between p_1 and p_0 (rad)
θ angle between r_3 and p_0 (rad)
ϕ inside diameter of pumping tube (mm)

Figure A.2 (*continued*)

Calculation example

T	rotor drive torque	8 840 N·m
r_0	radius of roller	100 mm
r_1	distance between pump casing centre and tube centre circle	475 mm
t	thickness of pumping tube	30 mm
ϕ	inside diameter of pumping tube	102 mm
N	rotating speed of rotor	38,3 min^{-1}

$$p_{th,max} = \frac{p_1}{S} \qquad 1,75 \text{ MPa}$$

$$p_1 = \frac{T}{2 \times \sin\beta_1 \times \left(\frac{r_1}{10^3}\right)} \qquad 25\ 344 \text{ N}$$

$$\beta_1 = \frac{(2\pi \times X_G)}{(2\pi \times r_3)} \qquad 0,376 \text{ rad}$$

$$X_G = \frac{(4 \times a)}{3\pi} \qquad 48,9 \text{ mm}$$

$$a = \left[2 \times r_3{}^2 \times (1 - \cos\theta)\right]^{1/2} \qquad 115,2 \text{ mm}$$

$$\theta = \cos^{-1}\left[\frac{(r_3 - \phi)}{r_3}\right] \times \frac{\pi}{180} \qquad 0,9 \text{ rad}$$

$$r_3 = r_0 + t$$ 130,0 mm

$$S = \left(\frac{\pi}{2}\right) \times a \times b$$ 14 490 mm^2

$$b = \left(\frac{1}{4}\right) \times (\pi \times \varphi)$$ 80,1 mm

$$V_1 = r_3 \times 2 \times \theta \times \pi \times \frac{\phi^2}{4}$$ 34 026 mm^3

$$q = \left[\frac{\left(2 \times \pi \times r_1 \times \pi \times \phi^2\right)}{4}\right] - \left(2 \times V_1\right)$$ 24 319 246 mm^3/r

$$Q_{\text{th,max}} = N \times 60 \times q \times 10^{-9}$$ 55,9 m^3/h

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