4/2/2015

Dr. Osama Ayadi

Air Conditioning (1)

H U AC

- H → Heating
- U → ventelation
- AC → Air conditioning

* Comfort Parameters:-

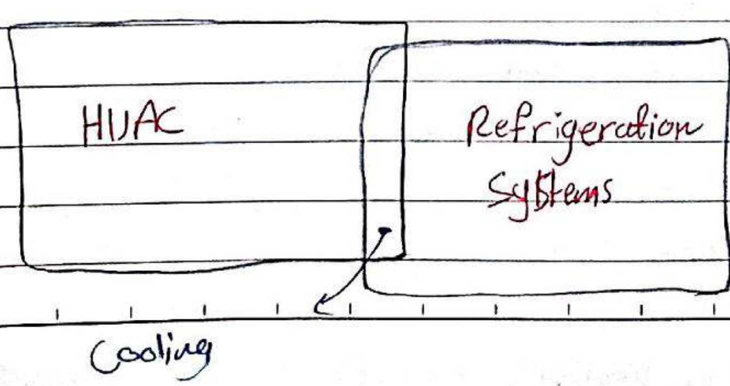
1- Temperature
2- Humidity
3- Distribution
4- Noise
5- Indoor Air Quality IAQ.

Q: What is the importance of studieing HUAC ??

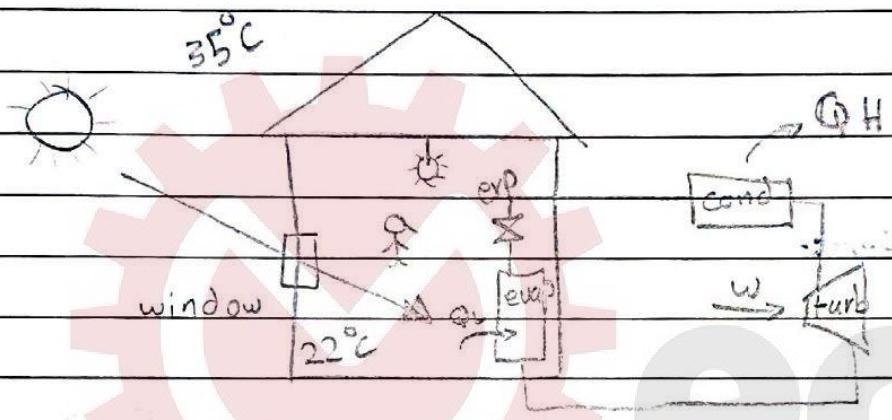
→ 1- Job
2- Comfort
3- system cost, Energy efficiency
4- Enviroment

} → Best Comfort for the least Cost

* Relation Between HUAC and Refrigeration System:-



* the Definition of Refrigeration is :- Cooling Below the Ambient Temp.



Air

Dry air   moist air

* HVAC course Discreption:-

CH 1+2 → Basics
CH 3 → Psychrometry
CH 4 → inside disign conditions, outside - - -
CH 5 → Heat transfer in Building
CH 6 → Heating load
CH 7 → water Heating System
CH 9 → Cooling load
CH 8 → under floor Heating.

* Adiabatic Mixing:-

ex:- Air Balance

$\dot{m}_{a3} = \dot{m}_{a1} + \dot{m}_{a2}$

$\frac{\dot{V}_{a1}}{v_1} + \frac{\dot{V}_{a2}}{v_2} = \dot{m}_{a3} = 60.53 + 22.497 = 83.02 \ kg/s$

Vapor Balance

$\dot{m}_{a1} w_1 + \dot{m}_{a2} w_2 = \dot{m}_{a3} w_3$ $w_3 = ??$

$w_3 = 0.0122$

$\frac{h_2 - h_1}{h_3 - h_1} = \frac{w_2 - w_3}{w_3 - w_1} \rightsquigarrow$ $h_3 = ??$

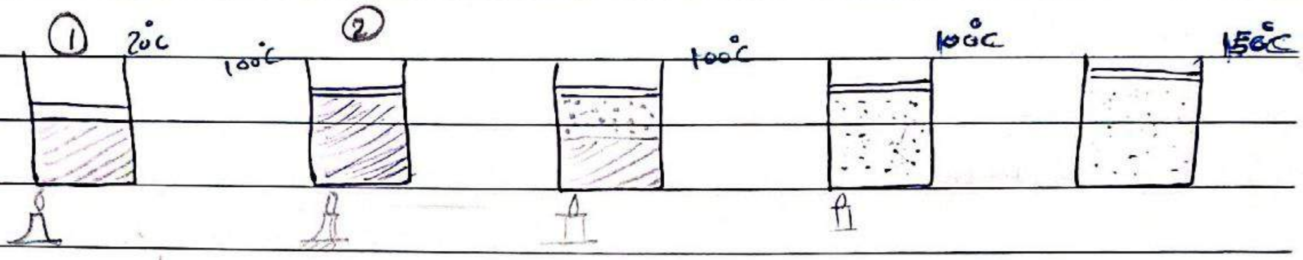
* ~~Energy~~ Balance:- $\frac{79 - h_3}{h_3 - 39.4} = \frac{60.5}{22.5} \rightarrow h_3 = 50.1 \ kJ/kg$

$h_3, w_3 \rightsquigarrow$ From psychrometric Chart

$T_{3db} \approx 19.0°C$

HD psy chart

* Sensible and latient Heat :-



(1) compressed leqiud (2) saturated liquid (3) saturated mixture (4) saturated vapor (5) superHeated

$\underbrace{\text{(2)} \quad \text{(3)} \quad \text{(4)}}_{\text{Phase change}}$

Phase change

* sensible Heat :- when we add energy to system → change in Temp. is noticed

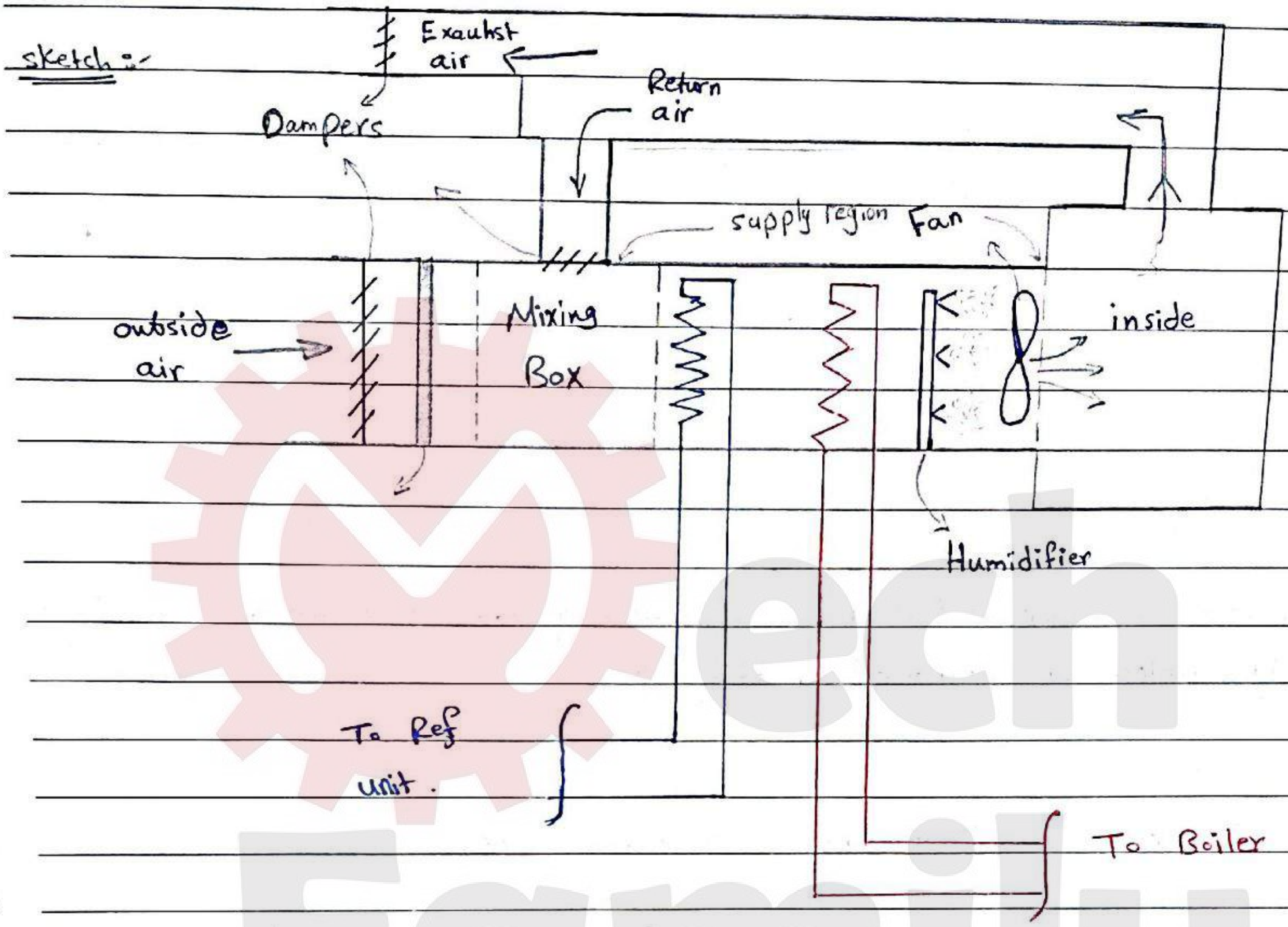
latient heat :- " " " " " " → No change in Temp is noticed , phase change Happens.

1 → 2	sensible Heating
2 → 3	latient "
3 → 4	"
4 → 5	sensible "

Hint :- See the Carrier HD psy chart Software for easy operation on psychrometric chart.

* Air Handling unit :-

sketch :-



example 3-13 :- ~~Retative~~ $\boxed{w_s = w_i}$ → heating load is sensible only.

$\dot{Q}_H = \dot{m}_s \, C_p \, (T_s - T_i) \Rightarrow 50 = \dot{m}_s \, (38-20) \rightarrow \dot{m}_s = 2.778$ kg/s

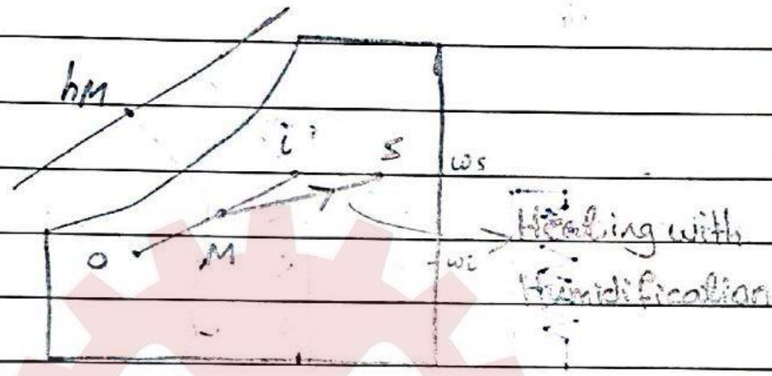
mass Balance → $\dot{m}_s = \dot{m}_R + \dot{m}_o \rightarrow \dot{m}_R = 2.778 - \underbrace{\left(\frac{3550}{3600}\right)}_{\text{from chart} = v_o} \rightarrow \dot{m}_R = 1.531 \ \frac{kg}{s}$

Energy Balance → $\dot{m}_o h_o + \dot{m}_R h_R = \dot{m}_s h_M \; ; \; \dot{m}_s = \dot{m}_M$

$h_M = 26.5 \ \frac{kJ}{kg}$; also $h_s = 56.8$ from chart

$$\dot{Q}_{HC} = (h_s - h_M)\,\dot{m}_s = 2.778\,(56.8 - 26.5) = 83.34\,kW$$

sketch :-



* Hint :- in Residential Buildings :- Heating load is considered sensible only ; unless we mentioned something else.

* if there is latient load, what to do ??

suppose :- $\dot{Q}_c = 70\,kw$, $\dot{Q}_s = 50\,kw$, $\dot{Q}_L = 20\,kw$, $T_s = 12°C$

① calculate $\dot{m}_s$ from $\dot{Q}_s = \dot{m}_s\,c_p\,(T_i - T_s)$ $\quad \dot{m}_s$ ✓

② calculate h_s from $\dot{Q}_L = \dot{m}_s\,(h_i - h_s)$ $\quad h_s$ ✓

③ everything is available now.

* Hint : if there is no fresh air ; Cooling // heating load equals the $\dot{Q}_{cc}$ // $\dot{Q}_{HC}$

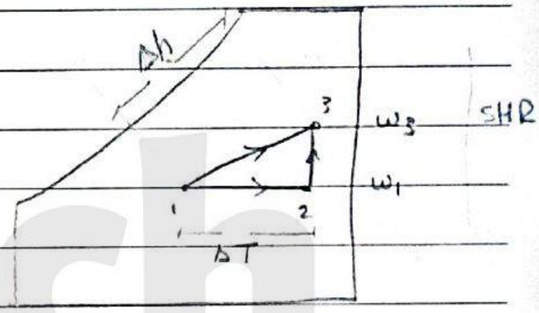
* Sensible Heat Ratio SHR :-

$$SHR = \frac{\dot{Q}_s}{\dot{Q}_t} = \frac{\dot{Q}_s}{\dot{Q}_s + \dot{Q}_L}$$

SHR = 1 → Heating only
SHR = 0 → Humidifing only

ex :- Suppose Heating with Humidification Process as shown :-

$$SHR = \frac{\Delta T}{\Delta h}$$



→ ΔT :- Diffusion Temp. defference

① $\Delta T = T_i - T_s$ for Summer Cooling

② $\Delta T = T_s - T_i$ for winter Heating

1-2 sensible load
2-3 latient load

$$\dot{m}_{air} \overset{1\ kJ/kg.°c}{c_{p_a}} (T_2 - T_1)$$

$$\dot{Q}_{H.C} = \dot{m}_w \overset{4.187}{c_{p_w}} (T_{ws} - T_{wr})$$

* لازم نعرف $\dot{m}_w$ من أجل أختيار المضخة المناسبة ، حيث نحتاج عاملين لأختيارها $\dot{m}_w$, head

head :- ΔP kPa ((m H_2O)) ; nedeed to know how much Power needed to resist friction in pipes

* For cooling load ; $T_s = 7°C$, $T_R = 12°C$

* Relation to find pipe size of cooling, Heating load if they are equal $\dot{Q}_H = \dot{Q}_C$

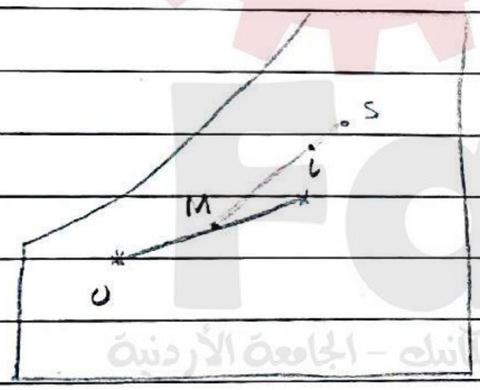
$$\cancel{\dot{Q}_{H.C}}^{50} = \dot{m}_{w_{H.C}} \cancel{cp_w} (\cancel{85-75})^{10}$$

$$\cancel{\dot{Q}_{C.C}}^{50} = \dot{m}_{w_{CC}} \cancel{cp_w} (\cancel{12-7})^{5} \rightarrow \frac{\dot{m}_{CW}}{\dot{m}_{HW}} = \frac{10}{5}$$

$$\boxed{2\dot{m}_{HW} = \dot{m}_{CW}}$$ → Double pipe size

example :- 3-17

→ sketch :-



* Allignment point :- 24°C Tdb
50% ϕ

→ Draw vertical line from it to SHR Scale → $\boxed{SHR = 1}$ there

* How To use it in our solutions ??

1. locate The Allignment point and calculate the SHR
2. Draw a line Between Allign' point and the SHR value on SHR scale
3. Draw a Parallel line To the above line ↑ Passing $\boxed{i}$ point
4. The supply point will Be any point on the last line.
5. if we have any information about Supply, then we can locate it place preciesly

مع أي نقطة على هذا الخط الموازي تحقق شروط التصميم ولكن عندنا معلومة تحدد المكان بالزبط وين فأستخدم

* also we need to select The air handling unit

→ We need 1 information Volume flow Rate $\dot{V}$

* Effects on calculating Heating // ~~cooling~~ loads :- "winter"

1) Exposed Surfaces
2) infiltration :- Cracks , Door opening
3) Domestic Heat water

$$\dot{Q} = \underline{U}\ A\ \Delta T$$

overall heat transfer
coeff" $W/m^2.K$
CH5

* First Step in Designing an HVAC system is :- Define the inside // outside Conditions

* A Different use for the room "space" Means a Different method and calculation Steps :- such as Schools, Mosques, Server room, Gym ---
; we must also know what Material it's made from

* CHAPTER 4 *

Human Comfort

* We focus on inside design Conditions to achieve the required Comfort needed
  → Table 4-4 , 4-5

* The outside Design Conditions is also important to know
  → Table 4-8 , Table A-7 for more info

* 97 ½ % : الموجودة بالجدول 4-8 معناها أنه درجة الحرارة بالخارج بتكون أعلى من اللي حصلت عليها % 97.5 من الوقت خلال الشتاء ((T_c))

* 2 ½ % : معناها أنه درجة الحرارة بالخارج بتكون أعلى من اللي حصلت عليها % 2.5 من الوقت خلال الصيف ((T_H))

* In New ashrae Codes :-

  instead of 97.5% we have 99.0% , 99.6% Depends on the application

  instead of 2.5% we have 0.4, 1, 2 % " "

* Wind Chill Tempreture :-

* Metabolism :-

→ Converting the Chemical Energy in food to Mechanical Energy expressed as movement or activity ; or Thermal energy

* The Rate of Heat produced by the Body through metabolism

1 met = 58.6 w

→ See Table 4-2.

* Heat is Removed from person By Two ways

sensible: rad, conv, cond ; time delayed transfer

latient: skin moist ; direct transfer

for 60 person :-

$$\dot{Q}_{occupants} = n \times (\dot{q}_{latient} + f\ \dot{q}_{sensible})$$

Cooling load Factor "CLF" → Table 4-3.

* if the number of persons is too large → CLF = 1

* The equation is valid only for 24 Hours operation "Full day"

11/3/2015

* in Cities like Aqaba ; The outside air temp ≈ 45°C at Summer ; So we need to heat the Refrigerant to 50°C at least to reject the heat ⇝ That's quite Hard ;.

* The Solution is the Sea ; No need to Air cooled condenser

⇝ instead; we put a heat exchanger Between the Refrigerant and the Sea water

* Notice That the Sea Water Temp is 15–16 average

⇝ That's excellent for Cooling !!

Table 4-6 ⇝ The ventilation Table

* indicates the required fresh air needed to put in the room so we make Sure that the room is ventilated well !

* it differs from a room to another (class room, kitchen, W.C ...)

* Ventilation Air Rate Requirements :-

Two ways → L/s /person ; → L/s/m² → if two values exists; use them Both !!

Example:- Classroom, 50 studients, outside air at 5°C and 50% ϕ, ΔT Between supply and Room = 20°C, $\dot{Q}_H$ = 50 kW, Supply Conditions 40°C, 50% ϕ, find fresh air needed for ventilation, Return air needed ??

Solution:- $Q_{H,sen} = 50\ kW = \dot{m}_s C_p \Delta T \rightarrow \dot{m}_s = \frac{\dot{Q}}{c_p \Delta T} = \frac{50}{20}$

$= 2.5\ kg/s$

from chart

Now $\dot{V} = \dot{m} v = 2.5 * 0.92 = 2.3\ m^3/s = 2300\ L/s$

From Table 4-6 → 50 studients, classroom → $\dot{V}_f = 50 * 8$ L/s/person

$= 400\ L/s$

$\dot{m}_f = \frac{\dot{V}_f}{v_f} = \frac{400}{0.79} = 0.56\ kg/s$ Ans.

(0.79 from chart)

→ Mass Balance on Mix Box :-

$\dot{m}_f + \dot{m}_R = \dot{m}_s \quad 0.56 + \dot{m}_R = 2.3$

$\dot{m}_R = 1.74\ kg/s$ ans.

* Table 4-6 (b) is for Residintial Building

* ACH :- Air change Per hour "N"

$\dot{V} = \frac{N * \dot{V} * 1000}{3600} = \text{—}\ L/s$ if $\dot{V}$ < the Value from table 4-6 (a)

→ we take →

Five Apple

* For the fan Selection :- we use ((cfm)) as unit.

cfm :- cubic feet per ~~meter~~ minute

$$\boxed{1 \text{ cfm} = 0.48 \text{ L/s}}$$

Ex:- W.C ; find required fan for ventilation ??

→ Table 4.6 → $\dot{V} = 10$ L/s/person

1 cfm → 0.48 L/s

x cfm → 10 L/s → $x = \frac{10}{0.48} = 21$ cfm

CHAPTER 5:- Heat Transfer in Residential Buildings

* Heat Transfer occurs in 3 ways:-

  1. conduction
  2. convection
  3. radiation

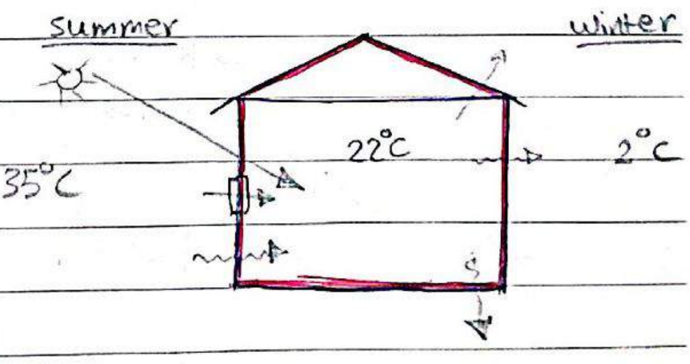
* Convection Depends on 3 parameters:-
  1. Convection heat transfer ~~Convection~~ Coefficient
  2. Area of action
  3. Temperature difference Between wall and fluid

* Radiation Depends on:-
  1. Temperature of the Body
  2. Area of action
  3. Emmissivity of the Body " surface Property "

* Building Envelope :- Insulating the whole Building

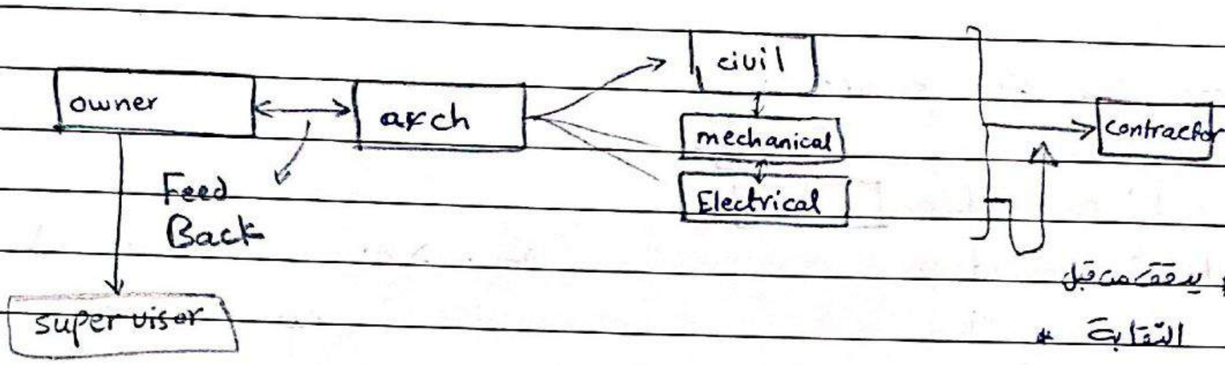
$$\dot{Q} = U\,A\,(\Delta T)$$

$\dot{Q}$ → W, U → $\frac{W}{m^2 \cdot K}$, A → m^2, ΔT → K



* We Interests in low Value of U in Summer and Winter

* Flow chart for Constraction process :-



* يدقق من قبل
* النقابة
* البلدية

* التنفيذ

يعرض على أستشاري ثم على شركة المقاولات

* لازم يحتوي العقد على ما يلي :-

① Plans → inside// outside cond. و U_{tot} :- اول صفحة

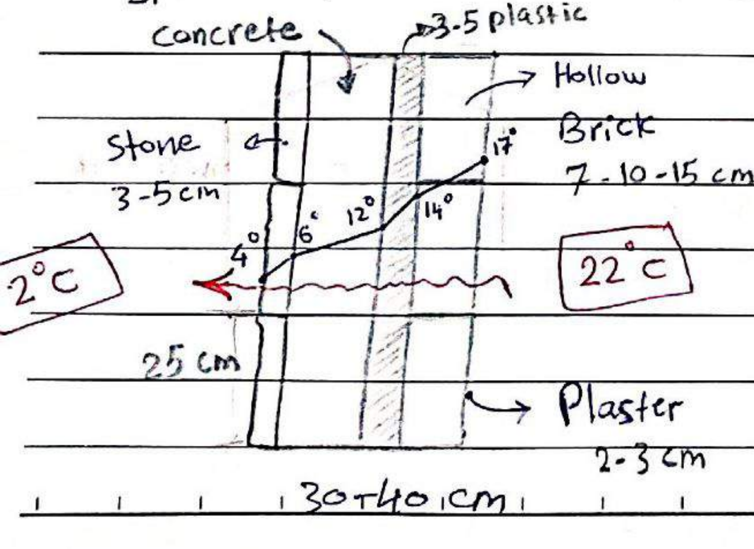
② specifications

③ BoQ حساب الكميات Bill of Quantity

* supervisor :- يتابع العمل وسيره وعلاقته مع المالك

$$U_{Building} = \frac{\sum U_{segment} * A_{segment}}{\sum A} < 1 \quad \text{for good insulation}$$

* Typical External wall :-

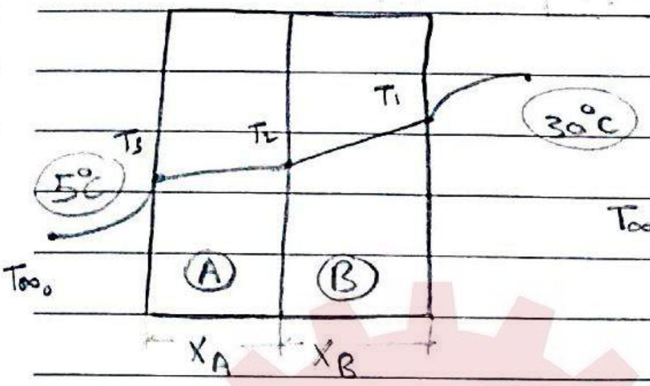


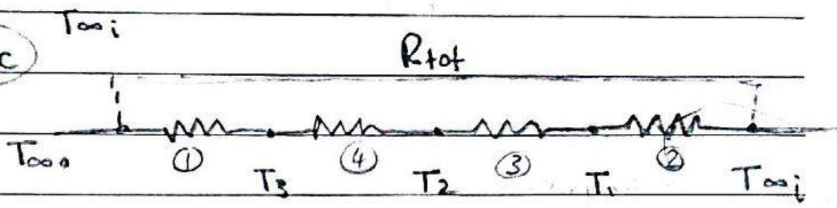
* Composite wall.

* Typical internal wall contains Brick 20cm with Plaster on two sides

* it has U_{int} Bigger than U_{ext}

* heat calculations for Composite wall :-





①,② Convection

③④ conduction

⟶ Assume $\boxed{A = 1\ m^2}$

* Conduction Resistance :- $R = f(L, k)$

$$R_{cond} = \Sigma \left(\frac{L}{k}\right)$$

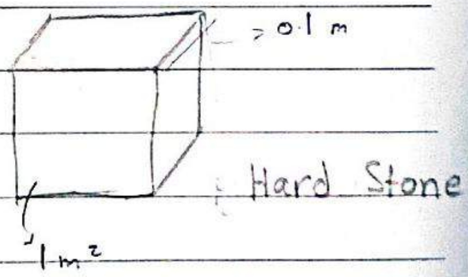
* Convection Resistance :- $R_{conv} = f(h)$ $R_{conv} = \Sigma \frac{1}{h}$

$R_{tot} = R_{cond} + R_{conv}$ ⟶ $U_{tot} = \frac{1}{R_{tot}}$

* U value Calculation

Ex :- $R_{cond} = \frac{\Delta x}{KA}$

$= \frac{0.1}{1 * (2.2)} = 0.045$

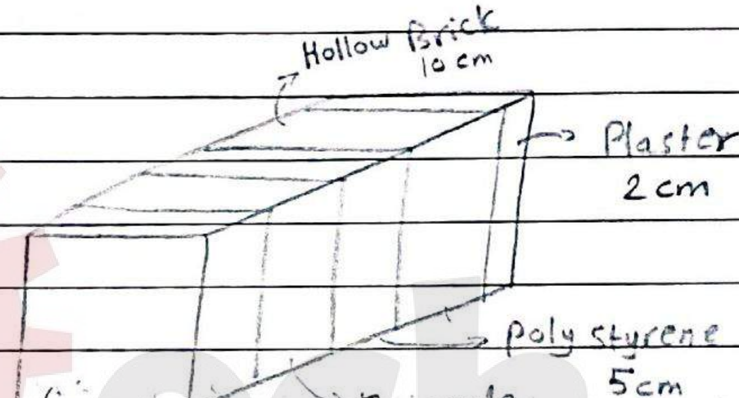


K :- obtained from $\boxed{\text{Table } 5-1}$

Ex:- if we added 5 cm of polystyrene Boards on the Hard Stone.

$$R_{cond_{poly}} = \frac{0.1}{0.03} = 1.67$$ 37 times the Stone

Ex:- Composite wall.



$$R_{cond} = \sum \frac{\Delta x}{kA}$$

$$R_{cond} = \left(\frac{0.05}{2.2} + \frac{0.1}{0.72} + \frac{0.05}{0.03} + \frac{0.1}{0.45} + \frac{0.02}{1.2} \right)$$

$$R_{cond} = 1.87$$

$$R_{tot} = \underbrace{R_i}_{\text{Table 5-2}} + \overbrace{\frac{\sum \Delta x}{k}}^{\text{Table 5-1}} + \underbrace{R_o}_{\text{Table 5-3}}$$

$$\rightarrow R_{tot} = 0.1 + 1.87 + 0.06 = 2.05$$

$$U = \frac{1}{R_{tot}} = \frac{1}{2.05} = 0.5 \ \frac{W}{m^2.K}$$

* Assuming :-

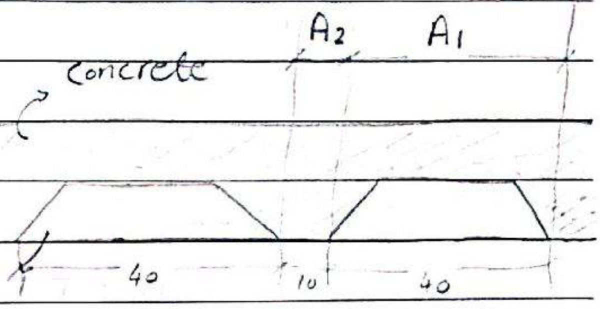
① On March, wind speed = 3 m/s $\rightarrow$ Table 5-3 $\rightarrow R_o = 0.06$

② we used the Construction Material Not Metals

$\rightarrow$ Table 5-2 $\rightarrow R_i = 0.1$

23/3/2015

* Composite Ceiling :-



U value for the ceiling :-

$$U_{avg} = \frac{U_1 A_1 + U_2 A}{\Sigma A}$$

$A_1 = \frac{40}{50} = 80\ \%$ $A_2 = \frac{10}{50} = 20\%$

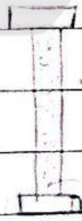
$\rightarrow \dot{Q} = U_{avg}\, A_{tot}\, (\Delta T) = (U_1 A_1 + U_2 A_2)(T_i - T_o)$

* Windows : Main use :- ① Day light ② ventilation

→ Thermal Conductivity for glass is too high $U_{glass} = 5.6\ \frac{W}{m^2 K}$

* Too much loss !!!

→ We can use Double-glazed glass



$U_{Double} = 3.2$ Massive Saving

→ See Table 5-4.

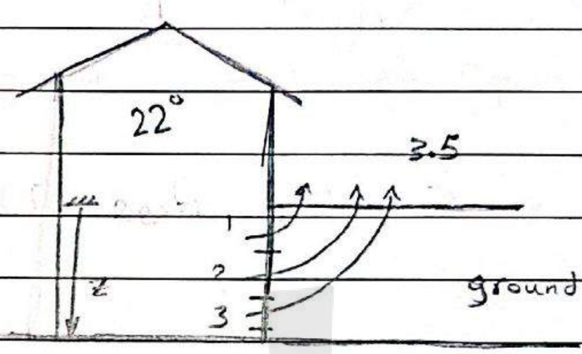
* Below grade walls :- حيطان التسوية

→ No Convection at the outside surface. $h_o = 0$

at Summer $T_g < T_{out}$ T_g → table A-7

at Winter $T_g > T_{out}$

* We take Sections 30 cm long each.



* → Table 5-8

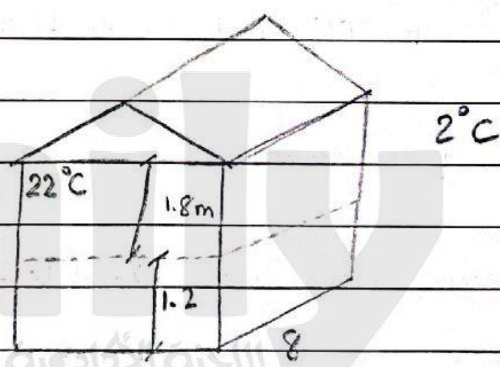
→ interpolation Can Be used

$U = f(Z, R)$

Ex:- Amman Q.A airport.

· insulation is polyster

thickness = 2cm

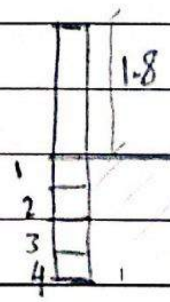


$\dot{Q}$ loss from ① wall below grade

② floor below grade.

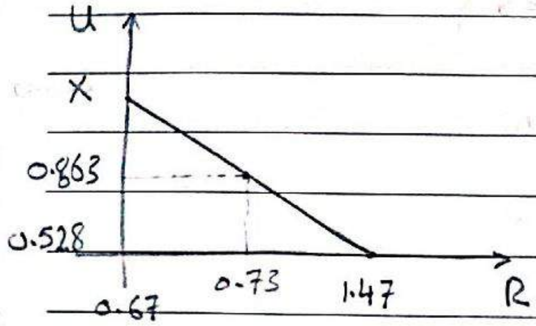
solution :- $\boxed{1}$ insulation → $R = \frac{x}{k} = \frac{0.02}{0.03} = 0.67$

$T_g = 10°c$ Table A-7 at January ((worst case))



Refering to Table 5-8 interpolation needed !!

* Extrapolation !!



	R	R	R
Z	0.67	0.73	1.47
0-0.3	X	0.863	0.528
0.3-0.6	y	0.558	0.449
0.6-0.9	Z	0.534	0.386
0.9-1.2	w	0.449	0.341

$$\frac{1.47-0.73}{1.47-0.67} = \frac{0.863-0.528}{X-0.528} \rightarrow \boxed{X = 0.89}$$

* if we take the value of R to Be approximated as 0.863.

$$\text{The error} = \frac{0.89-0.863}{0.863} = 3.2\ \%$$

→ Same For y, Z, w → But here we will take the R = 0.73 values roughly.

$U_1 = \cancel{0.324}\ 0.89 \rightarrow \dot{Q}_1 = 0.89\ (0.3 * 28) * (22-10)$
$= 89.7\ kw$

$\dot{Q}_2 = 0.558\ (0.3 * 28)\ (22-10) = 66.4\ kw$

$\sum U = 228\ kW$

$\dot{Q}_3 = 0.534\ (0.3 * 28)\ (22-10) = 53\ kw$

$\dot{Q}_4 = - - - - - = 45\ kw$

[12] Table 5-9 $\rightsquigarrow$ Depth = 1.2 m
Narrowest width = 6 } $\rightarrow$ $U = 0.198$

$$\dot{Q}_{floor} = (0.198)(6*8)(12) = 114 \text{ W}$$

* See Example 5-3

* Inside wall Surface Temp.

$$\dot{Q} = U A (T_i - T_o) = h_i A (T_i - T_w)$$

Now :- $$\frac{\dot{Q}}{A} = \dot{q} = U (T_i - T_o) = h_i (T_i - T_w)$$

For The previous example :- $T_i = 22°C$ $T_o = 2°C$

For a wall with Construction like Case 3 in table 5-6
$\rightarrow U = 1.7$

$h_i = \frac{1}{R_i}$ R_i :- Table 5-2 $= 0.12$

$$1.7 (22-2) = \frac{1}{0.12} (22 - T_w) \rightsquigarrow \boxed{T_w = 17.9°C}$$

Ex :- Window, single glaze, $T_i = 22°C$; $T_o = 2°C$ $\phi = 60\%$

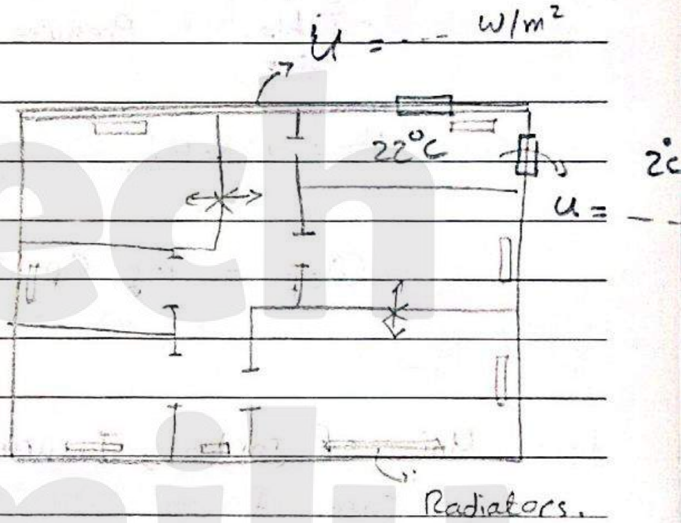
$$T_w = -\frac{5.6 (22-2)}{1/0.12} + 22 = 8.5°C$$

T dew point $\simeq 14.9°$ $\rightsquigarrow$ there will Be condensation !!

* CHAPTER 6 *

Heating Load

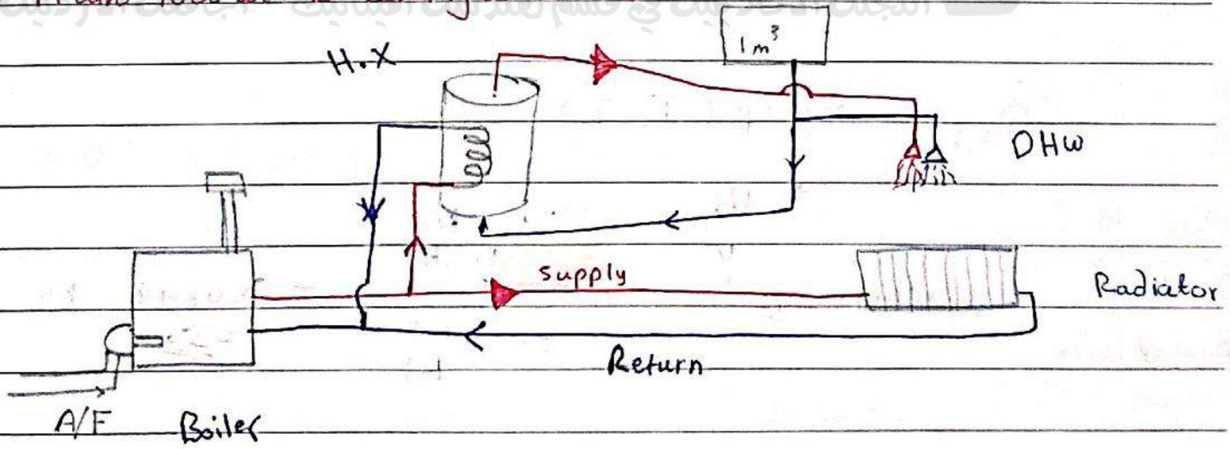
* Main Interests :-
  1. Building Envelope
  2. infiltrations
  3. Domestic Heat water "DHW"



* Procedure :-

1. Room By Room analysis
2. Boiler Sizing

* The Main Network Configuration :-



* Infiltrations :- Leakage of the outside Air through cracks and clearances and Door opening

* Two methods to calculate $\dot{\forall}$ infiltration

① Air change method :- complete change of space each hour.
② Crackage method

Tables — Pressure difference

① $\dot{\forall}_f = N * \forall_{Room}$ N :- Table 6.1

$\dot{Q}_{s,f} = \dot{m}_f \, C_p (T_i - T_o)$

Ex :- Uni. of Jordan, January $T_i = 22°C$ $\forall = 3*8*10 \ m^3$

Case I

Table 6.1

solution :- $\dot{\forall}_f = N * \forall_{Room} = 1 * 240 = 240 \ \frac{m^3}{h}$

$\dot{Q}_{s,f} = \dot{m}_f \, C_p (T_i - T_o)$

Table A-9

$T_o = 24°C$

$\phi = 75\%$

psychrometric

$\frac{\dot{\forall}_f}{v} = \frac{240 \ \frac{m^3}{h} \cdot \frac{1}{3600 \ \frac{s}{h}}}{0.785 \ \frac{m^3}{kg}} = 0.0849 \ \frac{kg}{s}$

$\Rightarrow \dot{Q}_{s,f} = 0.0849 * 1 * 20 = 1.69 \ kw$

2 Crackage Method :-

① Tables :- Table 6.2

~~$\dot{Q}_{s,f} = \frac{\rho}{3600}(N * V_s)\, C_p\, (T_i - T_o)$~~

Ex:- Double Hung Metal Sash frame window

$l_c = 8\,m$, $U_w = 3\,m/s \rightarrow 10.8\,\frac{km}{h}$

solution:-

$\Rightarrow 4.7\ \frac{m^3}{h \cdot \cancel{m_{l_c}}} \cdot 8\ \cancel{m_{l_c}} = 37.6\ m^3/h$

$\dot{Q}_{s,f} = \frac{\left(\frac{37.6}{3600}\right)}{0.785} * 1 * 20 = 0.266\ kw$

② Pressure Difference :-

$\dot{V}_f = K\, L_c\, (\Delta P)^{2/3}$ K :- Table 6-3

$L_c \rightarrow m$, $\Delta P \rightarrow P_a$

$\Delta P = 0.613\,(S_1\, S_2\, U_w)^2$, $U_w \rightarrow m/s$

S_1 :- Table 6.4

S_2 :- Table 6.5

* DHW Load :-

$$\dot{Q}_{HW} = M_{HW}\, C_p\, (T_h - T_c)$$

* $\dot{Q}_{HW}$:- hot water load in units of kJ / day
* M_{HW} :- The Constant Daily consumption of Domestic hot water.

→ For a known number family members, a daily Consumption of : ① 50 - 75 liter per day for each of the first Two Members and ② 30 - 50 L/day " " additional person in the family

Ex :- Family of 4 persons :- $T_{in_c} = 15°C$ $T_h = 60°C$

$$M_{HW} = (50-75)*2 + (30-50)*2 = \begin{matrix} 160 & L/day & \text{min} \\ 250 & L/day & \text{max} \end{matrix}$$

The Storage Tank needed for this family is 250 L

* the Time Needed to heat the 250 L is 1 hour "Standard"

* to Decrease the time :- the Energy Remains constant → The Power is increased

$$\dot{Q}_{HW} = \frac{250}{60*60}\, 4.18\,(60-15) = 13.0625 \text{ kW}$$

Five Apple

Scanned by CamScanner

* Note :- Section 6-5 from Book

هادا السكشن هو تلخيص لأجراءات حساب الـ Heating load لمبنى معين

وهو يتبع طريقة Room By Room analysis

* مهم جداً نطلع عليه

* CHAPTER 7 *

Hot water Heating system

* We Can Categorize it By

1. fuel
2. Capacity
3. Medium (HTF)
4. cenralized - Decentralized

* Temperature Ranges :-

1. low Temp $< 100°C$
2. Medium Temp $100-150\ °C$
3. High Temp $> 150°\ C$

* the low Temp. Range has an atmospheric pressure inside it By using open type expansion tank, else; we use pressurized - closed system for $T_h > 100°$

* Main Components :-

1. Heating Element :- Radiator, fan coil unit, - - - - .
2. Fittings :- Valves, elbows, Tee's, - - - - .
3. Pumps + pipes.
4. Boiler, Burner, chimney, fuel tank, expansion Tank, - - - .
5. DHW Storage tank.
6. Control.
7. Heat Exchangers.
8. Safety System.

* Pipe Systems arrangements :-

① Single-Pipe System arrangement

→ The hot water passes all Radiators in ~~[illegible]~~ serial Manner ie :- hot water exit from Radiator → Enters in the next Radiator

- advantages :- Saving the pipe lengths and the installation Cost.

- Dis advantages :- Need to install Bigger sizes of Radiators as the Distance from the Boiler increase

SEE figure 7-1

② Double-pipe system arrangement :-

→ Seperated supply pipe network and a seperated return network

- advantage :- the Temp. of water entering each Radiator is almost Equal, Small Temp difference Between them is due to losses in pipes

- Dis advantage :- Double pipe length needed.

→ it has two main Types :-

① Direct Return pipe size :- Pressure Drop in each Radiator is Different due to distance to the Boiler ; Balancing values are required for this system.

② Reversed-Return pipe system :-

→ same Distance from Boiler, called self-Balanced system.

But Requires the longest pipe Length.

SEE figure 7-2, 7-3

③ Three pipes system :- Mainly used for Double use Radiators.

Heating + Chilling

④ Four Pipe system :- all of the above uses Black steel pipes.

⑤ Radial-pipe system :- uses thermoplastic pipes

see figure 7-10

7.4 :- Types of pipes ; Read from Book.

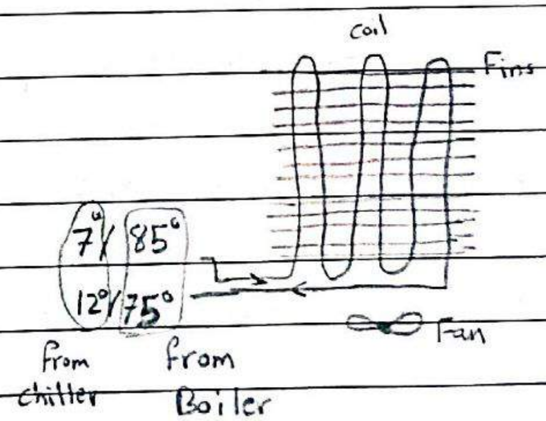
* Fan coil unit :- F.C.U

h is too low

→ we force the transfer

By a Fan

1-30 kW load.



* Main difference from A.H.U :- AHU for large central sys
FCU → small systems.

* شكلياً : لا يمكن التفريق بين F.CU وال split unit . نفس الشكل من الخارج ونفس عدد المداخل.

* F.CU : يمكن أستخدامها لـ large systems with small area's مثل الفنادق

-- فائدة هذا الحكي -- Better Control

* انواع split unit :- (1) wall mounted (2) ceiling Mounted
(3) ground mounted

* DX unit :- the fain coil هو نفسه الـ evaporator لل Ref. cycle.

* في نظام 2 pipe :- المشكلة أنو لازم نصمم الأنبوب المشترك على chiller load
لأنه ΔT أقل فبنحتاج $\dot{m}$ أكبر فبنغير الحجم.

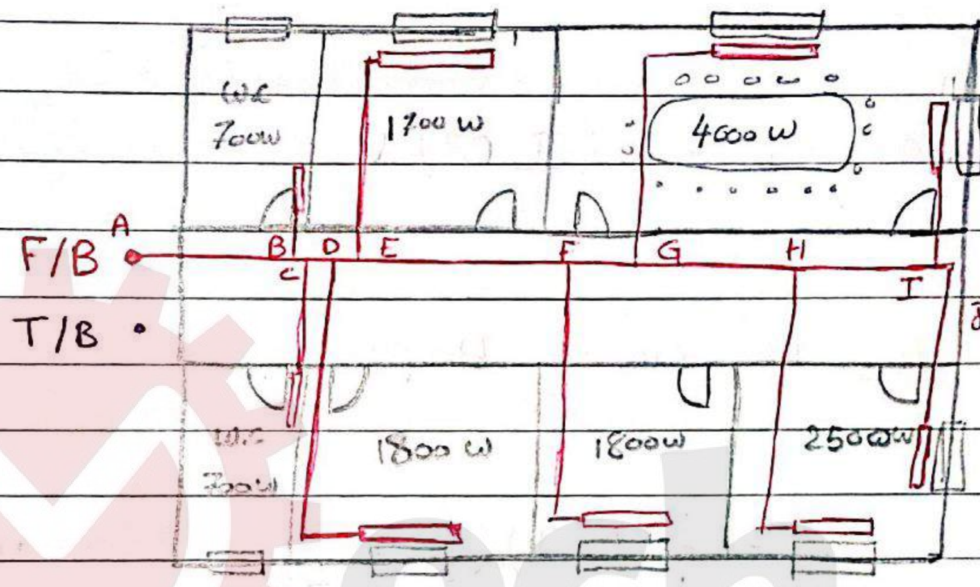
* الحل :- ____ لـ 4-pipe system مع coils منفصلات

* $$\text{Temperature lift} = T_H - T_L$$

* لما بدنا نعمل Zoning بنحط pumps على الـ supply

13/4/2015

Ex8:



→ $\dot{m}$ for the whole floor $Q = \dot{m} C_p \Delta T_w$ → Standard 10°C

$12\ kW = \dot{m} * 4.18 * 10\ k$ $\dot{m} = 0.286\ kg/s$

→ $\dot{m}$ for Meeting Room only:-

$4 = \dot{m}\ 4.18 * 10$ $\dot{m} = 0.107\ kg/s$

Pipe	flow	Ø
AB	0.286	
GH	0.107	

* Choosing The pump depends on the η curve for the pump

* The Required Diameter for the flow Can Be optimized By :-

$$\dot{m} = \rho\left(\frac{\pi}{4} D^4\right) V$$

* Finding The pressure Drop :-

$$\Delta P = \underbrace{f}_{\text{friction factor}} (L/d)(\rho V^2/2)$$

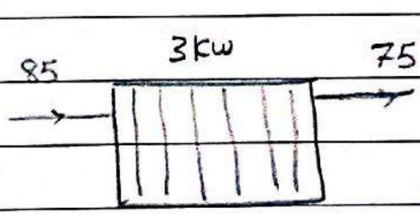
Velocity Range
0.6 – 1.2 m/s
⇒ for pipe up to ⌀ 50 mm

* Pressure head loss

$$\Delta h = f\,(L/D)\,(\rho V^2/2g)$$

* Figure 7-11 Show's a relation Between ΔP, $\dot{V}$, V
⇒ more practical.

Ex:-



Steel pipe

① $\dot{m} = \frac{\dot{Q}}{C_P \Delta T} = \frac{3}{41.8} = 0.07$ kg/s

② $\dot{V} = \frac{\dot{m}}{\rho} = 0.07$ L/s

③ $V = 1$ m/s → $\Delta P =$

a. $\Delta P = 200 - 450 \ Pa/m$ Restriction !!

from Figure 7-11 the Nearest Pipe Diameter for a(ΔP) Range 200 - 450 → 15 mm is the nearest

b. → $\Delta P = 200 \ Pa/m$

$D = 15 \ mm$

$V = 0.4 \ m/s$

→ $\dot{m} = 0.07 = \dot{V}$

$\Delta P = (200 - 450) \ Pa/m$

→ Fig 7-11 →

$$\Delta P = \left(\frac{\Delta P}{m}\right) * L$$

→ For fittings :- we call it Equivelant Length

→ ~~[illegible]~~

* Table 7-4 indecates The Pressure Drop for Fittings in units of equivelant length of Straight line

* The Total Pressure Drop for the cycle

$$= \left(\frac{\Delta P}{m}\right) * \text{Total length}$$

Total length → = Length of straight lines + Σ equivelant lengths for fittings.

$\left(\frac{\Delta P}{m}\right)$ → Figure 7-11

* in Circulating Pump :- we Care about the Full length No Care for the hieghts!

* Pump Performance curve :- "Charactarestic curve"