$$\therefore Q_A = \frac{20}{24 * 60 * 60} * \left(\frac{10.9375}{0.866}\right) * \left[55.5 - (-17.5)\right] * 1000$$

$$Q_A = 213.42 \text{ W}$$

• حمل المبخر ، ΣQ

$$\Sigma Q = Q_T + Q_S + Q_L + Q_A = 1137.76 \text{ W}$$

• بفرض ان عدد ساعات تشغيل الضاغط ~ 18 h ، معامل امان
١٠%

$$\text{سعة المبخر} = \Sigma Q * 1.1 * \frac{24}{18} = 1668.7 \text{ W}$$

$$= 1.6687 \text{ kW}$$

EX: A chilling room (غرفة تبريد فجائية) (15×10×4) m is used to chill 20 tons of beef (لحم بقري) per day from 32 °C to 2 °C in 18 hours. Four workers work in the room during the loading period. The lighting load is 1500 W. the floor located on uncondition space (الارضية موجودة حيز غير مكيف) is 12 cm concrete slab (طبقة خرسانية) insulated with 10 cm cork board (ألواح فلين) and finished with 8 cm concrete. The ceilling situated beneath an uncondition space (السقف اسفل حيز غير مكيف) is 12 cm concrete slab with 2.5 cm wood sleepers (خشب واقي) and insulating with 10 cm cork board. All the walls adjacent to uncondition space (كل الحوائط بجوار الحيز غير مكيف) are 10 cm cinder block (بلوكات خبث الفحم), insulated with 10 cm cork board and finished with one side with 1.25 plaster.

• Compute the cooling load in ton refrigration, based on 18 hr operating time and 10% factor of safty.

The following data are used: outside condition 30 °C db, 50% RH., inside condition 2 °C db, 80% RH, outside and inside film cofficient 6 W/m²·°C. number of air charge per day 5, heat loss per worker 290 W, specific heat of beef 3.14 kJ/kg·°C, cofficient of thermal conductivity for concrete, cork board, wood, cinder board and plaster are 1.72, 0.04, 0.13, 0.72 and 1.72 W/m·°C respectively.

. Solution .

Heat transmission load Q_T الحمل على انتقال الحرارة

$$Q_T = U \cdot A \cdot (t_o - t_i)$$

$$(t_o - t_i) = 30 - 2 = 28\ ^\circ C$$

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floor للارضية

$$\frac{1}{U_f} = \frac{1}{6} + \frac{0.12}{1.72} + \frac{0.1}{0.04} + \frac{0.08}{1.72} + \frac{1}{6} \Rightarrow$$

$$\therefore U_f = 0.338 \ W/m^2 . \mathring{C}$$

ceilling للسقف

$$\frac{1}{U_c} = \frac{1}{6} + \frac{0.12}{1.72} + \frac{0.025}{0.13} + \frac{0.1}{0.04} + \frac{1}{6}$$

$$\therefore U_c = 0.323 \ W/m^2 . \mathring{C}$$

walls للحوائط

$$\frac{1}{U_w} = \frac{1}{6} + \frac{0.1}{0.72} + \frac{0.1}{0.04} + \frac{0.0125}{1.72} + \frac{1}{6}$$

$$\therefore U_w = 0.334 \ W/m^2 . \mathring{C}$$

$$\therefore Q_T = 28 * [0.338 * (10*15) + 0.323 * (10*15) + 0.334 * (10+15) * 4 * 2]$$

$$\therefore Q_T = 4646.6 \ W$$

ثانياً حمل المواد Q_p product load

$$Q_p = \frac{m}{\tau} * C_{a.f} (t_1 - t_2) = \frac{20*10^3}{18*60*60} * 3.14 * (32-2) * 10^3$$

$$\therefore Q_p = 29047 \ W.$$

ثالثاً. حمل العمال worker load

$$Q_w = n * Q_o = 4 * 290 = 1160 \ W$$

رابعاً. حمل الاضاءه lighting load

$$Q_L = 1500 \ W$$

خامساً. حمل تغيير الهواء . Air charjing load Q_A

$$Q_A = \frac{\varepsilon}{24 * 60 * 60} * \frac{V_c}{V_o} (h_o - h_i) * 10^3$$

حيث ان $V_c = 15 * 10 * 4 = 600 \ m^3$ ، $\varepsilon = 5$

من ملحق ٣ . [illegible]

عند $t_o = 30°C$ db ، 50% RH

$h_o = 84 \ \frac{kJ}{kg}$, $V_o = 0.875 \ m^3/kg$

عند $t_i = 2°C$ db ، 80% RH

$h_i = 10.5 \ \frac{kJ}{kg}$.

$$\therefore Q_A = \frac{5}{24 * 60 * 60} * \frac{600}{0.875} (84 - 10.5) * 10^3 = 2917 \ W$$

سعة المبرد EC

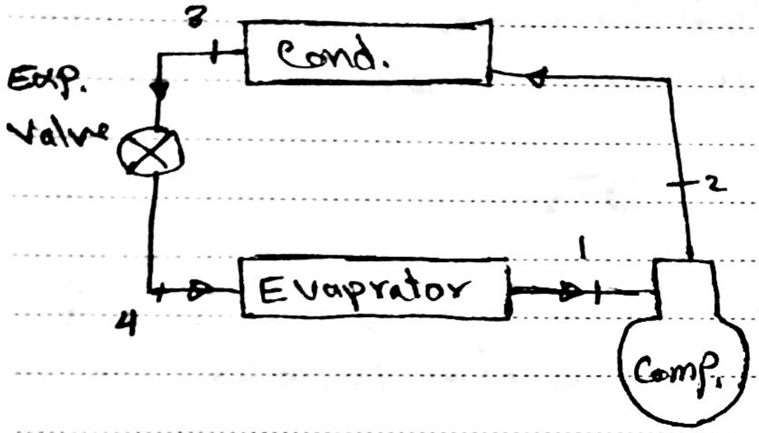
$$EC = (Q_T + Q_p + Q_L + Q_W + Q_A) * 1.1 * \frac{24}{18}$$

$$\therefore E.C. = 39270.6 \ W * \frac{1}{1000 * 3.5} = 11.22 \ TR$$

* Selection of Evaprator, Condenser, Compressor, Expansion valve.

Selection of Evaprator • اولاً.

قبل اختيار الأجزاء يتم حساب الإنثالبيا i عند مدخل ومخرج كل جزء.



1. Take the temperature difference between room and evaprator $8\,\mathring{C}$

   If $t_r = -2\,\mathring{C}$ ∴ $t_e = -2 - 8 = -10\,\mathring{C}$

2. Take the temperature difference between outside air and condenser $8\,\mathring{C}$

   If $t_o = 35\,\mathring{C}$ ⇒ $t_c = 35 + 8 = 43\,\mathring{C}$

3. from R-22 table

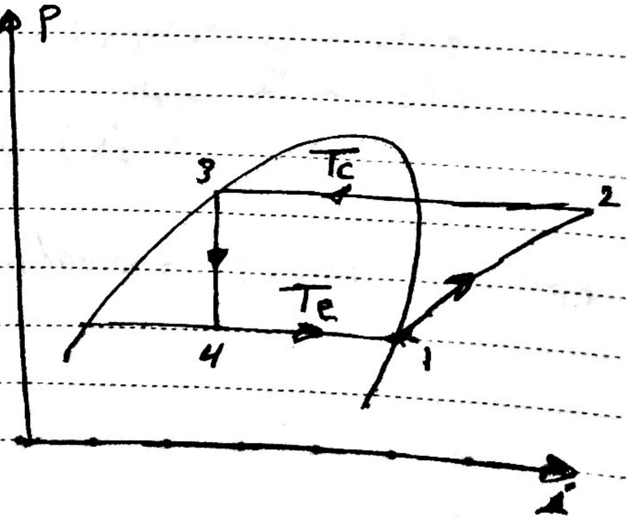
   at $t_e \rightarrow P_e$

   at $t_c \rightarrow P_c$

From chart R-22

i_1, i_2, i_3, i_4

v_1, v_2, v_3



(A) selection of Evaprator

From Catalogue for R-22

by $T_e = -10\,^\circ C$, EC — Evaprator capacity

يتم اختيار نوع المبخر ومواصفاته مع الأخذ في الاعتبار ان تكون القدرة المختارة أكبر من او يساوي EC

وبواسطة EC_{new}

$$EC_{new} = \dot{m}_R \cdot (i_1 - i_4) \Rightarrow \dot{m}_R \Rightarrow kg/s$$

من المعادلة السابقة نحصل على معدل تدفق الفريون .

(B) calculation of compressor power and condenser capacity

Take mechanical efficiency $\eta_m = 90\%$

$$\text{compressor power} = \dot{m}_R (i_2 - i_1) / \eta_m$$

→ select the compressor from catalogue

مع الأخذ في الاعتبار ان تكون القدرة المختارة أكبر من او يساوي القدرة المحسوبة .

→ condenser capacity $= \dot{m}_R (i_2 - i_3)$

→ ~~section~~ selection of condenser from catalogy.
by T_e , T_c

(C) selection of thermostatic expansion valve

by T_e , ΔP From catalogue

(D) selection of piping system

$$\dot{m}_R = \rho A C = \frac{AC}{v} \quad , \quad A = \frac{\pi}{4} d^2$$

C → velocity 8 : 15 m/s .

يتم تحديد d ومع الحساب d يتم اختيار نوع
الأنابيب

• Advanced study in air Conditioning

K.M.S

CH 1

• Water pipe system design.

- water system that convey heat to or from a conditioned space or process with hot or chilled water are called hydronic system.
- The water flow through piping that connects a boiler, water heater or chiller to suitable terminal heat transfer units located at the space or process.

- water system can be classified by.

1- operating temperature.
2- flow generation
3- pressurization
4- pipe arrangement
5- pump arrangement.

* Design of water system.

design parameter.

1- water temperature
2- flow rate
3- piping layout
4- Control method.
5- pump selection

* Hydronic system.

* Water system design depend on the space load and indoor environment requirements.
* Water system that convey heat to or from a conditioned space or process with hot or chilled water are called hydronic system.

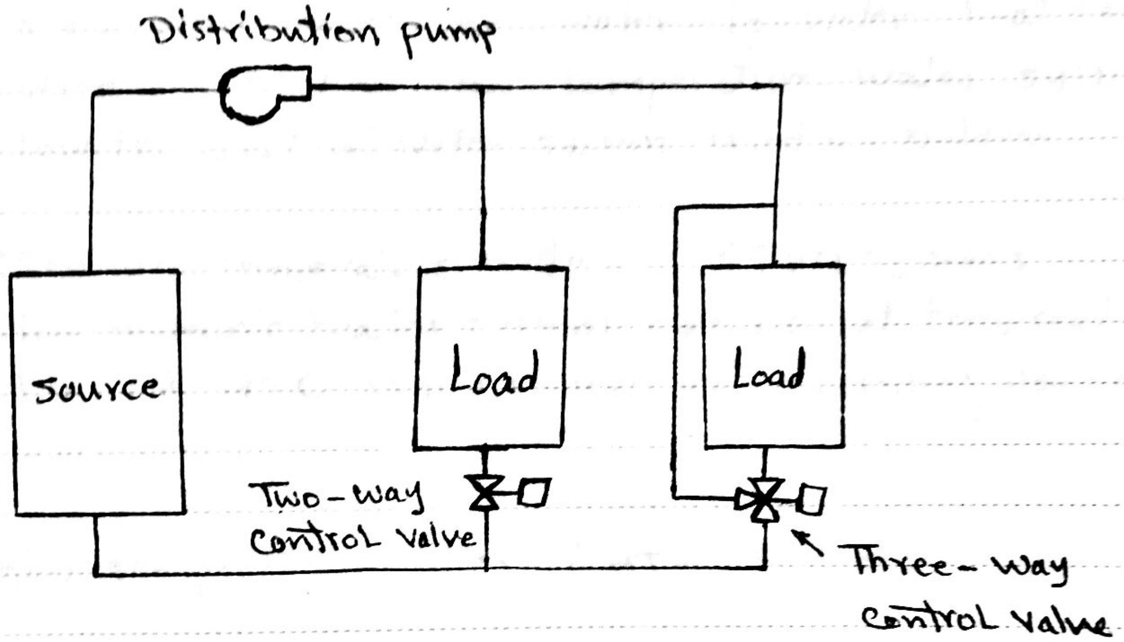


Fig. Source - distribution - Load of hydronic system.

* Source for heating " boiler " for cooled " water chiller "
* distribution system " pump and piping network "
* Control device (2-way valve , 3-way valve)
* Load " conditioned space "
* The system must be able to operate between part load and full load.

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- According to operating temperature. The water system can be classified.

1. Low temperature water (LTW) system:
   - This hydronic heating system operates at maximum temperature limitation of 120°C, maximum allowable working pressure is 1100 kPa
   - steam-to-water or water-to-water heat exchanger used to heating low-temperature water system. Low temperature water system used in building.

2. Medium-temperature water (MTW) system:
   This hydronic heating system operates at temperature between 120 and 175°C with pressure not exceeding 1100 kpa.

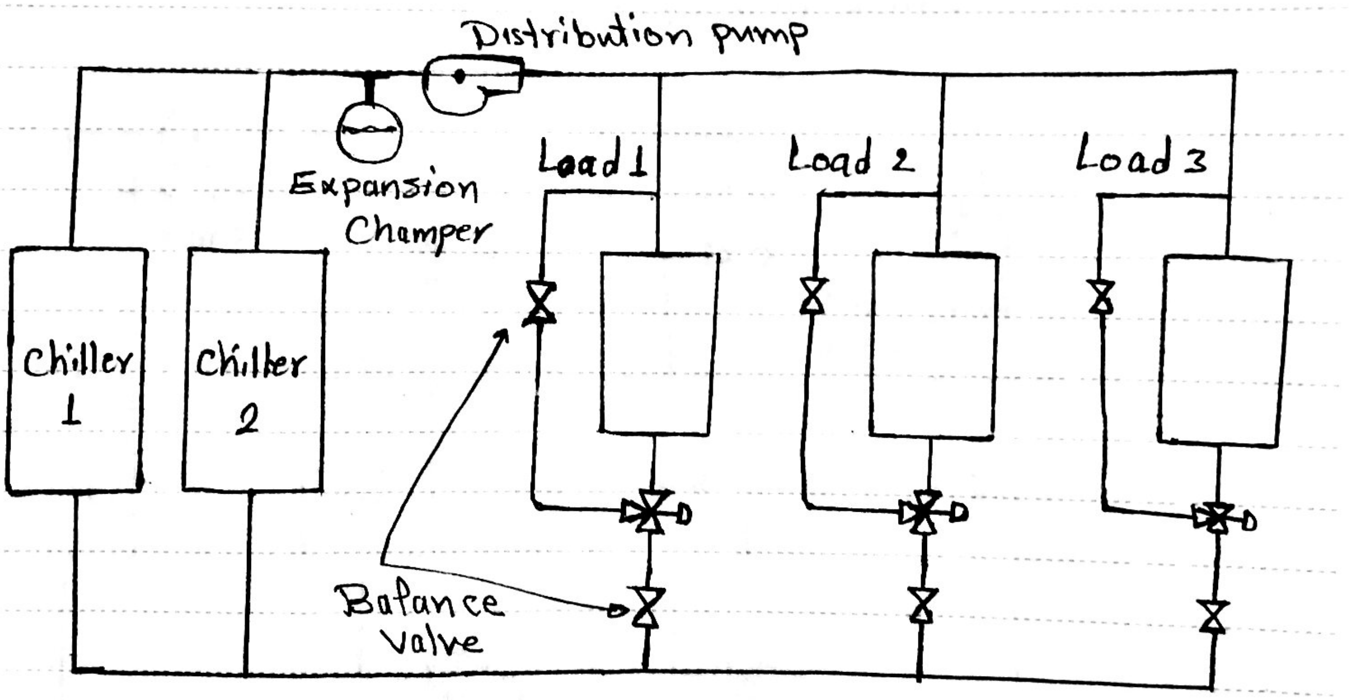
3. High temperature water (HTW) system-

   This hydronic heating system operates at pressure about 2 Mpa, The maximum supply water tempreature about to 200°C

4. Chilled water (CHW) system:

This hydronic cooling system normally operates with a design supply water temperature of 4 to 13 °C and at the pressure up to 830 kpa

Fig. shown the chilled water system for summer air conditioning application



The system consists of (two chiller) source station, distribution system (pump, pipe network), Load component (three Load) and control device (2-way valve, 3-way valve, Balance valve, expansion tank).

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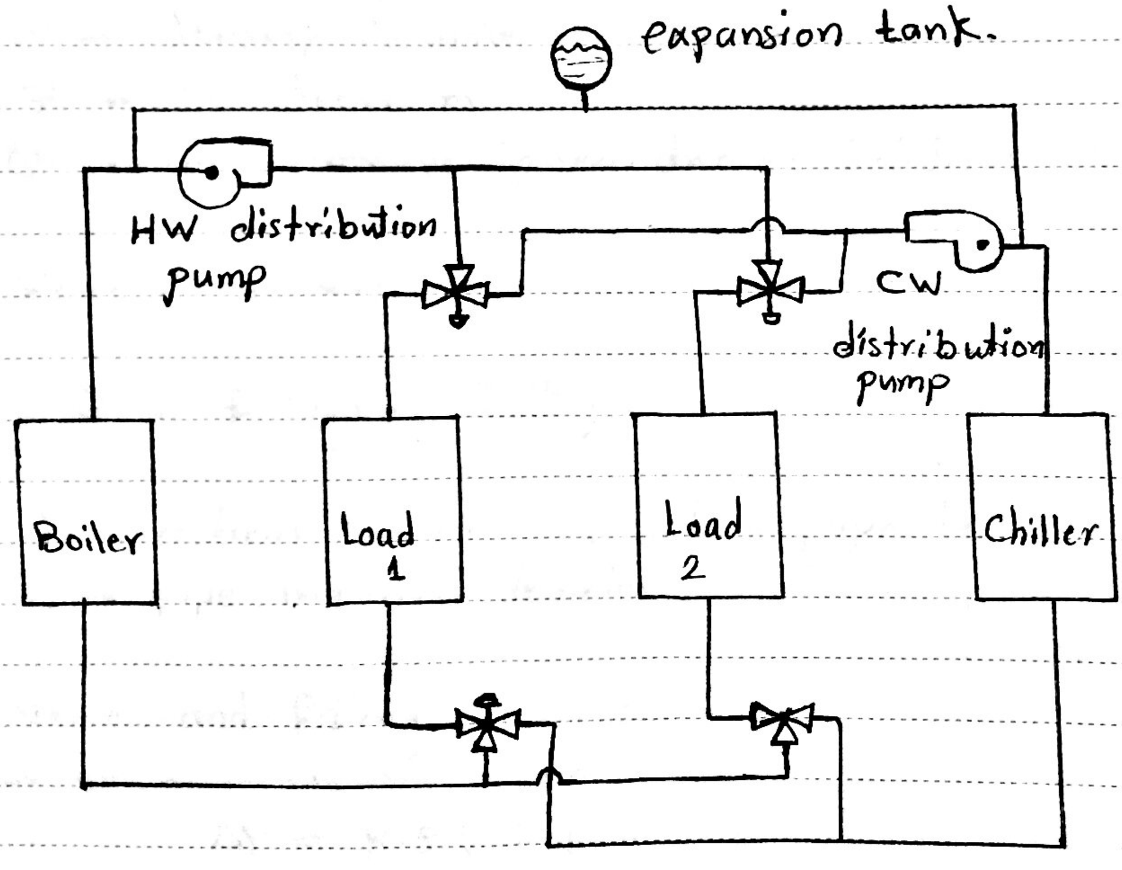
5. Dual- temperature water (DTW) system.

. This hydronic Combination heating and Cooling system Circulates hot and/or chilled water through pipe

- winter design supply water temperature of about 38 to 65 °C
- summer water temperature of 4 to 7 °C



The system consists of a water chiller and a boiler (two sources), distribution system (pumps and piping), Load component (two Loads), and control device (three-way valve, expansion tank).

* pressure drop.

• From Bernoulli's eqnation ,

$$\frac{\rho V_1^2}{2} + P_1 + \rho g Z_1 = \frac{\rho V_2^2}{2} + P_2 + \rho g Z_2 + \Delta P$$

V → avarage velocity m/s
P → absolute pressure pa (N/m^2)
ρ — density of water kg/m^3
Z → elevation m
ΔP → total pressure Losses due to friction pa.

• From Darcy equation

$$\Delta P = f \left(\frac{L}{D}\right) \cdot \left(\frac{\rho V^2}{2}\right).$$

f → friction factor , L → pipe Length m
D → pipe internal diameter.

• Valve and fitting losses.

$$\Delta P = K \cdot \rho \left(\frac{V^2}{2}\right).$$

K → factor depend on geometry - size

* range of pressure drop 100 pa/m — 400 pa/m

* Flow rate limitations.

water velocity based on type of service

Type of service	Velocity m/s
General service	1.2 to 3
City water	0.9 to 2.1
Boiler Feed	1.8 to 4.6
pump suction and drain lines	1.2 to 2.1

Velocity dependent noise in pipe system results from any or all of ~~four~~ Three sources -

- turbulence
- Cavitation
- water hummer

• Cavitation did not occurs in stright pipe.
• Cavitation did occurs in orifices of 1:8 area ratio at 1.5 m/s
• " " " " " " 1:4 " " " 3 m/s

* Water hummer:

for rigid pipe and instantanous closure valve.

$$\Delta P_h = \rho C_s V$$

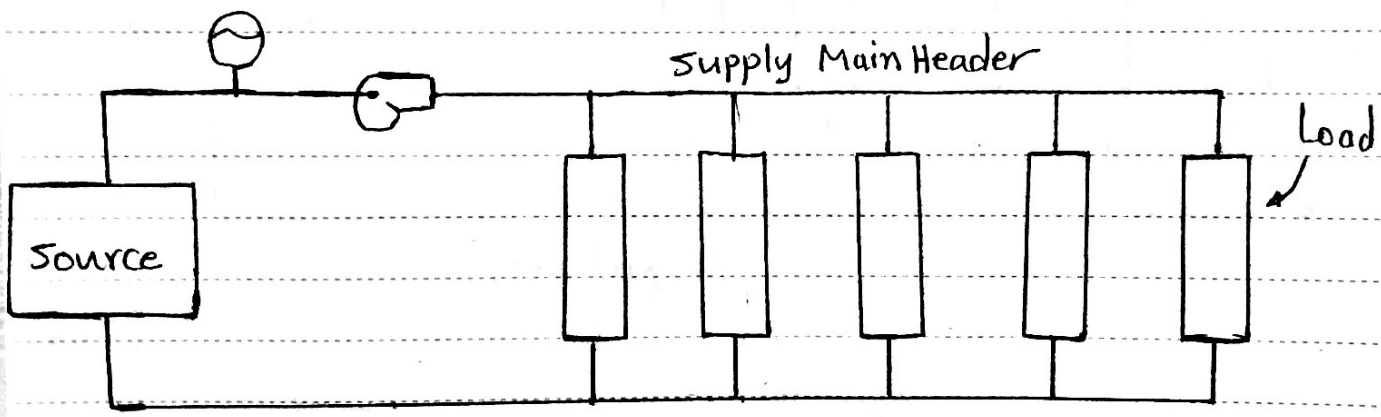
ΔP_h = pressure rise caused by water hammer Pa
C_s — velocity of sound in fluid 1439 m/s
V — Fluid flow velocity.

* pipe Layout.

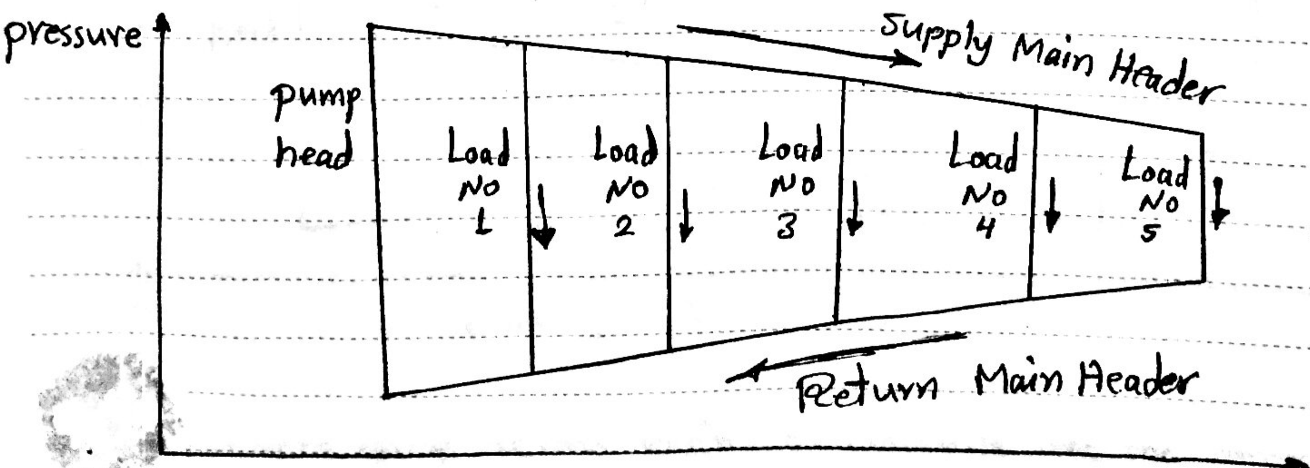
The two types of parallel piping networks are direct return and reverse return.

→ Direct return pipe system.

in the direct return system, the length of supply and return pipe through sub circuit is unequal.



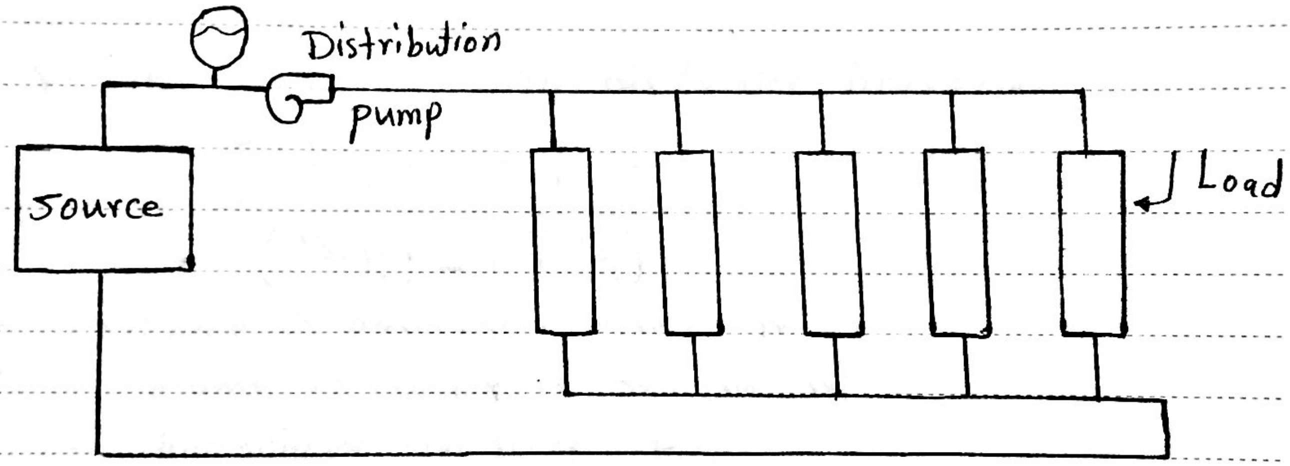
(a) pipe layout



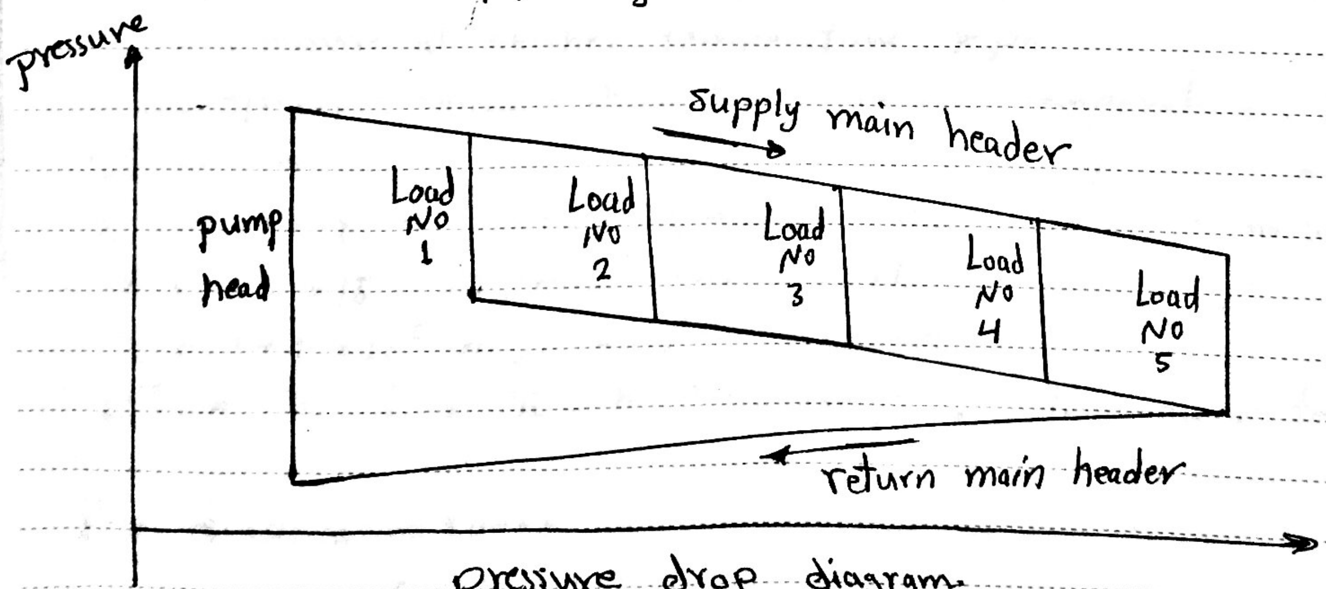
pressure drop diagram.

* The pressure drop in close sub circuits at higher values than those for the far subcircuits.
- Using control valve with a high pressure loss for close sub circuits

→ **The reverse return piping system.**



Pipe Layout



pressure drop diagram.

pressure drop across each sub circuits are the same.

* Expansion tank.

The make up water may be at a different temperature than the system water and subject to expansion or Contraction as it is heated or cooled

* size of expansion tank.

→ For closed tank with air/water interface-

$$V_T = V_s \frac{\left[\left(\frac{v_2}{v_1}\right)-1\right] - 3\alpha \Delta T}{(P_a/P_1) - (P_a/P_2)}$$

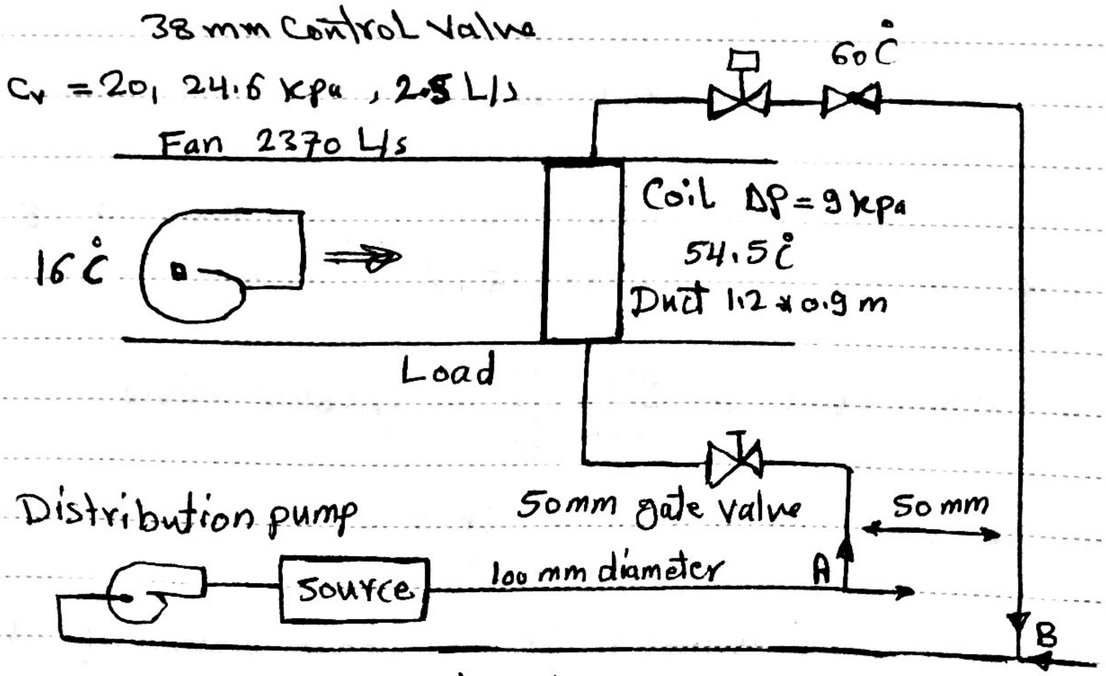
V_T — volume of expansion tank m^3
V_s — Volume of water in system m^3
P_a — atmosphere pressure kpa
P_1 — pressure at lower temperature kpa
P_2 — pressure at heigher temperature kpa
v_1 — specific volume of water at lower temperature m^3/kg
v_2 — " " " " " heigher " "
α — linear cofficient of thermal expansion $m^3/m.k$
$\alpha = 11.7 \times 10^{-6}$ $m^3/m.k$ for steel
$\alpha = 17.1 \times 10^{-6}$ $m^3/m.k$ for copper
$\Delta T = T_2 - T_1$, T_2 — heigher temp. , T_1 — lower temp

for diaphragm tanks

$$V_T = V_s \frac{\left[\left(\frac{v_2}{v_1}\right)-1\right] - 3\alpha \Delta T}{1 - (P_2/P_1)}$$

Ex: Determine the pipe sizing and total pressure drop for piping zone A-B of the system shown in Fig. The system consists of:

- 1 heating coil rated at 2.5 L/s and 9 kpa drop
- 1 gate valve - 50 mm screwed pipe.
- 1 control valve - 38 mm rated at 2.5 L/s at 24.6 kpa pressure drop
- 1 balance valve - 50 mm rated at 2.5 L/s at 6 kpa pressure drop
- 2 tees (branch flow)
- 4 elbows
- Total pipe length = 100 m. (screwed pipe).



pipe loop.

Solution.

1- Selecting the pipe for friction losses between 100 Pa/m to 400 Pa/m.

- select pipe material : commercial steel pipe " schedual 40
- From Fig 1 for 2.5 L/s → 50 mm pipe has a pressure drop 280 Pa/m.
- Checking 40 mm pipe a pressure drop 900 Pa/m
  65 mm " " " " 125 Pa/m

∴ select the pipe 50 mm.

2- pressure losses in 100 m pipe

$\Delta P = 100\ m * 280\ Pa/m = 28000\ Pa = 28\ kPa$

added 15% factor of safty

$\Delta P_{pipe} = 28 * 1.15 = 32.2\ kPa$

3- pressure drop in gate valve

From table 1 at 50 mm gate valve $K = 0.17$

$$\text{water velocity} = \frac{2.5 * 10^6}{\frac{\pi}{4}(50)^2} = 1273\ mm/s = 1.273\ m/s$$

$$\Delta P_{gate\ valve} = K \rho \frac{V^2}{2} = 0.17 * 1000 * \frac{(1.273)^2}{2} = 137.7\ Pa = 0.1377\ kPa$$

4- pressure drop in 90° Elbows

$$\Delta P_{Elbow} = 4\ elbows * K \rho \frac{V^2}{2}$$

From table 1, $K = 1$

$$\Delta P_{Elbow} = 4 * 1 * 1000 * \frac{(1.273)^2}{2} = 3241\ Pa = 3.241\ kPa$$