Urban Water - Exercise 06

Water distribution network

Aim of the task is to practice the dimensioning for arterial and meshed networks. The Kirchhoff's law of current and the Hardy Cross method are introduces and applied.

Repetition

For the dimensioning of pipelines you need the continuity equation and the formulae for the calculation of the headloss caused by friction. Set up these formulae.

Kirchhoff´s circuit laws deal with the conservation of charge and energy in electrical circuits but they have also an analogy in water pipes. What do they say?

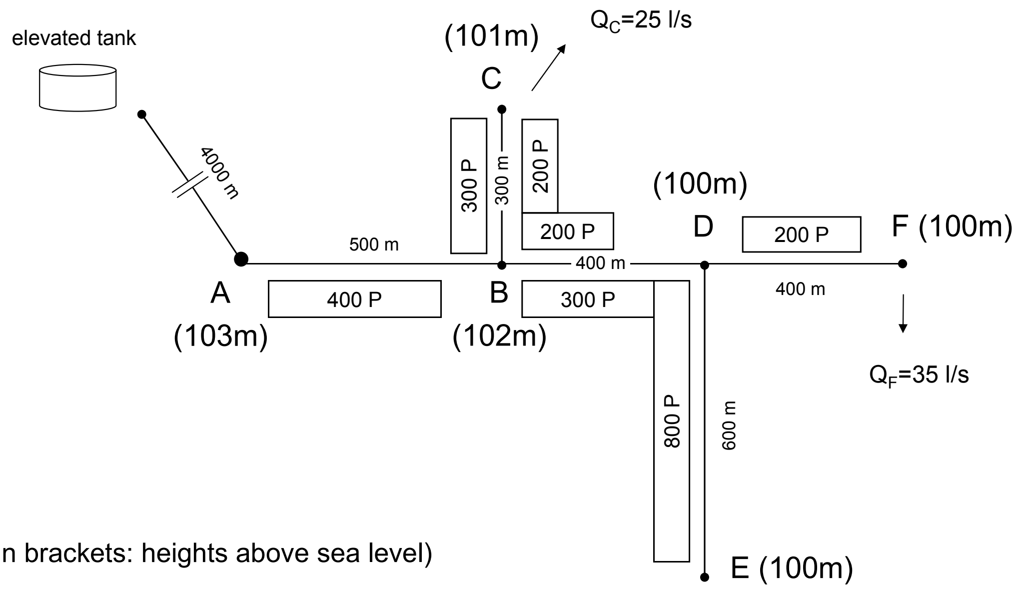
What are the principles of the Hardy Cross method for calculation of meshed networks?

Tasks

1. The arterial system of distribution (branched network) should be dimensioned for the peak hourly demand. Please calculate:

   a) The consumption of the network sections
   b) The nominal sizes of the pipes
   c) The elevation of the minimum water level in the tank, if the supply pressure in the network should always be higher than 2.0 bar
   d) The process of the hydraulic grade line

Sketch:



(in brackets: heights above sea level)

a) The discharge in the pipes

$q_{d,p}$ = 140 l/(d·capita)
f_h = 5.0

section	**Length** [m]	**Inhabitants** [P]	**consumption on pipe** [l/s]	**additional consumption** [l/s]	**total consumption** [l/s]	**discharge in pipe** [l/s]
	(1)	(2)	(4)	(5)	(6)	(7)
D-E						
D-F						
B-D						
B-C						
A-B						
HB-A						

b) The nominal sizes of the pipes

Integral roughness
Distribution network k_i = 1.0 mm
Transmission main k_i = 0.1 mm

Preferable velocity range v = 0.5 - 2.0 m/s

section	**K_i** [mm]	**Diameter** [mm]	**Velocity** [m/s]	**headloss** J [m/km]
	(8)	(9)	(10)	(11)
D-E				
D-F				
B-D				
B-C				
A-B				
HB-A				

c) The elevation of the minimum water level in the tank, if the supply pressure in the network should always be higher than 2.0 bar

minimum supply pressure (2 storey buildings): 2 bar

section	**headloss** [m]	**required supply pressure at end point** [m]	**hydraulic pressure line** beginning [m]	end
D-E				
D-F				
B-D				
B-C				
A-B				
HB-A				

The elevated tank must have a minimum water level from about ………. m above sea level.

d) The hydraulic pressure line

▼ 150,00						
▼ 145,00						
▼ 140,00						
▼ 135,00						
▼ 130,00						
▼ 125,00						
▼ 120,00						

≈ tank ≈ A B D C F E

▼ 105,00						
▼ 100,00						
distribution pipe system	transmission main	A - B	B - D	D - E		
diameter						
length [m]	4.000	500	400	600		
service connection			B – C; 300m; ∅ mm			
				D-F; 400m; ∅ mm		

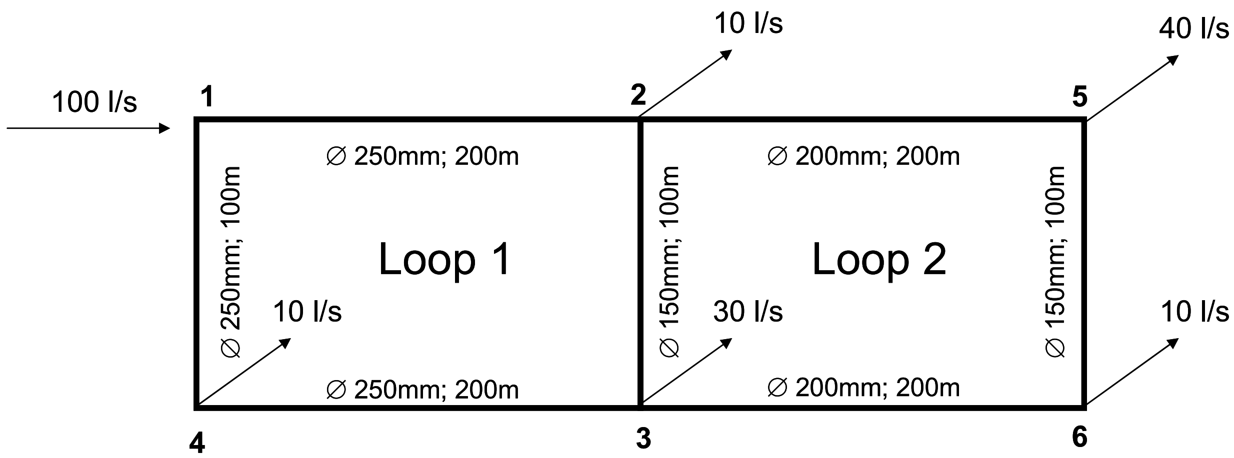
Steps for the Pressure Height Balance Method

- Start with an estimation of the flow.
  The flow in and out of a node should always be zero ($\Sigma Q = 0$).
- Calculate the headlosses in the links in each mesh.
  The headloss in each mesh should be $\Sigma h_f = 0$.
- From the deviation of the headloss a correction ΔQ (h_f, Q) of the previous estimated flow results for each mesh.
- Correct all the links in each mesh with ΔQ.
- Correct the flow in links belonging to 2 meshes, so that they have the same flow.

2. The two loops of the meshed distribution system below should be dimensioned with the iterative method after Hardy-Cross. The integral roughness is k_i = 1.0 mm.

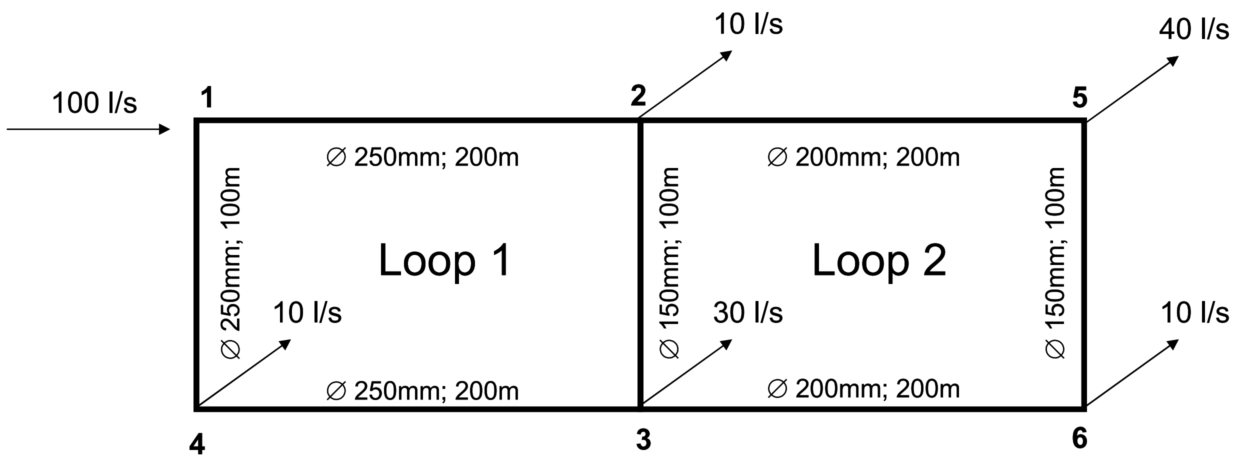
   Wanted:

   a) the discharge in the specific pipes
   b) the headloss in the specific pipes



First iteration with starting approximation values:

	Node	Link	Length [m]	Diam. [mm]	Cons. Q [l/s]	Disch. Q_0 [l/s]	Veloc. v [m/s]	Headl. J [m/km]	Headl. h_R [m]	h_R/Q_0 [ms/l]	ΔQ_0 [l/s]	Q_1' [l/s]	Q_1 [l/s]	Σ Node
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
L1	1													
		1-2	200	250										
	2													
		2-3	100	150										
	3													
		3-4	200	250										
	4													
		4-1	100	250										
								Σ						
L2		2-5	200	200										
	5													
		5-6	100	150										
	6													
		6-3	200	200										
		3-2	100	150										
								Σ						

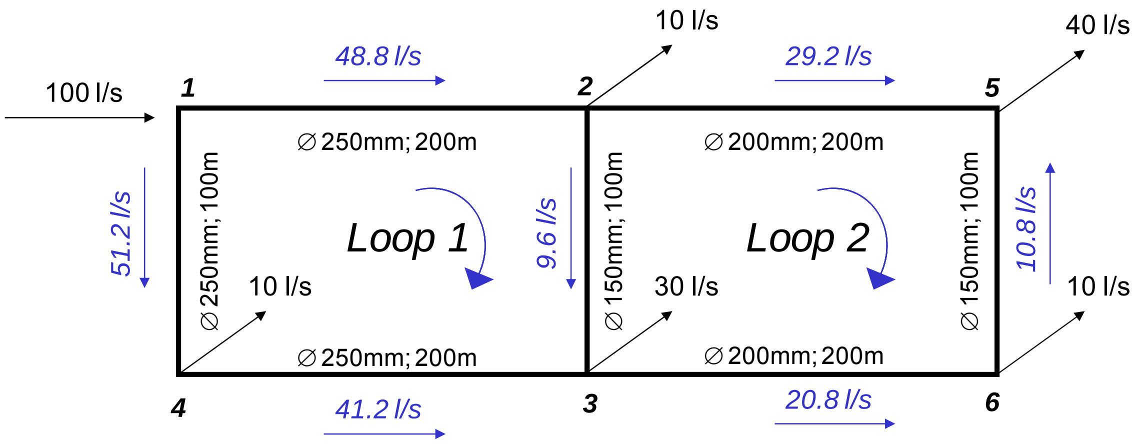


Homework (9 points)

Second iteration

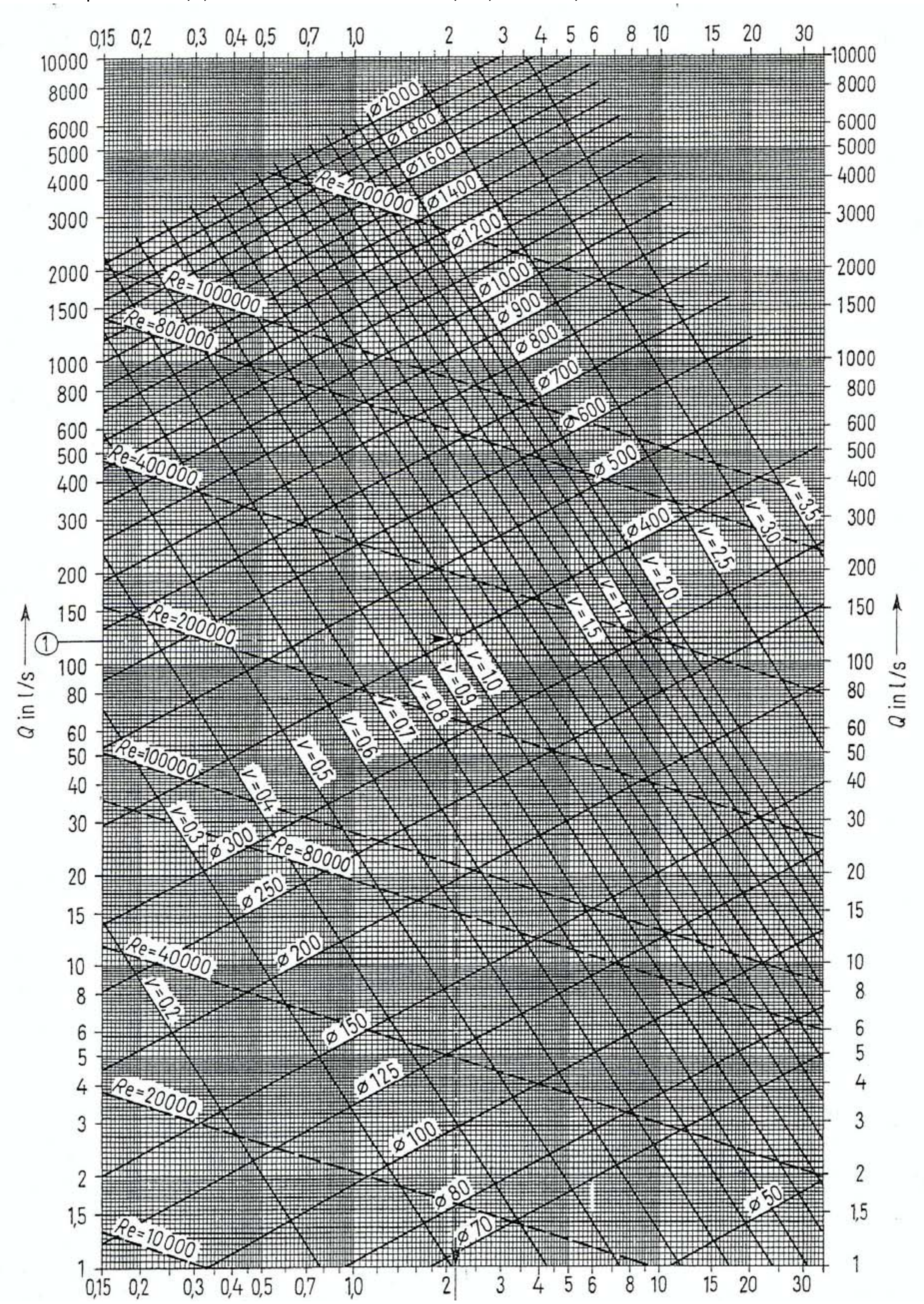
	Node	Link	Length [m]	Diam. [mm]	Cons. Q [l/s]	Disch. Q_0 [l/s]	Veloc. v [m/s]	Headl. J [m/km]	Headl. h_R [m]	h_R/Q_0 [ms/l]	ΔQ_0 [l/s]	Q_1' [l/s]	Q_1 [l/s]	Σ Node
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
L1	1													
		1-2	200	250										
	2													
		2-3	100	150										
	3													
		3-4	200	250										
	4													
		4-1	100	250										
								Σ						
L2		2-5	200	200										
	5													
		5-6	100	150										
	6													
		6-3	200	200										
		3-2	100	150										
								Σ						

Solution of second iteration:



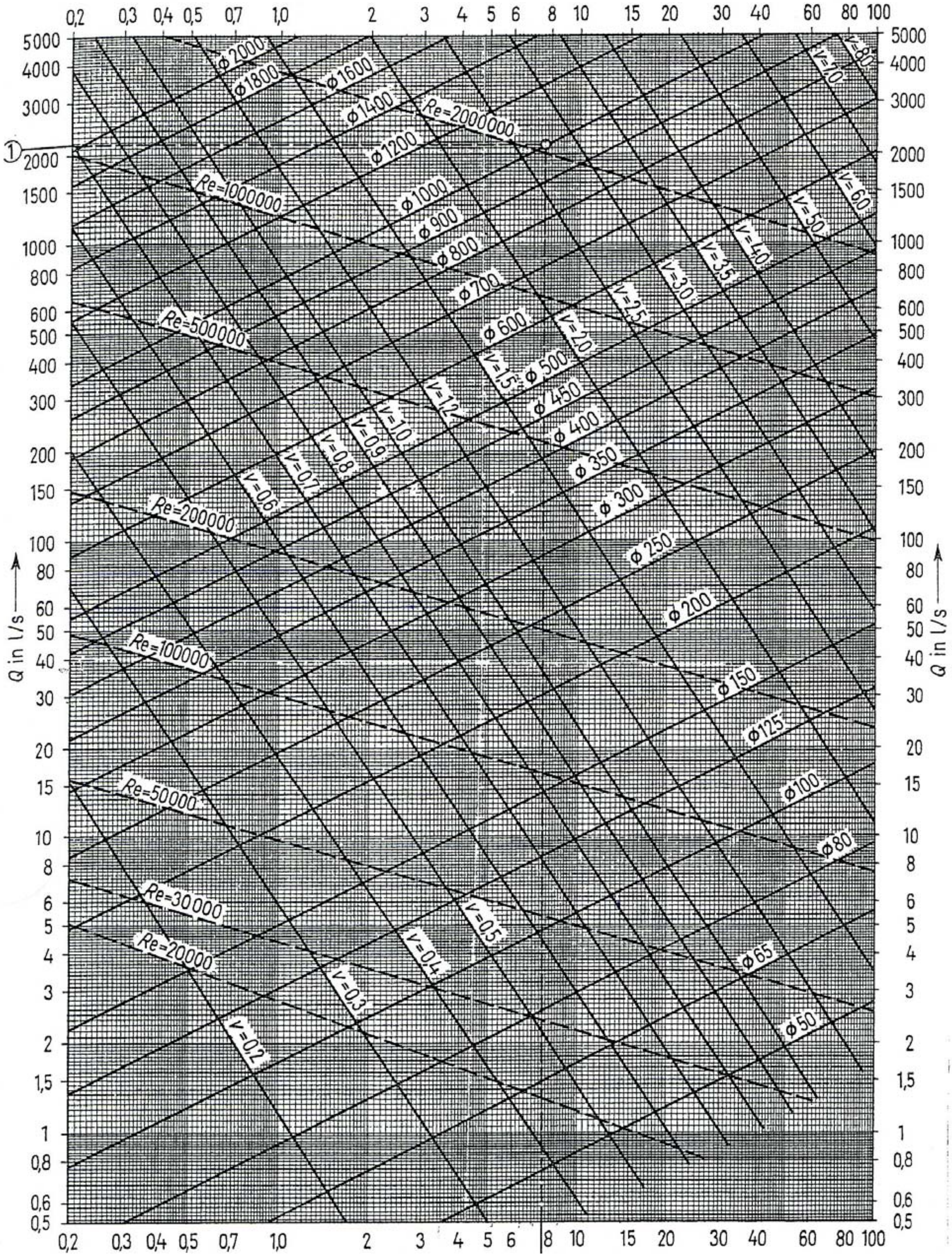
Solution is valid for following starting values:
Q_{12}=50 l/s, Q_{25} = 25 l/s, Q_{34}=-40 l/s, Q_{56}=-15 l/s, Q_{41}=-50 l/s, Q_{23}=15 l/s, Q_{63}=-25 l/s

Full flow, roughness factor k_i= 0.1mm
Dimensions of pipes with circular cross section
Long distance lines and interconnections
Example: Q=120 l/s, DN 400 -> headloss = 2.14 m/km, v = 1.0 m/s



headloss in m/km

Full flow, roughness factor k_i= 1.0 mm
Dimensions of pipes with circular cross section
New branched, meshed net
Example: Q=2150 l/s, DN 1000 -> headloss = 7.6 m/km, v = 2.74 m/s



headloss in m/km