CHAPTER 9

DESIGN OF COLD WATER DISTRIBUTION SYSTEM

9.1 CALCULATION METHOD:

To calculate the distribution pipe of cold water to the floors and to the indoor units, follow these steps:

Step 1:

Calculate the chilled water flow through each pipe section:

$$G = \frac{Q_0}{C \times \Delta t}, Kg/s$$

Inside:

Q_0: is the required cooling capacity of the space required for conditioning.

Δt : is the temperature difference of the water in and out of the indoor unit.

C: Specific heat of water at medium temperature, KJ/Kg.

Step 2: Select the preliminary preliminary velocity: ω = 0.5~2 (m/s).

Step 3: Determination of the inner diameter of the pipe section:

$$d_{in} = \sqrt{\frac{4 \times G}{\pi \times \omega \times \rho}}$$

Inside :

G: is the flow of water in the pipe, kg/s.

ω: The velocity of water moves in the tube, m/s.

ρ: is the specific mass of water at average temperature.

Select nominal diameter from d_{tr} we found.

Recalculate the actual velocity in the tube according to the selected inneral diameter.

$$\omega = \frac{4 \times G}{\rho \times \pi \times d_{tr}^2}$$

9.1.1 CALCULATION OF WATER PIPE CONNECTED WITH AHU,FCU

Calculation of water supply for Sever room ‘s AHU 285,8 kW.

Calculate the flow of cold water through each pipe section:

$$G = \frac{Q_0}{C \times \Delta t} = \frac{285,8}{4,186 \times 5} = 13,65\ Kg/s$$

Inside:

Q_0 : is the required cooling capacity of the space required for conditioning.

$\Delta t = 5℃$: is the temperature difference of the water in and out of the indoor unit.

C = 4.186 (kJ/kg.°K): Specific heat of water.

- Select the preliminary velocity: ω = 1,5 (m/s), ρ = 999,71 (kg/m^3).

Determination of diameter of pipe section:

$$d_{in} = \sqrt{\frac{4 \times G}{\pi \times \omega \times \rho}} = \sqrt{\frac{4 \times 13,65}{3,14 \times 1,5 \times 999,71}} = 0.107 \text{ m}$$

Inside:

- G: is the flow of water in the pipe, kg/s.

- ω: The velocity of water moves in the pipe, m/s.

- ρ : is the specific mass of water at average temperature.

We choose the nominal diameter DN100mm according to ASTM A53 pipe standard so that the losses are evenly in the branches.

Select nominal diameter d_N = 100 mm => $\begin{cases} d_{in} = 108.3\ mm \\ d_{ex} = 114.3\ mm \end{cases}$ with wall thickness by standard SCH40 6.0mm

Recalculate the actual velocity in the tube according to the inner diameter.

$$\omega = \frac{4 \times G}{\rho \times \pi \times d_{in}^2} = \frac{4 \times 13,65}{999,71 \times \pi \times 108,3_{in}^2} = 1,48\ m/s$$

NO	ROOM NAME	DEVICES	Qo (Kw)	C (kJ/kgK)	ρ (kg/m3)	G (kg/s)	DN	din	dex
CENTRAL PLANT-1F									
1	Fire room	FCU	11.90	4.19	999,71	0.57	20.00	23.8	27
2	Corridor	FCU	7.80	4.19	999,71	0.37	20.00	23.8	27
3	Server room	AHU	285.80	4.19	999,71	13.66	200.00	2118	220
4	Server room support	FCU	11.90	4.19	999,71	0.57	20.00	23.8	27
5	Corridor	AHU	44.40	4.19	999,71	2.12	40.00	45.3	49

6	Fuel Storage Tank	FCU	16.40	4.19	999,71	0.78	25.00	30	34
7	Transformer room	AHU	33.30	4.19	999,71	1.59	32.00	39	42
8	Medium voltage switchgear room	AHU	33.30	4.19	999,71	1.59	32.00	39	42
9	Transformer room	AHU	57.80	4.19	999,71	2.76	50.00	56.1	60
10	Low voltage switchgear room	AHU	44.40	4.19	999,71	2.12	40.00	45.3	49
11	Corridor	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
12	Control center	FCU	16.40	4.19	999,71	0.78	25.00	30	34
13	Technical room	FCU	11.90	4.19	999,71	0.57	20.00	23.8	27
14	Odor treatment room	FCU	11.90	4.19	999,71	0.57	20.00	23.8	27
CENTRAL PLANT-2F									
16	UPS battery room	FCU	7.80	4.19	999,71	0.37	20.00	23.8	27
17	Corridor	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
18	Server room support	AHU	112.80	4.19	999,71	5.39	65.00	67.8	73
19	Server room	AHU	112.80	4.19	999,71	5.39	65.00	67.8	73
20	Storage	FCU	6.20	4.19	999,71	0.30	20.00	23.8	27
21	Corridor	FCU	6.20	4.19	999,71	0.30	20.00	23.8	27
22	Janitor	FCU	6.20	4.19	999,71	0.30	20.00	23.8	27
23	Corridor-hành lang	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
24	Electrical workroom area	FCU	7.80	4.19	999,71	0.37	20.00	23.8	27
25	Control room	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
CENTRAL PLANT-RF									
27	Generator room	FCU	18.30	4.19	999,71	0.87	25.00	30	34
28	Mechanical room	FCU	11.90	4.19	999,71	0.57	20.00	23.8	27
29	AHU sever	FCU	16.40	4.19	999,71	0.78	25.00	30	34

LIBRARY-1F									
30	Conference/Training room	FCU	23.80	4.19	999,71	1.14	32.00	39	42
31	Storage	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
32	Janitor	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
33	Frist Aid	FCU	6.20	4.19	999,71	0.30	20.00	23.8	27
34	Aid relaxing room	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
35	Storage	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
36	Book return room	FCU	6.20	4.19	999,71	0.30	20.00	23.8	27
37	Corridor	FCU	8.82	4.19	999,71	0.42	20.00	23.8	27
38	Post room	FCU	6.20	4.19	999,71	0.30	20.00	23.8	27
39	Storageo/Receiving	FCU	6.20	4.19	999,71	0.30	20.00	23.8	27
40	Porter room	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
41	Uni shop	FCU	18.30	4.19	999,71	0.87	25.00	30	34
42	Coffee shop	FCU	8.82	4.19	999,71	0.42	20.00	23.8	27
43	Coffee Storage room	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
44	Mechanical room	FCU	11.90	4.19	999,71	0.57	20.00	23.8	27
45	Elec/tele	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
LIBRARY-2F									
46	Journal display/reading	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
47	Journal display/reading	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
48	Journal display/reading	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22

49	Journal display/reading	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
50	Group Workroom	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
51	Group Workroom	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
52	Group Workroom	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
53	Group Workroom	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
54	Storage	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
55	Storage	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
56	Storage	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
57	Prints/Storage	FCU	8.82	4.19	999,71	0.42	20.00	23.8	27
58	Kitchen/staff lounge	FCU	8.82	4.19	999,71	0.42	20.00	23.8	27
59	Directors office	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
60	Assistants desk	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
61	Meeting room	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
62	Computer pool	FCU	11.90	4.19	999,71	0.57	20.00	23.8	27
LIBRARY-3F									
63	Reading theatre	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
64	Reading theatre	FCU	8.82	4.19	999,71	0.42	20.00	23.8	27
65	Book stacks/Reading room	AHU	22.20	4.19	999,71	1.06	32.00	39	42
66	Learing room	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
67	Learing room	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
68	Storage	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22

69	Copy/print	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
70	Group Workroom	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
71	Group Workroom	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
72	Group Workroom	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
73	Group Workroom	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
74	Group Workroom	FCU	3.90	4.19	999,71	0.19	15.00	19.2	22
75	Study carells	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
76	Multiedia workroom	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22
LIBRARY-4F									
77	Book stacks/Reading room	FCU	18.30	4.19	999,71	0.87	25.00	30	34
78	Reading room	FCU	6.20	4.19	999,71	0.30	15.00	19.2	22

Table 9.1: Caculation of chilled water supply hose for AHU and FCU

9.1.2 CALCULATING OF WATER PIPE IN CHILLER ROOM

❖ **From condenser connector with cooling towers**

- Calculate the flow of cold water through each pipe section:

$$G = \frac{Q_0}{C \times \Delta t} = \frac{1361,15}{4,186 \times 5} = 64,97 Kg/s$$

Inside:

Q_0 : is the required cooling capacity of the chiller manifold.

Δt = 5℃ : is the temperature difference of water entering and exiting the chiller manifold.

C = 4,186 (kJ/kg.°K) : Specific heat of water.

- Select the preliminary velocity: ω = 1,5 (m/s).

Determine the diameter of the pipe section:

$d_{in} = \sqrt{\frac{4\times G}{\pi\times\omega\times\rho}} = \sqrt{\frac{4\times 64,97}{3,14\times 1,5\times 999,71}}$=0.23 m

Inside:

- G: is the flow of water in the pipe, kg/s.

- ω: The velocity of water moves in the pipe, m/s.

- ρ : is the specific mass of water at average temperature.

We choose the nominal diameter DN250mm according to ASTM A53 pipe standard so that the losses are evenly in the branches.

Select nominal diameter d_N = 250 mm => $\begin{cases} d_{in} = 263,8\ mm \\ d_{ex} = 273,1\ mm \end{cases}$ with wall thickness by standard SCH40 9.3mm

Recalculate the actual velocity in the tube according to the inner diameter.

$$\omega = \frac{4 \times G}{\rho \times \pi \times d_{in}^2} = \frac{4 \times 64,97}{999,71 \times \pi \times 273,1^2} = 1,11\ m/s$$

❖ **Contribution**

- Calculate the flow of cold water through each pipe section:

$$G = \frac{Q_0}{C\times\Delta t} = \frac{4.1298}{4,186.5} = 248,06\ Kg/s$$

Inside:

Q_0 : is the required cooling capacity of the chiller pipe.

Δt = 5℃ : is the temperature difference of the water in and out of the chiller.

C = 4,186 (kJ/kg.°K) : Specific heat of water.

- Select the preliminary velocity: ω = 1,5 (m/s).

Determine the diameter of the pipe section:

$d_{in} = \sqrt{\frac{4\times G}{\pi\times\omega\times\rho}} = \sqrt{\frac{4\times 248,06}{3,14\times 1,5\times 999,71}}$=0.459 m

Inside:

- G: is the flow of water in the pipe, kg/s.

- ω: The velocity of water moves in the pipe, m/s.

- ρ : is the specific mass of water at average temperature.

We choose the nominal diameter DN500mm according to ASTM A53 pipe standard so that the losses are evenly in the branches.

Select nominal diameter d_N = 500 mm => $\begin{cases} d_{in} = 491{,}9\ mm \\ d_{ex} = 508\ mm \end{cases}$ with wall thickness by standard SCH40 16.1mm

Recalculate the actual velocity in the tube according to the inner diameter.

$$\omega = \frac{4 \times G}{\rho \times \pi \times d_{in}^2} = \frac{4 \times 248{,}06}{999{,}71 \times \pi \times 491{,}9^2} = 1{,}31\ m/s$$

❖ **From evaporation connector with cooler:**

Calculate the flow of cold water through each pipe section:

$$G = \frac{Q_0}{C \times \Delta t} = \frac{1170{,}82}{4{,}186 \times 5} = 55{,}94\ Kg/s$$

Inside:

Q_0 is the required cooling capacity of the Cooling Tower

Δt = 5℃ : is the difference of water temperature in and out of Cooling Tower.

C = 4,186 (kJ/kg.°K) : Specific heat of water.

- Select the preliminary velocity: ω = 1,5 (m/s).

Determine the diameter of the pipe section:

$$d_{in} = \sqrt{\frac{4 \times G}{\pi \times \omega \times \rho}} = \sqrt{\frac{4 \times 55{,}94}{3{,}14 \times 1{,}5 \times 999{,}71}} = 0.22\ \text{m}$$

Inside:

- G: is the flow of water in the pipe, kg/s.
- ω: The velocity of water moves in the pipe, m/s.
- ρ : is the specific mass of water at average temperature.

We choose the nominal diameter DN250mm according to ASTM A53 pipe standard so that the losses are evenly in the branches.

Select nominal diameter d_N = 250 mm => $\begin{cases} d_{in} = 263{,}8\ mm \\ d_{ex} = 273{,}1\ mm \end{cases}$ with wall thickness by standard SCH40 9.3mm

Recalculate the actual velocity in the tube according to the inner diameter.

$$\omega = \frac{4 \times G}{\rho \times \pi \times d_{in}^2} = \frac{4 \times 55{,}94}{999{,}71 \times \pi \times 67{,}8^2} = 1{,}55\ m/s$$

❖ **Contribution**

- Calculate the flow of cold water through each pipe section:

$$G = \frac{Q_0}{C \times \Delta t} = \frac{4.1170,82}{4,186.5} = 223,75\ Kg/s$$

Inside:

Q_0 : is the required cooling capacity of the chiller pipe.

$\Delta t = 5℃$: is the temperature difference of the water in and out of the chiller.

C = 4,186 (kJ/kg.°K) : Specific heat of water.

- Select the preliminary velocity: ω = 1,5 (m/s).

Determine the diameter of the pipe section:

$$d_{in} = \sqrt{\frac{4 \times G}{\pi \times \omega \times \rho}} = \sqrt{\frac{4 \times 223,75}{3,14 \times 1,5 \times 999,71}} = 0.44 \text{ m}$$

Inside:

- G: is the flow of water in the pipe, kg/s.

- ω: The velocity of water moves in the pipe, m/s.

- ρ : is the specific mass of water at average temperature.

We choose the nominal diameter DN500mm according to ASTM A53 pipe standard so that the losses are evenly in the branches.

Select nominal diameter d_N = 500 mm => $\begin{cases} d_{in} = 491,9\ mm \\ d_{ex} = 508\ mm \end{cases}$ with wall thickness by standard SCH40 16.1mm

Recalculate the actual velocity in the tube according to the inner diameter.

$$\omega = \frac{4 \times G}{\rho \times \pi \times d_{in}^2} = \frac{4 \times 223,75}{999,71 \times \pi \times 491,9^2} = 1,18\ m/s$$

9.2 CALCULATE GAS-TUBE SIZE OF THE COMPRESSOR

9.2.1 Calculation the size of gas pipe size:

$$D = \sqrt{\frac{4.G}{\pi.\omega.\rho}}$$

With:

$$G = \frac{Q_o}{i_1 - i_4}$$

That is:

ρ = 34,817 kg/m^3 the steam status at the temperature point 4^{o}C

Q_o: Cooling capacity of the gas pipe connected to equipment (kW)

G: the mass flow of gas pipe (kg/s)

ω: the velocity of gas pipe (m/s)

Calculation of gas tube for Sever room 's AHU 285,8 kW:

$$G = \frac{Q_o}{i_1 - i_4} = \frac{285,8}{401,57 - 250,12} = 1,88 kg/s$$

$$D = \sqrt{\frac{4.G}{\pi.\omega.\rho}} = \sqrt{\frac{4\,.\,1,88}{3,14\,.\,13\,.\,34,817}} = 0,7274\ m = 72,74 mm$$

NO	ROOM NAME	DEVICES	Qo (Kw)	G (kg/s)	d_{in} (mm)	d_N (mm)	d_{in} choose (mm)	d_{ex} choose (mm)	ω (KT)
CENTRAL PLANT-1F									
1	Fire room	FCU	11.90	0.08	14.87	15	19.2	22	7.80
2	Corridor	FCU	7.80	0.05	12.04	15	19.2	22	5.11
3	Server room	AHU	285.80	1.89	72.87	80	83.4	90	9.93
4	Server room support	FCU	11.90	0.08	14.87	15	19.2	22	7.80
5	Corridor	AHU	44.40	0.29	28.72	25	30	34	11.92
6	Fuel Storage Tank	FCU	16.40	0.11	17.46	15	19.2	22	10.75
7	Transformer room	AHU	33.30	0.22	24.88	20	23.8	27	14.20
8	Medium voltage switchgear room	AHU	33.30	0.22	24.88	20	23.8	27	14.20
9	Transformer room	AHU	57.80	0.38	32.77	32	39	42	9.18
10	Low voltage switchgear room	AHU	44.40	0.29	28.72	25	30	34	11.92
11	Corridor	FCU	3.90	0.03	8.51	15	19.2	22	2.56
12	Control center	FCU	16.40	0.11	17.46	15	19.2	22	10.75

13	Technical room	FCU	11.90	0.08	14.87	15	19.2	22	7.80
14	Odor treatment room	FCU	11.90	0.08	14.87	15	19.2	22	7.80
CENTRAL PLANT-2F									
16	UPS battery room	FCU	7.80	0.05	12.04	15	19.2	22	5.11
17	Corridor	FCU	3.90	0.03	8.51	15	19.2	22	2.56
18	Server room support	AHU	112.80	0.74	45.78	50	56.1	60	8.66
19	Server room	AHU	112.80	0.74	45.78	50	56.1	60	8.66
20	Storage	FCU	6.20	0.04	10.73	15	19.2	22	4.06
21	Corridor	FCU	6.20	0.04	10.73	15	19.2	22	4.06
22	Janitor	FCU	6.20	0.04	10.73	15	19.2	22	4.06
23	Corridor-hành lang	FCU	3.90	0.03	8.51	15	19.2	22	2.56
24	Electrical workroom area	FCU	7.80	0.05	12.04	15	19.2	22	5.11
25	Control room	FCU	6.20	0.04	10.73	15	19.2	22	4.06
CENTRAL PLANT-RF									
27	Generator room	FCU	18.30	0.12	18.44	15	19.2	22	11.99
28	Mechanical room	FCU	11.90	0.08	14.87	15	19.2	22	7.80
29	AHU sever	FCU	16.40	0.11	17.46	15	19.2	22	10.75
LIBRARY-1F									
30	Conference/Training room	FCU	23.80	0.16	21.03	20	23.8	27	10.15
31	Storage	FCU	3.90	0.03	8.51	15	19.2	22	2.56
32	Janitor	FCU	3.90	0.03	8.51	15	19.2	22	2.56
33	Frist Aid	FCU	6.20	0.04	10.73	15	19.2	22	4.06
34	Aid relaxing room	FCU	3.90	0.03	8.51	15	19.2	22	2.56

35	Storage	FCU	3.90	0.03	8.51	15	19.2	22	2.56
36	Book return room	FCU	6.20	0.04	10.73	15	19.2	22	4.06
37	Corridor	FCU	8.82	0.06	12.80	15	19.2	22	5.78
38	Post room	FCU	6.20	0.04	10.73	15	19.2	22	4.06
39	Storageo/Receiving	FCU	6.20	0.04	10.73	15	19.2	22	4.06
40	Porter room	FCU	3.90	0.03	8.51	15	19.2	22	2.56
41	Uni shop	FCU	18.30	0.12	18.44	15	19.2	22	11.99
42	Coffee shop	FCU	8.82	0.06	12.80	15	19.2	22	5.78
43	Coffee Storage room	FCU	3.90	0.03	8.51	15	19.2	22	2.56
44	Mechanical room	FCU	11.90	0.08	14.87	15	19.2	22	7.80
45	Elec/tele	FCU	3.90	0.03	8.51	15	19.2	22	2.56
LIBRARY-2F									
46	Journal display/reading	FCU	3.90	0.03	8.51	15	19.2	22	2.56
47	Journal display/reading	FCU	3.90	0.03	8.51	15	19.2	22	2.56
48	Journal display/reading	FCU	3.90	0.03	8.51	15	19.2	22	2.56
49	Journal display/reading	FCU	3.90	0.03	8.51	15	19.2	22	2.56
50	Group Workroom	FCU	6.20	0.04	10.73	15	19.2	22	4.06
51	Group Workroom	FCU	6.20	0.04	10.73	15	19.2	22	4.06
52	Group Workroom	FCU	6.20	0.04	10.73	15	19.2	22	4.06
53	Group Workroom	FCU	6.20	0.04	10.73	15	19.2	22	4.06
54	Storage	FCU	3.90	0.03	8.51	15	19.2	22	2.56

55	Storage	FCU	3.90	0.03	8.51	15	19.2	22	2.56
56	Storage	FCU	3.90	0.03	8.51	15	19.2	22	2.56
57	Prints/Storage	FCU	8.82	0.06	12.80	15	19.2	22	5.78
58	Kitchen/staff lounge	FCU	8.82	0.06	12.80	15	19.2	22	5.78
59	Directors office	FCU	3.90	0.03	8.51	15	19.2	22	2.56
60	Assistants desk	FCU	3.90	0.03	8.51	15	19.2	22	2.56
61	Meeting room	FCU	6.20	0.04	10.73	15	19.2	22	4.06
62	Computer pool	FCU	11.90	0.08	14.87	15	19.2	22	7.80
LIBRARY-3F									
63	Reading theatre	FCU	6.20	0.04	10.73	15	19.2	22	4.06
64	Reading theatre	FCU	8.82	0.06	12.80	15	19.2	22	5.78
65	Book stacks/Reading room	AHU	22.20	0.15	20.31	20	23.8	27	9.47
66	Learing room	FCU	3.90	0.03	8.51	15	19.2	22	2.56
67	Learing room	FCU	3.90	0.03	8.51	15	19.2	22	2.56
68	Storage	FCU	3.90	0.03	8.51	15	19.2	22	2.56
69	Copy/print	FCU	3.90	0.03	8.51	15	19.2	22	2.56
70	Group Workroom	FCU	3.90	0.03	8.51	15	19.2	22	2.56
71	Group Workroom	FCU	3.90	0.03	8.51	15	19.2	22	2.56
72	Group Workroom	FCU	3.90	0.03	8.51	15	19.2	22	2.56
73	Group Workroom	FCU	3.90	0.03	8.51	15	19.2	22	2.56
74	Group Workroom	FCU	3.90	0.03	8.51	15	19.2	22	2.56

75	Study carells	FCU	6.20	0.04	10.73	15	19.2	22	4.06
76	Multiedia workroom	FCU	6.20	0.04	10.73	15	19.2	22	4.06
LIBRARY-4F									
77	Book stacks/Reading room	FCU	18.30	0.12	18.44	15	19.2	22	11.99
78	Reading room	FCU	6.20	0.04	10.73	15	19.2	22	4.06

Table 9.2: Calculation of gas tube

9.2.2 Calculation the size of liquid pipe size:

Calculation of liquid tube size:

$$D = \sqrt{\frac{4.G}{\pi.\omega.\rho}}$$

With:

$$G = \frac{Q_o}{i_1 - i_4}$$

That is:

ρ = 1159,8 kg/m^3 the liquid status at the temperature point 4^{o}C

Q_o: Cooling capacity of the gas pipe connected to equipment (kW)

G: the mass flow of gas pipe (kg/s)

ω: the velocity of gas pipe (m/s)

(ω < 1,52m/s for liquid gas pipe)

Calculation of liquid tube for Sever room ‘s AHU 285,8 kW:

$$G = \frac{Q_o}{i_1 - i_4} = \frac{285,8}{401,57 - 250,12} = 1,88 \text{ kg/s}$$

$$D = \sqrt{\frac{4.G}{\pi.\omega.\rho}} = \sqrt{\frac{4\,.\,1,88}{3,14\,.\,1,5\,.\,1159,8}} = 0,37 \text{ m} = 37,1\text{mm}$$

NO	ROOM NAME	DEVICES	Qo (Kw)	G (kg/s)	d_{in} (mm)	d_N (mm)	d_{in}choose (mm)	d_{ex}choose (mm)	ω (KT)
CENTRAL PLANT-1F									
1	Fire room	FCU	11.90	0.08	7.59	15	19.2	22	0.23
2	Corridor	FCU	7.80	0.05	6.14	15	19.2	22	0.15
3	Server room	AHU	285.80	1.89	37.17	32	39	42	1.36
4	Server room support	FCU	11.90	0.08	7.59	15	19.2	22	0.23
5	Corridor	AHU	44.40	0.29	14.65	15	19.2	22	0.87
6	Fuel Storage Tank	FCU	16.40	0.11	8.90	15	19.2	22	0.32
7	Transformer room	AHU	33.30	0.22	12.69	15	19.2	22	0.66
8	Medium voltage switchgear room	AHU	33.30	0.22	12.69	15	19.2	22	0.66
9	Transformer room	AHU	57.80	0.38	16.72	15	19.2	22	1.14
10	Low voltage switchgear room	AHU	44.40	0.29	14.65	15	19.2	22	0.87
11	Corridor	FCU	3.90	0.03	4.34	15	19.2	22	0.08
12	Control center	FCU	16.40	0.11	8.90	15	19.2	22	0.32
13	Technical room	FCU	11.90	0.08	7.59	15	19.2	22	0.23
14	Odor treatment room	FCU	11.90	0.08	7.59	15	19.2	22	0.23
CENTRAL PLANT-2F									
16	UPS battery room	FCU	7.80	0.05	6.14	15	19.2	22	0.15
17	Corridor	FCU	3.90	0.03	4.34	15	19.2	22	0.08
18	Server room support	AHU	112.80	0.74	23.35	20	23.8	27	1.44
19	Server room	AHU	112.80	0.74	23.35	20	23.8	27	1.44
20	Storage	FCU	6.20	0.04	5.48	15	19.2	22	0.12
21	Corridor	FCU	6.20	0.04	5.48	15	19.2	22	0.12
22	Janitor	FCU	6.20	0.04	5.48	15	19.2	22	0.12

23	Corridor-hành lang	FCU	3.90	0.03	4.34	15	19.2	22	0.08
24	Electrical workroom area	FCU	7.80	0.05	6.14	15	19.2	22	0.15
25	Control room	FCU	6.20	0.04	5.48	15	19.2	22	0.12
CENTRAL PLANT-RF									
27	Generator room	FCU	18.30	0.12	9.41	15	19.2	22	0.36
28	Mechanical room	FCU	11.90	0.08	7.59	15	19.2	22	0.23
29	AHU sever	FCU	16.40	0.11	8.90	15	19.2	22	0.32
LIBRARY-1F									
30	Conference/Training room	FCU	23.80	0.16	10.73	15	19.2	22	0.47
31	Storage	FCU	3.90	0.03	4.34	15	19.2	22	0.08
32	Janitor	FCU	3.90	0.03	4.34	15	19.2	22	0.08
33	Frist Aid	FCU	6.20	0.04	5.48	15	19.2	22	0.12
34	Aid relaxing room	FCU	3.90	0.03	4.34	15	19.2	22	0.08
35	Storage	FCU	3.90	0.03	4.34	15	19.2	22	0.08
36	Book return room	FCU	6.20	0.04	5.48	15	19.2	22	0.12
37	Corridor	FCU	8.82	0.06	6.53	15	19.2	22	0.17
38	Post room	FCU	6.20	0.04	5.48	15	19.2	22	0.12
39	Storageo/Receiving	FCU	6.20	0.04	5.48	15	19.2	22	0.12
40	Porter room	FCU	3.90	0.03	4.34	15	19.2	22	0.08
41	Uni shop	FCU	18.30	0.12	9.41	15	19.2	22	0.36
42	Coffee shop	FCU	8.82	0.06	6.53	15	19.2	22	0.17

43	Coffee Storage room	FCU	3.90	0.03	4.34	15	19.2	22	0.08
44	Mechanical room	FCU	11.90	0.08	7.59	15	19.2	22	0.23
45	Elec/tele	FCU	3.90	0.03	4.34	15	19.2	22	0.08
LIBRARY-2F									
46	Journal display/reading	FCU	3.90	0.03	4.34	15	19.2	22	0.08
47	Journal display/reading	FCU	3.90	0.03	4.34	15	19.2	22	0.08
48	Journal display/reading	FCU	3.90	0.03	4.34	15	19.2	22	0.08
49	Journal display/reading	FCU	3.90	0.03	4.34	15	19.2	22	0.08
50	Group Workroom	FCU	6.20	0.04	5.48	15	19.2	22	0.12
51	Group Workroom	FCU	6.20	0.04	5.48	15	19.2	22	0.12
52	Group Workroom	FCU	6.20	0.04	5.48	15	19.2	22	0.12
53	Group Workroom	FCU	6.20	0.04	5.48	15	19.2	22	0.12
54	Storage	FCU	3.90	0.03	4.34	15	19.2	22	0.08
55	Storage	FCU	3.90	0.03	4.34	15	19.2	22	0.08
56	Storage	FCU	3.90	0.03	4.34	15	19.2	22	0.08
57	Prints/Storage	FCU	8.82	0.06	6.53	15	19.2	22	0.17
58	Kitchen/staff lounge	FCU	8.82	0.06	6.53	15	19.2	22	0.17
59	Directors office	FCU	3.90	0.03	4.34	15	19.2	22	0.08
60	Assistants desk	FCU	3.90	0.03	4.34	15	19.2	22	0.08
61	Meeting room	FCU	6.20	0.04	5.48	15	19.2	22	0.12
62	Computer pool	FCU	11.90	0.08	7.59	15	19.2	22	0.23

LIBRARY-3F									
63	Reading theatre	FCU	6.20	0.04	5.48	15	19.2	22	0.12
64	Reading theatre	FCU	8.82	0.06	6.53	15	19.2	22	0.17
65	Book stacks/Reading room	AHU	22.20	0.15	10.36	15	19.2	22	0.44
66	Learing room	FCU	3.90	0.03	4.34	15	19.2	22	0.08
67	Learing room	FCU	3.90	0.03	4.34	15	19.2	22	0.08
68	Storage	FCU	3.90	0.03	4.34	15	19.2	22	0.08
69	Copy/print	FCU	3.90	0.03	4.34	15	19.2	22	0.08
70	Group Workroom	FCU	3.90	0.03	4.34	15	19.2	22	0.08
71	Group Workroom	FCU	3.90	0.03	4.34	15	19.2	22	0.08
72	Group Workroom	FCU	3.90	0.03	4.34	15	19.2	22	0.08
73	Group Workroom	FCU	3.90	0.03	4.34	15	19.2	22	0.08
74	Group Workroom	FCU	3.90	0.03	4.34	15	19.2	22	0.08
75	Study carells	FCU	6.20	0.04	5.48	15	19.2	22	0.12
76	Multiedia workroom	FCU	6.20	0.04	5.48	15	19.2	22	0.12
LIBRARY-4F									
77	Book stacks/Reading room	FCU	18.30	0.12	9.41	15	19.2	22	0.36
78	Reading room	FCU	6.20	0.04	5.48	15	19.2	22	0.12

Table 9.3: Calculation of liquid tube

9.3 CALCULATION OF PRESSURE COLUMN

9.3.1 Calculation of pressure column of cold water pump

Theoretical basis:

Because the system is a closed system, the pressure loss of the pump is a dynamic pressure loss, excluding static pressure losses.

The pressure loss of the water flowing in the pipe is a quantity to choose a pump with a suitable head for the system. When water or fluid flows in the tube, there are two types of force that appear: friction along the pipe length and local diffusion in you and accessories such as numbness, quail, U, sudden opening, sudden fall, branch,...

$\Delta p = \Delta p_{ms} + \Delta p_{cb}$

Therein: Δp : total pressure loss, Pa

Δp_{ms} : pipe friction losses, Pa

Δp_{cb} : local pressure loss, Pa

According to the [1], $\Delta p_{ms} = \lambda . \frac{I.\rho}{d} . \frac{\omega 2}{2}$, Pa

$\Delta p_{cb} = \zeta . \rho . \frac{\omega 2}{2}$, P

Therein: I : length of pipe section, m; ρ : water density, kg/m^3; ω : water speed, m/s;

d : inner diameter of pipe, m; λ : Friction impedance coefficient is determined by the following formula; ζ : Local impedance coefficients are determined according to the table 6.7 [1]

When the flow floor Re ≤ 2.10^3:

$\lambda = \frac{64}{Re} = \frac{64.v}{\omega.d}$

v : Kinematic viscosity of water, m^2/s

When the flow with Re > 10000: $\lambda = \frac{1}{(1{,}82 \log Re - 1{,}64)2}$

9.3.2 Re in the main pipe of the Central plants:

- **Evaporator water outlet main pipe and including supplying cold water to the library L=393m**

$Re = \frac{\omega.dtr}{v}$

$$\Delta p_{ms} = \lambda . \frac{L}{d} . \frac{V^2}{2g} . \gamma_n$$

- ν - Kinematic viscosity of water at temperature 10,5℃ $\nu = 1,291.10^{-6} m^2 / s$
- V – velocity of water in the tube V = 1,31m/s
- Δ - Surface roughness of selected tube $\Delta = 0,1mm$

$$Re = \frac{V.dtr}{v} = \frac{1,31x0,4919}{1,291.10^{-6}} = 507358,64$$

$$Re' = \frac{10.dtr}{\Delta} = \frac{10x0,4919}{0,1.10^{-3}} = 49190$$

$$Re' = \frac{500.dtr}{\Delta} = \frac{500x0,2118}{0,1.10^{-3}} = 2459500$$

But Re'<Re<Re"

⇒Disturbance in the hydraulic smooth wall area to the rough hydraulic wall

$$\Rightarrow \lambda = 0,11 \left(\frac{68}{Re} + \frac{\Delta}{d}\right)^{1/4} = 0,11 \left(\frac{68}{507358,64} + \frac{0,1.10^{-3}}{0,4919}\right)^{1/4} = 0,015$$

Friction losses on branch pipe supply to the furthest floor

$$\Rightarrow \Delta p_{ms} = 0,015 \frac{393.1,31^2}{0,4919.2.9,81} . 9810 = 10029,364 \text{ Pa}$$

Localized losses on the main pipe of the 1st floor

Including : 1 glove valve, 1 check valve, 2 90 elbow

$$\Rightarrow \Delta p_{cb} = (\zeta_v + \zeta_{co}) . \frac{V^2}{2g} = (2.0,04 + 2.0,15) . \frac{1,31^2}{2.9,81} = 0,033$$

9.3.3 Re in the branch pipe of the Centrals plants :

❖ **Pump inlet Central Plant L=386m:**

$$Re = \frac{\omega.dtr}{v}$$

$$\Delta p_{ms} = \lambda . \frac{L}{d} . \frac{V^2}{2g} . \gamma_n$$

- ν - Kinematic viscosity of water at temperature 10,5℃ $\nu = 1,291.10^{-6} m^2 / s$
- V – velocity of water in the tube V = 0,34m/s
- Δ - Surface roughness of selected tube $\Delta = 0,1mm$

$$Re = \frac{V.dtr}{v} = \frac{0,34x0,0238}{1,291.10^{-6}} = 5267,23$$

$$Re' = \frac{10.dtr}{\Delta} = \frac{10x0,0238}{0,1.10^{-3}} = 2380$$

$Re' = \frac{500.dtr}{\Delta} = \frac{500x0,0238}{0,1.10^{-3}} = 119000$

But Re'<Re<Re"

⇒Disturbance in the hydraulic smooth wall area to the rough hydraulic wall

$\Rightarrow \lambda = 0,11\left(\frac{68}{Re} + \frac{\Delta}{d}\right)^{1/4} = 0,11\left(\frac{68}{5267,23} + \frac{0,1.10^{-3}}{0,0238}\right)^{1/4} = 0,04$

Friction losses on branch pipe supply to the furthest floor

$\Rightarrow \Delta p_{ms} = 1,57\frac{386.0,34^2}{0,0238.2.9,81}.9810 = 44890,22$ Pa

Localized losses on the main pipe of the 1st floor

Including : 3 90 elbow, 1 tee

$\Rightarrow \Delta p_{cb} = (\zeta_{co} + \zeta_{tee}).\frac{V^2}{2g} = (3.0,3 + 1.0,7).\frac{0,34^2}{2.9,81} = 0,009$

Localized losses on supply and return water pipes							
No.	**Description**	**Quantity**	**V**	**ζ**	**Equivalent length**	**Total equivalent length**	**ΔPcb**
		(Set)	**(m/s)**		**(m)**	**(m)**	**(Pa)**
Chiller water suply pipe							
1	Gate Valve DN500	1	1.310	2.00	6.710	6.71	0.175
2	Gate Valve DN125	2	1.130	2.00	1.830	3.66	0.130
3	Tee 500-500-250	4	1.310	0.05	15.240	60.96	0.004
4	Tee 250-250-125	2	1.240	0.10	7.620	15.24	0.008
5	Tee 125-125-125	2	1.130	0.70	2.500	5.00	0.046
6	Tee 125-125-50	2	1.130	0.70	3.960	7.92	0.046
7	Tee 32-32-20	2	0.490	0.20	0.945	1.89	0.002
8	Tee 20-20-20	6	0.340	0.30	1.220	7.32	0.002
9	Reducing 125-65	4	1.130	0.70	3.960	15.84	0.046
10	Reducing 65-32	4	0.820	0.15	1.820	7.28	0.005
11	Reducing 32-20	4	0.490	0.20	1.006	4.02	0.002

12	Elbow 90 DN500	2	1.310	0.20	15.240	30.48	0.017
13	Elbow 90 DN125	2	1.130	0.20	2.500	5.00	0.013
14	Elbow 90 DN20	10	0.340	0.20	0.609	6.09	0.001
Chiller water return pipe							
1	Gate Valve DN500	2	1.310	2.00	6.71	13.42	0.175
2	Gate Valve DN250	4	1.240	2.00	3.66	14.64	0.157
3	Gate Valve DN125	2	1.130	2.00	1.83	3.66	0.130
4	Tee 500-500-300	1	1.310	0.05	15.24	15.24	0.004
5	Tee 500-500-250	9	1.310	0.05	15.24	137.16	0.004
6	Tee 250-250-125	2	1.240	0.10	7.62	15.24	0.008
7	Tee 125-125-125	2	1.130	0.70	2.50	5.00	0.046
8	Tee 125-125-50	2	1.130	0.70	3.96	7.92	0.046
9	Tee 32-32-20	2	0.490	0.20	0.95	1.89	0.002
10	Tee 20-20-20	6	0.340	0.30	1.22	7.32	0.002
11	Reducing 125-65	4	1.130	0.70	3.96	15.84	0.046
12	Reducing 65-32	4	0.820	0.15	1.82	7.28	0.005
13	Reducing 32-20	4	0.490	0.20	1.01	4.02	0.002
14	Elbow 90 DN500	2	1.310	0.20	15.24	30.48	0.017
15	Elbow 90 DN125	2	1.130	0.20	2.50	5.00	0.013
16	Elbow 90 DN20	10	0.340	0.20	0.61	6.09	0.001
Cooling tower inlet							
1	Gate Valve DN250	4	1.240	2.00	3.66	14.64	0.157
2	Tee 500-500-500	1	1.310	0.05	15.24	15.24	0.004
3	Tee 500-500-	8	1.310	0.05	15.24	121.92	0.004

	250						
4	Tee 250-250-250	16	1.240	0.10	7.62	121.92	0.008
5	Elbow 90 DN500	1	1.310	0.20	15.24	15.24	0.017
6	Elbow 90 DN250	4	1.130	0.20	4.88	19.52	0.013
Cooling tower outlet							
1	Gate Valve DN250	12	1.240	2.00	3.66	43.92	0.157
2	Tee 500-500-500	1	1.310	0.05	15.24	15.24	0.004
3	Tee 500-500-250	8	1.310	0.05	15.24	121.92	0.004
4	Tee 250-250-250	16	1.240	0.10	7.62	121.92	0.008
5	Elbow 90 DN500	1	1.310	0.20	15.24	15.24	0.017
6	Elbow 90 DN250	12	1.130	0.20	4.88	58.56	0.013

Table 9.4: Calculation of localized losses

ΣΔPcb=1,564

Friction losses on supply and return water pipes					
No.	**Description**	**L (m)**	**Re**	**λ**	**ΔPms (Pa)**
Central plant					
1	Evaporator water outlet main pipe	393.00	507358.64	0.015	10029.364
2	Evaporator water inlet main pipe	393.00	507358.64	0.015	10029.364
3	Condenser water outlet main pipe	50.00	507358.64	0.015	1276.000
4	Condenser water inlet main pipe	50.00	507358.64	0.015	1276.000
5	Outlet-branch pipe	386.00	5267.23	0.040	44890.220
6	Inlet-branch pipe	386.00	5267.23	0.040	44890.220
7	Chiller-Pump	10.00	253679.32	0.018	606.972
8	Pump-Cooling tower	20.00	253679.32	0.018	1213.943

Library					
1	Riser pipe 1F-RF outlet	30.00	253679.32	0.018	1820.915
2	Riser pipe 1F-RF inlet	30.00	253679.32	0.018	1820.915
3	Outlet-branch pipe	548.00	5267.23	0.040	63730.156
4	Inlet-branch pipe	548.00	5267.23	0.040	63730.156

Table 9.4: Calculation of friction losses

ΣΔPms=245314,223

9.4 SELECTION OF PUMP:

9.4.1 Calculate and select water pump for supply pipe:

ΣΔP=ΔPcb+ΔPms=1,564+245314,223=245315,79 Pa=25,02 mH20

$$V_b = \frac{Q_o}{\rho_w . C_w . \Delta t_w} = \frac{1170{,}82}{999{,}475.4{,}187.5} = 0{,}056\ m^3/s = 201{,}6\ m^3/h$$

ENR 2 Poles: 80-200 Version

Pump type ENR	Q=Capacity											
	m³/h	0	20	40	60	80	100	150	166	178	190	204	220
Three Phase	l/min	0	333,3	667	1000	1333	1667	2500	2767	2967	3167	3400	3667
	H=Total manometric head in meters												
ENR 80-200 Ø170		35,2	35	35	34	33	31	20	-	-	-	-	-
ENR 80-200 Ø180		41	41	41	40	39	37,5	28	25	-	-	-	-
ENR 80-200 Ø190		47	47	46	45,5	45	44	35	32	29	-	-	-
ENR 80-200 Ø 200		54	54	54	53	52,5	51,5	45	41	38	35	-	-
ENR 80-200 Ø207		59	58,5	58	58	57,5	57	52	50	47	44	40	-
ENR 80-200 Ø214		65	65	65	65	64	64	59	58,5	55	53	50	45,5

Choose 1 Pump Brand Ebara Model ENR 80-200 with H=40m and 204 m^3/h.

9.4.2 Calculate and select water pump for return pipe:

Based on the calculation figures in Chapter 6 in section 6.1.4, $P_o = 1.5\ bar = 15{,}3\ m\ H2O$

The amount of cooling water through a condenser:

$$G_w = \frac{Q_k}{C_w.\Delta t_w} = \frac{1361{,}15}{4{,}187.5} = 65{,}02\ \text{kg/s}=3979{,}22\ \text{l/min}$$

ENR 2 Poles: 100-200 Version

Pump type ENR	Q=Capacity									
	m³/h 0	50	100	150	200	226	250	270	288	312
Three Phase	l/min 0	833,3	1667	2500	3333	3767	4167	4500	4800	5200
	H=Total manometric head in meters									
ENR 100-200 Ø170	33,5	32,5	30,5	26	20	15	-	-	-	-
ENR 100-200 Ø180	38	37,5	37	34	29	24,9	21	-	-	-
ENR 100-200 Ø190	44,5	44	44	40,5	36	33	30	25,5	-	-
ENR 100-200 Ø200	50,5	50,5	50	47,5	45	41,5	39	35,5	34	-
ENR 100-200 Ø213	57	57	56,5	55	53	50	48	45,5	42,5	40

Choose 6 Pump Brand Ebara Model ENR 100-200 with H=21m and 4167 l/min