Fluid mechanics

i Calculation without errors.

ii Project information

? **Input section**

1.0 Units, Fluid Selection and Coefficients Setting

1.1	Calculation units		SI Units (N, mm, kW...)		
1.2	**Parameters of Fluid**				
1.3	Fluid Selection		02. Water (20 °C)		
1.4	Density	ρ	998.19	[kg/m³]	
1.5	Speed of Sound in Fluid	a	1481.88	[m/s]	
1.6	Bulk Modulus of Fluid	K	2.1920	[GPa]	
1.7	Kinematic viscosity	ν	0.0000010064	[m²/s]	
1.8	Dynamic viskosity	μ	0.0010046000	[Pa*s]	
1.9	**Environment settings**				
1.10	Altitude	Alt	0 (0)	[m]	
1.11	Reference barometric pressure	pb	101.325	[kPa]	
1.12	Acceleration of Gravity	g	9.8067	[m/s²]	
1.13	Critical Reynolds Number	Re,cr	2300	[~]	

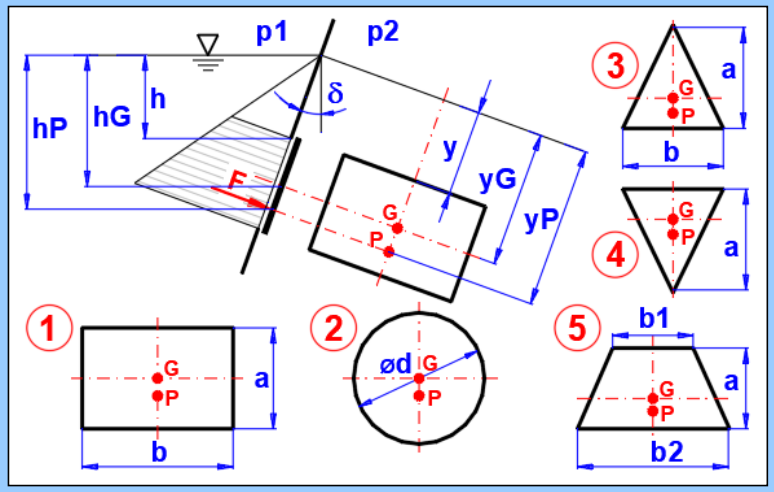
1.14 Units conversion

Length	1	m	1000	mm
Area	1	m²	10.76391042	feet²
Density	1	kg/m³	0.062427818	lb/ft³
Speed	1	m/s	3.280839895	ft/s
Pressure	1	MPa	10.1972	Atm
Kin.viscosity	1E-06	m²/s	1.08134E-05	ft²/s
Dyn.viscosity	0.001	Pa·s	2.08854E-05	lbf·s/ft²
Acceleration	1	m/s²	3.280839895	ft/s²
Power	1000	W	1.34102	HP
Force	1	N	0.224809	lbf
Flow rate	1	m³/s	35.31	ft³/s
Temperature	20	°C	68.00	°F

2.0 Hydrostatics

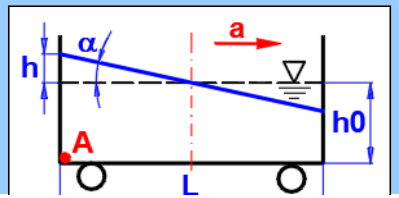
2.1 Hydrostatic Forces on Plane Areas

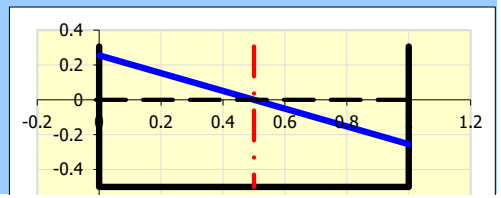
2.2	Area selection		2. Circle	
2.3	Pressure Above the Surface	p1	101.3250	[kPa]
2.4	External Pressure	p2	101.3250	[kPa]
2.5	Top Edge - Depth	h	3.0000	[m]
2.6	Diameter	d	1.0000	[m]
2.7	Width	b	0.9000	[m]
2.8	Width	b2	3.0000	[m]
2.9	Angle	δ	45.000	[°]
2.10	Surface	S	0.78540	[m²]
2.11	Force	F	25782.74	[N]
2.12	Top Edge - Distance y	y	4.2426	[m]
2.13	Center of Gravity - y Distance	yG	4.7426	[m]
2.14	Center of Pressure - y Distance	yP	4.7558	[m]
2.15	Centre of Gravity - Depth	hG	3.3536	[m]
2.16	Centre of Pressure - Depth	hP	3.3629	[m]



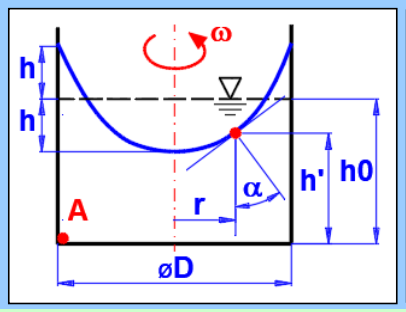
2.17 Fluid Equilibrium - Linear Acceleration

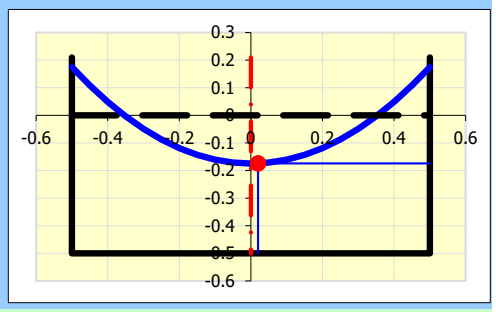
2.18	Length of Tank	L	1.0000	[m]
2.19	Fluid Level	h0	0.5000	[m]
2.20	Acceleration / Decceleration	a	5.0000	[m/s²]
2.21	Fluid Level Angle	α	27.02	[°]
2.22	Fluid Level Increase	h	0.2549	[m]





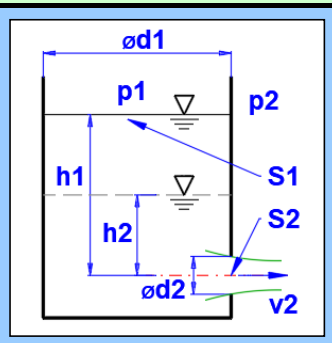
2.23	Pressure at Point A	pA	7.3899		[kPa]
2.24	**Fluid Equilibrium - Rotation**				
2.25	Tank Diameter	D	1.0000		[m]
2.26	Fluid Level	h0	0.5000		[m]
2.27	Turning Speed of the Tank	n	50.0000		[rpm]
2.28	Angular Velocity	ω	5.236		[rad/s]
2.29	Fluid Level Increase	h	0.1747		[m]
2.30	Pressure at Point A	pA	3.6018		[kPa]
2.31	Results for Radius	r	0.0200		[m]
2.32	Surface Angle	α	3.20		[°]
2.33	Fluid Level	h'	0.3258		[m]

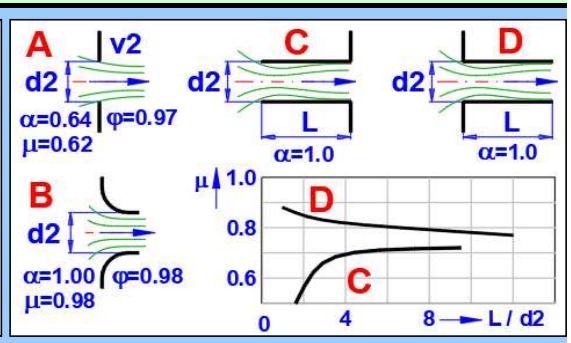


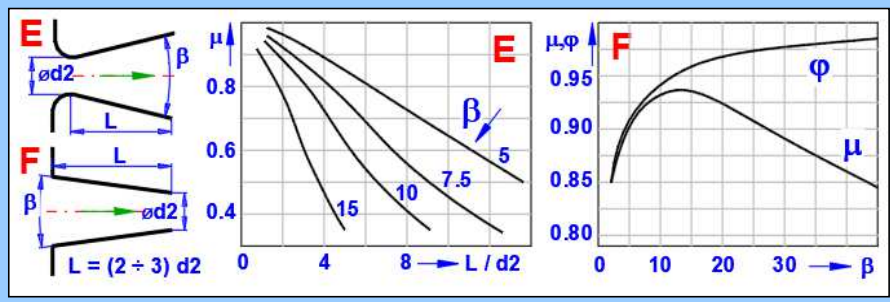


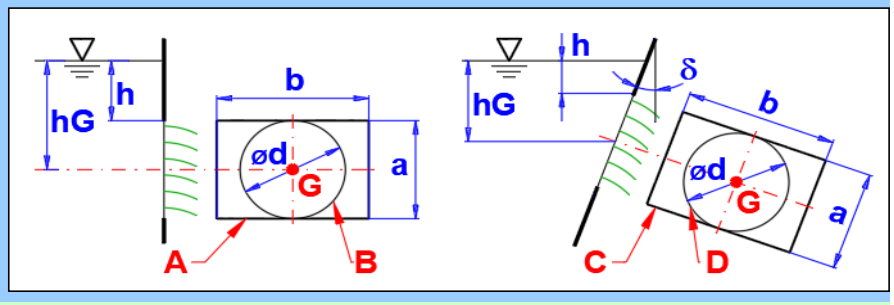
3.0 Stationary Fluid Discharge through Opening

3.1	**Fluid Discharge through Small Opening**				
3.2	Pressure Above the Surface	p1	101.3250		[kPa]
3.3	External Pressure	p2	101.3250		[kPa]
3.4	Fluid Level	h1	2.000		[m]
3.5	Tank Diameter	d1	2.000		[m]
3.6	Tank Area	S1	3.14		[m²]
3.7	Hole Diameter	d2	10.000		[mm]
3.8	Opening Area	S2	78.540		[mm²]
3.9	Theoretical Discharge Velocity	vt2	6.26		[m/s]
3.10	Reynolds Number / Coefficient of Discharge (figure A)	Re / μ	62231.52	0.62	[~]
3.11	Coefficient of Contraction	α	0.64		[~]
3.12	Coefficient of Velocity	φ	0.97		[~]
3.13	Coefficient of Discharge	μ	0.62		[~]
3.14	Real Discharge Velocity	v2	6.08		[m/s]
3.15	Flow Rate	Q	0.3054		[L/s]
3.16	Height of Level Required	h2	1.000		[m]
3.17	Time to empty the vessel from h1 to h2 (for p1=p2)	t	12052.78		[s]
3.18	Opening time (from h1)	to	1000		[s]
3.19	During the opening time, the outlet will flow out	Qo	301.6635		[L]
3.20	**Discharge of Fluid through Large Opening**				
3.21	Typ otvoru		B. Circle (vertical wall)		
3.22	Top Edge - Depth	h	2.000		[m]
3.23	Diameter	d	1.000		[m]
3.24	Width	b	2.000		[m]
3.25	Angle	δ	30.000		[°]
3.26	Coefficient of Discharge	μ	0.62		[~]
3.27	Centre of Gravity - Depth	hG	2.500		[m]
3.28	Flow Rate	Q	3.410		[m³/s]



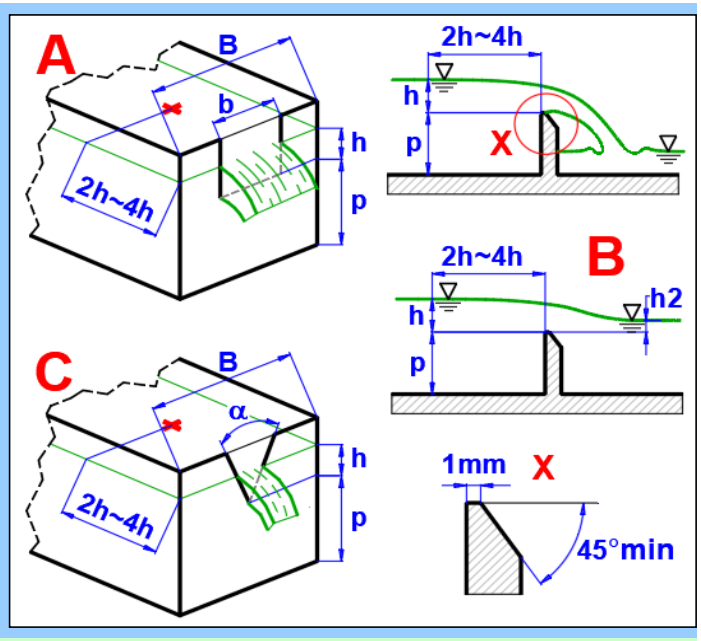






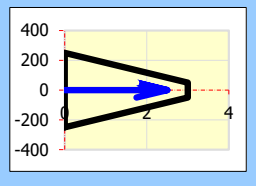
4.0 Stationary Discharge - Spillways (ISO 1438, Swiss Engineers, Hansen, Bazin, Frese)

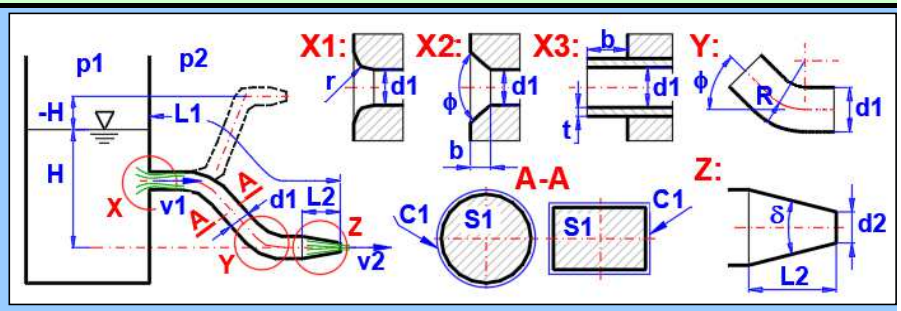
4.1	**A. Rectangular Spillway**					
4.2	Calculation type of Cd, Q		1. ISO 1438:2017			[h/p=0.44<2.5]
4.3	Measured Height above the Spillway	h	0.400		[m]	[h>0.03m]
4.4	Height of the Crest relative to the Floor	p	0.900		[m]	[p>0.10m]
4.5	Width of Approach Channel	B	8.000		[m]	[B>=b]
4.6	Measured Width of the Notch	b	2.000		[m]	[b>0.15m]
4.7	Coefficient of Discharge	Cd	0.590	0.590	[~]	
4.8	Volumetric Rate of Flow	Q	0.8850		[m³/s]	
4.9	**B. Rectangular Spillway - Flooded (ISO 1438)**					
4.10	Measured height Behind the Spillway	h2	0.200		[m]	[h/p=0.44<4]
4.11	Flooding Coefficient	f	0.755	0.755	[~]	[h2/h=0.5]
4.12	Volumetric Rate of Flow	Q	0.6685		[m³/s]	[0<h2/h<0.97]
4.13	**C. Triangular Spillway (ISO 1438)**					
4.14	Measured Height above the Spillway	h	0.500		[m]	[h>0.06m]
4.15	Notch Angle	α	99.00		[°]	[20°<α<100°]
4.16	Coefficient of Discharge	Cd	0.581	0.581	[~]	
4.17	Volumetric Rate of Flow	Q	0.2851		[m³/s]	



5.0 Stationary Flow of Viscous Fluid - Constant Pipe Cross Section with Outlet Nozzle / Diffuser

5.1	**Pipes and Input Conditions**					
5.2	Pressure Above the Surface	p1	101.3250		[kPa]	
5.3	External Pressure	p2	101.3250		[kPa]	
5.4	Level Height	H	200.00	>0	[m]	
5.5	Pipe Diameter	d1	500.00		[mm]	
5.6	Fluid Flow Cross Section (A-A)	S1	196349.54		[mm²]	
5.7	Wet Circuit (A-A)	C1	1570.80		[mm]	
5.8	Hydraulic Diameter	dh1	500.00		[mm]	
5.9	Pipe Length	L1	1000.00		[m]	
5.10	Pipe Material (Roughness)		10. Cast iron old pipe (k = 1 - 4.5)		[mm]	
5.11	Medium Pipe Roughness	k	2.5000	2.5000	[mm]	
5.12	Calculation Method Lambda		D. Colebrook - White (rough pipes)			
5.13	Coefficient of Friction Losses (Lambda)	λ	0.030444	0.030	[~]	
5.14	Input Loss Coefficient (detail X1, X2, X3)	ζI	0.5000		[~]	
5.15	Loss Coefficient of Bends+Valves (detail Y)	ζB+ζV	1.9000		[~]	
5.16	**Nozzle / Diffuser (detail Z:)**		A. Used			
5.17	Nozzle / Diffuser	d2	100.000		[mm]	
5.18	Outlet Nozzle / Diffuser Area	S2	7853.982		[mm²]	
5.19	Wet Circuit	C2	314.159		[mm]	
5.20	Hydraulický průměr	dh2	100.000		[mm]	
5.21	Nozzle / Diffuser Length	L2	3.000		[m]	
5.22	Peak Angle of Nozzle / Diffuser	δ	7.63	Nozzle	[°]	





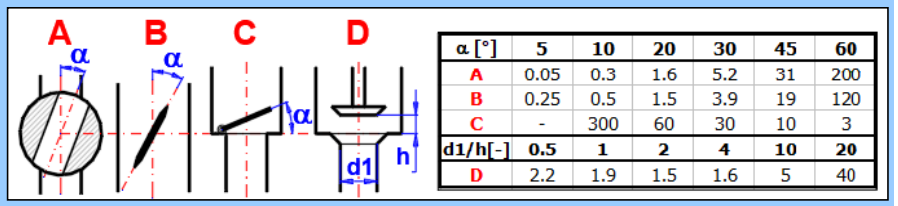
5.37	**Calculation of the loss in the rounded inlet (detail X1:)**				
5.38	Radius of Curvature	r	30.00	<=250	[mm]
5.39	Loss Coefficient	ζI	0.2000		[~]
5.40	**Calculation of the Loss in the Tapered Inlet (detail X2:)**				
5.41	Bevel Width	b	20.00	<=250	[mm]
5.42	Bevel Angle	ϕ	90.00	<=90	[mm]
5.43	Loss Coefficient	ζI	0.3540		[~]
5.44	**Calculation of the Loss in the Extended Inlet (detail X3 :)**				
5.45	Pipe Extension	b	20.00	<=250	[mm]
5.46	Wall Thickness	t	2.00	<=50	[mm]
5.47	Loss Coefficient	ζI	0.7280		[~]
5.48	**Calculation of Bending Loss (detail Y:)**				
5.49	Bending Radius	R	300.00	>250	[mm]

5.23	Nozzle / Diffuser Loss Coefficient	ζo	0.099	0.099	[~]
5.24	**Results**				
5.25	Pipe Velocity	v1	2.28700		[m/s]
5.26	Output Velocity	vo	57.17490		[m/s]
5.27	Reynolds number (pipe)	Re	1136201.7		[~]
5.28	Loss height (hydraulic losses)	hz	33.32896		[m]
5.29	Pipeline Efficiency	η	83.34		[%]
5.30	Pressure Power = Q*(p2-p1)	Pp	0.00000		[kW]
5.31	Height Power = Q*g*Ro*H	Ph	879.14229		[kW]
5.32	Power Losses = Q*g*Ro*hz	Pz	146.50451		[kW]
5.33	Output Power = Q*Ro*vo²/2	Po	732.63778		[kW]
5.34	Flow Rate	Q	0.449050604		[m³/s]

5.35	Units		[m³/s]	[m³/h]	[US Gal./s]	[US Gal./h]	[L/min]	[cm³/s]	[cm³/min]
5.36	Flow Rate	Q	0.449051	1616.582	118.62667	427056.021	26943.0363	449050.60	26943036.3

5.50	Bending Angle	ϕ	90		[°]
5.51	Loss Coefficient	ζB	1.0873		[~]
5.52	**Loss Coefficient of Discharge**	ζO	1.0000		[~]

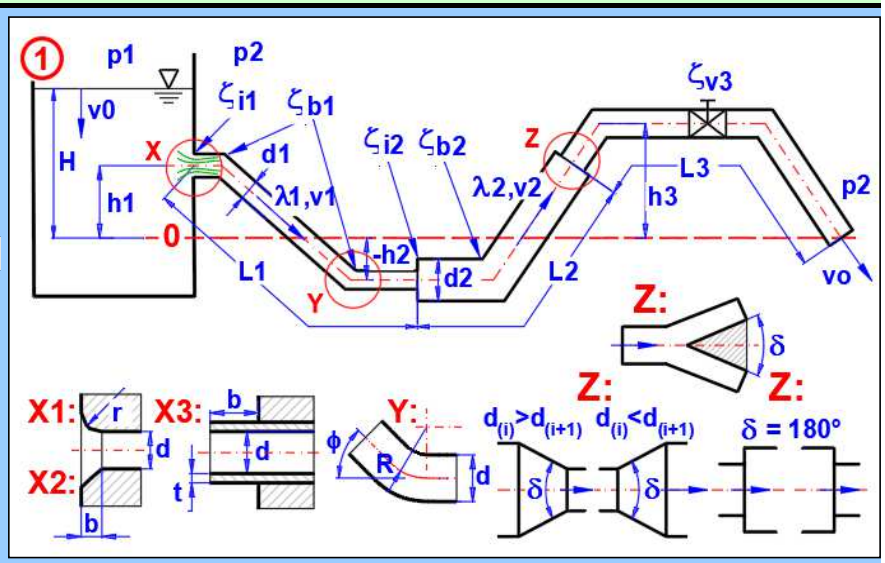
5.53 **Loss Coefficient of Valves**



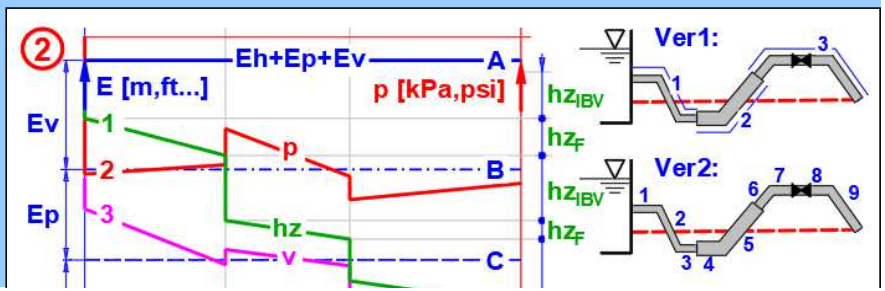
α [°]	5	10	20	30	45	60
A	0.05	0.3	1.6	5.2	31	200
B	0.25	0.5	1.5	3.9	19	120
C	-	300	60	30	10	3
d1/h[-]	0.5	1	2	4	10	20
D	2.2	1.9	1.5	1.6	5	40

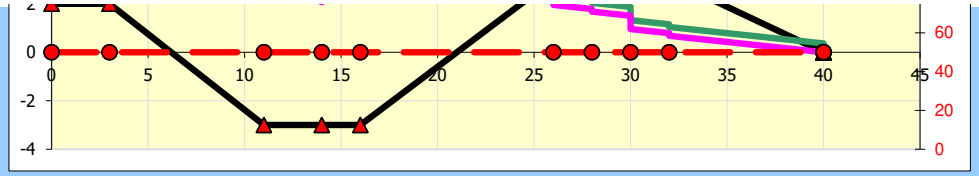
6.0 Stationary Flow of Viscous Fluid - Various Pipe Cross-Sections

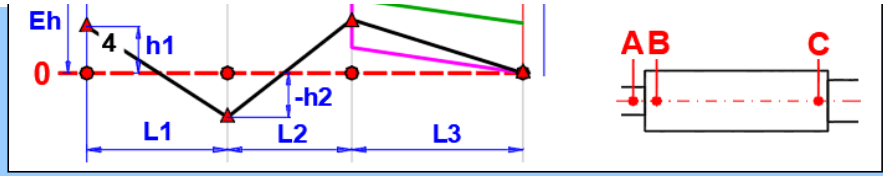
6.1	**Input Conditions**				
6.2	Pressure Above the Surface	p1	101.3250		[kPa]
6.3	External Pressure	p2	101.3250		[kPa]
6.4	Fluid Velocity	v0	0.0000		[m/s]
6.5	Level Height	H	10.000	>0	[m]
6.6	Calculation Method Lambda	D. Colebrook - White (rough pipes)			
6.7	**Results**				
6.8	Energy level	En	10.000000		[m]
6.9	Theoretical Output Velocity	vto	14.004749		[m/s]
6.10	Output Velocity	vo	2.674219		[m/s]
6.11	Loss height (hydraulic losses)	hz	9.63538		[m]
6.12	Pipeline Efficiency	η	3.65		[%]
6.13	Pressure Power = Q*(p2-p1)	Pp	0.00000		[kW]
6.14	Speed Power = Q*Ro*v0²/2	Pv	0.00000		[kW]
6.15	Height Power = Q*g*Ro*H	Ph	5.26333		[kW]
6.16	Power Losses = Q*g*Ro*hz	Pz	5.07142		[kW]
6.17	Output Power = Q*Ro*vo²/2	Po	0.19191		[kW]
6.18	Flow Rate	Q	0.053768363		[m³/s]



6.19 **Graph: Energy (left), Pressure (right)**







6.20 Pipeline Definition and Calculation Results

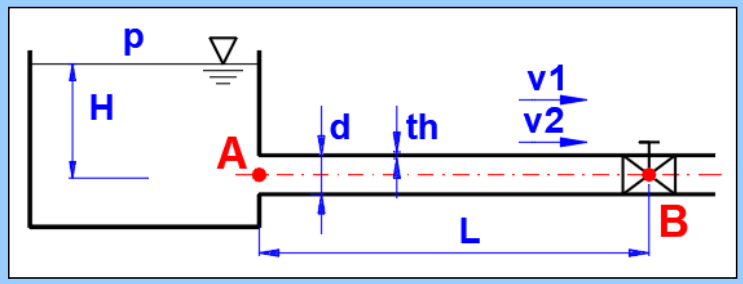
ID	A Number 9 Number	B Height h [m]	C Length L [m]	D Diameter d (dh) [mm]	E Area S [mm²]	F Delta δ [°]	G Geom ζI [~]	H Geom ζI+ζB+ζV [~]	I Roughness k [mm]	J Reynolds Re [~]	K Friction Lambda [~]	L Friction Lambda [~]	M Speed v [m/s]	N Selection 7. p-A [m]	O Selection 8. p-B
1	1	2	3	120	11309.73		0.5	0.5	1.5	566859.9	0.04101	0.04101	4.754167	18.35101	16.62243
2	1	2	8	120	11309.73	180	0	0.3	1.5	566859.9	0.04101	0.04101	4.754167	15.44095	15.09523
3	1	-3	3	120	11309.73	180	0	0.3	1.5	566859.9	0.04101	0.04101	4.754167	16.9446	16.59889
4	1	-3	2	240	45238.93	180	9	9	1.5	283429.9	0.03281	0.03281	1.188542	15.4174	15.84955
5	1	-3	10	240	45238.93	180	0	0.3	1.5	283429.9	0.03281	0.03281	1.188542	15.82986	15.80825
6	1	3	2	160	20106.19	180	0.309	0.309	1.5	425144.9	0.03723	0.03723	2.674219	9.709786	9.30452
7	1	3	2	160	20106.19	180	0	0.3	1.5	425144.9	0.03723	0.03723	2.674219	9.134833	9.025447
8	1	3	2	160	20106.19	180	0	1.5	1.5	425144.9	0.03723	0.03723	2.674219	8.855761	8.308827
9	1	3	8	160	20106.19	180	0	0.3	1.5	425144.9	0.03723	0.03723	2.674219	8.139141	8.029754
10	1	0	20	100	7853.982	180	0	0	1.5	0	0	0	0	0	0
11	1	0	20	100	7853.982	180	0	0	1.5	0	0	0	0	0	0
12	1	0	20	100	7853.982	180	0	0	1.5	0	0	0	0	0	0
13	1	0	20	100	7853.982	180	0	0	1.5	0	0	0	0	0	0
14	1	0	20	100	7853.982	180	0	0	1.5	0	0	0	0	0	0
15	1	0	20	100	7853.982	180	0	0	1.5	0	0	0	0	0	0

7.0 Water hammer

7.1 Transfer of Values from paragraph [5.0]

7.2 **Input Parameters**

7.3	Pipe Material		2. Cast iron, ordinary	
7.4	Modulus of Elasticity of the Pipe Material	E	60.00	[GPa]
7.5	Pipe Diameter	d	500.00	[mm]
7.6	Pipe Wall Thickness	th	20.00	[mm]
7.7	Pipe Length	L	1000.00	[m]
7.8	Fluid Velocity before Valve Closure	v1	2.32	[m/s]
7.9	Fluid Velocity after Valve Closure	v2	0.00	[m/s]
7.10	Valve Closing Time	tc	2.00	[s]



7.11 **Pipe Flexible (Elastic)**

7.12	Bulk Modulus of Fluid	K	2.1920	[GPa]
7.13	Velocity of Sound in Liquid	a	1071.32	[m/s]
7.14	Shock Wave Travel Time (B->A->B)	t	1.867	[s]
7.15	Intensity of Pressure Wave produced	p	1.1561	[MPa]
7.16	Meridional stress	σ_l	7.225	[MPa]

7.18 **Absolutely Rigid Piping**

7.19	Bulk Modulus of Fluid	K	2.1920	[GPa]
7.20	Velocity of Sound in Liquid	a	1481.88	[m/s]
7.21	Shock Wave Travel Time (B->A->B)	t	1.350	[s]
7.22	Intensity of Pressure Wave produced	p	1.1561	[MPa]
7.23	Meridional stress	σ_l	7.225	[MPa]

7.17	Circumferential stress	σ_c	14.451	[MPa]	7.24 Circumferential stress	σ_c	14.451	[MPa]
?	**Additions section**							
8.0	**Viscosity and density calculation**							
8.1	Fluid Selection		01. Water					
8.2	Temperature	T	50.00	[°C]				
8.3	Density	ρ	988.06	[kg/m³]				
8.4	Kinematic viscosity	ν	0.0000005743	[m²/s]				
8.5	Dynamic viskosity	μ	0.0005674722	[Pa*s]				
8.6	Transfer of Values to Paragraph [1.0]							