Calculation of Pipe Friction Loss

Engineering Management Group
Development Planning Department
Standard Pump Business Division

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1. Work flow of pipe calculation

(1) Adding up actual straight length of piping

(2) Count number of piping elements (pipe joints, valves and so on)

(3) Convert these piping elements to equivalent length of straight pipe

(4) Add the equivalent length of straight pipe to the actual straight length

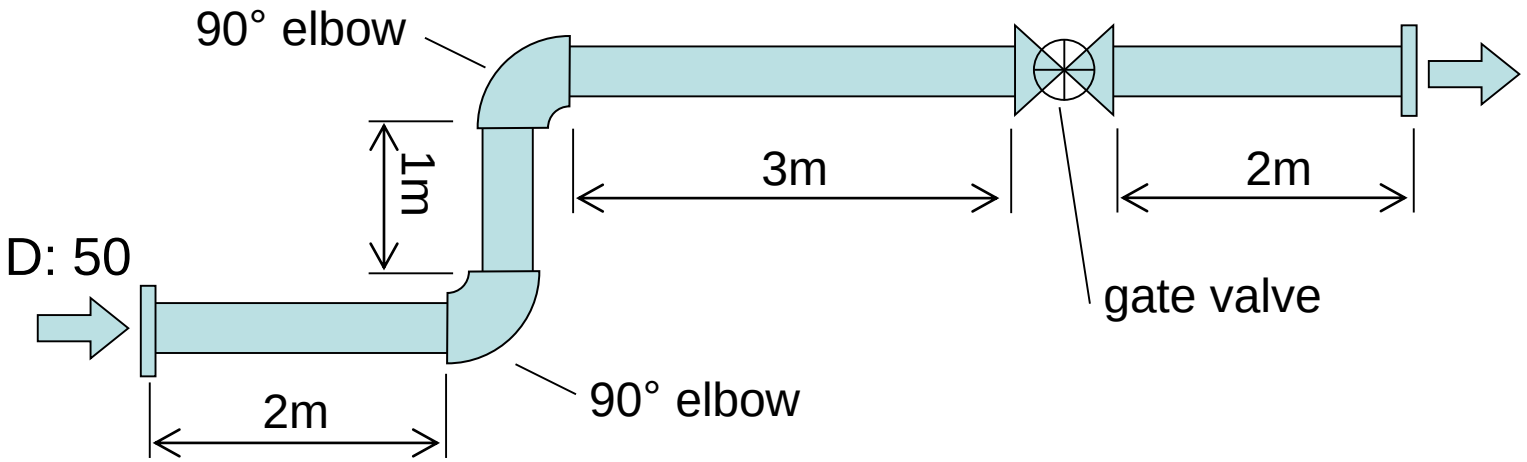
(5) Calculate pipe resistance by using calculation method or graphical method.

2. Equivalent Length of Straight Pipe

Example A

Top View

(There is no difference in height.)



(1) Integrate of actual straight length of piping

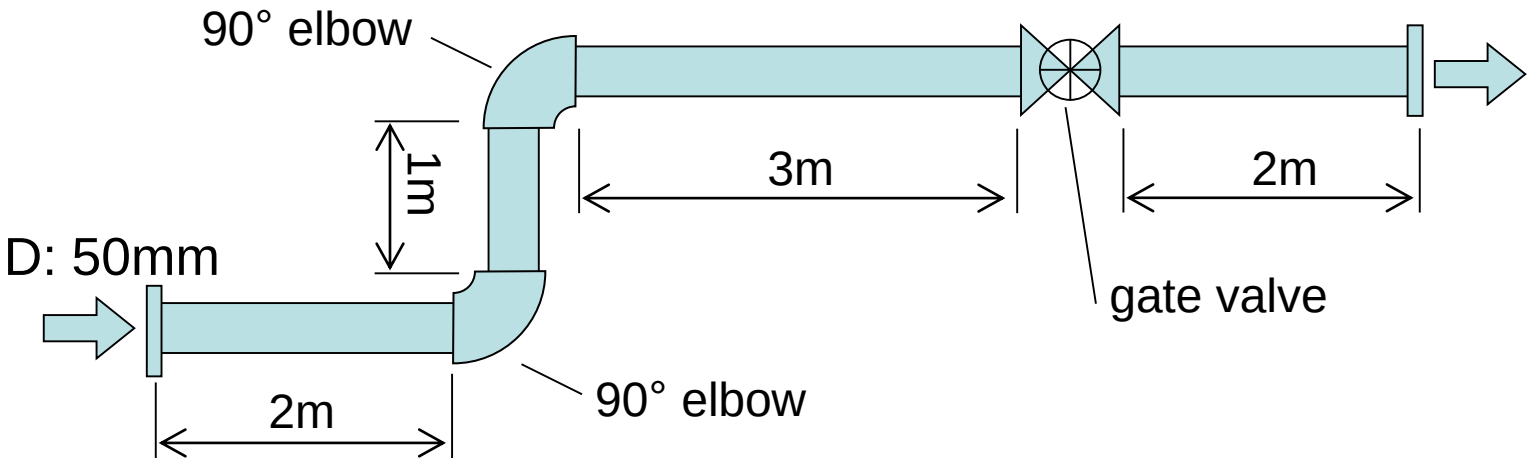
2 m + 1 m + 3 m + 2 m = 8m

2. Equivalent Length of Straight Pipe

Example A

Top View

(There is no difference in height.)



(2) Count the number of piping elements (pipe joints, valves and so on)

90° elbow	2
gate valve	1

2. Equivalent Length of Straight Pipe

+ Piping element loss

The table below shows the straight pipe equivalent length that produces the same friction loss caused by piping elements.

unit : m

Pipe element \ Pipe dia. (mm)	25	32	40	50	65	80	100	125	150	200	250
90º elbow	0.5	0.6	0.7	0.9	1.1	1.3	1.8	2.2	2.7	3.7	4.3
90º bend	0.5	0.6	0.7	0.8	0.9	1.0	1.3	1.5	1.7	2.1	2.4
Globe valve	13.7	16.5	18.0	21.3	23.5	28.6	36.5	—	—	—	—
Gate valve	—	—	—	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0
Check/ foot valve	2.2	3.1	3.7	5.2	6.4	8.2	11.6	15.2	19.2	27.4	36.6

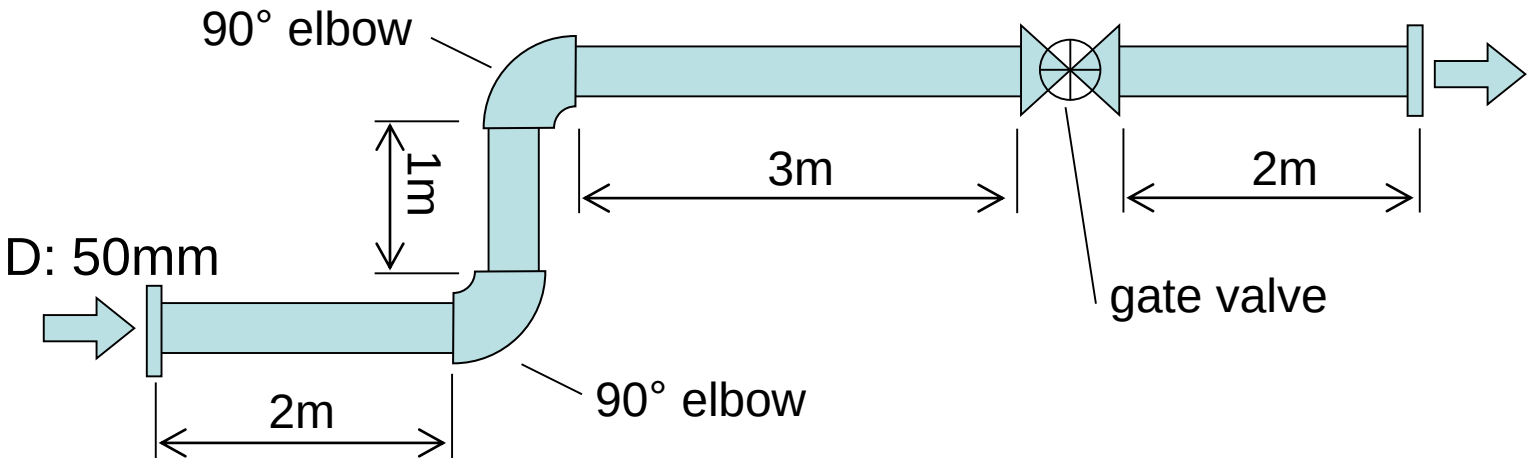
[Hydraulic Institute]

2. Equivalent Length of Straight Pipe

Example A

Top View

(There is no difference in height.)



(3) Convert these piping elements to equivalent length of straight pipe

90° elbow	2	⋯	0.9 m x 2 = 1.8 m
gate valve	1	⋯	0.8 m x 1 = 0.8 m

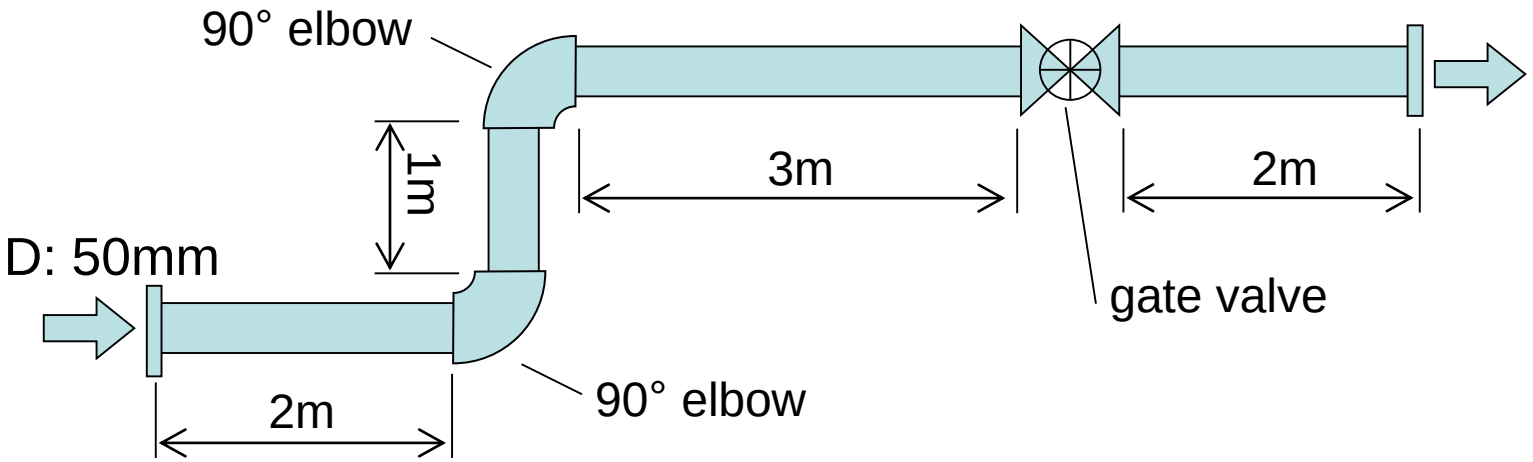
→ 2.6 m

2. Equivalent Length of Straight Pipe

Example A

Top View

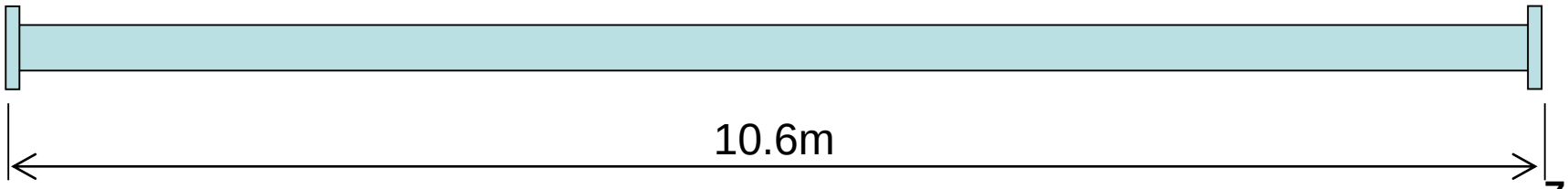
(There is no difference in height.)



(1) Integrate of actual straight length of piping 8m

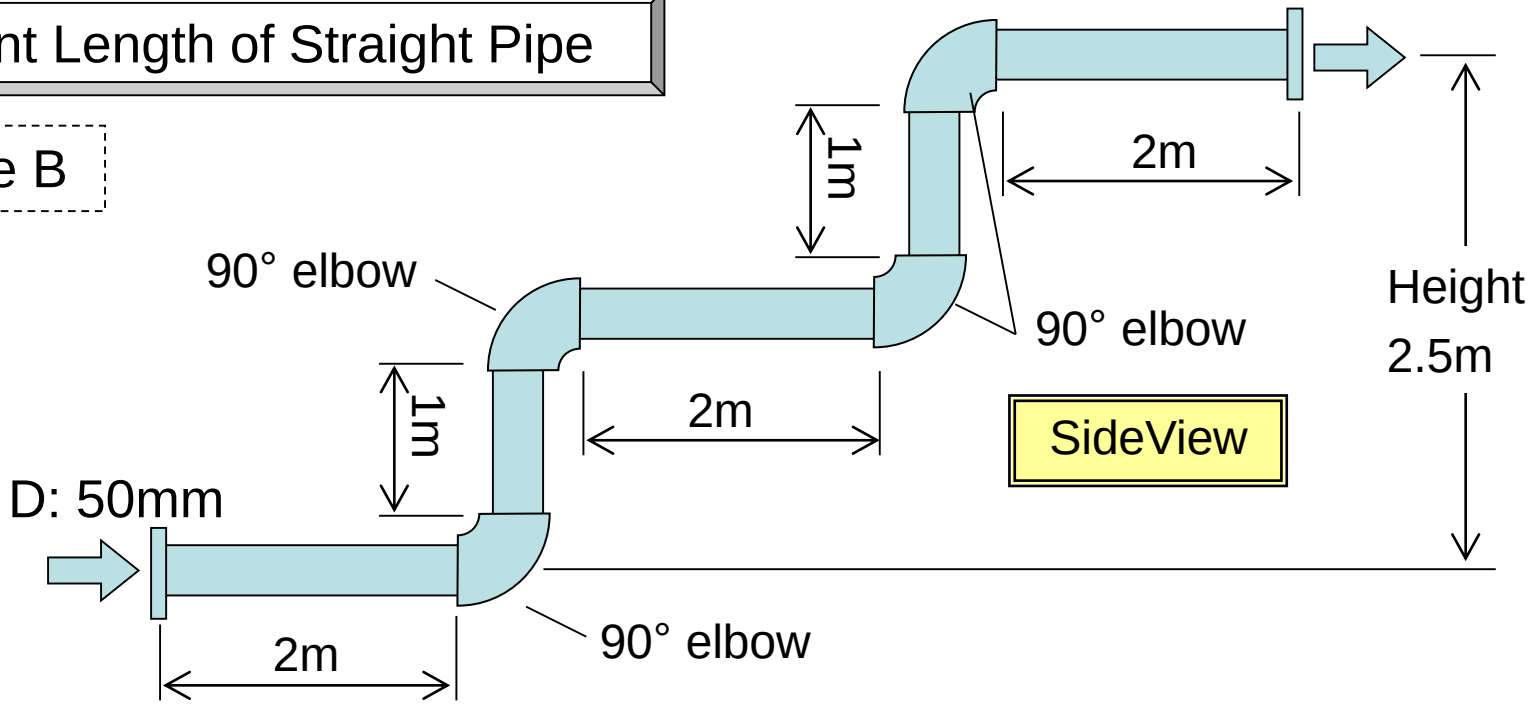
(3) equivalent length of straight pipe of piping elements 2.6 m

→ Total straight pipe length 10.6 m



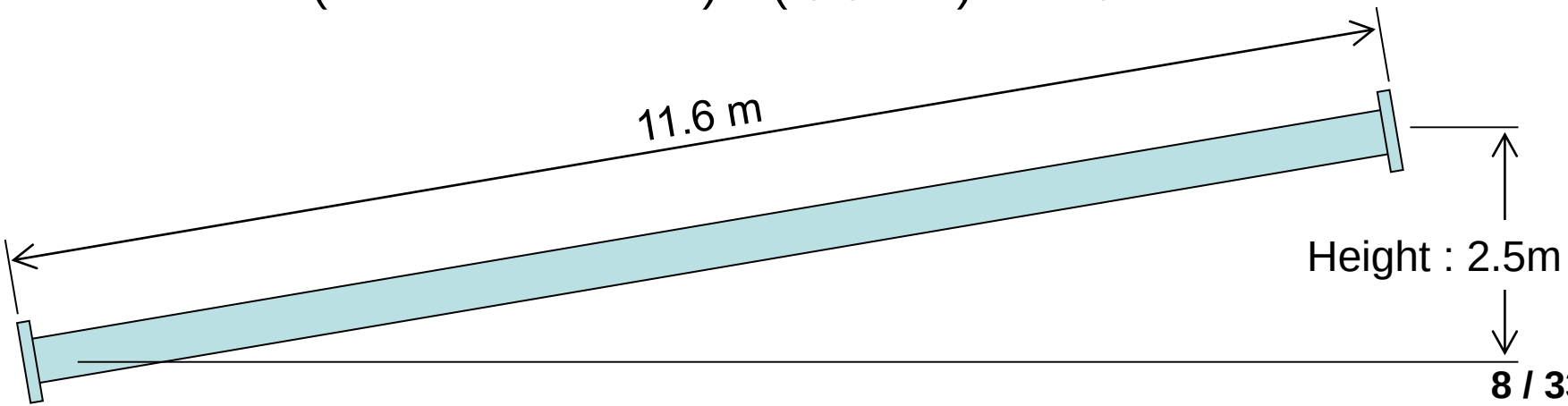
2. Equivalent Length of Straight Pipe

Example B



Total straight pipe length

$$(2 + 1 + 2 + 1 + 2) + (0.9 \times 4) = 11.6 \text{ m}$$



3. Head Loss for Straight Pipe (Calculation Method)

There are several methods to calculate the pipe friction loss. Among them, the following Darcy-Weisbach equation is commonly used.

$$Hf = \lambda \times \frac{L}{D} \times \frac{V^2}{2g}$$ (Darcy-Weisbach equation)

$$V = \frac{Q}{\frac{\pi}{4} \times D^2 \times 60} = 0.0212 \times \frac{Q}{D^2}$$

L: Pipe length (m)
D: Pipe inner diameter (m)
V: Flow velocity in pipe (m/s)
g: Gravity acceleration (9.8 m/s^2)
Q: Flow rate (m^3/min)

Hf: Head loss (m)

λ: Loss coefficient (Value variable with fluid viscosity, flow velocity, and diameter/surface roughness of the pipe). The loss coefficient can be obtained using the following equation that assumes water in a new steel pipe.

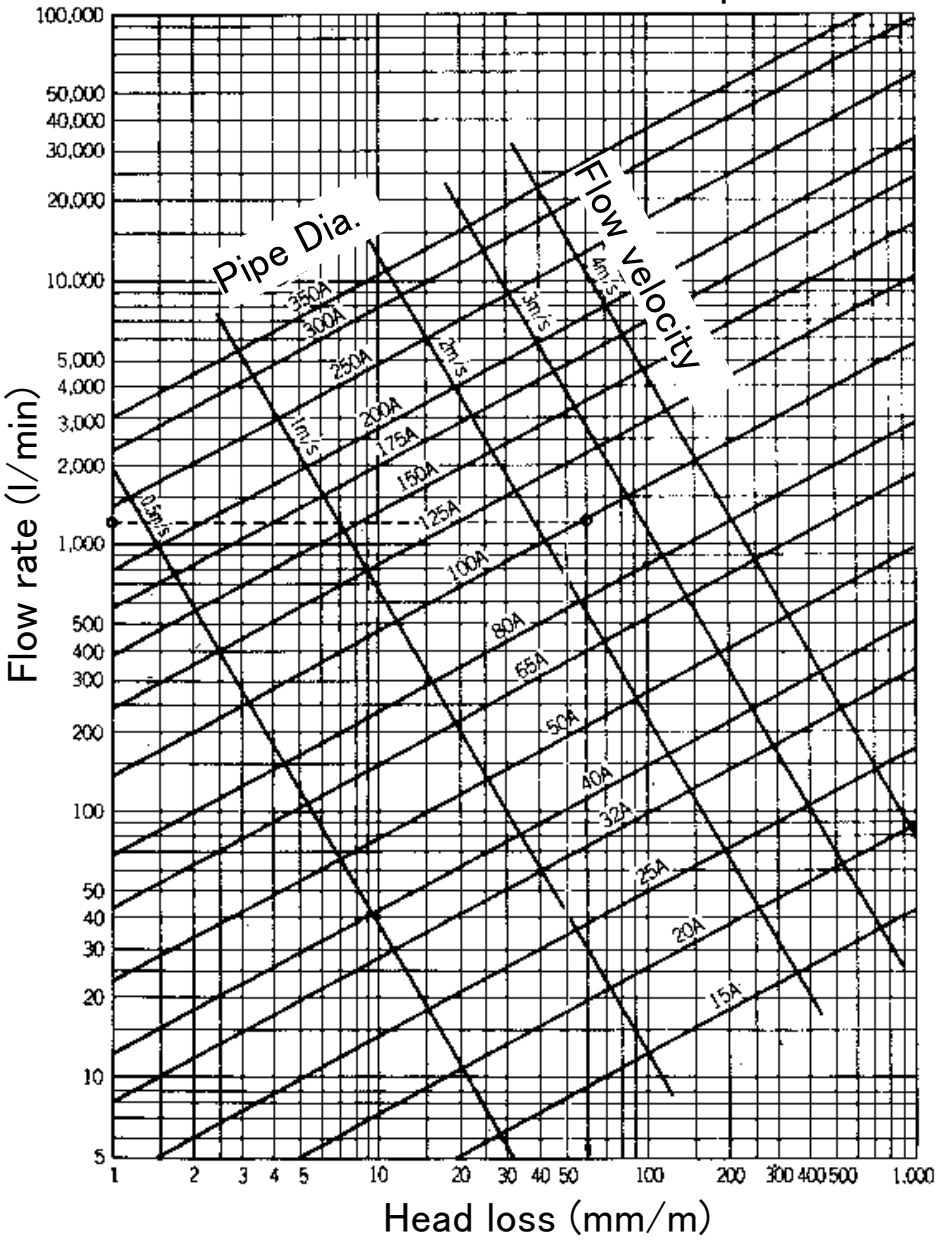
$$\lambda = 0.02 + \frac{1}{2000 \times D}$$

4. Head Loss for Straight Pipe (Graphical Method)

The head loss for steel pipe are as shown in the graph on the right. This graph however, indicate the head loss per meter for new pipe, and therefore the result obtained must be translated into the length as desired.

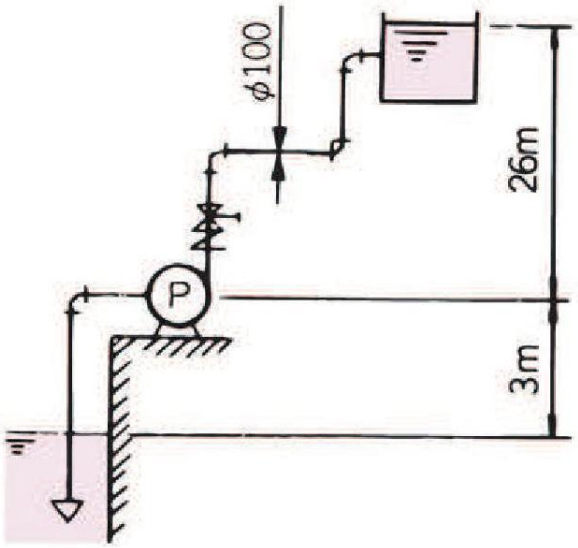
Taking into consideration an increase of friction loss caused by aging of the inner pipe wall, the obtained value is generally multiplied by 1.5.

Head Loss for Steel Pipe



4. Head Loss Calculation

+ Example Solution



Given information

Pipe Size :	**100mm**
Straight pipe Length:	**80m**
Foot Valve :	**1pcs**
90º Elbow :	**4pcs**
Check Valve :	**1pcs**
Gate Valve :	**1pcs**
Pipe :	**Steel**
Flow rate :	**1.2m^3/min**

To find the friction loss head

Straight pipe length : **80m**

Equivalent straight pipe length on piping elements : **31.3 m**

Foot Valve :	**11.6 x 1 = 11.6**
90º Elbow :	**1.8 x 4 =7.2**
Check Valve :	**11.6 x 1 = 11.6**
Gate Valve :	**0.9 x 1 = 0.9**

Equivalent total straight length: **111.3m**

4. Head Loss Calculation

+ Graphical Method

Flow rate : 1.2m^3/min

Head Loss (This reads in the graph):

0.06 mm/m

Total friction head loss :

0.06 x 111.3 = 6.7 m

Total head = Ha + Hf

= (3 + 26) + 6.7

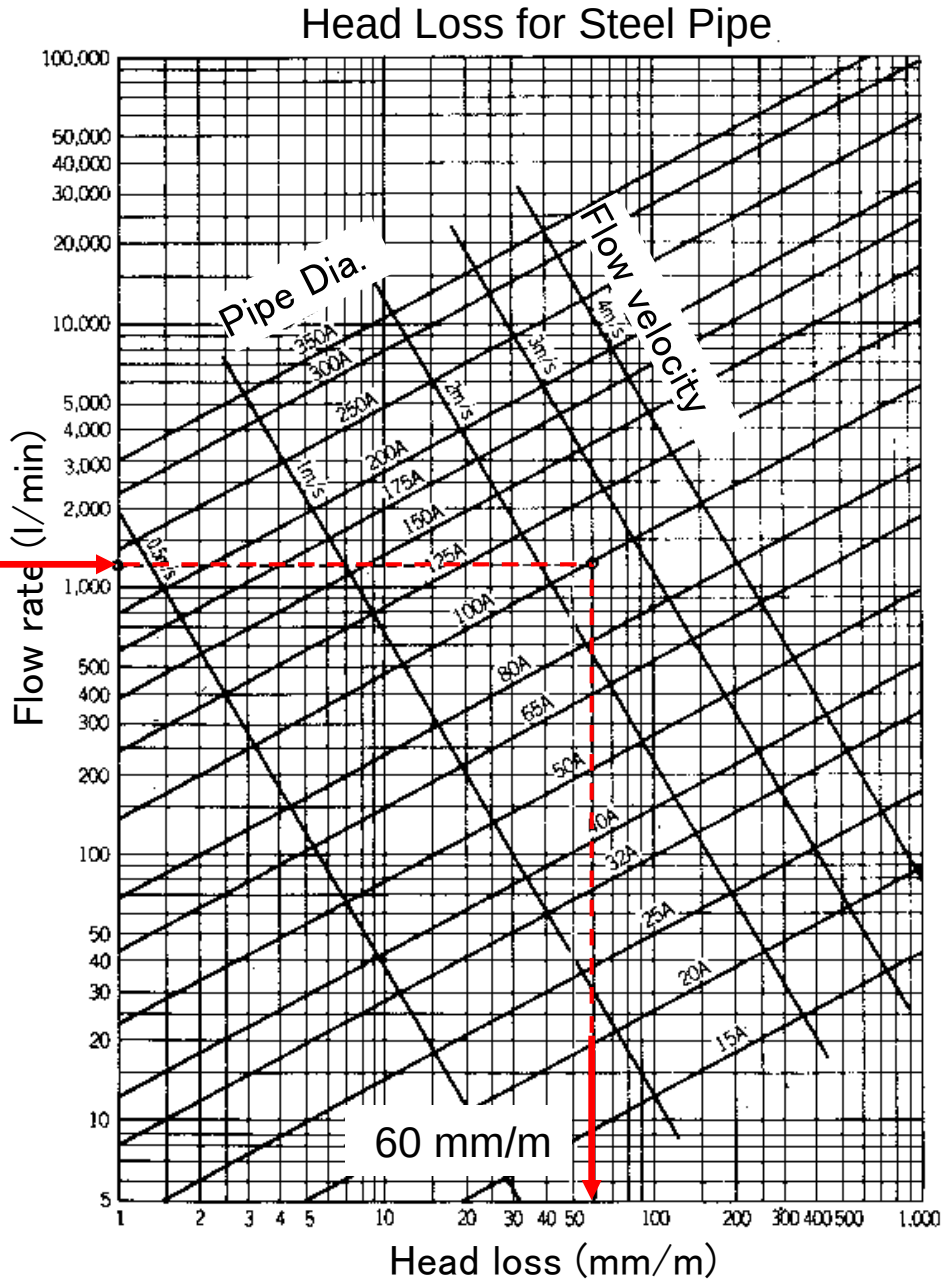
= 35.7 m

Ha : Actual Head

Hf : Friction Head Loss

***) Velocity Head ($V^2/2g$) is Neglected.**

If include, Total Head = 36.0 m



4. Head Loss Calculation

+ Calculation Method

Dia.100 Steel Pipe :

external dia. : 114.3mm

thickness : 4.5mm -> internal dia. : 105.3mm

$$\lambda = 0.02 + \frac{1}{2000 \times D} = 0.02 + \frac{1}{2000 \times 0.153} = 0.0247$$

$$V = 0.0212 \times \frac{Q}{D^2} = 0.0212 \times \frac{1.2}{0.1053^2} = 2.29 \text{ m/sec}$$

Total friction head loss :

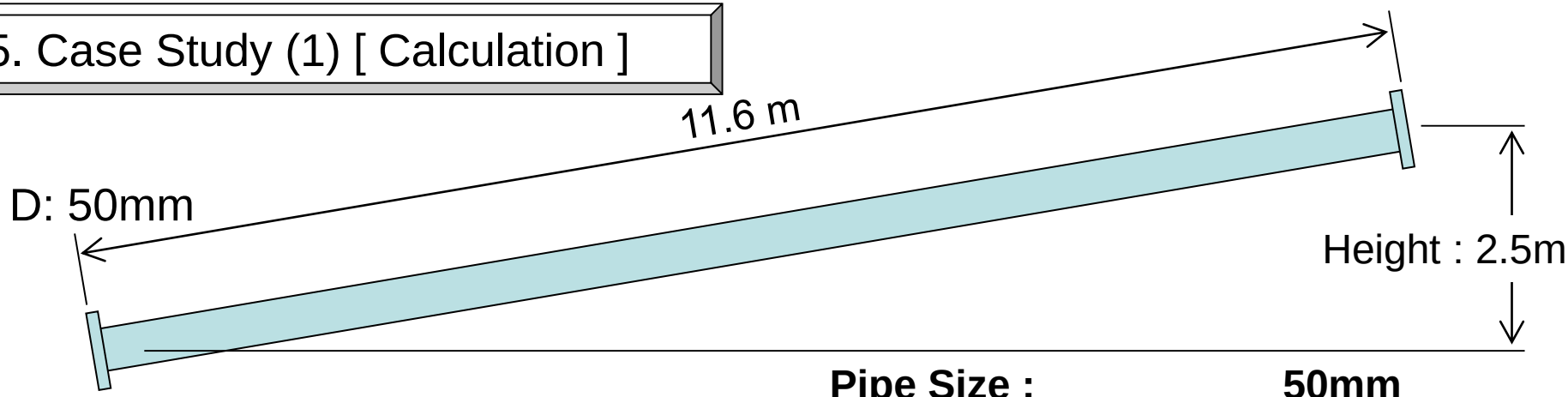
$$Hf = \lambda \times \frac{L}{D} \times \frac{V^2}{2g} = 0.0247 \times \frac{111.3}{0.1053} \times \frac{2.29^2}{2 \times 9.8} = 7.0 \text{ m}$$

Total head = Ha + Hf
= (3 + 26) + 7.0
= 36.0 m

Ha : Actual Head
Hf : Friction Head Loss
***) Velocity Head ($V^2/2g$) is Neglected.**
If include, Total Head = 36.3 m

SPAIX Pipe Calculation

5. Case Study (1) [Calculation]



Pipe Size : **50mm**
Straight pipe Length: **11.6m**
Flow rate : **0.3m³/min**

Dia.50 Steel Pipe :
external dia. : 60.5mm
thickness : 3.8mm -> internal dia. : 52.9mm

$$\lambda = 0.02 + \frac{1}{2000 \times D} = 0.02 + \frac{1}{2000 \times 0.0529} = 0.0295$$

$$V = 0.0212 \times \frac{Q}{D^2} = 0.0212 \times \frac{0.3}{0.0529^2} = 2.27 \text{ m/sec}$$

Total friction head loss :

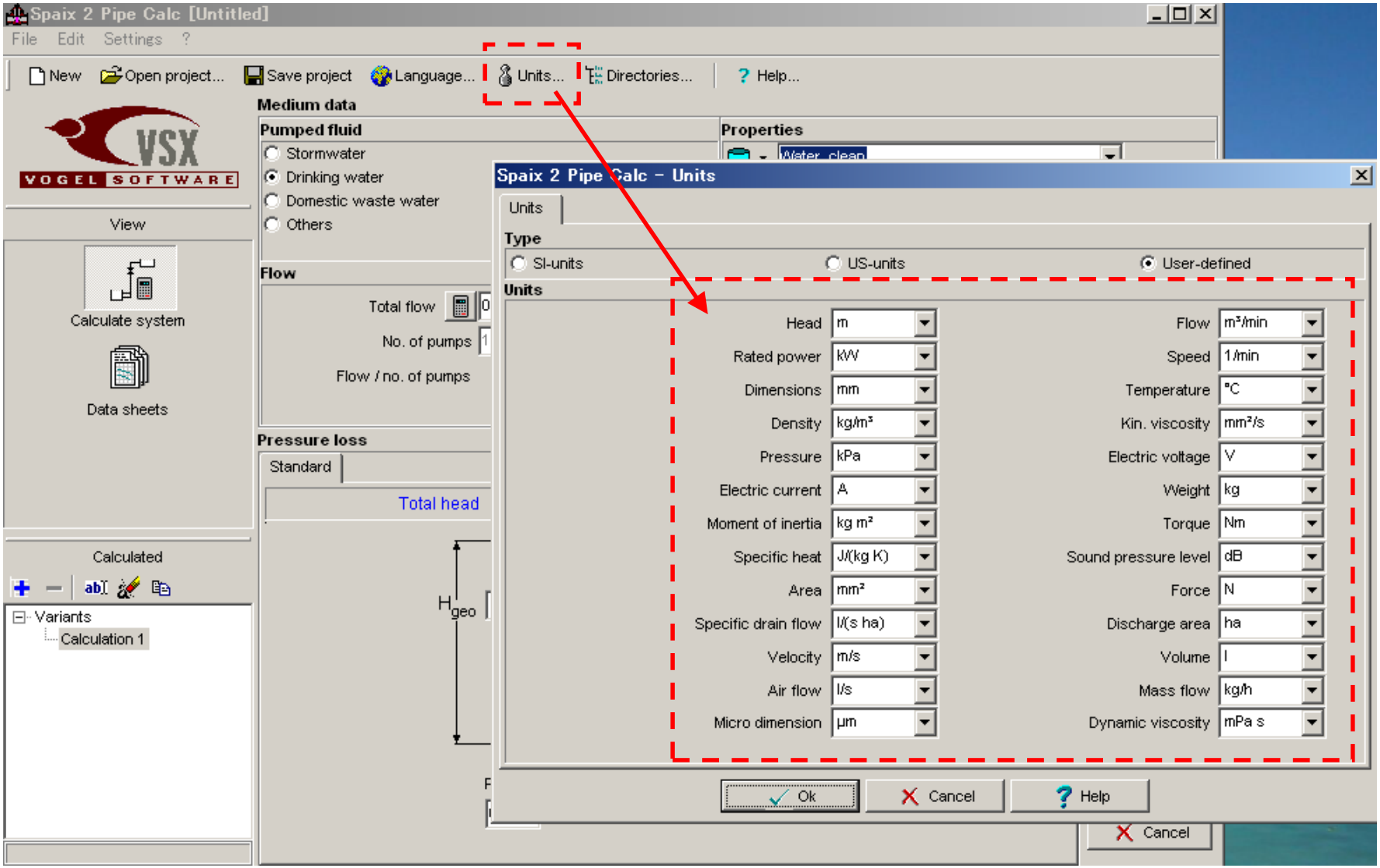
$$Hf = \lambda \times \frac{L}{D} \times \frac{V^2}{2g} = 0.0295 \times \frac{11.6}{0.0529} \times \frac{2.27^2}{2 \times 9.8} = 1.70 \text{ m}$$

Total head = Ha + Hf = 2.50 + 1.70 = 4.20 m

Ha : Actual Head
Hf : Friction Head Loss

***) Velocity Head ($V^2/2g$) is Neglected.** **If include,** Total Head = 4.46 m

5. Case Study (1) [by SPAIX]



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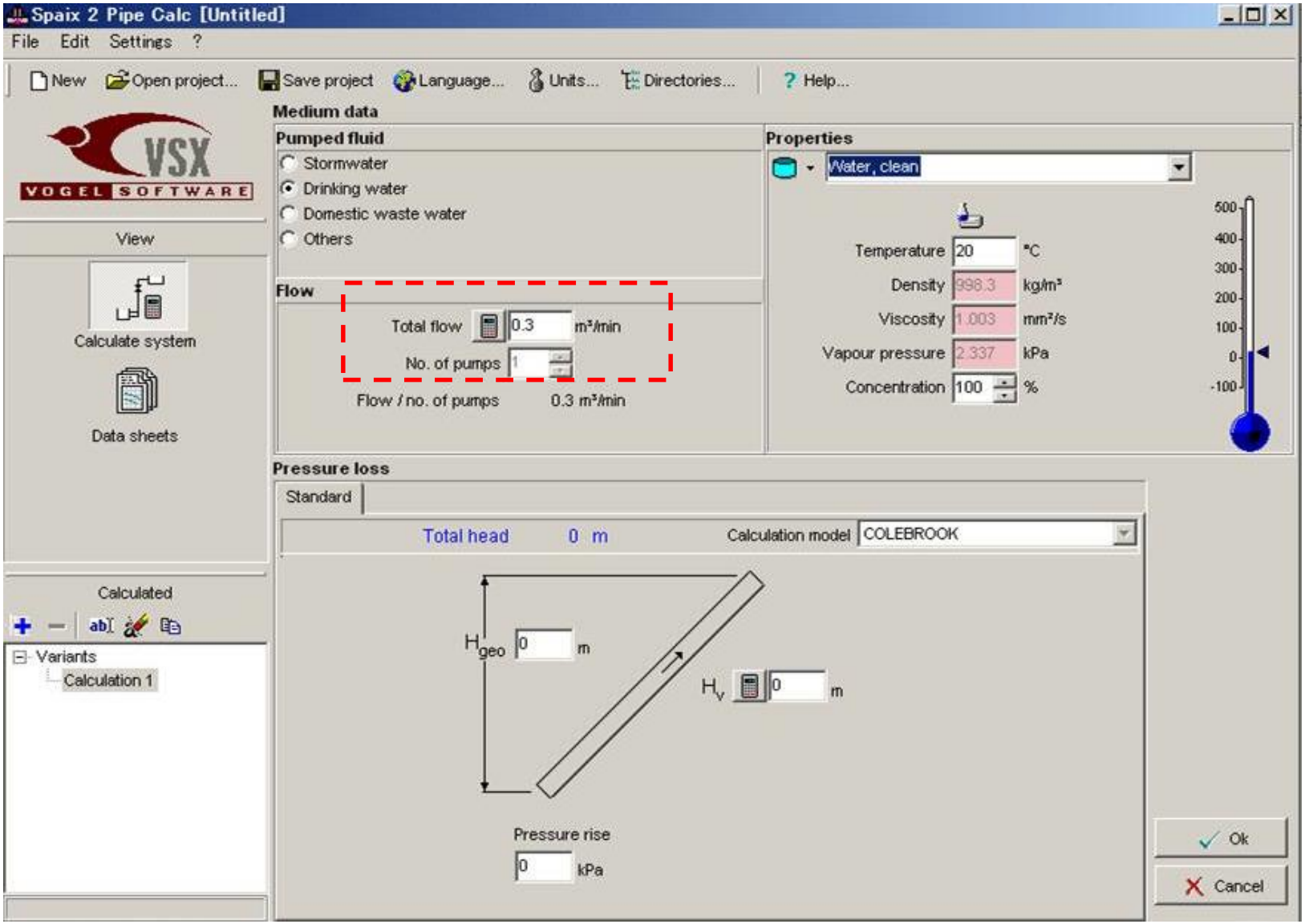

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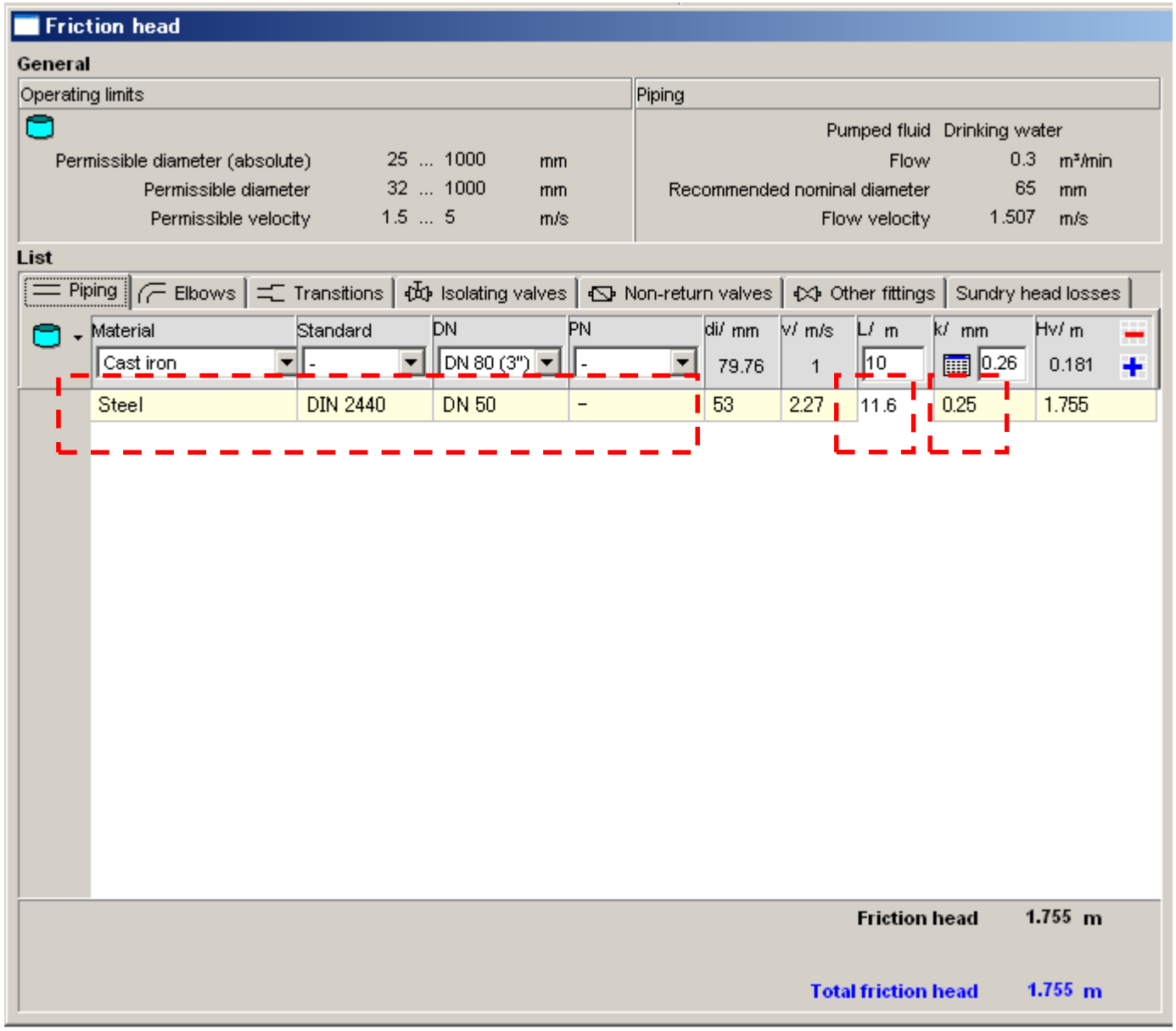

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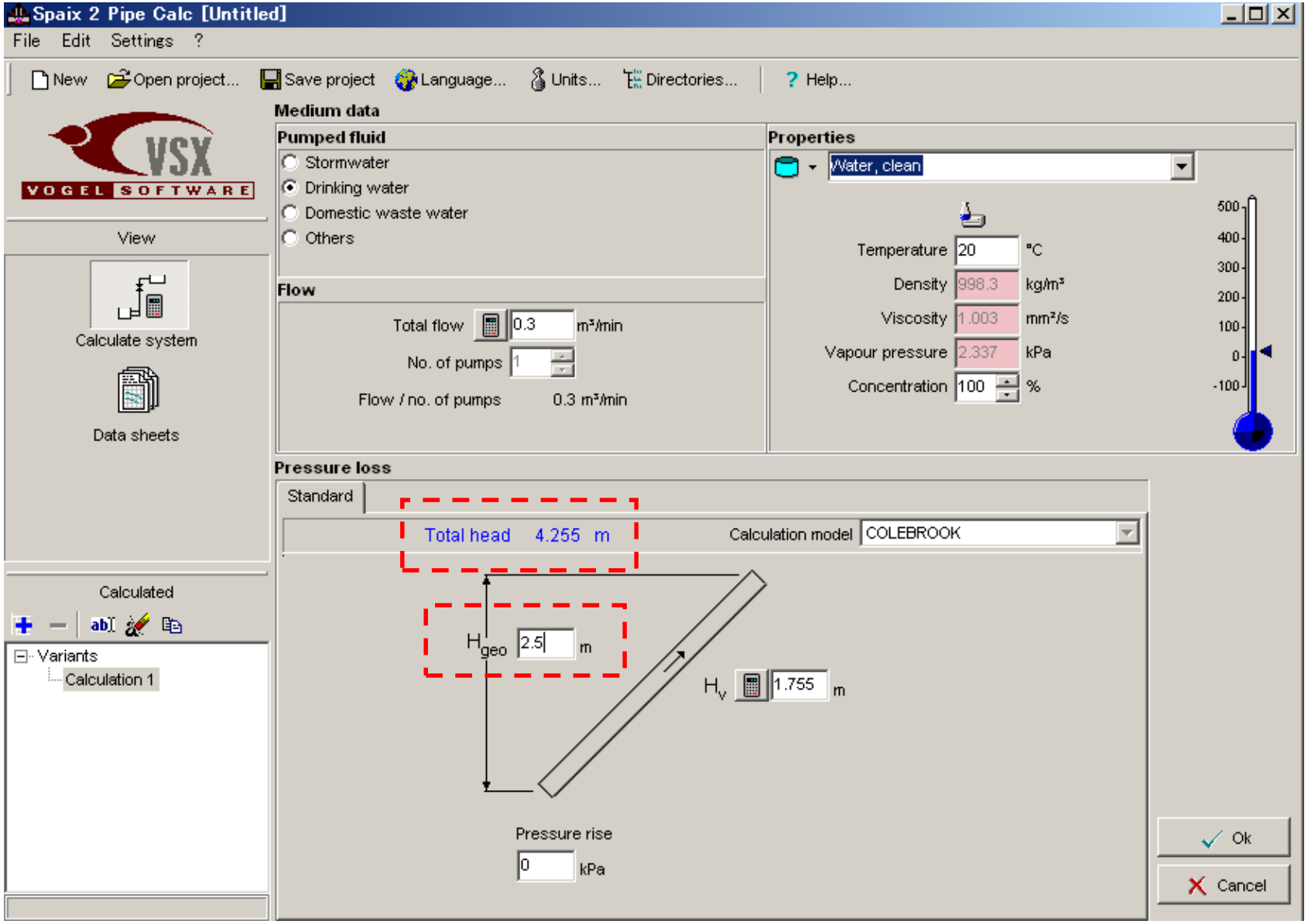
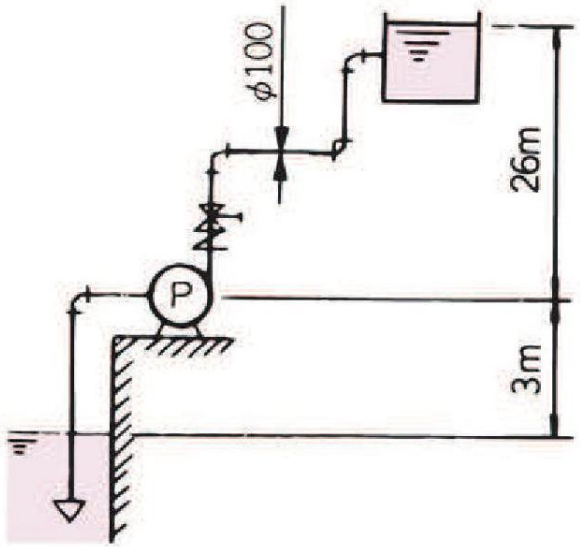


6. Case Study (2) [Calculation]

+ Example Solution

Given information



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Total head = Ha + Hf
= (3 + 26) + 7.0
= 36.0 m

Ha : Actual Head

Hf : Friction Head Loss

***) Velocity Head ($V^2/2g$) is Neglected.**

If include, Total Head = 36.27 m

6. Case Study (2) [Calculation]

+ Example Solution

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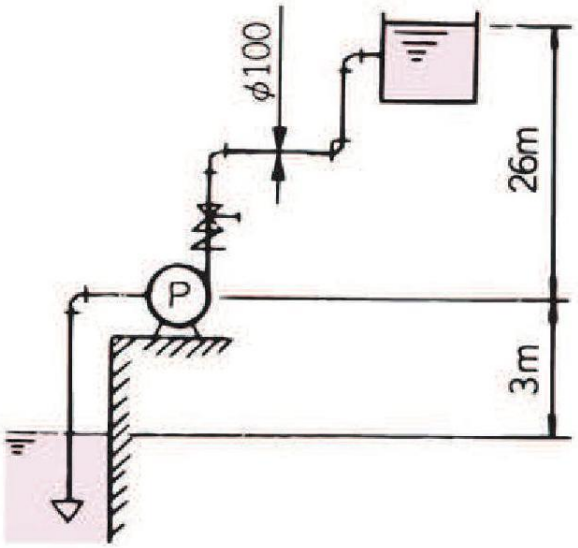

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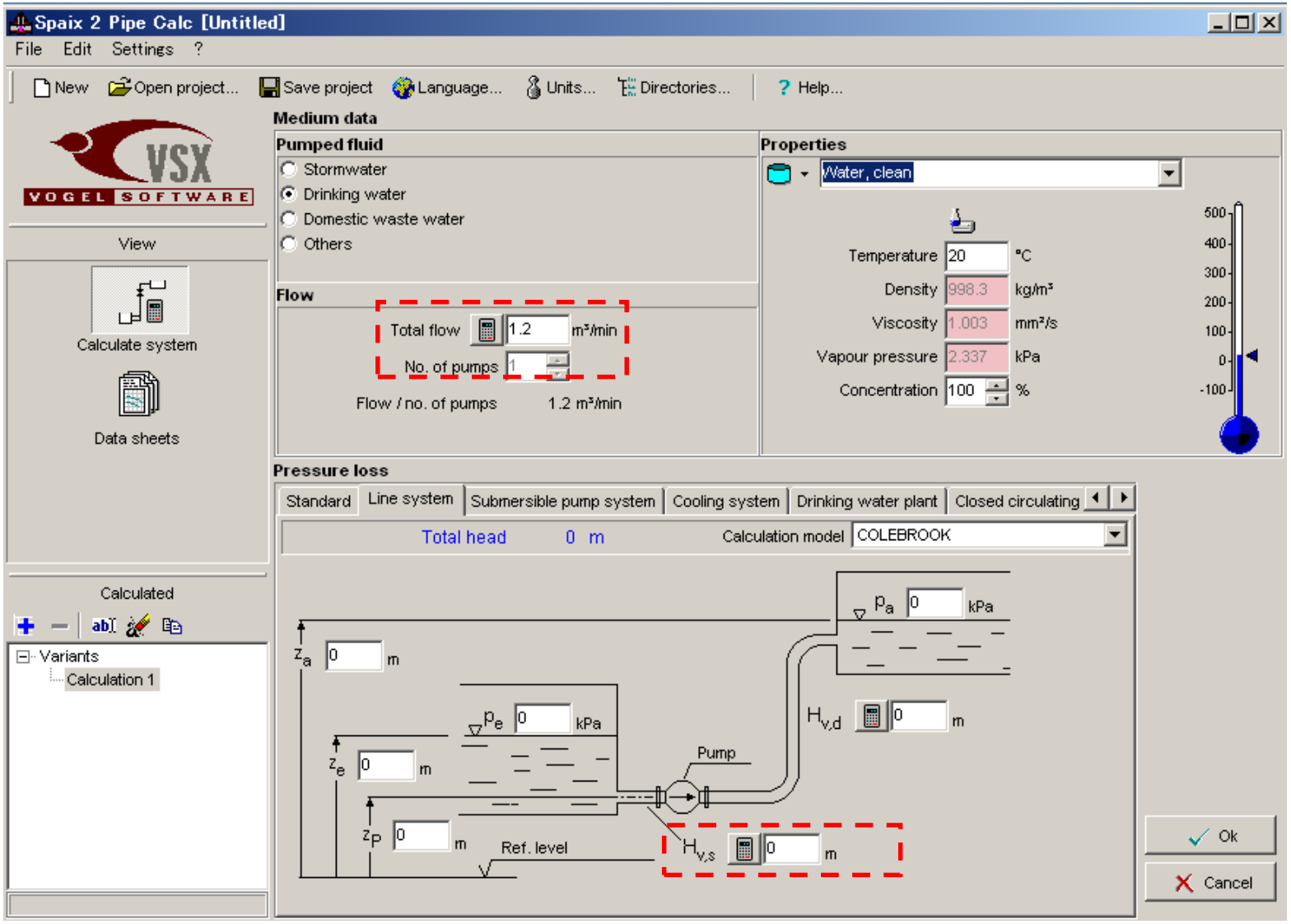

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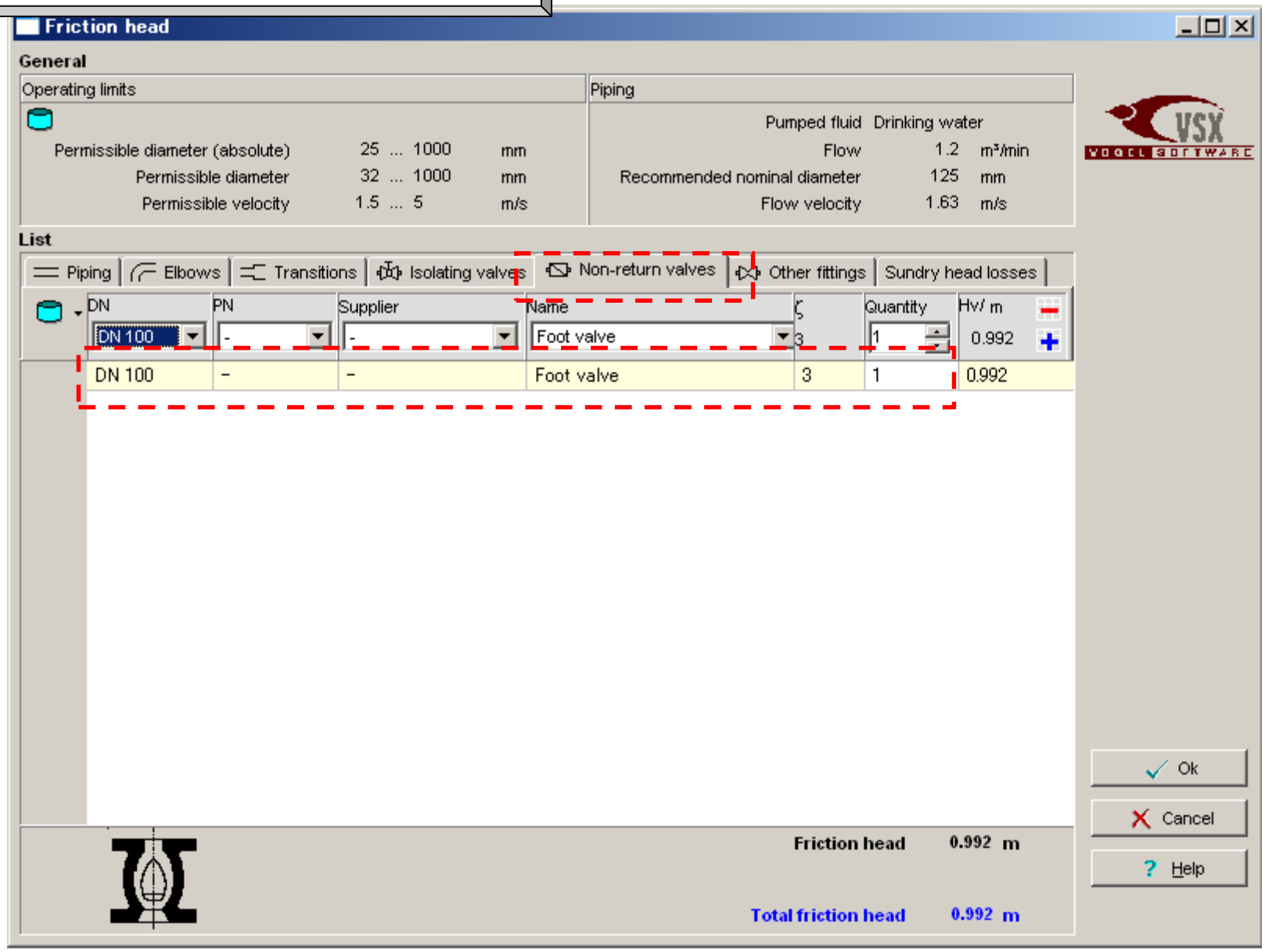

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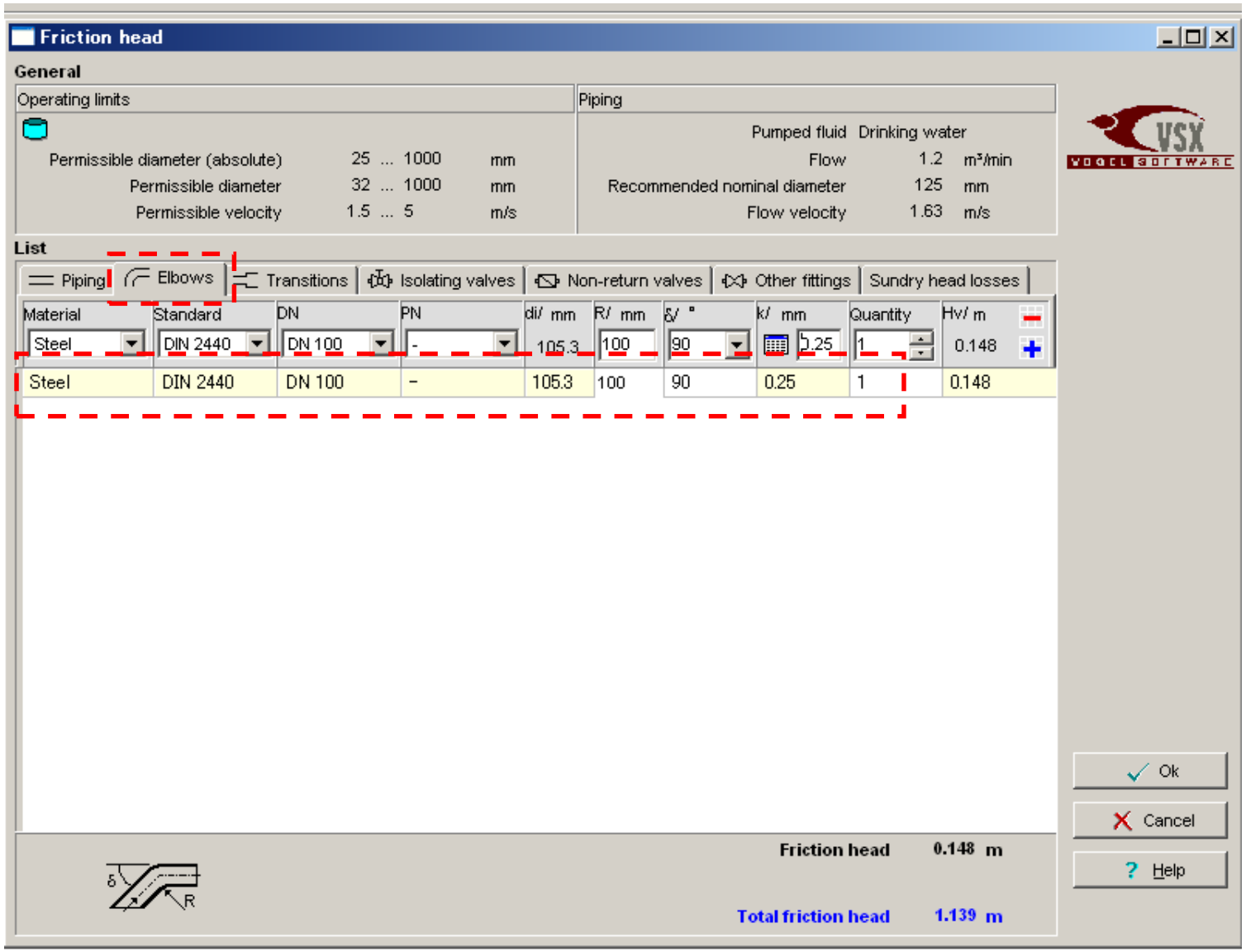

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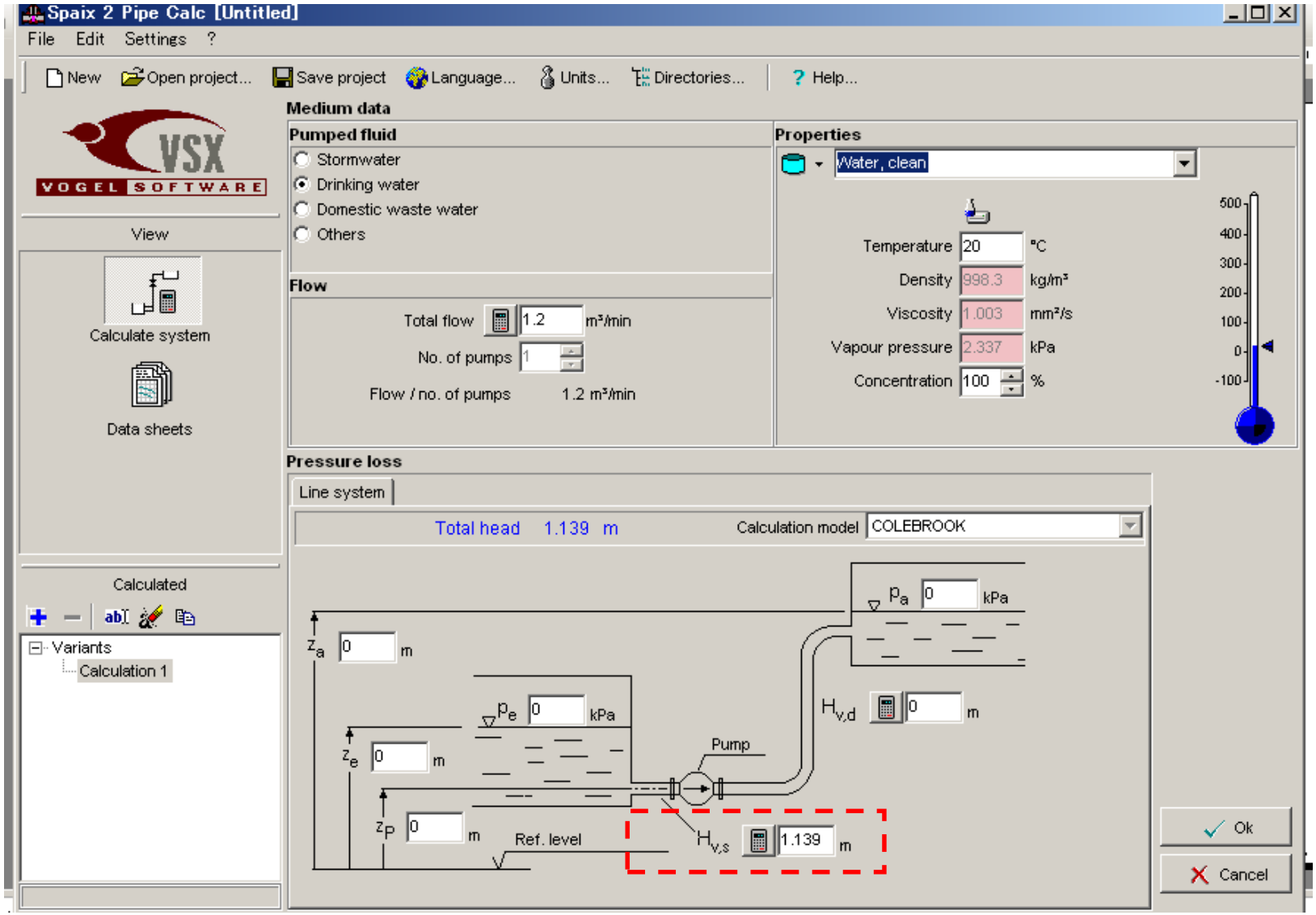

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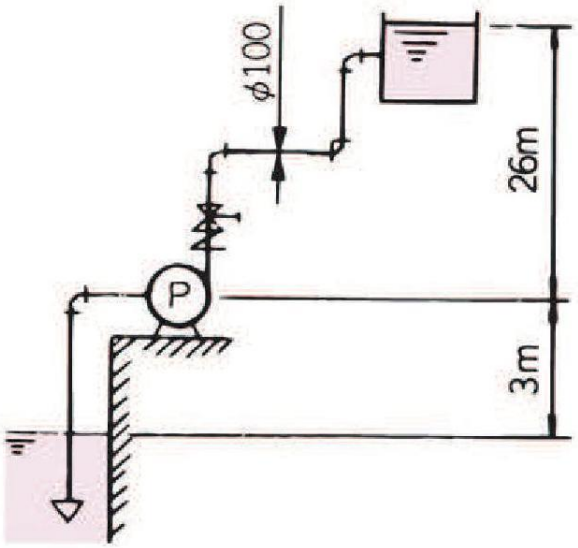
Flow rate :	**1.2m^3/min**



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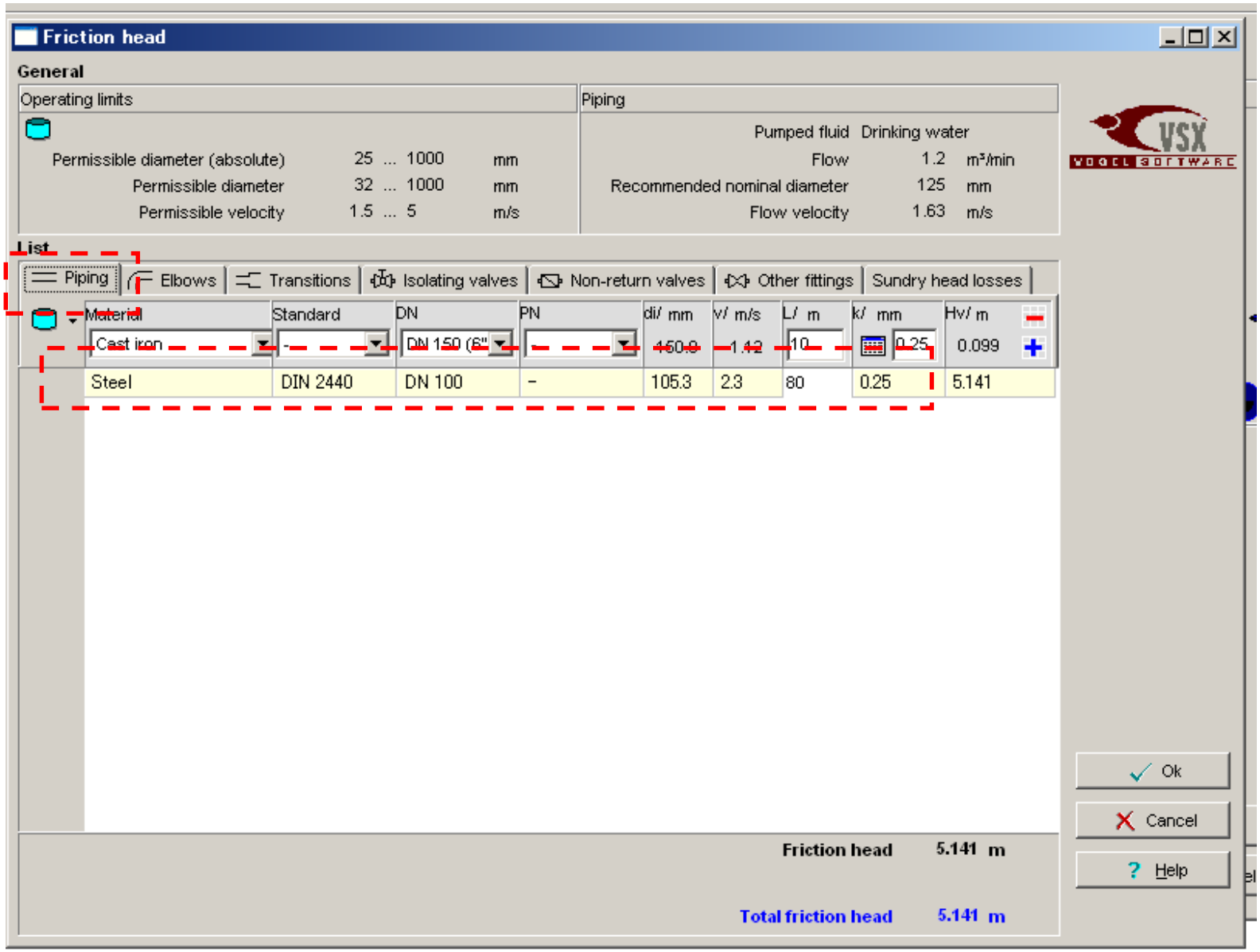

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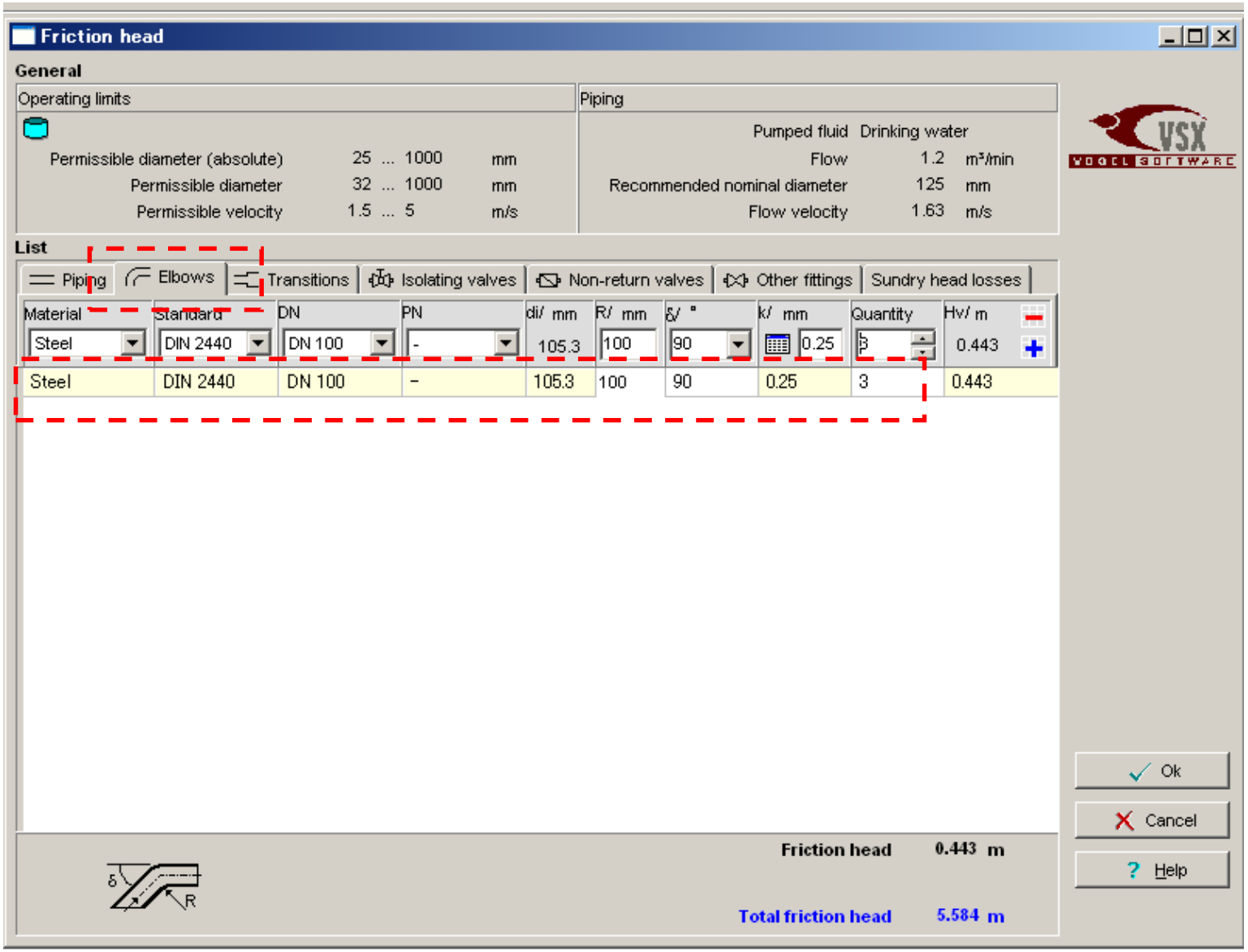

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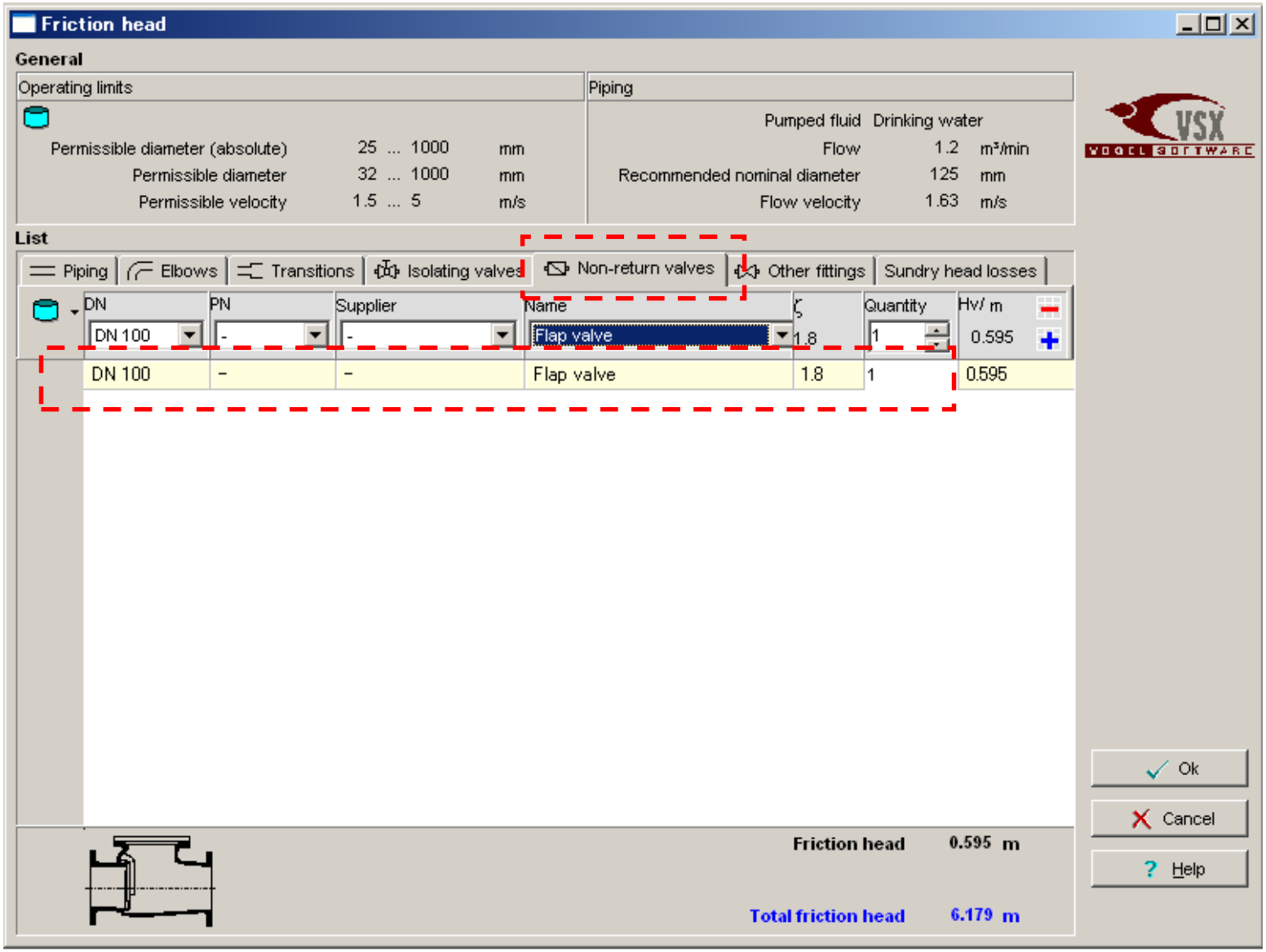

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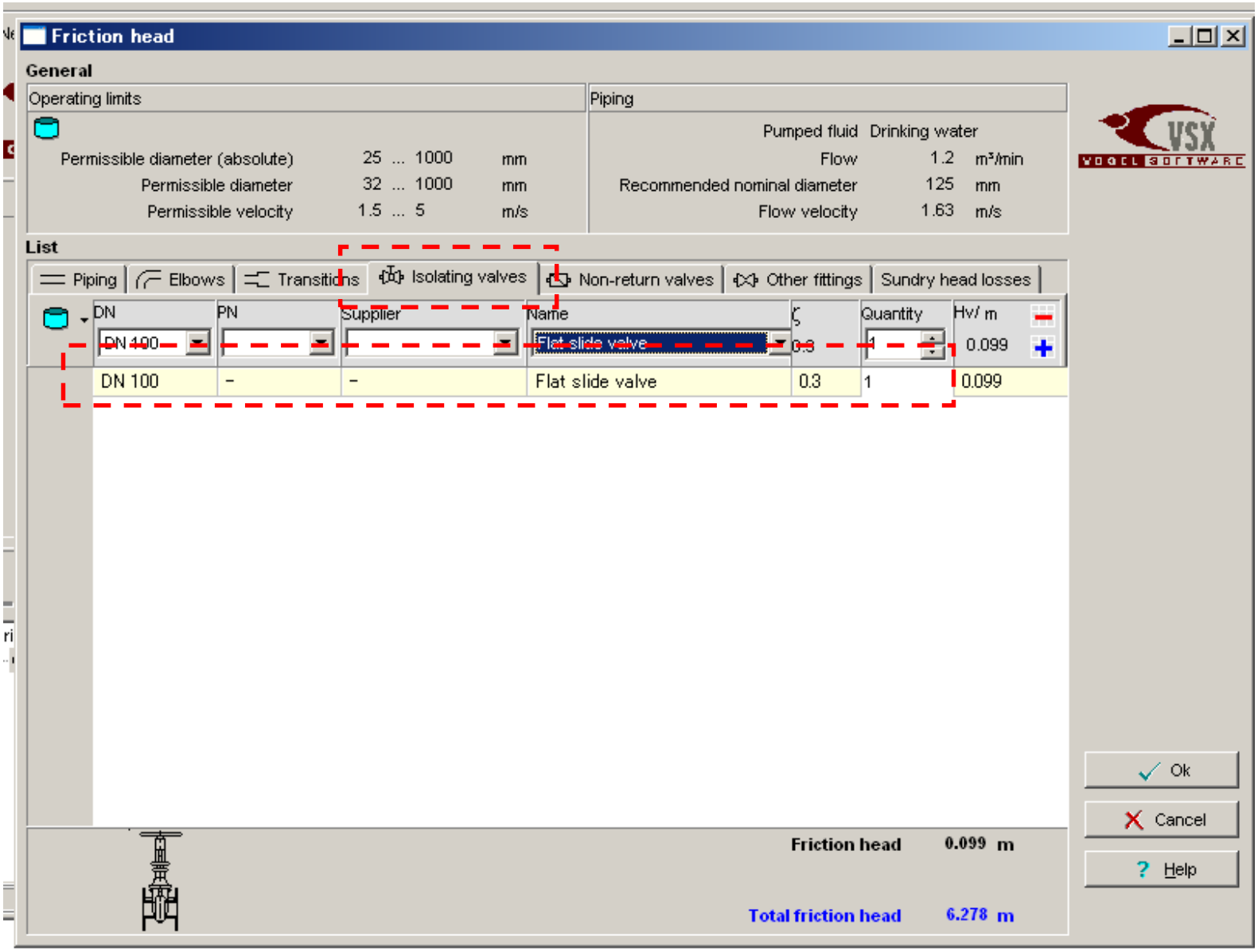

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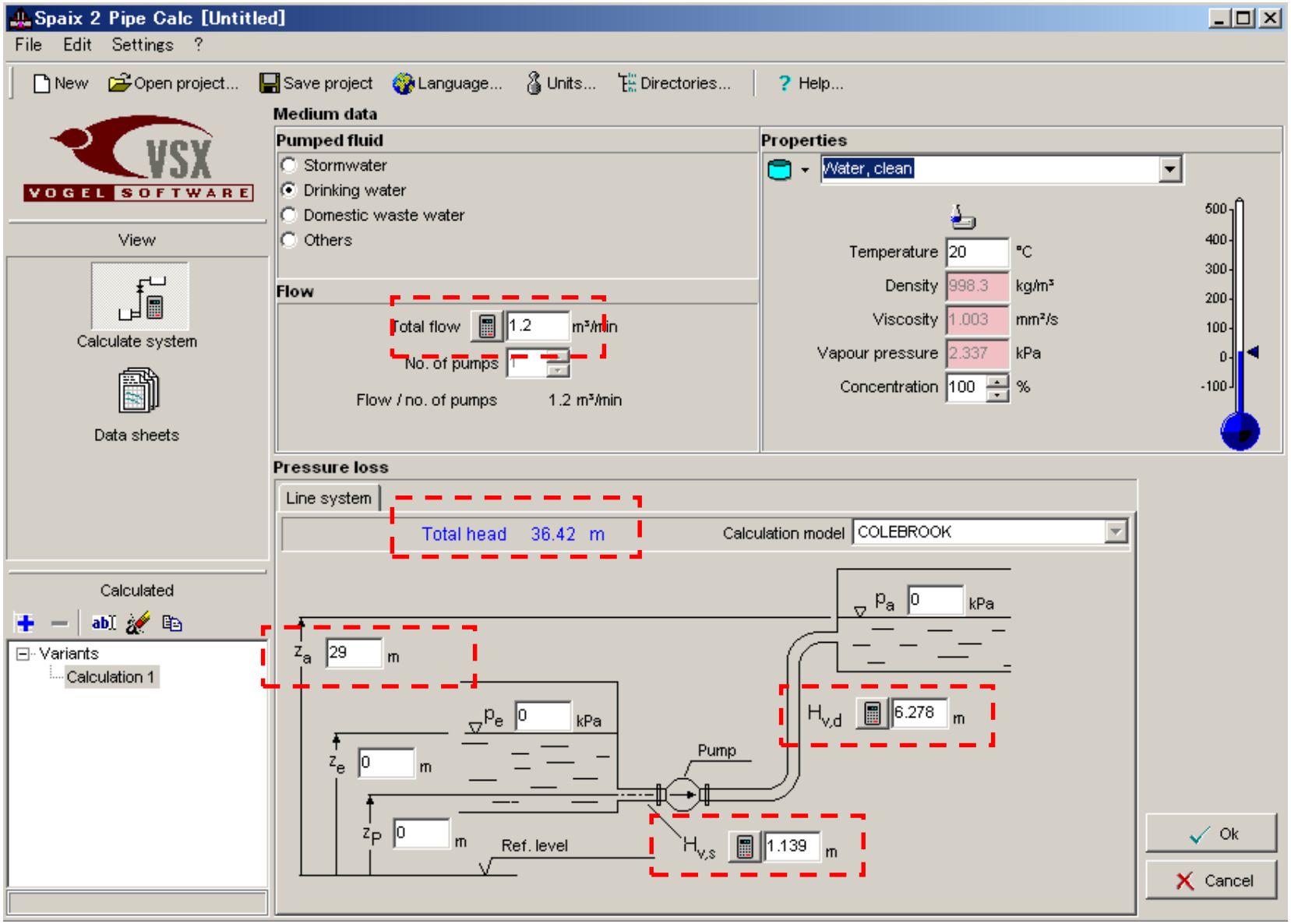

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