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HVAC Design

ANALYTICAL METHOD TO CALCULATE ROOM COOLING LOAD AND DUCT DESIGN FOR LIBERARY FLOOR

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Abstract

This report presents an analytical method for calculating room cooling loads, which is essential for HVAC design to ensure thermal comfort and indoor air quality. It covers both latent and sensible loads, considering detailed building data, indoor conditions, and outdoor weather. The methodology involves selecting design conditions, calculating surface areas, and assessing heat transfer coefficients, with a focus on externally and internally loaded buildings. The Cooling Load Temperature Differences (CLTD) method is introduced for simplified calculations, integrating engineering calculations and CFD simulations to enhance HVAC efficiency and practical application.

Additionally, the report details the design of a ventilation system for the AAiT Library ground floor, ensuring optimal indoor air quality for students and staff while protecting books and materials from dust, moisture, and mold. The design process includes generating a CAD drawing of the library floor plan and ventilation layout, sizing the airflow rate and ducts according to EBCS codes, and selecting an energy-efficient fan that meets the required airflow and pressure. Computational Fluid Dynamics (CFD) simulations are performed to optimize and validate the system's performance, demonstrating the integration of CAD software, engineering calculations, and CFD analysis in ventilation system design.

I. INTRODUCTION

The cooling load calculation and analysis for the Library of AAiT, AAU involves detailed building information, location, site and weather data, internal design information, and operating schedules. The following components are considered:

- **Outdoor Design Weather Conditions**
- **Building Characteristics**
- **Operating Schedules**
- **Indoor Design Conditions and Thermal Comfort**
- **Indoor Air Quality and Outdoor Air Requirements**

The total cooling load consists of both sensible and latent loads. Sensible loads include heat transfer through walls, roof, doors, and fenestration, while latent loads arise from infiltration and ventilation. Internal loads include heat generated by occupants, lighting, and equipment.

The building is analyzed as either externally loaded or internally loaded, affecting the design of the cooling system. Cooling load calculations consider heat transfer via conduction, convection, and radiation, influenced by local climate and building materials.

For duct design, the airflow required to maintain the desired indoor temperature and humidity is also calculated. Duct sizing is determined by the total cooling load, air distribution efficiency, and desired air velocity. The design ensures that sufficient airflow is provided to all areas, while minimizing energy losses.

The **Cooling Load Temperature Difference (CLTD)** method, as outlined in the ASHRAE Handbook of Fundamentals (2005), is used for simplified cooling load calculations, involving hand calculations for the heat gain and ductwork design.

The steps for calculating the total heat load are:

- ✓ Select indoor and outdoor design conditions (temperature, relative humidity).
- ✓ Determine the overall heat transfer coefficient.
- ✓ Calculate the area of walls, ceiling, floor, doors, and windows.
- ✓ Compute heat gain from transmission and solar heat gain.
- ✓ Assess sensible and latent heat gain from ventilation, infiltration, and occupants.
- ✓ Account for lighting and equipment heat gain.
- ✓ Design and size the duct system based on the total cooling load and airflow requirements.
- ✓ Calculate the total heat gain and verify system performance.

II. METHODOLOGY

1. Select inside design condition (Temperature, relative humidity).

- Dry bulb temperature (DBT)=22 deg C
- Relative Humidity (RH)=50%

2. Select outside design condition (Temperature, relative humidity).

Values of ambient dry-bulb, dew-point, and wet-bulb temperature corresponding to the various annual percentiles represent the value that is exceeded on average by the indicated percentage of the total number of hours in a year (8760). The 0.4%, 1.0%, 2.0%, and 5.0% values are exceeded on average 35, 88, 175, and 438 h per year, respectively, for the period of record. The 99.0% and 99.6% (cold) values are defined in the same way but are usually viewed as the values for which the corresponding weather element is less than the design condition for 88 and 35 h, respectively.. Tables A1.1 and A1.2 of EBCS represent the outdoor design condition for both cooling and heating respectively at different locations in Ethiopia.

Table A1.1: Outdoor Design Condition for Cooling

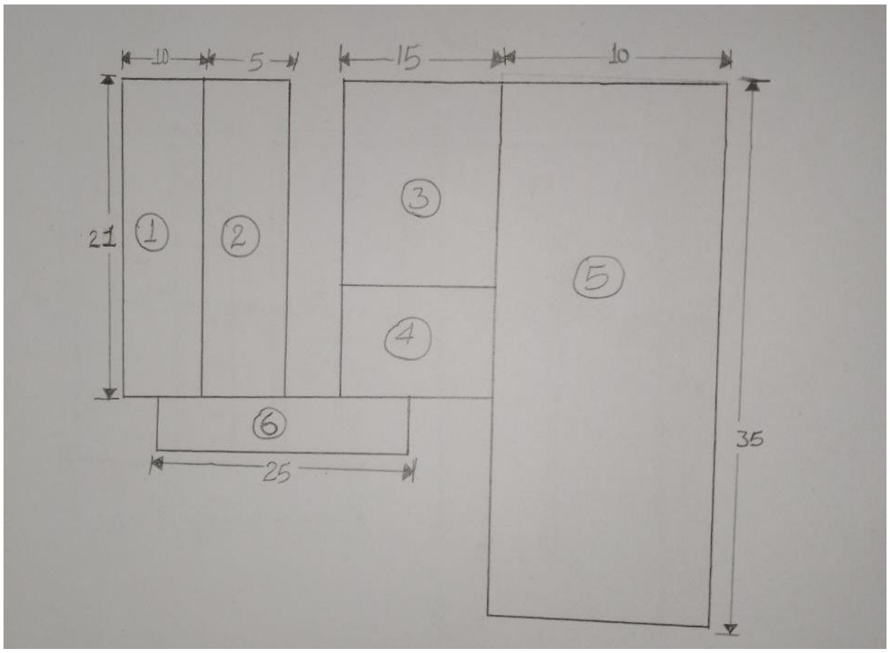
	Location				Annual cumulative frequency of occurrence (%)											
					0.4				1				2.5			
Region	City/Town	Latitude	Longitude	Elevation	DBT (°C)	CWB (°C)	DPT (°C)	MDR	DBT (°C)	CWB	DPT (°C)	MDR	DBT (°C)	CWB	DPT (°C)	MDR
Oromia	Adama	08°55'N	38°55'E	2485m	39.9	28.03	21.25	13.70	33.5	23.43	18.25	13.70	32.6	24.54	20.82	13.70
Addis Ababa	Addis Ababa	09°02'N	39°42'E	2355m	29	23.07	20.35	14.8	28.5	22.59	19.81	14.8	28	21.19	17.73	14.8
Benishangul-Gumuz	Assosa	10°04'N	34°32'E	1570m	35	22.86	14.56	15.7	34.5	21.7	14.16	15.7	34	22.94	17.02	15.7
Amhara	Bahirdar	11°37'N	37°10'E	1800m	33	21.48	14.72	17.6	32.6	19.73	11.3	17.6	32.2	21.09	14.52	17.6
Dire Dawa	Dire Dawa	09°35'N	41°45'E	1200m	38.5	25.88	19.8	13.21	38	27.4	22.75	13.21	37.6	25.99	20.53	13.21
Gambella	Gambella	08°15'N	34°34'E	514m	42.5	29.92	24.92	16.51	42	30.08	25.38	16.51	41.5	29.78	25.11	16.51
Somali	Gode	05°57'N	43°27'E	254m	39.6	34.78	33.13	12.63	39.2	33.94	32.1	12.63	38.7	33.33	31.44	12.63
Somali	Jijiga	09°20'N	42° 50'E	1609m	32.5	24.12	20.1	18.52	32.2	22.53	17.45	18.52	31.7	23.64	19.72	18.52
Tigray	Mekelle	13°33'N	39°30'E	2084m	30	27.97	27.18	13.78	29.8	27.48	26.57	13.78	29.4	27.28	26.44	13.78
Afar	semera	11°30'N	41° 12'E	633m	44.5	28.71	21.81	15.44	44	28.62	21.99	15.44	43.8	31.65	27.1	15.44

DBT= Dry Bulb Temperature
CWB = Coincident Wet Bulb Temperature
DP= Dew Point Temperature
MDR = Mean Daily Range (K)

- At annual frequency of occurrence (1%)

- **DBT=28.5 deg. C**
- **CWT=22.59 deg. C**
- **DPT=19.81 deg. C**
- **MDR=14.8 deg. C**

3. Calculate area of wall, ceiling, floor, door, windows.



I. AREA OF FLOOR (Aw) AND CEILING (Ac)

Sections/Part	Area(m2)
1	210
2	105
3	225
4	120
5	350
6	125
Total	1135

II. AREA OF WINDOW

Directions	Dimensions	Number-of Windows	Area(m2)
North	2.5*4.5	8	11.25*8=90
South	1.5*1	3	1.5*3=4.5

	3.5*4.5	1	15.75*1=15.75
	Total	4	20.25
East	2.5*4.5	14	11.25*14=157.5
West	3.5* 4.5	4	15.75*4=63
	Total	34	330.75

III. AREA OF WALL

Directions	Dimensions(m)	Net Area of Wall(m2)
North	5*40	200 - 90= 110
South	5*40	200 - 20.25=179.75
East	5*35	175-157.5=17.5
West	5*40	200 - 63=137

❖ Assumptions

- Cooling Load of Ceiling is neglected, since it is assumed that the above ground floor and what we have desired to perform are thermally maintained and no temperature difference, CLTD=0.
- Heat gain by conduction and radiation is assumed only for and others are assumed as shaded and heat gain is negligible.
- Library is assumed to be function for 16 hours and the light is turned start from 10:00 local time.

4. Determine the overall heat transfer coefficient

4.1. WALL

4.1.1. U-FACTOR WALL(U)

Table 1 Surface Conductances and Resistances for Air

Position of Surface	Direction of Heat Flow	Surface Emittance, ε					
		Non-reflective ε = 0.90		Reflective ε = 0.20		ε = 0.05	
		h_i	R	h_i	R	h_i	R
STILL AIR							
Horizontal	Upward	9.26	0.11	5.17	0.19	4.32	0.23
Sloping—45°	Upward	9.09	0.11	5.00	0.20	4.15	0.24
Vertical	Horizontal	8.29	0.12	4.20	0.24	3.35	0.30
Sloping—45°	Downward	7.50	0.13	3.41	0.29	2.56	0.39
Horizontal	Downward	6.13	0.16	2.10	0.48	1.25	0.80
MOVING AIR (Any position)		h_o	R				
Wind (for winter) 6.7 m/s (24 km/h)	Any	34.0	0.030	—	—	—	—
Wind (for summer) 3.4 m/s (12 km/h)	Any	22.7	0.044	—	—	—	—

R1= 0.2, R2=0.03

Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values[a] (*Continued*)

Description	Density, kg/m³	Conductivity[b] (k), W/(m·K)	Conductance (C), W/(m²·K)	Resistance[c] (R) 1/k, K·m/W	Resistance[c] (R) For Thickness Listed (1/C), K·m²/W	Specific Heat, kJ/(kg·K)
Gypsum plaster:						
Lightweight aggregate .... 13 mm	720	—	17.7	—	0.056	—
Lightweight aggregate .... 16 mm	720	—	15.2	—	0.066	—
Lightweight aggregate on metal lath .... 19 mm	—	—	12.1	—	0.083	—
Perlite aggregate	720	0.22	—	4.64	—	1.34
Sand aggregate	1680	0.81	—	1.25	—	0.84
Sand aggregate .... 13 mm	1680	—	63.0	—	0.016	—
Sand aggregate .... 16 mm	1680	—	51.7	—	0.019	—
Sand aggregate on metal lath .... 19 mm	—	—	43.7	—	0.023	—
Vermiculite aggregate	720	0.24	—	4.09	—	—

R3=0.056

MASONRY MATERIALS						
Masonry Units						
Brick, fired clay	2400	1.21-1.47	—	0.83-0.68	—	—
	2240	1.07-1.30	—	0.94-0.77	—	—
	2080	0.92-1.12	—	1.08-0.89	—	—
	1920	0.81-0.98	—	1.24-1.02	—	0.79
	1760	0.71-0.85	—	1.42-1.18	—	—
	1600	0.61-0.74	—	1.65-1.36	—	—
	1440	—0.52-0.62	—	1.93-1.61	—	—
	1280	0.43-0.53	—	2.31-1.87	—	—
	1120	0.36-0.45	—	2.77-2.23	—	—
Clay tile, hollow						
1 cell deep ....75 mm	—	—	7.10	—	0.14	0.88
1 cell deep ....100 mm	—	—	5.11	—	0.20	—
2 cells deep..150 mm	—	—	3.75	—	0.27	—
2 cells deep..200 mm	—	—	3.07	—	0.33	—
2 cells deep..250 mm	—	—	2.56	—	0.39	—
3 cells deep..300 mm	—	—	2.27	—	0.44	—
Concrete blocks[n, o]						
Limestone aggregate						
200 mm, 16.3 kg, 2210 kg/m³ concrete, 2 cores......	—	—	—	—	—	—
Same with perlite filled cores	—	—	2.73	—	0.37	—
300 mm, 25 kg, 2210 kg/m³ concrete, 2 cores.........	—	—	—	—	—	—
Same with perlite filled cores	—	—	1.53	—	0.65	—

R4=0.37

R5=R3=0.056

Equivalent Resistance of Wall=Req,w=R1+R2+R3+R4+R5=0.2+0.03+0.056+0.37+0.056

Req,w=1.446

$$U_{wall}=1/R_{wall}=1/(1.446)=0.692$$

4.1.2. HEAT GAIN BY WALL

Group E Walls

N	7	6	5	4	3	2	2	2	3	3	4	5	6	7	8	10	10	11	12	12	11	10	9	8	20	2	12	10
NE	7	6	5	4	3	2	3	5	8	11	13	14	14	14	14	14	15	14	14	13	12	11	9	8	16	2	15	13
E	8	7	6	5	4	3	3	6	10	15	18	20	21	21	20	19	18	18	17	15	14	12	11	9	13	3	21	18
SE	8	7	6	5	4	3	3	4	7	10	14	17	19	20	20	20	19	18	17	16	14	13	11	10	15	3	20	17
S	8	7	6	5	4	3	2	2	2	3	5	7	10	14	16	18	19	18	17	16	14	13	11	10	17	2	19	17
SW	12	10	8	7	6	4	4	3	3	3	4	5	7	10	14	18	21	24	25	24	22	19	17	14	19	3	25	22
W	14	12	10	8	6	5	4	3	3	4	4	5	6	8	11	15	20	24	27	27	25	22	19	16	20	3	27	24
NW	11	9	8	6	5	4	3	3	3	3	4	5	6	7	9	11	14	18	21	21	20	18	15	13	20	3	21	18

1. *Direct application of the table without adjustments:* Values in the table were calculated using the same conditions for walls as outlined for the roof CLTD table, Table 3.17. These values may be used for all normal air-conditioning estimates, usually without correction (except as noted below) when the load is calculated for the hottest weather. For totally shaded walls, use the north orientation values.
2. *Adjustments to table values:* The following equation makes adjustments for conditions other than those listed in note 1.

$$\boxed{CLTD_{corr} = (CLTD + LM)K + (78 - T_R) + (T_o - 85)}$$

where CLTD is from Table 3.19 at the wall orientation.
LM is the latitude-month correction from Table 3.20.
K is a color adjustment factor applied after first making month-latitude adjustment
$K = 1.0$ if dark colored or light in an industrial area
$K = 0.83$ if permanently medium-colored (rural area)
$K = 0.65$ if permanently light-colored (rural area)
Credit should not be taken for wall color other than dark except where permanence of color is established by experience, as in rural areas or where there is little smoke.

❖ CLTD at Lat-8degN and 16degN E/W in East Direction/Face

Table 9 CLTD Correction For Latitude and Month Applied to Walls and Roofs, North Latitudes (SI Units)

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	HOR
0	Dec	−1.6	−2.7	−2.7	−2.7	−1.1	0.0	1.6	3.3	5.0	−0.5
	Jan/Nov	−1.6	−2.7	−2.2	−2.2	−0.5	0.0	1.1	2.2	3.8	−0.5
	Feb/Oct	−1.6	−1.1	−1.1	−1.1	−0.5	−0.5	0.0	−0.5	3.8	−0.0
	Mar/Sept	−1.6	0.0	0.5	−0.5	−0.5	−1.6	−1.6	−2.7	−4.4	0.0
	Apr/Aug	2.7	2.2	1.6	0.0	−1.1	−2.7	−3.3	−4.4	−4.4	−1.1
	May/Jul	5.5	3.8	2.7	0.0	−1.6	−3.8	−4.4	−5.0	−4.4	−2.2
	Jun	6.6	5.0	2.7	0.0	−1.6	−3.8	−5.0	−5.5	−4.4	−2.7
8	Dec	−2.2	−3.3	−3.3	−3.3	−1.6	0.0	2.2	4.4	6.6	−2.7
	Jan/Nov	−1.6	−2.7	−3.3	−2.7	−1.1	0.0	1.6	3.3	5.5	−2.2
	Feb/Oct	−1.6	−2.2	−1.6	−1.6	−0.5	−0.5	0.5	1.1	2.2	−0.5
	Mar/Sept	−1.6	−1.1	−0.5	−0.5	−0.5	−1.1	−1.1	−1.6	−2.2	0.0
	Apr/Aug	1.1	1.1	1.1	0.0	−0.5	−2.2	−2.7	−3.8	−3.8	−0.5
	May/Jul	3.8	2.7	2.2	0.0	−1.1	−2.7	−3.8	−5.0	−3.8	−1.1
	Jun	5.0	3.3	2.2	0.0	−1.1	−3.3	−4.4	−5.0	−3.8	−1.1
16	Dec	−2.2	−3.3	−4.4	−4.4	−2.2	−0.5	2.2	5.0	7.2	−5.0
	Jan/Nov	−2.2	−3.3	−3.8	−3.8	−2.2	−0.5	2.2	4.4	6.6	−3.8
	Feb/Oct	−1.6	−2.7	−2.7	−2.2	−1.1	0.0	1.1	2.7	3.8	−2.2
	Mar/Sept	−1.6	−1.6	−1.1	−1.1	−0.5	−0.5	0.0	0.0	0.0	−0.5
	Apr/Aug	−0.5	0.0	−0.5	−0.5	−0.5	−1.6	−1.6	−2.7	−3.3	0.0
	May/Jul	2.2	1.6	1.6	0.0	−0.5	−2.2	−2.7	−3.8	−3.8	0.0
	Jun	3.3	2.2	2.2	0.5	−0.5	−2.2	−3.3	−4.4	−3.8	0.0

LM latitude – month correction from table is obtained for 9degN of E/W by interpolating Lat-8degN and 16degN of E/W from above table, **LM=-0.5**

$Q_{wall} = U_{wall}.A_{wall}.CLTD_{wall\ corrected}$

Time of Day	CLTD	CLTD corrected	Q(Btu/h)
1	8	9.575	4550.17
2	7	8.925	4241.28

3	6	8.275	3932.39
4	5	7.625	3623.50
5	4	6.975	3314.61
6	3	6.325	3005.72
7	3	6.325	3005.72
8	6	8.275	3932.39
9	10	10.875	5167.95
10	15	14.125	6712.39
11	18	16.075	7639.06
12	20	17.375	8256.84
13	21	18.025	8565.73
14	21	18.025	8565.73
15	20	17.375	8256.84
16	19	16.725	7947.95
17	18	16.075	7639.06
18	18	16.075	7639.06
19	17	15.425	7330.17
20	15	14.125	6712.39
21	14	13.475	6403.50
22	12	12.175	5785.73
23	11	11.525	5476.84
24	9	10.225	4859.06

4.2. Windows

4.2.1.U-FACTOR OF GLASS

30.8 **2001 ASHRAE Fundamentals Handbook (SI)**

Table 4 U-Factors for Various Fenestration Products in W/(m²·K)

Product Type	Glass Only		Vertical Installation: Operable (including sliding and swinging glass doors)					Vertical Installation: Fixed				
Frame Type / ID Glazing Type	Center of Glass	Edge of Glass	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl
Single Glazing												
1 3.2 mm glass	*5.91*	*5.91*	7.24	6.12	5.14	5.05	4.61	6.42	6.07	5.55	5.55	5.35
2 6.4 mm acrylic/polycarbonate	*5.00*	*5.00*	6.49	5.43	4.51	4.42	4.01	5.60	5.25	4.75	4.75	4.58
3 3.2 mm acrylic/polycarbonate	*5.45*	*5.45*	6.87	5.77	4.82	4.73	4.31	6.01	5.66	5.15	5.15	4.97
Double Glazing												
4 6.4 mm air space	*3.12*	*3.63*	4.93	3.70	3.25	3.13	2.77	3.94	3.56	3.19	3.17	3.04
5 12.7 mm air space	*2.73*	*3.36*	4.62	3.42	3.00	2.87	2.53	3.61	3.22	2.86	2.84	2.72
6 6.4 mm argon space	*2.90*	*3.48*	4.75	3.54	3.11	2.98	2.63	3.75	3.37	3.00	2.98	2.85
7 12.7 mm argon space	*2.56*	*3.24*	4.49	3.30	2.89	2.76	2.42	3.47	3.08	2.73	2.70	2.58
Double Glazing, e = 0.60 on surface 2 or 3												

$\boxed{U=7.24}$

30.48 **2001 ASHRAE Fundamentals Handbook (SI)**

Table 19 Interior Solar Attenuation Coefficients (IAC) for Single or Double Glazings Shaded by Interior Venetian Blinds or Roller Shades

Glazing System[a]	Nominal Thickness[b] Each Pane, mm	Glazing Solar Transmittance[b]: Outer Pane	Glazing Solar Transmittance[b]: Single or Inner Pane	Glazing SHGC	IAC: Venetian Blinds: Medium	IAC: Venetian Blinds: Light	IAC: Roller Shades: Opaque Dark	IAC: Roller Shades: Opaque White	IAC: Roller Shades: Translucent Light
Single Glazing Systems									
Clear, residential	3		0.87 to 0.80	0.86	0.75[d]	0.68[d]	0.82	0.40	0.40
Clear, commercial	6 to 13		0.80 to 0.71	0.82					
Clear, pattern	3 to 13		0.87 to 0.79						
Heat absorbing, pattern	3			0.59					
Tinted	5, 5.5		0.74, 0.71						

$\boxed{SC=SHGC/O.87=0.988}$

❖ **Another Option to find SC**

Table 11 Visible Transmission (VT), Shading Coefficient (SC), and Solar Heat Gain Coefficient (SHGC) at Normal Incidence for Single Pane Glass and Insulating Glass

Glazing System: ID, Glass Thick. mm	Center Glazing VT	Center Glazing SC	Glazing SHGC at Specified Incidence Angles: Normal 0°	40°	50°	60°	70°	Hemis. (Diffuse)	Total Window SHGC at Normal Incidence: Aluminum Operable	Aluminum Fixed	Other Frames Operable	Other Frames Fixed	Total Window VT at Normal Incidence: All Frames Operable	All Frames Fixed
Uncoated Single Glazing														
1a 3.2 Clear	0.90	1.00	0.86	0.85	0.83	0.78	0.67	0.78	0.75	0.78	0.63	0.75	0.65	0.78
1b 6.4 Clear	0.89	0.94	0.81	0.80	0.77	0.73	0.62	0.73	0.71	0.74	0.60	0.71	0.65	0.78
1c 3.2 Bronze	0.68	0.85	0.73	0.71	0.69	0.64	0.55	0.65	0.64	0.67	0.54	0.64	0.49	0.59
1d 6.4 Bronze	0.55	0.73	0.62	0.60	0.58	0.54	0.46	0.55	0.55	0.57	0.46	0.54	0.40	0.48
1e 3.2 Green	0.82	0.82	0.71	0.68	0.66	0.62	0.53	0.63	0.62	0.65	0.53	0.62	0.60	0.71
1f 6.4 Green	0.74	0.68	0.58	0.56	0.54	0.51	0.44	0.52	0.51	0.53	0.43	0.51	0.54	0.64
1g 3.2 Gray	0.62	0.82	0.70	0.68	0.66	0.61	0.53	0.63	0.61	0.64	0.52	0.61	0.45	0.54
1h 6.4 Gray	0.43	0.65	0.56	0.53	0.51	0.48	0.41	0.49	0.50	0.51	0.42	0.49	0.31	0.37
1i 6.4 Bluegreen	0.75	0.72	0.62	0.59	0.57	0.54	0.46	0.55	0.55	0.57	0.46	0.54	0.54	0.65
Reflective Single Glazing														
1j 6.4 SS on CLR 8%	0.08	0.22	0.19	0.19	0.18	0.17	0.15	0.17	0.18	0.18	0.15	0.17	0.06	0.07
1k 6.4 SS on CLR 14%	0.14	0.29	0.25	0.25	0.24	0.23	0.20	0.23	0.23	0.24	0.19	0.22	0.10	0.12
1l 6.4 SS on CLR 20%	0.20	0.36	0.31	0.30	0.30	0.28	0.24	0.28	0.28	0.29	0.24	0.27	0.15	0.17
1m 6.4 SS on GRN 14%	0.12	0.29	0.25	0.25	0.24	0.23	0.20	0.23	0.23	0.24	0.19	0.22	0.09	0.10
1n 6.4 TI on CLR 20%	0.20	0.34	0.29	0.29	0.28	0.26	0.23	0.27	0.27	0.27	0.22	0.26	0.15	0.17

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❖ SHGF at Lat-8deg and 12deg in East and West Direction/Face

8 Deg	N	NNE/ NNW	NE/ NW	ENE/ WNW	E/ W/	ESE/ WSW	SE/ SW	SSE/ SSW	S	HOR
Jan.	101	101	224	514	707	789	764	640	511	868
Feb.	107	107	360	609	754	782	691	521	347	928
Mar.	117	211	492	678	$\boxed{760}$	726	581	347	174	947
Apr.	139	369	581	697	710	615	423	167	123	912
May	233	461	625	694	659	527	306	123	120	874
June	284	489	631	685	631	445	259	123	123	849
July	243	457	615	678	644	511	294	126	123	858
Aug.	148	369	565	675	681	587	404	161	129	890
Sep	120	208	470	647	726	691	555	338	177	915
Oct.	110	110	353	590	729	754	666	505	341	909
Nov.	104	104	224	508	694	773	735	631	505	861
Dec.	98	98	174	470	678	776	779	678	565	836

					12 Deg					
	N	NNE/ NNW	NE/ NW	ENE/ WNW	E/ W	ESE/ WSW	SE/ SW	SSE/ SSW	S	HOR
Jan.	98	98	199	489	685	776	779	669	574	827
Feb.	107	107	331	587	741	782	713	558	420	902
Mar.	114	183	467	663	757	735	599	391	230	937
Apr.	126	341	562	691	716	631	448	202	126	915
May	189	439	612	694	669	546	334	126	126	883
June	237	470	625	685	644	508	284	126	126	864
July	199	439	603	678	653	530	322	129	129	868
Aug.	133	344	549	669	688	603	426	196	448	890
Sep.	117	180	448	634	722	700	574	382	230	905
Oct.	107	107	325	568	716	751	691	543	410	883
Nov.	101	101	199	483	675	760	767	659	565	820
Dec.	95	95	148	445	653	764	792	704	622	789

- We will find SHGF at Lat-9degN of E/W side by interpolating, since at Lat-8degN and 12degN in E/W is obtained from the above table.

  8degN=760

  9degN=SHGF

  12degN=75

  (9-8)/ (12-8) =(SHGF-760)/ (757-760) = 759.25

  - SHGF=759.25

4.2.2. Heat Gain Due to Window Conduction

Table 34 Cooling Load Temperature Differences (CLTD) for Conduction through Glass

Solar Time, h	CLTD, °C	Solar Time, h	CLTD, °C
0100	1	1300	7
0200	0	1400	7
0300	−1	1500	8
0400	−1	1600	8
0500	−1	1700	7
0600	−1	1800	7
0700	−1	1900	6
0800	0	2000	4
0900	1	2100	3
1000	2	2200	2
1100	4	2300	2
1200	5	2400	1

Corrections: The values in the table were calculated for an inside temperature of 25.5°C and an outdoor maximum temperature of 35°C with an outdoor daily range of 11.6°C. The table remains approximately correct for other outdoor maximums 33 to 39°C and other outdoor daily ranges 9 to 19°C, provided the outdoor daily average temperature remains approximately 29.5°C. If the room air temperature is different from 25.5°C and/or the outdoor daily average temperature is different from 29.5°C see note 2, Table 32.

Note 2. Adjustments to table data

- Design temperatures

  $$\text{Corr. CLTD} = \text{CLTD} + (25.5 - t_r) + (t_m - 29.4)$$

  where

  t_r = inside temperature and

  t_m = maximum outdoor temperature – (daily range)/2

- No adjustment recommended for color

$$\mathbf{Q_{window} = U_{window}.A_{window}.CLTD_{window,\ corrected}}$$

Time	CLTD (C)	CLTD corrected (C)	CLTD corrected (F)	Q(Btu/h)
1	1	3.6	6.48	14007.76

2	0	2.6	4.68	10116.71
3	-1	1.6	2.88	6225.67
4	-1	1.6	2.88	6225.67
5	-1	1.6	2.88	6225.67
6	-1	1.6	2.88	6225.67
7	-1	1.6	2.88	6225.67
8	0	2.6	4.68	10116.71
9	1	3.6	6.48	14007.76
10	2	4.6	8.28	17898.80
11	4	6.6	11.88	25680.90
12	5	7.6	13.68	29571.94
13	7	9.6	17.28	37354.03
14	7	9.6	17.28	37354.03
15	8	10.6	19.08	41245.08
16	8	10.6	19.08	41245.08
17	7	9.6	17.28	37354.03
18	7	9.6	17.28	37354.03
19	6	8.6	15.48	33462.99
20	4	6.6	11.88	25680.90
21	3	5.6	10.08	21789.85
22	2	4.6	8.28	17898.80
23	2	4.6	8.28	17898.80

24	1	3.6	6.48	14007.76

4.2.3.Heat gain by window due to radiation

Table 35B Zone Types for Use with SCL and CLF Tables, Single-Story Building

Zone Parameters[a]				Zone Type			Error Band	
No. Walls	Floor Covering	Partition Type	Inside Shade	Glass Solar	People and Equipment	Lights	Plus	Minus
1 or 2	Carpet	Gypsum	b	A	B	B	9	2
1 or 2	Carpet	Concrete block	b	B	C	C	9	0
1 or 2	Vinyl	Gypsum	Full	B	C	C	9	0
1 or 2	Vinyl	Gypsum	Half to None	C	C	C	16	0
1 or 2	Vinyl	Concrete block	Full	C	D	D	8	0
1 or 2	Vinyl	Concrete block	Half to None	D	D	D	10	6
3	Carpet	Gypsum	b	A	B	B	9	2
3	Carpet	Concrete block	Full	A	B	B	9	2
3	Carpet	Concrete block	Half to None	B	B	B	9	0
3	Vinyl	Gypsum	Full	B	C	C	9	0
3	Vinyl	Gypsum	Half to None	C	C	C	16	0
3	Vinyl	Concrete block	Full	B	C	C	9	0
3	Vinyl	Concrete block	Half to None	C	C	C	16	0
4	Carpet	Gypsum	b	A	B	B	6	3
4	Vinyl	Gypsum	Full	B	C	C	11	6
4	Vinyl	Gypsum	Half to None	C	C	C	19	−1

[a]A total of 14 zone parameters is fully defined in Table 20. Those not shown in this table were selected to achieve the minimum error band shown in the righthand column for Solar Cooling Load (SCL). The error band for Lights and People and Equipment is approximately 10%.
[b]The effect of inside shade is negligible in this case.

Zone Type C

Glass Face	Hour 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Solar Time																							
N	16	16	13	13	13	76	72	76	85	95	104	107	110	107	101	91	91	107	44	32	25	22	19	19
NE	22	19	19	16	19	236	334	337	277	192	154	148	142	135	126	113	98	79	50	41	35	32	28	25
E	28	25	25	22	25	261	410	466	457	391	280	195	176	164	148	135	117	95	63	54	47	41	38	35
SE	28	25	22	19	19	142	258	337	381	381	337	258	186	161	148	132	113	91	60	50	44	41	35	32
S	22	22	19	16	16	38	57	72	113	170	221	249	249	221	170	126	104	82	50	41	38	32	28	25
SW	44	38	35	32	28	47	66	82	91	104	113	180	271	347	391	394	350	252	117	88	72	63	54	47
W	54	47	41	38	35	54	69	85	98	107	113	117	186	309	416	482	491	403	158	110	88	76	66	60
NW	38	35	32	28	25	44	63	79	91	101	107	113	113	139	230	321	372	337	123	82	66	54	47	41
Hor	76	66	60	54	50	107	214	337	454	551	627	668	677	652	595	504	387	261	167	139	120	107	95	85

$$Q_{window,\ rad} = A_{window}.\ SC.SCL$$

Time	SCL	Q(Btu/h)
1	2	46899.22
2	25	41874.3
3	25	41874.3
4	22	36849.39

5	25	41874.3
6	261	437167.72
7	410	686738.56
8	466	780537
9	457	765462.25
10	391	654914.09
11	280	468992.19
12	195	326619.56
13	176	294795.09
14	164	274695.43
15	148	247895.87
16	135	226121.23
17	117	195971.74
18	95	159122.35
19	63	105523.24
20	54	90448.49
21	47	78723.69
22	41	68673.86
23	38	63648.94
24	35	58624.02

5. Heat Gain from the occupants

Table 37 Cooling Load Factors for People and Unhooded Equipment

Hours in Space	Number of Hours after Entry into Space or Equipment Turned On																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Zone Type D																							
2	0.59	0.67	0.13	0.09	0.08	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
4	0.60	0.67	0.72	0.76	0.20	0.16	0.13	0.11	0.10	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01
6	0.61	0.68	0.73	0.77	0.80	0.83	0.26	0.20	0.17	0.15	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02
8	0.62	0.69	0.74	0.77	0.80	0.83	0.85	0.87	0.30	0.24	0.20	0.17	0.15	0.13	0.11	0.10	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03
10	0.63	0.70	0.75	0.78	0.81	0.84	0.86	0.88	0.89	0.91	0.33	0.27	0.22	0.19	0.17	0.14	0.12	0.11	0.09	0.08	0.07	0.06	0.05	0.05
12	0.65	0.71	0.76	0.79	0.82	0.84	0.87	0.88	0.90	0.91	0.92	0.93	0.35	0.29	0.24	0.21	0.18	0.16	0.13	0.12	0.10	0.09	0.08	0.07
14	0.67	0.73	0.78	0.81	0.83	0.86	0.88	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.37	0.30	0.25	0.22	0.19	0.16	0.14	0.12	0.11	0.09
16	0.70	0.76	0.80	0.83	0.85	0.87	0.89	0.90	0.92	0.93	0.94	0.95	0.95	0.96	0.96	0.97	0.38	0.31	0.26	0.23	0.20	0.17	0.15	0.13
18	0.74	0.80	0.83	0.85	0.87	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.96	0.97	0.97	0.97	0.98	0.98	0.39	0.32	0.27	0.23	0.20	0.17

Note: See Table 35 for zone type. Data based on a radiative/convective fraction of 0.70/0.30.

Equations:

Q sen (Btu/hr) = N (number of people) x SHG (Btu/hr) x CLF

Q lat (Btu/hr) = N (number of people) x LHG (Btu/hr)

SHG =Sensible heat gain

LHG = Latent heat gain

Time of Day	Number of People	Hours in space	SHG(Btu/h)	LHG(Btu/h)	CLF	Qsensible (Btu/h)	Qlatent(Btu/h)	**Qtotal(Btu/h)**
1	100	17	255	187	0.08	2040	18700	20740
2	100	18	255	187	0.07	1785	18700	20485
3	100	19	255	187	0.06	1530	18700	20230
4	100	20	255	187	0.05	1275	18700	19975
5	0	21	255	187	0.05	0	0	0
6	0	22	255	187	0.04	0	0	0
7	0	23	255	187	0.04	0	0	0
8	200	24	255	187	0.03	1530	37400	38930
9	200	1	255	187	0.62	31620	37400	69020
10	200	2	255	187	0.69	35190	37400	72590
11	200	3	255	187	0.74	37740	37400	75140
12	200	4	255	187	0.77	39270	37400	76670
13	200	5	255	187	0.8	40800	37400	78200
14	200	6	255	187	0.83	42330	37400	79730
15	200	7	255	187	0.085	4335	37400	41735
16	200	8	255	187	0.87	44370	37400	81770
17	200	9	255	187	0.3	15300	37400	52700
18	200	10	255	187	0.24	12240	37400	49640
19	200	11	255	187	0.2	10200	37400	47600
20	200	12	255	187	0.17	8670	37400	46070
21	200	13	255	187	0.15	7650	37400	45050
22	200	14	255	187	0.13	6630	37400	44030
23	200	15	255	187	0.11	5610	37400	43010
24	200	16	255	187	0.1	5100	37400	42500

6. Heat Gain Due to Light

Qsen = 3.4 [Btu/hr/w] * CLF * Wattage * fb
Fb = ballast factor (= 1.3flurocent)

Table 39 Cooling Load Factors for Hooded Equipment

Hours in Operation	Number of Hours after Equipment Turned On																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Zone Type D																							
2	0.41	0.53	0.19	0.13	0.11	0.09	0.07	0.07	0.06	0.06	0.04	0.04	0.03	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4	0.43	0.53	0.60	0.66	0.29	0.23	0.19	0.16	0.14	0.11	0.10	0.09	0.07	0.07	0.06	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.01	0.01
6	0.44	0.54	0.61	0.67	0.71	0.76	0.37	0.29	0.24	0.21	0.19	0.16	0.13	0.11	0.10	0.09	0.07	0.07	0.06	0.04	0.04	0.04	0.04	0.03
8	0.46	0.56	0.63	0.67	0.71	0.76	0.79	0.81	0.43	0.34	0.29	0.24	0.21	0.19	0.16	0.14	0.11	0.10	0.09	0.07	0.07	0.06	0.06	0.06
10	0.47	0.57	0.64	0.69	0.73	0.77	0.80	0.83	0.84	0.87	0.47	0.39	0.31	0.27	0.24	0.20	0.17	0.16	0.13	0.11	0.10	0.09	0.09	0.07
12	0.50	0.59	0.66	0.70	0.74	0.77	0.81	0.83	0.86	0.87	0.89	0.90	0.50	0.41	0.34	0.30	0.26	0.23	0.19	0.17	0.14	0.13	0.13	0.11
14	0.53	0.61	0.69	0.73	0.76	0.80	0.83	0.84	0.87	0.89	0.90	0.91	0.93	0.93	0.53	0.43	0.36	0.31	0.27	0.23	0.20	0.18	0.17	0.16
16	0.57	0.66	0.71	0.76	0.79	0.81	0.84	0.86	0.89	0.90	0.91	0.93	0.93	0.94	0.94	0.96	0.54	0.44	0.37	0.33	0.29	0.26	0.24	0.21
18	0.63	0.71	0.76	0.79	0.81	0.84	0.87	0.89	0.90	0.91	0.93	0.93	0.94	0.96	0.96	0.96	0.97	0.97	0.56	0.46	0.39	0.35	0.33	0.29

Note: See Table 35 for zone type. Data based on a radiative/convective fraction of 1.0/0.

Time	**Hours in Operation**	**Wattage**	**fb**	**CLF**	**Q(Btu/h)**
1	**9**	136	1.3	**0.89**	534.9968
2	**10**	136	1.3	**0.9**	541.008
3	**11**	136	1.3	**0.91**	547.0192
4	**12**	136	1.3	**0.93**	559.0416
5	**13**	136	1.3	**0.93**	559.0416
6	**14**	136	1.3	**0.94**	565.0528
7	**15**	136	1.3	**0.94**	565.0528
8	**16**	136	1.3	**0.96**	577.0752
9	**17**	136	1.3	**0.54**	324.6048
10	**18**	136	1.3	**0.44**	264.4928
11	**19**	136	1.3	**0.37**	222.4144
12	**20**	136	1.3	0.33	198.3696
13	**21**	136	1.3	**0.29**	174.3248
14	**22**	136	1.3	**0.26**	156.2912
15	**23**	136	1.3	**0.24**	144.2688
16	**24**	136	1.3	**0.21**	126.2352
17	**1**	136	1.3	0.57	342.6384
18	**2**	136	1.3	0.66	396.7392
19	**3**	136	1.3	0.71	426.7952
20	**4**	136	1.3	0.76	456.8512

21	**5**	136	1.3	0.79	474.8848
22	**6**	136	1.3	0.81	486.9072
23	**7**	136	1.3	0.84	504.9408
24	**8**	136	1.3	0.86	516.9632

7. Infiltration Load

Mass flow rate : m_{inf} = density of air x (ACH x volume of the room)/3600

= 1.225 kg/m^3 * (1*10*35*5)/3600

= 0.595 kg/s

Sensible Infiltration Load : $Q_{s,inf} = m_{inf} * c_{pm}(To - Ti)$

= 0.595 * 1021.6* (301.5- 295)

= 3951.04 W

Latent heat Infiltration Load : $Q_{l,inf} = m_{inf} * h_{fg}(Wo - Wi)$

= 0.595 * 60 (0.0125-0.0085)

= 142.8 W

8. Load of Appliances

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Table 3 Rates of Heat Gain from Occupants of Conditioned Spaces

Degree of Activity		Total Heat, W: Adult Male	Total Heat, W: Adjusted, M/F[a]	Sensible Heat, W	Latent Heat, W	% Sensible Heat that is Radiant[b]: Low V	% Sensible Heat that is Radiant[b]: High V
Seated at theater	Theater, matinee	115	95	65	30		
Seated at theater, night	Theater, night	115	105	70	35	60	27
Seated, very light work	Offices, hotels, apartments	130	115	70	45		
Moderately active office work	Offices, hotels, apartments	140	130	75	55		
Standing, light work; walking	Department store; retail store	160	130	75	55	58	38
Walking, standing	Drug store, bank	160	145	75	70		
Sedentary work	Restaurant[c]	145	160	80	80		
Light bench work	Factory	235	220	80	140		
Moderate dancing	Dance hall	265	250	90	160	49	35
Walking 4.8 km/h; light machine work	Factory	295	295	110	185		
Bowling[d]	Bowling alley	440	425	170	255		
Heavy work	Factory	440	425	170	255	54	19
Heavy machine work; lifting	Factory	470	470	185	285		
Athletics	Gymnasium	585	525	210	315		

Qsen=N*Qs*CLF

Qlat=N*Ql

Table 37 Cooling Load Factors for People and Unhooded Equipment

Hours in Space	Number of Hours after Entry into Space or Equipment Turned On																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Zone Type A																								
2	0.75	0.88	0.18	0.08	0.04	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.75	0.88	0.93	0.95	0.22	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.75	0.88	0.93	0.95	0.97	0.97	0.23	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.24	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
10	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.99	0.99	0.24	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
12	0.75	0.88	0.93	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.25	0.12	0.07	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
14	0.76	0.88	0.93	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03	0.02	0.02	0.01	0.01
16	0.76	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03	0.02	0.02
18	0.77	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03
Zone Type B																								
2	0.65	0.74	0.16	0.11	0.08	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.65	0.75	0.81	0.85	0.24	0.17	0.13	0.10	0.07	0.06	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
6	0.65	0.75	0.81	0.85	0.89	0.91	0.29	0.20	0.15	0.12	0.09	0.07	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
8	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.31	0.22	0.17	0.13	0.10	0.08	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01
10	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.96	0.97	0.33	0.24	0.18	0.14	0.11	0.08	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01
12	0.66	0.76	0.81	0.86	0.89	0.92	0.94	0.95	0.96	0.97	0.98	0.98	0.34	0.24	0.19	0.14	0.11	0.08	0.06	0.05	0.04	0.03	0.02	0.02
14	0.67	0.76	0.82	0.86	0.89	0.92	0.94	0.95	0.96	0.97	0.98	0.98	0.99	0.99	0.35	0.25	0.19	0.15	0.11	0.09	0.07	0.05	0.04	0.03
16	0.69	0.78	0.83	0.87	0.90	0.92	0.94	0.95	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.35	0.25	0.19	0.15	0.11	0.09	0.07	0.05
18	0.71	0.80	0.85	0.88	0.91	0.93	0.95	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.35	0.25	0.19	0.15	0.11	0.09
Zone Type C																								
2	0.60	0.68	0.14	0.11	0.09	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
4	0.60	0.68	0.74	0.79	0.23	0.18	0.14	0.12	0.10	0.08	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
6	0.61	0.69	0.74	0.79	0.83	0.86	0.28	0.22	0.18	0.15	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01
8	0.61	0.69	0.75	0.79	0.83	0.86	0.89	0.91	0.32	0.26	0.21	0.17	0.14	0.11	0.09	0.08	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.02
10	0.62	0.70	0.75	0.80	0.83	0.86	0.89	0.91	0.92	0.94	0.35	0.28	0.23	0.18	0.15	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.03	0.03
12	0.63	0.71	0.76	0.81	0.84	0.87	0.89	0.91	0.93	0.94	0.95	0.96	0.37	0.29	0.24	0.19	0.16	0.13	0.11	0.09	0.07	0.06	0.05	0.04
14	0.65	0.72	0.77	0.82	0.85	0.88	0.90	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.38	0.30	0.25	0.20	0.17	0.14	0.11	0.09	0.08	0.06
16	0.68	0.74	0.79	0.83	0.86	0.89	0.91	0.92	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.39	0.31	0.25	0.21	0.17	0.14	0.11	0.09
18	0.72	0.78	0.82	0.85	0.88	0.90	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.98	0.98	0.99	0.99	0.99	0.39	0.31	0.26	0.21	0.17	0.14
Zone Type D																								
2	0.59	0.67	0.13	0.09	0.08	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
4	0.60	0.67	0.72	0.76	0.20	0.16	0.13	0.11	0.10	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01
6	0.61	0.68	0.73	0.77	0.80	0.83	0.26	0.20	0.17	0.15	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02
8	0.62	0.69	0.74	0.77	0.80	0.83	0.85	0.87	0.30	0.24	0.20	0.17	0.15	0.13	0.11	0.10	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03
10	0.63	0.70	0.75	0.78	0.81	0.84	0.86	0.88	0.89	0.91	0.33	0.27	0.22	0.19	0.17	0.14	0.12	0.11	0.09	0.08	0.07	0.06	0.05	0.05
12	0.65	0.71	0.76	0.79	0.82	0.84	0.87	0.88	0.90	0.91	0.92	0.93	0.35	0.29	0.24	0.21	0.18	0.16	0.13	0.12	0.10	0.09	0.08	0.07
14	0.67	0.73	0.78	0.81	0.83	0.86	0.88	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.37	0.30	0.25	0.22	0.19	0.16	0.14	0.12	0.11	0.09
16	0.70	0.76	0.80	0.83	0.85	0.87	0.89	0.90	0.92	0.93	0.94	0.95	0.95	0.96	0.96	0.97	0.38	0.31	0.26	0.23	0.20	0.17	0.15	0.13
18	0.74	0.80	0.83	0.85	0.87	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.96	0.97	0.97	0.97	0.98	0.98	0.39	0.32	0.27	0.23	0.20	0.17

Note: See Table 35 for zone type. Data based on a radiative/convective fraction of 0.70/0.30.

We selected zone D for the people.

9. Ventilation load

Q-sensible

For appliances:

Table 11 Recommended Load Factors for Various Types of Offices

Load Density of Office	Load Factor, W/m^2	Description
Light	5.4	Assumes 15.5 m^2/workstation (6.5 workstations per 100 m^2) with computer and monitor at each plus printer and fax. Computer, monitor, and fax diversity 0.67, printer diversity 0.33.
Medium	10.8	Assumes 11.6 m^2/workstation (8.5 workstations per 100 m^2) with computer and monitor at each plus printer and fax. Computer, monitor, and fax diversity 0.75, printer diversity 0.50.
Medium/ Heavy	16.1	Assumes 9.3 m^2/workstation (11 workstations per 100 m^2) with computer and monitor at each plus printer and fax. Computer and monitor diversity 0.75, printer and fax diversity 0.50.
Heavy	21.5	Assumes 7.8 m^2/workstation (13 workstations per 100 m^2) with computer and monitor at each plus printer and fax. Computer and monitor diversity 1.0, printer and fax diversity 0.50.

We use heavy load density that is CLF=21.5

Then **Q sensible =At*CLF**, we have that At=970m^2

Where At= total area

Qsen=970*21.5

Qsen= 20,855W = 70,907 Btu/hr

Qlat=0.................since we only consider the computers

10. Ventilation Load

TABLE 6.1 *(Continued)*
Minimum Ventilation Rates In Breathing Zone
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_P		Area Outdoor Air Rate R_A		Notes	Default Values		
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)	
	cfm/person	L/s•person	cfm/ft^2	L/s•m^2		#/1000 ft^2 (#/100 m^2)	cfm/person	L/s•person
Shipping/receiving	-	-	0.12	0.6	B	-		
Transportation waiting	7.5	3.8	0.06	0.3		100	8	4.1
Warehouses	-	-	0.06	0.3	B	-		
Public Assembly Spaces								
Auditorium seating area	5.0	2.5	0.06	0.3		150	5	2.7
Places of religious worship	5.0	2.5	0.06	0.3		120	6	2.8
Courtrooms	5.0	2.5	0.06	0.3		70	6	2.9
Legislative chambers	5.0	2.5	0.06	0.3		50	6	3.1
Libraries	5.0	2.5	0.12	0.6		10	17	8.5
Lobbies	5.0	2.5	0.06	0.3		150	5	2.7
Museums (children's)	7.5	3.8	0.12	0.6		40	11	5.3
Museums/galleries	7.5	3.8	0.06	0.3		40	9	4.6
Retail								

Ventilation Load (per room)

Sensible and Latent Load due to Ventilation

1. Sensible Load

CFM (air flow rate table 6-1) = persons*17

$\boldsymbol{Qsen} = \mathbf{1.08 * CFM * dT}$

dT =To-Ti

where To=83.3 deg F is outside temprature,

Ti=71.6 deg F inside temprature

dT=83.3-71.6=11.7 °F

2. Latent Load

$\boldsymbol{Qlat} = \mathbf{4840 * CFM * dw}$

dW = Humidity ratio of indoor (Wi) minus (-) outdoor humidity (Wo)

From psychrometric chart @Ti=22°C, To=28.5°C, relative humidity(Ǿ)=50%

Wo=0.0125

Wi=0.0083

dW=Wo-Wi=0.0037

Room 5 Area = 350 m2=3767.37ft^2

(3767.37/1000) * 10 = 37persons

CFM=37*17=646 ft^3/min

Qsen=8162.56 Btu/hr

Qlat =11568.568 Btu/hr

Room -4 area =120m^2=1291.67ft^2

(1291.67/1000) *10 = 105 persons

CFM = 13*17 =221 ft^3/min

Qsen=2792.556 Btu/hr

Qlat=3957.668 Btu/hr

Room 3 area =15 *15=225m^2=2421.88ft^2

(2421.88/1000) * 10 = 24persons

CFM=24*17=408 ft^3/min

Q_{sen}=5155.48 Btu/hr

Q_{lat}=7306.46 Btu/hr

Room 2 area105m^2=1130.21ft^2

(1130.21/1000) * 10 = 11 persons

CFM=11*17=187 ft^3/min

Q_{sen}=2362.93 Btu/hr

Q_{lat}=3348.79 Btu/hr

Room 1 area= 210m^2=2260.42ft^2

(2260.42/1000) * 10 = 23persons

CFM = 23*17 =391 ft^3/min

Q$_{sen}$=4940.67 Btu/hr

Q_{lat}=7002.03 Btu/hr

Summary

Room 5

Time	Walls (Btu/h)	Windows Conduction (Btu/h)	Windows Radiation (Btu/h)	People Sensible (Btu/h)	People Latent (Btu/h)	Lights (Btu/h)	Ventilation Sensible (Btu/h)	Ventilation Latent (Btu/h)	Appliance Sensible (Btu/h)	infiltration Sensible (Btu/h)	infiltration Latent (Btu/h)
1	244.94	14007.76	46899.22	2040	18700	534.9968	8162.856	11568.568	70907	13481.5	487.25
2	228.31	10116.72	41874.3	1785	18700	541.008	8162.856	11568.568	70907	13481.5	487.25
3	211.68	6225.67	41874.3	1530	18700	547.0192	8162.856	11568.568	70907	13481.5	487.25
4	195.05	6225.67	36849.39	1275	18700	559.0416	8162.856	11568.568	70907	13481.5	487.25
5	178.43	6225.67	41874.3	0	0	559.0416	8162.856	11568.568	70907	13481.5	487.25
6	161.8	6225.67	437167.72	0	0	565.0528	8162.856	11568.568	70907	13481.5	487.25
7	161.8	6225.67	686738.56	0	0	565.0528	8162.856	11568.568	70907	13481.5	487.25
8	211.68	10116.72	780537	1530	37400	577.0752	8162.856	11568.568	70907	13481.5	487.25
9	278.19	14007.76	765462.25	31620	37400	324.6048	8162.856	11568.568	70907	13481.5	487.25
10	361.33	17898.81	654914.09	35190	37400	264.4928	8162.856	11568.568	70907	13481.5	487.25
11	411.21	25680.9	468992.19	37740	37400	222.4144	8162.856	11568.568	70907	13481.5	487.25
12	444.47	29571.95	326619.56	39270	37400	198.3696	8162.856	11568.568	70907	13481.5	487.25
13	461.09	37354.04	294795.09	40800	37400	174.3248	8162.856	11568.568	70907	13481.5	487.25
14	461.09	37354.04	274695.43	42330	37400	156.2912	8162.856	11568.568	70907	13481.5	487.25
15	444.47	41245.08	247895.87	4335	37400	144.2688	8162.856	11568.568	70907	13481.5	487.25
16	427.84	41245.08	226121.23	44370	37400	126.2352	8162.856	11568.568	70907	13481.5	487.25
17	411.21	37354.04	195971.74	15300	37400	342.6384	8162.856	11568.568	70907	13481.5	487.25

18	411.21	37354.04	159122.35	12240	37400	396.7392	8162.856	11568.568	70907	13481.5	487.25
19	394.58	33462.99	105523.24	10200	37400	426.7952	8162.856	11568.568	70907	13481.5	487.25
20	361.33	25680.9	90448.49	8670	37400	456.8512	8162.856	11568.568	70907	13481.5	487.25
21	344.7	21789.86	78723.69	7650	37400	474.8848	8162.856	11568.568	70907	13481.5	487.25
22	311.45	17898.81	68673.86	6630	37400	486.9072	8162.856	11568.568	70907	13481.5	487.25
23	294.82	17898.81	63648.94	5610	37400	504.9408	8162.856	11568.568	70907	13481.5	487.25
24	261.56	14007.76	58624.02	5100	37400	516.9632	8162.856	11568.568	70907	13481.5	487.25

Room 4

		Windows		People			Ventilation		Appliance	infiltration	
Time	Walls (Btu/h)	Conduction (Btu/h)	Radiation (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)	Lights (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)	Sensible (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)
1	0	0	0	2040	18700	534.9968	2792.556	3957.668	70907	13481.5	487.25
2	0	0	0	1785	18700	541.008	2792.556	3957.668	70907	13481.5	487.25
3	0	0	0	1530	18700	547.0192	2792.556	3957.668	70907	13481.5	487.25
4	0	0	0	1275	18700	559.0416	2792.556	3957.668	70907	13481.5	487.25
5	0	0	0	0	0	559.0416	2792.556	3957.668	70907	13481.5	487.25
6	0	0	0	0	0	565.0528	2792.556	3957.668	70907	13481.5	487.25
7	0	0	0	0	0	565.0528	2792.556	3957.668	70907	13481.5	487.25
8	0	0	0	1530	37400	577.0752	2792.556	3957.668	70907	13481.5	487.25
9	0	0	0	31620	37400	324.6048	2792.556	3957.668	70907	13481.5	487.25
10	0	0	0	35190	37400	264.4928	2792.556	3957.668	70907	13481.5	487.25
11	0	0	0	37740	37400	222.4144	2792.556	3957.668	70907	13481.5	487.25

12	0	0	0	39270	37400	198.3696	2792.556	3957.668	70907	13481.5	487.25
13	0	0	0	40800	37400	174.3248	2792.556	3957.668	70907	13481.5	487.25
14	0	0	0	42330	37400	156.2912	2792.556	3957.668	70907	13481.5	487.25
15	0	0	0	4335	37400	144.2688	2792.556	3957.668	70907	13481.5	487.25
16	0	0	0	44370	37400	126.2352	2792.556	3957.668	70907	13481.5	487.25
17	0	0	0	15300	37400	342.6384	2792.556	3957.668	70907	13481.5	487.25
18	0	0	0	12240	37400	396.7392	2792.556	3957.668	70907	13481.5	487.25
19	0	0	0	10200	37400	426.7952	2792.556	3957.668	70907	13481.5	487.25
20	0	0	0	8670	37400	456.8512	2792.556	3957.668	70907	13481.5	487.25
21	0	0	0	7650	37400	474.8848	2792.556	3957.668	70907	13481.5	487.25
22	0	0	0	6630	37400	486.9072	2792.556	3957.668	70907	13481.5	487.25
23	0	0	0	5610	37400	504.9408	2792.556	3957.668	70907	13481.5	487.25
24	0	0	0	5100	37400	516.9632	2792.556	3957.668	70907	13481.5	487.25

Room 3

		Windows		People			Ventilation		Appliance	infiltration	
Time	Walls (Btu/h)	Conduction (Btu/h)	Radiation (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)	Lights (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)	Sensible (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)
1	0	0	0	2040	18700	534.9968	5155.488	7306.464	70907	13481.5	487.25
2	0	0	0	1785	18700	541.008	5155.488	7306.464	70907	13481.5	487.25
3	0	0	0	1530	18700	547.0192	5155.488	7306.464	70907	13481.5	487.25
4	0	0	0	1275	18700	559.0416	5155.488	7306.464	70907	13481.5	487.25
5	0	0	0	0	0	559.0416	5155.488	7306.464	70907	13481.5	487.25

6	0	0	0	0	0	565.0528	5155.488	7306.464	70907	13481.5	487.25
7	0	0	0	0	0	565.0528	5155.488	7306.464	70907	13481.5	487.25
8	0	0	0	1530	37400	577.0752	5155.488	7306.464	70907	13481.5	487.25
9	0	0	0	31620	37400	324.6048	5155.488	7306.464	70907	13481.5	487.25
10	0	0	0	35190	37400	264.4928	5155.488	7306.464	70907	13481.5	487.25
11	0	0	0	37740	37400	222.4144	5155.488	7306.464	70907	13481.5	487.25
12	0	0	0	39270	37400	198.3696	5155.488	7306.464	70907	13481.5	487.25
13	0	0	0	40800	37400	174.3248	5155.488	7306.464	70907	13481.5	487.25
14	0	0	0	42330	37400	156.2912	5155.488	7306.464	70907	13481.5	487.25
15	0	0	0	4335	37400	144.2688	5155.488	7306.464	70907	13481.5	487.25
16	0	0	0	44370	37400	126.2352	5155.488	7306.464	70907	13481.5	487.25
17	0	0	0	15300	37400	342.6384	5155.488	7306.464	70907	13481.5	487.25
18	0	0	0	12240	37400	396.7392	5155.488	7306.464	70907	13481.5	487.25
19	0	0	0	10200	37400	426.7952	5155.488	7306.464	70907	13481.5	487.25
20	0	0	0	8670	37400	456.8512	5155.488	7306.464	70907	13481.5	487.25
21	0	0	0	7650	37400	474.8848	5155.488	7306.464	70907	13481.5	487.25
22	0	0	0	6630	37400	486.9072	5155.488	7306.464	70907	13481.5	487.25
23	0	0	0	5610	37400	504.9408	5155.488	7306.464	70907	13481.5	487.25
24	0	0	0	5100	37400	516.9632	5155.488	7306.464	70907	13481.5	487.25

Room 2

Time	Walls (Btu/h)	Windows Conduction (Btu/h)	Windows Radiation (Btu/h)	People Sensible (Btu/h)	People Latent (Btu/h)	Lights (Btu/h)	Ventilation Sensible (Btu/h)	Ventilation Latent (Btu/h)	Appliance Sensible (Btu/h)	infiltration Sensible (Btu/h)	infiltration Latent (Btu/h)
1	0	0	0	2040	18700	534.9968	2362.932	3348.796	70907	13481.5	487.25
2	0	0	0	1785	18700	541.008	2362.932	3348.796	70907	13481.5	487.25
3	0	0	0	1530	18700	547.0192	2362.932	3348.796	70907	13481.5	487.25
4	0	0	0	1275	18700	559.0416	2362.932	3348.796	70907	13481.5	487.25
5	0	0	0	0	0	559.0416	2362.932	3348.796	70907	13481.5	487.25
6	0	0	0	0	0	565.0528	2362.932	3348.796	70907	13481.5	487.25
7	0	0	0	0	0	565.0528	2362.932	3348.796	70907	13481.5	487.25
8	0	0	0	1530	37400	577.0752	2362.932	3348.796	70907	13481.5	487.25
9	0	0	0	31620	37400	324.6048	2362.932	3348.796	70907	13481.5	487.25
10	0	0	0	35190	37400	264.4928	2362.932	3348.796	70907	13481.5	487.25
11	0	0	0	37740	37400	222.4144	2362.932	3348.796	70907	13481.5	487.25
12	0	0	0	39270	37400	198.3696	2362.932	3348.796	70907	13481.5	487.25
13	0	0	0	40800	37400	174.3248	2362.932	3348.796	70907	13481.5	487.25
14	0	0	0	42330	37400	156.2912	2362.932	3348.796	70907	13481.5	487.25
15	0	0	0	4335	37400	144.2688	2362.932	3348.796	70907	13481.5	487.25
16	0	0	0	44370	37400	126.2352	2362.932	3348.796	70907	13481.5	487.25
17	0	0	0	15300	37400	342.6384	2362.932	3348.796	70907	13481.5	487.25
18	0	0	0	12240	37400	396.7392	2362.932	3348.796	70907	13481.5	487.25

19	0	0	0	10200	37400	426.7952	2362.932	3348.796	70907	13481.5	487.25
20	0	0	0	8670	37400	456.8512	2362.932	3348.796	70907	13481.5	487.25
21	0	0	0	7650	37400	474.8848	2362.932	3348.796	70907	13481.5	487.25
22	0	0	0	6630	37400	486.9072	2362.932	3348.796	70907	13481.5	487.25
23	0	0	0	5610	37400	504.9408	2362.932	3348.796	70907	13481.5	487.25
24	0	0	0	5100	37400	516.9632	2362.932	3348.796	70907	13481.5	487.25

Room 1

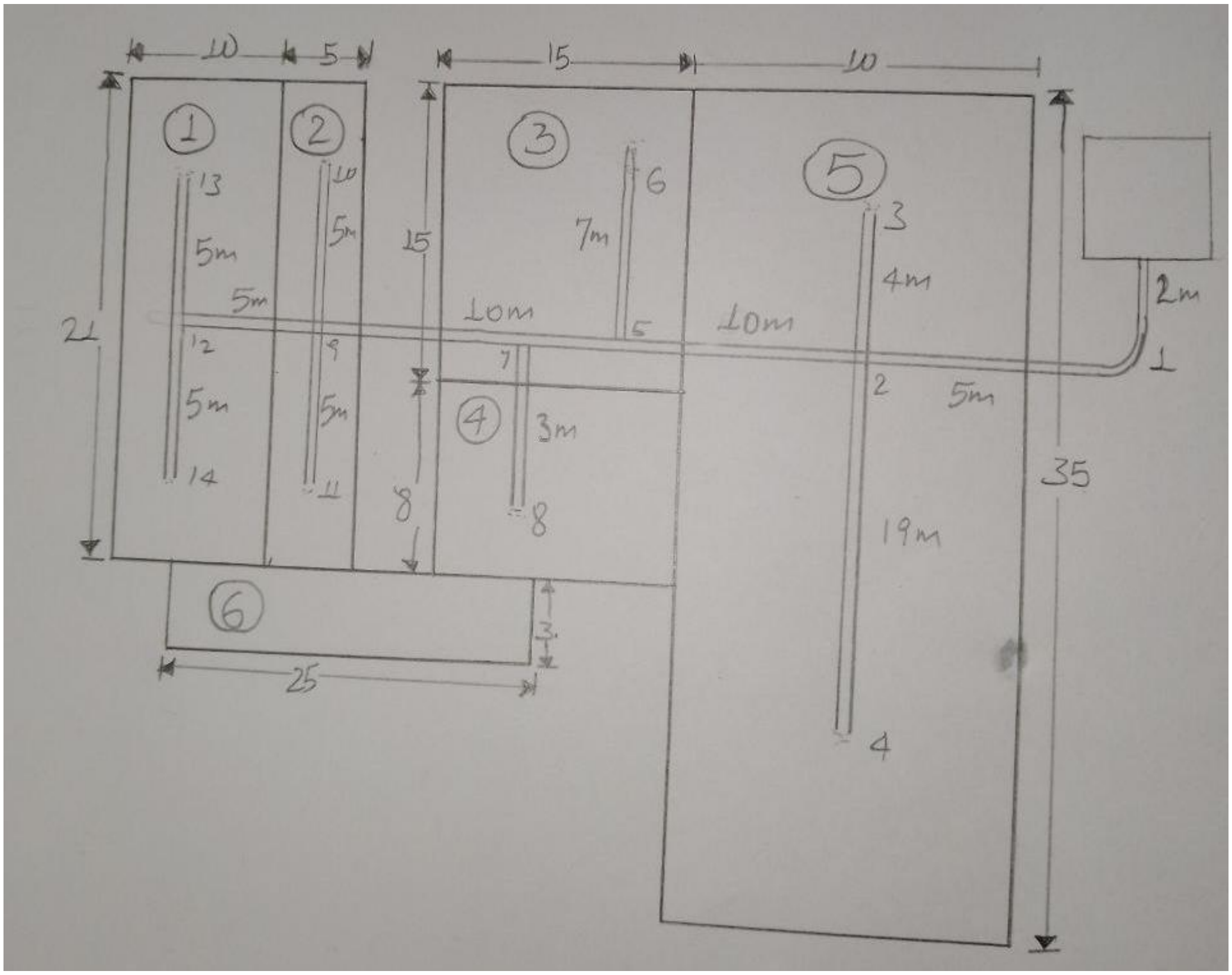
Time	Walls (Btu/h)	Windows		People		Lights (Btu/h)	Ventilation		Appliance	infiltration	
		Conduction (Btu/h)	Radiation (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)		Sensible (Btu/h)	Latent (Btu/h)	Sensible (Btu/h)	Sensible (Btu/h)	Latent (Btu/h)
1	0	0	0	2040	18700	534.9968	4940.676	7002.028	70907	13481.5	487.25
2	0	0	0	1785	18700	541.008	4940.676	7002.028	70907	13481.5	487.25
3	0	0	0	1530	18700	547.0192	4940.676	7002.028	70907	13481.5	487.25
4	0	0	0	1275	18700	559.0416	4940.676	7002.028	70907	13481.5	487.25
5	0	0	0	0	0	559.0416	4940.676	7002.028	70907	13481.5	487.25
6	0	0	0	0	0	565.0528	4940.676	7002.028	70907	13481.5	487.25
7	0	0	0	0	0	565.0528	4940.676	7002.028	70907	13481.5	487.25
8	0	0	0	1530	37400	577.0752	4940.676	7002.028	70907	13481.5	487.25
9	0	0	0	31620	37400	324.6048	4940.676	7002.028	70907	13481.5	487.25
10	0	0	0	35190	37400	264.4928	4940.676	7002.028	70907	13481.5	487.25
11	0	0	0	37740	37400	222.4144	4940.676	7002.028	70907	13481.5	487.25

12	0	0	0	39270	37400	198.3696	4940.676	7002.028	70907	13481.5	487.25
13	0	0	0	40800	37400	174.3248	4940.676	7002.028	70907	13481.5	487.25
14	0	0	0	42330	37400	156.2912	4940.676	7002.028	70907	13481.5	487.25
15	0	0	0	4335	37400	144.2688	4940.676	7002.028	70907	13481.5	487.25
16	0	0	0	44370	37400	126.2352	4940.676	7002.028	70907	13481.5	487.25
17	0	0	0	15300	37400	342.6384	4940.676	7002.028	70907	13481.5	487.25
18	0	0	0	12240	37400	396.7392	4940.676	7002.028	70907	13481.5	487.25
19	0	0	0	10200	37400	426.7952	4940.676	7002.028	70907	13481.5	487.25
20	0	0	0	8670	37400	456.8512	4940.676	7002.028	70907	13481.5	487.25
21	0	0	0	7650	37400	474.8848	4940.676	7002.028	70907	13481.5	487.25
22	0	0	0	6630	37400	486.9072	4940.676	7002.028	70907	13481.5	487.25
23	0	0	0	5610	37400	504.9408	4940.676	7002.028	70907	13481.5	487.25
24	0	0	0	5100	37400	516.9632	4940.676	7002.028	70907	13481.5	487.25

Room		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
Room 1	Sensible	91904	91655	91406	91163	89888	89894	89894	91436	121274	124784	127292	128798	130304	131815	93808	133825	104972	101966	99956	98456	97454	96446	95444	94946

	Latent	26189	26189	26189	26189	7489	7489	7489	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889	44889
Room 2	Sensible	89326	89077	88828	88585	87310	87316	87316	88859	118696	122206	124714	126220	127726	129238	91231	131248	102394	99388	97378	95878	94876	93868	92866	92368
	Latent	22536	22536	22536	22536	3836	3836	3836	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236	41236
Room 3	Sensible	92119	91870	91621	91378	90103	90109	90109	91651	121489	124998	127506	129012	130518	132030	94023	134040	105187	102181	100171	98671	97669	96661	95659	95161
	Latent	26494	26494	26494	26494	7794	7794	7794	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194	45194
Room 4	Sensible	89756	89507	89258	89015	87740	87746	87746	89288	119126	122636	125143	126649	128155	129667	91660	131677	102824	99818	97808	96308	95306	94298	93296	92798
	Latent	23145	23145	23145	23145	4445	4445	4445	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845	41845
Room 5	Sensible	156278	147097	142940	137656	141389	536672	786242	885524	904244	801180	625598	488656	466136	447548	386616	404842	341931	302076	242559	218169	201534	186552	180509	171062
	Latent	30756	30756	30756	30756	12056	12056	12056	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456	49456
Total Sensible		519383	509206	504053	497797	496430	891737	1141307	1246758	1384829	1295804	1130253	999335	982839	970298	757338	935632	757308	705429	637872	607482	586839	567825	557774	546335
Total Latent		129120	129120	129120	129120	35620	35620	35620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620	222620

Duct Design



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19m
4
2m
1

Lets calculate the Required flow rate for each rooms

$$\dot{m} = Q / C_p \Delta T$$

for room 1, $\dot{m} = \frac{Q_1}{C_p \Delta T} = \frac{81.2}{8 \times 1.293} = 7.67\, m^3/s \times 10^{-2}$

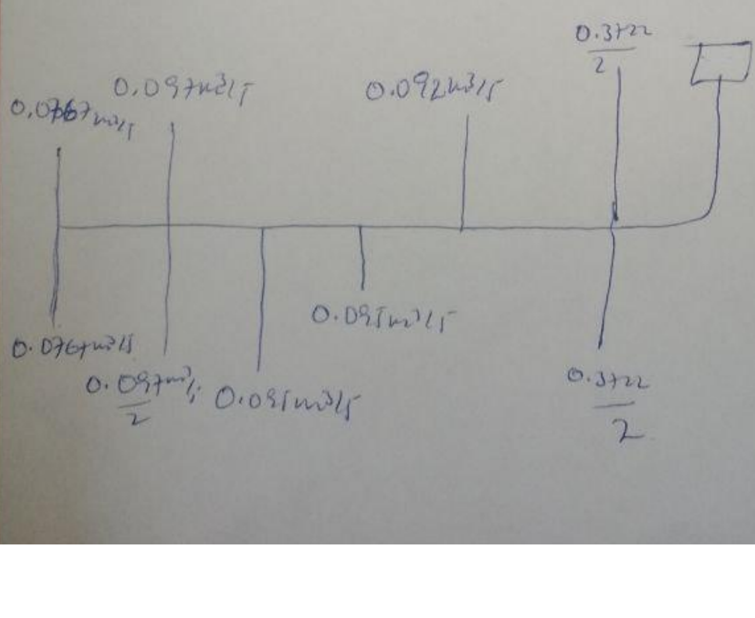
for room 2 $\dot{m} = \frac{Q_2}{C_p \Delta T} = \frac{79.2}{8.16} = 9.7\, m^3/s \times 10^{-2}$

for room 3 $\dot{m} = \frac{Q_3}{C_p \Delta T} = \frac{81.2}{8.16} = 9.95\, m^3/s \times 10^{-2}$

for room 4 $\dot{m} = \frac{Q_4}{C_p \Delta T} = \frac{79.5}{8.16} = 9.92\, m^3/s \times 10^{-2}$

for room 5 $\dot{m} = \frac{Q_5}{C_p \Delta T} = \frac{303.7}{8.16} = 37.22\, m^3/s \times 10^{-2}$.

then we have the following arrangements.



Duct layout and Sizing

Duct layout

The duct layout shows the arrangement and location of supply and return ducts in relation to the building structure and the diffusers and grilles. The duct layout should be designed to provide adequate air distribution, minimize pressure losses, reduce noise, and avoid conflicts with other building systems.

The supply and return duct layout for the library is shown in figure below, which is based on the CAD drawing provided. The supply ducts are indicated by solid green lines and the return ducts are indicated by solid red lines. The reducer and grilles are labeled with their respective airflow rates.

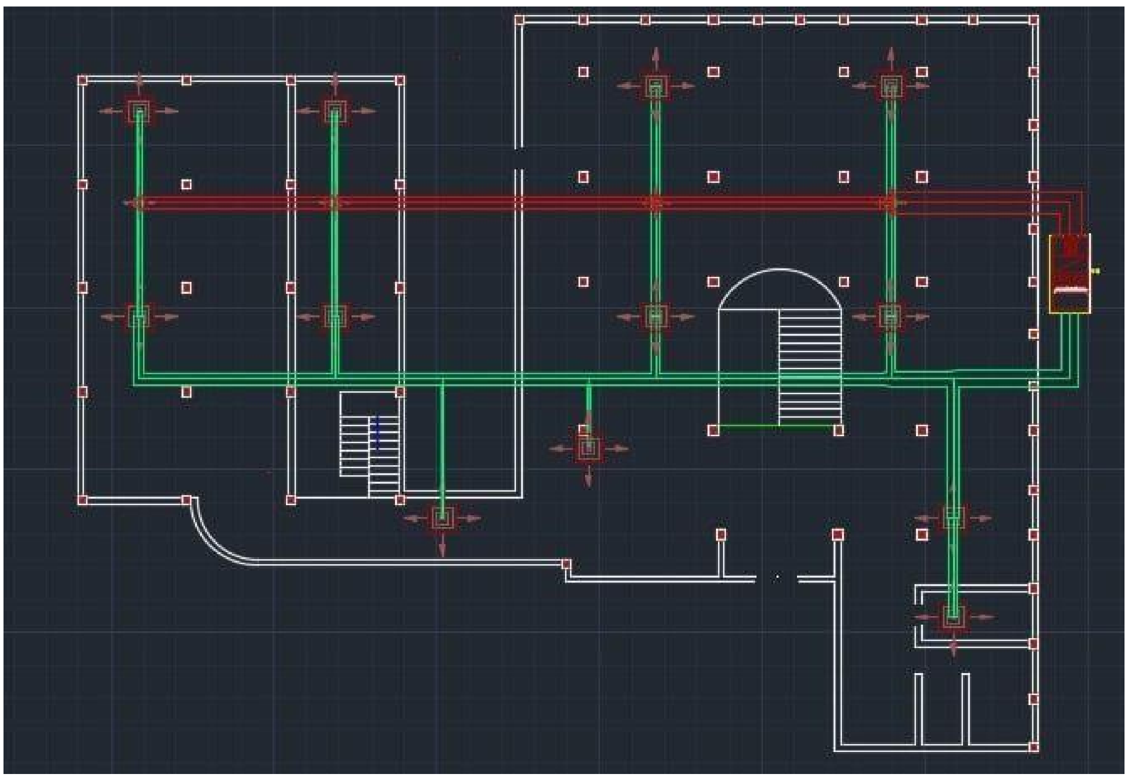


Figure 6 Supply(red) and Extraction(green) duct layout

The following factors are considered in designing the duct layout

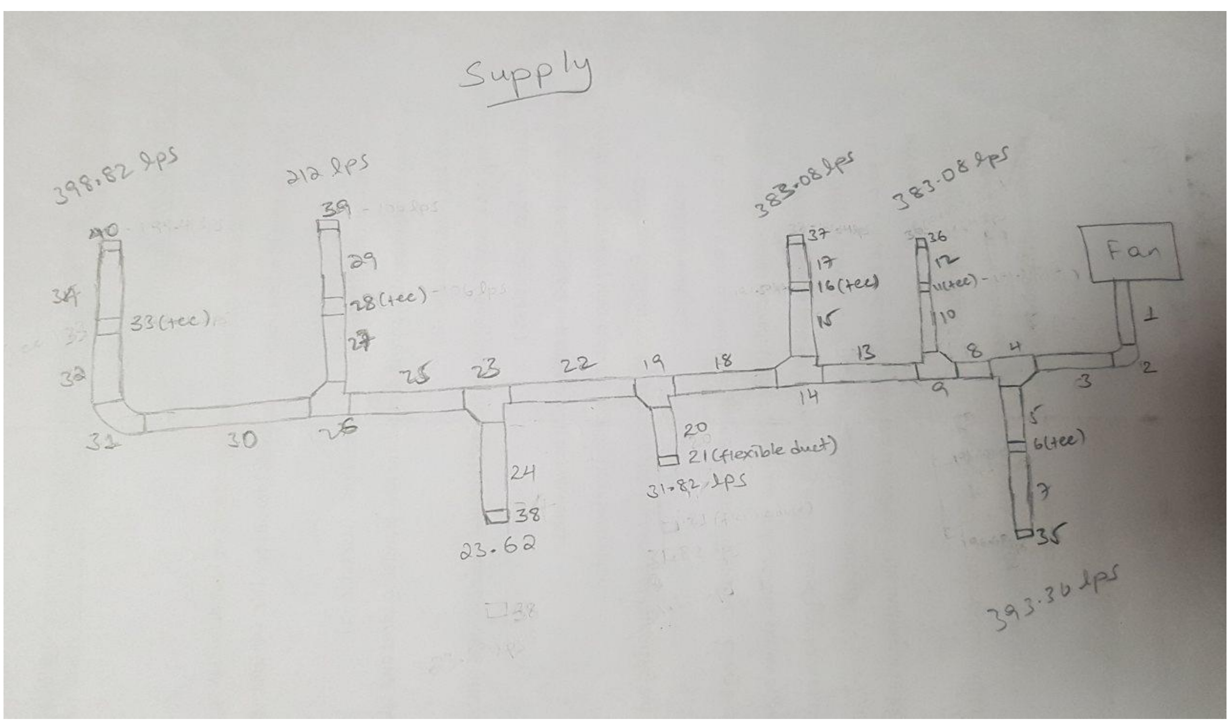
1. The supply ducts are sized to deliver the required airflow rate to each diffuser at a suitable velocity and pressure.
2. The return ducts are sized to collect the return air from each grille at a suitable velocity and pressure.

3. The ducts are routed along the shortest and straightest path possible to reduce friction losses and material costs.
4. The ducts are assumed to be supported by hangers or brackets at appropriate intervals to prevent sagging and vibration.
5. The ducts are insulated where necessary to prevent heat loss or gain and condensation.
6. The ducts are sealed at joints and connections to prevent air leakage and noise transmission.
7. The ducts are provided with dampers, valves, filters, fans, and other accessories as needed to control and maintain the system performance.

3.3.2 Duct sizing

Supply duct sizing

Supply duct sketch layout

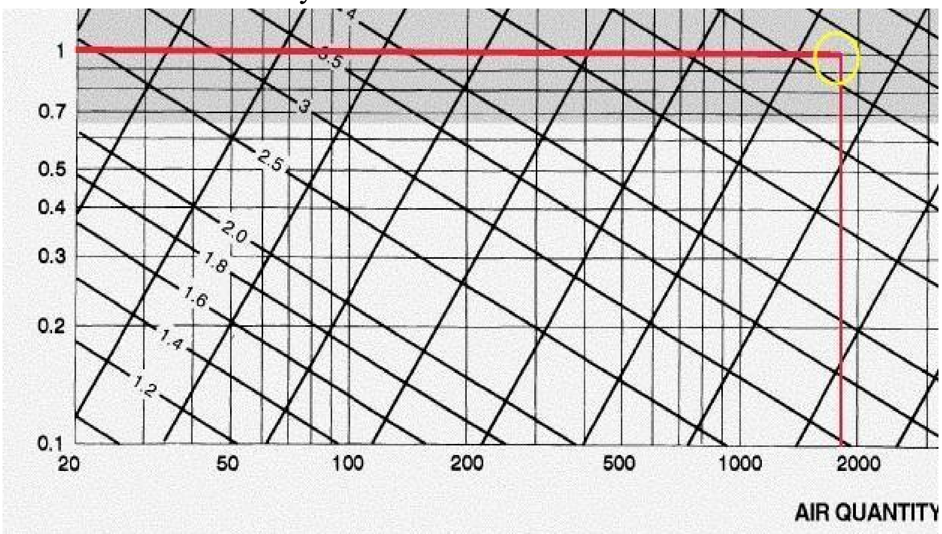


1. For duct 1 and 3

Q = 1825.85 L/s

$\Delta P/l = 1$ Pa/m

We can find the velocity and diameter from the friction chart



D = 560mm

V = 7.5m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of the rectangular duct for equal friction and capacity:

Table 2 Circular Equivalents of Rectangular D

Lgth Adj.[b]	Length One Side of Recta										
	100	125	150	175	200	225	250	275	300	350	4
	Circular Duct Di										
100	109										
125	122	137									
150	133	150	164								
175	143	161	177	191							
200	152	172	189	204	219						
225	161	181	200	216	232	246					
250	169	190	210	228	244	259	273				
275	176	199	220	238	256	272	287	301			
300	183	207	229	248	266	283	299	314	328		
350	195	222	245	267	286	305	322	339	354	383	
400	207	235	260	283	305	325	343	361	378	409	4
450	217	247	274	299	321	343	363	382	400	433	4
500	227	258	287	313	337	360	381	401	420	455	4
550	236	269	299	326	352	375	398	419	439	477	5
600	245	279	310	339	365	390	414	436	457	496	5
650	253	289	321	351	378	404	429	452	474	515	5
700	261	298	331	362	391	418	443	467	490	533	5
750	268	306	341	373	402	430	457	482	506	550	5
800	275	314	350	383	414	442	470	496	520	$\boxed{567}$	6
900	289	330	367	402	435	465	494	522	548	597	6

W= 800mm and H=350mm

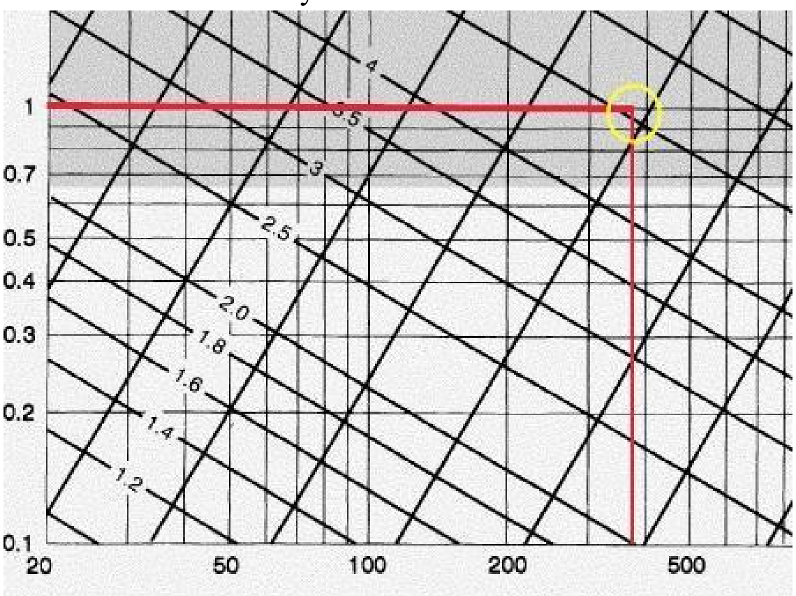
2. For branch

5 Q =

393.36L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 310mm

V = 5.1m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	[illegible]
100	109			
125	122	137		
150	133	150	164	
175	143	161	177	[illegible]
200	152	172	189	[illegible]
225	161	181	200	[illegible]
250	169	190	210	[illegible]
275	176	199	220	[illegible]
300	183	207	229	[illegible]
350	195	222	245	[illegible]
400	207	235	260	[illegible]
450	217	247	274	[illegible]
500	227	258	287	[illegible]
550	236	269	299	[illegible]
600	245	279	$\boxed{310}$	[illegible]
650	253	289	321	[illegible]

W= 600mm and H= 150mm

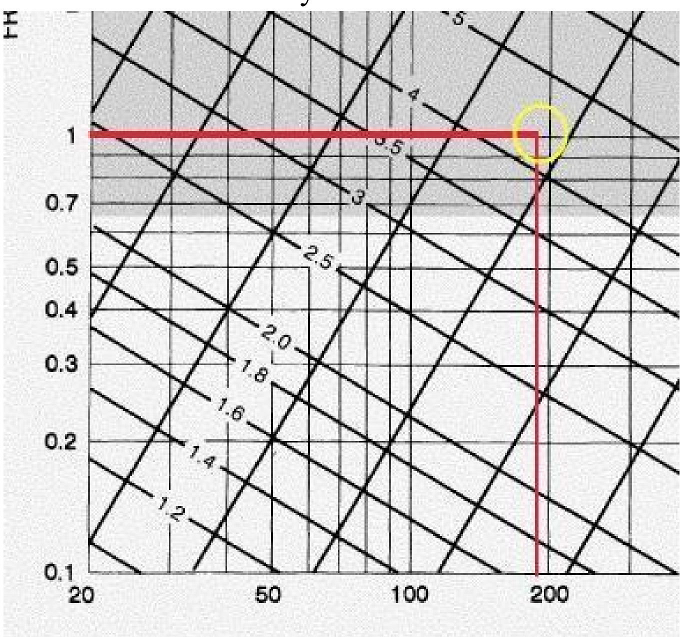
3. For branch

7 Q = 196.68

L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 235mm

V = 4.4m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125
100	109	
125	122	137
150	133	150
175	143	161
200	152	172
225	161	181
250	169	190
275	176	199
300	183	207
350	195	222
400	207	$\boxed{235}$

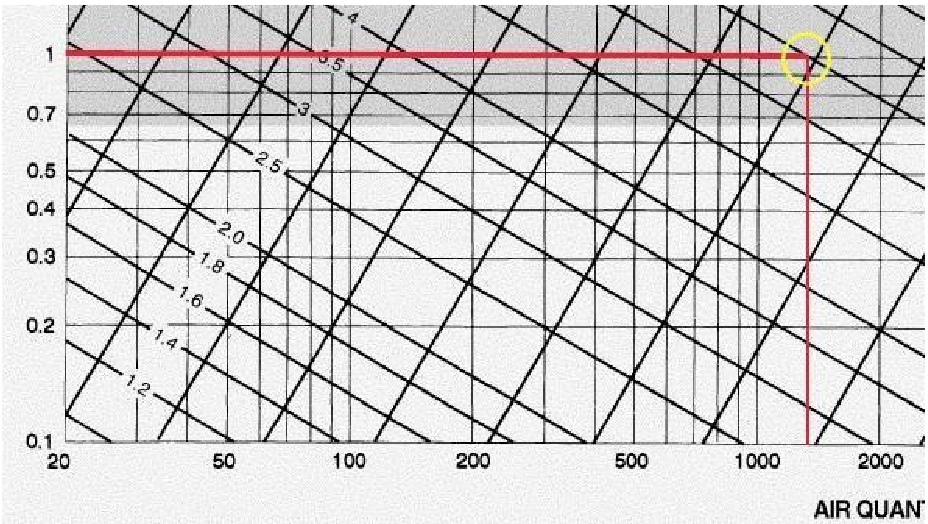
W= 400mm and H= 125mm

For duct-8

Q=1432.49 L/s

$\Delta P/l = 1$ Pa/m

We can find the velocity and diameter from the friction chart



D = 490mm

V = 7m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Table 2 Circular Equivalents of Rectang

Lgth Adj.[b]	Length One Side o									
	100	125	150	175	200	225	250	275	300	3
	Circular I									
100	109									
125	122	137								
150	133	150	164							
175	143	161	177	191						
200	152	172	189	204	219					
225	161	181	200	216	232	246				
250	169	190	210	228	244	259	273			
275	176	199	220	238	256	272	287	301		
300	183	207	229	248	266	283	299	314	328	
350	195	222	245	267	286	305	322	339	354	3
400	207	235	260	283	305	325	343	361	378	4
450	217	247	274	299	321	343	363	382	400	4
500	227	258	287	313	337	360	381	401	420	4
550	236	269	299	326	352	375	398	419	439	4
600	245	279	310	339	365	390	414	436	457	4
650	253	289	321	351	378	404	429	452	474	5
700	261	298	331	362	391	418	443	467	$\boxed{490}$	5
750	268	306	341	373	402	430	457	482	506	5

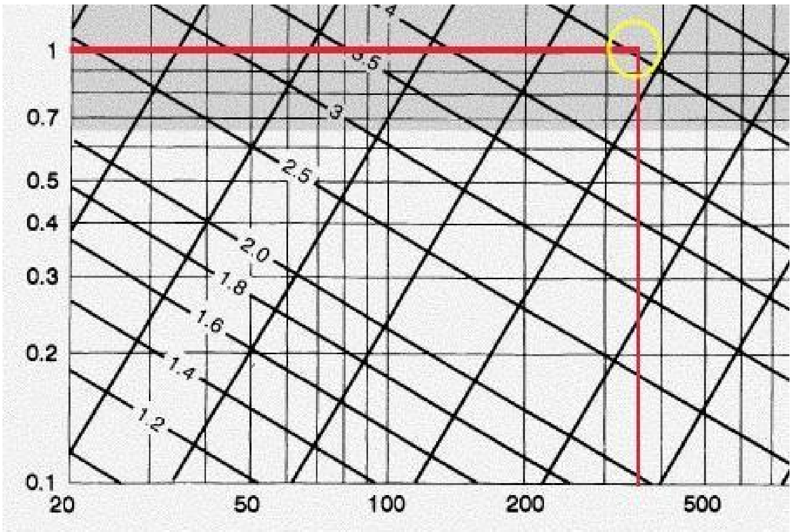
W= 700mm and H= 300 mm

For branch-10

Q = 383.08 L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 305mm

V = 5m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

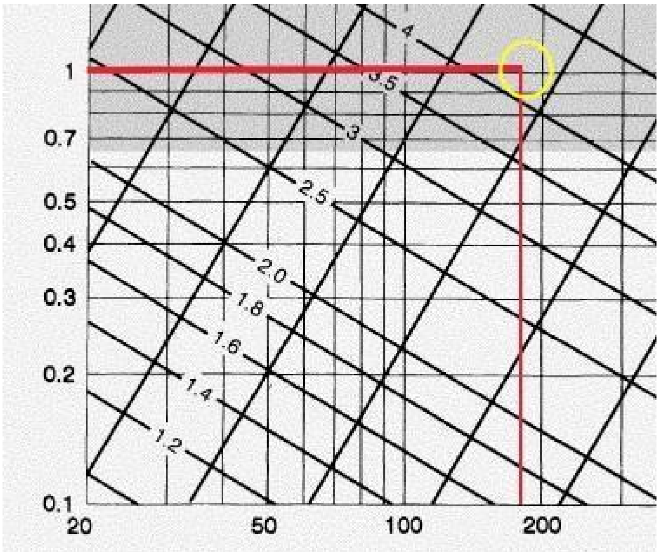
Lgth Adj.[b]	100	125	150	175	200
100	109				
125	122	137			
150	133	150	164		
175	143	161	177	191	
200	152	172	189	204	219
225	161	181	200	216	232
250	169	190	210	228	244
275	176	199	220	238	256
300	183	207	229	248	266
350	195	222	245	267	286
400	207	235	260	283	$\boxed{305}$

W= 400mm and H= 200 mm

For branch-12

Q = 191.54 L/s ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 230mm

V = 4.4m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125
100	109	
125	122	137
150	133	150
175	143	161
200	152	172
225	161	181
250	169	190
275	176	199
300	183	207
350	195	222
400	207	$\boxed{235}$

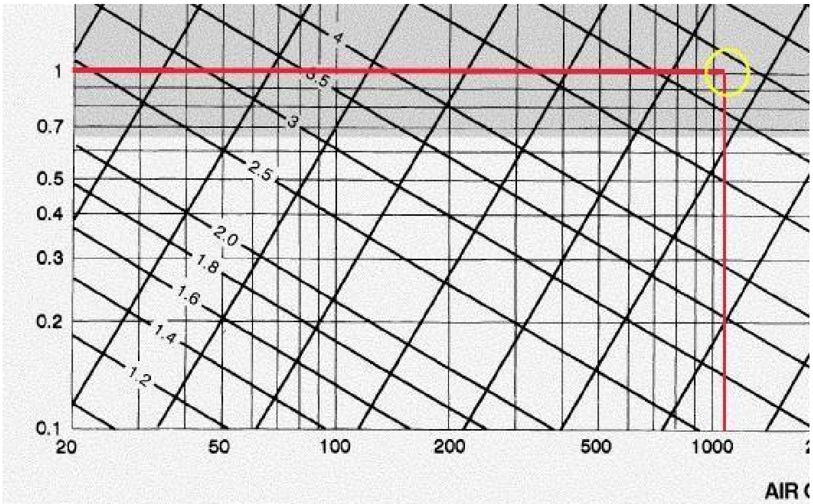
W= 400mm and H= 125mm

For duct 13

Q = 1049.41 L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 450mm

V = 6.6m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	175	200	225	250	275	300	350
									Circular Duct D	
100	109									
125	122	137								
150	133	150	164							
175	143	161	177	191						
200	152	172	189	204	219					
225	161	181	200	216	232	246				
250	169	190	210	228	244	259	273			
275	176	199	220	238	256	272	287	301		
300	183	207	229	248	266	283	299	314	328	
350	195	222	245	267	286	305	322	339	354	383
400	207	235	260	283	305	325	343	361	378	409
450	217	247	274	299	321	343	363	382	400	433
500	227	258	287	313	337	360	381	401	420	$\boxed{455}$
550	236	269	299	326	352	375	398	419	439	477

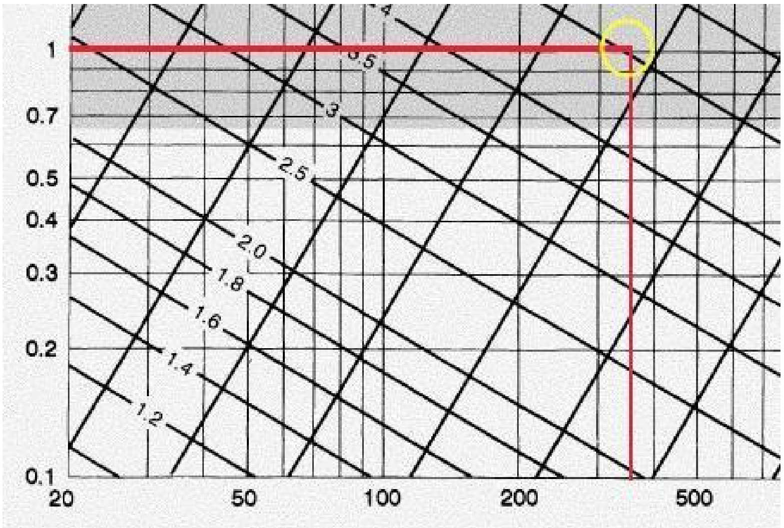
W= 500mm and H= 350mm

For branch 15

Q = 383.08 L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 305mm

V = 5m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

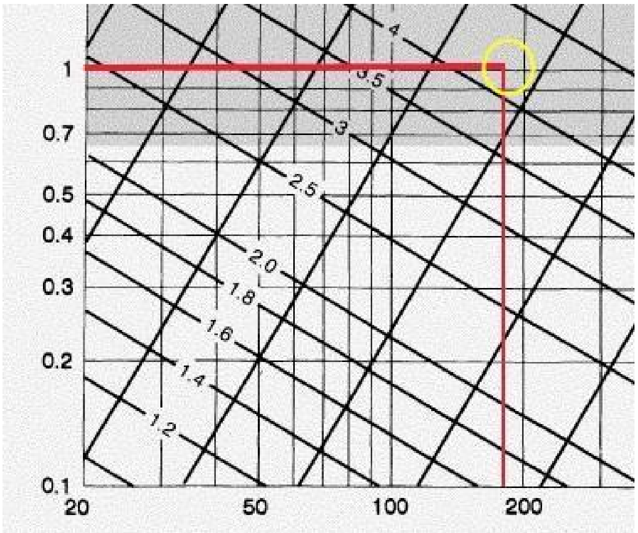
Lgth Adj.[b]	100	125	150	175	200
100	109				
125	122	137			
150	133	150	164		
175	143	161	177	191	
200	152	172	189	204	219
225	161	181	200	216	232
250	169	190	210	228	244
275	176	199	220	238	256
300	183	207	229	248	266
350	195	222	245	267	286
400	207	235	260	283	$\boxed{305}$

W= 400mm and H= 200mm

For branch 17

Q = 191.54 L/s ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 230mm

V = 4.4m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125
100	109	
125	122	137
150	133	150
175	143	161
200	152	172
225	161	181
250	169	190
275	176	199
300	183	207
350	195	222
400	207	$\boxed{235}$
450	217	247

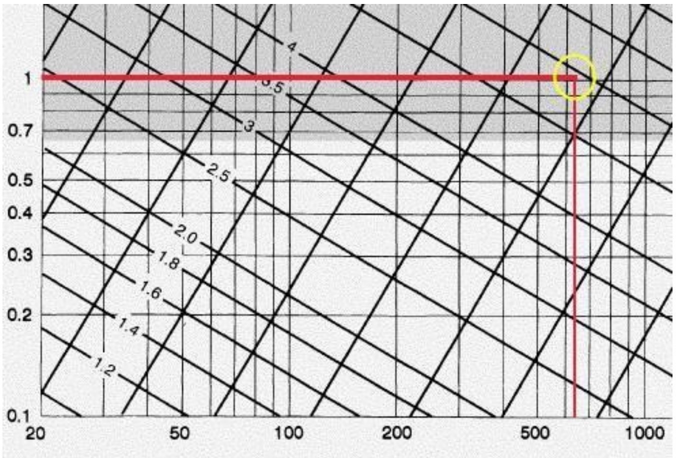
W= 400mm and H= 125 mm

For duct 18

Q = 666.33 L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 360mm

V = 5.9m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	175	200	225
100	109					
125	122	137				
150	133	150	164			
175	143	161	177	191		
200	152	172	189	204	219	
225	161	181	200	216	232	246
250	169	190	210	228	244	259
275	176	199	220	238	256	272
300	183	207	229	248	266	283
350	195	222	245	267	286	305
400	207	235	260	283	305	325
450	217	247	274	299	321	343
500	227	258	287	313	337	360
550	236	260	290	326	352	375

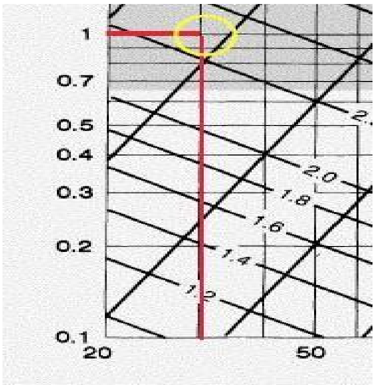
W= 500mm and H= 225mm

For branch 20

Q = 31.82 L/s

ΔP/l = 1 Pa/m

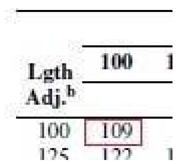
We can find the velocity and diameter from the friction chart



D = 115mm

V = 2.75m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:



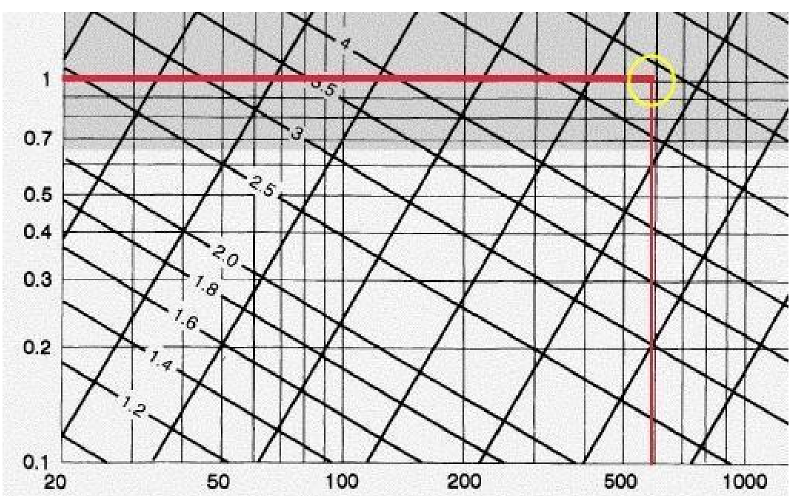
Lgth Adj.[b]	100
100	109

W= 100mm and H= 100mm

For duct 22

Q = 634.51 L/s ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 357mm
V = 5.8m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	175	200	225
100	109					
125	122	137				
150	133	150	164			
175	143	161	177	191		
200	152	172	189	204	219	
225	161	181	200	216	232	246
250	169	190	210	228	244	259
275	176	199	220	238	256	272
300	183	207	229	248	266	283
350	195	222	245	267	286	305
400	207	235	260	283	305	325
450	217	247	274	299	321	343
500	227	258	287	313	337	$\boxed{360}$
550	236	269	299	326	352	375

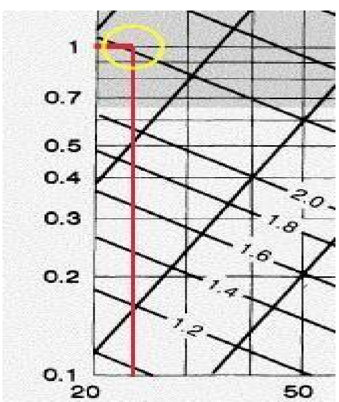
W= 500mm and H= 225mm

For branch 24

Q = 23.69 L/s

$\Delta P/l$ = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 110mm

V = 2.5m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

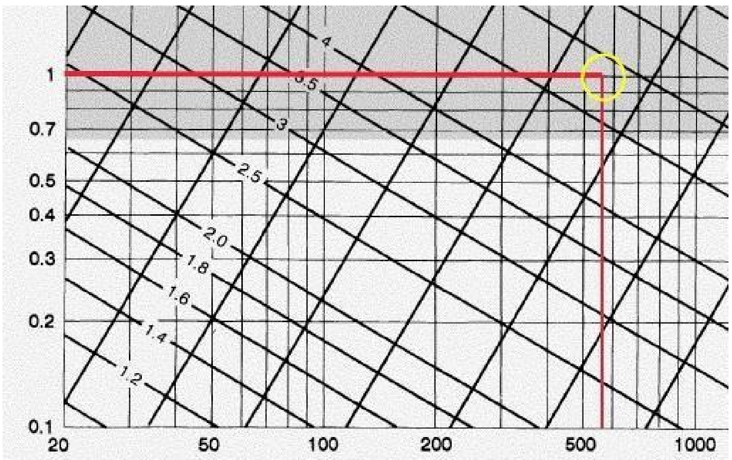
Lgth Adj.[b]	100
100	$\boxed{109}$
125	122

W= 100mm and H= 100mm

For duct 25

Q = 610.82 L/s ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 350mm

V = 5.7m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	175	200	225
100	109					
125	122	137				
150	133	150	164			
175	143	161	177	191		
200	152	172	189	204	219	
225	161	181	200	216	232	246
250	169	190	210	228	244	259
275	176	199	220	238	256	272
300	183	207	229	248	266	283
350	195	222	245	267	286	305
400	207	235	260	283	305	325
450	217	247	274	299	321	343
500	227	258	287	313	337	$\boxed{360}$
550	236	269	299	326	352	375

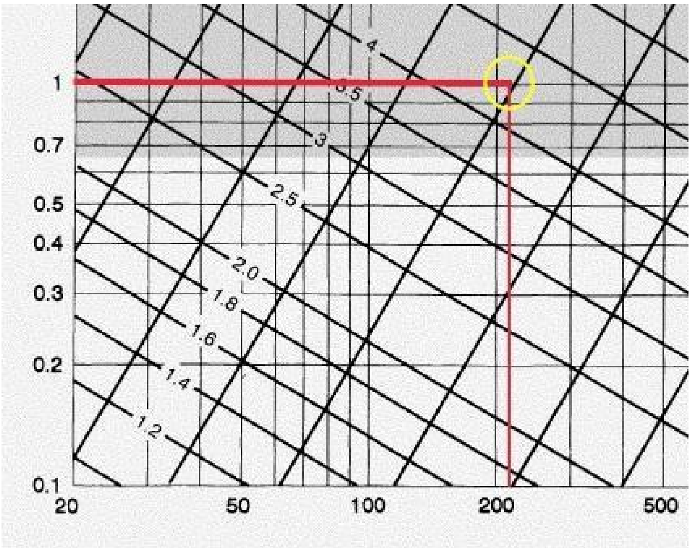
W= 500mm and H= 225mm

For branch 27

Q = 212 L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 250mm

V = 4.5m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	175
100	109			
125	122	137		
150	133	150	164	
175	143	161	177	191
200	152	172	189	204
225	161	181	200	216
250	169	190	210	228
275	176	199	220	238
300	183	207	229	$\boxed{248}$

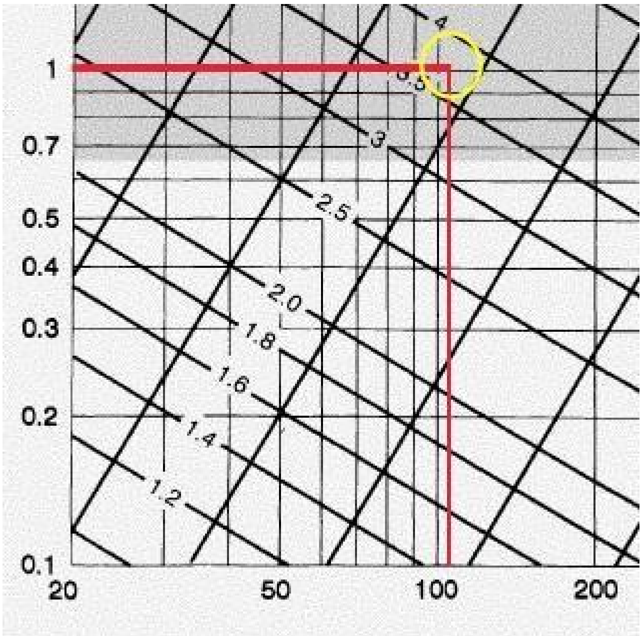
W= 300mm and H= 175mm

For branch 29

Q = 106 L/s

ΔP/l = 1 Pa/m

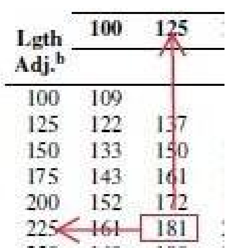
We can find the velocity and diameter from the friction chart



D = 185mm

V = 3.75m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:



Lgth Adj.[b]	100	125
100	109	
125	122	137
150	133	150
175	143	161
200	152	172
225	161	$\boxed{181}$

W= 225mm and H= 125mm

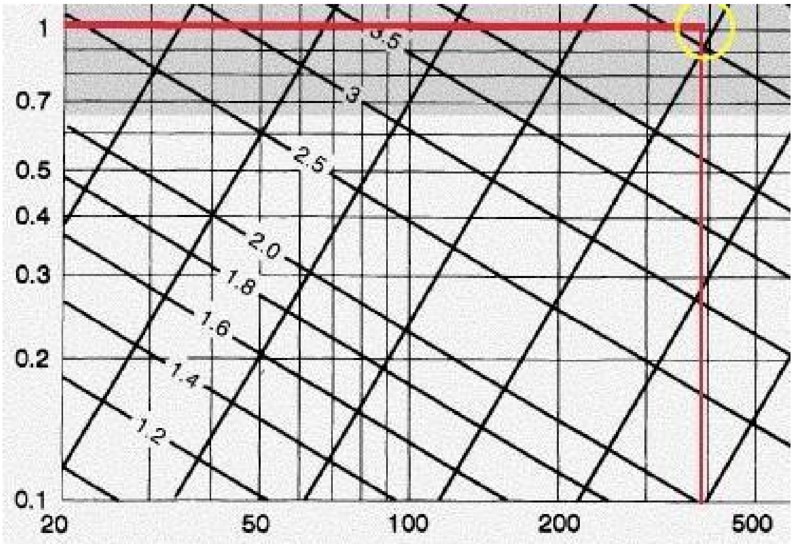
For branch 30 and 32

Q = 398.82

L/s ΔP/l =

1 Pa/m

We can find the velocity and diameter from the friction chart



D = 310mm

V = 5.3m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	175
100	109			
125	122	137		
150	133	150	164	
175	143	161	177	191
200	152	172	189	204
225	161	181	200	216
250	169	190	210	228
275	176	199	220	238
300	183	207	229	248
350	195	222	245	267
400	207	235	260	283
450	217	247	274	299
500	227	258	287	$\boxed{313}$
550	236	269	300	326

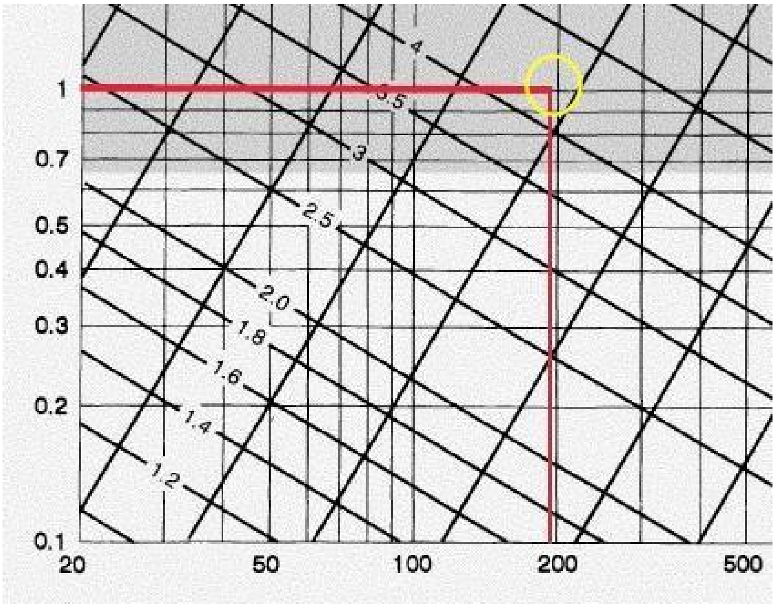
W= 500mm and H= 175mm

For branch 34

Q = 199.41 L/s

ΔP/l = 1 Pa/m

We can find the velocity and diameter from the friction chart



D = 240mm

V = 4.4m/s

To find the equivalent width and height of the rectangular duct, we use the ASHRAE's circular equivalents of rectangular duct for equal friction and capacity:

Lgth Adj.[b]	100	125	150	175
100	109			
125	122	137		
150	133	150	164	
175	143	161	177	191
200	152	172	189	204
225	161	181	200	216
250	169	190	210	228
275	176	199	220	$\boxed{238}$

W= 275mm and H= 175mm

Fittings

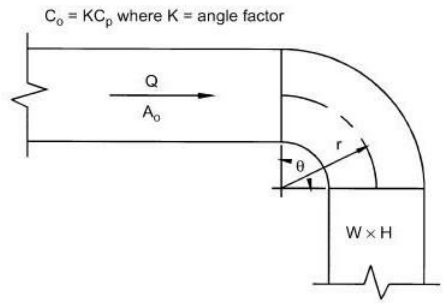
1. Elbow 2

RECTANGULAR FITTINGS

CR3-1 Elbow, Smooth Radius, Without Vanes

	C_p Values										
	H/W										
r/W	0.25	0.50	0.75	1.00	1.50	2.00	3.00	4.00	5.00	6.00	8.00
0.50	1.53	1.38	1.29	1.18	1.06	1.00	1.00	1.06	1.12	1.16	1.18
0.75	0.57	0.52	0.48	0.44	0.40	0.39	0.39	0.40	0.42	0.43	0.44
1.00	0.27	0.25	0.23	0.21	0.19	0.18	0.18	0.19	0.20	0.21	0.21
1.50	0.22	0.20	0.19	0.17	0.15	0.14	0.14	0.15	0.16	0.17	0.17
2.00	0.20	0.18	0.16	0.15	0.14	0.13	0.13	0.14	0.14	0.15	0.15

Angle Factor K											
θ	0	20	30	45	60	75	90	110	130	150	180
K	0.00	0.31	0.45	0.60	0.78	0.90	1.00	1.13	1.20	1.28	1.40



W= 800 mm and H= 350 mm

H/W=350/800=0.5

Taking(assuming) r/W=0.5 and k=1 for 90 degree

C_p= 1.38

C_o= KC_p = 1 x 1.38 = 1.38

Dynamic pressure loss = (Co x δ x V^2) / 2 = 46.58 Pa

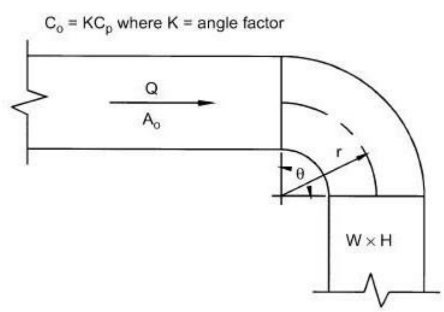
2. Elbow 31

RECTANGULAR FITTINGS

CR3-1 Elbow, Smooth Radius, Without Vanes

	C_p Values										
	H/W										
r/W	0.25	0.50	0.75	1.00	1.50	2.00	3.00	4.00	5.00	6.00	8.00
0.50	1.53	1.38	1.29	1.18	1.06	1.00	1.00	1.06	1.12	1.16	1.18
0.75	0.57	0.52	0.48	0.44	0.40	0.39	0.39	0.40	0.42	0.43	0.44
1.00	0.27	0.25	0.23	0.21	0.19	0.18	0.18	0.19	0.20	0.21	0.21
1.50	0.22	0.20	0.19	0.17	0.15	0.14	0.14	0.15	0.16	0.17	0.17
2.00	0.20	0.18	0.16	0.15	0.14	0.13	0.13	0.14	0.14	0.15	0.15

Angle Factor K											
θ	0	20	30	45	60	75	90	110	130	150	180
K	0.00	0.31	0.45	0.60	0.78	0.90	1.00	1.13	1.20	1.28	1.40



W= 500 mm and H= 175 mm

H/W=350/800=0.35

Taking(assuming) r/W=0.5 and k=1 for 90 degree

C_p= 1.38

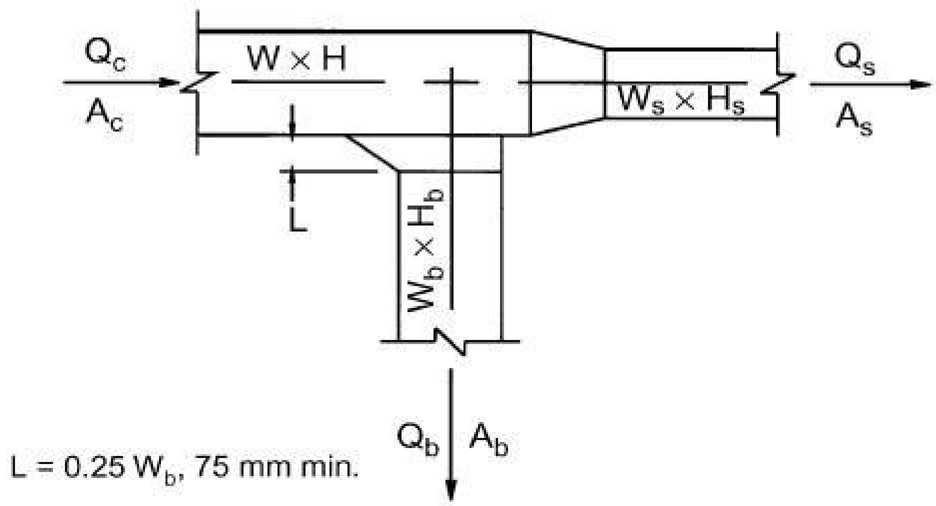
$C_o = KC_p = 1 \times 1.38 = 1.38$

Dynamic pressure loss = (Co x δ x V²) / 2 = 23.26 Pa

Elbow Name	Width(mm)	Height	Angle factor (K)	H/W ratio	r/W ratio	Cp	Co	δ (kg/m3)	Velocity (m/s)	Dynamic pressure loss (Pa)
2	800	350	1	0.44	0.5	1.38	1.38	1.2	7.5	93.15
31	500	175	1	0.35	0.5	1.38	1.38	1.2	5.3	46.52
									Total	139.67

3. Tee fitting 4

Tee, 45 Degree Entry Branch, Diverging



Where, Qc represents the flow coming from the fan
Qb is the flow delivered to branch 5
Qs is the downstream flow that moves on to the duct 8
Ac is the area of the flow delivered from the fan
Ab is the area of the flow delivered to branch 5
As is the area of the downstream flow i.e., duct 8.

___= 0.3

___= 0.8

___= 0.2

___= 0.8

SR5-13 Tee, 45 Degree Entry Branch, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.73	0.34	0.32	0.34	0.35	0.37	0.38	0.39	0.40
0.2	3.10	0.73	0.41	0.34	0.32	0.32	0.33	0.34	0.35
0.3	7.59	1.65	0.73	0.47	0.37	0.34	0.32	0.32	0.32
0.4	14.20	3.10	1.28	0.73	0.51	0.41	0.36	0.34	0.32
0.5	22.92	5.08	2.07	1.12	0.73	0.54	0.44	0.38	0.35
0.6	33.76	7.59	3.10	1.65	1.03	0.73	0.56	0.47	0.41
0.7	46.71	10.63	4.36	2.31	1.42	0.98	0.73	0.58	0.49
0.8	61.79	14.20	5.86	3.10	1.90	1.28	0.94	0.73	0.60
0.9	78.98	18.29	7.59	4.02	2.46	1.65	1.19	0.91	0.73

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	0.10	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables C_b=1.65 and C_s=0.04 find the total pressure loss in the downstream section and the branch as follows

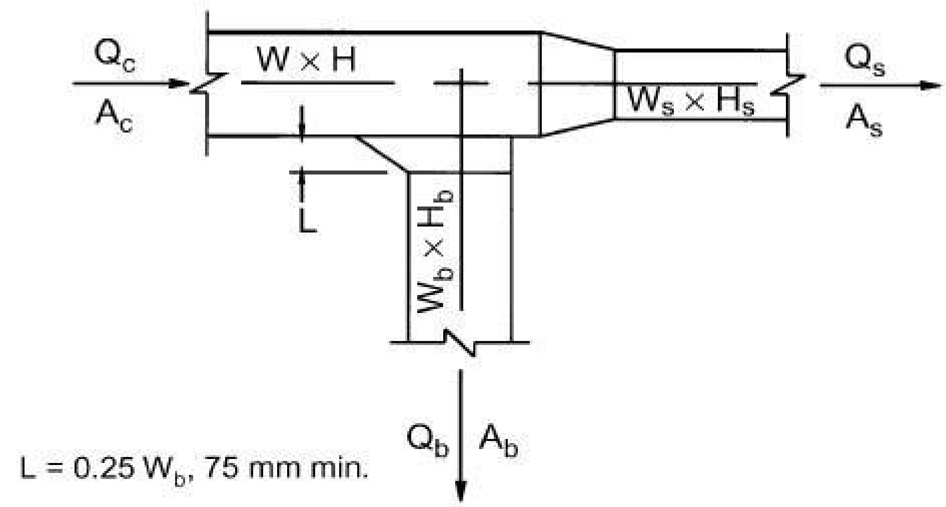
$\Delta Pj = Cc,s\ x\ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b\ x\ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
$Pv,c = (\delta \times V^2) / 2 =$ 33.75 Pa

Therefore

ΔPj (downstream) = 1.35 Pa ΔPj (branch) = 55.69 Pa

4. Tee fitting 9

Tee, 45 Degree Entry Branch, Diverging



Where, Qc represents the flow coming from duct 8
Qb is the flow delivered to branch 10
Qs is the downstream flow that moves on to the duct 13
Ac is the area of the flow delivered from the duct 8
Ab is the area of the flow delivered to branch 10
As is the area of the downstream flow i.e., duct 13.

__=0.4

___= 0.8

___= 0.3

___= 0.7

SR5-13 Tee, 45 Degree Entry Branch, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.73	0.34	0.32	0.34	0.35	0.37	0.38	0.39	0.40
0.2	3.10	0.73	0.41	0.34	0.32	0.32	0.33	0.34	0.35
0.3	7.59	1.65	0.73	0.47	0.37	0.34	0.32	0.32	0.32
0.4	14.20	3.10	$\boxed{1.28}$	0.73	0.51	0.41	0.36	0.34	0.32
0.5	22.92	5.08	2.07	1.12	0.73	0.54	0.44	0.38	0.35
0.6	33.76	7.59	3.10	1.65	1.03	0.73	0.56	0.47	0.41
0.7	46.71	10.63	4.36	2.31	1.42	0.98	0.73	0.58	0.49
0.8	61.79	14.20	5.86	3.10	1.90	1.28	0.94	0.73	0.60
0.9	78.98	18.29	7.59	4.02	2.46	1.65	1.19	0.91	0.73

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	0.10	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	$\boxed{0.08}$	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

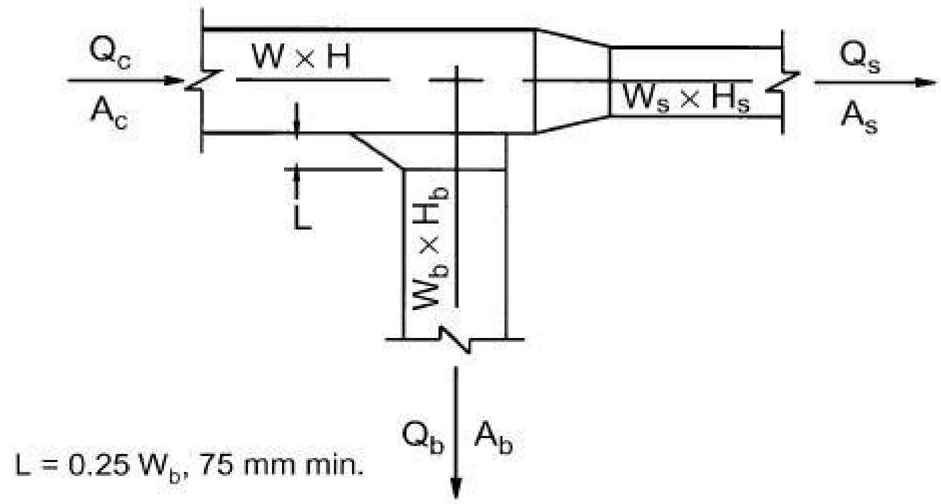
Reading from the above tables C_b=1.28 and C_s=0.08 find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s \ x \ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b \ x \ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
Pv,c = (δ x V^2) / 2 = 29.4 Pa

Therefore ΔPj (downstream) = 2.35 Pa ΔPj (branch) = 55.69 Pa

5. Tee fitting 14

Tee, 45 Degree Entry Branch, Diverging



Where, Qc represents the flow coming from duct 13
Qb is the flow delivered to branch 15
Qs is the downstream flow that moves on to the duct 18
Ac is the area of the flow delivered from the duct 13
Ab is the area of the flow delivered to branch 15
As is the area of the downstream flow i.e., duct 18.

__=0.5

___= 0.6

___= 0.4

___= 0.6

SR5-13 Tee, 45 Degree Entry Branch, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.73	0.34	0.32	0.34	0.35	0.37	0.38	0.39	0.40
0.2	3.10	0.73	0.41	0.34	0.32	0.32	0.33	0.34	0.35
0.3	7.59	1.65	0.73	0.47	0.37	0.34	0.32	0.32	0.32
0.4	14.20	3.10	1.28	0.73	0.51	0.41	0.36	0.34	0.32
0.5	22.92	5.08	2.07	$\boxed{1.12}$	0.73	0.54	0.44	0.38	0.35
0.6	33.76	7.59	3.10	1.65	1.03	0.73	0.56	0.47	0.41
0.7	46.71	10.63	4.36	2.31	1.42	0.98	0.73	0.58	0.49
0.8	61.79	14.20	5.86	3.10	1.90	1.28	0.94	0.73	0.60
0.9	78.98	18.29	7.59	4.02	2.46	1.65	1.19	0.91	0.73

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	0.10	$\boxed{0.04}$			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables C_b=1.12 and C_s=0.04 find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s\ x\ Pv,c$ -pressure loss for the downstream section

$\Delta Pj = Cc,b\ x\ Pv,c$ - pressure loss in the branch section

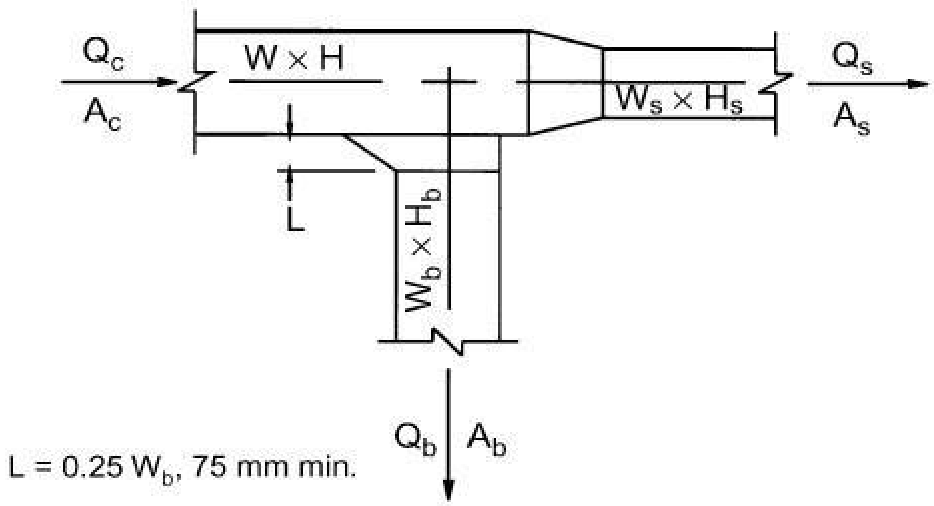
And Pv,c is the dynamic pressure loss at the common section and is given by

Pv,c = (δ x V^2) / 2 = 26.14 Pa

Therefore ΔPj (downstream) = 1.05 Pa ΔPj (branch) = 29.27 Pa

6. Tee fitting 19

Tee, 45 Degree Entry Branch, Diverging



Where, Qc represents the flow coming from duct 18

Qb is the flow delivered to branch 20

Qs is the downstream flow that moves on to the duct 22

Ac is the area of the flow delivered from the duct 18

Ab is the area of the flow delivered to branch 20

As is the area of the downstream flow i.e., duct 22.

___=0.1

___= 0.9

___= 0.1

___= 0.9

SR5-13 Tee, 45 Degree Entry Branch, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	$\boxed{0.73}$	0.34	0.32	0.34	0.35	0.37	0.38	0.39	0.40
0.2	3.10	0.73	0.41	0.34	0.32	0.32	0.33	0.34	0.35
0.3	7.59	1.65	0.73	0.47	0.37	0.34	0.32	0.32	0.32
0.4	14.20	3.10	1.28	0.73	0.51	0.41	0.36	0.34	0.32
0.5	22.92	5.08	2.07	1.12	0.73	0.54	0.44	0.38	0.35
0.6	33.76	7.59	3.10	1.65	1.03	0.73	0.56	0.47	0.41
0.7	46.71	10.63	4.36	2.31	1.42	0.98	0.73	0.58	0.49
0.8	61.79	14.20	5.86	3.10	1.90	1.28	0.94	0.73	0.60
0.9	78.98	18.29	7.59	4.02	2.46	1.65	1.19	0.91	0.73

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	0.10	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	$\boxed{0.04}$

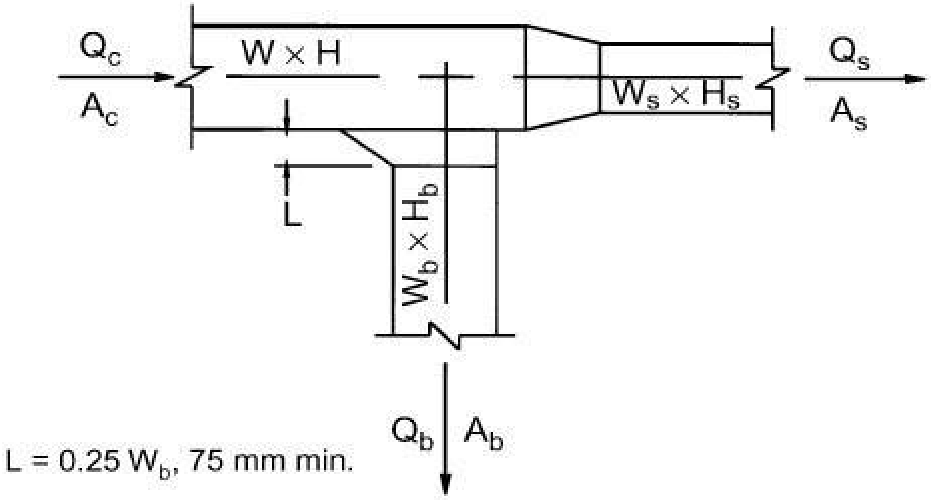
Reading from the above tables C_b=0.73 and C_s=0.04 find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s\ x\ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b\ x\ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
Pv,c = (δ x V^2) / 2 = 20.89 Pa

Therefore
ΔPj (downstream) =
0.84 Pa ΔPj (branch) =
15.25 Pa

7. Tee fitting 23

Tee, 45 Degree Entry Branch, Diverging



Where, Qc represents the flow coming from duct 22

Qb is the flow delivered to branch 24

Qs is the downstream flow that moves on to the duct 25

Ac is the area of the flow delivered from the duct 22 Ab is the area of the flow delivered to branch 24

As is the area of the downstream flow i.e., duct 25.

__=0.1

___= 0.9

___= 0.1

___= 0.9

SR5-13 Tee, 45 Degree Entry Branch, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	$\boxed{0.73}$	0.34	0.32	0.34	0.35	0.37	0.38	0.39	0.40
0.2	3.10	0.73	0.41	0.34	0.32	0.32	0.33	0.34	0.35
0.3	7.59	1.65	0.73	0.47	0.37	0.34	0.32	0.32	0.32
0.4	14.20	3.10	1.28	0.73	0.51	0.41	0.36	0.34	0.32
0.5	22.92	5.08	2.07	1.12	0.73	0.54	0.44	0.38	0.35
0.6	33.76	7.59	3.10	1.65	1.03	0.73	0.56	0.47	0.41
0.7	46.71	10.63	4.36	2.31	1.42	0.98	0.73	0.58	0.49
0.8	61.79	14.20	5.86	3.10	1.90	1.28	0.94	0.73	0.60
0.9	78.98	18.29	7.59	4.02	2.46	1.65	1.19	0.91	0.73

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	0.10	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	$\boxed{0.04}$

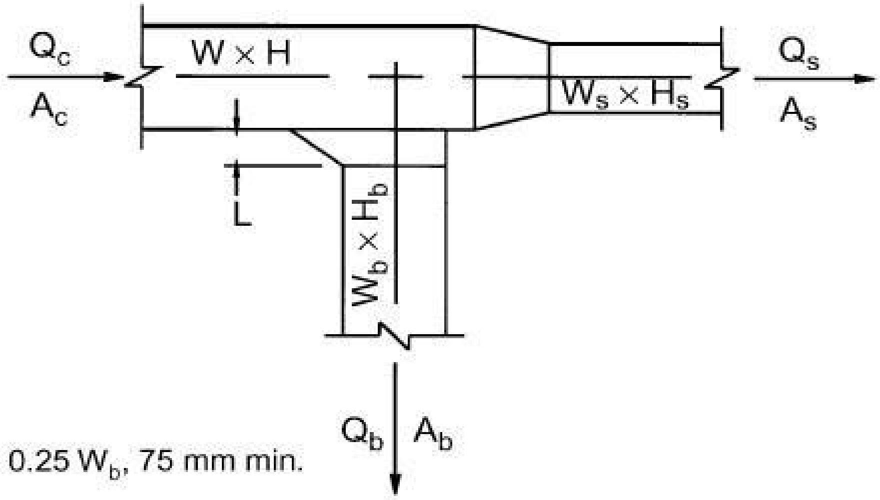
Reading from the above tables C_b=0.73 and C_s=0.04 find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s \ x \ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b \ x \ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
Pv,c = (δ x V^2) / 2 = 20.89 Pa

Therefore ΔPj (downstream) = 0.84 Pa ΔPj (branch) = 15.25 Pa

8. Tee fitting 26

Tee, 45 Degree Entry Branch, Diverging



$L = 0.25\ W_b$, 75 mm min.

Where, Qc represents the flow coming from duct 25

Qb is the flow delivered to branch 27

Qs is the downstream flow that moves on to the branch 30

Ac is the area of the flow delivered from the duct 25

Ab is the area of the flow delivered to branch 27

As is the area of the downstream flow i.e., duct 30.

__=0.5

___= 0.8

___= 0.4

___= 0.7

C_b Values

	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.73	0.34	0.32	0.34	0.35	0.37	0.38	0.39	0.40
0.2	3.10	0.73	0.41	0.34	0.32	0.32	0.33	0.34	0.35
0.3	7.59	1.65	0.73	0.47	0.37	0.34	0.32	0.32	0.32
0.4	14.20	3.10	1.28	0.73	0.51	0.41	0.36	0.34	0.32
0.5	22.92	5.08	2.07	$\boxed{1.12}$	0.73	0.54	0.44	0.38	0.35
0.6	33.76	7.59	3.10	1.65	1.03	0.73	0.56	0.47	0.41
0.7	46.71	10.63	4.36	2.31	1.42	0.98	0.73	0.58	0.49
0.8	61.79	14.20	5.86	3.10	1.90	1.28	0.94	0.73	0.60
0.9	78.98	18.29	7.59	4.02	2.46	1.65	1.19	0.91	0.73

C_s Values

	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	0.10	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	$\boxed{0.08}$	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables C_b=1.12 and C_s=0.08 find the total

pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s\ x\ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b\ x\ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
Pv,c = (δ x V^2) / 2 = 19.49 Pa

Therefore ΔPj (downstream) = 1.56 Pa ΔPj (branch) = 21.83 Pa

9. Tee fitting 6

Here the flow coming from branch 5 goes to flexible duct 6' and branch 7.

The diameter of the flexible duct 6' can be chosen from table below according to the flow rate

$Q_{6'}$=196.68 L/s ≈ 170 L/s

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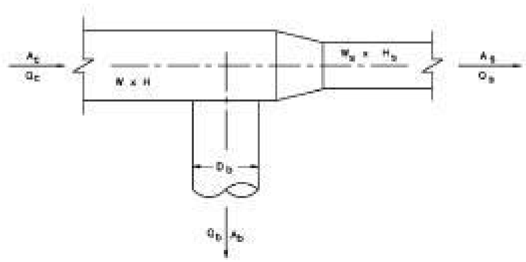
MAXIMUM RECOMMENDED AIR QUANTITY (LITRES PER SECOND)	FLEXIBLE DUCT DIAMETER (mm)
44 l/s	Ø 150
92 l/s	Ø 200
170 l/s	Ø 250
275 l/s	Ø 300
385 l/s	Ø 350
503 l/s	Ø 400
636 l/s	Ø 450
785 l/s	Ø 500
950 l/s	Ø 550

So D=250mm= 0.25m

Now, for tee fitting 6

SR5-11 Tee, Rectangular Main to Round Tap, Diverging



Where, Qc represents the flow coming from branch 5
Qb is the flow delivered to flexible duct 6'
Qs is the downstream flow that moves on to the branch 7
Ac is the area of the flow delivered from the branch 5

Ab is the area of the flow delivered to flexible duct 6'
As is the area of the downstream flow i.e., branch7.

__=0.6

___= 0.6

___= 0.5

— = 0.5

SR5-11 Tee, Rectangular Main to Round Tap, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.58	0.94	0.83	0.79	0.77	0.76	0.76	0.76	0.75
0.2	4.20	1.58	1.10	0.94	0.87	0.83	0.80	0.79	0.78
0.3	8.63	2.67	1.58	1.20	1.03	0.94	0.88	0.85	0.83
0.4	14.85	4.20	2.25	1.58	1.27	1.10	1.00	0.94	0.90
0.5	22.87	6.19	3.13	2.07	1.58	1.32	1.16	1.06	0.99
0.6	32.68	8.63	4.20	2.67	$\boxed{1.96}$	1.58	1.35	1.20	1.10
0.7	44.30	11.51	5.48	3.38	2.41	1.89	1.58	1.38	1.24
0.8	57.71	14.85	6.95	4.20	2.94	2.25	1.84	1.58	1.40
0.9	72.92	18.63	8.63	5.14	3.53	2.67	2.14	1.81	1.58
	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	$\boxed{0.10}$	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables C_b=1.96 and C_s=0.10 find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc{,}s \ x \ Pv{,}c$ -pressure loss for the downstream section
$\Delta Pj = Cc{,}b \ x \ Pv{,}c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
Pv,c = (δ x V²) / 2 = 15.61 Pa

Therefore ΔPj (downstream) = 1.56 Pa ΔPj (branch) = 30.59 Pa

10. Tee fitting 11

Here the flow coming from branch 10 goes to flexible duct 11' and branch 12.

The diameter of the flexible duct 11' can be chosen from table below according to the flow rate

$Q_{11'}$=191.54 L/s ≈ 170 L/s

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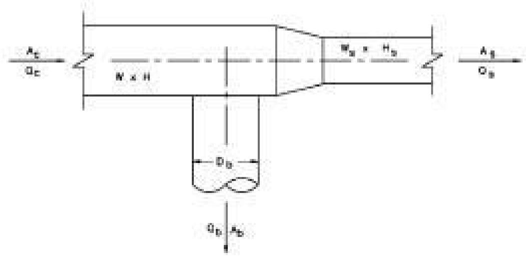
MAXIMUM RECOMMENDED AIR QUANTITY (LITRES PER SECOND)	FLEXIBLE DUCT DIAMETER (mm)
44 l/s	Ø 150
92 l/s	Ø 200
170 l/s	Ø 250
275 l/s	Ø 300
385 l/s	Ø 350
503 l/s	Ø 400
636 l/s	Ø 450
785 l/s	Ø 500
950 l/s	Ø 550

So D=250mm= 0.25m

Now, for tee fitting 11

SR5-11 Tee, Rectangular Main to Round Tap, Diverging



Where, Qc represents the flow coming from branch 10
Qb is the flow delivered to flexible duct 11’
Qs is the downstream flow that moves on to the branch 12 Ac is the area of the flow delivered from the branch 10 Ab is the area of the flow delivered to flexible duct 11’ As is the area of the downstream flow i.e., branch 12.

__=0.6

___= 0.6

___= 0.5

___= 0.5

SR5-11 Tee, Rectangular Main to Round Tap, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.58	0.94	0.83	0.79	0.77	0.76	0.76	0.76	0.75
0.2	4.20	1.58	1.10	0.94	0.87	0.83	0.80	0.79	0.78
0.3	8.63	2.67	1.58	1.20	1.03	0.94	0.88	0.85	0.83
0.4	14.85	4.20	2.25	1.58	1.27	1.10	1.00	0.94	0.90
0.5	22.87	6.19	3.13	2.07	1.58	1.32	1.16	1.06	0.99
0.6	32.68	8.63	4.20	2.67	$\boxed{1.96}$	1.58	1.35	1.20	1.10
0.7	44.30	11.51	5.48	3.38	2.41	1.89	1.58	1.38	1.24
0.8	57.71	14.85	6.95	4.20	2.94	2.25	1.84	1.58	1.40
0.9	72.92	18.63	8.63	5.14	3.53	2.67	2.14	1.81	1.58

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	$\boxed{0.10}$	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables C_b=1.96 and C_s=0.10 find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s\ x\ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b\ x\ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
$Pv,c = (\delta \times V^2) / 2 =$ 15.00 Pa

Therefore ΔPj (downstream) = 1.5 Pa ΔPj (branch) = 29.40 Pa

11. Tee fitting 16

Here the flow coming from branch 15 goes to flexible duct 16' and branch 17.

The diameter of the flexible duct 16' can be chosen from table below according to the flow rate

$Q_{16'}$=191.54 L/s ≈ 170 L/s

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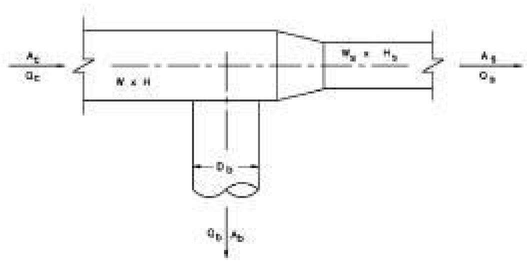
MAXIMUM RECOMMENDED AIR QUANTITY (LITRES PER SECOND)	FLEXIBLE DUCT DIAMETER (mm)
44 l/s	Ø 150
92 l/s	Ø 200
170 l/s	Ø 250
275 l/s	Ø 300
385 l/s	Ø 350
503 l/s	Ø 400
636 l/s	Ø 450
785 l/s	Ø 500
950 l/s	Ø 550

So D=250mm= 0.25m

Now, for tee fitting 16

SR5-11 Tee, Rectangular Main to Round Tap, Diverging



Where, Qc represents the flow coming from branch 15

Qb is the flow delivered to flexible duct 16’

Qs is the downstream flow that moves on to the branch 17

Ac is the area of the flow delivered from the branch 15
Ab is the area of the flow delivered to flexible duct 16’
As is the area of the downstream flow i.e., branch 17.

__=0.6

___= 0.6

___= 0.5

— = 0.5

SR5-11 Tee, Rectangular Main to Round Tap, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.58	0.94	0.83	0.79	0.77	0.76	0.76	0.76	0.75
0.2	4.20	1.58	1.10	0.94	0.87	0.83	0.80	0.79	0.78
0.3	8.63	2.67	1.58	1.20	1.03	0.94	0.88	0.85	0.83
0.4	14.85	4.20	2.25	1.58	1.27	1.10	1.00	0.94	0.90
0.5	22.87	6.19	3.13	2.07	1.58	1.32	1.16	1.06	0.99
0.6	32.68	8.63	4.20	2.67	$\boxed{1.96}$	1.58	1.35	1.20	1.10
0.7	44.30	11.51	5.48	3.38	2.41	1.89	1.58	1.38	1.24
0.8	57.71	14.85	6.95	4.20	2.94	2.25	1.84	1.58	1.40
0.9	72.92	18.63	8.63	5.14	3.53	2.67	2.14	1.81	1.58

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	$\boxed{0.10}$	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables

C_b=1.96 and C_s=0.10

find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s \ x \ Pv,c$ -pressure loss for the downstream section

$\Delta Pj = Cc,b \ x \ Pv,c$ - pressure loss in the branch section

And Pv,c is the dynamic pressure loss at the common section and is given by

Pv,c = (δ x V^2) / 2 = 15.00 Pa

Therefore

ΔPj (downstream) = 1.5 Pa ΔPj (branch) = 29.40 Pa

12. Tee fitting 28

Here the flow coming from branch 27 goes to flexible duct 28’ and branch 29.

The diameter of the flexible duct 28’ can be chosen from table below according to the flow rate

$Q_{16'}=106$ L/s ≈ 92 L/s

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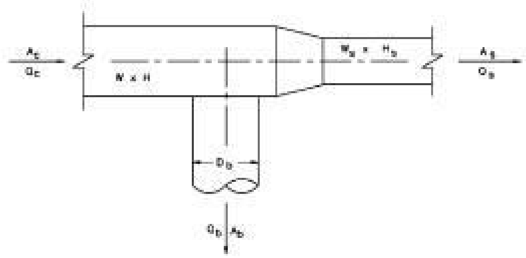
MAXIMUM RECOMMENDED AIR QUANTITY (LITRES PER SECOND)	FLEXIBLE DUCT DIAMETER (mm)
44 l/s	Ø 150
92 l/s	Ø 200
170 l/s	Ø 250
275 l/s	Ø 300
385 l/s	Ø 350
503 l/s	Ø 400
636 l/s	Ø 450
785 l/s	Ø 500
950 l/s	Ø 550

So D=200mm= 0.2m
Now, for tee fitting 28

SR5-11 Tee, Rectangular Main to Round Tap, Diverging



Where, Qc represents the flow coming from branch 27

Qb is the flow delivered to flexible duct 28’

Qs is the downstream flow that moves on to the branch 29

Ac is the area of the flow delivered from the branch 27

Ab is the area of the flow delivered to flexible duct 28’

As is the area of the downstream flow i.e., branch 29.

__=0.6

___= 0.5

___= 0.5

___= 0.5

SR5-11 Tee, Rectangular Main to Round Tap, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.58	0.94	0.83	0.79	0.77	0.76	0.76	0.76	0.75
0.2	4.20	1.58	1.10	0.94	0.87	0.83	0.80	0.79	0.78
0.3	8.63	2.67	1.58	1.20	1.03	0.94	0.88	0.85	0.83
0.4	14.85	4.20	2.25	1.58	1.27	1.10	1.00	0.94	0.90
0.5	22.87	6.19	3.13	2.07	1.58	1.32	1.16	1.06	0.99
0.6	32.68	8.63	4.20	2.67	1.96	1.58	1.35	1.20	1.10
0.7	44.30	11.51	5.48	3.38	2.41	1.89	1.58	1.38	1.24
0.8	57.71	14.85	6.95	4.20	2.94	2.25	1.84	1.58	1.40
0.9	72.92	18.63	8.63	5.14	3.53	2.67	2.14	1.81	1.58

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	0.10	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables C_b=1.96 and C_s=0.04 find the total pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s \ x \ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b \ x \ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
Pv,c = (δ x V^2) / 2 = 12.15 Pa
Therefore ΔPj (downstream) = 0.49 Pa ΔPj (branch) = 24.3 Pa

13. Tee fitting 33

Here the flow coming from branch 32 goes to flexible duct 33' and branch 34.

The diameter of the flexible duct 16' can be chosen from table below according to the flow rate $Q_{16'}$=199.41 L/s ≈ 170 L/s

FLEXIBLE DUCTWORK
FLEXIBLE DUCT SIZING GUIDE

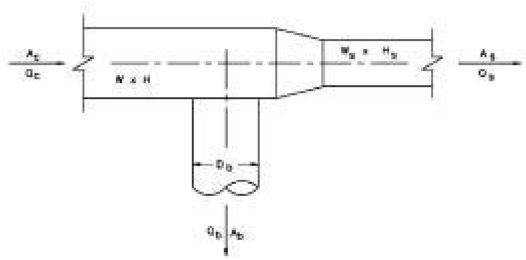
AdvantageAir

MAXIMUM RECOMMENDED AIR QUANTITY (LITRES PER SECOND)	FLEXIBLE DUCT DIAMETER (mm)
44 l/s	Ø 150
92 l/s	Ø 200
170 l/s	Ø 250
275 l/s	Ø 300
385 l/s	Ø 350
503 l/s	Ø 400
636 l/s	Ø 450
785 l/s	Ø 500
950 l/s	Ø 550

So D=250mm= 0.25m

Now, for tee fitting 33

SR5-11 Tee, Rectangular Main to Round Tap, Diverging



Where, Qc represents the flow coming from branch 32

Qb is the flow delivered to flexible duct 33'

Qs is the downstream flow that moves on to the branch 34

Ac is the area of the flow delivered from the branch 32
Ab is the area of the flow delivered to flexible duct 33’
As is the area of the downstream flow i.e., branch 34.

__=0.6

___= 0.6

___= 0.5

— = 0.5

SR5-11 Tee, Rectangular Main to Round Tap, Diverging

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.58	0.94	0.83	0.79	0.77	0.76	0.76	0.76	0.75
0.2	4.20	1.58	1.10	0.94	0.87	0.83	0.80	0.79	0.78
0.3	8.63	2.67	1.58	1.20	1.03	0.94	0.88	0.85	0.83
0.4	14.85	4.20	2.25	1.58	1.27	1.10	1.00	0.94	0.90
0.5	22.87	6.19	3.13	2.07	1.58	1.32	1.16	1.06	0.99
0.6	32.68	8.63	4.20	2.67	$\boxed{1.96}$	1.58	1.35	1.20	1.10
0.7	44.30	11.51	5.48	3.38	2.41	1.89	1.58	1.38	1.24
0.8	57.71	14.85	6.95	4.20	2.94	2.25	1.84	1.58	1.40
0.9	72.92	18.63	8.63	5.14	3.53	2.67	2.14	1.81	1.58

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.04								
0.2	0.98	0.04							
0.3	3.48	0.31	0.04						
0.4	7.55	0.98	0.18	0.04					
0.5	13.18	2.03	0.49	0.13	0.04				
0.6	20.38	3.48	0.98	0.31	$\boxed{0.10}$	0.04			
0.7	29.15	5.32	1.64	0.60	0.23	0.09	0.04		
0.8	39.48	7.55	2.47	0.98	0.42	0.18	0.08	0.04	
0.9	51.37	10.17	3.48	1.46	0.67	0.31	0.15	0.07	0.04

Reading from the above tables C_b=1.96 and C_s=0.1 find the total

pressure loss in the downstream section and the branch as follows

$\Delta Pj = Cc,s \ x \ Pv,c$ -pressure loss for the downstream section
$\Delta Pj = Cc,b \ x \ Pv,c$ - pressure loss in the branch section
And Pv,c is the dynamic pressure loss at the common section and is given by
Pv,c = (δ x V^2) / 2 = 16.85 Pa

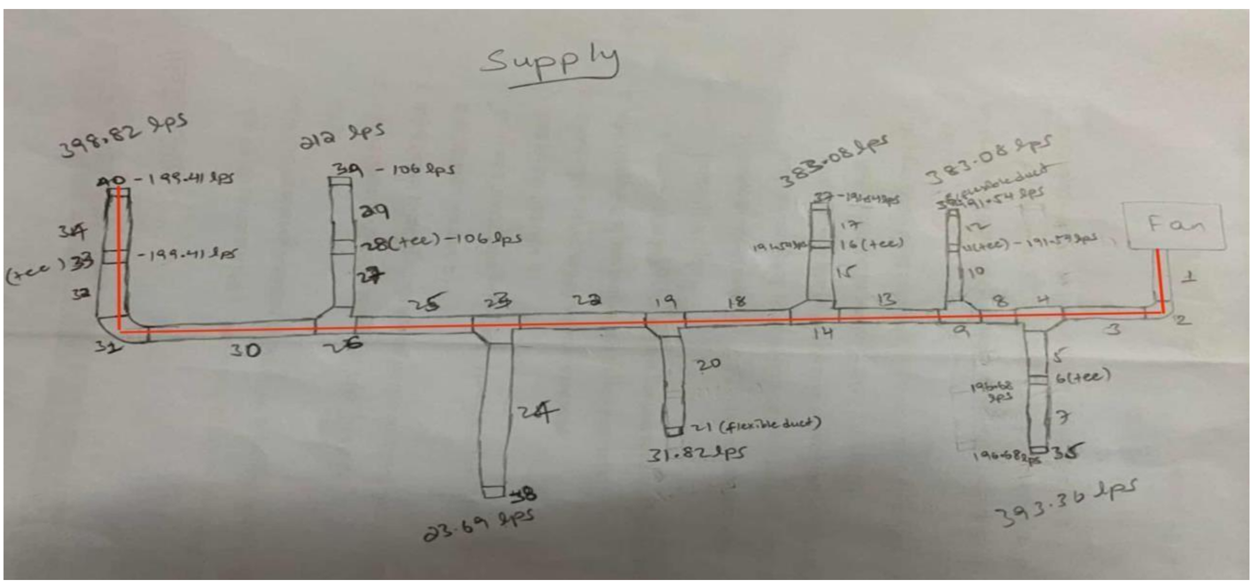
Therefore
ΔPj (downstream) = 1.69 Pa
ΔPj (branch) = 33.03 Pa

Tee Name	Qc	Qb	Qs	Ac	Ab	As	Ab/Ac	As/Ac	Qb/Qc	Qs/Qc	Cb	Cs	δ(kg/m3)	Velocity(m3/s)	Pv,c	ΔPj (branch)	ΔPj (downstream)	Total loss
4	1825.9	393.36	1432.5	280000	90000	210000	0.32	0.75	0.22	0.78	1.65	0.04	1.2	7.5	33.75	55.69	1.35	57.04
9	1432.5	383.08	1049.4	210000	80000	175000	0.38	0.83	0.27	0.73	1.28	0.08	1.2	7	29.40	37.63	2.35	39.98
14	1049.4	383.08	666.33	175000	80000	112500	0.46	0.64	0.37	0.63	1.12	0.04	1.2	6.6	26.14	29.27	1.05	30.32
19	666.33	31.82	634.51	112500	10000	112500	0.09	1.00	0.05	0.95	0.73	0.04	1.2	5.9	20.89	15.25	0.84	16.08
23	634.51	23.69	610.82	112500	10000	112500	0.09	1.00	0.04	0.96	0.73	0.04	1.2	5.8	20.18	14.73	0.81	15.54
26	610.82	212	398.82	112500	52500	87500	0.47	0.78	0.35	0.65	1.12	0.08	1.2	5.7	19.49	21.83	1.56	23.39
6	393.36	196.68	196.68	90000	49063	50000	0.55	0.56	0.50	0.50	1.96	0.1	1.2	5.1	15.61	30.59	1.56	32.15
11	383.08	191.54	191.54	80000	49063	50000	0.61	0.63	0.50	0.50	1.96	0.1	1.2	5	15.00	29.40	1.50	30.90
16	383.08	191.54	191.54	80000	49063	50000	0.61	0.63	0.50	0.50	1.96	0.1	1.2	5	15.00	29.40	1.50	30.90
28	212	106	106	52500	31400	28125	0.60	0.54	0.50	0.50	1.96	0.04	1.2	4.5	12.15	23.81	0.49	24.30
33	398.82	199.41	199.41	87500	49063	48125	0.56	0.55	0.50	0.50	1.96	0.1	1.2	5.3	16.85	33.03	1.69	34.72

o For flexible ducts 21 and 38

Fan Selection

For this, we will be using the Daikin Air Handling Unit Selection catalog. For this selection, the longest pressure drop path will be used. This path is going to be 1,2,3,4,8,9,13,14,18,19,22,23,25,26,30,31,32,33,32,40.



Total pressure drop on this path becomes: 300 Pa.

Total flow rate required it: 1825.85 Lps

As such, from the table below we select our AHU.

UNIT SIZE	Air Flow LPS	ESP Pa	4-ROWS COOLING COIL S.C kW	T.C.C kW	Water flow lps	WPD kPa	Circuit	1-ROW HEATING COIL T,C kW	Water flow lps	WPD kPa	MOTOR kW
0404	646	300	7.3	7.7	0.37	0.27	F	4.7	0.11	0.04	0.75
0407	1027	300	12.6	15.0	0.71	1.16	F	8.8	0.21	0.19	1.1
0410	1408	300	18	22.7	1.08	3.04	F	13.1	0.32	0.48	1.5
0413	1789	300	22.7	30.8	1.47	6.25	F	17.3	0.42	0.95	2.2
0707	1670	300	20.4	24.4	1.16	1.16	F	14.3	0.35	0.19	2.2
0710	2289	300	32.1	42.9	2.04	4.82	F	24.8	0.6	0.76	2.2
0713	2908	300	38.4	50	2.38	6.26	F	28.1	0.69	0.95	3
0715	3321	300	44.5	26	2.79	9.21	F	32.8	0.8	1.39	3.7
1010	3169	350	41.9	54.5	2.60	6.98	M	29.5	0.72	0.48	4
1013	4026	350	54.7	72.9	3.47	14.01	M	39.0	0.95	0.95	5.5
1015	4598	350	68.4	96.0	4.57	30.53	M	52.2	1.27	2.16	4
1019	5741	350	80.0	109.3	5.21	38.05	M	58.8	1.43	0.65	7.5
1021	6312	350	88.7	122.1	5.82	50.05	M	65.8	1.60	3.50	7.5
1315	5619	350	75.3	99.2	4.72	9.2	F	55.4	1.35	1.39	7.5
1319	7016	350	95.3	127.1	6.05	17.09	F	71.8	1.75	2.64	7.5
1321	7715	350	106.1	143.3	6.83	22.83	F	81.4	1.96	3.50	11
1519	7654	450	103.9	138.6	6.60	17.09	F	78.3	1.91	2.65	11
1521	8416	450	115.8	156.3	7.45	22.83	F	87.7	2.14	3.50	11
1819	9568	500	129.9	178.8	8.26	17.09	F	97.9	2.39	2.65	15
1821	10520	500	144.7	195.4	9.31	22.83	F	109.6	2.67	3.50	15
1823	11473	500	167.1	232.5	11.07	38.25	F	130.2	3.17	5.88	15
1827	13378	500	187.2	256.7	12.23	45.29	F	141.9	3.46	6.81	18.5
2027	14270	750	188.6	245.3	11.69	5.69	D	151.4	3.69	6.8	22
2033	17300	750	246.1	335.7	16.50	15.90	D	187.2	5.10	18.5	30
2233	19482	750	262.1	356.9	16.52	10.08	D	210.3	5.12	11.71	37
2239	22900	750	395.0	490.0	23.30	25.60	D	252.2	6.85	28.60	55
2539	24800	750	530.6	389.1	25.27	25.61	D	273.3	7.42	28.57	55

From this table our selection that can provide the specified flow rate and pressure is one with size 0710.

UNIT SIZE	Air Flow	ESP	4-ROWS COOLING COIL					1-ROW HEATING COIL			MOTOR kW
			S.C	T.C.C	Water flow	WPD	Circuit	T,C	Water flow	WPD	
	LPS	Pa	kW	kW	lps	kPa		kW	lps	kPa	
0404	646	300	7.3	7.7	0.37	0.27	F	4.7	0.11	0.04	0.75
0407	1027	300	12.6	15.0	0.71	1.16	F	8.8	0.21	0.19	1.1
0410	1408	300	18	22.7	1.08	3.04	F	13.1	0.32	0.48	1.5
0413	1789	300	22.7	30.8	1.47	6.25	F	17.3	0.42	0.95	2.2
0707	1670	300	20.4	24.4	1.16	1.16	F	14.3	0.35	0.19	2.2
0710	2289	300	32.1	42.9	2.04	4.82	F	24.8	0.6	0.76	2.2
0713	2908	300	38.4	50	2.38	6.26	F	28.1	0.69	0.95	3
0715	3321	300	44.5	26	2.79	9.21	F	32.8	0.8	1.39	3.7

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[2] ASHREA HAND BOOK 1981 FUNDAMENTAL CHAPTER 23 table 3A [3] ASHREA HAND BOOK 1981 FUNDAMENTAL CHAPTER 26 table 6

[4] ASHREA HAND BOOK 1981 FUNDAMENTAL CHAPTER 26 table 7

[5] ASHREA HAND BOOK 1981 FUNDAMENTAL CHAPTER 26 table 9

[6] ASHREA HAND BOOK 1981 FUNDAMENTAL CHAPTER 26 table 10

[7] ASHREA HAND BOOK 1981 FUNDAMENTAL CHAPTER 26 table 311

[8] ASHREA HAND BOOK 1981 FUNDAMENTAL CHAPTER 27 table 35

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