Palestine Polytechnic University
College of Engineering

Mechanical work for Birzeit girl housing students

Prepared by:
Ayman Maali Wasim Saleh

Supervisor: Dr. Kazem Osaily

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TABLE OF CONTENTS

SUBJECT **Page**

LIST OF TABLES

LIST OF FIGURES

إهداء

لابد لنا ونحن نخطو خطواتنا الأخيرة في الحياة الجامعية من وقفة نعود إلى أعوام قضيناها في رحاب الجامعة مع أساتذتنا الكرام الذين قدموا لنا الكثير باذلين بذلك جهودا كبيرة في بناء جيل الغد لتبعث الأمة من جديد...

وقبل أن نمضي نقدم أسمى آيات الشكر والامتنان والتقدير والمحبة إلى الذين حملوا أقدس رسالة في الحياة...

الى مشرفنا الدكتور كاظم عسيلي

إلى أمهاتنا وآباءنا

إلى أساتذتنا

إلى زملائنا وزميلاتنا

إلى الشموع التي تحترق لتضئ للآخرين

إلى كل من علمني حرفا

أهدي هذا البحث المتواضع راجياً من المولى

عز وجل أن يجد القبول والنجاح

Acknowledgment

It would be unfair to forget the precious knowledge and assistance provided by our teachers during those past years, especially those who helped us in University and outside it.

We would like to dedicate this project to our supervisor, **Dr. Kazem Osaily** a faculty member in PPU University, who really helped us to complete this project, by providing us with his advises, steps, knowledge, and the necessary data required to finish this project.

خلاصة

تعد أنظمة الارتياح الحراري أحد أهم متطلبات الحياة العصرية،ويتطلب ذلك توفير درجة الحرارة الملائمة للغرفة صيفا وشتاءً بهدف الحصول على الأجواء الملائمة لاستمرار النشاط الانساني بشكل طبيعي ،وقد تتعدى هذه الانظمة الى أشكال اخرى مثل توفير المياه الساخنة والباردة للاستعمال اليومي والتخلص السليم من هذه المياه او معالجتها للاستخدامات الأخرى , كذلك فان هذه الانظمة تتضمن توفير كميات المياه اللازمة للتغلب على الحرائق في حال حدوثها ,كل هذه الانظمة وغيرها تندرج تحت منظومة الاعمال الميكانيكية التي يتم اعدادها في المبنى لتوفير درجة من الراحة والأمان.

تم في هذا العمل والذي يندرج تحت مساق (مقدمة الى مشروع التخرج)،اجراء دراسة على كافة الاعمال الميكانيكية المنوي القيام بها في سكن الطالبات الداخلي والذي تنوي جامعة بيرزيت البدء في انجازه قريبا .

بدأت هذه الدراسة بحساب الاحمال الحرارية للمباني من خلال دراسة مكونات المباني الانشائية ، بعد ذلك تم البدأ بعمل اختيار للنظام الملائم للتدفئة من خلال اجراء مقارنة بين اكثر من نوع من هذه الانظمة ،كذلك فقد تم اجراء دراسة تقديرية على كميات المياه الساخنة والباردة اللازمة للاستعمال اليومي،وما ينتج عنها من مياه عادمة .كذلك فقد تم اجراء دراسة على انظمة مكافحة الحرائق واختيار نظام يتلائم ونوع المبنى للتغلب على الحريق في حال اندلاعه.

تم في مقدمة مشروع التخرج هذه اجراء كافة الدراسات وذلك للبدء في انجاز مشروع التخرج للفصل القادم والذي يشمل تصميم كامل لنظام التدفئة الملائم للمبنى،وما يتبعه من انظمة اخرى مساعدة (مثلا انظمة اللواقط الشمسيه)

كذلك فان هذا العمل سيشمل وجود طريقة فعالة للتعامل مع الحرائق في حال حدوثها,كل هذه الاعمال سيتم القيام بها بناء على الحسابات والتقديرات التي تم القيام بها في العمل الحالي.

Abstract

Birzeit University intends to build a student dormitory for girl at the place of the old building, in order to make their study life easier, and to near the way to university. This project concentrates on providing the services for students at its highest quality, and minimum cost.

As mechanical engineers are interested in providing the comfort conditions for living. These comfort conditions include the availability of suitable temperature for living space, and suitable temperature expands to suitable air conditions. In this project it intend to make a complete study for the different possible ways for heating & cooling by use Chilled water system, this system is applied by using chiller(outdoor unit) & Fan coil unit(in door unit),. In order to start the design of the proper system, the load must be estimated at each element of building construction (wall, floor, window…..etc.).

Another need for the building is the domestic clean water supply. Domestic water divided into two main parts, hot and cold water, hot water for shower, washing, and the cold water for the cleaning and toilet flushing. The water usage rate must be estimated in order to prepare the suitable system for water supply, this estimation depend on many variables (e.g. number of students, load factor, type of usage…etc.). As for waste water, we intend to study the different choices for waste water disposal e.g. (waste water treatment plant for other requirements such as irrigation, toilet flushing).

Firefighting system is another important part of the mechanical works in the building, since it controls the fire expansion. As a result it should design and estimate the amount of water needed for firefighting system, and this will be done by determining the severity (light, ordinary and extra hazard) of the system that will use. Many components of the firefighting system must be determined (e.g. Water tank and its alternatives, the pumps required, design of the pipe network, sizes of pipes of fire hose cabinets or CO_2).

Time table

In this section the tasks it shown below:

Task ID	Task Description
T1	Choosing the project
T2	Overview previous projects
T3	Overall heat transfer coefficient calculations for walls, ceiling, floor, doors,
T4	Heating and cooling loads calculations
T5	Water supply system calculations
T6	Drainage system calculations
T7	Editing and modifying
T8	Design Chiller & Fan coil unit system
T9	Design the Chilled air duct in the building
T10	Design Fresh air & exhaust air duct & fan
T11	Design the plumbing system
T12	Design the firefighting system
T13	Selection and drawing the relevant systems
T14	Doing bill of quantity tables
T15	Printing

Table 1.2: Time table

1st															
Task/Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
T1															
T2															
T3															
T4															
T5															
T6															
T7															
T8															
2nd															
Task/Week	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
T9															
T10															
T11															
T12															
T13															
T14															
T15															

Chapter One: Building Characteristics

1.1 Introduction:

1.2 Modes of heat transfer:

1.2.1 Convection.

1.2.2 Radiation.

1.3 Thermal resistance:

1.4. Overall heat transfer coefficient (U factor).

1.4.1. Overall heat transfer coefficient for the external walls.

1.4.2 Overall heat transfer coefficient for the exposed roof.

1.4.4. Overall heat transfer coefficient for the windows.

1.4.5. Overall heat transfer coefficient for the doors.

1.1 Introduction:

In mechanical work one of the most important issue to study conditions in order to build the suitable systems of heating, cooling and ventilation, etc. to build efficient system we need to understand the fundamentals of heat transfer modes (conduction, convection, radiation).

Heat transfer processes are classified into three types. The first is conduction, which is defined as transfer of heat occurring through intervening matter without bulk motion of the matter. A solid (a block of metal, say) has one surface at a high temperature and one at a lower temperature. This type of heat conduction can occur, for example, through a turbine blade in a jet engine. The outside surface, which is exposed to gases from the combustor, is at a higher temperature than the inside surface, which has cooling air next to it. The level of the wall temperature is critical for a turbine blade.

The second heat transfer process is convection, or heat transfer due to a flowing fluid. The fluid can be a gas or a liquid; both have applications in aerospace technology. In convection heat transfer, the heat is moved through bulk transfer of a non-uniform temperature fluid.

The third process is radiation or transmission of energy through space without the necessary presence of matter. Radiation is the only method for heat transfer in space. Radiation can be important even in situations in which there is an intervening medium; a familiar example is the heat transfer from a glowing piece of metal or from a fire.

Each material has different thermal properties; it has different conductivity, emissivity, and thermal resistance. By studying these terms we can choose the proper materials with the suitable properties to reduce heat losses .Now, since each material has different thermal properties, more generalized method will be used, in order to get the thermal properties for a multiple layered assemblies material.

In this chapter we will make a complete study about the heat losses from the dorms, based on the common method of heat transfer. The thermal properties for each type of construction will be discussed. And the thermal property (overall heat transfer coefficient) will be found based on scientific data about each type.

1.2 Modes of heat transfer:

Heat Transfer is the thermal energy transported due to a temperature difference. In other words, it is explain the energy gained by the cold part from the hot part of the space. There are two common modes of heat transfer.

1.2.1 Convection:

It is the transfer of energy which occurs between fluids (liquids, gases) in motion, and surface when there is a difference in temperature.

Convection heat transfer consists of two mechanisms, the random molecular motion which it is known as **diffusion**, and the bulk **macroscopic motion of fluid.**

The convection heat transfer can be categorized according to the nature of the flow, there is the forced convection when flow is induced by external ways like fans or pumps, and there is the free convection, the flow is induced by **buoyancy** forces, which arises from density difference due to temperature difference .The rate equation of the convection heat transfer is as Known as **Newton's law of cooling.**

$$\mathbf{Q} = \mathrm{h}(\mathrm{T_s} - \mathrm{T_\infty}) \qquad (2.2)$$

h: the convection heat transfer coefficient of the fluid $(\mathrm{W/m^2.°C})$

$\mathbf{T_s}$: is the temperature of the surface in contact with the fluid.

$\mathbf{T_\infty}$: is the temperature of the fluid.

(Asaad & Hammad)

1.2.2 Radiation:

It is the energy emitted by a surface at a given temperature. Unlike the conduction and the convection heat transfer, the radiation heat transfer doesn't need medium to transfer energy. Radiation occurs more efficiently in a vacuum because the energy of radiation is transported by electromagnetic waves, energy exchange between a surface and its surrounding is given by the equation below.

$$\mathbf{q} = \varepsilon\sigma A\left(T_s{}^4 - T_{surr}{}^4\right) \tag{2.3}$$

Where:

σ: (Stephan- Boltzmann constant) =$5.67 \times 10^{-8} w/m^2k^4$

ε: is the emissivity, the value of it is between 0< ε<1 , 1 is for blackbody

$$\mathbf{Qrad} = \ hr\, A(Ts \ - \ Tsurr) \tag{2.4}$$

$$\mathbf{hr} = \varepsilon\sigma(T_s \ - T_{surr})\left(T_s{}^2 - T_{surr}{}^2\right) \tag{2.5}$$

1.3 Thermal resistance:

The thermal resistance of material is defined as the ability of a material to resist heat flow. In other words it is a measure of how much the material behaves as an insulator. High thermal resistances indicate better performance of insulating.

The rate equations for both the conduction and convection heat transfer is linear, but for radiation, the rate equation is not linear.

Heat transfer calculations could be simplified if the radiation heat transfer equation became linear and that could be achieved by transforming Steven Boltzmann equation into linear equation by adding hr in the equation. After we do this step, we realize that all three equations is a function of a constant multiplied by area multiplied by temperature difference. It is possible to analog the equation with

When the heat transfer equation is written according to Ohm's law, the equations became like:

$$\mathbf{Q} = \frac{\Delta T}{R_{th}} \qquad (2.6)$$

Where R_{th}: is the thermal resistance.

For any type of construction the thermal resistance will be :

$$\mathbf{R} = \frac{L}{K} \qquad (2.7)$$

For the air, the thermal resistance will be as tabulated below as shown:

Air thermal resistance	
Type	Thermal resistance ($\mathbf{W/m^2.°C}$)
Horizontal, still air, heat flow up	0.11
Horizontal, still air, heat flow down	0.16
, heat flow horizontal Vertical	0.12
Outside air film (horizontal& vertical)	0.029
Horizontal air space	0.24
Vertical air space	0.14

Table 1: Air thermal resistance.

1.4. Overall heat transfer coefficient (U factor):

Overall heat transfer coefficient is a combination between different thermal properties, for multi layered section. This coefficient has a unit of W/m².°C, which is the same as the conduction coefficient, since both measure the same thing. On the other hand convection and radiation is coupled into formula such as conduction. In our case, we interested in lower (U) factor, which mean better insulation.

$$\mathbf{U} = \frac{1}{R} = \frac{QA}{\Delta T} = \frac{K}{L} \quad (2.9)$$

U: over all heat transfer coefficient $(W/m^2 °C)$

R: the summation of thermal resistance $(m^2 . °C/W)$

L: Thickness (m)

K: Thermal Conductivity ($W/m\ °C$).

1.4.1. Overall heat transfer coefficient for the external walls:

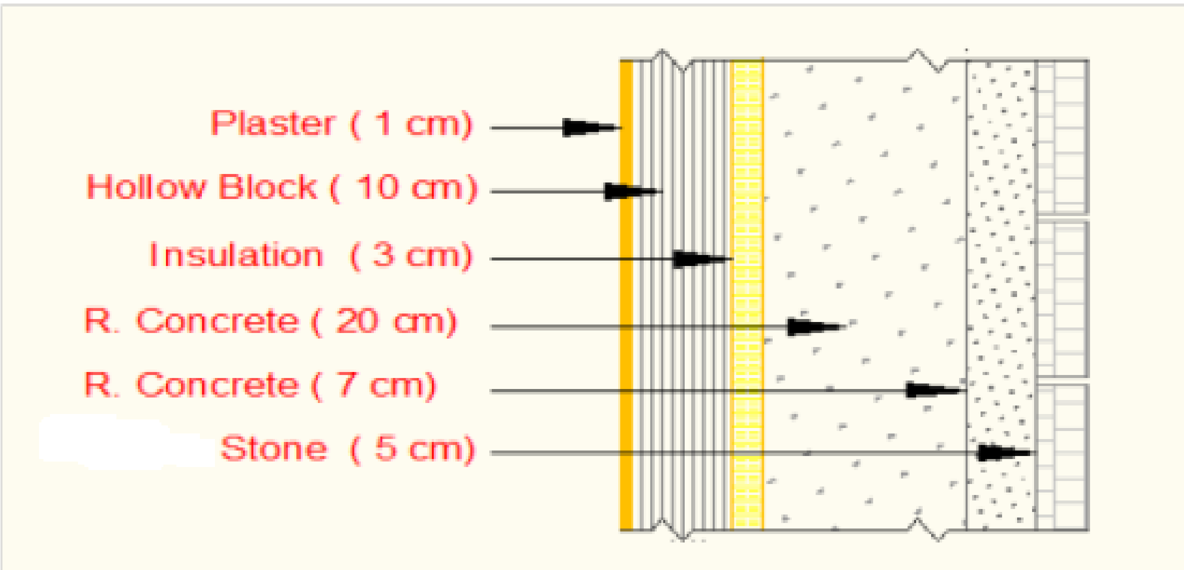

Figure 1: Cross section for the external wall.

Over All heat Transfer Coefficient (U) for External wall			
Material Type	Thickness(L) (m)	Thermal Conductivity (k) (W/m °C)	Thermal Resistance (R) = (L/K) (m^2.°C /W)
Outside air film	----------------	-------------------	0.029
stone	0.05	1.69	0.030
Concrete	0.27	1.75	0.154
Insulation	0.03	0.036	0.833
Hollow Block	0.1	0.72	0.139
Plastering	0.01	1.2	0.008
Inside air film	------------------	---------------------	0.12
Over All Heat Transfer Coefficient (U - **W/m °C**) = (1/ΣR)			0.76

Table 2: Absolute calculation of (U) factor for the external wall.

The following table shows the overall heat transfer coefficient(U):

1.4.2 Overall heat transfer coefficient for the exposed roof:

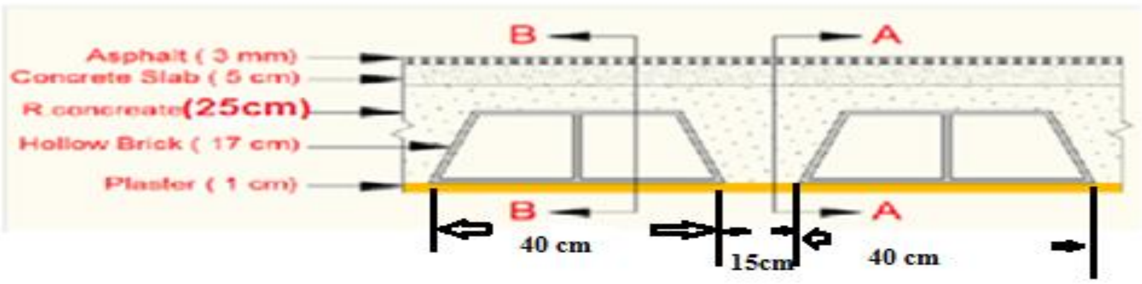

Figure 2:Cross section for the external roof.

The exposed roof construction can be divided into two sections (A and B) , these section are illustrated in the figure above.

We will find an average value for U factor, based on the assumption of 40/55 section B, and 15/55 of section A by area.
a/b = ¼ , A+B= 5 section note for brick = 4 / 5, Or concrete = 1/5

The following table shows the heat Transfer Coefficient (U) for material used in roof:

Over All heat Transfer Coefficient (U) for Exposed Roof section (A)			
Element	Thickness(L) (m)	Thermal Conductivity(k) W/m.°C)	Thermal Resistance R=(L/k)(m².°C/W)
Outside air film	-----------------	----------------------	0.029
R. Concrete	0.25	1.75	0.14285
Plaster	0.01	1.2	0.0083
Asphalt	0.003	0.7	0.004
Concrete slab	0.05	1.75	0.029
Inside air film	---------------------	-----------------------	0.16
Over All Heat Transfer Coefficient (U- W/m². °C) = (1/ΣR)			2.68
Over All heat Transfer Coefficient (U) for Exposed Roof section (B)			
Outside air film	-------------	----------------	0.029
R. Concrete	0.08	1.75	0.045
Plaster	0.01	1.2	0.0083
Asphalt	0.003	0.7	0.004
Concrete slab	0.05	1.75	0.029
Hollow Bricks	0.17	0.95	0.179
Inside air film	--------------	-------------------	0.16
Over All Heat Transfer Coefficient (U- W/m²°C =1/Σ R)			2.19
Average Value= 15/55*2.68+40/55*2.19			2.32

Table 3: Tabulated calculation of (U) factor for the exposed roof.

1.4.3. Overall heat transfer coefficient for the roof floor:

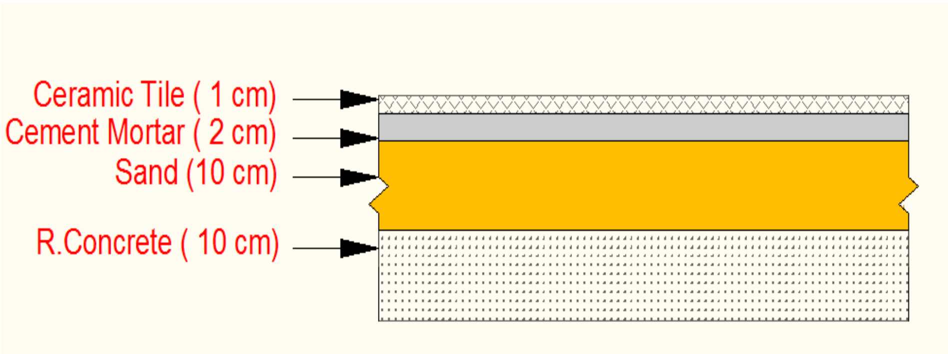

Figure 3:Construction of the ground floor

The following table shows the heat Transfer Coefficient (U) for Tabulated calculation of (U) factor for the ground floor:

Over All heat Transfer Coefficient (U) for Exposed Roof section (A)			
Element	Thickness(L) (m)	Thermal Conductivity (K) (W/m °C)	Thermal Resistance (R)= (L/k) (m^2.°C /W)
inside air film	-----------------	----------------------	0.11
R. Concrete	0.1	1.75	0.0571
Sand	0.1	0.3	0.333
Cement mortar	0.02	1.75	0.0114
Ceramic tile	0.01	1.05	0.00952
Over All Heat Transfer Coefficient (U- W/m^2°C) = (1/ΣR)			1.92

Table 4:Tabulated calculation of (U) factor for the ground floor.

1.4.4. Overall heat transfer coefficient for the windows:

The window that used is double glazing with 6 mm air gap. The air space between the glass layers will lower the amount of heat losses, since the still air has high thermal resistance (0.17 m^2°C /W). The amount of (U) factor for double glazing is 3.2 W/m^2°C.

1.4.5. Overall heat transfer coefficient for the doors:

External doors are made from glass, it is the same as the double glazing _ U factor =3.2 W/m^2°C.

Internal door is made from wood _ U factor =3W/m^2°C.

Window Area = 2 m^2

Door = 2 m^2

(Asaad & Hammad)

Chapter Two: Heating& cooling Loads Estimation.

2.1 Introduction.

2.2 Thermal comfort.

2.3 Cooling loads calculation:

2.3.1 Transmission load.

2.3.2. Estimated cooling load.

2.1 Introduction:

Heat transfer is an important science in the field of our study; it is an extension for Thermodynamics analysis. Heat transfer is the thermal energy transported due to at temperature difference; it also deals with the rate of transfer of thermal energy. It is used in many engineering applications. Many buildings are designed based on the principle of heat transfer, like the heating and air conditioning systems, refrigerators, and freezers.

2.2 Thermal comfort:

Thermal comfort is defined as "that condition of mind which expresses satisfaction with the thermal environment". This condition is also sometimes called as "neutral condition", though in a strict sense, they are not necessarily same. A living human body may be likened to a heat engine in which the chemical energy contained in the food it consumes is continuously converted into work and heat. A human body is very sensitive to temperature. The body temperature must be maintained within a narrow range to avoid discomfort, and within a somewhat wider range, to avoid danger from heat or cold stress. Studies show that at neutral condition, the temperatures should be

Skin temperature, skin ≈ 33.7ºC

Core temperature, core ≈ 36.8ºC

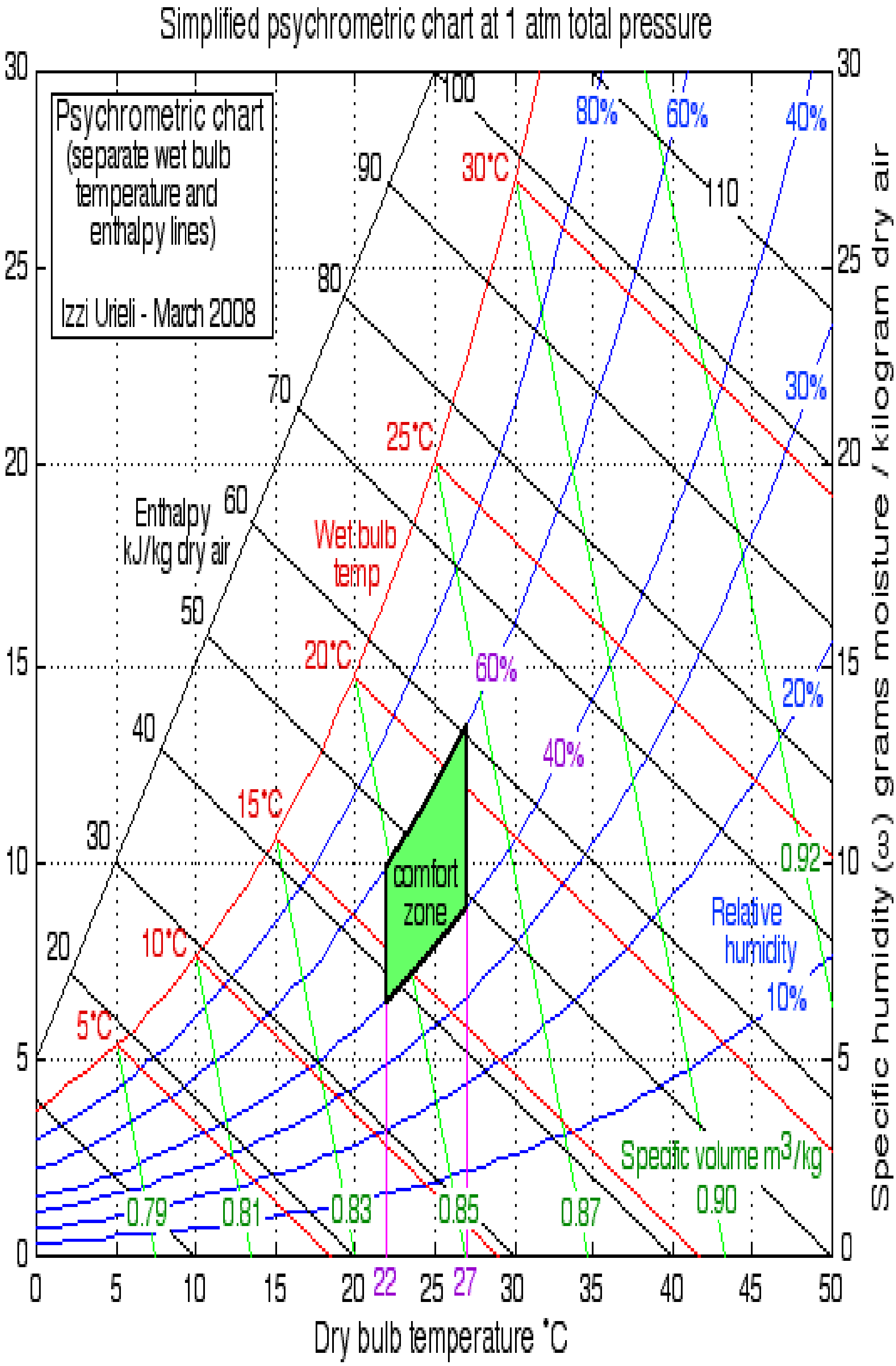

Figure 4: Thermal comfort zone.

Thermal comfort is important in our life, because it makes you feel psychologically comfortable and increases the worker productivity, or makes the students focus in their studies ……etc.

Most people think that the temperature of the surrounding air is the only factor that affects the thermal comfort, but in fact there are six factors that can be categorized into environmental and personal aspects.

1. Environmental aspect includes radiant temperature which represents the radiant heat from a hot body, air velocity and humidity which represent the amount of moisture content in the air. (Asaad & Hammad)

2. Personal aspect which includes the insulation of clothing, it represents the amount of clothing layers the person wear, and the type of material it made from , which minimizes the heat loss from the human body, and the last factor is the metabolic heat which represents the amount of heat generated in our bodies when doing a physical activates, which increases the heat loss from the human body to prevent it from overheating ,thus the type of human activity ,age , sex, weight and size all these factors affect the human comfort which should be considered when designing an effective air conditioning system.

2.3 Cooling loads calculation:

The primary function of cooling load calculation is to estimate the capacity that will be required for various Cooling & Heating components, necessary to maintain comfort within a space. These calculations are therefore based on peak load conditions corresponding to environmental conditions which are normally taken near the extremes. The Cooling load consists in general of three major types, first is the transmission loads, second is the infiltration load and the ventilation load, we calculate cooling load since it is large than heating load & cooling components is also used for heating system.

2.3.1 Transmission load:

For the transmission load, the load comes from the heat transfer through walls, roofs, windows and floors to the surrounding. It is given by the relation

$$\mathbf{q_t} = UA\,(T_o - T_i) \qquad (2.1)$$

Where:

q: is the thermal load in watts.
U: is overall heat transfer coefficient in W/ m^2 . °C
A: is the surface area of the floor, ceiling....etc. in m^2.
T_o: is the temperature of the outdoor.
T_i: is the temperature of the indoor
This load is totally sensible. Because it is a function of temperature difference between inner surface and outer surface.

2.3.2. Estimated cooling & heating load:

The shown sample calculation is for room number G16; the area for this room is 22.04 m^2.

Heating load:

Some variable must be known:

T_o =2 °C
Relative Humidity out = 75 %
Velocity of air =1.4 m/s
T_i = 24 °C
Relative humidity in= 50 %
U (over all heat transfer for outside wall) = 0.76 W/m^2. °C
U (over all heat transfer for inside wall) = 2.6 W/m^2. °C

T_{un}= 12 °C, U floor = U =1.92W/m². °C

Q from inside wall

Q wall inside = U *A*ΔT

Q_{in} = 2.6*6.3*(24-12) = 196.5 W

Q wall outside = U*A*ΔT

Q_o= 0.76 *((1.8*3.08+10.14)*(24-2) = 262.2 W

Q floor = U * A *ΔT

Q floor = 1.92*(5.8*3.8)*(24-12) = 507.8 W

Q from window = U *A *ΔT

U window = 3.2 W/m². °C

Q = 3.2* (2)*(24-2) =140.8W

Q from door = U*A*ΔT = 3 * 2*(24-12) = 72 W

Q from ceiling = zero

$V_{infltriation} = \frac{ACH * v*1000}{3600} = \frac{1*5.8*3.8*3.08*1000}{3600}$ = 18.8 L/S

ACH from table 4-6

Q_{inf} = 1.2 *V_{inf}* ($T_{in-}T_o$) = 1.2*18.8 *(24-2) = 496.32

Total heating load for room #16 = 196.5+262.2+507.8+140.8+496.32 =1603.6 W

The heating load from bath room :

Q floor = 1.92 * 5.8*12 = 133.6 W

V_{inf}= (0.5*5.8*3.3*1000)/3600 = 2.6 L/S

Q_{inf}= 2.6*1.2*(24-2) = 68.6 W

Q from inside wall = U*A*ΔT = 2.6*6.25*12 =195 W

Q door =U*A*ΔT = 3 * 2 * 12 = 72 W

The total heat = 133.6 +68.6 +195 +72 = 469.2 W

Cooling load:

Some variable must be known:

$V_{infltriation} = \frac{inside\ volume\ * v*1000}{3600}$

ACH: air change per hour from (table 4-6 in Appendix A)

For G16 ACH = 18.8 L/s

V_{Vent} : Air ventilation requirement, from (table 4-5 in Appendix A)

V_{Vent} = 7.5 L/s/person.

Number of people in this room = 4

Q wall, in = the heat loss convection from inside wall

The north wall the heat loss = 0

The west wall the heat loss= $U * A * (T_{un} - T_{in})$,

T_{un} = temp in the room unconditioned

T_{in}= temp room condition

Q wall, in = 2.6*(1.2*3.3)*6.6 = 68 W

The south wall = $U * A * (CLTD_{corr})$

$CLTD_{corr}$ For south wall= $(CLTD + LM) * K + (25.5 - T_i) + (T_o - 29.4) * f$

k = 0.83 for medium color

CLTD from (table 9-4 in Appendix A) group c wall at solar time 4 pm= 8

LM: latitude month,

From table (9-2 in Appendix A), Latitude 32° at June = -2.2

T_{in} = 22°C, T_{out}= 32°C

$CLTD_{corr} = (8 - 2.2) * 0.83 + (25.5 - 22) + (32 - 29.4) = 11°C$

Heat loss = 0.76 * 3.08*1.8*11 = 46.3 W

From east wall CLTD corr = 11.08

Heat loss = 0.76*10.14*11.08 = 85.38 W

Q floor = U * A* (T_{ground} - T_{in})

U = 1.92 w/m². °C

Q = 1.92*.3.8*5.8*6 = 253.9 W

Q_{Roof} = zero because the first floor condition

Q_{door} = U*A*(To-Ti)

U =3 W/m² . °C

Q_{door} = 3 *2*0 = 0 W

Q_{Window}:

1- Heat transmitted = A*(SHG)*(SC)*(CLF)

SHG= solar heat gain factor (table 9.7 in Appendix A)

SC= shading factor (table 9.8 and table 9.9 in Appendix A)

CLF = cooling load factor (table 9.10 and table 9.11 in Appendix A)

Q = A*(SHG)*(SC)*(CLF)

Q = 2*675*0.95*0.3 = 384.75 W

2- Convection heat = U*A*($CLTD_{corr}$)

U = 3.2 w/m^2. °C

A = area = $2m^2$

$CLTD_{corr}$= (CLTD +LM) *k (25.5-T_i) + (T_o-29.4)*f

From (Table 9-12 in Appendix A), CLTD = 8

$CLTD_{corr}$= 14.1 °C

Q_{conv}= = 3.2*2*14.1 = 90.2 W

The total heat from window = 474.9 W

Q_{light} = 10 W/ m^2

The total heat = 10 * 22.04 = 220.4 W

Q_{people} = 1- sensible = q_s * n * CLf, q_s = sensible heat

From (table 4.2 in Appendix A), n = number of people in the space, CLF = cooling load factor

$Q_{people,sensible}$ = 70*4*0.9 =252 W

Latent = q_l * n,

q_l From table 4.2 =30

$Q_{l people,latent}$ =30*4 =120 W

$Q_{s,eqp} = Q_{sensible\ equipment}$ = q_s *CLf, q_s (from table 9.13 in Appendix A),

CLf: cooling load factor

Q_s = 1100 W

Q_l = ql (from table 9.13 in Appendix A), =0 W

$Q_{sen,vent}$ = heat sensible ventilation

$Q_{sen,vent}$ = 1.2 * Vvent *(To-Tin) = 1.2 * 30*(32-22) = 360 W

V_{Vent} = air change requirement

$Q_{latent,Vent}$ = heat latent from ventilation

$Q_{latent,Vent}$ = 3 * Vvent *(Wo-Wi),

W_o & W_i from psychometric chart moisture content,

W_o= 18 g/Kg, W_{in} 6 g/Kg

Q = 3 * 30*12= 1080 W

$Q_{sen,tot}$ = Q sensible total= $Q_{wall\ in}$ + $Q_{wall\ external}$ + Q_{floor} + Q_{roof}+ Q_{door} + Q_{window}+ Q_{light}+ $Q_{people,sensible}$ + $Q_{equipment\ sensible}$ +$Q_{sensible\ ventilation}$ = 2792.88 W

$Q_{sen,tot}$= 1.15 *Q sensible total = 1.15 *2792 = 3211.8 W,

Where 1.15 is safety factor

$Q_{Lat,tot}$= Q latent ventilation+ Q latent equipment+ Q latent people= 1200W

Where $Q_{Lat,tot}$= Q latent total

V_{circ}, L/s = V circulation in litter per second =

V_{circ}, L/s = ($Q_{Lat,tot}$+$Q_{sen,tot}$)/1.2*(T_{circ} -T_{in})

(T_{circ} -T_{in}) = 10 °C

V_{circ} = (1200+3211.8)/12 = 367.6 L/S

CFM = 2.2* V_{circ} = 2.2*367.6= 807 CFM

To determine the number of diffuser:

Of Diffuser per room if the dimension of diffuser is 40 cm * 40 cm we supply 300CFM

#Diffuser = # CFM/ 300

#Diffuser = 807 /300 = 3 diffuser / room

In the same way; cooling loads calculate for all rooms in the building, as shown in the Appendix c.

Then, when calculate the cooling loads for all rooms in the building, the suitable outdoor & indoor machine can be select.

Chapter 3: HVAC Systems & duct design.

3.1. Introduction.

3.2. Heating system.

3.3 Ventilation.

3.4 Air conditioning system.

3.5. Indoor & outdoor.

3.5.1. Outdoor unit (Chiller).

3.5.2 Indoor unit (Fan Coil Unit F.C.U).

3.6 Calculation and Duct design.

3.1 Introduction:

Heating, ventilation and air conditioning (HVAC) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. Refrigeration is sometimes added to the field's abbreviation as HVAC&R or HVACR, or ventilating is dropped as in HACR (such as the designation of HACR-rated circuit breakers).

HVAC is an important part of residential structures such as single family homes, apartment buildings, hotels and senior living facilities, medium to large industrial and office buildings such as skyscrapers and hospitals, onboard vessels, and in marine environments, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors.

Ventilating or ventilation (the V in HVAC) is the process of exchanging or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, carbon dioxide, and other gases. Ventilation removes unpleasant smells and excessive moisture, introduces outside air, keeps interior building air circulating, and prevents stagnation of the interior air.

Ventilation includes both the exchange of air to the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings. Methods for ventilating a building may be divided into mechanical/forced and natural types.

3.2 Heating system:

Heaters are appliances whose purpose is to generate heat (i.e. warmth) for the building. This can be done via central heating. Such a system contains a boiler, furnace, or heat pump to heat water, steam, or air in a central location such as a furnace room in a home, or a mechanical room in a large building. The heat can be transferred by convection, conduction, or radiation.

3.3 Ventilation:

Ventilation is the process of changing or replacing air in any space to control temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria, or carbon dioxide, and to replenish oxygen. Ventilation includes both the exchange of air with the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings. Methods for ventilating a building may be divided into mechanical/forced and natural types.

Mechanical or forced ventilation:

Mechanical, or forced, ventilation is provided by an air handler (AHU) and used to control indoor air quality. Excess humidity, odors, and contaminants can often be controlled via dilution or replacement with outside air. However, in humid climates more energy is required to remove excess moisture from ventilation air.

Kitchens and bathrooms typically have mechanical exhausts to control odors and sometimes humidity. Factors in the design of such systems include the flow rate (which is a function of the fan speed and exhaust vent size) and noise level. Direct drive fans are available for many applications, and can reduce maintenance needs.

Ceiling fans and table/floor fans circulate air within a room for the purpose of reducing the perceived temperature by increasing evaporation of perspiration on the skin of the occupants. Because hot air rises, ceiling fans may be used to keep a room warmer in the winter by circulating the warm stratified air from the ceiling to the floor.

3.4 Air conditioning system:

An air conditioning system, or a standalone air conditioner, provides cooling and humidity control for all or part of a building. Air conditioned buildings often have sealed windows, because open windows would work against the system intended to maintain constant indoor air conditions. Outside, fresh air is generally drawn into the system by a vent into the indoor heat exchanger section, creating positive air pressure. The percentage of return air made up of fresh air can usually be manipulated by adjusting the opening of this vent. Typical fresh air intake is about 10%.

Air conditioning and refrigeration are provided through the removal of heat. Heat can be removed through radiation, convection, or conduction. Refrigeration conduction media such as water, air, ice, and chemicals are referred to as refrigerants. A refrigerant is employed either in a heat pump system in which a compressor is used to drive thermodynamic refrigeration cycle, or in a free cooling system which uses pumps to circulate a cool refrigerant (typically water or a glycol mix).

A simple stylized diagram of the refrigeration cycle:

1) Condensing.
2) Expansion valve.
3) Evaporator coil.
4) Compressor.

The refrigeration cycle uses four essential elements to cool.

The system refrigerant starts its cycle in a gaseous state. The compressor pumps the refrigerant gas up to a high pressure and temperature.

From there it enters a heat exchanger (sometimes called a condensing coil or condenser) where it loses energy (heat) to the outside, cools, and condenses into its liquid phase.

An **expansion valve** (also called metering device) regulates the refrigerant liquid to flow at the proper rate.

The liquid refrigerant is returned to another heat exchanger where it is allowed to evaporate, hence the heat exchanger is often called an evaporating coil or evaporator. As the liquid refrigerant evaporates it absorbs energy (heat) from the inside air, returns to the compressor, and repeats the cycle. In the process, heat is absorbed from indoors and transferred outdoors, resulting in cooling of the building.

In variable climates, the system may include a reversing valve that switches from heating in winter to cooling in summer. By reversing the flow of refrigerant, the heat pump refrigeration cycle is changed from cooling to heating or vice versa. This allows a facility to be heated and cooled by a single piece of equipment by the same means, and with the same hardware.

3.5 Indoor & outdoor:

3.5.1. Outdoor unit (Chiller):

Chilled water is a commodity often used to cool a building's air and equipment, especially in situations where many individual rooms must be controlled separately, such as a hotel. The chilled water can be supplied by a vendors, such as a public utility or created at the location of the building that will use it, which has been the norm.

Thin in the modern time the manufactured company developed the chiller to use it in heating sys, by convert the direction of the flow loop, thus, it can use for cooling and heating, & and contributed to reducing the initial costs (like install the system) and the running cost.

The chiller is connect to indoor unit by using pipe, and then to make air change in the room we use air diffuser, the air diffuser is connect the indoor unit by use iron duct.

The following picture show the outdoor machine Chiller:

Figure 5:This picture show the Chiller.

3.5.2 Indoor unit (Fan Coil Unit F.C.U):

A Fan Coil Unit (FCU) is a simple device consisting of a heating and/or cooling heat exchanger or 'coil' and fan. It is part of an HVAC system found in residential, commercial, and industrial buildings. A fan coil unit is a diverse device sometimes using ductwork, and is used to control the temperature in the space where it is installed, or serve multiple spaces. It is controlled either by a manual on/off switch or by a thermostat, which controls the throughput of water to the heat exchanger using a control valve and/or the fan speed.

Due to their simplicity and flexibility, fan coil units can be more economical to install than ducted 100% fresh air systems (VAV) or central heating systems with air handling units or chilled beams. Various unit configurations are available, including horizontal (ceiling mounted) or vertical (floor mounted).

Noise output from FCUs, like any other form of air conditioning, is principally due to the design of the unit and the building materials around it. A correctly selected

FCU, like some of those from the UK, can offer noise levels as low as NR25 or NC25.

The output from an FCU can be established by looking at the temperature of the air entering the unit and the temperature of the air leaving the unit, coupled with the volume of air being moved through the unit. This is a simplistic statement, and there is further reading on sensible heat ratios and the specific heat capacity of air, both of which have an effect on thermal performance.

The following picture show the indoor machine Fan Coil Unit:

Figure 6: Fan Coil Unit (F.C.U)

3.6 Calculation and Duct design:

Exhaust air = $V_{infltriation} = \frac{ACH * Room\ volume*1000}{3600}$ = L/s

ACH = number of change air per hour (from table 4.5 in Appendix A):

ACH for living room = 5

ACH for kitchen = 15

ACH for office = 6

ACH for passage = 4

For room # G 16:

Exhaust air $= \frac{5*22.04 \ *3.3*1000}{3600}$ = 101 L/s

Fresh air for this room from calculation the less than exhaust air but we must fresh air equal or greater than exhaust air

Fresh air for room # G 16 = 101 L /s.

M chiller (mass flow rate for chiller) $= \frac{\text{total cooling load (watt)}}{\text{cp} *\text{T}}$

Cp: specific heat for water = 4186 W/ Kg. °C

T = the amount of temperature exchange between air and water

$M = \frac{1192326.3}{4186*6}$ = 47.4 L/s

Pressure loss in pipe in general = 200 to 550 Pa/m

We assume the pressure loss in this network = 300 Pa/ m

The longest path in this network = 208 meter including fitting

The head of pump chiller = 62.4 KPa

M/room = mass flow rate per room inlet the fun coil unit

m = cooling load / (4186 *6)

For room G16 the cooling load = 4504.3/ (4186*6) = 0.179 L/s

The size of pipe (PVC plastic pipe) from figure 7-15a

The condition of selection: The velocity of water = (0.6 to 1.2 m/s), pressure loss = 300 pa /m

The variable known: mass flow rate and pressure loss, form graph we find the size of pipe.

The size of pipe in this room = 25 mm, and the return = 25 mm

The diffuser size 40 cm * 40 cm we supply 300 cfm

The diffuser size 60 cm * 60 cm we supply 400 cfm

The duct size: first step select velocity 5 m/s in main branch and we find the pressure loss and save this value and second step we make this value constant in other branch and we design the ducts For room G16 the calculation of supply air duct from fan coil unit to diffuser size:

(Hint: this Design if we want to add duct, diffuser & grill in the small rooms)

Duct section	V(L/s)	V(m/s)	A(m^2)	Size (rectangle)	Size (diameter)	pa/m
1	367	5	0.073	200*400mm	305 mm	1.05
2	245	4.5	0.054	200*300mm	281 mm	1.05
3	122	3.8	0.032	200*175mm	201 mm	1.05
4	122	3.8	0.032	200*175mm	201 mm	1.05
5	122	3.8	0.032	200*175mm	201 mm	1.05

Table 5: Sample calculation for duct design

V: (l/s): mass flow rate of the air in the branch.

V: (m/s): velocity of air in the branch.

A: area of the section branch.

Pa/m: pressure loss.

Assume the velocity in the main branch 5 m/s and we calculate if area of the Section: A = mass flow rate / velocity = 0. 367/5 = 0.073 m^2

Now calculate the diameter of section $D = (4 * A / 3.14)^{0.5} = 305$ mm

From (table 10.2 in Appendix A) find the size as rectangle = 200 *400 mm

From (figure 10.5a in Appendix A) find the pressure loss = 1.05 Pa/m

Now the size in the sub section assume the pressure 1.05, find the velocity from (figure 10.5a in Appendix A) = 3.8 and , now calculate the diameter, and from (table 10.2 in Appendix A) find the size as rectangle.

Size the duct exhaust air:

Assume the velocity of air 5 m/s and the mass flow = 101 L/s

Same step in the supply duct and the fresh air same as

From table 9.2 in Appendix A; The CLTD for all directions equal:

CLTD for north direction = 7.87°C

CLTD for east direction = 13.87°C

CLTD for south direction = 11°C

CLTD for west direction = 11.08°C

Over all heat for inside wall =2.6 W/m^2.°C

Over all heat for floor = 1.92 W/m^2.°C

Over all heat for external wall = .76 W/m^2.°C

Over all heat for roof = .88W/m^2.°C

T_{un} Condition room and place = 28.6°C

T_{in} = 22°C

T_O = 32 °C

The duct for all rooms is calculate and design In the same way. (Asaad & Hammad)

Chapter Four: Water Consumption Estimation.

4.1. Introduction.

4.2. Domestic water requirements estimation.

4.3. Water storage system.

4.4. System Design.

4.4.1 Pipe Sizing.

4.1 Introduction:

Water supply is an important aspect of life, so we should design an efficient system to supply the water requirements at any time, either for domestic uses or any other thing, such as firefighting. Water supply system depends on some factors:

1. Building type, building type describe the way by which the water is consumed, and its amount. For example homes , factories , offices, hospitals and schools , each one of these has a different characteristic, which make its water requirements different , for our case the building is designed for students dorms.
2. The number of people live in the building, each person consume fixed amount of water daily.
3. Water storage system, water storage system is important side of the system. This should be build based on the suitable data about the daily consumptions, and the time period between each supply from the utility.
4. Supply schematic and its related characteristic (pipe sizing, pumping …etc.).
5. Waste water amount per occupant, and its percentage of the total amount.
6. Amount of water needed for the fire protection system, this depend on the class of building hazard, and the area of the building. (Stein, 1997)
7. Type of fire protection system, since each type consumes water in different amount. For example, water cabinet consumes water more than water sprinkler.

4.2. Domestic water requirements estimation:

The largest water requirement in the home can be seen in the toilet flushing, laundry, and showers. This two side represent nearly 85% of total uses. The rest uses (kitchen, cleaning…..etc.) occupy only 15%, the figure below show the water source of uses in home:

In order to estimate the water requirements in the home, the water volume in liters is estimated per person. This estimation based on a universal code for hot and cold water requirements. However, the universal code is not valid in Palestine.

Moreover a Girl dorm does not use water as residential homes, but in lower amount, this may be due to:

1. Students usually spend most of his time at the university, so the water amount required is not necessary the same as in residential uses.

2. The building contains a laundry room, but most students go homes for laundry. The major water source of use will be the toilet flushing and may a shower every day.

Because of this the water amount in the dorms assumed to be 50% of the universal consumptions. This amount tabulated as below:

Type of building	Consumption per occupant (L/day)	Peak demand per occupant (L/day)
Factories	22-45	9
Hospitals(general)	160	30
Hospitals(mental)	110	22
Hostels	90	45
Hotels	90-160	45
Houses and flats	90-160	45
Offices	22	9
School(boarding)	115	20
School(day)	15	20

Table 6: Universal water consumptions. Universal water consumptions.

4.3. Water storage system:

The suitable water storage system should be designed in order to:

1. Provide for an interruption of supply.
2. Accommodate peak demand.
3. Provide a pressure (head) for gravity supplies.

Water storage system design requirements:

1. Time period between each supply from the utility.

2. The daily water consumption per person and the total consumption.

3. Total storage tank or well can be calculated based on the previous.

4.4 System Design:

4.4.1 Pipe Sizing:

To size the pipe, we follow this steps:

To size the pipe, we follow this steps:

1. From Table 6-14: take the fixture unit for every fixture type.
2. From table 6-2: take the flow rate for every fixture.
3. Calculate the total flow at all pipe section.
4. From Table 6-3a & 6.8: take the suitable main diameter pipe.
5. From table 6-15: take the pipe size for every fixture.

In this project, there are several plumbing fixture usage such as shower, water closet, lavatories and sink.

There is reference to the code for each unit a certain number of fixture unit for example: sink = 1.5 fixture unit, But there are network design for each some of plumbing fixture usage Collector cold water and hot water is distributed to these units and is calculated flow water in the pipes, and from the code we take size of pipe.

The Fixture unit that used in our project is shown on the following table with the fixture unit & pipe size for every fixture:

Fixture Type	Fixture Unit (FU)	Fixture Pipe size (in)	Flow rate (Gpm)	Total FU For room
Sink	1.5	½	3.8	1*1.5=1.5
Shower	1.5	½	3.8	1*1.5=1.5
Lavatories	.75	½	3.8	2*0.75=1.5
water closet	3	1	10.8	3
Total				7.5

Table 7: the Fu, pipe size & flow for every fixture type.

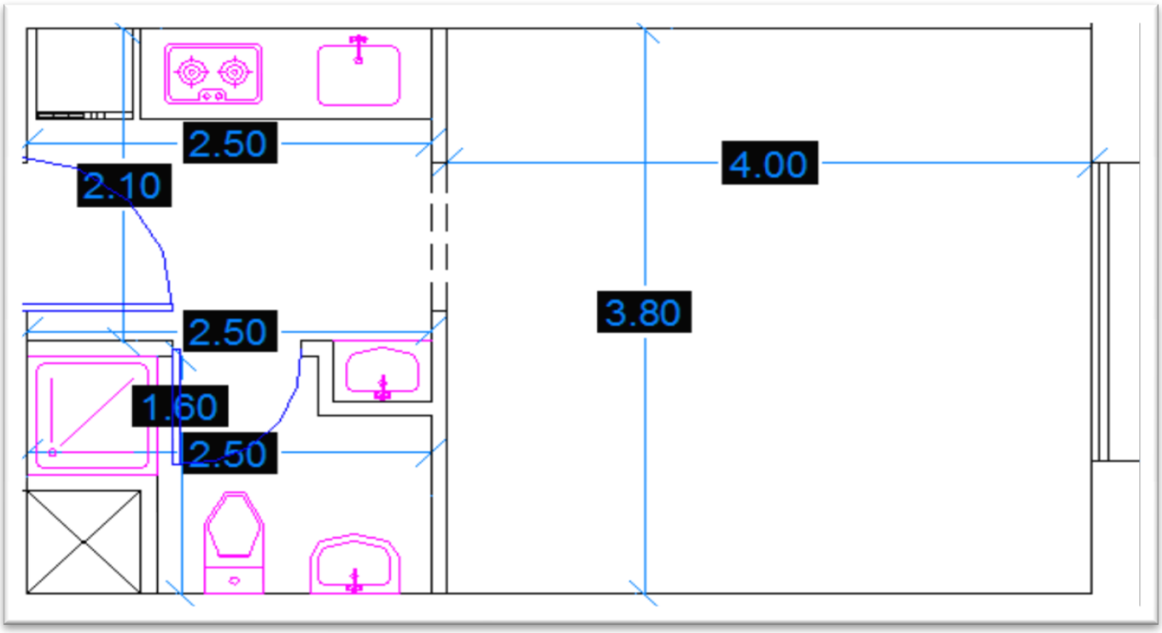

Figure 7: Sample Room

After calculate the total Fu (7.5 FU); the flow rate equal 12.3 GPM for the supply pipe, then when use 0.8 diversity factor; the total flow rate is = (12.3 * 0.8 = 9.84 Gpm), so the suitable pipe size is equal 1".

Pipe size calculations for main supply:

By using the up feed distribution system in which the water is supplied to the building water tank.

Before us calculations should now some information's:

1. The main pressure is equal 50 psi.
2. The friction loss through the water meter equal 7.7psi by chart water meter
3. The total equivalent length from the source to critically fixture unit is 42 meter and equal 138.15 feet.
4. The static pressure equal 17.71 meter equal 58.25 feet and equal 25.22 psi
5. Flow of the total building 11.6 $\frac{\text{liter}}{\text{sec}}$ equal 183.86 US gpm

Main Pressure = Static pressure+ Friction head loss

Static pressure $= 17.71 \times \frac{0.433}{0.304} = 25.22psi$

Friction head loss = 50-25.22-7.7= 17.08psi

Suppose that the diameter of the water meter is ø 3"

Then: friction head loss water meter 7.7 psi

Then: friction head loss = 17.08psi

Equivalent length == $138.15 \times 1.5 = 207.22\ feet$

Uniform design friction loss = $\frac{Availble\ head\ loss}{Equivalent\ length}$

= $\frac{17.08 \times 100}{207.22} = 8.24\ \frac{psi}{100ft}$

Diameter of the water meter is ø 3" at 8 psi

The diameter of the main feeder tube of the building   ø 2.1/2" at 8.24 psi

And velocity 10.5 FPS

(Stein, 1997)

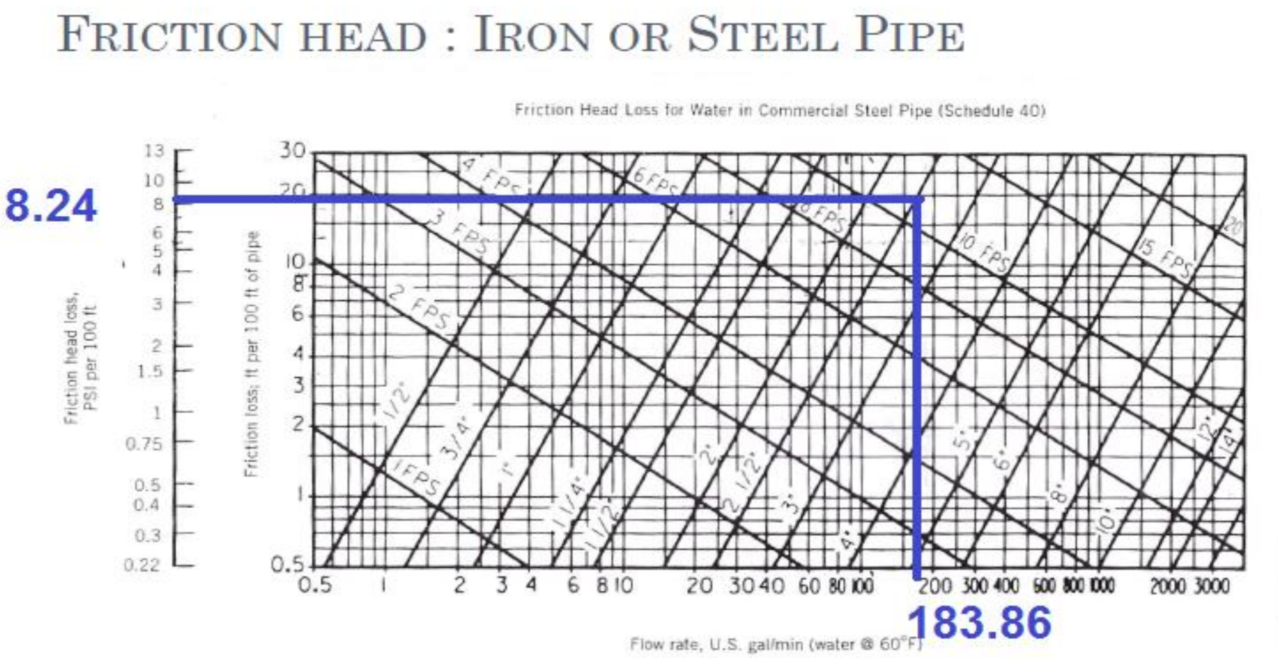

Figure 8: Friction Head loss in black steel pipe.

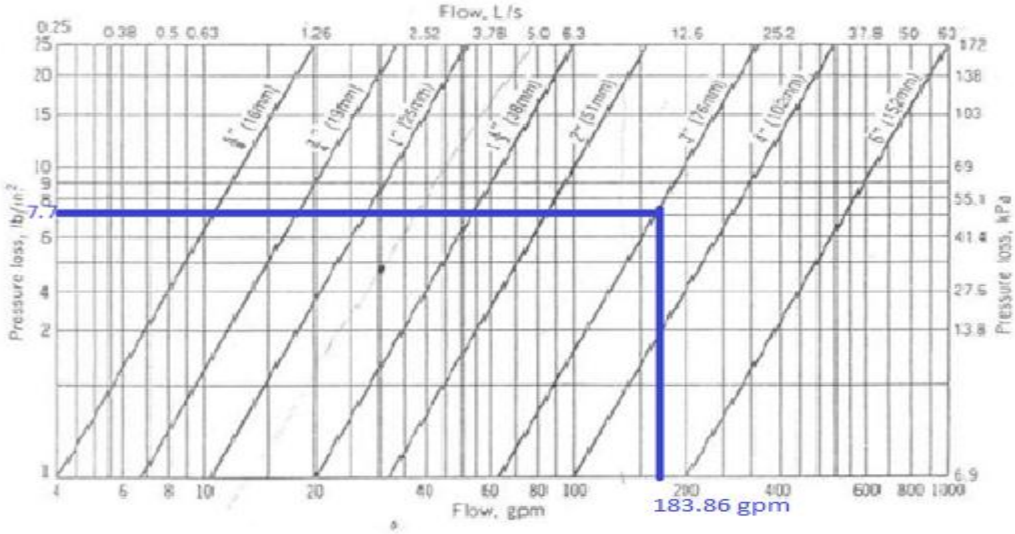

Figure 9: Pressure loss in disk-type water meter.

Pump Selection:

Final step calculate the pressure we supply this network.

From the code there for each plumbing fixture usage pressure flow, and the pressure loss in the pipe and gravity weight of water from elevation.

The tank of cold water Placed on the roof of the building.

The tank of hot water placed on the basement of the building.

The tank of fire fitting placed on the roof of the building.

This calculation shows the head of pumps for three system.

The cold water and by reference the Auto cad drawing.

First step calculate the pressure loss in the pipe:

Cold Water Pressure:

Section A-B = 30 pa /m * 8 = 240 pa

Section B-C = 13 pa/m * 6.7 = 87.1 pa

Section C-D = 28pa/m*4.45 = 124.6 pa

Section D-F = 18 pa/m * 3.47 = 62.46 pa

Section F-M = 15pa/m * 5.51 = 82.65pa

Section M-G = 30pa/m * 5.11 =153.3 pa

Section G-L = 41 pa /m *8.83 = 362.03pa

Section L-H = 200 pa/m *3.49 = 698 pa

The total pressure loss * 1.8 = 1810.14*1.8=3258.25pa

The gravity weight = - 3*9.81 = -29.43 kpa

Pressure flow = 81.6 kpa

The head of pump = 81.6 + 3.26 – 29.34 = 55.86 kpa

Tank capacity:

We assume the pump will work 1 hour per day, so the tank capacity can determined by use the following equation:

$$\text{The capacity of tank } = \frac{\text{flow rate } * \# \text{ hour} * 3600}{1000} = \text{ m}^3 = \frac{11.6 * 1 * 3600}{1000}$$

$$= 42 \text{ m}^3$$

Boiler Selection:

To select boiler we use the number of fixture method in the room:

The following table show the quantity of consumption for every fixture:

Fixture		Capacity (Litter)
Lavatory	**Hand clean**	2
	Hair clean	6
Shower		13
Bathtub		15
Sink		5

Table 8: Water quantity consumption for every fixture.

To determine the capacity volume for electrical boiler:

The consumption for every fixture= capacity * # of fixture * # of use

Lavatory = (2+6) * 2 * 2 = 32 litter.

Sink = 5 * 1 * 1 = 5 litter.

Bathtub = 15 * 1 * 2 = 30 litter.

Total capacity = 32 + 5 + 30 = 67 litter.

We use electrical boiler with 80 litter capacity, produced by Ariston company; model VLS PLUS 80.

(التعليم، 2011)

4.5 Sanitary Drainage system:

The main object of drainage system is to carry the waste water from the fixture unit to manhole and from the manhole to the septic tank or to the municipal sewage system.

The provision of drainage systems: Sanitary drainage.

4.5.1 Drainage system components:

The main components of drainage system are:

- Fixture units .
- Trap .
- Clean out .
- Drainage pipe.
- Stack and vent pipes .
- Manholes
- Septic tank or municipal sewage system
- Accessories.

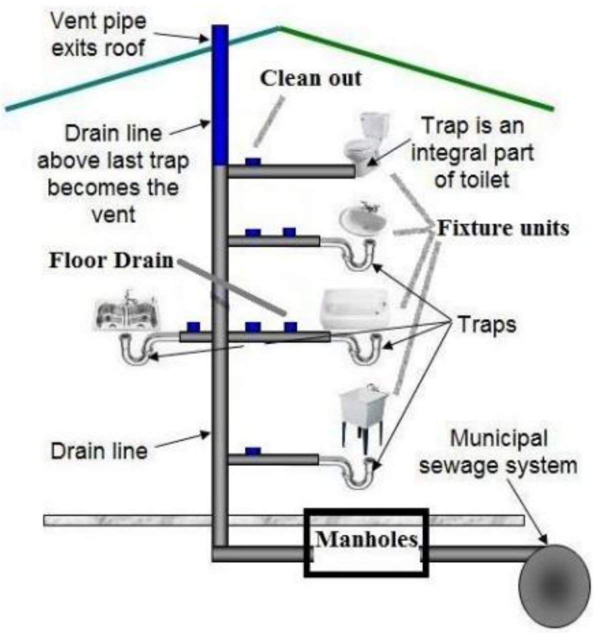

Figure 4.4: Drainage system components.

This project deals with two types of wastewater which is gray and black water, the separation of waste water will rationalize consumption of water and reuse it in irrigation and in flushing water closet.

4.5.2 Design & pipe sizing:

Pipe size is calculated by using a concept of fixture units (DFU) instead drainage water. This unit takes into account not only the fixtures water use but also its frequency of use, which is the DFU has a built–in diversity factor. This enables us, exactly add DFU of various fixtures to obtain the maximum expected drainage flow.

for a particular number of drainage fixture units, according to Tables (10.1), (10.2), (10.3), (10.5) in Appendix B.

These tables are built into the fill factors, which are:

- 50% fill in branches (horizontal pipes)
- (25-33)% fills in stack (vertical pipes)
- 50% fill in building and swear drains

The recommended velocity for drainage piping:

- For branches the recommended velocity is 2 ft/s
- For building pipes the recommended velocity is 3 ft/s
- For greasy flow the recommended velocity is 4 ft/s

Velocity of water flow through drainage piping depends on:

- Pipe diameter
- Slope
- Minimum slope requirements for horizontal drainage piping:
- For pipes of diameter ≤ 3" the minimum slope is 1/4”/ft (2%)

Design procedure:

1. Calculation of the number of DFU for each branch by using Table (10.3).
2. Calculation of the number of DFU for each stack.
3. Choosing the branch pipe diameter by using Table (10.2).
4. Choosing the stack pipe diameter by using Table (10.2).
5. Comparing the stack pipe diameter with branch diameter.
6. Choosing the building drain pipe diameter by using Table (10.2).

To achieve the recommended velocities which are 3 fps in building drain, it will be chosen the slope and flow velocity in building drain by using Appendix

B . (10.1).(10.5)

Sample calculation:

From Table 10.2 , take the fixture unit of every type fixture, and from table 10.3 we take the size of every fixture; as shown in the following table:

Fixture	DFU	Size
Water Closet	6	3”
Lavatory	2	$1\frac{1}{2}$”
Shower	2	$1\frac{1}{2}$”
Floor drain 2”	3	2”
Floor drain 4”	6	4”
Trap 2”	3	2”
Trap 4”	6	4”

Table 9:Sizing & DFU for every fixture.

But the general sizes that used in Palestine work since not produce this size like $1\frac{1}{2}$” are; the size are shown in the following table:

Fixture	Size
Water Closet	4”
Lavatory	2”
Shower	2”
Floor drain 2”	2”
Floor drain 4”	4”
Trap 2”	2”
Trap 4”	4”

Table 10: General size use in Palestine Shops & works.

To select the suitable pipe size of the branch, stack & building stake; We follow the following steps (The following size for stack #1):

1. From Table 10.3; we select the require size for any fixture.
2. From Table 10.2:

- Under (any Horizontal ….) select the size of branch; for stack 1 pipe branch size =4".
- Under (Stack more than 3 – total at one story) select the size of stack; for stack 1 pipe branch size =4".

3. From Table 10.2select the size of building drain pipe.

Fixture type	DFU	size
Third branch	23	4"
Third to second floor stake	23	4"
Second branch	23	4"
Second to First floor branch	46	4"
First branch	23	4"
First to Ground stake	69	4"
Ground Branch	23	4"
Ground to building drain	92	4"

Table 11: Sizing of stack1.

# of stake	Total DFU	Diameter	Slope%
1	128	4"	1/4
2	256	5"	1/4
3	256	5"	1/4
4	256	5"	1/4
5	256	5"	1/4
6	128	4"	1/4
8	230	5"	1/4
9	200	5"	1/4
11	256	5"	1/4
12	256	5"	1/4
14	128	4"	1/4
15	288	6"	1/4
16	256	5"	1/4
17	128	4"	1/4

Table 12: Sizing of black water stacks and building drain.

4.5.3 Manhole Design:

The main purpose of the manholes is to carry the water from stacks to various drainage points.

The design of the manholes depend on the ground and its nature around the building, and so as the first manhole height should not be less than 60 cm, and the depth of the other manholes will depend on the distance between the manholes and the slope of the pipe that connecting them.

According to the table below, it will be estimated the diameter of the manhole according to their depth. (Stein, 1997)

Depth(cm)	Diameter(cm)
70-80	60
80-140	80
140-250	100
250-∞	125

Table 13: Diameter of the manhole according to their depth.

Manhole Calculation:

The depth of the first manhole is 50 cm, the calculation of the second manhole done according to the first manhole and so on. Using these equations does the calculations:

- Depth: (M2= M1+ (Slope × Distance)+ 5+ Level Difference) cm
- Top level: Manholes face level on the ground
- (Invert level = Top level - Depth) in m
- Outlet level = - (Depth - 0.05) in m

The figure below shows the details of the manholes:
(sewerhistory.org, 2004)

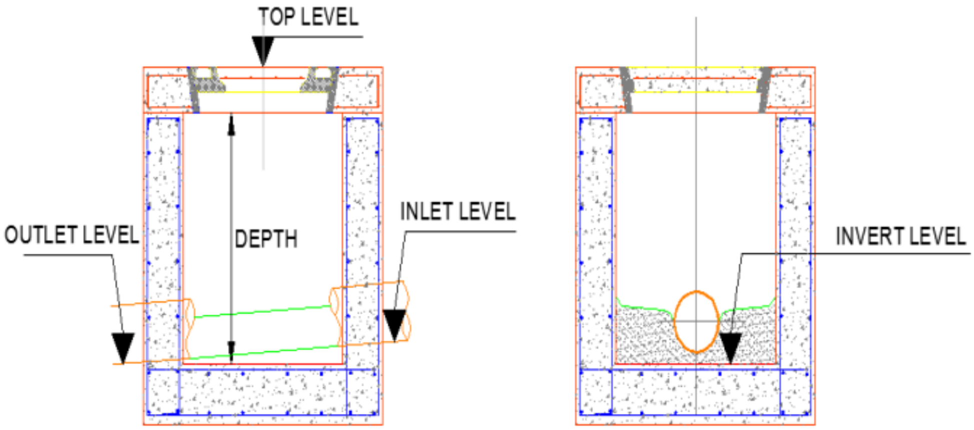

Figure 10 : Manholes details

The result calculation manholes is listed in the tables below:

Manhole Number	Top Level (M)	Invert Level (M)	Outlet Level (M)	Depth (Cm)	Diameter (Cm)	Cover Type
1	+0.00	-0.6	-0.55	60	60	Concrete
2	+0.00	-0.72	-0.67	72	60	Concrete
3	+0.00	-0.85	-0.80	85	80	Concrete
4	+0.00	-1.03	-0.98	103	80	Concrete
5	+0.00	-1.16	-1.11	116	80	Concrete
6	+0.00	-1.28	-1.23	128	80	Concrete
7	+0.00	-1.51	-1.46	151	100	Concrete
8	+0.00	-1.74	-1.69	174	100	Concrete
9	+0.00	-1.90	-1.85	190	100	Concrete
10	+0.00	-2.13	-2.08	213	100	Concrete
11	+0.00	-0.6	-0.55	60	60	Concrete
12	+0.00	-0.76	-0.71	76	60	Concrete
13	+0.00	-0.99	-0.94	99	80	Concrete
14	+0.00	-1.22	-1.17	122	80	Concrete
15	+0.00	-1.38	-1.33	138	80	Concrete
16	+0.00	-1.66	-1.61	166	100	Concrete
17	+0.00	-1.71	-1.66	171	100	Concrete

Table 14: the depth of manholes & Pipe diameter. (sewerhistory.org, 2004)

4.6 Storm Drainage:

The design of the rain collection piping, whether exterior gutters, and leaders, or interior conductors and drain depends upon three factors:

- The amount of rain fall in a specified period of time.
- The size of the area being drained.
- The degree of pipe fill, that is whether a pipe or gutter runs 50%, 33% or 100% fill

The general rule for the distribution of floor drains (FD):

- Every 100 m^2 from roof area needs one 4" FD.
- The roof area of this building is 1200m^2, and therefore needs Sixteenth 4" FD.

Chapter Five: Fire Protection System:

5.1 Introduction.

5.2 Types of firefighting system:

5.2.1 Fire extinguishers.

5.2.2 Fire hose reel.

5.2.3 Fire hydrant system.

5.2.4 Automatic sprinkler system.

5.3 Pump selection.

5.1 Introduction:

Firefighting or fire protection system is another important service in the building you live in. It protects your life, your home and your property. In order to design the suitable firefighting system, we should be familiar with its components. Fire protection system consists of main component such as:

1. Firefighting water storage tank, this may be a large tank, or a large well near the building.
2. Pumping system, the pumping system for firefighting consist mainly of three types of pumps. The first is the primary, this is usually an eclectic pump. The second pump is diesel powered and it is used directly when there is no electricity. The last one is the jokey pump; this pump used to keep the suitable pressure in the pipeline. However, the pump size usually depends on the area covered by the cabinet and the number of cabinet.
3. Piping system. Piping system extends from the storage tank to the water supplier through the pump.

The previous component of firefighting system is variable and can be determined based on the class of hazard of the building. These classes of hazard are three:

1. Low (light) hazard: this type is used when no flammable materials exist. And the fire is expected to release low amount of heat. This is common in offices, classrooms, meeting rooms, residential, dorms…etc.
2. Ordinary (moderate) hazard: this is used when the amount of combustible materials is moderate. Moderate amount of heat is expected to release. This can be used in malls, light manufacturing or research operations, parking garages, workshops.
3. Extra (high) hazard: high flammable material is present. High quality and quick expanded fire is expected. This usually used in air craft, laboratory, car repaid garages, coating, storage areas.

Due to these requirements and equipment, we note that the firefighting system is too expensive, and the building standard in Palestine is lower than this. So the fire protection system in the dorms will be limited in a main pipe line, extended from the main water tank for protection, and fire cabinet furnished with foam fire extinguisher.

5.2 Types of firefighting system:

- Fire extinguishers.
- Fire hose reels.
- Fire hydrant systems.
- Automatic sprinkler systems.

5.2.1 Fire Extinguishers:

Fire extinguishers are provided for a 'first attack' firefighting measure generally undertaken by the occupants of the building before the fire service arrives. It is important that occupants are familiar with which extinguisher type to use on which fire.
Most fires start as a small fire and may be extinguished if the correct type and amount of extinguishing agent is applied whilst the fire is small and controllable.

5.2.2 Fire Hose reel:

Fire hose reel systems consist of pumps, pipes, water supply and hose reels located strategically in a building, ensuring proper coverage of water to combat a fire.
The system is manually operated and activated by opening a valve enabling the water to flow into the hose that is typically 30 meters away. The usual working pressure of a firehouse can vary between 8 and 20 (116 and 290 psi).
Fire hose reels are provided for use by occupants as a first attack firefighting measure but May, in some instances, also be used by firefighters. When stowing a fire hose reel, it is important to first attach the nozzle end to the hose reel valve,

then close the hose reel valve, then open the nozzle to relieve any pressure in the wound hose, then close the nozzle.(منقوش، 2016)

Figure 11: Fire hose reel

5.2.3 Fire Hydrate System:

Fire hydrant systems are installed in buildings to help fire fighters quickly attack the fire.

Essentially, a hydrant system is a water reticulation system used to transport water in order to limit the amount of hose that fire fighters have to lay; thus speeding up the firefighting process.(منقوش، 2016)

Fire hydrants are for the sole use of trained fire fighters (which includes factory firefighting teams). Because of the high pressures available serious injury can occur if untrained persons attempt to operate the equipment connected to such installations. Fire hydrant systems sometimes include ancillary parts essential to their effective operation such as pumps, tanks and fire service booster connections. These systems must be maintained and regularly tested if they are to be effective when needed. (K.Y.Tao, 2009)

Figure 12: Fire Hydrate System (normteknik, 2015)

5.2.4 Automatic Sprinkler System:

Time is essential in the control of fire. Automatic sprinkler systems are one of the most reliable methods available for controlling fires. Today's automatic fire sprinkler systems offer state of the art protection of life and property from the effects of fire. Sprinkler heads are now available which are twenty times more sensitive to fire than they were ten years ago.

A sprinkler head is really an automatic (open once only) tap. The sprinkler head is connected to a pressurized water system. When the fire heats up the sprinkler head, it opens at a preset temperature, thus allowing pressurized water to be sprayed both down onto the fire and also up to cool the hot smoky layer and the building structure above the fire. This spray also wets combustible material in the vicinity of the fire, making it difficult to ignite, thereby slowing down or preventing fire spread and growth.

When a sprinkler head operates, the water pressure in the system drops, activating an alarm, which often automatically calls the fire brigade via a telephone connection. (K.Y.Tao, 2009)

Figure 13: Sprinkler. (normteknik, 2015)

5.2.5 Landing valve:

A firefighting landing valve is a core part of the hose system that acts as a manual stop valve giving you complete control over your firefighting system.
By rotating the landing valve handle anti-clockwise, you can simply activate the water flux in the firefighting system.
Everybody can benefit from our top notch and non-stop supply of the landing valve with many different connectors (including but not limited to).
Our company's top priority is satisfying your needs and even above that.
Keeping all our standards intact, we yet focus on keeping these priorities of our customers in mind at every step of the manufacturing process of the landing valve.
And this is not limited to just the production itself, it also encompass the continuous improvement processes that we employ to make our landing valves, and products in general, better and safer. (K.Y.Tao, 2009)

Figure 14: Landing valve. (normteknik, 2015)

5.3 Pump Selection:

In our project we use landing valve & cabinet, the Flow rate for this type is 250Gpm & 100Gpm.

Pressure loss in the pipe:

We divide the pipe in the building to section, as shown in the Auto Cad planes, to calculate the Pressure loss, the following steps is show how to calculate the pressure loss:

Section 1-2 = .234psi/ Ft* 9.51 Ft = 2.22 psi

Section 2-3-4 = .05 psi /Ft* 114.83 Ft = 5.74 psi

Section 4-5 = .445psi /Ft *7 Ft = 3.115 psi

The total pressure loss = 10.8*1.8 = 19.44 psi = 133 Kpa

The gravity weight of water = -3 m *9.81 Kpa/m =- 29.34 Kpa

Pressure flow 6.9 bar

The total head = 6.9 + 1.33- 0.29 = 8 bar

Jokey pump connected series with the main pump and the head of jokey pump = 8.4 bar and flow rate = 10 Gpm

And the main function of jokey pump support the main pump, if the shortage has become the pressure network

From Ebara Catalog company:

Electrical Pump×2: Model: 64_FSPA, Q= 500 Gpm, Head: 126 psi.

Jockey Pump: Model: SFP 50 – 20EH

, Q= 50 Gpm, Head= 129 Psi.

Hint: Review the catalog in appendix B.

(K.Y.Tao, 2009)

Chapter Six: Bill of quantity (BOQ):

Table 6.1 Bill of quantities

Mechanical work for Birzeit girl housing students					
Item No.	**Description**	Unit	QTY.	Unit Rate $	Total $
	Mechanical works **Preamble:** Water Tanks, Sanitary Fixtures and sanitary fixture accessories shall all be measured per piece and paid for according to their unit rates. All pipes, whether domestic and firefighting, supply pipes, sewage drainage UPVC pipes from sanitary fixture to the final disposing point (including vent and stack pipes), storm water UPVC drain pipes, measured at actual and paid for in linear meters according to the corresponding bill item. Floor drains and traps, roof drains, as well as, clean-outs, and the like, shall be measured per piece and paid for accordingly and in line with the corresponding unit rate. Manholes, gullies and the like shall be measured in numbers. Rates of all fitting, fixtures appliances, and pipe laying shall include supply of material; workmanship; installation; testing; adjusting; balancing and	.			
	commissioning. Rates to include also all pieces and fittings including bypasses, floats, automatic vents, vent and stack mesh covers, and non-return valves, all needed to complete the works according to specifications and Engineer's satisfaction. This shall also bedding, backfilling and benching and all works connected with pipe laying; all ties, sleeves, joint, tie bolts and rods, hangers and brackets,				

	and the like.				
HVAC system					
1	Air conditioning Chiller system: Supply and installation testing and commissioning of the following spilt unit, ceiling mounted cassette and wall mounted type indoor unit, complete with electrical connections				
1.1	Outdoor unit (Chiller) Alberta Company				
A.	model number (APSa270-3S, Lwt=50) Chiller	Unit	1	20000	20000
1.2	Indoor unit (Fan Coil Unit)				
A.	PCC/PFC5-L-85-65-27	Unit	13	1000	13000
B.	PCC/PFC6-M-76-63-26	Unit	10	1000	10000
C.	PCC/PFC6-M-78-6-3-26	Unit	2	1000	2000
D.	PCC/PFC3-H-76-67-27	Unit	4	1000	4000
E.	PCC/PFC4-H-85-67-27	Unit	2	1000	2000
F.	PCC/PFC6-M-85-63-26	Unit	5	1000	5000
G.	PCC/PFC8-M-80-63-26	Unit	19	1000	19000
H.	PCC/PFC6-H-78-65-26	Unit	14	1000	14000
I.	PCC/PFC4-L-76-63-27	Unit	4	1000	4000
J.	PCC/PCF5-L-80-63-27	Unit	4	1000	4000

K.	PCC/PCF5-L-80-63-27	Unit	2	1000	2000
L.	PCC/PFC6-H-85-63-26	Unit	2	1000	2000
M.	PCC/PFC4-H-78-63-27	Unit	6	1000	6000
N.	PCC/PFC8-L-78-63-26	Unit	35	1000	35000
O.	PCC/PFC5-M-76-63-27	Unit	1	1000	1000
P.	PCC/PFC12-M85-67-26	Unit	6	1000	6000
Q.	PCC/PFC3-M-80-63-27	Unit	1	1000	1000
R.	PCC/PFC3-H-76-65-27	Unit	1	1000	1000
S.	PCC/PFC8-L-78-67-26	Unit	4	1000	4000
T.	PCC/PFC5-M-85-67-26	Unit	3	1000	3000
U.	CB/CBP12-H-76-67-16	Unit	7	1000	7000
V.	PCC/PFC3-H-85-67-27	Unit	6	1000	6000
W.	PCC/PFC4-H-8063-27	Unit	15	1000	15000
X.	PCC/PFC5-H-80-65-27	Unit	6	1000	6000
Y.	PCC/PCF5-H-85-65-27	Unit	3	1000	3000
Z.	PCC/PFC5-H-78-67-27	Unit	15	1000	15000
AA.	PCC/PFC4-H-78-67-27	Unit	6	1000	6000
AB.	PCC/PFC5-L-85-67-27	Unit	3	1000	3000
AC.	PCC/PFC4-M-76-63-27	Unit	3	1000	3000
AD.	PCC/PFC5-M-76-67-27	Unit	6	1000	6000
AE.	PCC/PFC5-L-76-67-27	Unit	6	1000	6000
AF.	PCC/PFC4-L76-67-27	Unit	3	1000	3000
AG.	PCC/PFC5-M-76-65-27	Unit	3	1000	3000
AH.	PCC/PFC12-M-80-6526	Unit	3	1000	3000
Total Page Carried Forward					225000

Total Price for previous calculations(tables)					2250000
Item No.	Description	Unit	QTY.	Unit Rate	Total
1.3	Connection Duct: Insulated Galvanized duct to move chilled air from the chiller to F.C.U				
A.	Supply, install, test and commission galvanized air ducts of various thicknesses FOR ventilation as required in (ASHRAE) and as described and detailed on drawings, including hanging, digging, sleeves, and all fittings needed as drawings and supervision engineer approval.	430	M^2	35	15050
1.4	Ventilation: Supply, install, and connect, testing and commissioning of, inline centrifugal fan, Shall include all required electrical connections as per specifications, drawings and related codes.				
A.	CFM in wall fan	Unit	4	1200	4800
B.	CFM in wall fan	Unit	4	1300	5200
C.	CFM in wall fan	Unit	4	1600	6400
D.	CFM in wall fan	Unit	4	1700	6800
2	**Water supply**				
	Supply, install, test and commission water supply pump set (factory assembled), one duty, one stand-by, IP54 protection, diaphragm type. The unit price shall include pressure vessel, electric control panel, electrical wiring, galvanized steel frame, inertia base, vibration isolators, concrete base and all required valves and fittings as detailed on the drawings.				

2.1	Distribution pipes Supply: install, test and commission ML 2280121 Cross-linked polyethylene (PEX) pipes to DIN 16892/3, 20 bar working pressure, for cold and hot water distribution from metal water pipes to sanitary fixtures, complete with sleeves and service valve for each connection. The unit price shall include rubber ring seal, brass elbow/adapter inside PVC termination box built in wall for connection with the sanitary fixtures, dielectric unions, excavation, bedding, backfilling, chasing in wall and all works required as shown on drawings, specifications and P.M. instructions. 16 mm O.D. x 2.2mm thick, sleeve 25 mm diameter.				
A.	1/2" Diameter	2050	Ml	0.8	1640
B.	3/4" Diameter	132	Ml	1	132
2.2	Galvanized Steel Pipes: install, test and commission galvanized steel pipe work to ASTMA53 grade "A", schedule (40) for the domestic hot and cold water supply pipe work up to the water outlet. The unit price shall include valves, expansion joints, pressure regulators, air vents, fittings and all accessories and works required to complete the work as shown on drawings, specifications and P.M. instructions.				
A.	1" Diameter	365	Ml	25	9125
B.	1 1/4" Diameter	260	Ml	30	7800
C.	1 1/2" Diameter	260	Ml	38	9880
2.3	Supply and installation of collector complexes and pipes For hot and cold water To connect to sanitary cutting sites And the proposed boilers and washing machines 16 mm diameter pipes The quality of PAL PEX is certified Palestinian specifications Coated with PVC outer shell 32mm and 25 mm diameter with all necessary Of brass elbow and copper eyes Italian-made toast first Equipped with a padlock on each outlet And a metal cabinet of painted iron Thermally and white color is final and so As required The price includes all necessary gaskets				

	Automatic Italian Record and air relief valve Make the first toast on each collector The price includes all that is needed for installation Installation, testing and operation Specifications and instructions of the supervisor engineer Price per eye 1 "/ 16 mm and 1.25"/16mm				
A.	1.25" two out late	Unit	0	0	0
B.	1.25" three outdate	Unit	154	12	1848
C.	1.25" Four out late	Unit	12	12	144
D.	1" two outdate	Unit	4	10	40
E.	1" three out late	Unit	316	10	3160
F.	1" Four outdate	Unit	12	10	120
J	metal cabinet	unit	90	15	1350
2.4	Air vents 1/2"	Unit	200	5	1000
2.5	Supply and install hot water cylinder electrical heater, of 80 liter capacity, (approved by Palestine Standards Institution) located as shown on drawings with pressure not less than 3 bar and electrical capacity 2KW price include, valves, fitting, electrical connections, automatic air vent, connection from and to collectors and drain line pipe to the nearest floor drain and any other necessary parts and accessories to complete works per specifications and as directed by Engineer.	Unit	90	400	36000
Total Price for previous calculations(tables)					2360489

2.6	**<u>Fittings:</u>** Supply, install, test and commission, water tank, water pump, including air vent, check valve, strainer, connection to municipality's potable water supply network, fittings, and all accessories and works required to complete the work as shown on the drawings and as per the preamble, specifications and the supervision engineer's requirements.				
A.	1" strainer	No.	14	7	98
B.	Check valve	No.	1	6	6
C.	25mm*1" copper nipple record	No.	14	6	84
D.	½ " copper elbow	No.	1500	1.5	2250
2.7	**<u>Water tank:</u>** . Supply and installation of cold water tanks On the plastic surface According to the drawings and specifications Capacity 500 liters and price includes rules Ferried iron also has all the pieces Necessary for the grid with water supply For apartments with all necessary connections Ventilation and taps, and connecting and also numbering Per tanks by plastic plates and so on Schemes and instructions of the supervisor.	No.	90	114	10260
2.8	**<u>WATER METER</u>**: Supply and install Water meter inside steel box, as per specification, drawings and supervisor engineer. Price includes all galvanized steel main water pipes (Ø 1") or more, (Class A and approved by Palestine Standards Institution) with asphalt protection (factory covered), laid underground with all necessary fittings e.g. elbows, T's, unions, stop valves, non-return valves, automatic air vents, of best quality (Class A	NO	90	400	36000

	and approved by Palestine Standards Institution).				
3	**<u>Rain Water pipes</u>**: - U.P.V.C rain(storm) water pipes down to a free discharge with wired mesh above ground level, with all required hanging accessories, fittings and vent caps, all as shown in drawings, specifications, and approval of supervisor engineer. U.P.V.C Pipe of Æ 4 -inch diameter.	NO	12	15	180
	Waste and Drainage System				
3.1	Vertical and Horizontal UPVC Pipe Supply: install UPVC pipes and fittings similar to local made P.S SN 8.The rate shall include all needed connections and all types of fittings caps, all done according to drawings, specifications and the approval of the supervision engineer.				
A.	4" Diameter	540	ML	80	43200
B.	5" Diameter	310	ML	90	27900
C.	6" Diameter	85	ML	100	8500
D.	8" Diameter	90	ML	120	10800
E.	10" Diameter	60	ML	140	8400
F.	12" Diameter (As Request)	0	ML	0	0
3.2	**<u>Floor Drain</u>** Supply, install, testing and commissioning of, 4"chrome plated threaded 15x15cm cast brass cover, multi inlet adjustable with trap floor drain. Including, floor clean out plug, HDPE siphon or equivalent and necessary accessories, connections with fixtures and main drain pipes. As be drawings, specifications and related codes.	NO	226	80	18080
Total Price for previous calculations(tables)					2517567

3.3	**Clean Out** Supply, install, testing and commissioning of the following, HDPE or equivalent , non-adjustable 15x15 cm stainless steel cover, and floor clean out with gas and water tightness ABS plug and necessary accessories as per drawings, specifications and related codes. (Ø 4")	NO	226	70	15820
3.4	**Manholes** Supply and install PRE- CAST concrete manholes of 15 cm thick walls and base with heavy duty cast iron covers and frames of 25 tons load strength with all necessary excavation back filling as specified to the required depth with steps of galvanized pipe of 1/2" benching and connecting it to main city manholes as shown in drawing and in accordance to specifications and approval engineers.				
A.	Manholes Ø 60 cm clear size	NO	4	350	1400
B.	Manholes Ø 80 cm clear size	NO	7	450	3150
C.	Manholes Ø 100 cm clear size	NO	6	550	3300
	Sanitary Fixture and Their Accessories				
4	**Lavatory** Supply and installation of porcelain wash basin glazed white (from creavit or equivalent) with chrome plated mixer adoption of the supervising engineer) half leg measuring 56 × 42 cm and isolate it from the wall using the Sika Anti-gray color of the rot with water mixer (of the finest international standards, according to the supervising engineer adoption) and Siphon and all chrome-plated The price includes valves angle 13 mm chrome holder soap of the finest varieties mirror 40× 60 cm with aluminum frame and providing sink series and rubber stopper and all necessary for installation, operation and drainage to the nearest packet assembly floor drain , and P.V.C Trap1.1/2" to floor drain . according to the specifications and plans and instructions of the supervising engineer.	NO	190	400	76000

Total Price for previous calculations(tables)					2617237
4.1	**Water Closet** Supply, install, testing and commissioning of, floor mounted, white color, Porcelain, siphon jet water closet/toilet with an elongated bowl, seat with open front and check hinge, and carrier. or equivalent including necessary accessories, 9-lt capacity cistern, valves, fittings, 13mm stop angle valves, chrome plated 13mm hose, heavy duty side l m length 13mm Chrome plated hand shower, connection to drainage and water systems as per drawings, specifications and	NO	115	600	69000
4.2	**Paper Holder** Supply and installing of: surface mounted satin finish stainless steel, sanitary napkin disposal or equivalent. Disposal features a flip-up cover, secured to the container by a heavy duty stainless steel piano-hinge. Disposal secured to wall or toilet partition. As per drawings, specifications and the approval of the Engineer	NO	115	20	2300
4.3	**Sink :** Supply, install, testing and commissioning of glazed porcelain basin sink white size 20 × 40 × 60 cm excellent water mixer chrome the price shall include plastic Siphon and the drain to the nearest floor drain and all that is required for installation and installation according to plans and specifications and instructions of the supervising engineer. Counter top Kitchen sink	NO	100	450	45000
4.4	**Faucet** Supply, install, testing and commissioning of, Chrome plated cast brass construction, washer less ceramic disc mixing cartridge, gooseneck spout, with elbow/ wrist/ gear blade control handles or equivalent. including, sockets, copper adaptors, 3/8" angle valves and all necessary accessories, as per drawings, specifications and related codes and RE approval. Single lever Gear control handle faucet.	NO	290	200	58000

4.5	Water Pump Supply, install, test and commission water pump for gray water system with cast iron body and stainless steel impeller Grundfos factory assembly or E.A. The rate shall include bolts, nuts, concrete slab, foot valve, ball valves, electrical float, check valve and any accessories needed in the suction and discharge line to connect with the network as shown in pump details Q - 11.86 L/sec H - 20.89 m Model no : NKG 80-50-250/263 A2-F-A-E-	NO	1	500	500
4.6	**Shower** Supply and install Porcelain shower , white color, type Roca or E.A, of size 80X80cm, complete with chrome plated mixers, plug and chain, 1.5m flexible hose with chrome lever handle and stand, and all associated water supply pipes, and brackets screwed to concrete or block work, sealing joint to worktop or wall with mastic sealant.	NO	90	72	6480
	Fire Fighting system				
5	**Fire Hose Reel Cabinets** Supply, install, test and commission fire hose reel & landing valve cabinets to, complete with 30 meters long 2 ½” diameter rubber hose of 16 bar working pressure. The unit price shall include hose cabinet, pressure reducing valve, globe valve and automatic swinging recessed type cabinet as detailed on drawings and as per the specifications and the supervision engineer's requirements	NO	12	645	7740
5.1	**Fire fighting** Pipes to ASTM-A53grade " A" schedule-40 for firefighting system pipe work, inside building. The unit price shall include valves, fittings,				

	and all accessories and works required to complete the work and as per preambles, specifications, and the supervision of engineer's requirements.				
A.	Galvanized Sch - 40 Pipe 2.5”	ML	230	50	11500
B.	Galvanized Sch - 40 Pipe 4”	ML	58	80	4640
C.	Galvanized Sch - 40 Pipe 1.5”	ML	55	40	2200
5.2	The price includes all the necessary pieces For operation and connection with proposed fire engines On the surface and the pallets are connected and clamped Electrical and electrical panel for control and protection With the possibility of operation and shutdown By pressure regulator and pressure tank So that it is proportional to the capacity of the pump Specifications and instructions of the supervisor engineer Q- 500gpm H - 80 m	NO	2	500	1000
5.3	The supply and installation of the Jockey pump to maintain the pressure inside the pipes and compensating the infusion including all the requirements of operation including the electric motor and the joints and operating system Model no : SFP 50 – 20EH RPM- 3500 Q- 50gpm H - 89 m	NO	1	500	500
Total Price for previous calculations(tables)					2836357

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Appendix A

HVAC and duct Tables

TABLE 4–2 Instantaneous heat gain from occupants in units of Watts[a].

Type of Activity	Typical Application	Total Heat Dissipation Adult Male	Total Adjusted[a] Heat Dissipation	Sensible Heat, W	Latent Heat, W
Seated at rest	*Theater*:				
	Matinee	111.5	94.0	64.0	30.0
	Evening	111.5	100.0	70.0	30.0
Seated, very light work	Offices, hotels, apartments, restaurants	128.5	114.0	70.0	44.0
Moderately active office work	Offices, hotels, apartments	135.5	128.5	71.5	57.0
Standing, light work, walking	Department store, retail store, supermarkets	157.0	143.0	71.5	71.5
Walking, seated	Drug store	157.0	143.0	71.5	71.5
Standing, walking slowly	Bank	157.0	143.0	71.5	71.5
Sedentary work	Restaurant	168.5	157.0	78.5	78.5
Light bench work	Factory	238.0	214.0	78.0	136.0
Moderate work	Small-Parts assembly	257.0	243.0	87.0	156.0
Moderate dancing	Dance halls	257.0	243.0	87.0	156.0
Walking at 1.5 m/s	Factory	286.0	285.0	107.0	178.0
Bowling (participant)	Bowling alley	428.5	414.0	166.0	248.0
Heavy work	Factory	428.5	414.0	166.0	248.0

(a) Adjusted heat dissipation is based on the percentage of men, women and children for the application.

TABLE 4–5 Minimum outside air requirements for mechanical ventilation[4].

Application	Maximum Occupancy Per 100 m²	Ventilation Air Requirements	
		L/s/Person	L/s/m²
Offices:			
Office space	7	10.0	2.5-10.0
Reception areas	60	8.0	3.5-7.5
Telecomm. Centers	60	10.0	—
Conference rooms	50	10.0	—
Public spaces:			
Corridors	—	—	0.25
Public restrooms	100	25.0	—
Locker and dressing rooms	50	7.5-17.5	5-2.5
Smoking lounge	70	30.0	—
Elevators:	—	7.5	5.00
Laundries:			
Commercial laundry	10	13.0	—
Commercial dry cleaner	30	15.0	—
Coin-operated laundries	20	8.0	—
Coin operated dry cleaner	20	8.0	—
Food and beverage services:			
Dining rooms	70	10.0	—
Cafeteria	100	10.0	—
Bars	100	15.0	—
Kitchens	20	8.0	—
Garages, service stations:			
Enclosed parking garage	—	5L/s/car	7.50
Auto repair rooms	—	—	7.50
Factories:	—	—	0.80
Retail stores:			
Basement and street stores	30	2.5-12.5	1.50
Upper floors	20	2.5-12.5	1.00
Storage rooms	15	2.5-12.5	0.75
Dressing rooms	—	3.5-12.5	1.00
Malls	20	2.5-5.0	1.00
Warehouses	5	2.5-5.0	0.25
Smoking lounge	70	30.0	—
Specialty shops:			
Barbers	25	8.0	—
Beauty saloons	25	13.0	—
Reducing saloons	20	8.0	—
Florist	8	8.0	—
Supermarkets	8	8.0	—
Hardware, drugs, fabrics	8	8.0	—
Pet shops	—	—	5.00
Furniture stores	—	—	1.50
Sports:			
Spectator areas	70-150	3.5-17.5	—

[4] Adapted from "*ASHRAE Handbook of Fundamentals,*" 1993.

Application	Maximum Occupancy Per 100 m^2	Ventilation Air Requirements	
		L/s/Person	L/s/m^2
Bath, toilets[3]	—	10.0	—
Hotels and motels:			
Bedrooms	—	—	7.5-15 L/s/room
Living rooms	—	—	5-10 L/s/room
Bathes	—	—	15-25 L/s/room
Lobbies	30	2.5-7.5	—
Conference rooms	50	3.5-17.5	—
Assembly rooms	120	3.5-17.5	—
Dormitory sleeping areas	20	8.0	—
Gambling casinos	120	15.0	—

[1] or 0.35 air change/hour [2] or 50 L/s intermittent or openable window.
[3] or 25 L/s intermittent or openable window.

Table 4-6 Number of air change per hour(1) in residences and commercial application[5].

Type of Room or Building	***No.* of Air Change per Hour**
Rooms with no windows or exterior doors	0.5
Rooms with windows or exterior doors on one side only	1.0
Rooms with windows or exterior doors on two sides	1.5
Rooms with windows or exteriors doors on three sides	2.0
Entrance halls	2.0-3.0
Factories, machine shops	1.0-1.5
Recreation rooms, assembly rooms, gymnasium	1.5
Homes, apartments, offices	1.0-2.0
Classrooms, dining rooms, lounges, hospital rooms, kitchens, laundries, ballrooms, bathrooms	2.0
Stores, public buildings	2.0-3.0
Toilets, auditorium	3.0

(1) For rooms with weather stripped windows or storm sash, use 2/3 of these values.

Table 5-2 Inside film resistance, R_i.

Element	Heat Direction	Material Type	R_i $m^2 \cdot °C/W$
Walls	Horizontal	Construction materials	0.12
		Metals	0.31
Ceilings and floors	Upward	Construction materials	0.10
		Metals	0.21
	Downward	Construction materials	0.15

Table 5-3 Outside film resistance, R_o.

Wind Speed		Less than 0.5 m/s	0.5 - 5.0 m/s	More than 5.0 m/s
Element	Material Type	Outside Resistance R_o, $m^2 \cdot °C/W$		
Walls	Construction materials	0.08	0.06	0.03
	Metals	0.10	0.07	0.03
Ceilings	Construction materials	0.07	0.04	0.02
	Metals	0.09	0.05	0.02
Exposed floors	Construction materials	0.09	—	—

TABLE 5-4 Overall Heat Transfer Coefficient for Windows, $W/m^2 \cdot °C$

Material Type and Frames	Wind Speed, m/s					
	Single Glass			Double Glass, 6mm air gap		
	< 0.5	0.5 - 5.0	> 5.0	< 0.5	0.5 - 5.0	> 5.0
Wood	3.8	4.3	5.0	2.3	2.5	2.7
Aluminum	5.0	5.6	6.7	3.0	3.2	3.5
Steel	5.0	5.6	6.7	3.0	3.2	3.5
PVC	3.8	4.3	5.0	2.3	2.5	2.7

TABLE 5–5 Overall heat transfer coefficients for wood and metal doors, $W/m^2 \cdot °C$.

Door Type	Without Storm Door	With Wood Storm Door	With Metal Storm Door
25 mm-wood	3.6	1.7	2.2
35 mm-wood	3.1	1.6	1.9
40 mm-wood	2.8	1.5	1.8
45 mm-wood	2.7	1.5	1.8
50 mm-wood	2.4	1.4	1.7
Aluminum	7.0	—	—
Steel	5.8	—	—
Steel with:			
Fiber core	3.3	—	—
Polystyrene core	2.7	—	—
Polyurethane core	2.3	—	—

TABLE 5–7 Overall heat transfer coefficients for typical ceiling constructions, $W/m^2 \cdot °C$, for $R_o = 0.03\ m^2 \cdot °C/W$.

No.	Construction	R_{th} $m^2 \cdot °C/W$	Thickness	Layer
	Asphalt Mix	0.028	0.02 m	①
	Concrete	0.029	0.05 m	②
	Insulation	0.750	0.03 m	③
(1)	Reinforced Concrete	0.034	0.03 m	④
	Cement Block	0.147	0.14 m	⑤
	Plaster	0.017	0.02 m	⑥
	$U = 0.88$			

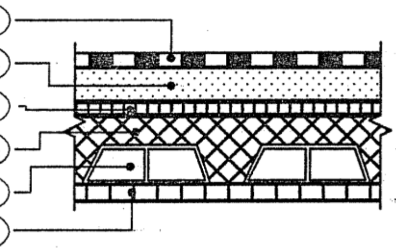


TABLE 6–2 Values of infiltration air coefficient *K*.[2] for windows.

Window Type	Infiltration Air Coefficient *K*		
	Average	Minimum	Maximum
Sliding			
Iron	0.36	0.25	0.40
Aluminum	0.43	0.25	0.70
Hung			
Iron	0.25	0.10	0.60
Aluminum (side pivoted)	0.36	0.07	0.70
Aluminum (horizontal pivoted)	0.30	0.07	0.50
PVC	0.10	0.03	0.15

TABLE 6–3 Values of the factor S_1 of Eq. (6–7).

№	Topography of Location	Value of S_1
1	Protected locations by hills or buildings (wind speed = 0.5 m/s)	0.9
2	Unprotected locations such as sea shores, hill tops, etc.	1.1
3	Locations other than that listed in item (1) or (2) of this table.	1.0

Class (1) Locations having very high and close obstacles such as capital cities, down town of large cities, etc.

Class (2) Locations having numerous and close obstacles such as small cities, suburbs of large cities, etc.

Class (3) Locations having obstacles whose height less than 10 m such as airports, villages, etc.

Class (4) Locations with obstacles whose height is less than 1.5 m such as desert areas, plains without trees, etc.

Catagory A Structures and buildings whose maximum horizontal or vertical dimension is more than 50 m.

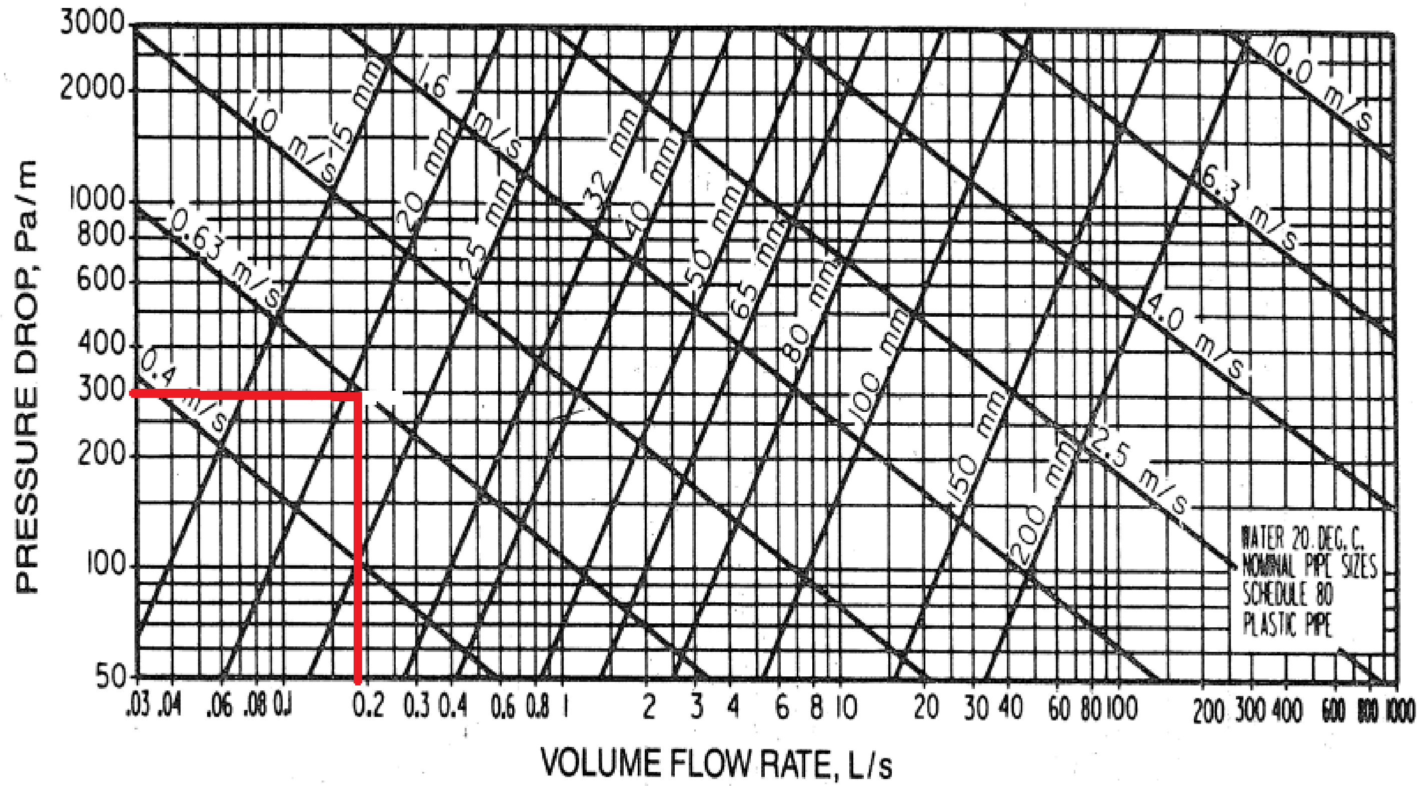
Catagory B Structures and buildings whose maximum dimension (horizontal or vertical) is less than 50 m.

Catagory C Individual structures.

TABLE 6–4 Values of the factor S_2 of Eq. (6–7).

Location Class	Class 1			Class 2			Class 3			Class 4		
Building Height, m	A	B	C	A	B	C	A	B	C	A	B	C
3	0.47	0.52	0.56	0.55	0.60	0.64	0.63	0.67	0.72	0.73	0.78	0.83
5	0.50	0.55	0.60	0.60	0.65	0.70	0.70	0.74	0.79	0.78	0.83	0.88
10	0.58	0.62	0.67	0.69	0.74	0.78	0.83	0.88	0.93	0.90	0.95	1.00
15	0.64	0.69	0.74	0.78	0.83	0.88	0.91	0.95	1.00	0.94	0.99	1.03
20	0.70	0.75	0.79	0.85	0.90	0.95	0.94	0.98	1.03	0.96	1.01	1.06
30	0.79	0.85	0.90	0.92	0.97	1.01	0.98	1.03	1.07	1.00	1.05	1.09
40	0.89	0.93	0.97	0.95	1.00	1.05	1.01	1.06	1.10	1.03	1.08	1.12
50	0.94	0.98	1.02	1.00	1.04	1.08	1.04	1.08	1.12	1.06	1.10	1.14
60	0.98	1.02	1.05	1.02	1.06	1.10	1.06	1.10	1.14	1.08	1.12	1.15
80	1.03	1.07	1.10	1.06	1.10	1.13	1.09	1.13	1.17	1.11	1.15	1.18
100	1.07	1.10	1.13	1.09	1.12	1.16	1.12	1.16	1.19	1.13	1.17	1.20
120	1.10	1.13	1.15	1.11	1.15	1.18	1.14	1.18	1.21	1.15	1.19	1.22
140	1.12	1.15	1.17	1.13	1.17	1.12	1.16	1.19	1.22	1.17	1.20	1.24
160	1.14	1.17	1.19	1.15	1.18	1.21	1.18	1.21	1.24	1.19	1.22	1.25
180	1.16	1.19	1.20	1.17	1.20	1.23	1.19	1.22	1.25	1.20	1.23	1.26
200	1.18	1.21	1.22	1.18	1.21	1.24	1.21	1.24	1.26	1.21	1.24	1.27

The size pipe fan coil unit = 25mm



1. The chart is based on straight tees, *i.e.*, branches A, B, and C are the same size.
2. Pressure loss in desired circuit is obtained by selecting proper curve according to illustrations, determining the flow at the circles branch, and multiplying the pressure loss for the same size elbow at the flow rate in the circled branch by the equivalent elbows indicated.
3. When the size of an outlet is reduced, the equivalent elbows shown in the chart do not apply. Therefore, the maximum loss for any circuit for any flow will not exceed 2 elbow equivalents at the maximum flow occurring in any branch of the tee.
4. .ne top curve of the chart is the average of 4 curves, one for each of the tee circuits illustrated.

FIGURE 7–15(a) Pressure drop per unit pipe length for water flowing in standard plastic pipes.

TABLE 9-2 Latitude-Month correction factor LM, as applied to walls and horizontal roofs, north latitudes.

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	Horizontal Roofs
16	December	−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/July	2.2	1.6	1.6	0.0	−0.5	−2.2	−2.7	−3.8	−3.8	0.0
	June	3.3	2.2	2.2	0.5	−0.5	−2.2	−3.3	−4.4	−3.8	0.0
24	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.2	−3.3	−4.4	−5.0	−3.3	−1.6	−1.6	5.0	7.2	−6.1
	Feb./Oct.	−2.2	−2.7	−3.3	−3.3	−1.6	−0.5	1.6	3.8	5.5	−3.8
	Mar/Sept.	−1.6	−2.2	−1.6	−1.6	−0.5	−0.5	0.5	1.1	2.2	−1.6
	Apr./Aug.	−1.1	−0.5	0.0	−0.5	−0.5	−1.1	−0.5	−1.1	−1.6	0.0
	May/July	0.5	1.1	1.1	0.0	0.0	−1.6	−1.6	−2.7	−3.3	0.5
	June	1.6	1.6	1.6	0.5	0.0	−1.6	−2.2	−3.3	−3.3	0.5
32	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.7	−3.8	−5.0	−6.1	−4.4	−2.2	1.1	5.0	6.6	−8.3
	Feb./Oct.	−2.2	−3.3	−3.8	−4.4	−2.2	−1.1	2.2	4.4	6.1	−5.5
	Mar/Sept.	−1.6	−2.2	−2.2	−2.2	−1.1	−0.5	1.6	2.7	3.8	−2.7
	Apr./Aug.	−1.1	−1.1	−0.5	−1.1	0.0	−0.5	0.0	5.0	0.5	−0.5
	May/July	0.5	0.5	0.5	0.0	0.0	−0.5	−0.5	−1.6	−1.6	0.5
	June	0.5	1.1	1.1	0.5	0.0	−1.1	−1.1	−2.2	−2.2	1.1
40	December	−3.3	−4.4	−5.5	−7.2	−5.5	−3.8	0.0	3.8	5.5	−11.6
	Jan./Nov.	−2.7	−3.8	−5.5	−6.6	−5.0	−3.3	0.5	4.4	6.1	−10.5
	Feb./Oct.	−2.7	−3.8	−4.4	−5.0	−3.3	−1.6	1.6	4.4	6.6	−7.7
	Mar/Sept.	−2.2	−2.7	−2.7	−3.3	−1.6	0.5	2.2	3.8	5.5	−4.4
	Apr./Aug.	−1.1	−1.6	−1.6	−1.1	0.0	0.0	1.1	1.6	2.2	1.6
	May/July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
	June	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0	−0.5	1.1
48	December	−3.3	−4.4	−6.1	−7.7	−7.2	−5.5	−1.6	1.1	3.3	−13.8
	Jan./Nov.	−3.3	−4.4	−6.1	−7.2	−6.1	−4.4	−0.5	2.7	4.4	−13.3
	Feb./Oct.	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	0.5	4.4	6.1	−10.0
	Mar/Sept.	−2.2	−3.3	−3.3	−3.8	−2.2	−0.5	2.2	4.4	6.1	−6.1
	Apr./Aug.	−1.6	−1.6	−1.6	−1.6	−0.5	0.0	2.2	3.3	3.8	−2.7
	May/July	0.0	−0.5	0.0	0.0	0.5	0.5	1.6	1.6	2.2	0.0
	June	0.5	0.5	1.1	0.5	1.1	0.5	1.1	1.1	1.6	1.1

TABLE 9-3 Approximate CLTD values for sunlit roofs, °C.

Solar Time	Roof Construction		
	Light	Medium	Heavy
10:00	5	—	—
11:00	12	—	—
12:00	19	3	0
13:00	25	8	2
14:00	29	14	5
15:00	31	19	8
16:00	31	23	10
17:00	29	25	12
18:00	24	26	14
19:00	19	25	15
20:00	11	22	16

TABLE 9–4 Cooling load temperature differences (CLTD) for various construction groups of sunlit walls, °C.

North Latitude Wall Facing	Solar Time *h* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Hour of Max. CLTD	Min. CLTD	Max. CLTD	Difference CLTD
Group A Walls																												
N	8	8	8	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	8	8	2	6	8	2
NE	11	11	10	10	10	9	9	9	8	8	8	9	9	9	9	10	10	10	11	11	11	11	11	11	22	8	11	3
E	14	13	13	13	12	12	11	11	10	10	10	11	11	12	12	13	13	13	14	14	14	14	14	14	22	10	14	4
SE	13	13	13	12	12	11	11	10	10	10	10	10	10	11	11	12	12	13	13	13	13	13	13	13	22	10	13	3
S	11	11	11	11	10	10	9	9	9	8	8	8	8	8	8	8	9	9	10	10	11	11	11	11	23	8	11	3
SW	14	14	14	14	13	13	12	12	11	11	10	10	10	9	9	10	10	10	11	12	13	13	14	14	24	9	14	5
W	15	15	15	14	14	14	13	13	12	12	11	11	10	10	10	10	10	11	11	12	13	14	14	15	1	10	15	5
NW	12	12	11	11	11	11	10	10	10	9	9	8	8	8	8	8	8	8	9	9	10	11	11	11	1	8	12	4
Group B Walls																												
N	8	8	8	7	7	6	6	6	5	5	5	5	5	5	5	6	6	7	7	8	8	8	8	8	24	5	8	3
NE	11	10	10	9	9	8	7	7	7	7	8	8	9	9	10	10	11	11	11	12	12	12	11	11	21	7	12	5
E	13	13	12	11	10	10	9	8	8	9	9	10	12	13	13	14	14	15	15	15	15	15	14	14	20	8	15	7
SE	13	12	12	11	10	10	9	8	8	8	8	9	10	11	12	13	14	14	14	14	14	14	14	14	21	8	14	6
S	12	11	11	10	9	9	8	7	7	6	6	6	6	7	8	9	10	11	11	12	12	12	12	12	23	6	12	6
SW	15	15	14	13	13	12	11	10	9	9	8	8	7	7	8	9	10	11	13	14	15	15	16	16	24	7	16	9
W	16	16	15	14	14	13	12	11	10	9	9	8	8	8	8	8	9	11	12	14	15	16	16	17	24	8	17	9
NW	13	12	12	11	11	10	9	9	8	7	7	7	6	6	7	7	8	8	9	11	12	13	13	13	24	6	13	7
Group C Walls																												
N	9	8	7	7	6	5	5	4	4	4	4	4	5	5	6	6	7	8	9	9	9	10	9	9	22	4	10	6
NE	10	10	9	8	7	6	6	6	6	7	8	10	10	11	12	12	12	13	13	13	13	12	12	11	20	6	13	7
E	13	12	11	10	9	8	7	7	8	9	11	13	14	15	16	16	17	17	16	16	16	15	14	13	18	7	17	10
SE	13	12	11	10	9	8	7	6	7	7	9	10	12	14	15	16	16	16	16	16	16	15	14	13	19	6	16	10
S	12	11	10	9	8	7	6	6	5	5	5	5	6	8	9	11	12	13	14	14	14	14	13	12	20	5	14	9
SW	16	15	14	12	11	10	9	8	7	7	6	6	6	7	8	10	12	14	16	18	18	18	13	17	22	6	18	12
W	17	16	15	14	12	11	10	9	8	7	7	7	7	7	8	9	11	13	16	18	19	20	19	18	22	7	20	13

TABLE 9-7 Solar heat gain factor (SHG) for sunlit glass, W/m², for a latitude angle of 32 °N.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
N	76	85	101	114	120	139	126	117	104	88	76	69
NNE/NNW	76	85	117	252	350	385	350	249	110	88	76	69
NE/NW	91	205	338	461	536	555	527	445	325	199	91	69
ENE/WNW	331	470	577	631	656	656	643	615	546	451	325	265
E/W	552	647	716	716	694	675	678	691	678	615	546	511
ESE/WSW	722	764	748	691	628	596	612	663	716	738	710	688
SE/SW	786	782	716	590	489	439	473	571	688	754	773	776
SSE/SSW	789	732	615	445	213	262	303	429	596	710	776	795
S	776	697	555	363	233	189	227	350	540	678	767	795
Horizontal	555	685	795	855	874	871	861	836	770	672	552	498

TABLE 9-8 Shading coefficient (SC) for glass windows without interior shading.[1]

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, $W/m^2 \cdot K$	
			$h_o = 22.7$	$h_o = 17.0$
Single Glass				
Clear	3	0.84	1.00	1.00
	6	0.78	0.94	0.95
	10	0.72	0.90	0.92
	12	0.67	0.87	0.88
Heat absorbing	3	0.64	0.83	0.85
	6	0.46	0.69	0.73
	10	0.33	0.60	0.64
	12	0.42	0.53	0.58
Double Glass				
Regular	3	—	0.90	—
Plate	6	—	0.83	—
Reflective	6	—	0.20-0.40	—
Insulating Glass				
Clear	3	0.71	0.88	0.88
	6	0.61	0.81	0.82
Heat absorbing*	6	0.36	0.55	0.58

[1] Heat absorbing glas is gray, bronze, and green tinted heat absorbing glass.

TABLE 9–9 Shading coefficient (SC) for glass windows with interior shading.

Type of Glass	Nominal Thickness, mm	Type of Interior Shading: Venetian Blinds: Medium	Venetian Blinds: Light	Roller Shade: Opaque: Dark	Roller Shade: Opaque: White	Roller Shade: Translucent: Light
Single Glass						
Clear, regular	2.5-6.0	—	—	—	—	—
Clear, plate	6.0-12.0	—	—	—	—	—
Clear Pattern	3.0-12.0	0.64	0.55	0.59	0.25	0.39
Heat Absorbing	3	—	—	—	—	—
Pattern or Tinted(gray sheet)	5.0-5.5	—	—	—	—	—
Heat Absorbing, plate	5.0-6.0	0.57	0.53	0.45	0.30	0.36
Pattern or Tinted, gray sheet	3.0-5.5	—	—	—	—	—
Heat Absorbing Plate or Pattern Heat Absorbing	10	0.54	0.52	0.40	0.82	0.32
Heat Absorbing or Pattern	—	0.42	0.40	0.36	0.28	0.31
Reflective Coated Glass	—	0.30	0.25	0.23	—	—
	—	0.40	0.33	0.29	—	—
	—	0.50	0.42	0.38	—	—
	—	0.60	0.50	0.44	—	—
Double Glass						
Regular	3	0.57	0.51	0.60	0.25	—
Plate	6	0.57	0.51	0.60	0.25	—
Reflective	6	0.20-0.40	—	—	—	—
Insulating Glass						
Clear	2.5-6.0	0.57	0.51	0.60	0.25	0.37
Heat Absorbing	5.0-6.0	0.39	0.36	0.40	0.22	0.30
Reflective Coated	—	0.20	0.19	0.18	—	—
	—	0.30	0.27	0.26	—	—
	—	0.40	0.34	0.33	—	—

***Note*:** Shading coefficient SC, for other shading types and shading devices that are not included in Table 9–9 are as follows:

Dark venetian blinds	0.72
Canva awning	0.25
Roof overhang	0.25
Outside shading screen	0.30
Wood sash	0.85

TABLE 9–10 Cooling load factors (CLF) for glass windows without interior shading, north latitudes.

Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N Shaded	L	0.17	0.14	0.11	0.09	0.08	0.33	0.24	0.48	0.56	0.61	0.71	0.76	0.80	0.82	0.82	0.79	0.75
	M	0.23	0.20	0.18	0.16	0.14	0.34	0.14	0.46	0.53	0.59	0.65	0.70	0.73	0.75	0.76	0.74	0.75
	H	0.25	0.23	0.21	0.20	0.19	0.38	0.45	0.49	0.55	0.60	0.65	0.69	0.72	0.72	0.72	0.70	0.70
NNE	L	0.06	0.05	0.04	0.03	0.03	0.26	0.43	0.47	0.44	0.41	0.40	0.39	0.39	0.38	0.36	0.33	0.30
	M	0.09	0.08	0.07	0.06	0.06	0.24	0.38	0.42	0.39	0.37	0.37	0.36	0.36	0.36	0.34	0.33	0.30
	H	0.11	0.10	0.09	0.09	0.08	0.26	0.39	0.42	0.39	0.36	0.35	0.34	0.34	0.33	0.32	0.31	0.28
NE	L	0.04	0.04	0.03	0.02	0.02	0.23	0.41	0.51	0.51	0.45	0.39	0.36	0.33	0.31	0.28	0.26	0.23
	M	0.07	0.06	0.06	0.05	0.04	0.21	0.36	0.44	0.45	0.40	0.36	0.33	0.31	0.30	0.28	0.26	0.24
	H	0.09	0.08	0.08	0.07	0.07	0.23	0.37	0.44	0.44	0.39	0.34	0.31	0.29	0.27	0.26	0.24	0.22
ENE	L	0.04	0.03	0.03	0.02	0.02	0.21	0.40	0.52	0.57	0.53	0.45	0.39	0.34	0.31	0.28	0.25	0.22
	M	0.07	0.06	0.05	0.05	0.04	0.20	0.35	0.45	0.49	0.47	0.41	0.36	0.33	0.30	0.28	0.26	0.23
	H	0.09	0.09	0.08	0.07	0.07	0.22	0.36	0.46	0.49	0.45	0.38	0.31	0.30	0.27	0.25	0.23	0.21
E	L	0.04	0.03	0.03	0.02	0.02	0.19	0.37	0.51	0.57	0.57	0.50	0.42	0.37	0.32	0.29	0.25	0.22
	M	0.07	0.06	0.06	0.05	0.05	0.18	0.33	0.44	0.50	0.51	0.46	0.39	0.35	0.31	0.29	0.26	0.23
	H	0.09	0.09	0.08	0.08	0.07	0.20	0.34	0.45	0.49	0.49	0.43	0.39	0.32	0.29	0.26	0.24	0.22
ESE	L	0.05	0.04	0.03	0.03	0.02	0.17	0.34	0.49	0.58	0.61	0.57	0.48	0.41	0.36	0.32	0.28	0.24
	M	0.08	0.07	0.06	0.05	0.05	0.16	0.31	0.43	0.51	0.54	0.51	0.44	0.39	0.35	0.32	0.29	0.26
	H	0.10	0.09	0.09	0.08	0.08	0.19	0.32	0.43	0.50	0.52	0.49	0.41	0.36	0.32	0.29	0.26	0.24
SE	L	0.05	0.04	0.04	0.03	0.03	0.13	0.28	0.43	0.55	0.62	0.63	0.57	0.48	0.42	0.37	0.33	0.28
	M	0.09	0.08	0.07	0.06	0.05	0.14	0.26	0.38	0.48	0.54	0.56	0.51	0.45	0.40	0.36	0.33	0.29
	H	0.11	0.10	0.10	0.09	0.08	0.17	0.28	0.40	0.49	0.53	0.53	0.48	0.41	0.36	0.33	0.30	0.27
SSE	L	0.07	0.05	0.04	0.04	0.03	0.06	0.15	0.29	0.43	0.55	0.63	0.64	0.60	0.25	0.45	0.40	0.35
	M	0.11	0.09	0.08	0.07	0.06	0.08	0.16	0.26	0.38	0.58	0.55	0.57	0.54	0.48	0.43	0.39	0.35
	H	0.12	0.11	0.11	0.10	0.09	0.12	0.19	0.29	0.40	0.49	0.54	0.55	0.51	0.44	0.39	0.35	0.31
S	L	0.08	0.07	0.05	0.04	0.04	0.06	0.09	0.14	0.22	0.34	0.48	0.59	0.65	0.65	0.59	0.50	0.43
	M	0.12	0.11	0.09	0.08	0.07	0.08	0.11	0.14	0.21	0.31	0.42	0.52	0.57	0.58	0.53	0.47	0.41
	H	0.13	0.12	0.12	0.11	0.10	0.11	0.14	0.17	0.24	0.33	0.43	0.51	0.56	0.55	0.50	0.43	0.37
SSW	L	0.10	0.08	0.07	0.06	0.05	0.06	0.09	0.11	0.15	0.19	0.27	0.39	0.52	0.62	0.67	0.65	0.58
	M	0.14	0.12	0.11	0.09	0.08	0.09	0.11	0.13	0.15	0.18	0.25	0.35	0.46	0.55	0.59	0.59	0.53
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.14	0.16	0.18	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49
SW	L	0.12	0.10	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.24	0.36	0.49	0.60	0.66	0.66
	M	0.15	0.14	0.12	0.10	0.09	0.09	0.10	0.12	0.13	0.15	0.17	0.23	0.33	0.44	0.53	0.58	0.59
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.25	0.34	0.44	0.52	0.56	0.56
WSW	L	0.12	0.10	0.08	0.07	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.17	0.26	0.40	0.52	0.62	0.66
	M	0.15	0.13	0.12	0.10	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.17	0.24	0.35	0.46	0.54	0.58
	H	0.15	0.14	0.13	0.12	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.19	0.26	0.36	0.46	0.53	0.56
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.08	0.10	0.11	0.12	0.14	0.20	0.32	0.45	0.57	0.64

Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
W	M	0.15	0.13	0.11	0.10	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.19	0.29	0.40	0.50	0.56
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.21	0.30	0.40	0.49	0.54
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.15	0.17	0.26	0.40	0.53	0.63
WNW	M	0.15	0.13	0.11	0.10	0.09	0.09	0.10	0.11	0.12	0.11	0.14	0.15	0.17	0.24	0.35	0.47	0.55
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.25	0.36	0.46	0.53
	L	0.11	0.09	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.17	0.19	0.23	0.33	0.47	0.59
NW	M	0.14	0.12	0.11	0.09	0.08	0.09	0.10	0.11	0.13	0.14	0.16	0.17	0.18	0.21	0.30	0.42	0.51
	H	0.14	0.12	0.11	0.10	0.10	0.10	0.12	0.13	0.15	0.16	0.18	0.18	0.19	0.22	0.30	0.41	0.50
	L	0.12	0.09	0.08	0.06	0.05	0.07	0.11	0.14	0.18	0.22	0.25	0.27	0.29	0.30	0.33	0.44	0.57
NNW	M	0.15	0.13	0.11	0.10	0.09	0.10	0.12	0.15	0.18	0.21	0.23	0.26	0.27	0.28	0.31	0.39	0.51
	H	0.14	0.13	0.12	0.11	0.10	0.12	0.15	0.17	0.20	0.23	0.25	0.26	0.28	0.28	0.31	0.38	0.49
	L	0.11	0.09	0.07	0.06	0.05	0.07	0.14	0.24	0.16	0.48	0.58	0.66	0.72	0.74	0.73	0.67	0.59
HORIZ.	M	0.16	0.14	0.12	0.11	0.11	0.11	0.16	0.24	0.13	0.43	0.52	0.59	0.64	0.67	0.66	0.62	0.56
	H	0.17	0.16	0.15	0.14	0.13	0.15	0.20	0.28	0.16	0.45	0.52	0.59	0.62	0.64	0.62	0.58	0.51

TABLE 9–11 Cooling Load factors (CLF) for glass windows with interior shading, North latitude.

Fenestration Facing	Solar Time, *h*																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N	0.08	0.07	0.06	0.06	0.07	0.73	0.66	0.65	0.73	0.80	0.86	0.89	0.89	0.86	0.82	0.75	0.78
NNE	0.03	0.03	0.02	0.02	0.03	0.64	0.77	0.62	0.42	0.37	0.37	0.37	0.36	0.35	0.32	0.28	0.23
NE	0.03	0.02	0.02	0.02	0.02	0.56	0.76	0.74	0.58	0.37	0.29	0.27	0.26	0.24	0.22	0.20	0.16
ENE	0.03	0.02	0.02	0.02	0.02	0.52	0.76	0.80	0.71	0.52	0.31	0.26	0.24	0.22	0.20	0.18	0.15
E	0.03	0.02	0.02	0.02	0.02	0.47	0.72	0.80	0.76	0.62	0.41	0.27	0.24	0.22	0.20	0.17	0.14
ESE	0.03	0.03	0.02	0.02	0.02	0.41	0.67	0.79	0.80	0.72	0.54	0.34	0.27	0.24	0.21	0.19	0.15
SE	0.03	0.03	0.02	0.02	0.02	0.30	0.57	0.74	0.81	0.79	0.68	0.49	0.33	0.28	0.25	0.22	0.18
SSE	0.04	0.03	0.03	0.03	0.02	0.12	0.31	0.54	0.72	0.81	0.81	0.71	0.54	0.38	0.32	0.27	0.22
S	0.04	0.04	0.03	0.03	0.03	0.09	0.16	0.23	0.38	0.58	0.75	0.83	0.80	0.68	0.50	0.35	0.27
SSW	0.05	0.04	0.04	0.03	0.03	0.09	0.14	0.18	0.22	0.27	0.43	0.63	0.78	0.84	0.80	0.66	0.46
SW	0.05	0.05	0.04	0.04	0.03	0.07	0.11	0.14	0.16	0.19	0.22	0.38	0.59	0.75	0.83	0.81	0.69
WSW	0.05	0.05	0.04	0.04	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.23	0.44	0.64	0.78	0.84	0.78
W	0.05	0.05	0.04	0.04	0.03	0.06	0.09	0.11	0.13	0.15	0.16	0.17	0.31	0.53	0.72	0.82	0.81
WNW	0.05	0.05	0.04	0.03	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.18	0.22	0.43	0.65	0.80	0.84
NW	0.05	0.04	0.04	0.03	0.03	0.07	0.11	0.14	0.17	0.19	0.20	0.21	0.22	0.30	0.52	0.73	0.82
NNW	0.05	0.05	0.04	0.03	0.03	0.11	0.17	0.22	0.26	0.30	0.32	0.33	0.34	0.34	0.39	0.61	0.82
HORIZ.	0.06	0.05	0.04	0.04	0.03	0.12	0.27	0.44	0.59	0.72	0.81	0.85	0.85	0.81	0.71	0.58	0.42

***Note*:** Values of the cooling load factors (CLF) of Tables 9–10 and 9–11 for the hours 18:00 to 24:00 may be obtained from McQuiston and Parker, 1994, "*Heating, Ventilating, and Air Conditioning*", 4th ed., Wiley.

TABLE 9-12 Cooling load temperature differences (CLTD) for convection heat gain for glass windows.

Solar 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
CLTD °C	1	0	−1	−1	−1	−1	−1	0	1	2	4	5	7	7	8	8	7	7	6	4	3	2	2	1

TABLE 9–13 Heat gain rate from miscellaneous appliances, W.(2)

Appliances	Without Hood			With Hood
	Sensible	Latent	Total	All Sensible
Hair dryers (Blower type)	675	120	795	—
Hair dryers (Helmet type)	550	100	650	—
Coffee brewer (electrical)	225	65	290	95
Coffee brewer (gas)	490	210	700	415
Water heater	1,130	335	1,465	—
Coffee urn (electrical)	1,075	350	1,425	440
Coffee urn (gas)	1,460	625	2,085	415
Deep fat fryer (electrical)	820	1,930	2,750	730
Deep fat fryer (gas)	2,080	2,080	4,160	830
Toaster	1,055	705	1,760	440
Domestic gas oven	2,430	1200	3,630	—
Roasting oven	500	320	820	—
Food warmer (gas)	1,550	400	1,950	400
Egg boiler	335	220	555	—
Frying griddle	13,600	7,200	20,800	4,150
Hotplate	1,550	1,060	2,610	780
Neon sign, per meter length	56	—	56	—
Sterilizer	190	350	540	—
Laboratory burner	470	120	590	—
Small copy machine	1,760	—	1,760	—
Large copy machine	3,515	—	3,515	—
Motors:				
400–2,000 W	1,100	—	1,100	—
2,000–15,000 W	2,430	—	2,430	—

TABLE 9-16 Cooling load factor due to occupants $(CLF)_{occ.}$, for sensible heat gain.[5]

Hours after each entry into space	Total hours in space							
	2	4	6	8	10	12	14	16
1	0.49	0.49	0.50	0.51	0.53	0.55	0.58	0.62
2	0.58	0.59	0.60	0.61	0.62	0.64	0.66	0.70
3	0.17	0.66	0.67	0.67	0.69	0.70	0.72	0.75
4	0.13	0.71	0.72	0.72	0.74	0.75	0.77	0.79
5	0.10	0.27	0.76	0.76	0.77	0.79	0.80	0.82
6	0.08	0.21	0.79	0.80	0.80	0.81	0.83	0.85
7	0.07	0.16	0.34	0.82	0.83	0.84	0.85	0.87
8	0.06	0.14	0.26	0.84	0.85	0.86	0.87	0.88
9	0.05	0.11	0.21	0.38	0.87	0.88	0.89	0.90
10	0.04	0.10	0.18	0.30	0.89	0.89	0.9	0.91
11	0.04	0.08	0.15	0.25	0.42	0.91	0.91	0.92
12	0.03	0.07	0.13	0.21	0.34	0.92	0.92	0.93
13	0.03	0.06	0.11	0.18	0.28	0.45	0.93	0.94
14	0.02	0.06	0.10	0.15	0.23	0.36	0.94	0.95
15	0.02	0.05	0.08	0.13	0.20	0.30	0.47	0.95
16	0.02	0.04	0.07	0.12	0.17	0.25	0.38	0.96
17	0.02	0.04	0.06	0.10	0.15	0.21	0.31	0.49
18	0.01	0.03	0.06	0.09	0.13	0.19	0.26	0.39

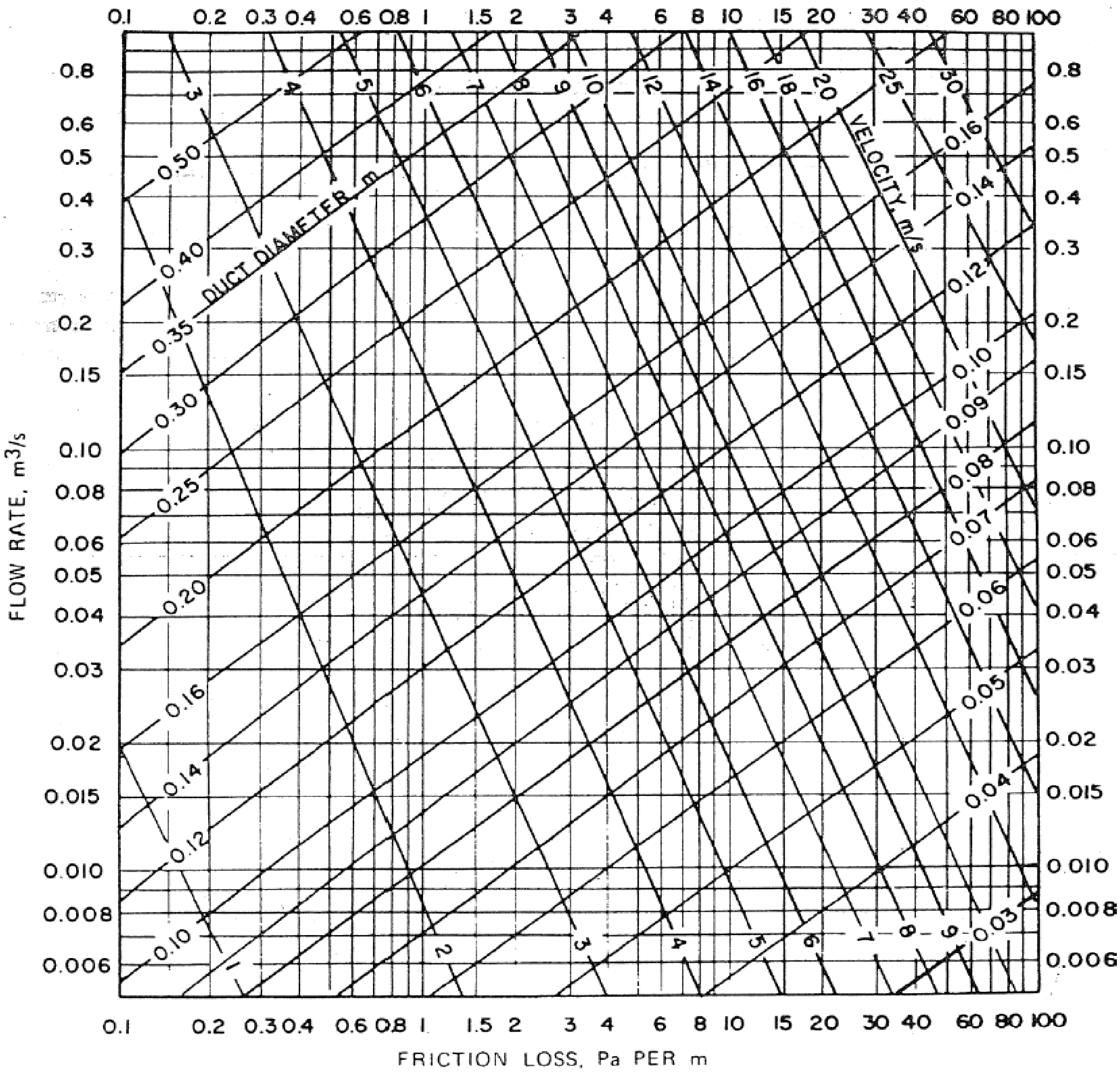


FIGURE 10–5 (*a*) Pressure drop (ΔP/EL), for low flow rates of air in galvanized steel ducts, based on round duct

TABLE 10–2 Circular equivalent diameters of rectangular ducts for equal pressure drop and flow rate[3].

Lgth. Adj.	Length of One Side of Rectangular Duct , mm																			
	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	750	800	900
100	109																			
150	133	150	164																	
200	152	172	189	204	219															
250	169	190	210	228	244	259	273													
300	183	207	229	248	266	283	299	314	328											
400	207	235	260	283	305	325	343	361	378	409	437									
500	227	258	287	313	337	360	381	401	420	455	488	518	547							
600	245	279	310	339	365	390	414	436	457	496	533	567	598	628	656					
700	261	298	331	362	391	418	443	467	490	533	573	610	644	677	708	737	765			
800	275	314	350	383	414	442	470	496	520	567	609	649	687	722	755	787	818	847	875	
900	289	330	367	402	435	465	494	522	548	597	643	686	726	763	799	833	866	897	927	984
1000	301	344	384	420	454	486	517	546	574	626	674	719	762	802	840	876	911	944	976	1037
1200	324	370	413	453	490	525	558	590	620	677	731	780	827	872	914	954	993	1030	1066	1133
1400	344	394	439	482	522	559	595	629	662	724	781	835	886	934	980	1024	1066	1107	1146	1220
1600	362	415	463	508	551	591	629	665	700	766	827	885	939	991	1041	1088	1133	1177	1219	1298
1800	379	434	485	533	577	619	660	698	735	804	869	930	988	1043	1096	1146	1195	1241	1286	1371
2000	395	453	506	555	602	646	688	728	767	840	908	973	1034	1092	1147	1200	1252	1301	1348	1438
2200	410	470	525	577	625	671	715	757	797	874	945	1013	1076	1137	1195	1251	1305	1356	1406	1501
2400	424	486	543	597	647	695	740	784	826	905	980	1050	1116	1180	1241	1299	1355	1409	1461	1561
2600	437	501	560	616	668	717	764	810	853	935	1012	1085	1154	1220	1283	1344	1402	1459	1513	1617
2800	450	516	577	634	688	738	787	834	879	964	1043	1119	1190	1259	1324	1387	1447	1506	1562	1670

Lgth. Adj.[b]	Length of One Side of Rectangular Duct (a), mm																			
	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900
1000	1093																			
1100	1146	1202																		
1200	1196	1256	1312																	
1300	1244	1306	1365	1421																
1400	1289	1354	1416	1475	1530															
1500	1332	1400	1464	1526	1584	1640														
1600	1373	1444	1511	1574	1635	1693	1749													
1700	1413	1486	1555	1621	1684	1745	1803	1858												
1800	1451	1527	1598	1667	1732	1794	1854	1912	1968											
1900	1488	1566	1640	1710	1778	1842	1904	1964	2021	2077										
2000	1523	1604	1680	1753	1822	1889	1952	2014	2073	2131	2186									
2100	1558	1640	1719	1793	1865	1933	1999	2063	2124	2183	2240	2296								
2200	1591	1676	1756	1833	1906	1977	2044	2110	2173	2233	2292	2350	2405							
2300	1623	1710	1793	1871	1947	2019	2088	2155	2220	2283	2343	2402	2459	2514						
2400	1655	1744	1828	1909	1986	2060	2131	2200	2266	2330	2393	2453	2511	2568	2624					
2500	1685	1776	1862	1945	2024	2100	2173	2243	2311	2377	2441	2502	2562	2621	2678	2733				
2600	1715	1808	1896	1980	2061	2139	2213	2285	2355	2422	2487	2551	2612	2672	2730	2787	2842			
2700	1744	1839	1929	2015	2097	2177	2253	2327	2398	2466	2533	2598	2661	2722	2782	2840	2896	2952		
2800	1772	1869	1961	2048	2133	2214	2292	2367	2439	2510	2578	2644	2708	2771	2832	2891	2949	3006	3061	
2900	1800	1898	1992	2081	2167	2250	2329	2406	2480	2552	2621	2689	2755	2819	2881	2941	3001	3058	3115	3170

Table based on $D_e = 1.30(ab)^{0.625}/(a + b)^{0.25}$.
[b] Length of adjacent side of rectangular duct , mm.

Appendix B

plumbing tables

Water tables

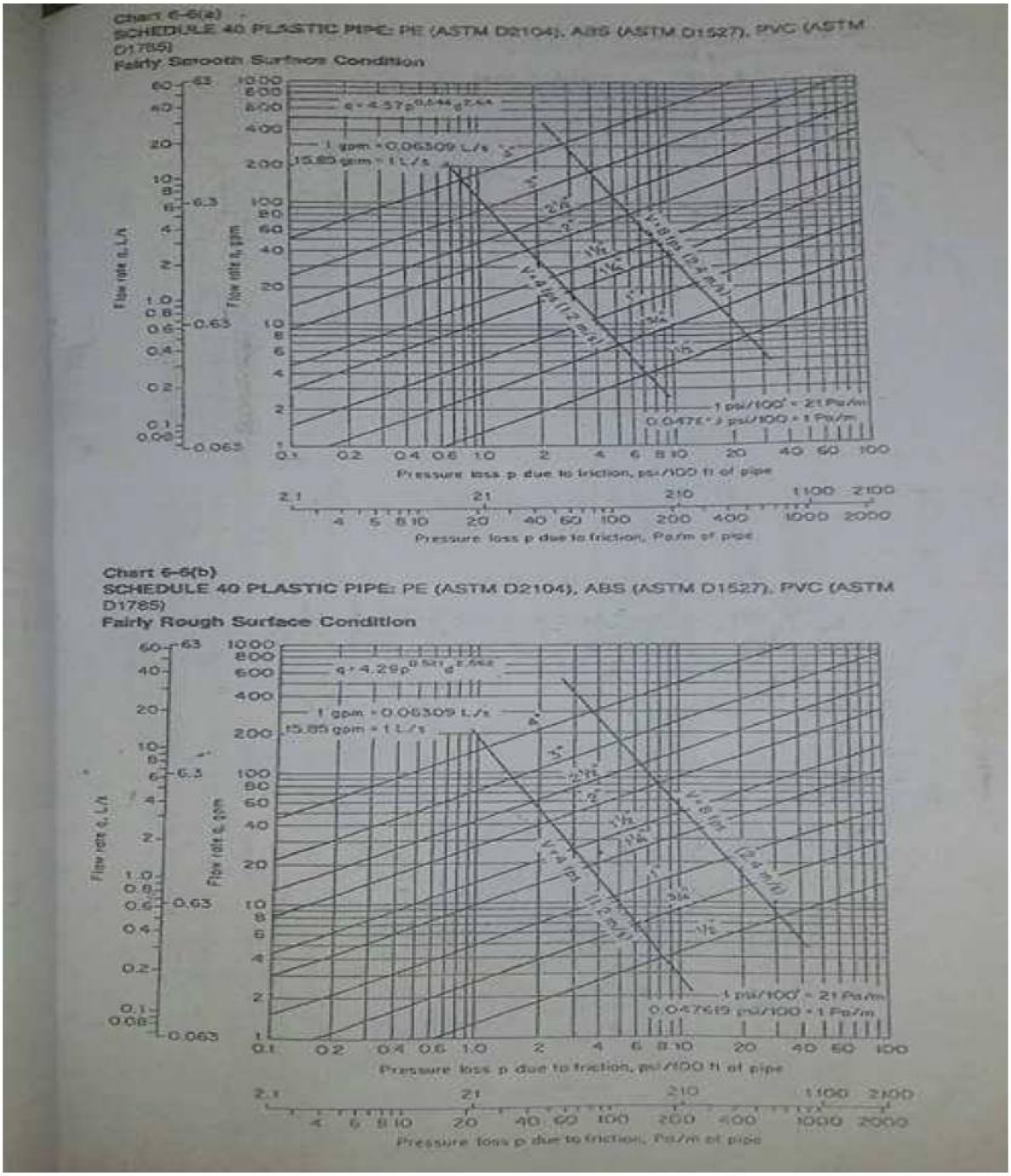
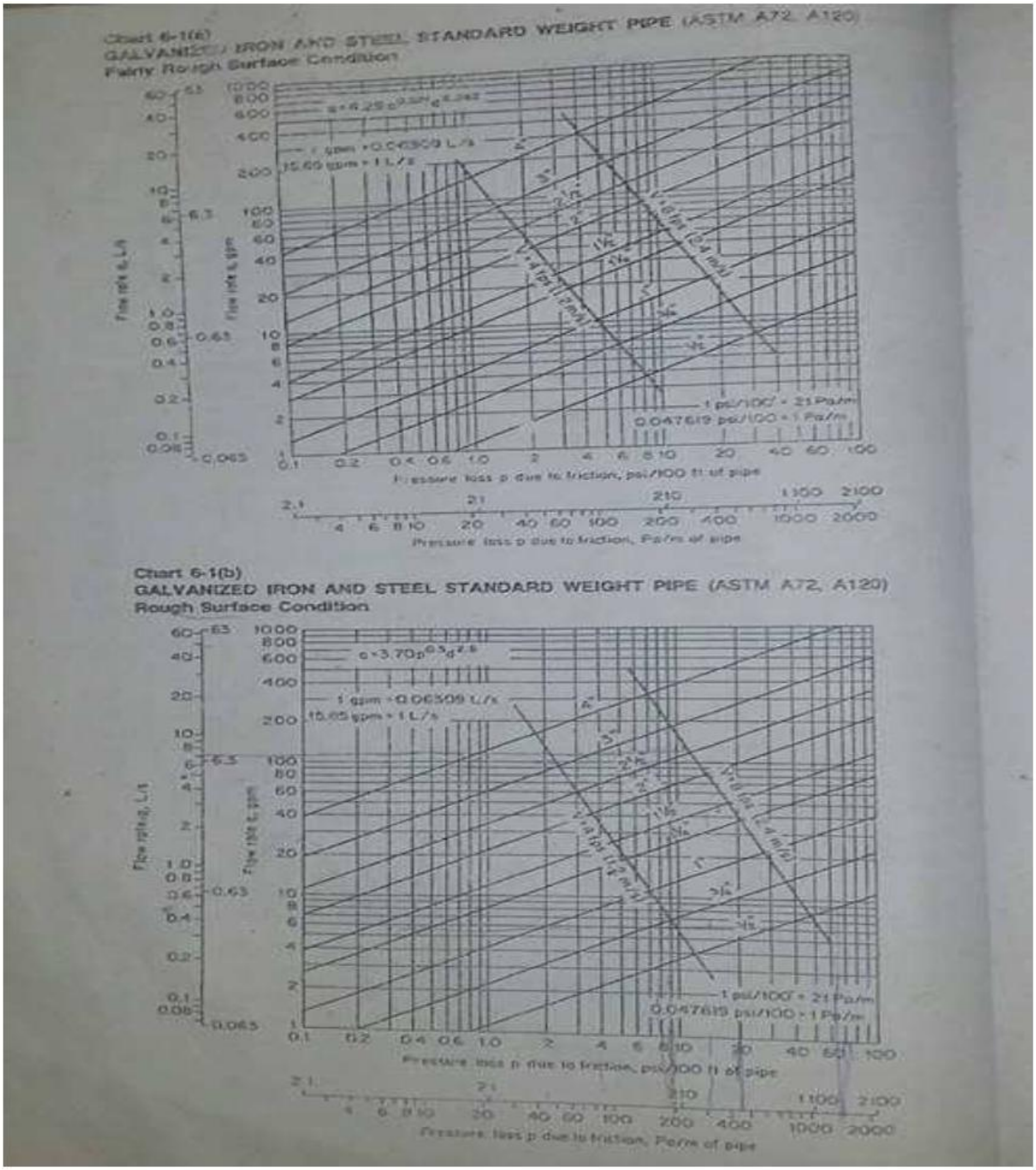


Chart 6-6(a)
SCHEDULE 40 PLASTIC PIPE: PE (ASTM D2104), ABS (ASTM D1527), PVC (ASTM D1785)
Fairly Smooth Surface Condition

Chart 6-6(b)
SCHEDULE 40 PLASTIC PIPE: PE (ASTM D2104), ABS (ASTM D1527), PVC (ASTM D1785)
Fairly Rough Surface Condition

Water tables



Water tables

Table (6-15)

Table 6-15
MINIMUM SIZE OF FIXTURE SUPPLY PIPES

Fixture or device	Size in	Size mm
Bathtub	½	12.7
Combination sink and laundry tray	½	12.7
Drinking fountain	⅜	9.5
Dishwashing machine (domestic)	½	12.7
Kitchen sink (domestic)	½	12.7
Kitchen sink (commercial)	¾	19.0
Lavatory	⅜	9.5
Laundry tray (1, 2, or 3 compartments)	½	12.7
Shower (single head)	½	12.7
Sink (service, slop)	½	12.7
Sink (flushing rim)	¾	19.0
Urinal [1" (25.4 mm) flush valve]	1	25.4
Urinal [¾" (19.0 mm) flush valve]	¾	19.0
Urinal (flush tank)	½	12.7
Water closet (flush tank)	⅜	9.5
Water closet (flush valve)	1	25.4
Hose bib	½	12.7
Wall hydrant or sill cock	½	12.7

Note: For fixtures not listed in the above table, the minimum size of fixture supply pipes shall be the same as given in the table for comparable fixtures.

Water tables

Table (6-14)

Fixture	Occupancy	Type of supply control	Load values assigned, water supply fixture units		
			Cold	Hot	Total
Water closet	Public	Flush valve	10		10
Water closet	Public	Flush tank	5		5
Urinal	Public	1" (25.4 mm) flush valve	10		10
Urinal	Public	¾" (19 mm) flush valve	5		5
Urinal	Public	Flush tank	3		3
Lavatory	Public	Faucet	1.5	1.5	2
Bathtub	Public	Faucet	3	3	4
Showerhead	Public	Mixing valve	3	3	4
Service sink	Offices, etc.	Faucet	2.25	2.25	3
Kitchen sink	Hotel, restaurant	Faucet	3	3	4
Drinking fountain	Offices, etc.	⅜" (9.52 mm) valve	0.25		0.25
Water closet	Private	Flush valve	6		6
Water closet	Private	Flush tank	3		3
Lavatory	Private	Faucet	0.75	0.75	1
Bathtub	Private	Faucet	1.5	1.5	2
Shower stall	Private	Mixing valve	1.5	1.5	2
Kitchen sink	Private	Faucet	1.5	1.5	2
Laundry trays (1 to 3)	Private	Faucet	2.25	2.25	3
Combination fixture	Private	Faucet	2.25	2.25	3
Dishwashing machine	Private	Automatic		1	1
Laundry machine [8 lb (3.6 kg)]	Private	Automatic	1.5	1.5	2
Laundry machine [8 lb (3.6 kg)]	Public or general	Automatic	2.25	2.25	3
Laundry machine [16 lb (7.3 kg)]	Public or general	Automatic	3	3	4

Note: For fixtures not listed, loads should be assumed by comparing the fixture with one listed using water in similar quantities and at similar rates. The assigned loads for fixtures with both hot and cold water supplies are given for separate hot and cold water loads and for total load, the separate hot and cold water loads being three-fourths of the total load for the fixture in each case.

Water tables

Table(6-8)

Table 6-6a
SIZING TABLE BASED ON VELOCITY LIMITATION—U.S. CUSTOMARY UNITS
Schedule 40 Plastic Pipe (PE, PVC, and ABS)

Nominal size, in	Actual ID, in	Velocity = 4 fps				Velocity = 8 fps			
		Flow q, gpm	Load WSFU (col. A)*	Load WSFU (col. B)†	Friction p, psi/100 ft‡	Flow q, gpm	Load WSFU (col. A)*	Load WSFU (col. B)†	Friction p, psi/100 ft‡
½	0.622	3.8	1.5		6.5	7.6	3.7		24.2
¾	0.824	6.7	3.0		5.1	13.4	8.4		18.0
1	1.049	10.8	6.1		3.7	21.6	25.3	7.7	13.2
1¼	1.380	18.6	17.5	6.0	2.6	37.2	77.5	23.7	[illegible]
1½	1.610	25.4	37.0	9.3	2.3	50.8	132.3	52.0	8.2
2	2.067	41.8	93.0	29.8	1.7	83.6	293.0	171.6	6.1
2½	2.469	59.8	174.0	75.6	1.4	119.6	477.0	361.0	4.8
3	3.068	92.0	335.0	209.0	1.1	184.0	842.0	808.0	3.8
4	4.026	158.6	688.0	615.0	0.8	317.2	1930.0	1930.0	2.8

* Col. A applies to piping which does not supply flush valves.

† Col. B applies to piping which supplies flush valves.

‡ Friction loss p corresponding to flow rate q for piping having fairly smooth surface condition after extended service applying the formula

$p = 4.57\, p_{ref}\, q_{ref}$

Water tables

Table 6-3*b*
SIZING TABLE BASED ON VELOCITY LIMITATION—SI UNITS
Galvanized Iron and Steel Pipe, Standard Pipe Size

Nominal size, mm	Actual ID, mm	Velocity = 1.2 m/s				Velocity = 2.4 m/s			
		Flow q, L/s	Load WSFU (col. A)*	Load WSFU (col. B)†	Friction p, Pa/m‡	Flow q, L/s	Load WSFU (col. A)*	Load WSFU (col. B)†	Friction p, Pa/m‡
12.7	15.8	0.23	1.5		172.3	0.47	3.7		651.5
19.0	20.9	0.42	3.0		126.1	0.84	8.4		472.8
25.4	26.6	0.68	6.1		96.7	1.36	25.3	7.7	361.5
31.8	35.1	1.17	17.5	6.0	71.5	2.34	77.3	23.7	269.0
38.1	40.9	1.60	37.0	9.3	60.9	3.20	132.3	52.0	227.0
50.8	52.5	2.63	93.0	29.8	46.2	5.27	293.0	171.6	176.5
63.5	62.7	3.77	174.0	75.6	37.8	7.54	477.0	361.0	142.9
76.2	77.7	5.80	335.0	209.0	29.4	11.60	842.0	806.0	113.5
102.0	102.3	10.00	688.0	615.0	23.1	20.01	1930.0	1930.0	86.2

* Col. A applies to piping which does not supply flush valves.

† Col. B applies to piping which supplies flush valves.

‡ Friction loss p, corresponding to flow rate q, for piping having fairly smooth surface condition after extended service applying the formula

$$q = 4.57\, p^{0.546}\, d^{2.64}$$

Water tables

Table(6-3a)

Table 6-3a

SIZING TABLE BASED ON VELOCITY LIMITATION—U.S. CUSTOMARY UNITS

Galvanized Iron and Steel Pipe, Standard Pipe Size

		Velocity = 4 fps				Velocity = 8 fps			
Nominal size, in	Actual ID, in	Flow q, gpm	Load WSFU (col. A)*	Load WSFU (col. B)†	Friction p, psi/100 ft‡	Flow q, gpm	Load WSFU (col. A)*	Load WSFU (col. B)†	Friction p, psi/100 ft‡
½	0.622	3.8	1.5		8.2	7.6	3.7		31.0
¾	0.824	6.7	3.0		6.0	13.4	8.4		22.5
1	1.049	10.8	6.1		4.6	21.6	25.3	7.7	17.2
1¼	1.380	18.6	17.5	6.0	3.4	37.2	77.3	23.7	12.8
1½	1.610	25.4	37.0	9.3	2.9	50.8	132.3	52.0	10.8
2	2.067	41.8	93.0	29.8	2.2	83.6	293.0	171.6	8.4
2½	2.469	59.8	174.0	75.6	1.8	119.6	477.0	361.0	6.8
3	3.068	92.0	335.0	209.0	1.4	184.0	842.0	806.0	5.4
4	4.026	158.6	688.0	615.0	1.1	317.0	1930.0	1930.0	4.1

* Col. A applies to piping which does not supply flush valves.

† Col. B applies to piping which supplies flush valves.

‡ Friction loss p, corresponding to flow rate q, for piping having fairly smooth surface condition after extended service applying the formula

$$q = 4.57\, p^{0.545}\, d^{2.64}$$

Water tables

Table (6-1) ,(6-2)

Table 6-1
DEMAND AT INDIVIDUAL WATER OUTLETS

Type of outlet	Demand gpm	Demand L/s
Ordinary lavatory faucet	2.0	0.126
Self-closing lavatory faucet	2.5	0.158
Sink faucet, ⅜" (9.52 mm) or ½" (12.7 mm)	4.5	0.284
Sink faucet, ¾" (19 mm)	6.0	0.378
Bath faucet, ½" (12.7 mm)	5.0	0.315
Shower head, ½" (12.7 mm)	5.0	0.315
Laundry faucet, ½" (12.7 mm)	5.0	0.315
Ball cock in water closet flush tank	3.0	0.189
1" (25.4 mm) flush valve [25 psi (172 kPa) flow pressure]	35.0	2.210
1" (25.4 mm) flush valve [15 psi (103 kPa) flow pressure]	27.0	1.703
¾" (19.0 mm) flush valve [15 psi (103 kPa) flow pressure]	15.0	0.946
Drinking fountain jet	0.75	0.047
Dishwashing machine (domestic)	4.0	0.252
Laundry machine [8 lb (3.6 kg) or 16 lb (7.3 kg)]	4.0	0.252
Aspirator (operating room or laboratory)	2.5	0.158
Hose bib or sill cock, ½" (12.7 mm)	5.0	0.315

Table 6-2
TABLE FOR ESTIMATING DEMAND

Supply systems predominantly for flush tanks			Supply systems predominantly for Flushometer valves		
Load	Demand		Load	Demand	
Water supply fixture units (WSFU)	gpm	L/s	Water supply fixture units (WSFU)	gpm	L/s
1	3.0	0.19			
2	5.0	0.32			
3	6.5	0.41			
4	8.0	0.51			
5	9.4	0.59	5	15.0	0.95
6	10.7	0.68	6	17.4	1.10
7	11.8	0.74	7	19.8	1.25
8	12.8	0.81	8	22.2	1.40
9	13.7	0.86	9	24.6	1.55
10	14.6	0.92	10	27.0	1.70
12	16.0	1.01	12	28.6	1.80
14	17.0	1.07	14	30.2	1.91
16	18.0	1.14	16	31.8	2.01
18	18.8	1.19	18	33.4	2.11
20	19.6	1.24	20	35.0	2.21

drainage tables

Table 10.1 Approximate Discharge Rates and Velocities[a] in Sloping Drains Flowing Half Full[b]

Actual Inside Diameter of Pipe, in.	1/16 in./ft Slope		1/8 in./ft Slope		1/4 in./ft Slope		1/2 in./ft Slope	
	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocit fps
1¼							3.40	1.78
1⅜					3.13	1.34	4.44	1.90
1½					3.91	1.42	5.53	2.01
1⅝					4.81	1.50	6.80	2.12
2					8.42	1.72	11.9	2.43
2½			10.8	1.41	15.3	1.99	21.6	2.82
3			17.6	1.59	24.8	2.25	35.1	3.19
4	26.70	1.36	37.8	1.93	53.4	2.73	75.5	3.86
5	48.3	1.58	68.3	2.23	96.6	3.16	137.	4.47
6	78.5	1.78	111.	2.52	157.	3.57	222.	5.04
8	170.	2.17	240.	3.07	340.	4.34	480.	6.13
10	308.	2.52	436.	3.56	616.	5.04	872.	7.12
12	500.	2.83	707.	4.01	999.	5.67	1413	8.02

drainage tables

TABLE 10-2
MAXIMUM PERMISSIBLE LOADS FOR SANITARY DRAINAGE PIPING
In Terms of Fixture Units

Pipe diameter		Any horizontal fixture branch	One stack of 3 stories or less in height	Stacks more than 3 stories in height		Building drain, and building drain branches from stacks: Slope, in/ft (mm/m)		
in	mm			Total for stack	Total at one story	1/16 (5.2)	1/8 (10.4)	1/4 (20.8)
1½*	37.5	3	4	8	2	np	np	np
2*	50	6	10	24	6	np	np	21
2½*	62.5	12	20	42	9	np	np	24
3	75	20†	48‡	72‡	20†	np	np†	42†
4	100	160	240	500	90	np	180	216
5	125	360	540	1100	200	np	390	480
6	150		960	1900	350	np	700	840
8	200			3600	600	1400	1600	1920
10	250			5600	1000	2500	2900	3500
12	300					3900	4600	5600

* No water closets permitted.

† Not over two water closets permitted.

‡ Not over six water closets permitted.

drainage tables

Table 10.3 Drainage Fixture Unit Values for Various Plumbing Fixtures

Type of Fixture or Group of Fixtures	*Drainage Fixture Unit Value, dfu*
Automatic clothes washer (2-in. standpipe and trap required, direct connection)	3
Bathtub group consisting of a water closet; lavatory and bathtub or shower stall:	6
Bathtub (with or without overhead shower)[a]	2
Bidet	1
Clinic sink	6
Clothes washer	2
Combination sink-and-tray with food waste grinder	4
Combination sink-and-tray with one 1-in. trap	2
Combination sink-and-tray with separate 1-in. trap	3
Dental unit or cuspidor	1
Dental lavatory	1
Drinking fountain	1/2
Dishwasher, domestic	2
Floor drains with 2-in. waste	3
Kitchen sink, domestic, with one 1-in. trap	2
Kitchen sink, domestic, with food waste grinder	2
Kitchen sink, domestic, with food waste grinder and dishwasher 1-in. trap	3
Kitchen sink, domestic, with dishwasher 1-in trap	3
Lavatory with 1-in. waste	1
Laundry tray (1 or 2 compartments)	2
Shower stall, domestic	2
Showers (group) per head	2
Sinks	
surgeon's	3
flushing rim (with valve)	6
service (trap standard)	3
service (P trap)	2
pot, scullery, etc.	4
Urinal, syphon jet blowout	6
Urinal, wall lip	4
Wash sink (circular or multiple) each set of faucets	2
Water closet, private	4
Water closet, general use	6
Fixtures not already listed	
trap size 1 1/4 in. or less	1
trap size 1 1/2 in.	2
trap size 2 in.	3
trap size 2 1/2 in.	4
trap size 3 in.	5
trap size 4 in.	6

[a] A shower head over a bathtub does not increase the fixture unit value.

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drainage tables

Table 10.5 Building Drains and Sewers[a]

Diameter of Pipe, in.	Maximum Number of Fixture Units That May Be Connected to Any Portion of the Building Drain or the Building Sewer			
	Slope per Foot			
	1/16 in.	1/8 in.	1/4 in.	1/2 in.
2			21	26
2½			24	31
3			42[b]	50[b]
4		180	216	250
5		390	480	575
6		700	840	1000
8	1400	1600	1920	2300
10	2500	2900	3500	4200
12	2900	4600	5600	6700
15	7000	8300	10,000	12,000

<u>Firefighting Table</u>

Table 3F Water Flow Tables
WATER FLOWING IN 3 INCH SCHEDULE 40 STEEL PIPE
I.D. = 3.068 inches

Q (gpm)	Pf (psi/ft) C=100	Pf (psi/ft) C=120	Velocity (fps)
30	0.002	0.001	1.30
40	0.004	0.003	1.74
50	0.005	0.004	2.17
60	0.007	0.005	2.60
70	0.010	0.007	3.04
80	0.013	0.009	3.47
90	0.016	0.011	3.91
100	0.019	0.014	4.34
110	0.023	0.016	4.77
120	0.027	0.019	5.21
130	0.031	0.022	5.64
140	0.036	0.026	6.08
150	0.041	0.029	6.51
155	0.043	0.031	6.73
160	0.046	0.033	6.94
165	0.049	0.035	7.16
170	0.051	0.037	7.38
175	0.054	0.039	7.60
180	0.057	0.041	7.81
185	0.060	0.043	8.03
190	0.063	0.045	8.25
195	0.066	0.047	8.46
00	0.069	0.049	8.68
05	0.073	0.052	8.90
10	0.076	0.054	9.11
15	0.079	0.057	9.33
20	0.083	0.059	9.55
25	0.086	0.062	9.77
30	0.090	0.064	9.98
35	0.093	0.067	10.20
0	0.097	0.069	10.42
5	0.101	0.072	10.63
0	0.011	0.075	10.85
5	0.109	0.078	11.07
0	0.113	0.080	11.28
5	0.117	0.083	11.50
0	0.121	0.086	11.72
5	0.125	0.089	11.94

Q (gpm)	Pf (psi/ft) C=100	Pf (psi/ft) C=120	Velocity (fps)
280	0.129	0.092	12.15
285	0.134	0.095	12.37
290	0.138	0.098	12.59
295	0.142	0.102	12.80
300	0.147	0.105	13.02
305	0.151	0.108	13.24
310	0.156	0.111	13.45
315	0.161	0.115	13.67
320	0.165	0.118	13.89
325	0.170	0.122	14.11
330	0.175	0.125	14.32
335	0.180	0.129	14.54
340	0.185	0.132	14.76
345	0.190	0.136	14.97
350	0.195	0.139	15.19
355	0.200	0.143	15.41
360	0.206	0.147	15.62
365	0.211	0.151	15.84
370	0.716	0.154	16.06
375	0.222	0.158	16.28
380	0.227	0.162	16.49
385	0.233	0.166	16.71
390	0.239	0.170	16.93
395	0.244	0.174	17.14
400	0.250	0.178	17.36
405	0.256	0.183	17.58
410	0.262	0.187	17.79
415	0.268	0.191	18.01
420	0.274	0.195	18.23
425	0.280	0.200	18.45
430	0.286	0.204	18.66
435	0.292	0.208	18.88
440	0.298	0.213	19.10
445	0.305	0.217	19.31
450	0.311	0.222	19.53
455	0.317	0.226	19.75
460	0.324	0.231	19.96
465	0.330	0.236	20.18

Table 3G Water Flow Tables
WATER FLOWING IN 4 INCH SCHEDULE 40 STEEL PIPE
I.D. = 4.026 inches

Q (gpm)	Pf (psi/ft) C=100	Pf (psi/ft) C=120	Velocity (fps)
100	0.005	0.004	2.52
125	0.008	0.006	3.15
150	0.011	0.008	3.78
175	0.014	0.010	4.41
200	0.018	0.013	5.04
225	0.023	0.016	5.67
250	0.028	0.020	6.30
275	0.033	0.024	6.93
300	0.039	0.028	7.56
325	0.045	0.032	8.19
350	0.052	0.037	8.82
375	0.059	0.042	9.45
400	0.067	0.048	10.08
425	0.074	0.053	10.71
450	0.083	0.059	11.34
475	0.091	0.065	11.97
500	0.101	0.072	12.60
510	0.104	0.074	12.85
520	0.108	0.077	13.11
530	0.112	0.080	13.36
540	0.116	0.083	13.61
550	0.120	0.086	13.86
560	0.124	0.089	14.11
570	0.128	0.091	14.37
580	0.132	0.094	14.62
590	0.137	0.097	14.87
600	0.141	0.101	15.12
610	0.145	0.104	15.37
620	0.150	0.107	15.63
630	0.154	0.110	15.88
640	0.159	0.113	16.13
650	0.163	0.117	16.38
660	0.168	0.120	16.63
670	0.173	0.123	16.89
680	0.178	0.127	17.14
690	0.183	0.130	17.39
700	0.187	0.134	17.64
710	0.192	0.137	17.89
720	0.197	0.141	18.15
730	0.203	0.145	18.40
740	0.208	0.148	18.65
750	0.213	0.152	18.90
760	0.218	0.156	19.16
770	0.224	0.160	19.41
780	0.229	0.163	19.60
790	0.234	0.167	19.91

Appendix C

Room Number	Q total Kw	Room Number	Q total Kw	Room Number	Q total Kw
1	3.7	**2**	4.2	**3**	3.6
4	4.2	**5**	3.56	**6**	4.3
7	3.8	**8**	4.3	**9**	3.6
10	4.2	**11**	3.77	**12**	4.2
13	4.35	**14**	4.2	**15**	3.87
16	4.41	**17**	4.87	**18**	24.9
19	5.62	**20**	2.84	**21**	3.06
22	4.5	**23**	4.5	**24**	5
25	4.54	**26**	3.88	**27**	4.2
28	5.35	**29**	3.73	**30**	4.2
31	3.6	**32**	4.2	**33**	3.84
34	4.23	**35**	3.31	**36**	4.26
37	3.1	**38**	4.22	**39**	3.8
40	4.2	**41**	10.67	**42**	10.67
43	5	**44**	2.21	**45**	24.35
46	3.41	**47**	10.73	**48**	5.87
49	5.66	**50**	4.8	**51**	4.73
52	14.5	**53**	4.8	**54**	3.66

Table C1: Cooling load for ground floor.

Room Number	Q total	Room Number	Q total	Room Number	Q total
1	3.67	**2**	4.22	**3**	4.1
4	4.23	**5**	4	**6**	4.32
7	4.41	**8**	4.32	**9**	4.06
10	4.22	**11**	3.77	**12**	4.21
13	5.55	**14**	4.22	**15**	3.86
16	5	**17**	5	**18**	5
19	5	**20**	5.24	**21**	4.26
22	5.62	**23**	2.8	**24**	3.42
25	4.62	**26**	5.25	**27**	5.45
28	4.9	**29**	5	**30**	5
31	3.86	**32**	4.22	**33**	5.45
34	3.82	**35**	4.22	**36**	3.82
37	4.22	**38**	4.1	**39**	4.89
40	3.79	**41**	4.22	**42**	10.56
43	4	**44**	4.1	**45**	5
46	4.85	**47**	14.84	**48**	14.88
49	9	**50**	3.68	**51**	5.77
52	4.55	**53**	19	**54**	3.7
55	4.21	**56**	4.11	**57**	4.85

Table C2: Cooling load for first floor.

Room Number	Q total	Room Number	Q total	Room Number	Q total
1	3.67	**2**	4.22	**3**	4.07
4	4.22	**5**	4	**6**	4.31
7	4.4	**8**	4.32	**9**	4.06
10	4.22	**11**	3.77	**12**	4.21
13	5.55	**14**	4.22	**15**	3.86
16	5	**17**	5	**18**	5
19	5	**20**	5.24	**21**	4.26
22	2.8	**23**	2.8	**24**	3.4
25	4.71	**26**	5.16	**27**	5.45
28	5	**29**	5	**30**	5
31	3.86	**32**	4.22	**33**	5.45
34	3.82	**35**	4.23	**36**	3.82
37	4.22	**38**	4.1	**39**	5
40	3.8	**41**	4.22	**42**	10.56
43	4.13	**44**	4.16	**45**	5
46	4.85	**47**	14.8	**14.48**	14.88
49	9	**50**	3.68	**51**	5.77
52	4.55	**53**	19	**54**	3.7
55	4.2	**56**	4.11	**57**	4.85

Table C3: Cooling load for second floor.

Room Number	Q total	Room Number	Q total	Room Number	Q total
1	3.68	**2**	4.22	**3**	4.1
4	4.22	**5**	4	**6**	4.32
7	4.22	**8**	4.32	**9**	4.1
10	4.22	**11**	3.78	**12**	4.22
13	5.61	**14**	4.22	**15**	3.87
16	5	**17**	5	**18**	5
19	5	**20**	5.26	**21**	2.27
22	5.71	**23**	2.8	**24**	4.43
25	4.73	**26**	5.16	**27**	5.47
28	5	**29**	5	**30**	5
31	3.87	**32**	4.22	**33**	5.51
34	3.83	**35**	4.22	**36**	3.83
37	4.22	**38**	4.12	**39**	5
40	3.81	**41**	4.22	**42**	10.6
43	4.14	**44**	4.16	**45**	5
46	4.86	**47**	14.87	**48**	15
49	9	**50**	3.7	**51**	5.77
52	4.57	**53**	19.01	**54**	3.72
55	4.22	**56**	4.12	**57**	4.86
The total load for all building				**1192.33 KW**	

Table C4: Cooling load for third floor.

Room	fcu selection	cfm	Room	fcu selection	cfm	Room	fcu selection	cfm
G1	PCC/PFC5-L-85-65-27	677.20	**G2**	PCC/PFC6-M-76-63-26	769.90	**G3**	PCC/PFC5-L-85-65-27	652.74
G4	PCC/PFC6-M-76-63-26	769.90	**G5**	PCC/PFC5-L-85-65-27	652.74	**G6**	PCC/PFC6-M-78-63-26	786.66
G7	PCC/PFC3-H-76-67-27	695.06	**G8**	PCC/PFC6-M-78-63-26	786.66	**G9**	PCC/PFC5-L-85-65-27	658.65
G10	PCC/PFC6-M-76-63-26	769.90	**G11**	PCC/PFC3-H-76-67-27	691.96	**G12**	PCC/PFC6-M-76-63-26	769.90
G13	PCC/PFC4-H-85-67-27	980.75	**G14**	PCC/PFC6-M-76-63-26	769.90	**G15**	PCC/PFC3-H-76-67-27	711.16
G16	PCC/PFC6-M-85-63-26	825.78	**G17**	PCC/PFC8-M-80-63-26	893.81	**G18**		4567.13
G19	PCC/PFC6-H-78-65-26	1029.68	**G20**	PCC/PFC4-L-76-63-27	521.26	**G21**	PCC/PCF5-L-80-63-27	562.55
G22	PCC/PFC6-M-85-63-26	824.79	**G23**	PCC/PFC6-H-85-63-26	905.20	**G24**	PCC/PFC6-M-85-63-26	821.78
G25	PCC/PFC6-H-85-63-26	916.58	**G26**	PCC/PFC6-M-85-63-26	832.28	**G27**	PCC/PFC4-H-78-63-27	712.47
G28	PCC/PFC6-M-76-63-26	769.90	**G29**	PCC/PFC4-H-85-67-27	981.65	**G30**	PCC/PFC3-H-76-67-27	684.83
G31	PCC/PFC6-M-76-63-26	769.90	**G32**	PCC/PFC5-L-85-65-27	660.33	**G33**	PCC/PFC6-M-76-63-26	769.90
G34	PCC/PFC4-H-78-63-27	703.74	**G35**	PCC/PFC8-L-78-63-26	776.57	**G36**	PCC/PFC5-M-76-63-27	607.62
G37	PCC/PFC8-L-78-63-26	781.47	**G38**	PCC/PCF5-L-80-63-27	564.21	**G39**	PCC/PFC6-M-76-63-26	774.80
G40	PCC/PFC4-H-78-63-27	695.44	**G41**	PCC/PFC6-M-76-63-26	769.90	**G42**	PCC/PFC12-M-85-67-26	1956.90
G43	PCC/PFC12-M-85-67-26	1956.90	**G44**	PCC/PFC6-M-85-63-26	824.99	**G45**	PCC/PFC2-M-80-63-27	406.09
G46	.	4464.44	**G47**	PCC/PFC3-H-76-65-27	626.01	**G48**	PCC/PFC12-M-85-67-26	1967.91
G49	PCC/PFC8-L-78-67-26	1077.26	**G50**	PCC/PFC6-H-78-65-26	1038.68	**G51**	PCC/PFC5-M-85-67-27	880.59
G52	PCC/PFC5-M-85-67-27	867.83	**G53**	CB/CBP12-H-76-67-16	2655.98	**G54**	PCC/PFC5-M-85-67-27	879.46

C5: Ground floor F.C.U selection & quantity of air in rooms.

Room	FCU selection	CFM	Room	FCU selection	CFM	Room	FCU selection	CFM
1	PCC/PFC5-L-85-65-27	672.43	**2**	PCC/PFC8-L-78-63-26	773.84	**3**	PCC/PFC3-H-85-67-27	747.34
4	PCC/PFC8-L-78-63-26	773.84	**5**	PCC/PFC4-H-80-63-27	721.01	**6**	PCC/PFC5-H-80-65-27	791.93
7	PCC/PCF5-H-85-65-27	808.27	**18**	PCC/PFC5-H-80-65-27	791.93	**9**	PCC/PFC3-H-85-67-27	746.13
10	PCC/PFC8-L-78-63-26	773.84	**11**	PCC/PFC4-H-78-63-27	691.03	**12**	PCC/PFC8-L-78-63-26	772.58
13	PCC/PFC6-H-78-65-26	1018.01	**14**	PCC/PFC8-L-78-63-26	773.84	**15**	PCC/PFC4-H-80-63-27	708.53
16	PCC/PFC5-H-78-67-27	908.89	**17**	PCC/PFC8-M-80-63-26	897.76	**18**	PCC/PFC5-H-78-67-27	912.79
19	PCC/PFC8-M-80-63-26	897.76	**20**	PCC/PFC4-H-78-67-27	961.18	**21**	PCC/PFC5-L-85-67-27	782.53
22	PCC/PFC6-H-78-65-26	1030.83	**23**	PCC/PFC4-L-76-63-27	511.52	**24**	PCC/PFC4-M-76-63-27	628.05
25	PCC/PFC5-M-76-67-27	848.12	**26**	PCC/PFC4-H-78-67-27	962.96	**27**	PCC/PFC6-H-78-65-26	1000.05
28	PCC/PFC5-H-78-67-27	898.63	**29**	PCC/PFC5-H-78-67-27	913.32	**30**	PCC/PFC8-M-80-63-26	897.76
31	PCC/PFC4-H-80-63-27	708.53	**32**	PCC/PFC8-L-78-63-26	773.84	**33**	PCC/PFC6-H-78-65-26	1000.59
34	PCC/PFC4-H-80-63-27	701.15	**35**	PCC/PFC8-L-78-63-26	773.84	**36**	PCC/PFC4-H-80-63-27	701.15
37	PCC/PFC8-L-78-63-26	773.84	**38**	PCC/PFC5-L-76-67-27	752.67	**39**	PCC/PFC8-M-80-63-26	897.76
40	PCC/PFC4-L-76-67-27	695.67	**41**	PCC/PFC8-L-78-63-26	773.84	**42**	PCC/PFC12-M-85-67-26	1937.56
43	PCC/PFC5-M-76-65-27	732.06	**44**	PCC/PFC8-L-78-63-26	763.30	**45**	PCC/PFC5-H-78-67-27	917.66
46	PCC/PFC8-M-80-63-26	890.17	**47**	CB/CBP12-H-76-67-16	2721.91	**48**	CB/CBP12-H-76-67-16	2728.82
49	PCC/PFC12-M-80-65-26	1634.90	**50**	PCC/PFC5-L-85-65-27	676.02	**51**	PCC/PFC8-L-78-67-26	1058.17
52	PCC/PFC5-M-76-67-27	835.03	**53**		3476.58	**54**	PCC/PFC5-L-85-65-27	679.56
55	PCC/PFC8-L-78-63-26	773.42	**56**	PCC/PFC5-L-76-67-27	753.87	**57**	PCC/PFC8-M-80-63-26	890.17

C6: First & second floor F.C.U selection & quantity of air in rooms.

Room	FCU selection	CFM	Room	FCU selection	CFM	Room	FCU selection	CFM
1	PCC/PFC5-L-85-65-27	674.93	2	PCC/PFC8-L-78-63-26	774.71	3	PCC/PFC3-H-85-67-27	750.2109
4	PCC/PFC8-L-78-63-26	774.71	5	PCC/PFC4-H-80-63-27	723.509	6	PCC/PFC5-H-80-65-27	792.796
7	PCC/PCF5-H-85-65-27	810.77	8	PCC/PFC5-H-80-65-27	792.796	9	PCC/PFC3-H-85-67-27	748.9467
10	PCC/PFC8-L-78-63-26	774.71	11	PCC/PFC4-H-78-63-27	693.529	12	PCC/PFC8-L-78-63-26	773.4415
13	PCC/PFC6-H-78-65-26	1028.3	14	PCC/PFC8-L-78-63-26	774.706	15	PCC/PFC4-H-80-63-27	711.028
16	PCC/PFC5-H-78-67-27	912.52	17	PCC/PFC8-M-80-63-26	898.621	18	PCC/PFC5-H-78-67-27	916.7288
19	PCC/PFC8-M-80-63-26	898.62	20	PCC/PFC4-H-78-67-27	964.803	21	PCC/PFC5-L-85-67-27	783.3928
22	PCC/PFC6-H-78-65-26	1046.5	23	PCC/PFC4-L-76-63-27	512.127	24	PCC/PFC4-M-76-63-27	628.9453
25	PCC/PFC5-M-76-67-27	868.24	26	PCC/PFC4-H-78-67-27	947.324	27	PCC/PFC6-H-78-65-26	1003.986
28	PCC/PFC5-H-78-67-27	899.54	29	PCC/PFC5-H-78-67-27	916.943	30	PCC/PFC8-M-80-63-26	898.6215
31	PCC/PFC4-H-80-63-27	711.03	32	PCC/PFC8-L-78-63-26	774.706	33	PCC/PFC6-H-78-65-26	1010.95
34	PCC/PFC4-H-80-63-27	703.65	35	PCC/PFC8-L-78-63-26	774.706	36	PCC/PFC4-H-80-63-27	703.6488
37	PCC/PFC8-L-78-63-26	774.71	38	PCC/PFC5-L-76-67-27	755.483	39	PCC/PFC8-M-80-63-26	898.6215
40	PCC/PFC4-L-76-67-27	698.17	41	PCC/PFC8-L-78-63-26	774.706	42	PCC/PFC12-M-85-67-26	1941.683
43	PCC/PFC5-M-76-65-27	759.86	44	PCC/PFC8-L-78-63-26	764.165	45	PCC/PFC5-H-78-67-27	921.2866
46	PCC/PFC8-M-80-63-26	891.03	47	CB/CBP12-H-76-67-16	2727.9	48	CB/CBP12-H-76-67-16	2734.728
49	PCC/PFC12-M-80-65-26	1638	50	PCC/PFC5-L-85-65-27	678.106	51	PCC/PFC8-L-78-67-26	1059.029
52	PCC/PFC5-M-76-67-27	839.21	53		3485.13	54	PCC/PFC5-L-85-65-27	682.0595
55	PCC/PFC8-L-78-63-26	774.28	56	PCC/PFC5-L-76-67-27	756.747	57	PCC/PFC8-M-80-63-26	891.0315

C7: Third floor F.C.U selection & quantity of air in rooms.

(Ground floor)	
Room	**KW**
1	1.06
2	0.78
3	1.66
4	1.66
5	1.6
6	1.012
7	1.012
8	1.6
9	1.66
10	1.66
11	1.6
12	1.012
13	1.6
14	1.6
15	3.25
16	1.6
17	0.97
18	1.6
19	1.6
20	1.6
21	1.6
22	3.56
23	1.19
24	1.6
25	1.6
26	1.6
corridor	7.913
Total	**50.169Kw**

Table C.8: Heating loads for ground floor.

First floor	
Room	kW
1	0.62
2	0.47
3	0.79
4	0.46
5	0.43
6	0.43
7	0.62
8	0.43
9	0.79
10	0.46
11	0.46
12	0.62
13	0.40
14	0.48
15	0.42
16	0.779
17	0.779
18	0.42
19	0.48
20	0.4
21	0.4
22	0.4
23	0.63
24	0.69
25	0.69
26	0.63
27	0.4
28	0.4
29	0.548
corridor	2.33
Total	18 Kw

Table C.9: Heating loads for First floor.

Second floor	
Room	kW
1	0.62
2	0.47
3	0.79
4	0.46
5	0.43
6	0.43
7	0.62
8	0.43
9	0.79
10	0.46
11	0.46
12	0.62
13	0.40
14	0.48
15	0.42
16	0.779
17	0.779
18	0.42
19	0.48
20	0.4
21	0.4
22	0.4
23	0.63
24	0.69
25	0.69
26	0.63
27	0.4
28	0.4
29	0.548
corridor	2.33
Total	18 Kw

Table C.10: Heating loads for Second floor.

Third floor	
Room	kW
1	1.48
2	1.25
3	1.63
4	1.63
5	1.25
6	1.48
7	1.48
8	1.25
9	1.63
10	1.63
11	1.25
12	1.48
13	1.74
14	1.72
15	1.8
16	2.15
17	1.72
18	1.8
19	1.72
20	1.74
21	1.85
22	1.74
23	1.93
24	2.76
25	2.765
26	1.93
27	1.74
28	1.85
29	1.06
corridor	14.7
Total	64.305 Kw

Table C.11: Heating loads for Third floor.

Ground floor	
bathroom	**Watt**
1	**403.26**
2	**469**
3	**473.6**
4	**473.6**
5	**469**
6	**403.26**
7	**403.26**
8	**469**
9	**473.6**
10	**473.6**
11	**469**
12	**403.26**
13	**469**
14	**469**
15	**0**
16	**469**
17	**469**
18	**469**
19	**469**
20	**0**
21	**469**
22	**469**
23	**469**
24	**0**
25	**0**
26	**0**
Total	**9.604 Kw**

Table C.12: Heating loads for Ground floor bathrooms.

First and Second **floor**	
Bathroom	**Watt**
1	**184.5**
2	**0.49**
3	**252.05**
4	**252.05**
5	**0.49**
6	**184.5**
7	**184.5**
8	**0.49**
9	**252.05**
10	**252.05**
11	**0.49**
12	**184.5**
13	**0.49**
14	**0.49**
15	**0.49**
16	**252.05**
17	**0.49**
18	**0.49**
19	**0.49**
20	**0.49**
21	**0**
22	**0.49**
23	**0.49**
24	**0**
25	**0**
26	**0.49**
27	**0.49**
Total	**2Kw**

Table C.13: Heating loads for First and second floor bathrooms.

Third Floor	
Bathroom	**Watt**
1	**673.2**
2	**491.9**
3	**743.5**
4	**743.5**
5	**491.95**
6	**673.23**
7	**673.23**
8	**491.95**
9	**743.5**
10	**743.5**
11	**491.95**
12	**673.23**
13	**491.95**
14	**491.95**
15	**491.95**
16	**743.51**
17	**491.95**
18	**491.95**
19	**491.95**
20	**491.95**
21	**0**
22	**491.95**
23	**491.95**
24	**0**
25	**0**
26	**491.95**
27	**491.95**
Total	**13.78 Kw**

Table C.14: Heating loads for Third floor bathrooms

Catalogue

selection of jockey pump

select jockey pump @50gpm and 129psi

BARE SHAFT PUMPS					MOTOR DRIVEN DETAILS	DIESEL DRIVEN DETAILS	JOCKEY PUMP
Flow (GPM)	Model Dsg.	APPROX SPEED (RPM)	Head Bar (PSI) UL Listing	Head Bar (PSI) FM APPROVED	POWER RANGE (HP)	POWER RANGE (HP)	Motor Rating (HP)
50 GPM	SFP 50-20 EM	2900	4.69 (68) 5 6 (87)	4.69 (68) 5 6.07 (88)	15-20	15-20	2-5.5
50 GPM	SFP 50-20 EH	3500	6.97 (101) 7.03 (102) 7.5 8 8.9 (129)	7.03 (102) 7.5 8 8.9 (129)	15-20	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
50 GPM	SFP 50-28 EM	2900	7.93 (115) 9 9.17 (133) 9.66 (140)	7.93 (115) 9 9.17 (133)	15-20	15-20	2-5.5
50 GPM	SFP 50-28 EH	3500	11.24 (163) 11.59 (168) 12 13 13.45 (195) 14.2 (206)	11.59 (168) 12 13 13.45 (195)	20-30	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
100 GPM	SFP 100-28 EH	3500	10.97 (159) 12 13 13.45 (195)		30-40	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
100 GPM	SFP 100-50 EH	3500	7.17 (104) 7.31(106) 8 8.83 (128)	7.31(106) 8 8.83 (128) 8.96 (130)	20-25	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
100 GPM	SFP 100-28 EM	2900	7.52 (109) 8 9 9.24 (134)		20-25	20-30	2-5.5
100 GPM	SFP 100-42 EH	3000	8 (116) 9 9.86 (143)		20-25	20-30	2-5.5
100 GPM	SFP 100-40 EH	3500	11.17 (162) 12 13 13.66 (198)		40-50	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
150 GPM	SFP 150-42 EH	3000	7.38 (107) 8 9 9.31 (135)		25-30	20-30	2-5.5
150 GPM	SFP 150-28 EH	3500	10.76 (156) 11 12 13.17 (191)		50-60	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
150 GPM	SFP 150-20 EH	3500	7.03 (102) 7.17 (104) 7.5 8 8.69 (126)	7.17 (104) 7.5 8 8.69 (126) 8.89 (129)	25-30	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
200 GPM	SFP 200-20 EH	3500	6.62 (96) 6.76 (98) 7 8 8.28 (120)	6.76 (98) 7 8 8.28 (120) 8.55 (124)	25-40	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
200 GPM	SFP 200-86 EM	2900	7.93 (115) 9 9.38 (136)	7.93 (115) 9 9.38 (136)	30-40	30-57	2-5.5
250 GPM	SFP 250-28 EM	2900	7.79 (113) 8 9 9.24 (134)	7.72(112) 7.79 (113) 8 9 9.24 (134)	40-50	30-57	2-5.5
250 GPM	SFP 250-20 EH	3500	7.1 (103) 7.24(105) 8 8.55 (124)	7.24(105) 8 8.55 (124) 8.62 (125)	40-50	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5
300 GPM	SFP 300-28 EM	2900	7.59 (110) 8 8.97 (130) 9.1 (132)	7.45 (108) 7.59 (110) 8 8.97 (130)	40-50	30-57	2-5.5
300 GPM	SFP 300-20 EH	3500	6.97 (101) 7.03 (102) 7.5 8 8.48 (123)	7.03 (102) 7.5 8 8.48 (123)	40-50	NOT POSSIBLE WITH DIESEL ENGINE ARRANGEMENTS	3-7.5

NOTES

- TORNATEC CONTROLLERS
- ELECTRIC MOTOR - GPx Series (Alternatively GPL for 30 HP and below)

IESEL ENGINE - GPD
)CKEY PUMP - JP3

PERFORMANCE DATA TABLES [60 Hz] [Cont.]

APSa PETRA

select chiller 348.7 ton

Model	LWT	AMBIENT TEMPERATURE [°F]																			
		85				95				105				115				125			
		CAP	GPM	PI	WPD	CAP	GPM	PI	WPD	CAP	GPM	PI	WPD	CAP	GPM	PI	WPD	CAP	GPM	PI	WPD
	40	179.1	429.8	171.6	4.2	167.2	401.3	189.9	3.7	155.3	372.7	210.1	3.2	143.4	344.2	232.4	2.8	131.4	315.4	257.1	2.3
	42	185.8	445.9	174.4	4.5	173.4	416.2	192.9	3.9	161.1	386.6	213.4	3.4	148.7	356.9	236.1	2.9	136.3	327.1	261.2	2.5
	44	192.5	462.0	177.1	4.8	179.7	431.3	196.0	4.2	166.8	400.3	216.8	3.7	154.0	369.6	239.8	3.1	141.2	338.9	265.3	2.7
APSa 160-2S	45	195.8	469.9	178.5	4.9	182.8	438.7	197.5	4.3	169.7	407.3	218.5	3.8	156.7	376.1	241.7	3.2	143.7	344.9	267.4	2.8
	46	199.1	477.8	179.9	5.1	185.9	446.2	199.0	4.5	172.6	414.2	220.2	3.9	159.4	382.6	243.6	3.4	146.1	350.6	269.5	2.9
	48	205.8	493.9	182.6	5.4	192.1	461.0	202.1	4.7	178.4	428.2	223.5	4.1	164.7	395.3	247.3	3.6	151.0	362.4	273.6	3.0
	50	212.5	510.0	185.4	5.7	198.3	475.9	205.1	5.0	184.2	442.1	226.9	4.4	170.0	408.0	251.0	3.8	155.9	374.2	277.7	3.2
	40	188.0	451.2	186.6	4.6	175.5	421.2	206.4	4.0	163.0	391.2	228.3	3.5	150.5	361.2	252.6	3.0	138.0	331.2	279.5	2.6
	42	194.8	467.5	189.6	4.9	181.8	436.3	209.7	4.3	168.9	405.4	232.0	3.7	155.9	374.2	256.7	3.2	142.9	343.0	284.0	2.7
	44	201.6	483.8	192.6	5.2	188.2	451.7	213.1	4.6	174.8	419.5	235.7	4.0	161.3	387.1	260.7	3.4	147.9	355.0	288.5	2.9
APSa 165-3S	45	205.0	492.0	194.1	5.4	191.4	459.4	214.7	4.7	177.7	426.5	237.5	4.1	164.1	393.8	262.8	3.5	150.4	361.0	290.7	3.0
	46	208.4	500.2	195.6	5.5	194.5	466.8	216.4	4.9	180.7	433.7	239.4	4.2	166.8	400.3	264.8	3.7	152.9	367.0	293.0	3.1
	48	215.2	516.5	198.6	5.9	200.9	482.2	219.7	5.2	186.5	447.6	243.1	4.5	172.2	413.3	268.9	3.9	157.9	379.0	297.5	3.3
	50	222.0	532.8	201.6	6.2	207.2	497.3	223.0	5.5	192.4	461.8	246.7	4.8	177.7	426.5	273.0	4.1	162.9	391.0	302.0	3.5
	40	212.8	510.7	183.8	5.8	198.7	476.9	203.4	5.1	184.5	442.8	225.0	4.5	170.3	408.7	248.9	3.8	156.2	374.9	275.4	3.3
	42	220.5	529.2	186.6	6.2	205.9	494.2	206.4	5.5	191.2	458.9	228.3	4.8	176.5	423.6	252.6	4.1	161.8	388.3	279.5	3.5
	44	228.2	547.7	189.3	6.6	213.1	511.4	209.4	5.8	197.9	475.0	231.7	5.1	182.7	438.5	256.3	4.4	167.5	402.0	283.6	3.7
APSa 185-2S	45	232.1	557.0	190.7	6.9	216.7	520.1	211.0	6.0	201.2	482.9	233.4	5.2	185.8	445.9	258.2	4.5	170.3	408.7	285.6	3.8
	46	236.0	566.4	192.1	7.1	220.3	528.7	212.5	6.2	204.5	490.8	235.1	5.4	188.8	453.1	260.0	4.6	173.1	415.4	287.7	3.9
	48	243.7	584.9	194.8	7.5	227.5	546.0	215.5	6.6	211.2	506.9	238.4	5.7	195.0	468.0	263.7	4.9	178.8	429.1	291.8	4.2
	50	251.4	603.4	197.5	8.0	234.7	563.3	218.5	7.0	217.9	523.0	241.8	6.1	201.2	482.9	267.5	5.2	184.5	442.8	295.9	4.5
	40	225.1	540.2	214.8	4.2	210.1	504.2	237.6	3.7	195.2	468.5	262.9	3.2	180.2	432.5	290.8	2.8	165.2	396.5	321.8	2.3
	42	233.5	560.4	218.0	4.5	218.0	523.2	241.2	3.9	202.4	485.8	266.8	3.4	186.9	448.6	295.2	2.9	171.3	411.1	326.6	2.5
	44	241.9	580.6	221.2	4.8	225.8	541.9	244.8	4.2	209.7	503.3	270.8	3.7	193.6	464.6	299.5	3.1	177.5	426.0	331.4	2.7
APSa 200-4S	45	246.1	590.6	222.8	4.9	229.7	551.3	246.5	4.3	213.3	511.9	272.7	3.8	196.9	472.6	301.7	3.2	180.6	433.4	333.8	2.8
	46	250.3	600.7	224.5	5.1	233.6	560.6	248.3	4.5	217.0	520.8	274.7	3.9	200.3	480.7	303.9	3.4	183.6	440.6	336.2	2.8
	48	258.7	620.9	227.7	5.4	241.4	579.4	251.9	4.8	224.2	538.1	278.6	4.1	207.0	496.8	308.2	3.6	189.8	455.5	341.0	3.0
	50	267.0	640.8	230.9	5.8	249.3	598.3	255.4	5.1	231.5	555.6	282.6	4.4	213.7	512.9	312.6	3.8	195.9	470.2	345.8	3.2
	40	243.0	583.2	252.3	4.8	226.8	544.3	279.1	4.2	210.7	505.7	308.8	3.7	194.5	466.8	341.6	3.2	178.3	427.9	377.9	2.7
	42	251.7	604.1	256.6	5.1	235.0	564.0	283.9	4.5	218.2	523.7	314.1	3.9	201.5	483.6	347.4	3.4	184.7	443.3	384.4	2.9
	44	260.5	625.2	260.9	5.5	243.1	583.4	288.7	4.8	225.8	541.9	319.3	4.2	208.5	500.4	353.3	3.6	191.1	458.6	390.8	3.1
APSa 220-4S	45	264.8	635.5	263.1	5.7	247.2	593.3	291.0	5.0	229.6	551.0	322.0	4.3	212.0	508.8	356.2	3.7	194.3	466.3	394.0	3.2
	46	269.2	646.1	265.2	5.8	251.3	603.1	293.4	5.1	233.4	560.2	324.6	4.5	215.4	517.0	359.1	3.8	197.5	474.0	397.2	3.3
	48	277.9	667.0	269.5	6.2	259.4	622.6	298.2	5.4	240.9	578.2	329.9	4.7	222.4	533.8	364.9	4.1	203.9	489.4	403.7	3.5
	50	286.7	688.1	273.8	6.6	267.6	642.2	302.9	5.8	248.5	596.4	335.1	5.0	229.4	550.6	370.7	4.3	210.3	504.7	410.1	3.7
	40	271.9	652.6	258.8	5.8	253.8	609.1	286.3	5.1	235.7	565.7	316.7	4.4	217.6	522.2	350.3	3.8	199.5	478.8	387.6	3.2
	42	282.0	676.8	262.9	6.2	263.2	631.7	290.9	5.5	244.5	586.8	321.8	4.8	225.7	541.7	356.0	4.1	206.9	496.6	393.8	3.5
	44	292.1	701.0	267.1	6.6	272.6	654.2	295.5	5.8	253.2	607.7	326.9	5.1	233.7	560.9	361.7	4.4	214.3	514.3	400.1	3.7
APSa 250-3S	45	297.1	713.0	269.2	6.9	277.3	665.5	297.8	6.0	257.5	618.0	329.5	5.2	237.8	570.7	364.5	4.5	218.0	523.2	403.2	3.8
	46	302.1	725.0	271.3	7.1	282.0	676.8	300.1	6.2	261.9	628.6	332.0	5.4	241.8	580.3	367.3	4.7	221.7	532.1	406.4	4.0
	48	312.2	749.3	275.5	7.5	291.4	699.4	304.8	6.6	270.6	649.4	337.2	5.7	249.8	599.5	373.0	4.9	229.1	549.8	412.6	4.2
	50	322.2	773.3	279.7	8.0	300.8	721.9	309.4	7.0	279.3	670.3	342.3	6.1	257.9	619.0	378.7	5.3	236.4	567.4	418.9	4.5
	40	316.9	760.6	275.0	7.7	295.8	709.9	304.2	6.8	274.7	659.3	336.6	5.9	253.6	608.6	372.3	5.1	232.5	558.0	411.9	4.3
	42	328.2	787.7	279.0	8.3	306.4	735.4	308.6	7.3	284.5	682.8	341.5	6.3	262.7	630.5	377.7	5.4	240.8	577.9	417.9	4.6
	44	339.6	815.0	283.0	8.8	317.0	760.8	313.1	7.7	294.4	706.6	346.3	6.7	271.8	652.3	383.2	5.8	249.1	597.8	423.9	4.9
APSa 270-3S	45	345.2	828.5	285.0	9.1	322.3	773.5	315.3	8.0	299.3	718.3	348.8	6.9	276.3	663.1	385.9	6.0	253.3	607.9	426.9	5.1
	46	350.9	842.2	287.0	9.4	327.5	786.0	317.5	8.2	304.2	730.1	351.2	7.2	280.8	673.9	388.6	6.2	257.5	618.0	429.9	5.2
	48	362.3	869.5	291.0	9.9	338.1	811.4	321.9	8.7	314.0	753.6	356.1	7.6	289.9	695.8	394.0	6.5	265.8	637.9	435.9	5.6
	50	373.6	896.6	295.0	10.5	348.7	836.9	326.4	9.3	323.9	777.4	361.0	8.1	299.0	717.6	399.4	6.9	274.1	657.8	441.9	5.9

Legend:

- LWT: Leaving Chiller Water Temperature [°F]
- CAP : Capacity [T.R]
- PI: Power Input (Compressor only) [T.R.]
- GPM : Water flow rate
- WPD: Water Pressure Drop [Psi]

Note:

- All cooling capacities are based on 10°F water temperature difference between inlet and outlet water temperature.

Selection Electrical Pump×2: Model: 64_FSPA, Q= 500 Gpm, Head: 126 psi.

•SELECTION DATA

End Suction Pump

Flow Rate	Head PSI (kPa)	Pump Model	Max. Power at 2900 rpm HP	Electric motor RPM	Electric motor HP
250 USGPM ($57\ m^3/h$)	87 (600)	43 FSPA	25	2900	25
	105 (724)		32		40
	122 (841)		38		40
	139 (958)		44		50
300 USGPM ($68\ m^3/h$)	85 (586)	43 FSPA	27	2900	30
	102 (703)		34		40
	121 (834)		42		50
	138 (951)		48		50
350 USGPM ($80\ m^3/h$)	82 (565)	43 FSPA	29	2900	30
	100 (689)		37		40
	119 (820)		45		50
	136 (937)		52		60
400 USGPM ($91\ m^3/h$)	78 (538)	43 FSPA	31	2900	40
	97 (669)		38		40
	117 (806)		47		50
	133 (917)		55		60
450 USGPM ($102\ m^3/h$)	73 (503)	43 FSPA	30	2900	40
	93 (641)		40		40
	113 (779)		49		50
	129 (889)		57		60
500 USGPM ($113\ m^3/h$)	74 (510)	54 FSPA	49	2900	50
	86 (593)		60		60
	101 (696)		74		75
	116 (800)		85		100
	126 (869)	64 FSPA	71	2900	75
	144 (993)		82		100
	162 (1117)		93		100
	183 (1262)		115		125
	205 (1413)		131		150
750 USGP ($170\ m^3/h$)	68 (469)	54 FSPA	53	2900	60
	82 (565)		63		75
	97 (669)		85		100
	112 (772)		98		100
	113 (779)	64 FSPA	70	2900	75
	132 (910)		98		100
	152 (1048)		115		125

Selection fan coil

Performance Data Tables

CB / CBP Units

Cooling 4 -Rows

Ceiling Basic / Ceiling Basic with Plenum [CB/CBP]				Entering Wet Bulb Temperature (F)											
				63				65				67			
MODEL	Fan Speed	Air Flow Rate	DBT	Total Cap.	Sens. Cap.	GPM	WPD	Total Cap.	Sens. Cap.	GPM	WPD	Total Cap.	Sens. Cap.	GPM	WPD
CB/CBP 6	H	603	76	19371	14703	3.87	5.35	22623	14572	4.53	7.15	26338	14560	5.27	9.49
			78	19525	15899	3.91	5.43	22923	15835	4.59	7.32	26611	15803	5.32	9.67
			80	19795	17148	3.96	5.57	23082	17030	4.62	7.42	26646	16946	5.33	9.69
			85	20160	20125	4.03	5.77	23710	20118	4.74	7.80	27052	19943	5.41	9.97
	M	539	76	17787	13469	3.56	4.57	20761	13360	4.15	6.09	23988	13283	4.80	7.97
			78	17984	14581	3.60	4.67	21082	14522	4.22	6.27	24241	14423	4.85	8.13
			80	18147	15683	3.63	4.74	21167	15589	4.23	6.31	24432	15533	4.89	8.25
			85	18315	18315	3.66	4.83	21502	18304	4.30	6.50	24778	18247	4.96	8.47
	L	441	76	15130	11430	3.03	3.39	17715	11379	3.54	4.54	20404	11311	4.08	5.90
			78	15232	12342	3.05	3.43	17906	12331	3.58	4.63	20624	12276	4.13	6.02
			80	15426	13294	3.09	3.51	18089	13274	3.62	4.72	20694	13171	4.14	6.05
			85	15665	15561	3.13	3.61	18334	15548	3.67	4.83	21091	15510	4.22	6.27
CB/CBP 8	H	700	76	22980	17287	4.60	7.89	26952	17214	5.39	10.61	31342	17224	6.27	14.04
			78	23373	18763	4.68	8.14	27200	18627	5.44	10.79	31421	18571	6.28	14.10
			80	23444	20107	4.69	8.19	27510	20073	5.50	11.02	31659	19987	6.33	14.30
			85	24079	23656	4.82	8.60	27878	23511	5.58	11.29	32223	23498	6.45	14.78
	M	601	76	20373	15304	4.08	6.31	23979	15293	4.80	8.54	27614	15215	5.52	11.09
			78	20633	16565	4.13	6.46	24227	16554	4.85	8.70	27884	16484	5.58	11.30
			80	20763	17778	4.15	6.54	24278	17732	4.86	8.74	27961	17674	5.59	11.36
			85	21354	20918	4.27	6.89	24639	20772	4.93	8.98	28483	20782	5.70	11.75
	L	509	76	17981	13422	3.60	5.01	20983	13369	4.20	6.67	24190	13337	4.84	8.68
			78	18048	14452	3.61	5.04	21198	14467	4.24	6.79	24227	14354	4.85	8.70
			80	18244	15542	3.65	5.15	21270	15499	4.25	6.84	24478	15463	4.90	8.87
			85	18629	18215	3.73	5.35	21684	18180	4.34	7.09	24767	18091	4.95	9.07
CB/CBP 10	H	1037	76	34381	25791	6.88	7.59	40353	25713	8.07	10.22	46516	25585	9.30	13.32
			78	34931	27984	6.99	7.81	40657	27793	8.13	10.36	46980	27736	9.40	13.56
			80	35273	30078	7.06	7.96	40854	29832	8.17	10.46	47344	29836	9.47	13.76
			85	35936	35237	7.19	8.24	41696	35062	8.34	10.86	47855	34920	9.57	14.04
	M	916	76	31056	23317	6.21	6.28	36444	23258	7.29	8.45	41975	23137	8.40	11.00
			78	31468	25245	6.29	6.44	36820	25174	7.36	8.62	42394	25069	8.48	11.20
			80	31659	27090	6.33	6.51	37131	27072	7.43	8.75	42800	27010	8.56	11.40
			85	32578	31880	6.52	6.86	37910	31799	7.58	9.10	43607	31750	8.72	11.81
	L	741	76	26333	19658	5.27	4.62	30935	19677	6.19	6.23	35486	19567	7.10	8.04
			78	26611	21248	5.32	4.72	30982	21162	6.20	6.25	35865	21190	7.17	8.21
			80	26878	22833	5.38	4.80	31163	22701	6.23	6.32	35926	22683	7.19	8.23
			85	27300	26674	5.46	4.94	31693	26598	6.34	6.52	36327	26522	7.27	8.40
CB/CBP 12	H	1177	76	38058	28576	7.61	9.16	44494	28399	8.90	12.26	51453	28279	10.29	16.07
			78	38369	30885	7.67	9.30	44732	30673	8.95	12.38	51957	30656	10.39	16.37
			80	38845	33256	7.77	9.52	45262	33061	9.05	12.65	52443	33026	10.49	16.66
			85	39612	39011	7.92	9.87	46111	38839	9.22	13.10	53057	38722	10.61	17.02
	M	1010	76	33521	25189	6.70	7.24	39435	25144	7.89	9.79	45491	25040	9.10	12.77
			78	33973	27297	6.80	7.42	39838	27232	7.97	9.98	45931	27132	9.19	13.01
			80	34499	29426	6.90	7.63	40140	29269	8.03	10.12	46359	29216	9.27	13.23
			85	35243	34520	7.05	7.94	40846	34340	8.17	10.45	47173	34338	9.44	13.67
	L	880	76	30220	22627	6.04	5.97	35360	22547	7.07	7.99	40724	22440	8.15	10.39
			78	30410	24412	6.08	6.04	35722	24409	7.14	8.14	41107	24312	8.22	10.58
			80	30778	26273	6.16	6.18	36070	26253	7.21	8.29	41238	26066	8.25	10.64
			85	31241	30717	6.25	6.35	36521	30699	7.30	8.49	41991	30640	8.40	11.00

Legend: Air Flow Rate In Cubic Feet Per Minute [CFM]

- Fan Speed : [L: Low, M: Medium, H: High]
- DBT : Entering Dry Bulb Temperature in Degree Fahrenheit [°F]
- Total Cap. : Total Cooling Capacity in [BTUH]
- Sens. Cap. : Sensible Cooling Capacity in [BTUH]
- GPM : Water Flow Rate in U.S Gallon Per Minute [GPM]
- WPD : Water Pressure Drop in [ft of water]

Notes:

- All data are based on:
  Entering water temperature 45 F°
  0.1" External Static Pressure [E.S.P]
- Interpolation is permissible but not extrapolation

selection Boiler

WALL-HUNG ELECTRIC STORAGE WATER HEATER 50 / 80 / 100

VELIS PLUS

ECO FUNCTION · SAFETY PACKAGE · LCD DISPLAY PROGRAMMER · SHOWER READY · TITANIUM · NANOMIX + BEST · FLAT · POLYURETHANE INSULATION · MULTIPOSITION VERTICAL AND HORIZONTAL

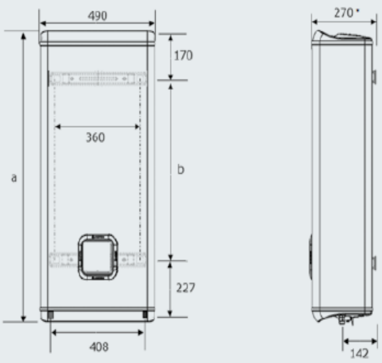
COMFORT
- Shower ready logic
- Digital temperature regulation
- High precision NTC temperature sensors

EFFICIENCY&ENERGY SAVING
- Eco function
- Daily programming
- Ecological polyurethane insulation

QUALITY
- Titanium glasslined inner tank tested at 16 bar
- Two magnesium anodes
- Two 5-bolts flanges
- Pressure safety valve tested at 8 bar
- ABS safety package

DESIGN
- New exclusive metal brushed panel
- Soft touch display
- Multiposition installation
- Only 27 cm deep
- Exclusive Italian design
- Wall-hung

innovation and style

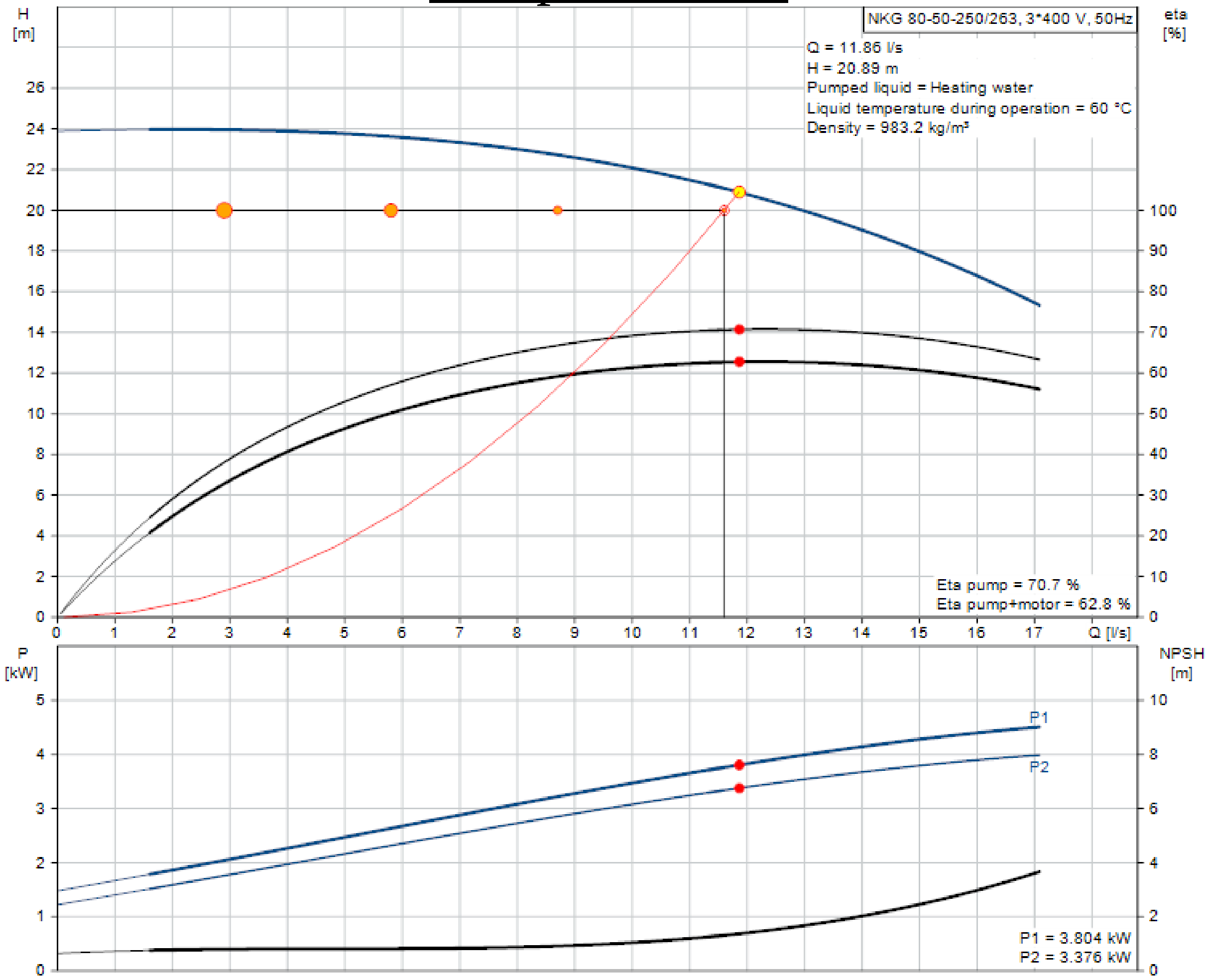


* 300 mm with interface included

TECHNICAL DATA		VLS PLUS 50	VLS PLUS 80	VLS PLUS 100
Capacity	l	50	80	100
Installation		Multiposition (V/H)	Multiposition (V/H)	Multiposition (V/H)
Power	kW	1,5	1,5	1,5
Voltage	V	230	230	230
Heating time (ΔT=45°C)	h,min	2,02	2,56	3,42
Max working pressure	bar	8	8	8
Max working temperature	°C	80	80	80
Weight	kg	20	26	30
Class	IP	IPX4	IPX4	IPX4
OVERALL DIMENSIONS				
a	mm	800	1090	1275
b	mm	405	695	880

CODE			
With Plug and Cable (PL)	3623262	3623263	3623264

Pump selection



Product name	NKG 80-50-250/263 A2-F-A-E-BAQE
Product No	97831767
EAN number	5710625420897

Technical

Speed for pump data	1460 rpm
Actual calculated flow	11.86 l/s
Resulting head of the pump	20.89 m
Actual impeller diameter	263 mm
Impeller nom	250 mm
Primary shaft seal	BAQE
Secondary shaft seal	NONE