DAIKIN

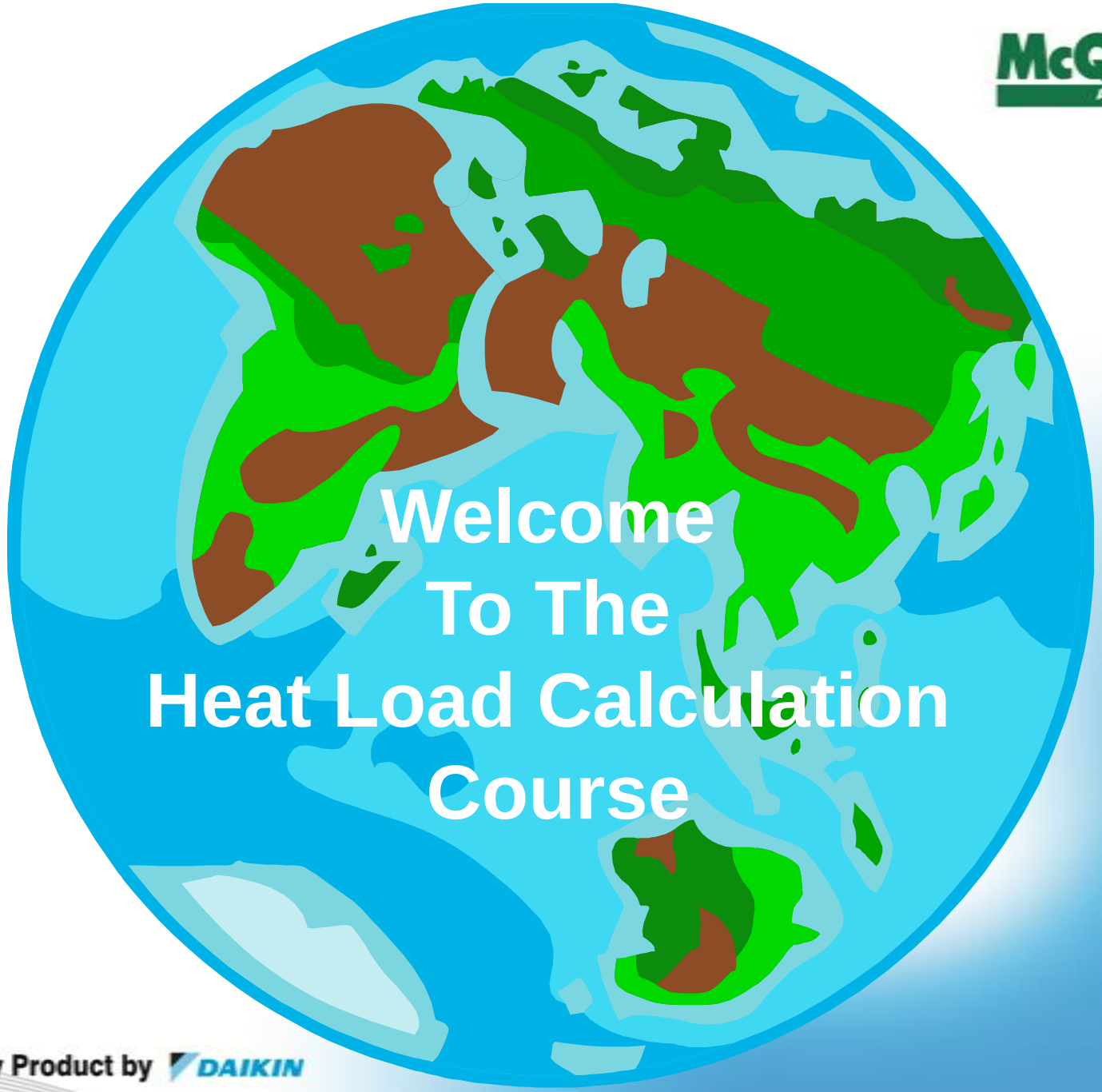
PT. DAIKIN APPLIED SOLUTIONS INDONESIA

(Formerly PT. Tatasolusi Pratama)

Understanding "Heat Load & Psychometric“

by Djunaidi HS

McQuay Air Conditioning



Welcome To The Heat Load Calculation Course

What is the heat load? ⇒ It refers to the cooling and heating loads.

What is the heat load calculation? ⇒ It is the calculation of the cooling and heating loads.

Usually software is used to do the calculations.

The calculation results are used to determine the capacity of air conditioners.

Understanding Of Heat Load

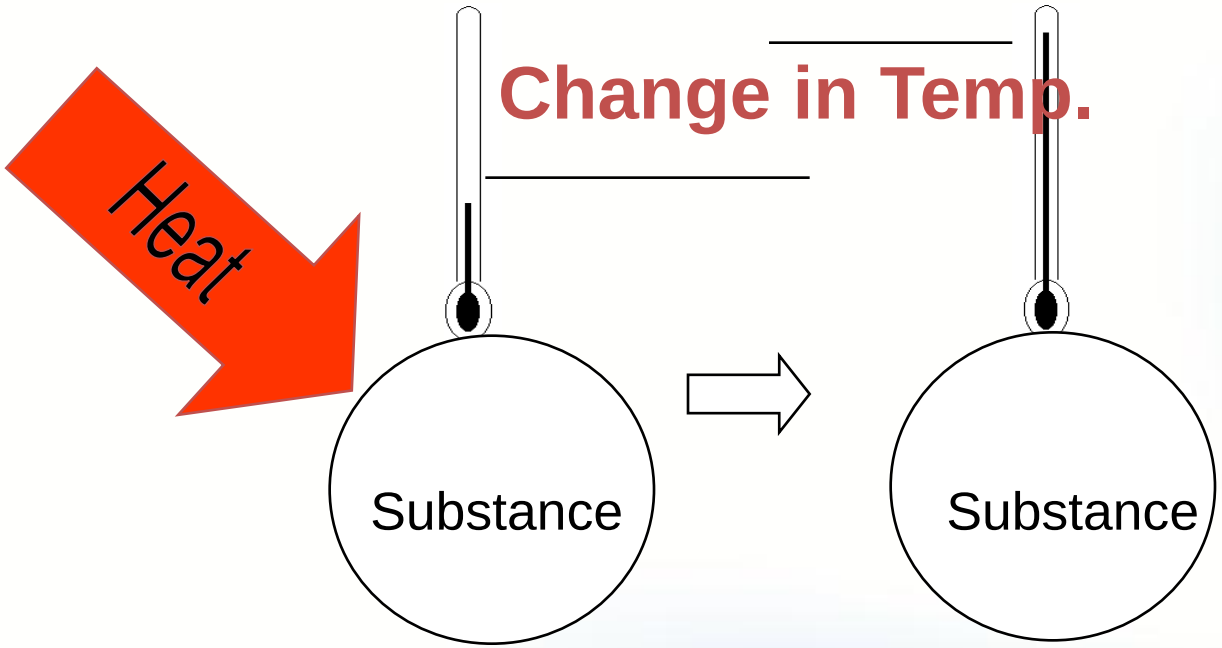
(Human Comfort)

1) Heat Load

- Classified into 2 main types :

1. **Sensible Heat**
2. **Latent Heat**

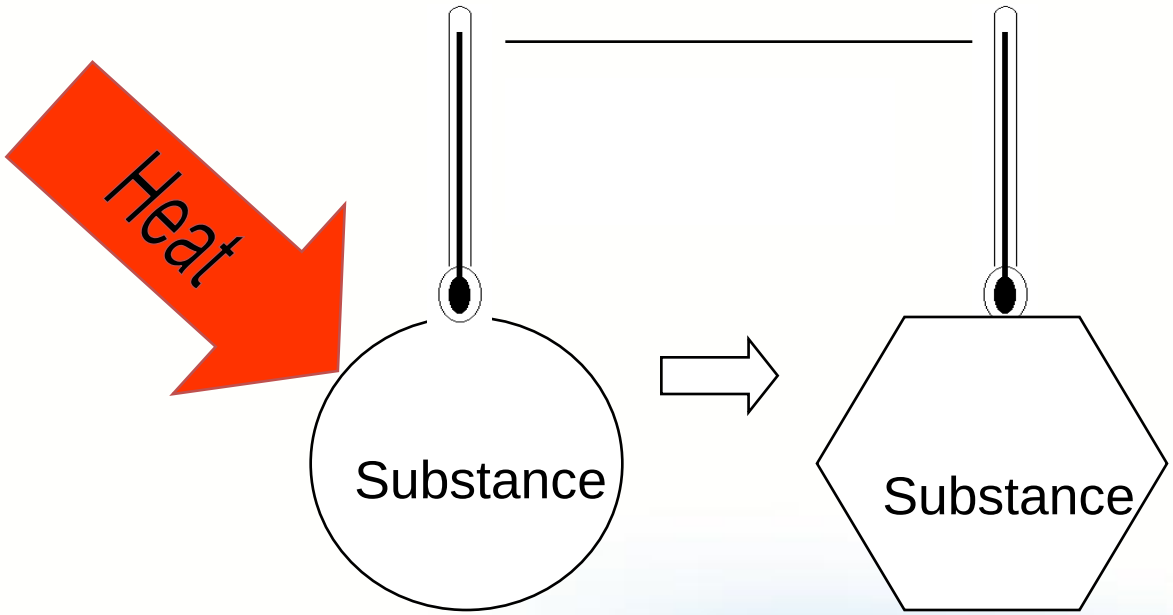
Sensible Heat



(No change in physical state)

Latent Heat

No change in temperature



(Physical state is changed)

1.2) Classification of Cooling Loads

1) Skin Loads

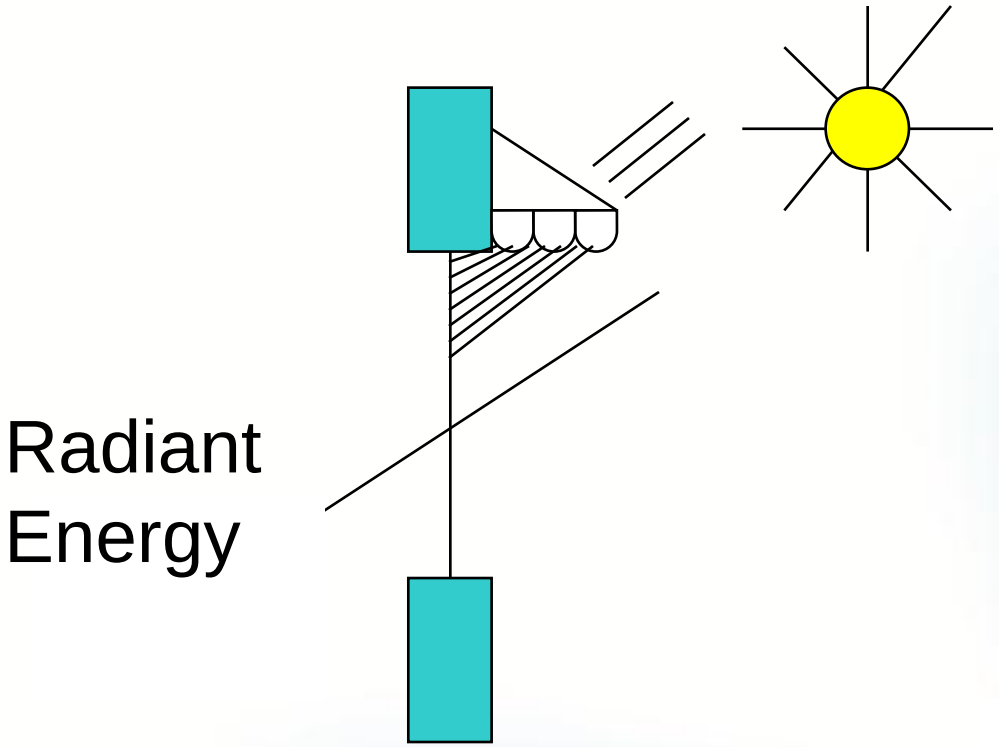
2) Internal Loads

3) Other Loads

1) Skin Loads

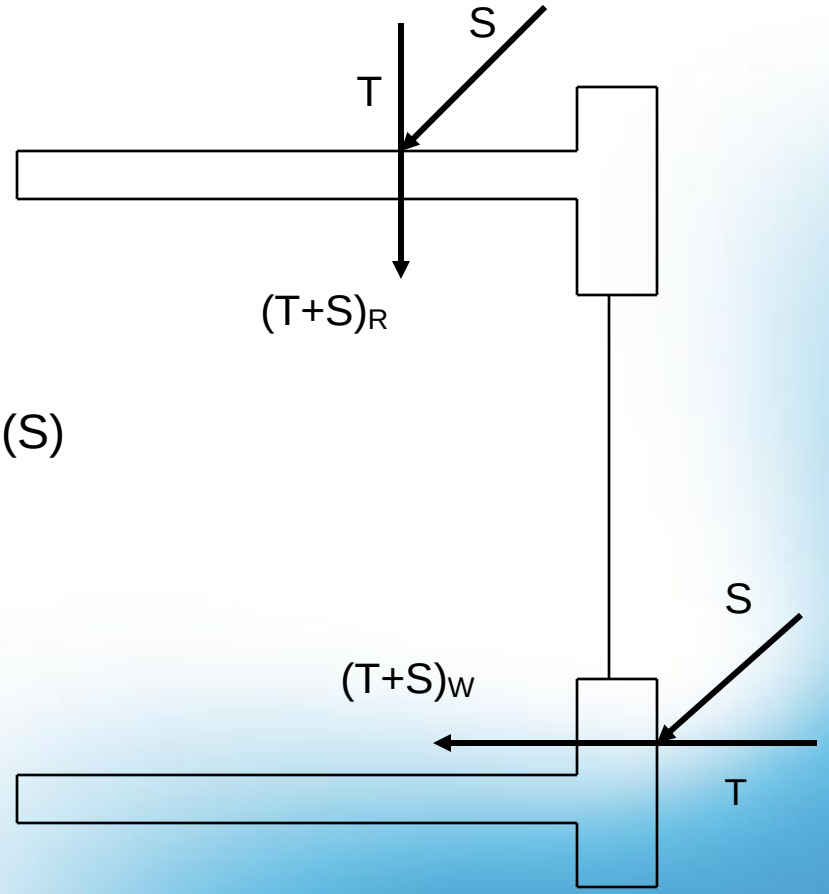
Skin loads originate from the heat sources outside or external to the conditioned space

a) Solar Gain Through glass (SG).



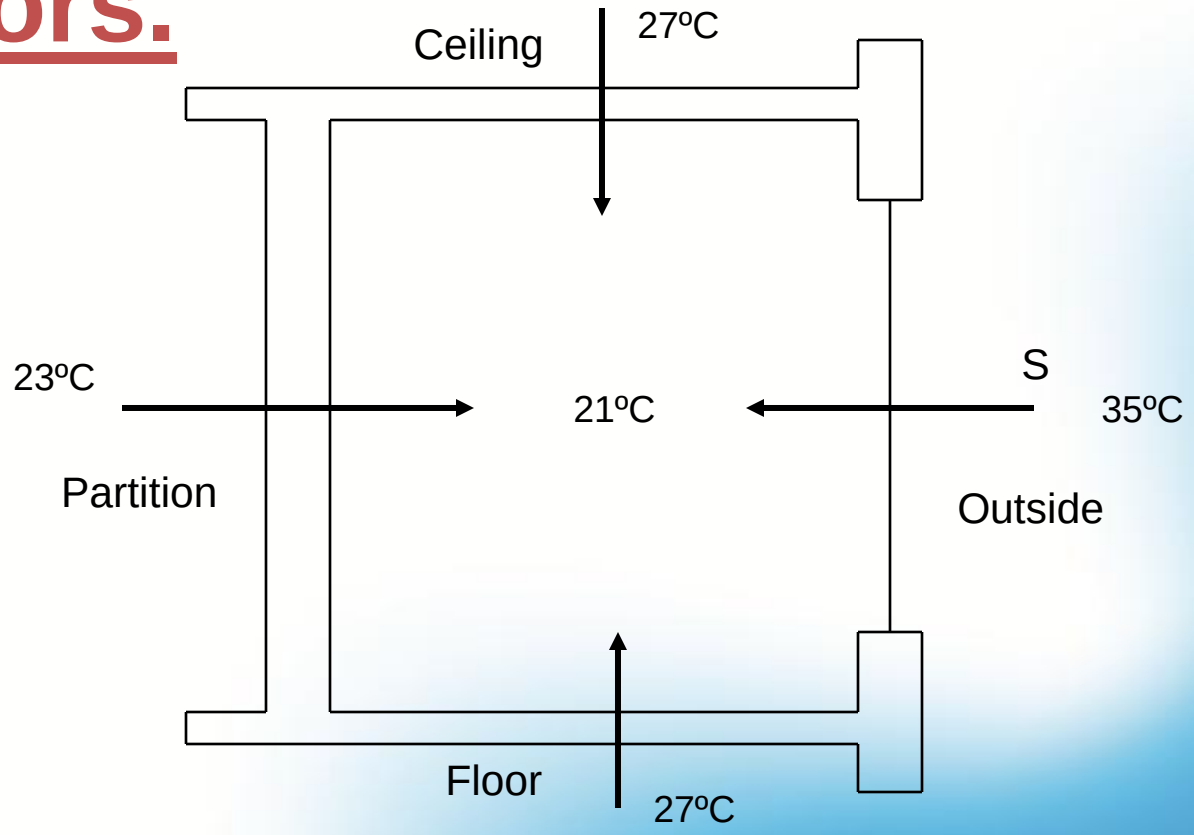
Solar heat gain is reduced by the use of internal or external shading devices such as overhang.

b) Solar & Transmission Gain Thru Walls and Roofs.

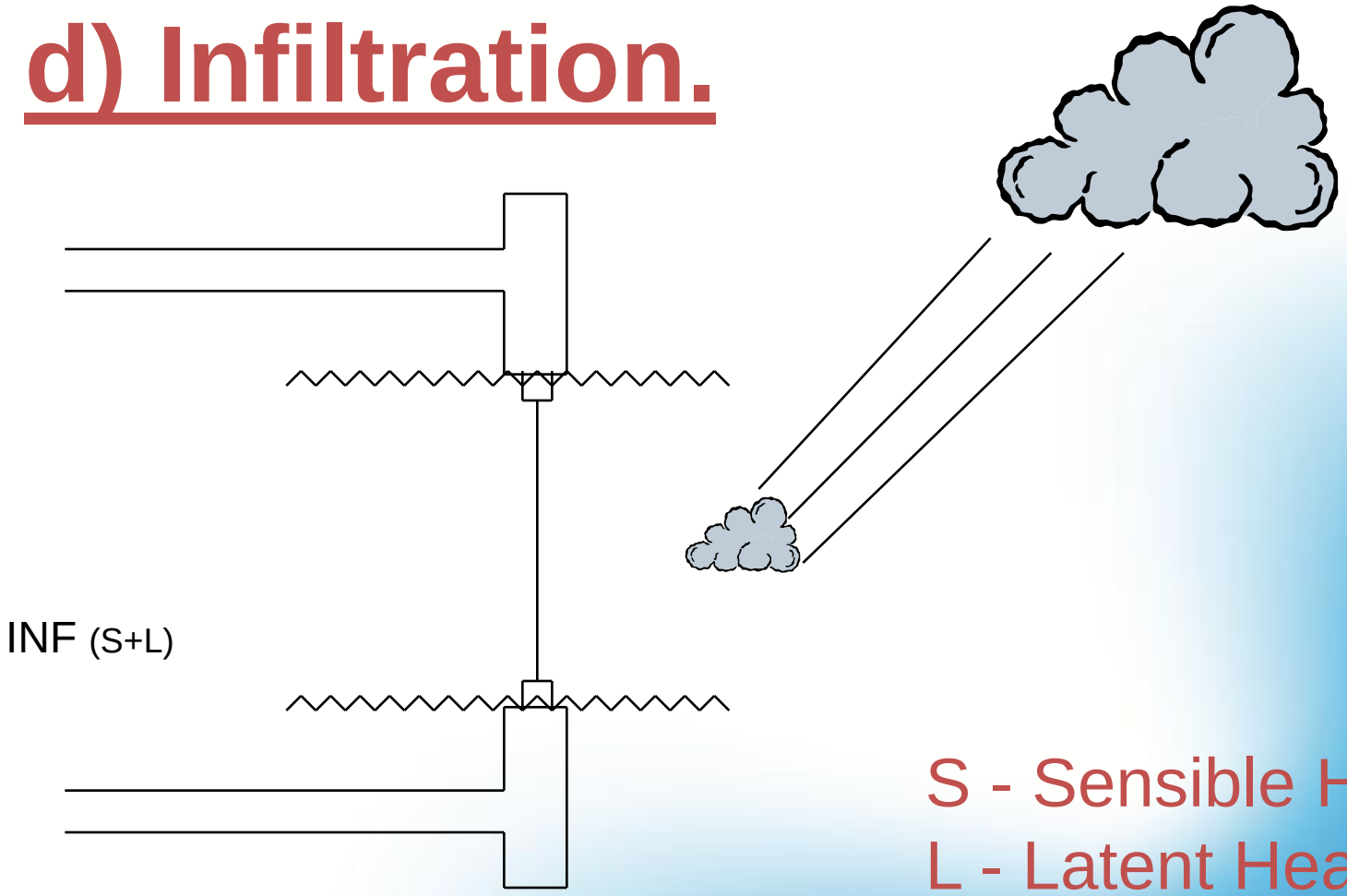


Absorbed Solar Energy (S)
Transmission (T)

c) Transmission Thru Glass, Ceiling, Partitions or Floors.

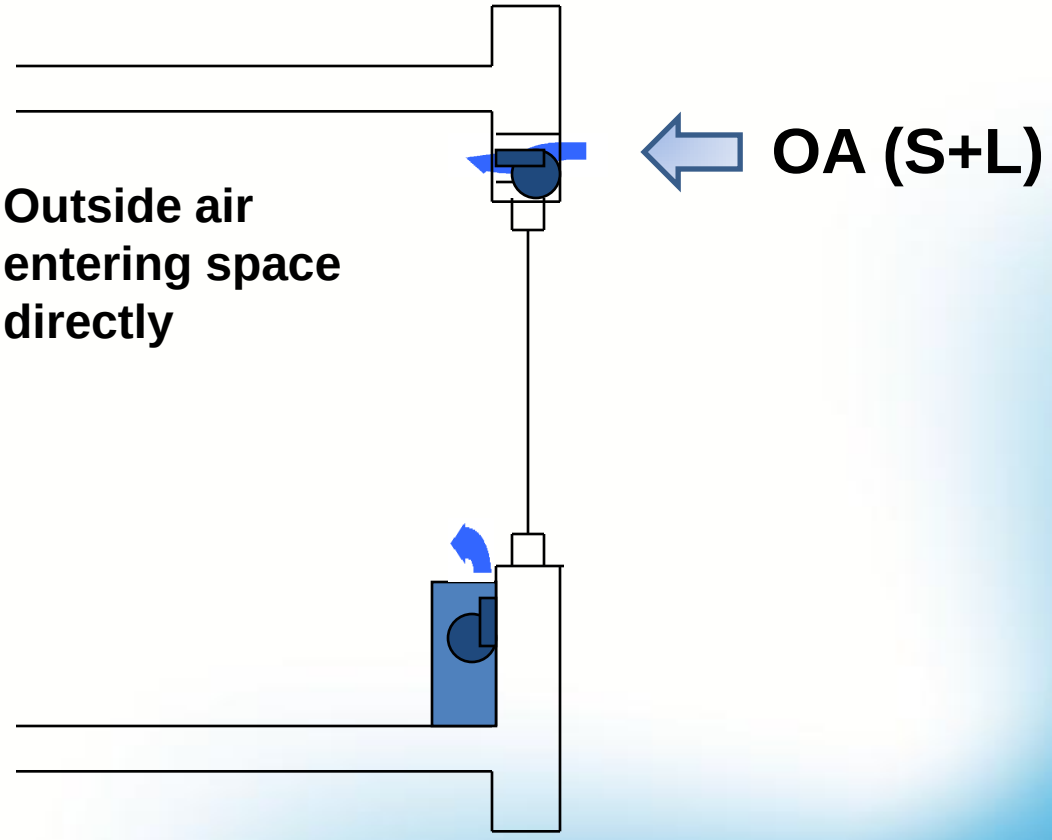


d) Infiltration.



S - Sensible Heat
L - Latent Heat

e) Ventilation (O.A)



Skin Loads

a) Solar Gain Through glass (SG).

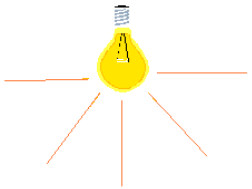
b) Solar and Transmission Gain Through Walls and Roofs.

c) Transmission Through Glass, Ceiling, Partitions or Floors.

d) Infiltration.

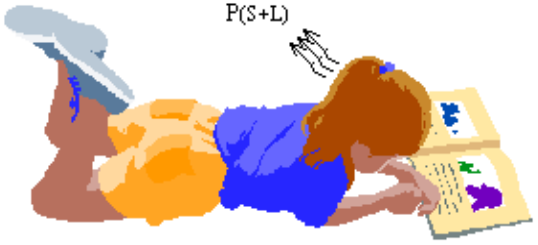
e) Ventilation (O.A)

2) Internal Loads



a)Lighting Loads

b)People Loads



c)Equipment Loads

Room Loads

- Add all sensible loads together results in sensible heat gain.
- Add all latent load together results in latent heat gain.

Sum of the Room Sensible Heat and the Room Latent Heat Is the Room Total Heat

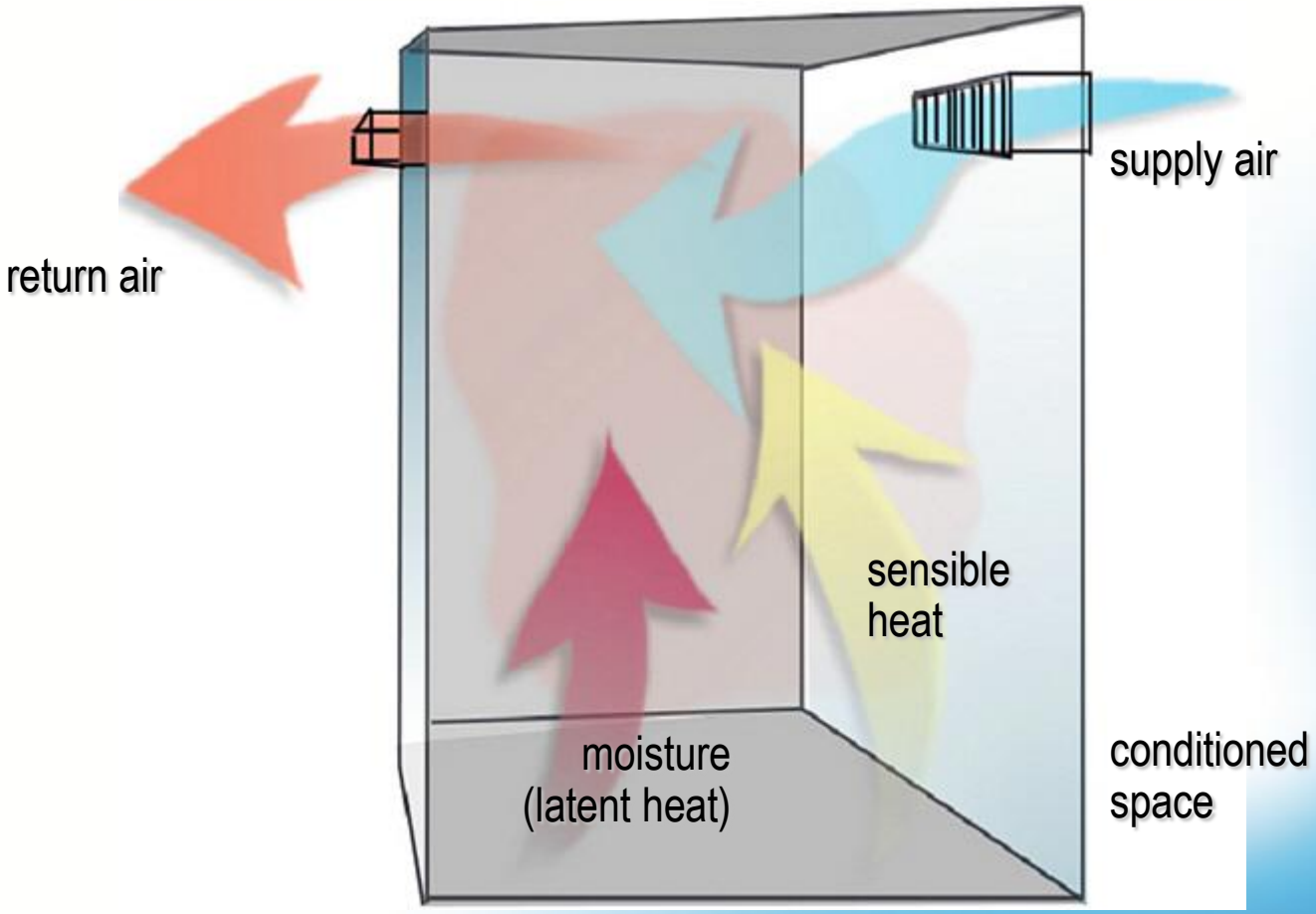
3) Other Loads

a. Supply Air Side

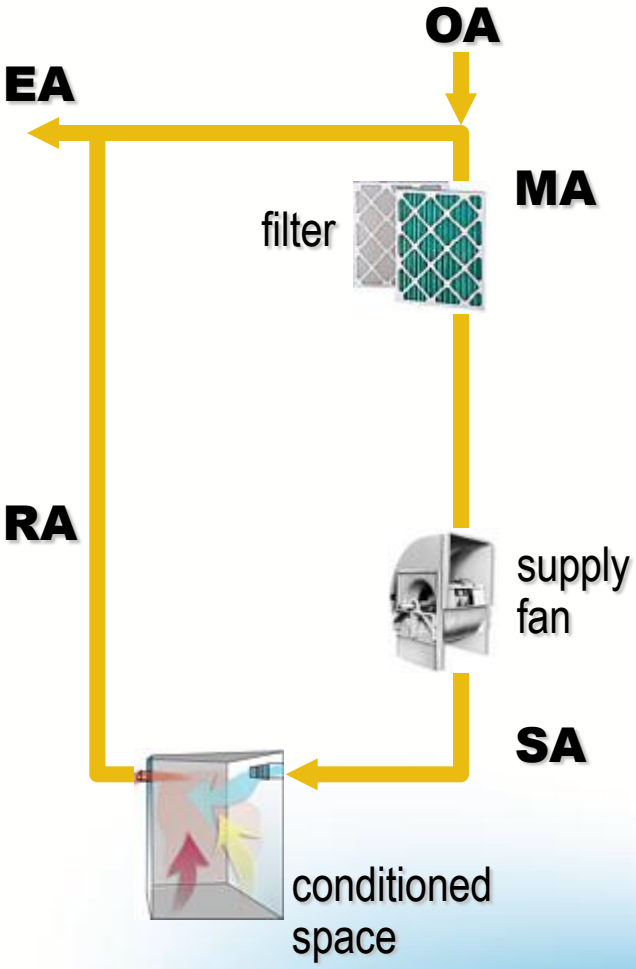
b. Return Air Side

c. Outside or Ventilation Air

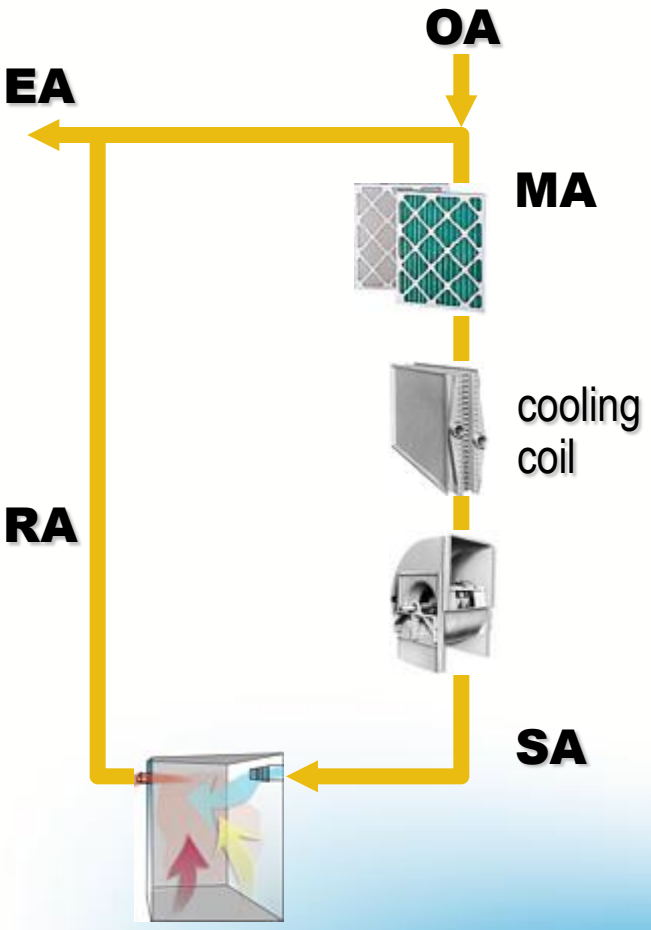
Airside Loop



Supply Fan and Filter

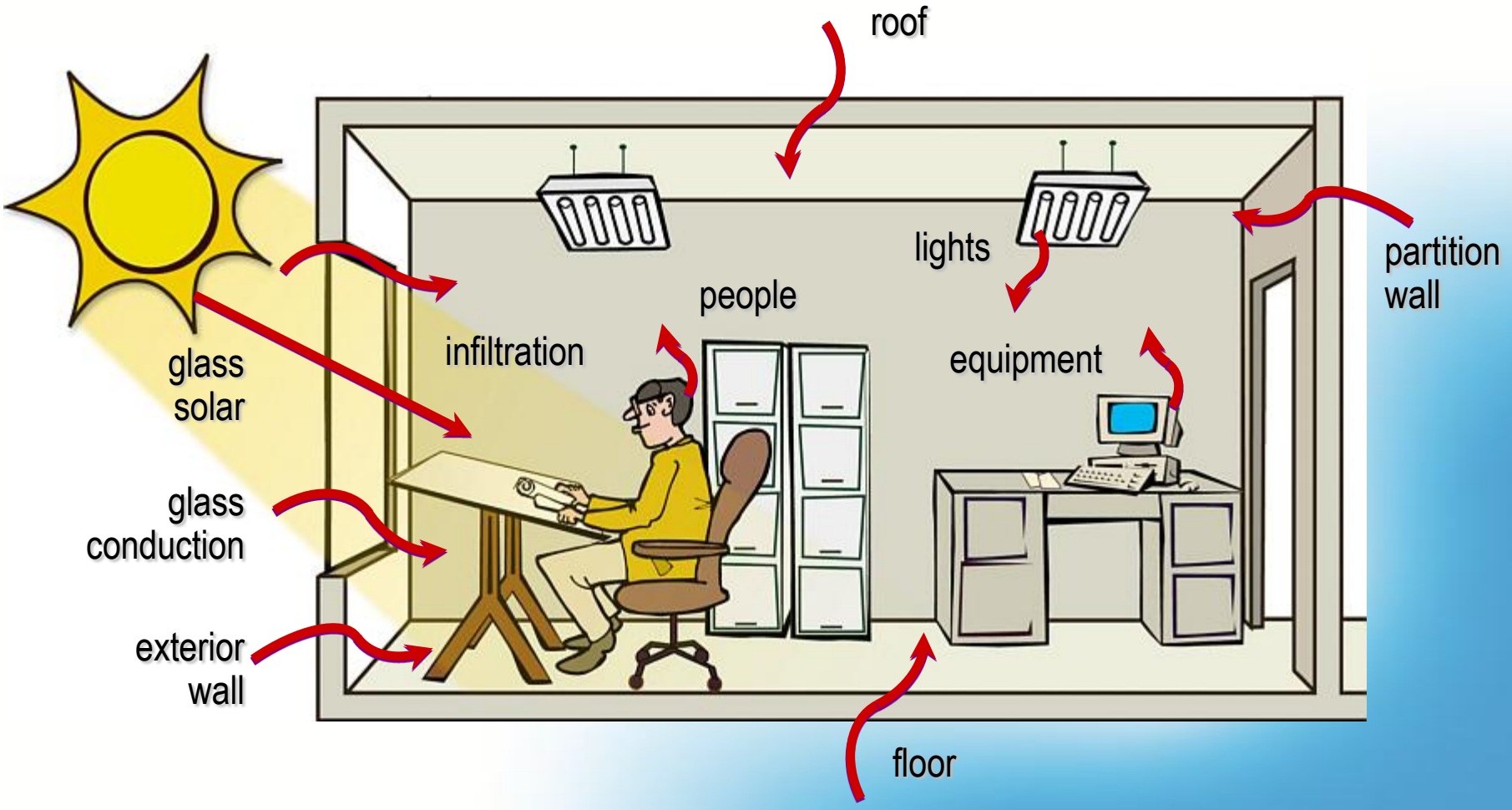


Cooling Coil



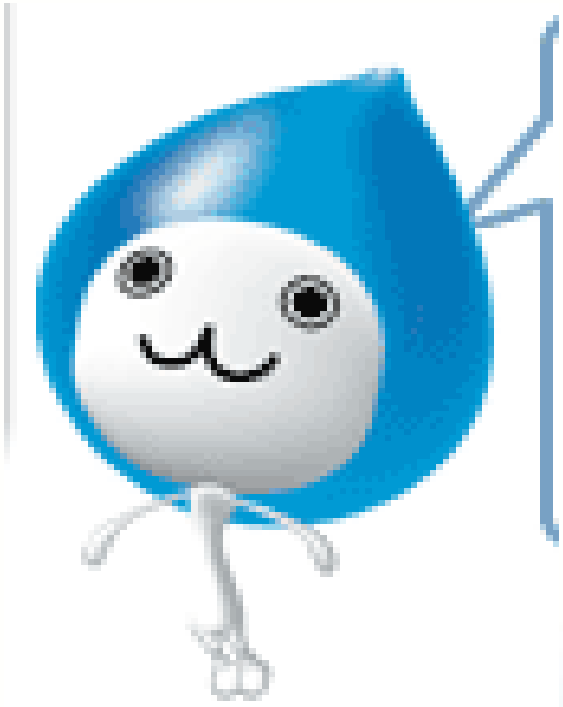
Cooling Load Components

1.Radiation 2.Conduction 3.Convection



Cooling Load Components

cooling load components	sensible load	latent load	space load	coil load
conduction through roof, walls, windows, and skylights	✓		✓	✓
solar radiation through windows, skylights	✓		✓	✓
conduction through ceiling, interior partition walls, and floor	✓		✓	✓
people	✓	✓	✓	✓
lights	✓		✓	✓
equipment/appliances	✓	✓	✓	✓
infiltration	✓	✓	✓	✓
ventilation	✓	✓		✓
system heat gains	✓			✓



WHY Heat Load Calculation?

Cooling Load Estimation

Recommended IAQ (SS 554:2009)

By law, the indoor conditions of an air con space shall maintained within the following limits :

Design Temp. : 25ºC +/- 1 ºC

Relative Humidity : < 65% (for new buildings)

< 70% (for existing buildings)

Air movement : 0.10 ~ 0.30 m/s

Note : At occupant level of 1.5m above floor.

Heat Transfer Coefficient (U-value)

Defined as the quantity of heat transmitted under steady state conditions through unit area of the material of unit time when the temperature difference exists between it opposite surfaces.

($W/m^2 {}^oC$)

Calculation of U- value

(Coefficient of heat transmission of wall structure)

$$1/U = 1/\alpha_0 + l_1/\lambda_1 + l_2/\lambda_2 + \ldots\ldots + l_n/\lambda_n + R + 1/\alpha_1$$

α_0 : External surface heat transfer coefficient [23] [W/m^2 ºC]

α_1 : Internal surface heat transfer coefficient [9] [W/m^2 ºC]

l : Thickness of material [m]

λ : Coefficient of thermal conductivity of material [W/m ºC]

R : Thermal resistance of air layer [m^2 ºC/W]

Exercise : Calculate U value of outside wall

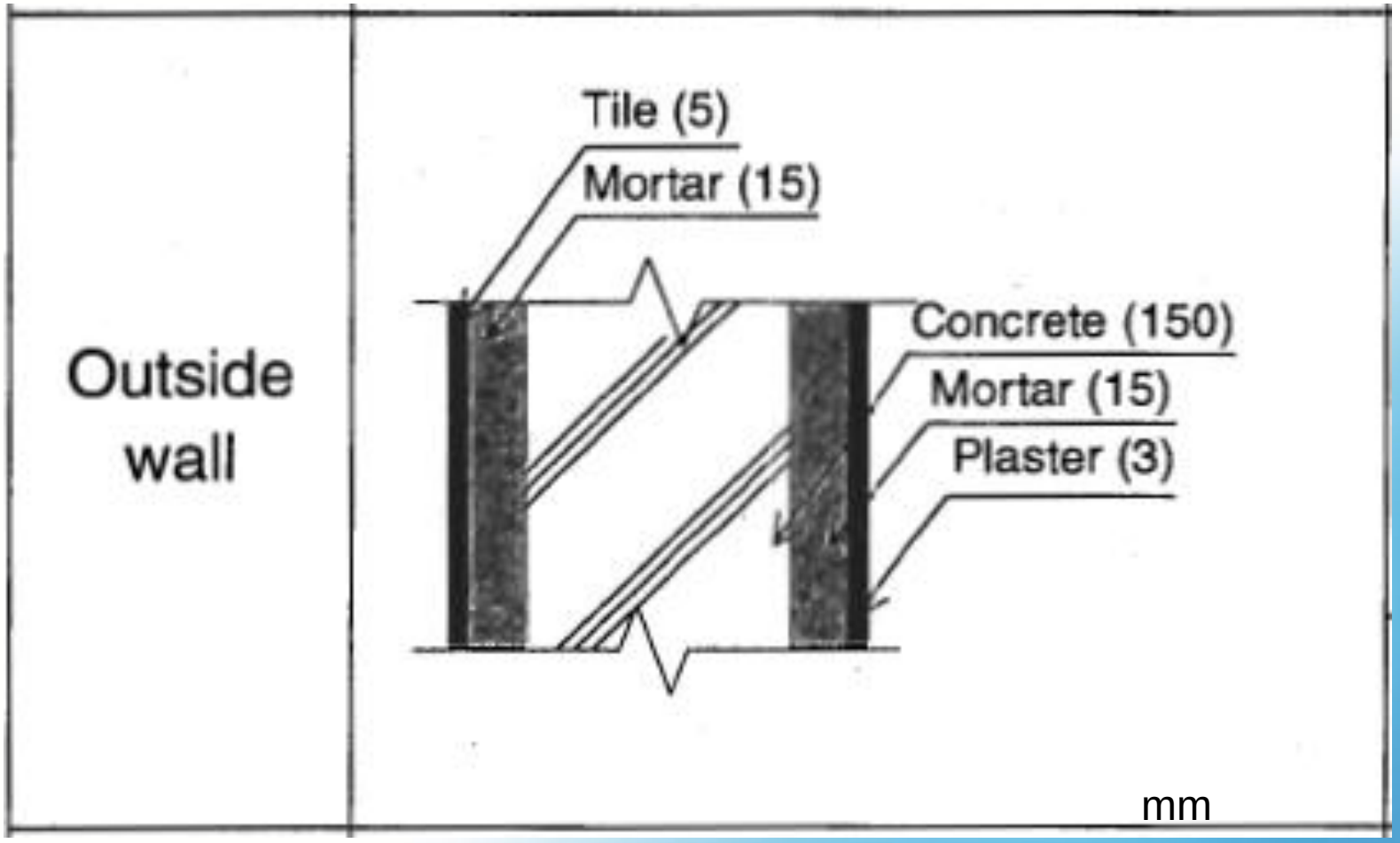


Table 4-11 External surface heat transfer coefficient, αo [W/m^2.°C]

Location of surface	Summertime	Wintertime
Rectangular exterior wall surface	17	23
Rooftop surface	23	35
Planceer	17	17

Table 4-12 Internal surface heat transfer coefficient, αi [W/m^2.°C]

Location of surface	Direction of heat flow	
	Upward	Downward
Horizontal	9.26	6.13
Inclined	9.08	7.49
Vertical	Horizontal	8.29

Table 4-13 Coefficient of Thermal Conductivity of Materials, λ [W/m^2·°C]

Name of material	Coefficient of thermal conductivity λ [W/m²·°C]	Name of material [W/m.⁰C]	Coefficient of thermal conductivity λ [W/m²·°C]
Air (static)	0.022	alt and the like [W/m.⁰C]	[W/m.⁰C]
Water (static)	0.6	Moisture-proof paper and the like	0.21
Ice	2.2	Tatami mat	0.15
Snow	0.06	Composite tatami mat	0.07
Steel	45	Carpet and the like	0.08
Aluminum	210	Wood (heavy-weight)	0.19
Copper	390	Wood (medium-weight)	0.17
Rock (heavy-weight)	3.10	Wood (light-weight)	0.14
Rock (light-weight)	1.40	Plywood	0.19
Soil (argilliferous)	1.50	Soft fiber board	0.056
Soil (arenaceous)	0.90	Semi-soft fiber board	0.14
Gravel	0.62	Hard fiber board	0.22

PC concrete	1.50
Plain concrete	1.40
Light-weight concrete	0.78
Autoclaved lightweight concrete (ALC)	0.17
Concrete block (heavy-weight)	1.10
Concrete block (light-weight)	0.53
Mortal	1.50
Asbestos slate	1.20
Plaster	0.79
Plaster board / Lath board	0.17
Grout	0.74
Mud wall	0.69
Glass	0.78
Tile	1.30
Brick wall	0.64
Roofing tile	1.00
Synthetic resin / Linoleum	0.19
FRP	0.26

Particle board	0.17
Wood wool cement board	0.19
Glass wool (24K)	0.042
Glass wool (32K)	0.040
Rock wool heat insulating material	0.042
Sprayed rock wool	0.051
Rock wool acoustic board	0.064
Polystyrene foam board (bead)	0.047
Polystyrene foam board (extruded)	0.037
Polystyrene foam board (Freon molded)	0.026
Rigid urethane foam board	0.028
Soft urethane foam board	0.050
Polyethylene foam board	0.044
Rigid PVC foam board	0.036

Airtight hollow layer, R = 0.15 $m^2 \cdot ^\circ C/W$

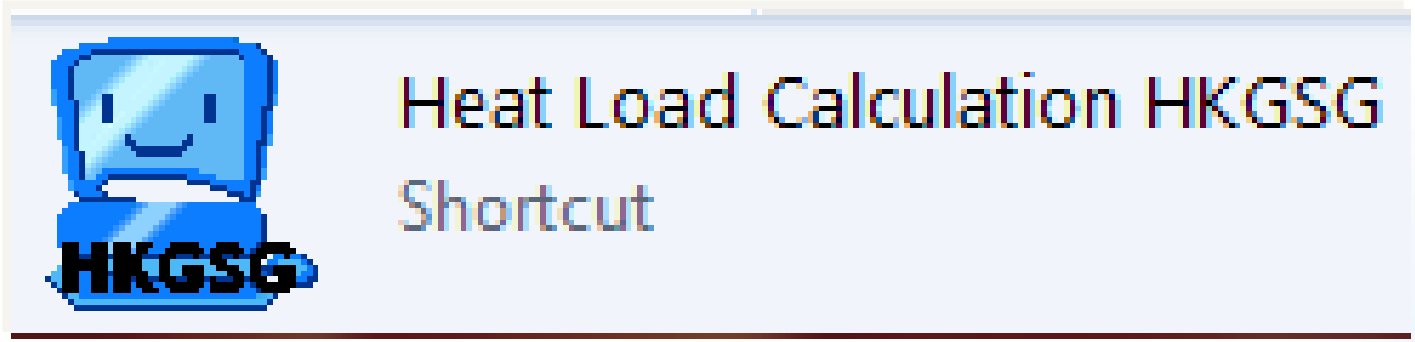
Non- airtight hollow layer, R = 0.07 $m^2 \cdot ^\circ C/W$

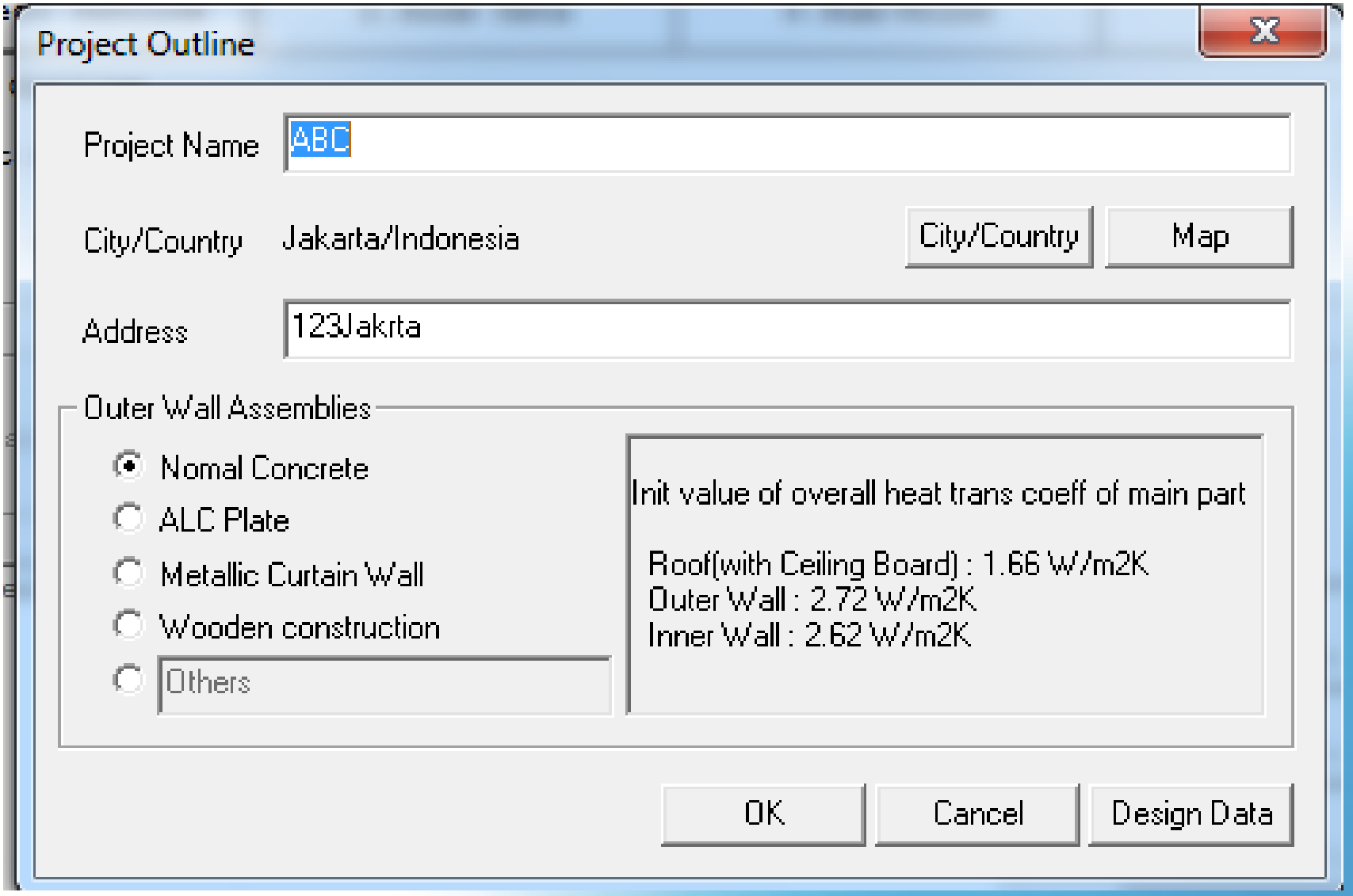
Answer :

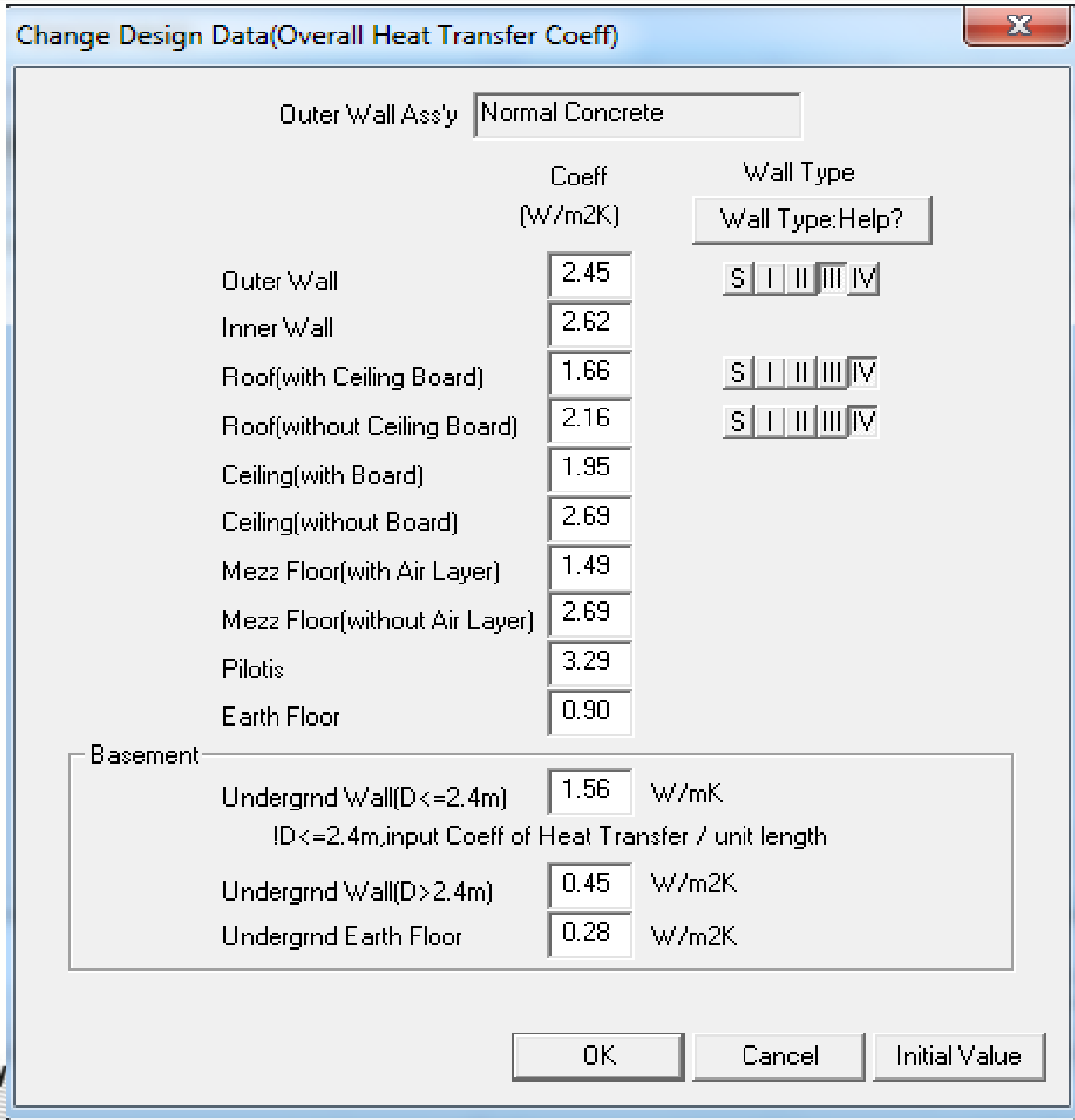
$$\frac{1}{U} = \frac{1}{23} + \frac{0.005}{1.3} + \frac{0.015}{1.5} + \frac{0.15}{1.4} + \frac{0.015}{1.5} + \frac{0.003}{0.79} + \frac{1}{9} = 0.289$$

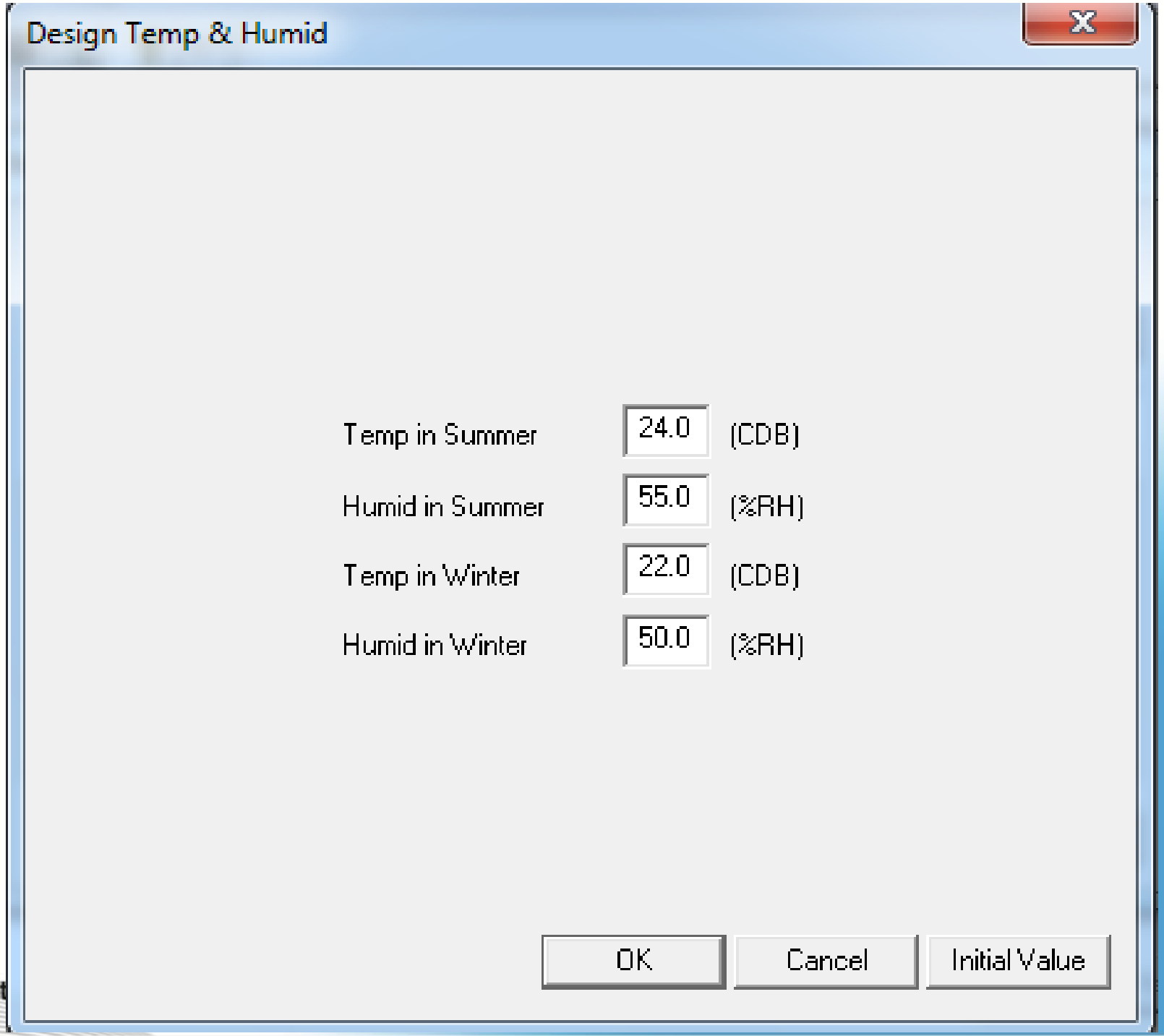
$U = 3.46\ W/m^2\ ^oC$

Introduction


HKGSG
Heat Load Calculation HKGSG
Shortcut


Project Outline
Project Name
ABC
City/Country
Jakarta/Indonesia
City/Country
Map
Address
123Jakrta
Outer Wall Assemblies
Nomal Concrete
ALC Plate
Metallic Curtain Wall
Wooden construction
Others
Init value of overall heat trans coeff of main part
Roof(with Ceiling Board) : 1.66 W/m2K
Outer Wall : 2.72 W/m2K
Inner Wall : 2.62 W/m2K
OK
Cancel
Design Data





Room spec

No. 2 Room Name New Room Floor 1 Qty 1 System 1 Prev room Next room

Usage of Room

○ Office ○ Shop ○ Hotel ○ Hospital ○ Factory ○ Condominium ○ Detached ◉ Meeting

Ventilation System

○ Natural ◉ Vent Fan ○ Total Heat Exc

Ceiling Board

◉ Avail ○ No

Floor Area 0.0 m2

Ceiling Height 2.7 m

Roof&Non-Cond.Ceiling Area(m2)

Upper Room	0.0
Flat Roof	0.0
Inclined Roof	0.0
Glass	0.0

Non-Conditioned Floor Area(m2)

Earth Floor	0.0
Air Layer Exist	0.0
Air Layer No	0.0
Pilotis	0.0

Equipments

Sensible Heat 0 W

Latent Heat 0 W

Heat Source Input

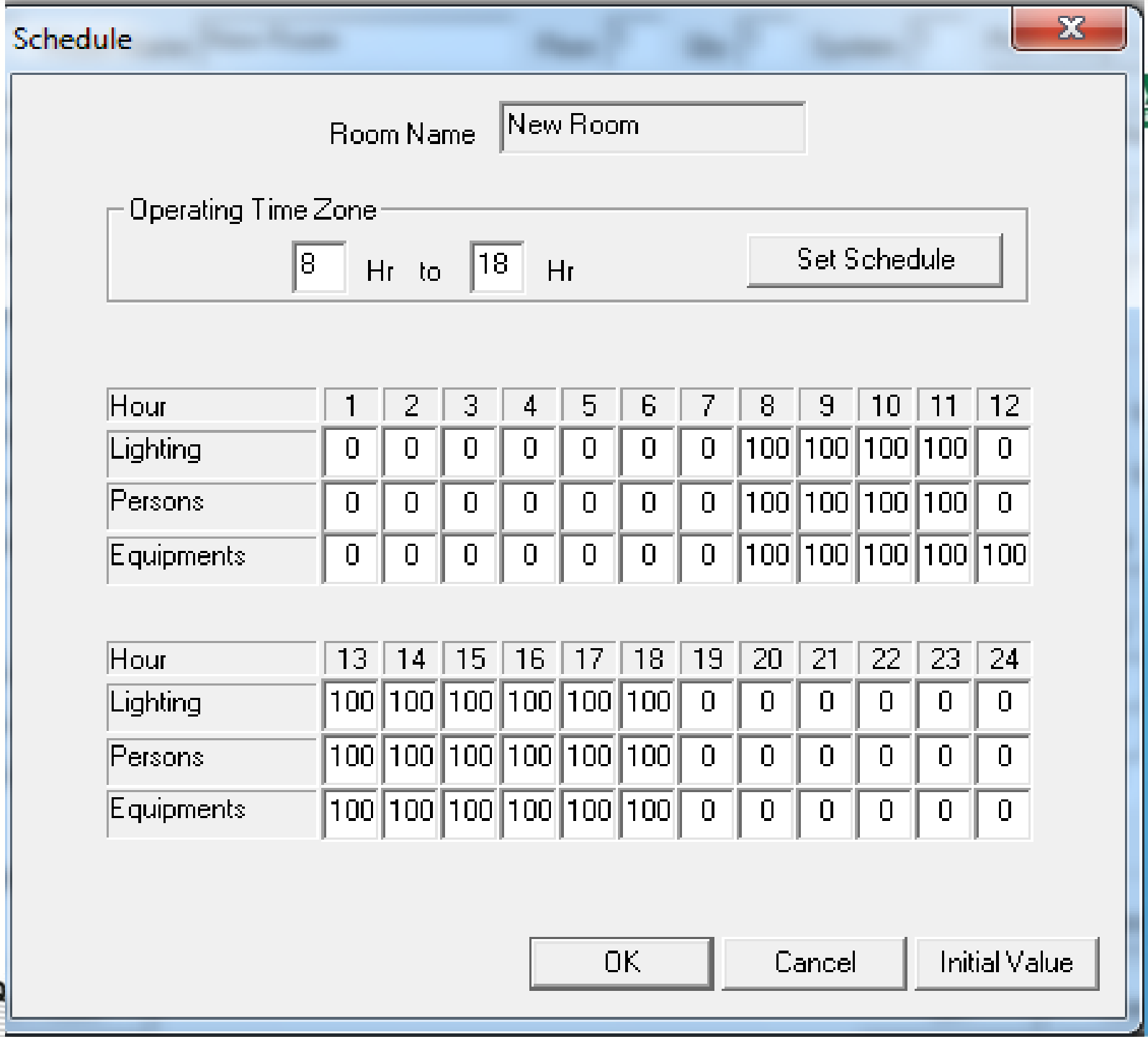
	N	E	S	W	NE	SE	SW	NW	Shade
Outer Wall Length(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Window area on Outer Wall(m2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inner Wall Length for Non-Cond. Space(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

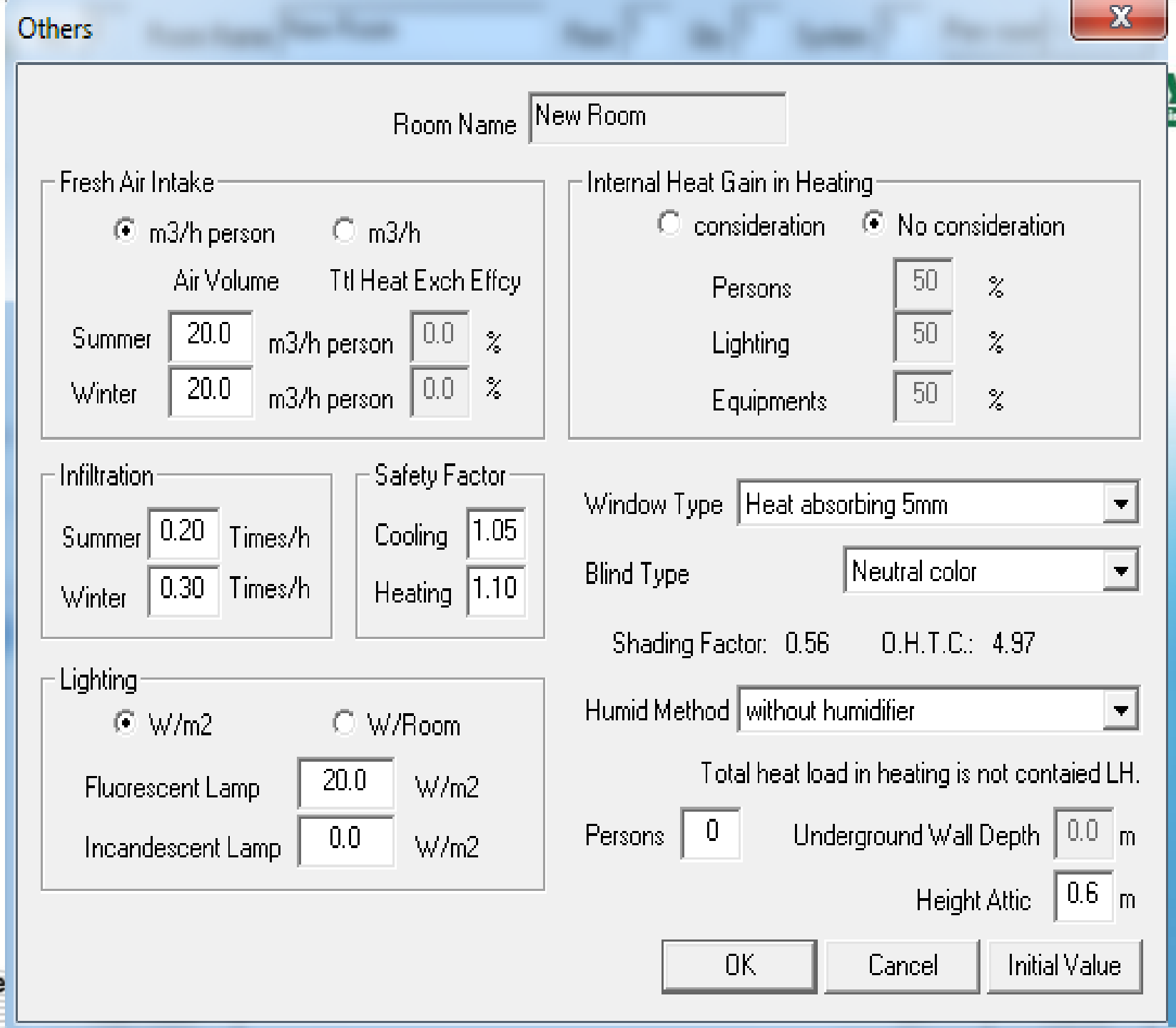
Change Std Data

O.H.T.C. | Temp&Humid | Schedule | Others | Canopy | Material II | Extension

Add Room OK Cancel

Input room name.


Schedule
Room Name
New Room
Operating Time Zone
8
Hr to
18
Hr
Set Schedule
Hour 1 2 3 4 5 6 7 8 9 10 11 12
Lighting 0 0 0 0 0 0 0 100 100 100 100 0
Persons 0 0 0 0 0 0 0 100 100 100 100 0
Equipments 0 0 0 0 0 0 0 100 100 100 100 100
Hour 13 14 15 16 17 18 19 20 21 22 23 24
Lighting 100 100 100 100 100 100 0 0 0 0 0 0
Persons 100 100 100 100 100 100 0 0 0 0 0 0
Equipments 100 100 100 100 100 100 0 0 0 0 0 0
OK
Cancel
Initial Value

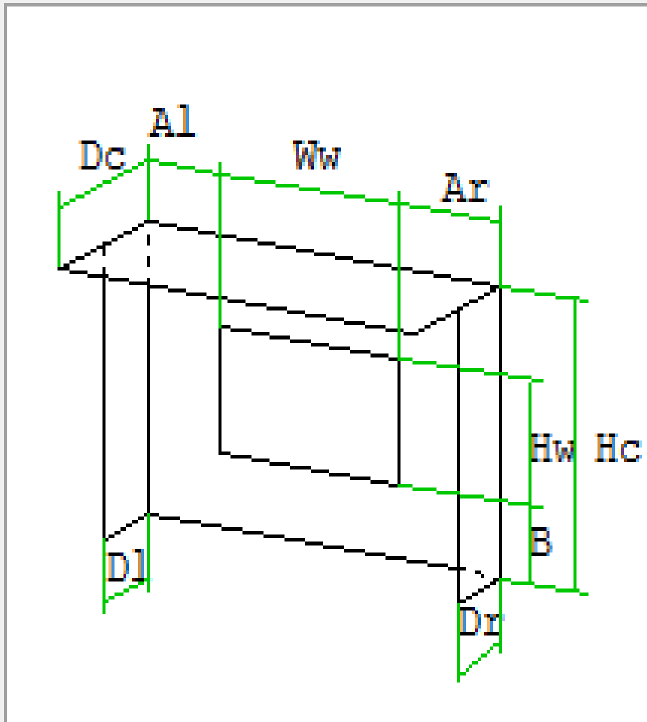

Others
Room Name
New Room
Fresh Air Intake
m3/h person
m3/h
Air Volume
Ttl Heat Exch Effcy
Summer
20.0
m3/h person
0.0
%
Winter
20.0
m3/h person
0.0
%
Internal Heat Gain in Heating
consideration
No consideration
Persons
50
%
Lighting
50
%
Equipments
50
%
Infiltration
Summer
0.20
Times/h
Winter
0.30
Times/h
Safety Factor
Cooling
1.05
Heating
1.10
Window Type
Heat absorbing 5mm
Blind Type
Neutral color
Shading Factor: 0.56
O.H.T.C.: 4.97
Humid Method
without humidifier
Lighting
W/m2
W/Room
Fluorescent Lamp
20.0
W/m2
Incandescent Lamp
0.0
W/m2
Total heat load in heating is not contaied LH.
Persons
0
Underground Wall Depth
0.0
m
Height Attic
0.6
m
OK
Cancel
Initial Value

Input window and Canopy

Please select direction of window with

If there is window without canopy in the same direction, please input zero for canopy dimensions.

Direction	Dc	Dl	Dr	Al	Ww	Ar	B	Hw	Hc (m)	Qty
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0



OK

Cancel

Material II

Room Name: New Room

O.H.T.C.(W/m2K)

Wall Type: S | I | II | III | IV

Outer Wall: 0.00

Inner Wall: 0.00

Window

Window Type: Clear 5mm

Blind Type: Neutral color

Shading Factor: 0.63 O.H.T.C.: 4.97

	N	E	S	W	NE	SE	SW	NW	Shade
Outer Wall Length(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Window Area on Outer Wall(m2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inner Wall Length for Non-Cond.Space(m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

OK Cancel

Extension

Room Name: New Room

!Detail Set Room Data. Nomally no need to change.

Personnel Heat Gain per Person

Sensible Heat: 56 W/person Latent Heat: 76 W/person

Glass Surface Ratio(without sash area)

Glass Area = Ttl Window Area * 0.95 !Use for Solar heat gain through

Next Room Condotion

Next room temp diff is calculated using below factor.

(dt)=(O/D Temp-I/D Temp) * Temp Diff Coeff

		N	E	S	W	NE	SE	SW	NW	Ceiling	Floor
Coeff Temp Diff	Cooling	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	Heating	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Boiler/Kitchen is in Next Room		No	No	No	No	No	No	No	No	No	No

OK Cancel Initial Value

Aircon heat load calculation sheet

Project Name: Kesuma Resort,Bali

Address: Samabe,Bali

13/September/2012

Heat load sum up table

(Upper:W, Lower:kcal/h)

Room name	Fl	Sys -tem	Qty. of rooms	Cooling				Heating				Floor area	Heat load per area	
				Indoor SH	Total	Selected	Time	Total	Selected	Humid.	Time		Cooling	Heating
				[W] (kcal/h)			[Hr]	[W] (kcal/h)		[kg/h]	[Hr]	[m2]	[W/m2] (kcal/hm2)	
Living Room 1	1	1	1	5114	6744	7081	16	7	8	-0.99	6	25.3	279.9	0.3
				(4398)	(5800)	(6090)		(6)	(7)				(240.7)	(0.3)
Living Room 2	1	1	1	2590	3564	3742	17	4	4	-0.61	6	16.8	222.8	0.3
				(2227)	(3065)	(3218)		(3)	(4)				(191.6)	(0.2)
Entrance	1	1	1	2088	3053	3206	17	4	4	-0.59	6	15.3	209.5	0.3
				(1796)	(2626)	(2757)		(3)	(4)				(180.2)	(0.2)
Peak load of building			3	9663	13260	13923	16	15	17	-2.19	6	57.4	242.6	0.3
				(8310)	(11404)	(11974)		(13)	(14)				(208.6)	(0.2)

SH : Sensible heat

Table of system heat load

(Upper:W, Lower:kcal/h)

Sys -tem	Cooling							Heating						
	Time	F/A vol	Indoor SH	Indoor	Outside	Total	Selected	Time	F/A vol	Indoor	Outside	Total	Selected	Humid.
	[Hr]	[m3/h]	[W] (kcal/h)					[Hr]	[m3/h]	[W] (kcal/h)				[kg/h]
1	16	220	9663 (8310)	10968 (9432)	2292 (1971)	13260 (11404)	13923 (11974)	6	220	0 (0)	15 (13)	15 (13)	17 (14)	-2.19

If total indoor heat load is negative, it is not calculated.

F/A : Fresh air

SH : Sensible heat

System table

System	Room name	Floor	Rooms
1	Living Room 1	1	1
1	Living Room 2	1	1
1	Entrance	1	1

System	Room name	Floor	Rooms

Room data(Input data)

Project name	Kesuma Resort,Bali
Address	Sanabe,Bali
City	Den Pakar/Indonesia
Outer wall assembly	Normal Concrete
Max. fresh air temp. in summer(C)	31.9
Min. fresh air temp. in winter(C)	21.9
Room name	Living Room 1
Floor No	1
System No	1
No of rooms	1
Usage of Room	Hotel
Ceiling board	Available
Method of fresh air intake	Common ventilation fan
Floor area(m2)	25.3
Ceiling height(m)	3.6

Roof&Non-air-conditioned ceiling area(m2)	Overhead room	Flat roof	Inclined roof	Window glass
	0.0	0.0	25.3	0.0

Non-air-conditioned floor area(m2)	Earth floor	with air layer	Without air layer	Pilotis
	0.0	5.6	0.0	0.0

	N	E	S	W	NE	SE	SW	NW	Shade
Outer wall length(m) <1>	0.0	0.0	0.0	0.0	0.0	4.6	5.5	0.0	0.0
Window area on outer wall(m2) <1>	0.0	0.0	0.0	0.0	0.0	0.4	0.7	0.0	0.0
Non-conditioned inner wall length(m) <1>	0.0	0.0	0.0	0.0	0.0	2.7	5.5	0.0	

!Outer wall length with negative value is regarded as underground wall.

Cooling load heat gain from equipments(W)	Sensible heat	Latent heat
	500	0

Operating time zone 8:00 to 24:00

Internal heatgaing schedule(%)

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Lighting	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Persons	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Equipments	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Design room temperature in summer(CDB)	26.0
Design room humidity in summer(RH%)	50.0
Design room temperature in winter(CDB)	22.0
Design room humidity in winter(RH%)	50.0

Fresh air intake	Air volume(m3/h person)
Summer	20.0
Winter	20.0

Infiltration ventilation(Times/h)	
Summer	0.20
Winter	0.30

Heating load internal heat gain(to ratio of cooling load internal heat gain)(%)
Lighting: 50 Persons: 50 Equipments: 50

Window type <1>	Heat absorbing 5mm
Blind type	Neutral tints
Shading factor/OWTC	0.56/4.97

Lighting	Fluorescent lamp(W/m2)	30.0
	Incandescent lamp(W/m2)	0.0

No of persons	5
Depth of underground wall(m)	0.0

!Underground wall is valid only when outer wall is negative value.

Height above attic(m)	0.6
Humidifying method	Without humidifier

Overall heat transfer coefficient (W/m2K)			Wall type
Outer wall	<1>	2.72	III
Inner Wall	<1>	2.62	
Roof(with ceiling board)		1.66	IV
Ceiling(with ceiling board)		1.95	
Mezz floor(with air layer)		1.49	
Mezz floor(without air layer)		2.69	
Pilotis		3.29	
Earth floor		0.90	
Underground wall(depth<=2.4m)		1.56	(W/mK)
Underground wall(depth>2.4m)		0.45	

Safety factor		
Cooling		1.05
Heating		1.10

OWTC : Overall heat transfer coefficient

Table of room heat load

Room name	Floor	System	Rooms	Usage	Fl area(m2)	Height(m)	No of person	F/A volume(m3/h)
Living Room 1	1	1	1	Hotel	25.3	3.6	5	Summer 100.0/Winter 100.0

[Cooling load] Condition of indoor design temprature & humidity: 26.0(CDB) 50.0(%RH) [W] (kcal/h)

Time	F/A cond.		Outer Wall	Roof & Ceiling	Inner Wall	Floor	Window	Infiltration		Human body		Light -ing	Equipments		Indoor heat		Fresh air	Total heat load
	CDB	%RH						SH	LH	SH	LH		SH	LH	SH	LH		
4	27.1	88.8	45	23	34	4	94	7	147	295	430	880	500	0	1882	577	845	3304(2841)
5	27.0	89.3	35	18	31	3	85	6	147	295	430	880	500	0	1853	577	842	3272(2814)
6	27.0	89.3	35	18	31	3	85	6	147	295	430	880	500	0	1853	577	842	3272(2814)
7	27.2	88.7	28	14	37	4	1125	7	149	295	430	880	500	0	2890	579	857	4326(3720)
8	27.7	86.6	40	14	52	6	1521	10	150	295	430	880	500	0	3318	580	882	4780(4111)
9	28.5	83.4	86	28	77	8	1688	15	153	295	430	880	500	0	3577	583	925	5085(4373)
10	29.4	79.6	154	74	106	11	1557	20	155	295	430	880	500	0	3597	585	962	5144(4424)
11	30.4	75.8	228	148	136	15	1502	26	158	295	430	880	500	0	3730	588	1012	5330(4584)
12	31.1	72.8	304	259	158	17	1625	31	158	295	430	880	500	0	4069	588	1035	5692(4895)
13	31.7	70.4	368	393	176	19	1657	34	158	295	430	880	500	0	4322	588	1055	5965(5130)
14	31.8	70.0	425	541	179	19	1635	35	158	295	430	880	500	0	4509	588	1058	6155(5293)
15	31.7	70.4	471	670	176	19	1843	34	158	295	430	880	500	0	4888	588	1055	6531(5617)
*16	31.3	72.0	507	753	164	18	1965	32	158	295	430	880	500	0	5114	588	1042	6744(5800)
17	30.6	75.0	542	781	142	15	1726	28	158	295	430	880	500	0	4909	588	1019	6516(5604)
18	29.9	77.7	559	748	121	13	927	23	156	295	430	880	500	0	4066	586	988	5640(4850)
19	29.1	80.9	549	656	96	10	263	19	155	295	430	880	500	0	3268	585	952	4805(4132)
20	28.5	83.4	495	527	77	8	212	15	153	295	430	880	500	0	3009	583	925	4517(3885)
21	28.1	85.0	415	388	65	7	179	13	152	295	430	880	500	0	2742	582	903	4227(3635)
22	27.8	86.1	325	263	55	6	153	11	150	295	430	880	500	0	2488	580	885	3953(3400)
23	27.6	87.1	239	162	49	5	136	10	150	295	430	880	500	0	2276	580	879	3735(3212)
24	27.4	87.7	167	92	43	5	119	8	149	295	430	880	500	0	2109	579	863	3551(3054)

F/A : Fresh air
SH : Sensible heat
LH : Latent heat

[Heating load] Condition of indoor design temprature & humidity: 22.0(CDB) 50.0(RH) [W] (kcal/h)

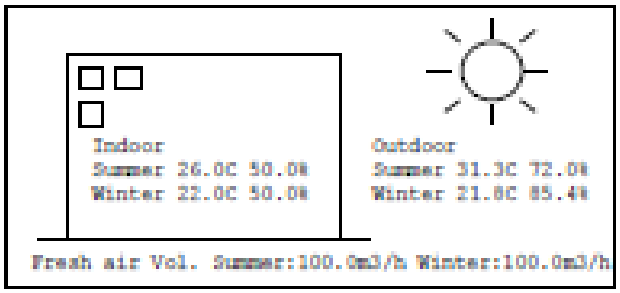
Time	F/A cond.		Outer Wall	Roof & Ceiling	Inner Wall	Floor	Window	Infiltration		Human body		Light -ing	Equipments		Indoor heat		Fresh air	Total heat load	
	CDB	RH						SH	LH	SH	LH		SH	LH	SH	LH			
4	22.2	83.9	0	268	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
5	22.0	84.3	0	277	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
* 6	21.8	85.4	15	286	6	1	19	2	0	-148	0	-440	-250	-0	0	0	7	7	6)
7	22.0	84.3	0	277	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
8	22.6	82.4	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
9	23.4	79.6	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
10	24.4	76.5	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
11	25.4	73.0	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
12	26.3	70.1	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
13	26.8	68.5	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
14	27.0	67.7	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
15	26.9	68.1	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
16	26.7	69.0	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
17	26.4	69.7	0	0	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
18	25.9	71.4	0	97	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
19	25.3	73.5	0	125	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
20	24.8	75.2	0	148	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
21	24.4	76.5	0	166	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
22	24.0	77.8	0	185	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
23	23.6	79.2	0	203	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)
24	23.2	80.6	0	222	0	0	0	0	0	-148	0	-440	-250	-0	0	0	0	0	0)

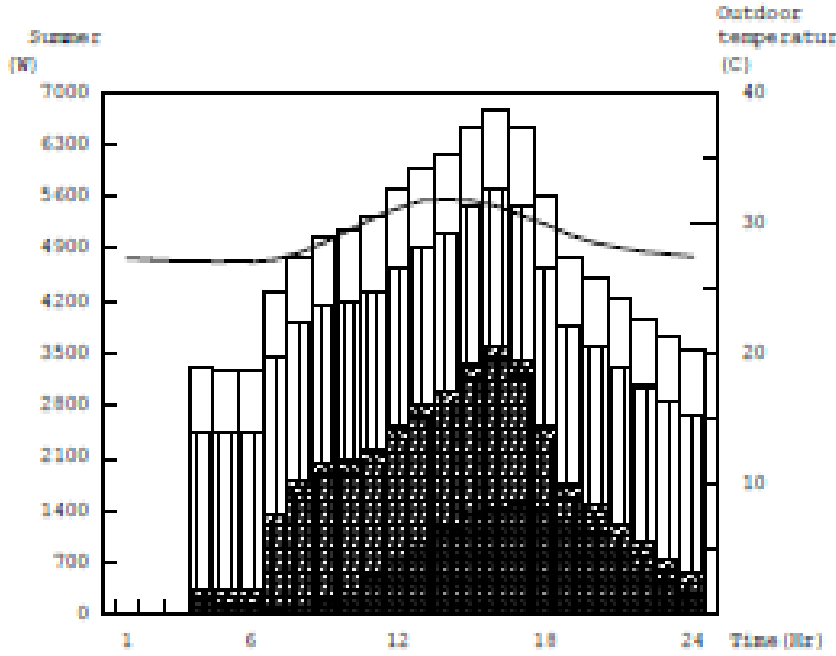
Total heat load in heating is not contained latent heat.If total indoor heat load is negative,it is not calculated.

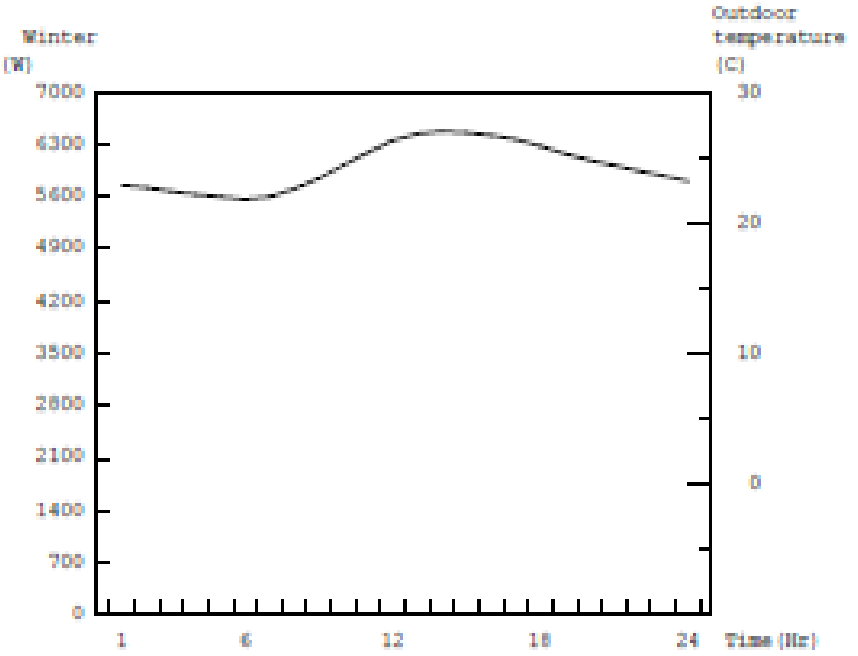
F/A : Fresh air
SH : Sensible heat
LH : Latent heat

Heat load graph

Room name	Floor	System	Rooms	Usage	Fl area(m2)	Height(m)	No of person
Living Room 1	1	1	1	Hotel	25.3	3.6	5







[Detail]

(W)	Time	Outer wall	Roof & Ceiling	Inner wall	Floor	Window	Infiltration		Human body		Light -ing	Equipments		Fresh air	Total heat load	Selected heat load
							SH	LH	SH	LH		SH	LH			
Summer	16	507	753	164	18	1965	32	158	295	430	880	500	0	1042	6744	7081
Winter	6	15	286	6	1	19	2	0	-148	0	-440	-250	-0	7	7	8

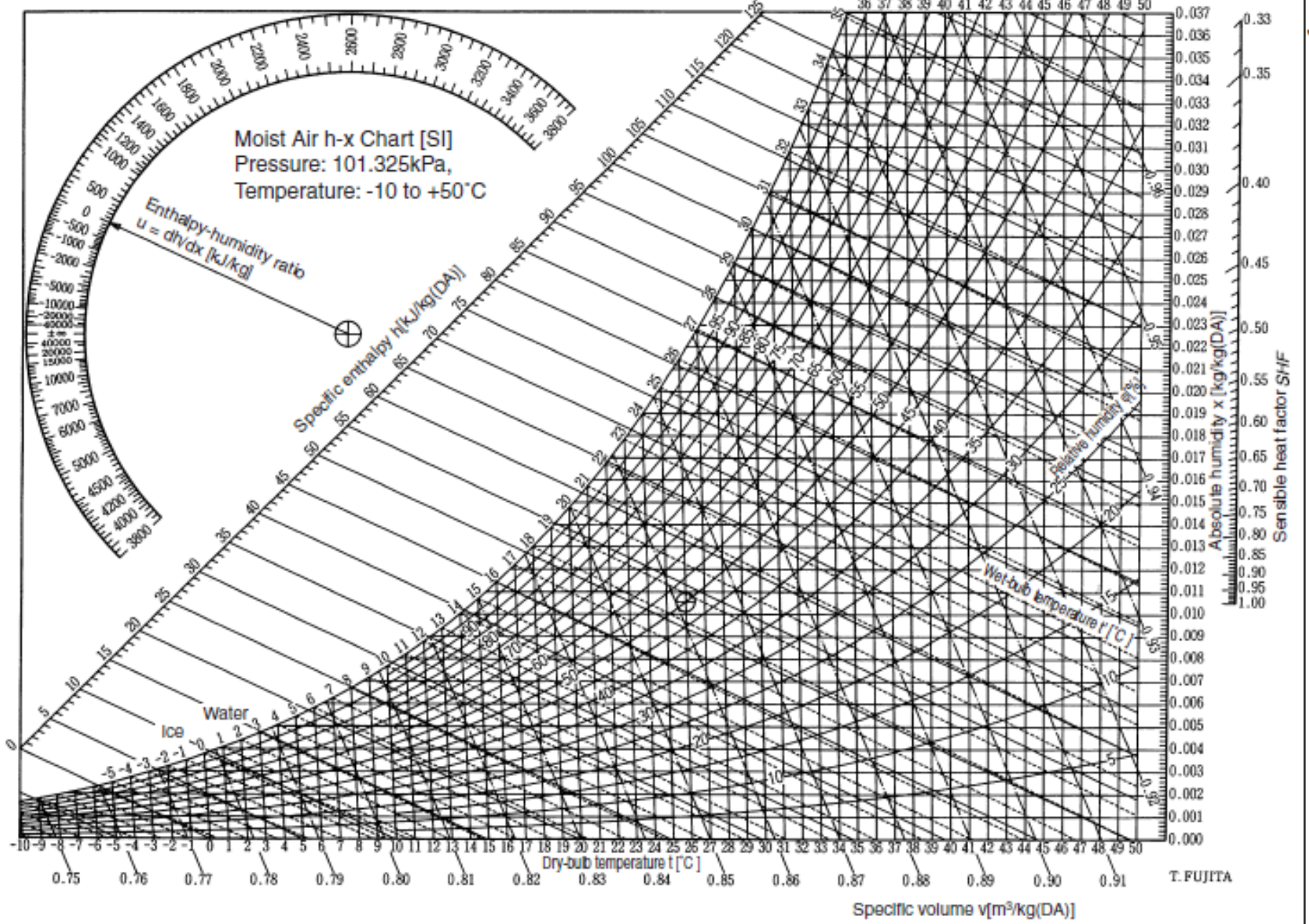
Note) Total indoor heat load & selected heat load are not contained latent heat.If total indoor heat load is negative, it is not calculated.
SH : Sensible heat
LH : Latent heat

Any Question ?

Psychometric Chart

How to use the Psychometric Chart

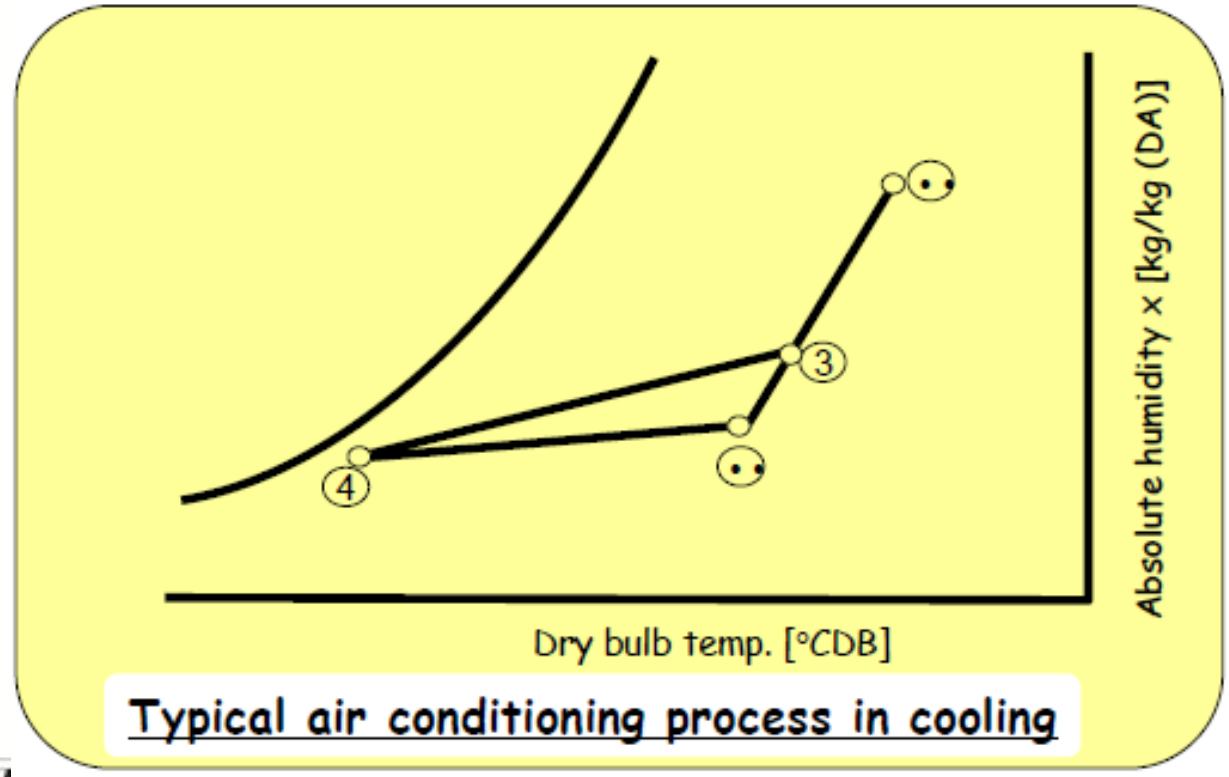
- **- Mixture of Air -**


Moist Air h-x Chart [SI]
Pressure: 101.325kPa,
Temperature: -10 to +50˚C
Enthalpy-humidity ratio
u = dh/dx [kJ/kg]
Specific enthalpy h[kJ/kg(DA)]
Relative humidity φ[%]
Wet-bulb temperature t'[˚C]
Absolute humidity x [kg/kg(DA)]
Sensible heat factor SHF
Water
Ice
Dry-bulb temperature t [˚C]
Specific volume v[m³/kg(DA)]
T. FUJITA

Introduction

- The psychrometric chart allows for:

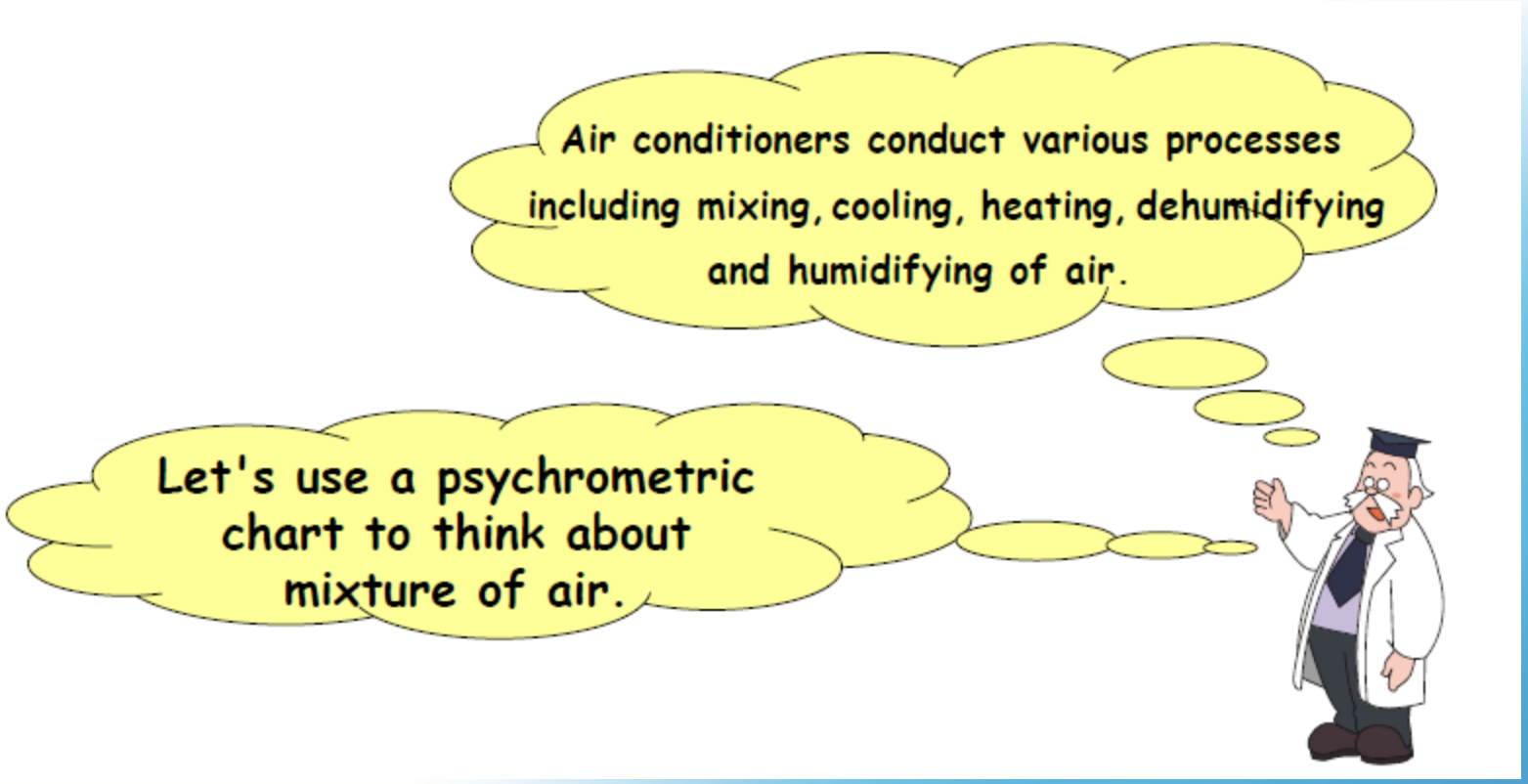
Instant understanding of air properties;
Display of change of the state of the air;
Display of the air conditioning process.



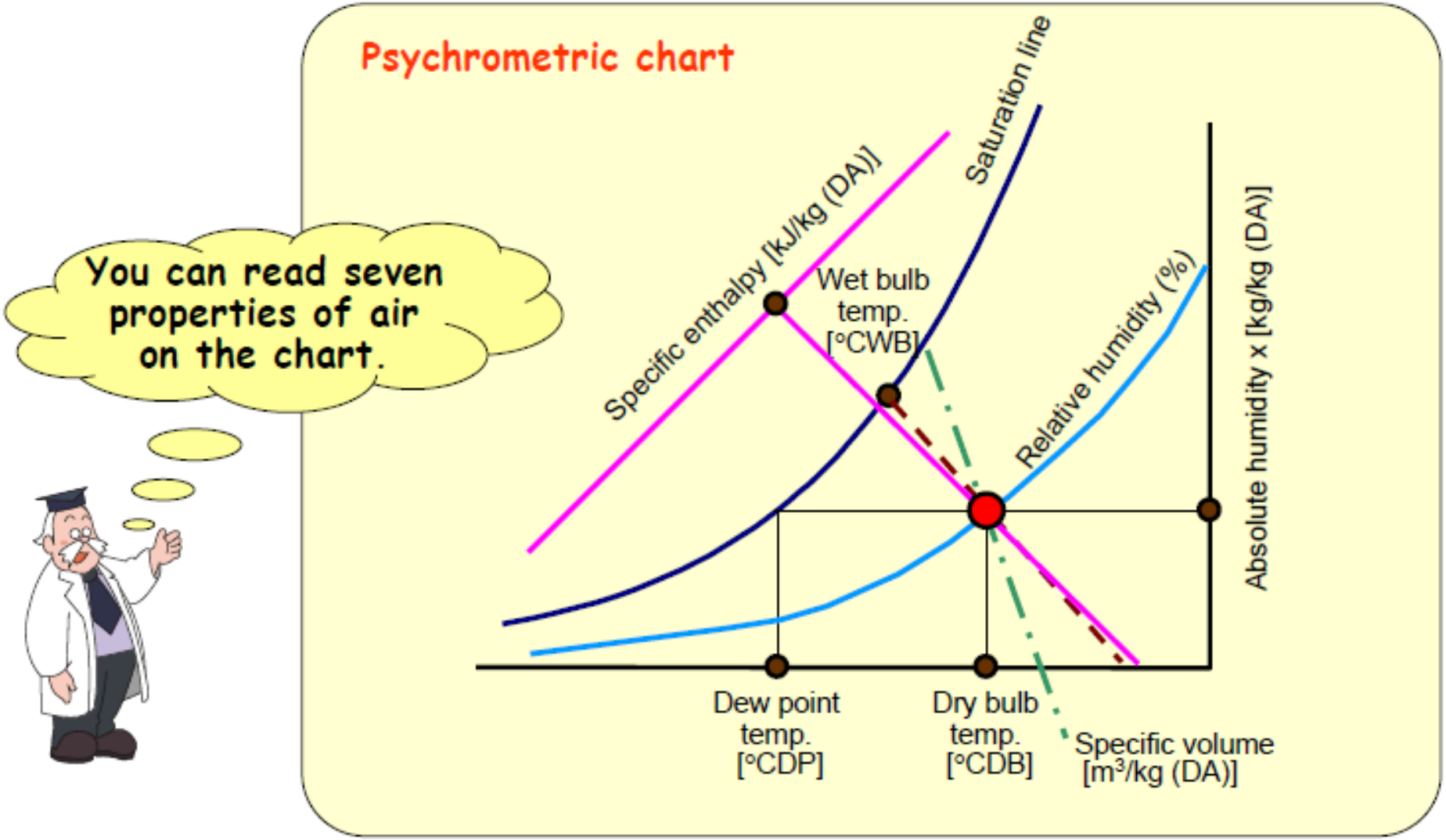
Typical air conditioning process in cooling

Contents

1. **What the composes the Psychometric Chart**
2. **Mixture of Air**
3. **Summary**

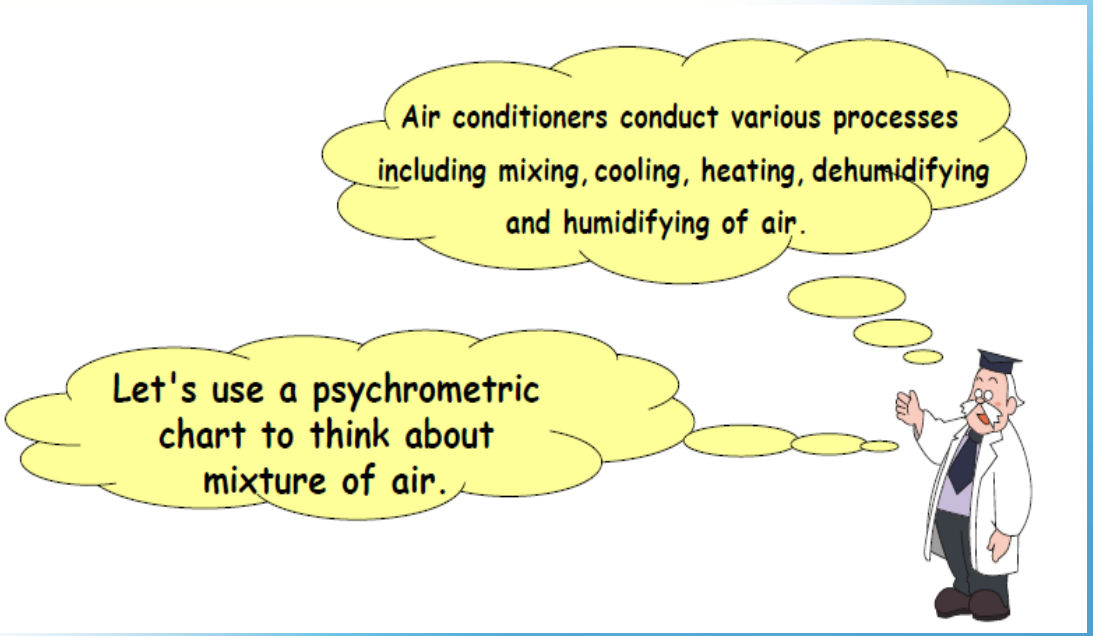


1. What Compose the Psychrometric Chart



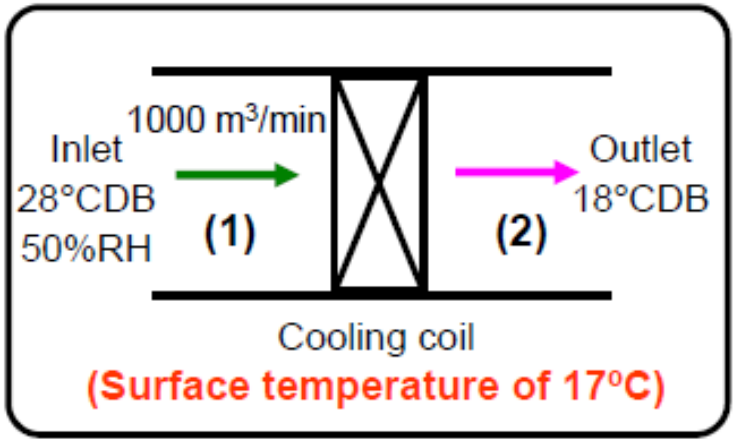
Changes in Air State

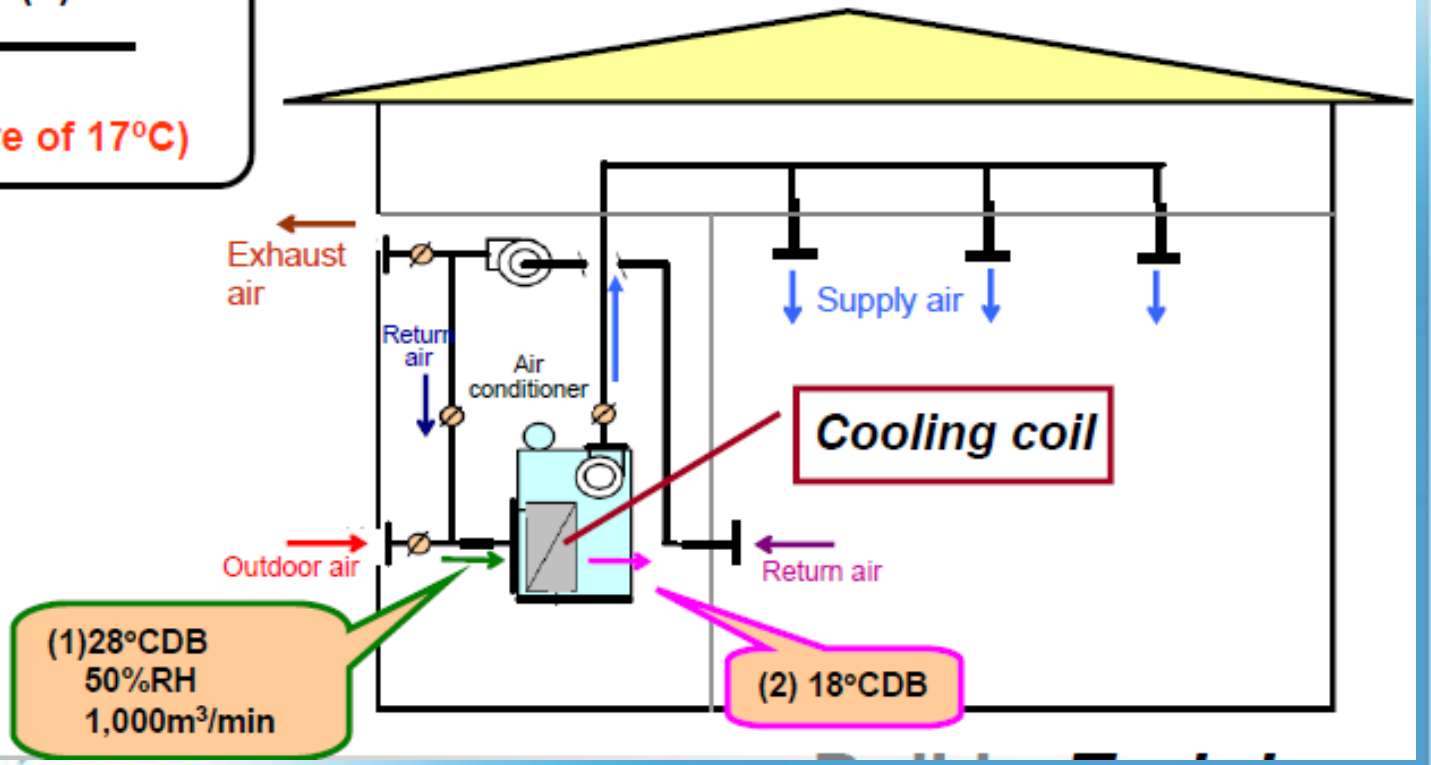
- *Heating*
- *Cooling*
- *Cooling/Dehumidification*
- *Humidification*



Summary Chart

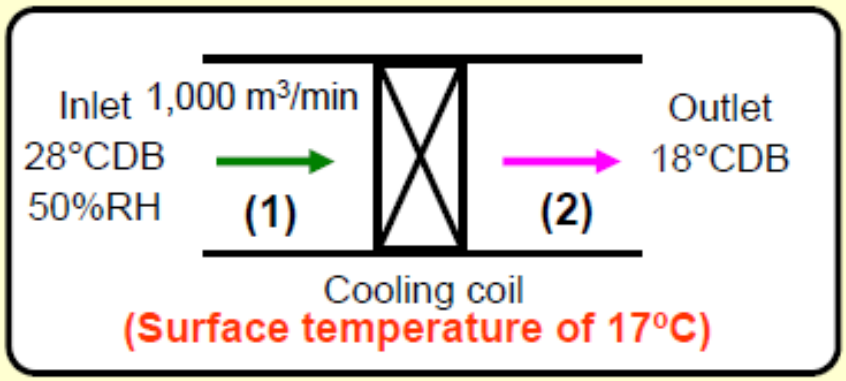
Heating	Humidification	Cooling	Cooling/Dehumidification





Summary Chart

Heating	Humidification	**Cooling**	Cooling/Dehumidification

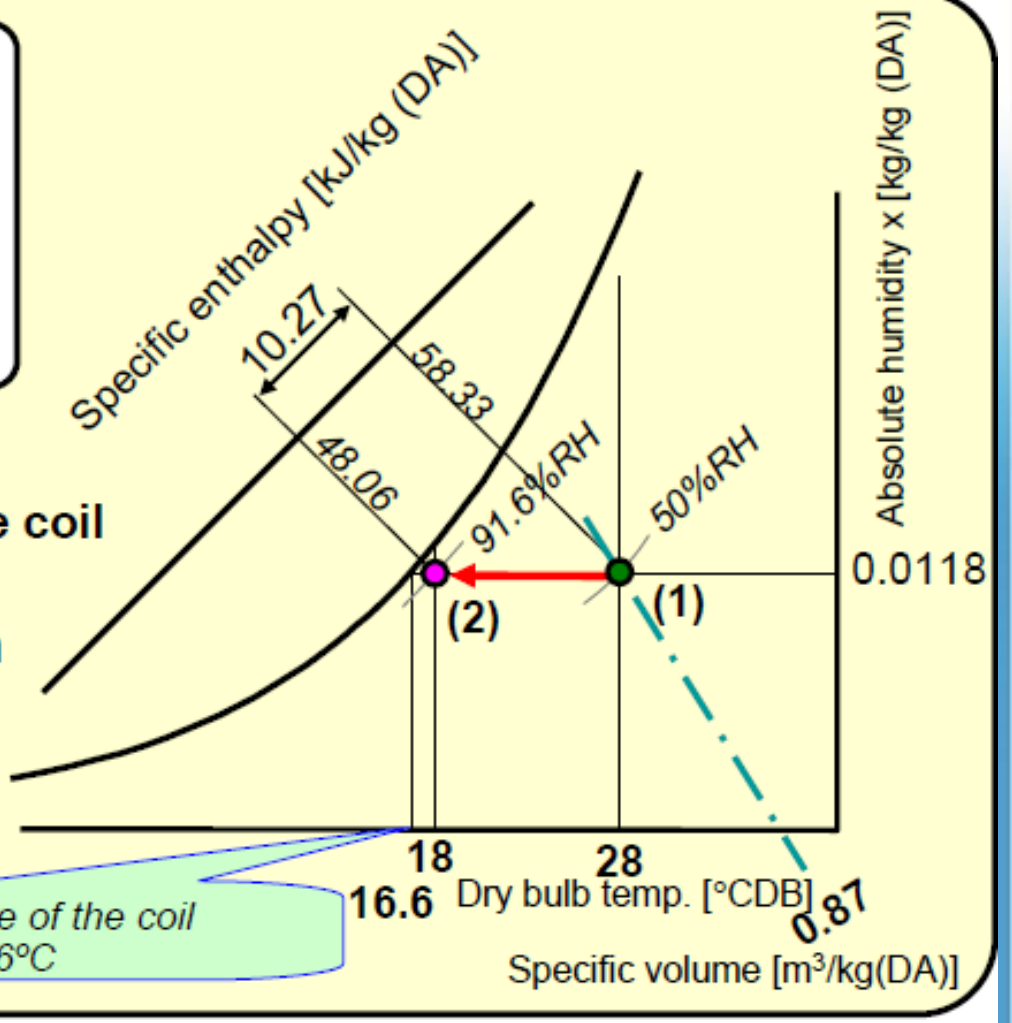


Amount of cooling generated by the coil

$$10.27 \times \frac{1{,}000}{0.87} = 11{,}805 \text{ kJ/min}$$

= 197 kJ/s

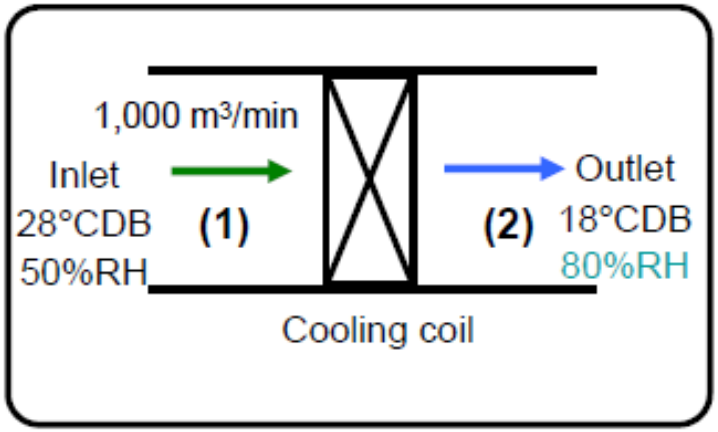
= 197 kW

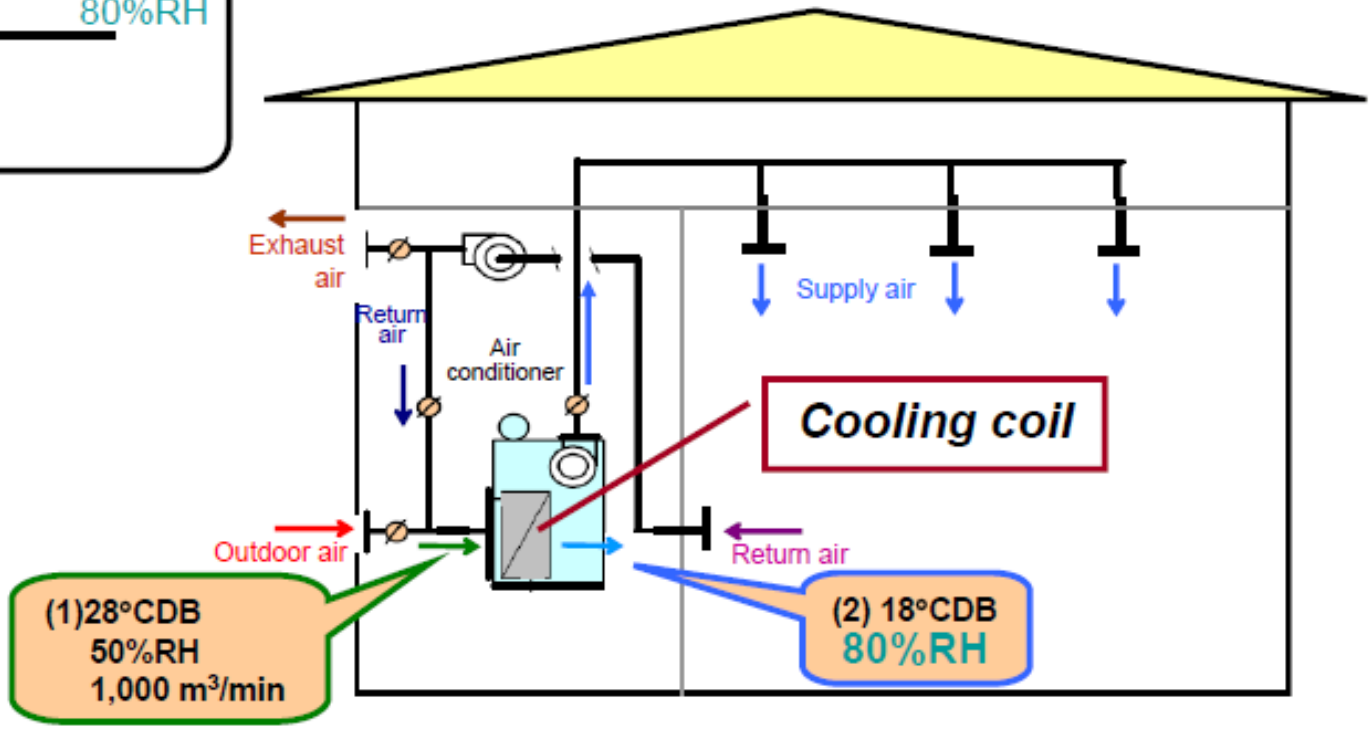


Dew point temperature of the coil inlet air is 16.6°C

Summary Chart

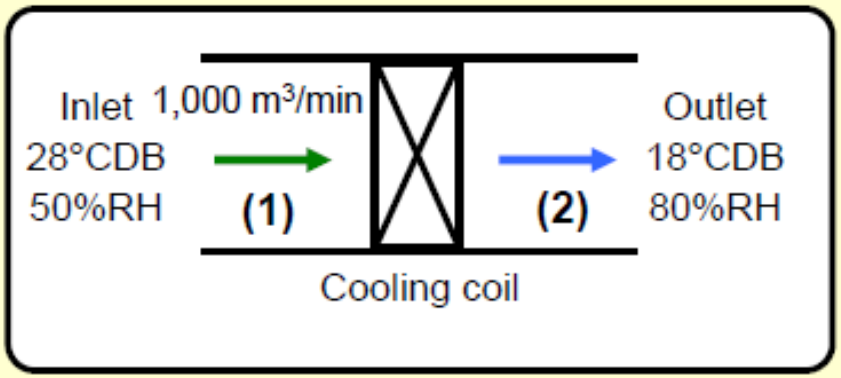
Heating	Humidification	Cooling	Cooling/Dehumidification





Summary Chart

Heating	Humidification	Cooling	Cooling/Dehumidification



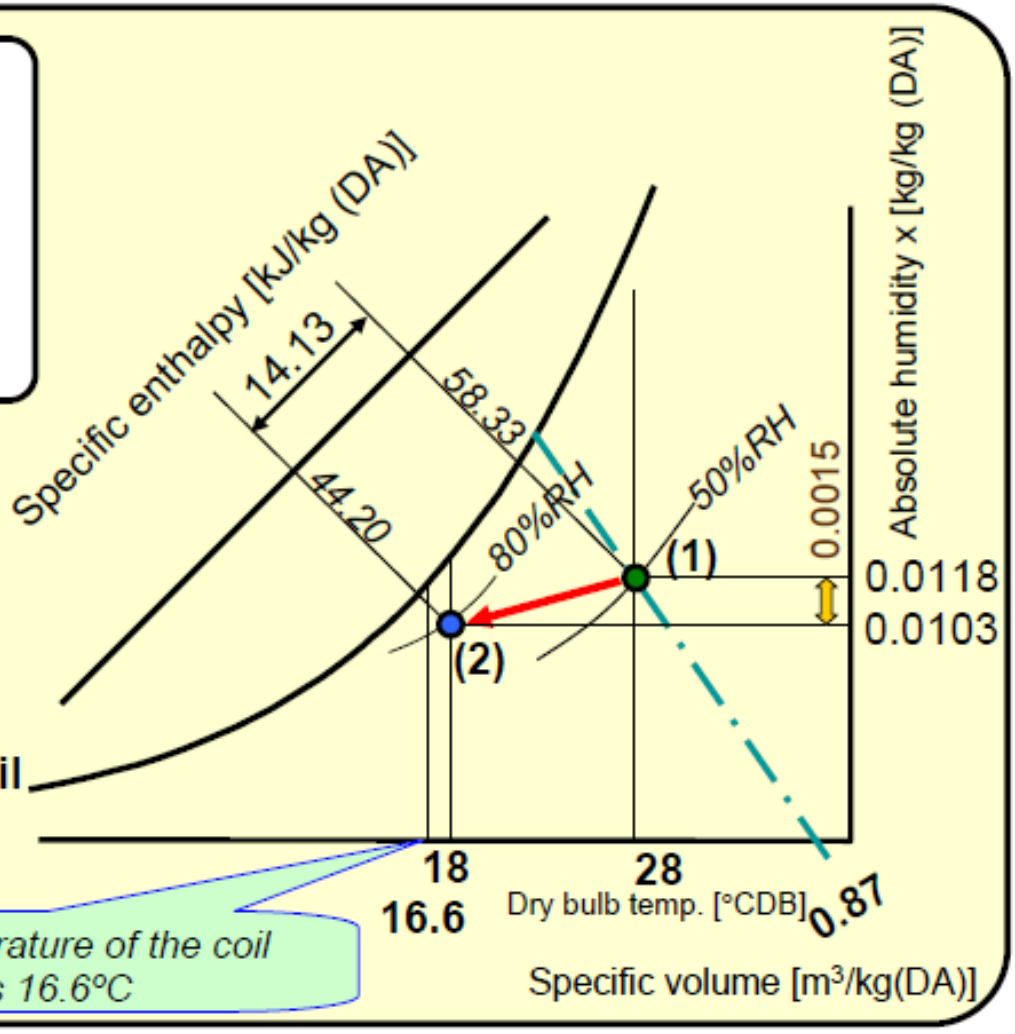
Amount of cooling by the coil

$$14.13 \times \frac{1{,}000}{0.87} = 16{,}241 \text{ kJ/min}$$

= 271 kJ/s = 271kW

Amount of dehumidification by the coil

$$0.0015 \cdot \cdot \frac{1{,}000}{0.87} = 1.72 \text{ kg/min}$$

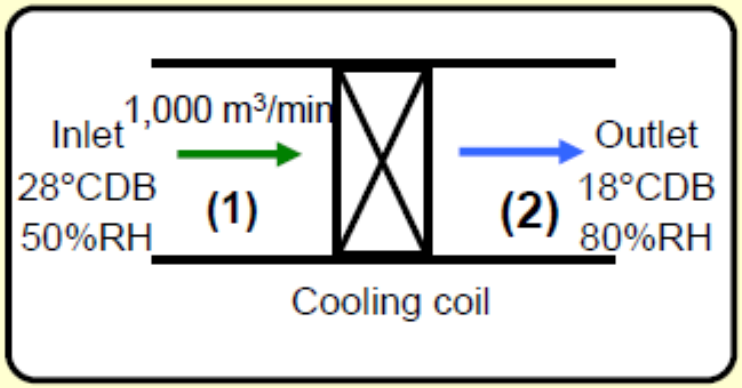


Dew point temperature of the coil inlet air is 16.6°C

Summary Chart

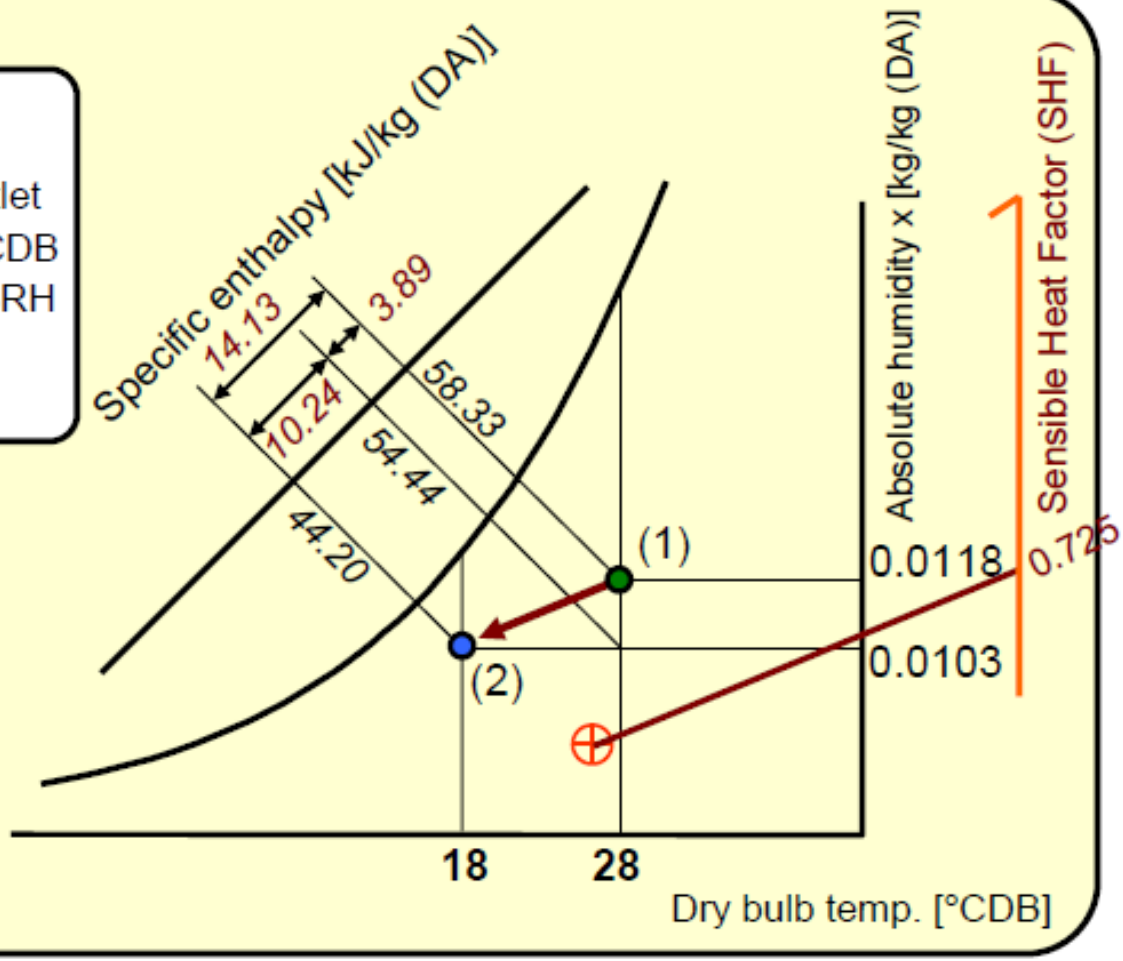
Heating	Humidification	Cooling	Cooling/Dehumidification

<SHF>



SHF (Sensible Heat Factor)

$$= \frac{\text{Sensible heat}}{\text{Total heat}} = \frac{10.24}{14.13} = 0.725$$



3 Method of Cooling Load

1. *Heat Load Calculation*
2. ACH (Air Change per Hour)
3. Assuming method….. Ex 1 m^2 = 700 btu/h

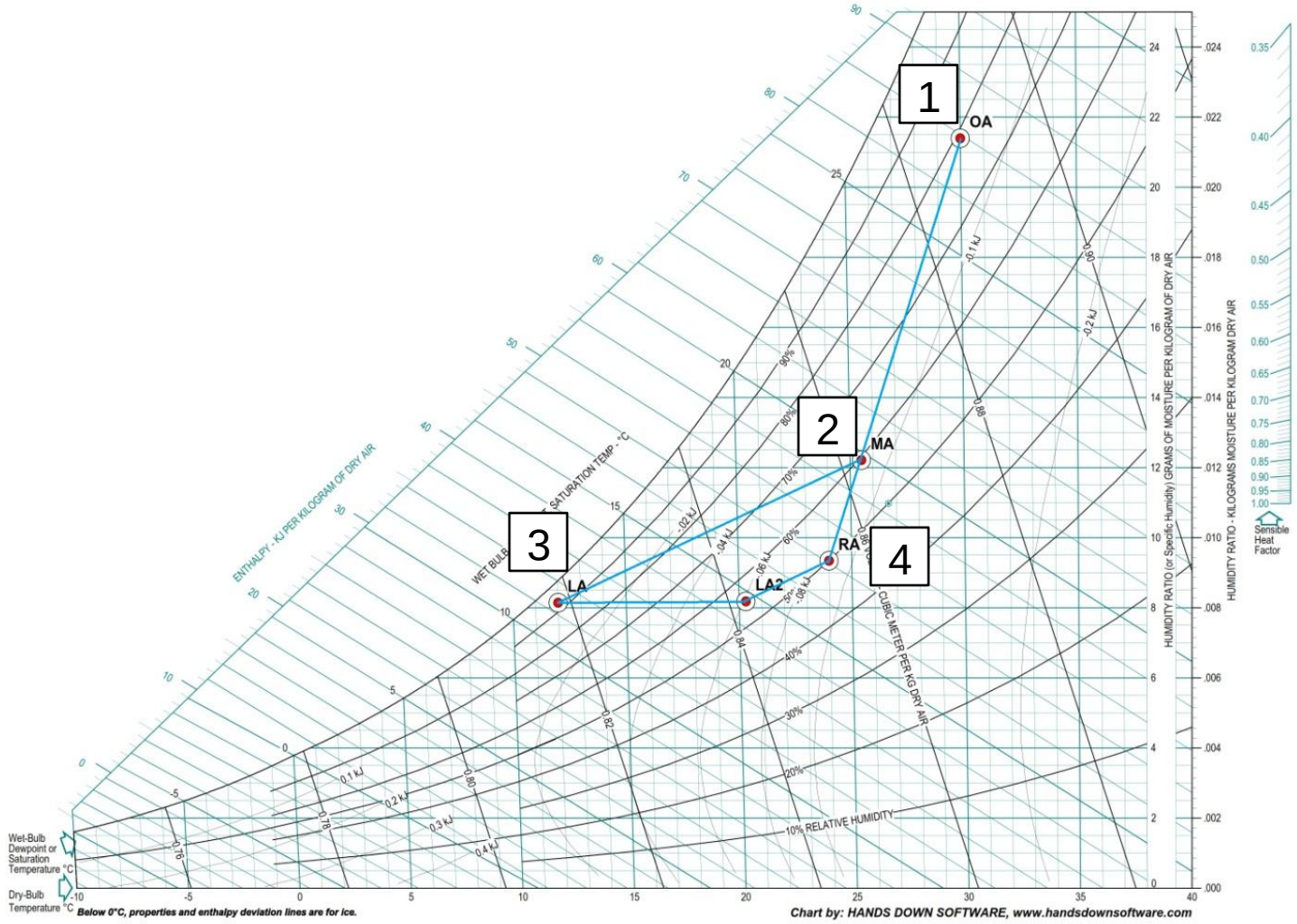
Calculate Heat Load with ACH

- *Room Dimension (L x W x H)= 13 x 10 x 6 = 780 m^3*
- *Ambient Temperature* = 30 ^{O}C, RH = 79%
- *Target Room Condition = 24* ^{O}C, RH = 50%
- ACH = 15 kali
- Fresh Air Assume 10%

DETERMINE ????

1. Airflow = 15 ACH x 780 m3 = 11700 CMH
   6886 CFM
2. Fresh Air = 10% x Airflow = 1170 CMH
   688.6 CFM
3. Mixing Air (Tma) = 25.5^{O}C, RH = 59.5%

4. Leaving Air Condition T_{LA} = 12^{O}C
   RH = 93%


1
OA
2
MA
3
LA
4
RA
LA2
ENTHALPY - KJ PER KILOGRAM OF DRY AIR
SATURATION TEMP - °C
WET BULB
HUMIDITY RATIO (or Specific Humidity) GRAMS OF MOISTURE PER KILOGRAM OF DRY AIR
HUMIDITY RATIO - KILOGRAMS MOISTURE PER KILOGRAM DRY AIR
CUBIC METER PER KG DRY AIR
10% RELATIVE HUMIDITY
Sensible Heat Factor
Wet-Bulb Dewpoint or Saturation Temperature °C
Dry-Bulb Temperature °C
Below 0°C, properties and enthalpy deviation lines are for ice.
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

Calculate Cooling Load

1. $Q_{sensible} = 4,5 \times CFM \times (h_x - h_{la})$
   183,753 Btu/h or 53.85 kW or 15.31 TR
2. $Q_{Laten} = 4,5 \times CFM \times (h_{mix} - h_x)$
   137,582 Btu/h or 40.32 kW or 11.47 TR
3. $Q_{Total} = 4,5 \times CFM \times (h_{mix} - h_{la})$
   321,335 Btu/h or 94.17 kW or 26.7 TR
4. **Sensible Heat Ratio = 0.572**
5. **Air Condition After Reheat = *20.3*^{O}C RH =55%**
3. $Q_{Reheat} = 4,5 \times CFM \times (h_{la2} - h_{la})$
   114.032 Btu/h or 33.42 kW

Conclusion

1. Cooling Capacity = 94.2 kW
2. Capacity Reheat = 33.4 kW
3. Airflow = 11700 CMH or 6886 cfm
4. Room is class 100,000 should be complete with Medium and HEPA filter

Thank You