Mondi Štětí a.s.

STANDARD

Part 10.02

CENTRIFUGAL PUMPS

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Worked out by:	Verified by:	Approved by:
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The objective of this standard is a pump dimensioning and selection and their peripheral equipment.

1 Implemantary regulations

1.1 General

a) In general, pumps must meet industrial standards. In case the used material is deviating from the standard, it must be visibly stated on the extra written form.

b) Pump and motor must be mounted on the common stable assembly frame (exceptions only after approval). Base plate must be executed in such way that it is suitable for the possibly biggest motor with the use of the possibly biggest impeller wheel.

c) Pump dimensioning must be executed in such way that it is the 20 % output increase is possible with the use of the bigger impeller wheel .

d) Motor rotations should be on principle 1500 rpm, if it is not possible, 3000 rpm are also allowed.

e) Impeller wheel exchange, coupling, or schaft sealing must be possible without motor and piping disassembly.

f) All free-standing parts, moving parts (shaft ends, couplings, etc.) must be equiped with the safety cover. Coupling protection must be made of steel - plate, color RAL 1016 or stainless- steel plate with yellow-black stickers.

g) Base frames assembly with mounted pumps and motors is done with heavy-load anchors and threaded bars (bolts) from the raw concrete. Construction of the base frames is minimally with welding ST 37-2.

h) Grount must allow leaked liquids draining away (without puddle formations - see the principle sketch incl. inbuild parts)

i) Removing or adjusting of the coupling must be done only after hardened grount, as well as piping assembly. There must be a record taken about coupling alignment (see attached example).

j) Painting of the all pump parts (also foundation frame) must be done according to the painting Mondi Štětí standard. Stainless parts do not require any paintcoat.

k) If MC pumps or pumps which transferring pulp (pulp over 4%) and where vibrations are, necessary is between pump and outlet pipe placed compensator.

1.2 Material selection recommendations

On the grounds of the used media ,pipe materials and costs (stock lot, etc.), there are pump types determined for pulp and paper industry.

Following materials were selected on the basis of the media used in the operation and their pH values as a minimum requirement for the pump material. They can not be considered general, as the medium with the chemical properties and characteristics must be taken to account.

The manufacturer may recommend some technologically preferable materials.

pH value: 6 - 14 (for example. water, alkali, etc.)

Casing:	GG 25 (gray cast iron = graues Gusseisen)
Impeller wheel + wearing insertions:	1.4460
Shaft:	1.4439 or 1.4460
Bearing housing:	GG 25

pH value: 2 - 6 (acid) (for example diluted lixivium, etc.)

Casing:	1.4460
Impeller wheel + wearing insertions:	1.4460
Shaft:	1.4439 or 1.4460
Bearing housing:	GG 25

pH value : $<$ 2 (strong acid) (for example. used condensate, etc.)

Casing:	1.4571 or equal
Impeller wheel + wearing insertions:	1.4571 or equal
Shaft:	1.4439 or 1.4460
Bearing housing:	GG 25

1.3 Impeller wheel recommendations

Substance density	$<$ 0,5 %	closed impeller wheelImpeller wheel
Substance density	0,5 - 4 %	open impeller wheel
Substance density	4 - 7 %	open impeller wheel, screew wheel

Substance density $>$ 8 % MC pump

1.4 Shaft sealing specifications

Wherever it is possible and meaningful, single seals with sliding rings must be taken into account.

Material combination: Silicon carbides/carbon preferred , depending on use.

- single (single acting) media seals, water dilutable;
- double (double acting) media seals, no diluting, under no conditions there must be allowed transported medium blowing or various pressure conditions which allow opening of the sliding ring.

When the stuffing box packings is applied, pump shafts must be equipped with exchangeable shaft sleeves (application only after the agreement with Mondi Štětí). Standard stuffing box packings string must be used.

All pumps must be constructed in such way, that it is possible to convert from sliding rings to packing strings and vice versa.

Special sealings after agreement, or as an alternative.

1.5 Lubrication

All fat lubricating places must be equipped with flat lubricating heads in accordance with DIN 3404.

Exceptions are only places of use, construction or insufficiency reasons require to use conic lubrication heads in accordance with DIN 71412.

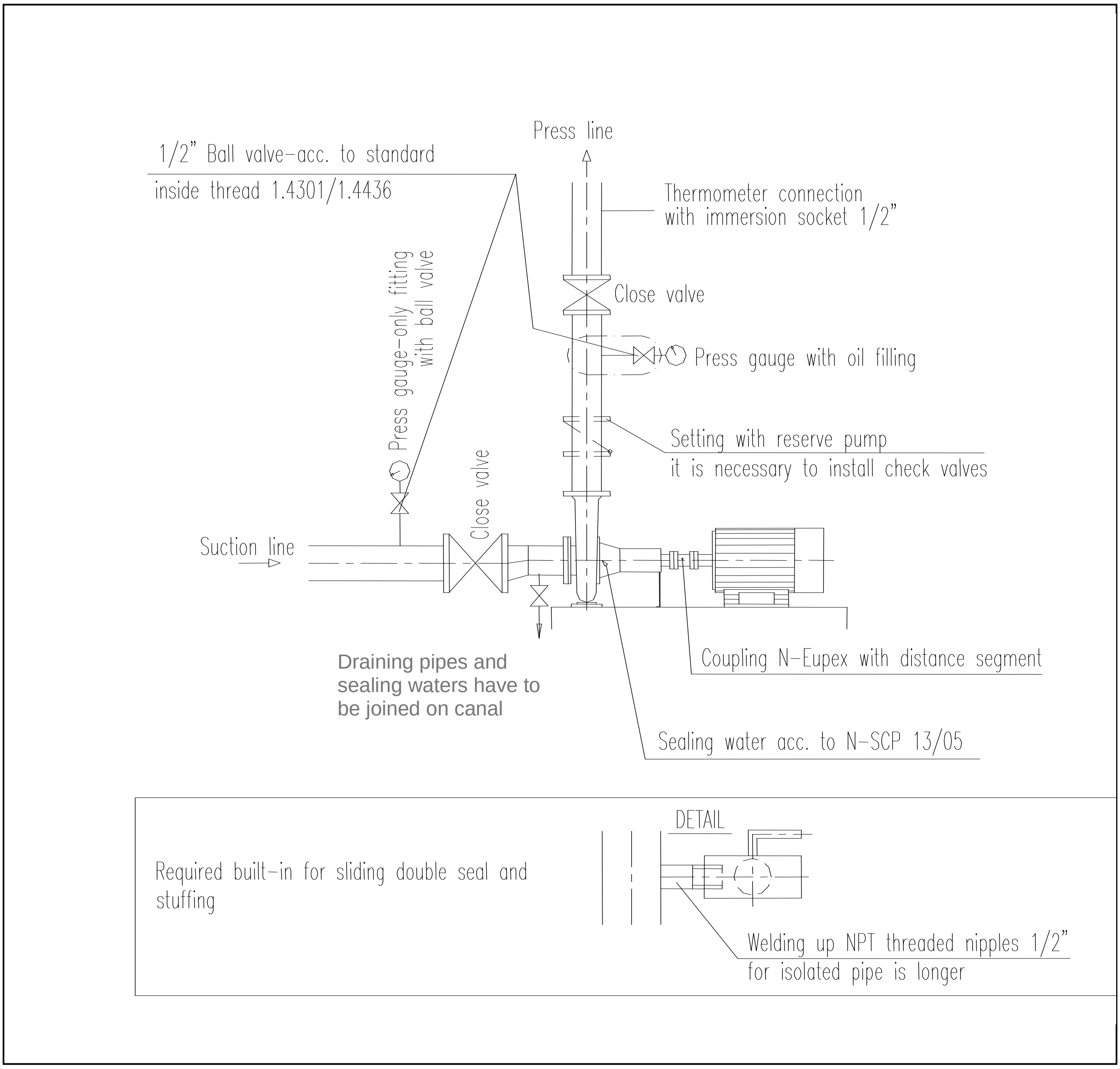
1.6 Coupling

Couplings must be type N-Eupex or Samiflex with the assembly insert part.

2 Peripheral equipment of the pump

2.1 Standard facilities

Obligatory assembly of the double seals with sliding rings and stuffing box packings



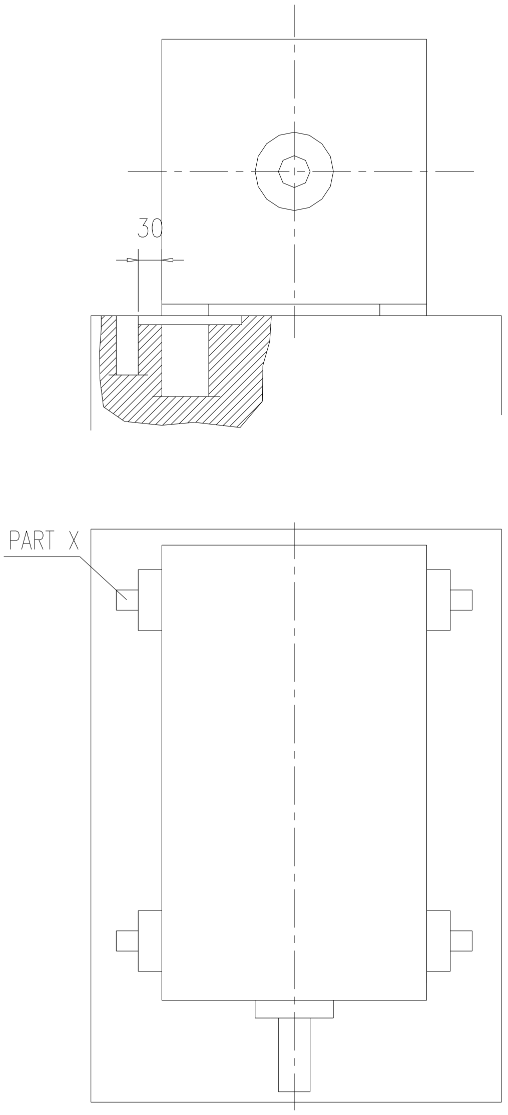
In case any equipment, instrument or a machine is separated by armature from the piping system, it is necessary to mind that equipment, instrument or a machine are separable without cutting and system emptying.

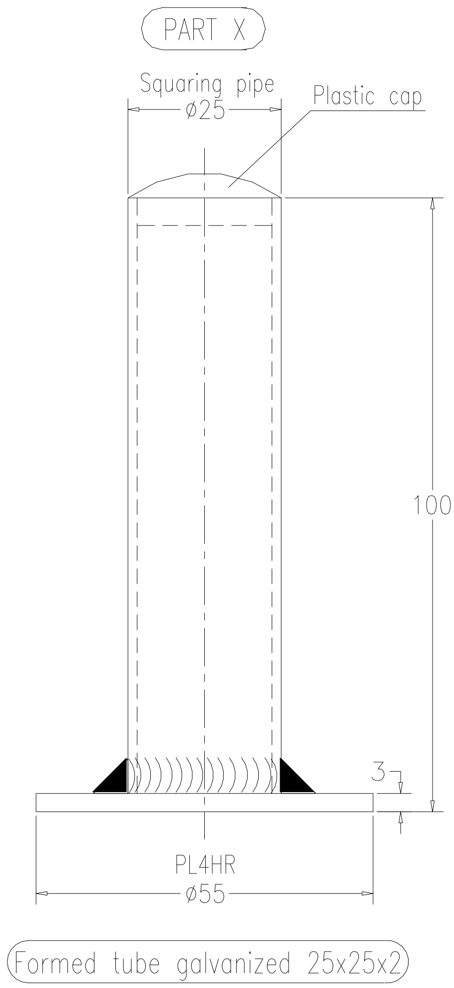
- Body on flanges, or
- Separating place according to the armature (flange/screwing)

In case of inseparable bodies, exchangeability of the ball-valves must be done by screwing.

2.2 Adjusting instrument for coupling alignment

Description: Into section pipe, square irons with adjustable screws are inserted, which allows to move the motor.





3 Pump specification

Identification	Normal.	Min.	Max.
Running no../ position n.			
Pieces			
Kind of Pump			
Pump type			
Operational conditions			
Transported material			
Temperature [°C]			
Operational pressure [bar]			
Abrasive – corroding components, medium [pH]			
Consistency / Density [%] / [kg/m^3]			
Dynamic viscosity [mPa∗s]			
Transported quantity [m^3/hod]			
Transport height [m FS]			
NPSH equipment [m]			
NPSH of a required pump [m]			
Nominal number of the pump rotation [1/min]			
Grade of pump efficiency [%]			
Power consumption [kW]			
Motor power consumption [kW]			
Construction			
Suction nozzle: DN / PN [mm] / [bar]			
Force nozzle: DN / PN [mm] / [bar]			
Position form (horizont./vert.); (dry; wet)			
Form of the impeller			
Diameter of the impeller [mm]			

Max. diameter of of the impeller [mm]			
Justification of tension with			
Steps number			
Coupling- type/product			
Bearing / lubrication			
Construction lenght vert. [mm]			
Schaft sealing			
Closing liquid (Quench medium)			
Baseanchor type / size			
Base (Sole)plate dimensions			
Motor			
Construction size of the motor / Construction form (construction)			
Power / rpm [kW]/[1/min]			
Voltage / nominal current [V] / [A]			
Frequency / IP [Hz]			
Frequeny convertor			
Material			
Scroll case/ inter -wheel			
Impeller wheel / distributing wheel			
Sealing packings			
Shaft / shaft sleeve			
Base(Sole) plate			
Coupling			
Protection of couplings			
Packing material			
Seats with sliding rings			
Price			
Motor-free pump			
Assembly coupling + housing			
Plate for pump and motor			
Base anchors			
Threaded bars(bolts)			
Motor assembly			
Motor			

Counter flanges			
Pump assembly / pcs			
Unit price			
Totla price			
Rabat			
Time of supply			
Price assesment			
Weight without/ with motor			
Supply weight			

4 List of the preferred suppliers

4. Preferred manufacturers for standard parts

Application	Producer
Pums for middle consistency pulp	SULZER METSO PAPER KVARNER PULPING
Pums for low consistency pulp	ANDRITZ SULZER
Chemical pumps	KSB SULZER VOGEL
Water pumps	KSB SULZER SIGMA META VOGEL
Deionizated water, condensate	KSB (trust-proof casing, deep-pulled) SULZER

Acids, liquors	KSB - Asyndetic pumps SULZER
Kaoline, lime	CHESTERTON NETZSCH SEEPEX
Pulper rejects	CHESTERTON SULZER
Vacuum pumps	NASH BINGHAM SIHI SIEMENS
Noncondensible gases (NCG)	HERMETIC Pumpen

5 Supplement to the calculation for transport high – only for information

Dimensioning of the transport height
For centrifugal pumps
(for information only)

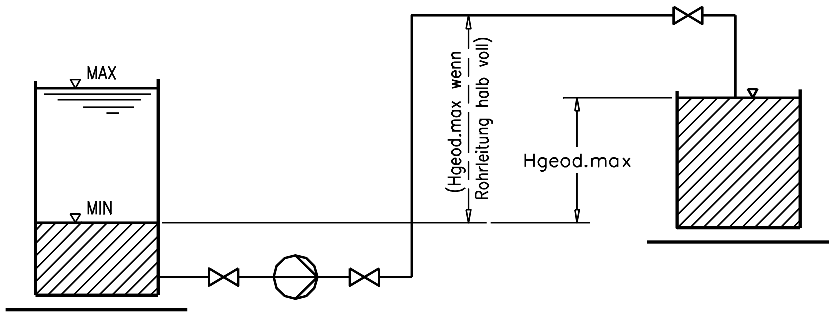
Using the special logaritmic meter

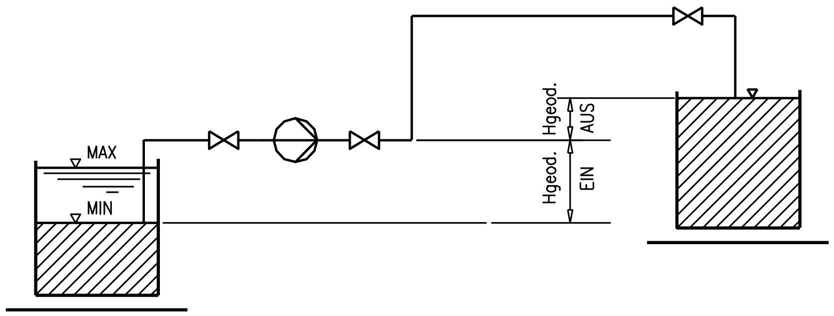
5.1 Notes

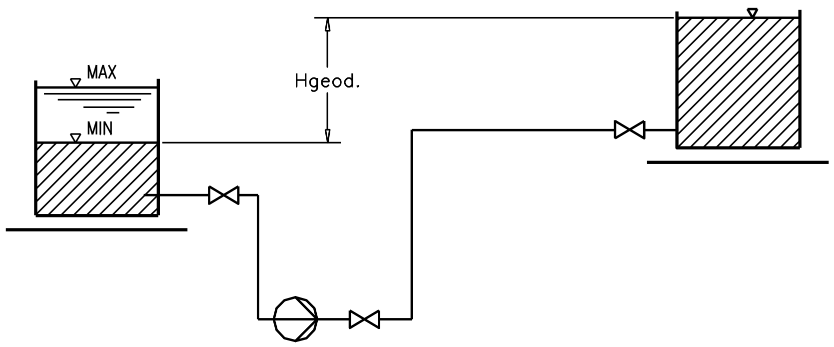
Transport height

Generally, transportheight consists of geodetic transport height (= height between liquid levels - input/output, which has to be eclipsed) and of loss heights specific for equipment (= resistance in piping, bends, valves, etc.)

Principle – figures







5.2 Executing of the necessary details

Necessary for calculations:

- Transport quantity required Q (m^3/s)
- transported medium
- Stuff density SD (%)
- Stuff temperature T (°C)
- Transported medium density (kg/m^3)
- Kinematic viscosity v (m^2/s)
- internal pressure, when the tank is under pressure /vacuum (bar)
- exact equipment information:
  - pump location
  - pipeline
- isometric sketch
- Kv value of the control armatures
- Number of the diverse inbuilted units:
  - Gate & check valves, T- pieces, etc.

5.3 List of pulp suspensions

1. For simplification there is a following calcuation page (5.4)
2. Fill in all existing (relevant) nominal internal pipe areas
3. Calculate flow velocity ”v” (m/s)

$$\mathbf{v} = \frac{\mathbf{Q}}{\mathbf{A}} = \frac{\textbf{transported quantity}}{\textbf{pipe cross section area}} = \frac{\mathbf{m^3/s}}{\mathbf{m^2}}$$

4. Fill in individual pipe lengths for the nominal internal pipe areas in (m).

5. With attached calculating meter (Andritz) appropriate

„pressure loss“ (m)

will be calculated for the nominal internal pipe area.

a) determine substance density in (%) to corresponding flow velocity ”v” (m/s)
b) nominal internal pipe area (right bottom panel) substract corresponding pressure loss Dv (m) and divide 100.

ATTENTION : Substracted value is valid for 100 m of the pipe leght !

6. This pressure loss Dv is multiplied by corection factor ”Korr” and pipe lenght L (m) corresponding to the nominal internal pipe area.

Hv = L * Korr * Dv (m)

Korr... corection factors for substance sort and piping material (see list 5.7)
Hv ... loss hight corresponding to the nominal internal pipe area depending on medium and piping characteristics.

7. Difference of the pressure heights ... Hdruck,when is tank under pressure

$$\mathbf{Hdruck} = \frac{\textbf{full pressure of the tankr - suction pressure}}{\textbf{density * grav. acceleration (9,81 m/s}^2\textbf{)}} = \frac{\textbf{bar * 100.000}}{\textbf{kg/m}^3 \textbf{ * m/s}^2}$$

8. At the end it adds up :

H = Hv + Hz + Hgeod + Hdruck (m)

5.4 Calculating list

			unit	DN1	DN2	DN3	DN4	DN5
	1. Transported quantity per sec		m^3/s					
	2. Nominal dia	DN	m					
	3. Flow velocity	v	m/s					
	4. Substance density absolut dry	SD	%					
Mutiply	5. Piping lenght	L	m					
	6. Correction factors	Korr						

	7. Mediated. Pressure loss from the calculation meter (Andritz)	Dv	0,01m					
Sumarize	8. Loss height = L* Korr * Dv (result from 5 * 6 * 7) 9. Resistances for inbuilt: Bends, armatures, T pieces (see table 5.8) 10. Conrtol armatures resistances 11. Other resistances 12. Geodetic height 13. Pressure height at the tank closure	Hv Hz Hz Hz Hgeod Hdruck	m m m m m m	plus minus				
	14. Required Pump transport height (sum of 8,9, 10, 11 + 12 + 13)	H	m					
	15. Value NPSH Equipment 16. Value NPSH Pump 17. Zero transport height equipment 18. Zero transport height pump		m m m m					O.K.? O.K.? O.K.? O.K.?

5.5 Equipment calculation - NPSH – value

<u>Value NPSH</u>
It is useful for safety verification of the pump cavitation. To follow the definition following must be observed:

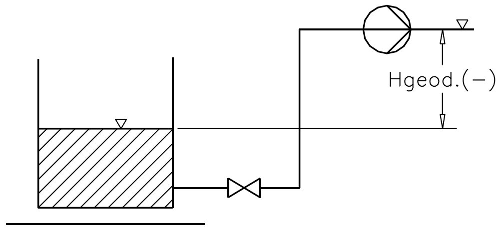
$NPSH_{equip.} > NPSH_{pump} + 0,5$

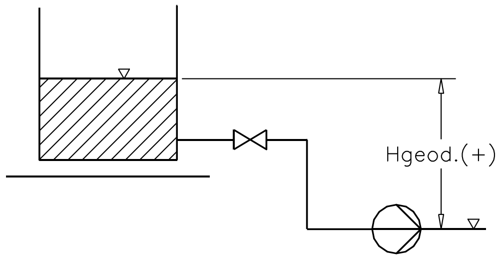
<u>NPSH - equipment</u>
According to the definition, NPSH of the equipment is existing absolute pressure on the entrance section of the pump minus steam pressure at this state, in absolute mWS (m of the spout).

<u>Value NPSH pump</u> see manufacturer´s pump data

a) in the suction mode

b) with inflow height





Calculation model		**Unit**	**Value to be written here**
Internal pressure, tank closed	PE	bar relat.	
Atmosperic air pressure	PB	bar	1,00
Steam pressure of a liquid	PD	bar	
Density of a liquid	Density	kg/m^3	
Acceleration of the gravity	g	m/s^2	9,81
Calculated outflow velocity	ve	m/s	
Calculated suction loss height [1)]	Hvs	m	
Hgeod (+), or (-)	Hgeod	m	

$$\text{NPSH equipm.} = \frac{(P_E + P_B - PD) * 100.000}{\text{Density} * g} + \frac{ve^2}{2g} - H_{VS} +/- H_{geod}$$

[1)] see the calculation technique

Simplified formula:

$$\text{NPSH equipment} = \frac{(P_E + P_B - PD) * 10.000}{\text{Density}} - H_{VS} +/- \text{Hgeod}$$

Simplified way for water and substance up to 50 °C, density < 4 %, open tanks:

NPSH equipment = 8 - H_{VS} + / - Hgeod

Calculated value of NPSH equipment value of NPSH pump		m m	

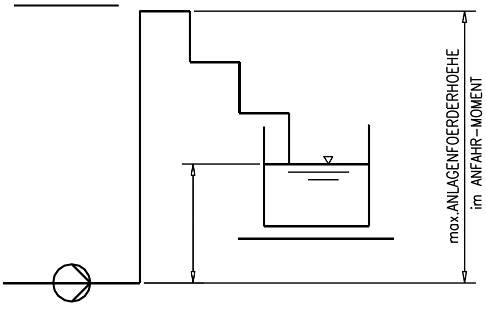
5.6 Verifying calculation for the zero transport height

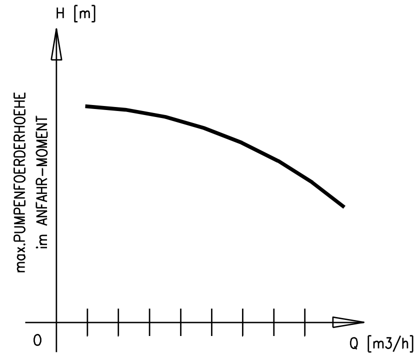
A great amount of equipment has a mean effective transport height smaller than an actual height, which has to be overcome by the pump at the start.

For example: rising pipe line following with descend.

Therefore, it is necessary to compare minimum necessary transport height of the equipment and the maximum transport height of the pump at the moment of start (transport quantity is practical zero).

Sinnbild





Application method

1. Zero transport height - equipment

   Transport height to the maximum height of equipment must be calculated analogicaly to a check list and calculation list for transport heights (see calculation modus).

2. Zero transport height – pump

   Using the pump characteristics, maximum transport height must be deducted if the transport quantity equals or is larger than zero.

Transport height of the pump must be higher than a transport height of the equipment.

The larger Q/H value must be selected acc. to diagram (quantity/ transport height) if the pump has too small power at the start up.

Foreign pipe line filling is useful in case the deviations are too large eventually for too large nominal pipe internal areas (> 300 mm).

5.7 Correction factors: Parts resistance built into piping

Correction factors

Lambda ..... For differrent types of substances
K ..... Friction resistance of the pipe 0,7 ... for common pipes
Stainless steel
(1.4436, 1.4301, 1.4571)
(17352, 17240,17348)

$\boxed{\text{"KORR"} = \text{Lambda} * \text{K}}$

Valid for:

”KORR” ...	Ungrinded sulphit bleached	0,525
”KORR” ...	Grinded sulphit bleached	0,490
”KORR” ...	Ungrinded salt bleached	0,560
”KORR” ...	Grinded salt bleached	0,525
”KORR” ...	waste	0,500

<u>Resistances Zeta-values</u>

(Loss heights ... m) for armatures and shaped pieces

ZETA ..... resitance digit of the tube part , armature or shaped pieces

$$Hz = Sum\ ZETA * \frac{v^2}{2 * g}$$

Hz ... loss height in armature (m) or shaped pieces
v ... flow velocity (m/s)
g ... acceleration of gravity ... 9,81 m/s^2

”Sum ZETA” ... Zeta-values of all armatures and shaped piecess must add up.
This is necessary for the same nominal internal areas of pipe.

ZETA-values ... see table

See a following standadized form

5.8 Standardized form for zeta - values

		DN1	DN2	DN3	DN4	DN5	DN6
Nominal internal areas of pipe DN							
Flow velocity v							
Pcs	**List** Elbow s, T-pieces,armatures, inbuilt parts						

Summary making on nomminal internal area all pieces							
$\frac{v^2}{2g}$ for nominal internal area							
Hz = ”sum ZETA” $* \frac{v^2}{2g}$							

Back to the calculation modus

5.9 Annex

Loss height Hv in armatures and shaped piecess

$$Hv = \xi * \frac{v^2}{2g}$$ in meters, where v = middle flow velocity in base section in m/s

ξ = resistance digit of the contact parts of the pipe

or

$$Hv = \Sigma \xi * \frac{v^2}{2g}$$ in metres,

ξ- values of all armatures and shaped piecess are added up first .The same nominal internal area DN must be observed. In the following setting resistance digits are sytated for the most common armatures and shaped piecess. With the known values v and ξ loss height can be simply stated Hv using the table 15, page 144.

Armatures

Base section: Section is calculated from the nominal internal area DN.

Flow valves (completely opened valve)

Directly seated valve	Casted valves, DN 25 up to 200	ξ = 2,5

(stem vertically)	Wrought valves, DN 25 up to 50	ξ = 6,5

Aslope seated valve, direct valve (with aslope stem)

DN	25	32	40	50	65	80	100	125 až 200
ξ	1,7	1,4	1,2	1,0	0,9	0,8	0,7	0,6

Corner valves (valve completely open) DN 25 up to 200: ξ = 2,0

Reverse valve

Directly seated valve, DN 25 up to 200	ξ = 3,5
Aslope seated valve, DN 50 up to 200	ξ = 2,0

Foots valves with a suction basket (to DN 350 included)

DN		50 up to 80	100 up to 350
ξ when	v = 1 m/s	4,1	3
	v 2 m/s	3,0	2,25

Foots valves in a group set-up (from DN 400)

DN	400	500	600	700	800	1000	1200
ξ	7,0	6,1	5,45	4,95	4,55	4,05	3,9

Sealing chek-valves (closing check-valves), ring sealing check-valves(check-valve- completely open)

DN		400	600	800	1000	1200	1500
ξ pri	PN 2,5			0,08	0,06	0,05	0,13
	PN 4		0,16	0,12	0,11	0,20	0,17
	PN 6			0,16	0,30	0,25	0,22
	PN 10	0,48	0,33	0,50	0,45	0,41	0,37
	PN 16	1,20	0,85	0,73	0,63		

Return Check- valves, without lever and weight

DN		50	200	300	500	600	700	800	1000	1200
ξ with	v=1m/s	3,05	2,95	2,90	2,85	2,70	2,55	2,40	2,30	2,25
	v=2m/s	1,35	1,30	1,20	1,15	1,05	0,95	0,85	0,80	0,75
	v=3m/s	0,86	0,76	0,71	0,66	0,61	0,54	0,46	0,41	0,36

If the check –valves are provided with lever and weight, resistance digits can represent multiplied nominal value according to the weight setting. Gross approximate values can be gained for v x 2,5 m/s multiplying factor 2,5.

Turning check valves (knife check valves), with lever and weight/load (axis of rotation of shutter is situated in the upper semicircular area)

v	1 m/s	1,5 m/s	2 m/s	2,5 m/s
ξ	8	3	1,3	0,7

Shutter closures (drainage check valves, High water shutters)

Resistance digits of the shutter closures depend on the flow velocity, construction and flap weight, so that binding values can be stated only by manufacturer.

It can be considered for the aproximate calculations: ξ = 1,0 upto 1,5

With stop from reverse flow HYDRO-STOP

DN		50	100	150	200	250	300	400
ζ pri	v=2m/s	5	6	8	7,5	6,5	6	7
	v=3m/s	1,8	4	4,5	4	4	1,8	3,4
	v=4m/s	0,9	3	3	2,5	2,5	1,2	2,2

With flat gate valve (slide completely open)

DN	100	200	300	400	500	600 až 800	900 až 1200
ζ	0,18	0,16	0,14	0,13	0,11	0,10	0,09

With oval gate valve and cylinder valve (slide completely open)

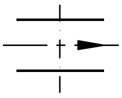
DN	100	200	300	400	500	600 až 800	900 až 1200
ζ	0,22	0,18	0,16	0,15	0,13	0,12	0,11

Round gate valve (slide completely open)

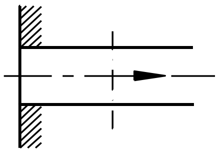
	Refering to the narrowest section
ζ	0,5 up to 0,8

<u>Shaped piecess</u>

Relative section for flow velocity <u>v</u> is always marked

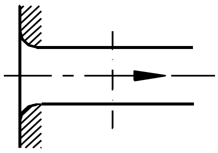


Square inlet



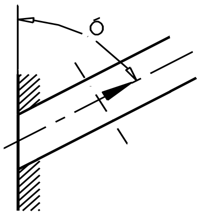
Very sharp $\zeta = 0{,}5$
normally round $\zeta = 0{,}25$
Rough phase $\zeta = 0{,}2$

Round inlet



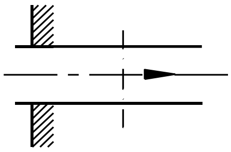
according to the smootheness $\zeta = 0{,}06$ till 005
normal $\zeta = 0{,}05$

square linlet
angle α



α	45°	60°	75°
ζ	0,8	0,7	0,6

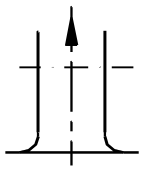
Far overhung
square feed



very sharp $\zeta = 3$
normally rounded $\zeta = 0{,}6$

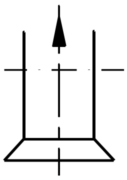
<u>Feeder bodies</u>

Pipe-form feed



$\zeta = 0{,}05$

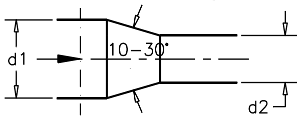
With sloped form feed



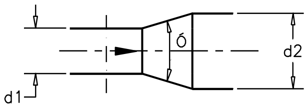
$\zeta = 0{,}20$

<u>Outlet</u> (outlet loss) $\zeta = 1$
(flow velocity is determining in the outlet inter-section)

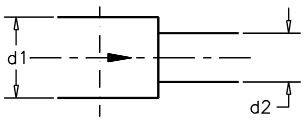
Intersection changes



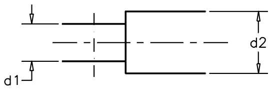
d_1/d_2	0,5	0,6	0,7	0,8	0,9
ζ	0,56	0,46	0,24	0,13	0,04



d_1/d_2		0,5	0,6	0,7	0,8	0,9
ζ pri	α= 8°	0,12	0,09	0,07	0,04	0,02
	α=16°	0,19	0,14	0,09	0,05	0,02
	α=25°	0,33	0,25	0,16	0,08	0,03

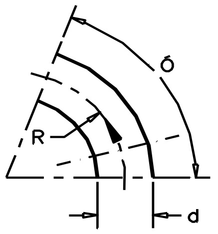


d_1/d_2	1,2	1,4	1,6	1,8	2,0
ζ	0,10	0,22	0,29	0,33	0,35



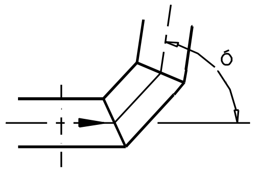
d_1/d_2	1,2	1,4	1,6	1,8	2,0
ζ	0,02	0,05	0,10	0,17	0,26

Bends



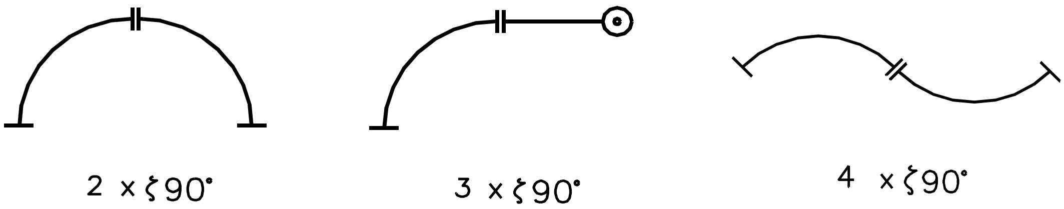
α		45°		60°		90°	
		Surface		Surface		Surface	
		Smooth	Rough	Smooth	Rough	Smooth	Rough
ζ for	R = d	0,14	0,34	0,19	0,46	0,21	0,51
	R = 2d	0,09	0,19	0,12	0,26	0,14	0,30
	R ≥ 5d	0,08	0,16	0,10	0,20	0,10	0,20

Segment welded

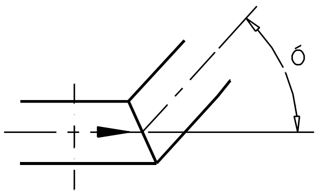


α	45°	60°	90°
Number of the round welds	2	3	3
ζ	0,15	0,2	0,25

In -line bends - 90°

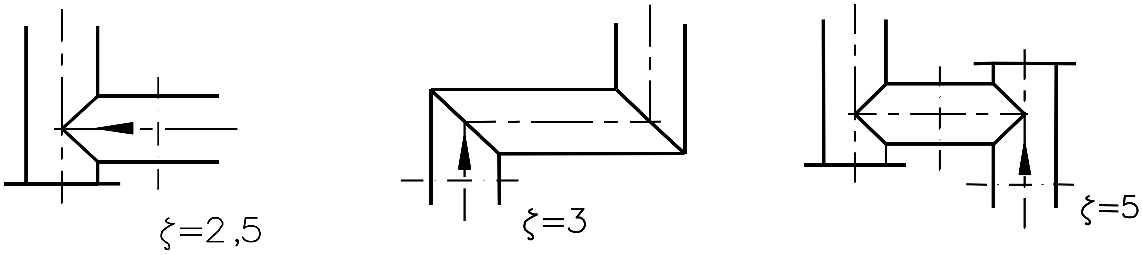


Elbows



α	45°		60°		90°	
	Surface		Surface		Surface	
	Smooth	Rough	Smooth	Rough	Smooth	Rough
ζ	0,25	0,35	0,50	0,70	1,15	1,30

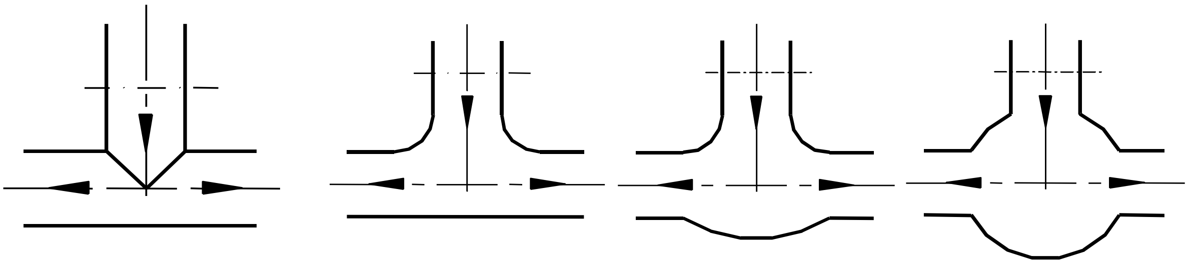
Combination with 90° elbows



Compensator

- Wave tube – compensator with/without guide pipe — ζ = 0,3/2,0
- Compensator - lyre (with smooth pipe) — ζ = 0,7
- Compensator - lyre – Bellows tube — ζ = 1,4

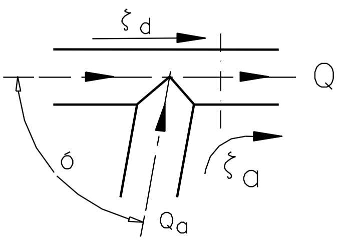
T – pieces (flow division)



With sharp edge	round With flat bottom	Ball-shaped with rounded neck inside	Ball-shaped
ζ = 1,3	ζ = 0,7	ζ = 0,9	ζ = 2,5 - 4,9

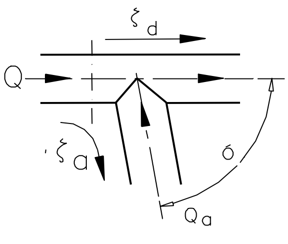
Branch pipes (main piping and branch pipe with the same internal area)

Linking of flow



		Q_a = 0	Q_a = 0,5Q	Q_a = 0,8Q	Q_a = Q
α = 90°	ζ_d=	0,04	0,35	0,5	-
	ζ_a=	-	0,3	0,7	0,9
α = 45°	ζ_d=	0,04	0,1	0	-
	ζ_a=	-	0,1	0,35	0,4

Flow sharing



		Q_a = 0	Q_a = 0,5Q	Q_a = 0,8 Q	Q_a = Q
α = 90°	ζ_d=	0,04	0,01	0,2	-
	ζ_a=	-	0,9	1,1	1,3
α = 45°	ζ_d=	0,04	0,2	0,2	-
	ζ_a=	-	0,4	0,35	0,5