Palestine Polytechnic University

College of Engineering & Technology
Mechanical Engineering Department

Design Of Mechanical Systems For A Social Building In Hebron

Prepared by:
Mutaz Dweik

Supervisor:
Dr. Kazem Osaily

Submitted to the College Of Engineering
In Partial Fulfillment of the requirements for the
Bachelor degree in Refrigeration & Air Conditioning Engineering

Hebron – Palestine

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Palestine Polytechnic University

Collage of Engineering

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Design Of Mechanical Systems

For A Social Building In Hebron

Project Team:

Mu'taz Mohammad Na'im Dweik

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Supervisor Signature

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Testing Committee Signature

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Chair of the Department Signature

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April 2018

شكر وتقدير

إلى دائرة الهندسة الميكانيكية

وجامعة بوليتكنك فلسطين

أشكركم على تفانيكم ودعمكم وللعلم الذي تلقيناه منكم

من دكاترة ومهندسين ومشرفي مختبرات

وأخص بالشكر الجزيل

الدكتور كاظم العسيلي ، الدكتور إسحق سدر،

المهندس محمد عوض والدكتور إياد الهشلمون

إهداء

الى من كانوا قدوةً لي وأمدوني بالدعم لأكمل مسيرة
علمي وأرفع من شأني

إلى والدي العزيز

أنت معلمي ومداد حروف تعلمتها في صغري الى أن كبرت
فأنت نبراسي وقدوتي

إلى زوجتي العزيزة وعائلتي

يا من صبرتم وجاهدتم لتوفير جو دراسي لأنجح
وأكمل تعليمي بعد هذه السنين

إلى أخوتي وأخواتي

شكراً للدعم الذي قدمتموه لي فأنتم سندي

ABSTRACT

The aim of the project is to design o f Mechanical Systems for Headquarters Charities building which is located in Hebron city-Abu Ktaila . This building consists of Five Floors with Total area of 2000 m^2, While these services are certainly designed to verify human comfort.

In this project, chosen the Air Conditioning System type Variable Refrigerant Flow (VRF) with known advantages efficient and economical . Also, using the technique of Grey Water conventional treatment to be used in irrigation and flushing valve in order to save water.

Using modern Software Autodesk Revit to built the Mechanical Services like HVAC-VRF, Plumbing and Fire fighting , Estimation the heating and cooling loads of the Space Zones .

الملخص

الهدف من المشروع هو تصميم نظام ميكانيكي لبناء مجمع الجمعيات الخيرية في مدينة الخليل-أبو اكتيلا. يتكون هذا المبنى من خمسة طوابق بمساحة إجمالية ٢٠٠٠ م²، في حين تم تصميم هذه الخدمات لتحقيق الراحة البشرية.

في هذا المشروع، اختيار نظام تكييف الهواء نوع (VRF) مع مزايا معروفة كفاءةً واقتصاديةً ، أيضا إستخدام تقنية معالجه تقليدية للمياه الرمادية لاستخدامها في الري و تغذية صمام التواليت من أجل توفير المياه.

استخدام برنامج أوتوديسك ريفيت لإنشاء الخدمات الميكانيكية مثل HVAC -VRF، السمكرة، مكافحة الحرائق ، التقدير للأحمال الحرارية والتبريد للحيز .

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Chapter One

Introduction

1.1 Introduction

Air conditioning is to maintain the environment in enclosed spaces at conditions that induce the feeling of comfort to all occupants of the spaces ,This feeling of comfort is influenced by a number of air related parameters which are inside air temperature , humidity air motion and its speed and the air purity .

Modern plumbing design for buildings , is to safely and reliably provide domestic water , cooking gas and water for fire fighting and to remove sanitary wastes, So in this project, the outlet water that goes from all fixture units except water closets are treated and reused to feed the toilet flushing valve which its consumption relative is 35% of the total daily consumption.

Fire safety is very important in all places. Without fire alarms, a lot of things may be lost like people and expensive things. In this case, firefighting system should be installed to save the material inside building .

1.2 Project objectives

1) To design the mechanical services for the social building.
2) To use the gray water and reuse it.
3) Design variable refrigeration flow (VRF) air conditioning system for the building.
4) Design fire fighting system.

1.3 Project importance

1) In order to achieve all means for human comfort .
2) Water conservation and optimum exploitation for Grey water which treated.
3) To protect people and expensive things from fire.

1.4 Building description

Headquarters of charities building site is in Abu Ktaila . It consists of five floors, the area of each floor is 400 m^2 .

1.5 Project outline

The project contains four chapters; these chapters are arranged as follows:

Chapter one: - Introduction

This chapter include overview about the project, project objectives, building description and time planning.

Chapter Two: - Heating Ventilating And Air Conditioning " HVAC System".

This chapter talks about the air conditioning system which is Variable Refrigerant Flow (VRF) .

Chapter Three: - Plumbing System.

This chapter include the water distribution calculation, drainage system and include procedures of grey water treatment and use it for flushing tank and irrigation.

Chapter Four: - Firefighting system.

This chapter present the suitable choice depends on the function of the building by the fire extinguishing system .

1.6 Key words

1. HVAC : Heating Ventilation and Air Conditioning .
2. VRF : Variable Refrigeration Flow .
3. WSFU: Water Supply Fixture Unit used to calculate the portable maximum water demand for the building .
4. DFU: Drainage Fixture Unit used to calculate the provision of drainage system .

1.7 Time table:

Table (1.1): Time table for the first semester.

Objective	Week #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Estimate goals of project																
Planning, setting project concepts and goals																
Establishing scientific background and visit Engineers																
Studying mechanical services books																
Analyzing data																
HVAC calculations																
Writing report																
Presentation																

Table (1.2): Time table for next semester.

Objective	Week #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Set and review goals of Project																
Design plumbing system																
Design Gray water and Irrigation System																
Design Firefighting system																
Design HVAC system																
Writing documentation																
Printing documentation out																

Chapter Two

Heating Ventilating And Air Conditioning

HVAC Systems

2.1 Overview

Heating and cooling loads are the measure of energy needed to be added or removed from a space by the Heating Ventilating and Air Conditioning (HVAC) system to provide the desired level of comfort within a space.

The heating and cooling loads calculation is the first step for HVAC design procedure, selecting HVAC equipment and designing the air distribution system to meet the accurate predicted heating and cooling loads begins with an accurate understanding of the heating and cooling loads on a space .

2.2 Thermal Comfort Criteria for Inside Design Condition

The inside design conditions refer to temperature, humidity, air speed and quality of inside air that will induce comfort to occupants of the space at minimum energy consumption . There are several factors that control the selection of the inside design conditions and expenditure of energy to maintain those conditions:

1- The outside design conditions.
2- The period occupancy of the conditioned space.
3- The level of activity of occupants in the conditioned space.

ASHRAE is an abbreviation for the American Society of Heating Refrigerating and Air Conditioning Engineers. Its Standard Thermal Environmental Conditions for Human Occupancy describes the combinations of indoor space conditions and personal factors necessary to provide comfort in the effective way. There are no static rules that indicate the best atmospheric condition for making all the individual comfortable because human comfort is affected by several factors such as health, age, clothing, etc. Figure 2.1 shows ASHRAE human comfort chart.

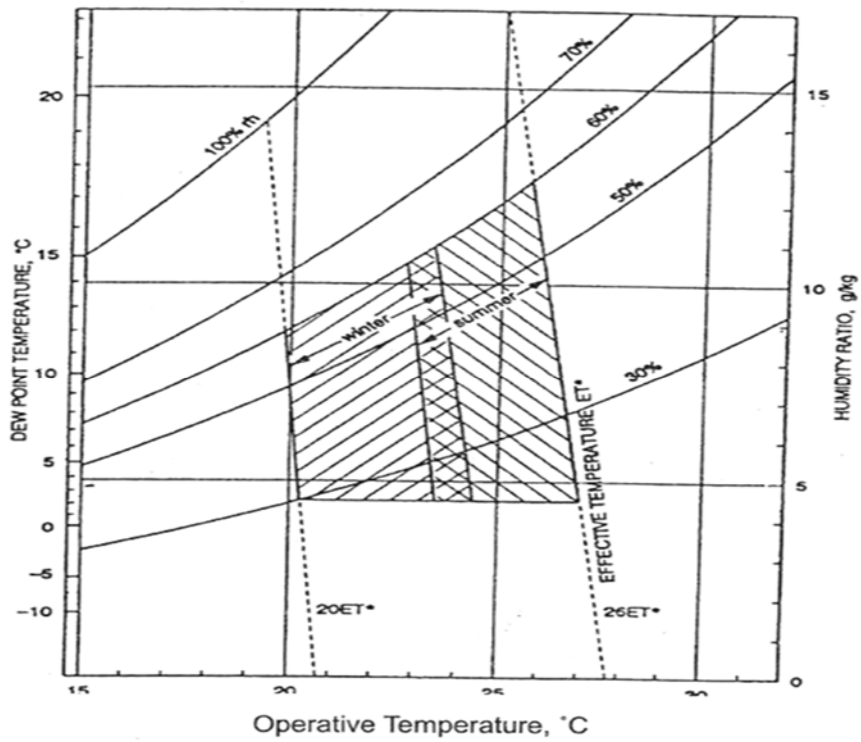

Figure (2.1): Human comfort chart

The ASHRAE comfort chart indicates the acceptable zones of selecting the inside operative temperature and the inside relative humidity for winter heating , summer cooling and year-round air conditioning applications .The operative temperature (T_{oper},) is the uniform temperature of an imaginary black (ideal radiation) enclosure in which an occupant would exchange the same amount of heat by convection and radiation as that in the actual non-uniform temperature environment . Thus , the operative temperature can be considered as the temperature of uniform environment that will transfer heat at the same value as the actual environment . it is defined as the numerical average value of the inside air temperature(T_i,) and the mean radiant temperature (T_{MRT}), weighted by their respective heat transfer coefficients as follows :

$$T_{oper} = \frac{h_c\ T_i + h_r\ T_{MRT}}{h_c + h_r} \quad \text{.........(2.1)}$$

Where h_C and h_r are the convection and radiation heat transfer coefficients, respectively .

The operative temperature depends on the mean radiant temperature , which is given by the equation (2.2) :

$T^4{}_{MRT} = T^4{}_g + C\bar{V}0.5(T_g - T_a)$……………………………..………………(2.2)

Where :

$T_{MRT} = mean\ radiant\ temperature, R\ or\ K$

$T_g = globe\ temperature\ , R\ or\ K$

$T_a = ambient\ air\ temperature\ , R\ or\ K$

$\bar{V} = air\ velocity\ , fpm\ or\ m/s$

$C = 0.103 \times 10^9 (English\ units)$

$= 0.247 \times 10^9 (SI\ units)$

The operative temperature (T_{oper}) , *at air speed of* 0.4 $m/$s or less and mean radiant temperature value less than 50 °C is approximately equal to the average value of inside air temperature (T_i) ,and mean radiant temperature (T_{MRT}) .

New Effective Temperature :

Effective temperature is not an actual temperature in the sense that it can be measured by a thermometer. It is an experimentally determined index of the various combinations of dry-bulb temperature, humidity, radiant conditions, and air movement that induce the same thermal sensation.

Those combinations that induce the same feeling of warmth or cold are called thermo-equivalent conditions.

Table (2.1): The values of inside film thermal resistances of the air films (Ri)

Element/ construction materials	Ri [m^2.°C/W] (summer and winter)
Walls	0.12
Ceilings	0.1
Floors	0.15

From Palestinian code the air velocity in Hebron is 1.4 m/s .

Table (2.2): the values of the outside film thermal resistances of the air films(Ro)

Element/ construction materials	Ro [$m^2.°C/W$](winter and summer)
Walls	0.06
Ceilings	0.04
Floors	0

Table (2.3): inside and outside conditions in Hebron City

Property	For Heating (Winter)	For Cooling (Summer)
T_o (°C)	4	30
T_i (°C)	24.5	24.5
ΔT_{adj} °C [between conditioned and unconditioned space]	10.25	28.2
Φ_o %	72	57
Φ_i %	35	40
Air Velocity m/s	1.4	1.4
h_i [kJ/kg]	42	45
h_o [kJ/kg]	13	68.5
v_i [m^3/kg]	0.855	0.855
v_o [m^3/kg]	0.7875	0.88

Where:

$\mathbf{h_i}$ Inside Enthalpy

$\mathbf{v_i}$: Inside Specific volume

$\mathbf{T_i}$: Inside temperature

$\mathbf{\Phi_i}$:Inside Relative Humidity

$\mathbf{h_o}$: Outside Enthalpy

$\mathbf{v_o}$: outside Specific volume

$\mathbf{T_o}$: Outside Temperature

$\mathbf{\Phi_o}$: outside Relative Humidity

2.2.1 Inside Design temperature for Unheated spaces :

In many buildings, certain areas such as hallways and attics are unheated ,these spaces receive their heat through partitions , ceilings and floors . the value of the inside temperature of such unheated spaces (T_{un}) is between the outside temperature (T_o) and the inside design temperature (T_i) .The inside air temperature of unheated or uncooled space that is adjacent to a heated or cooled room should be determined in order to calculate the heat looses through the walls ,ceiling or floor separating the two rooms .The followings guidelines and rules are followed to determine the design temperature of such unheated or uncooled spaces:

a) Summer cooling with unconditioned space adjacent :

The temperature of the unconditioned space (T_{un}) ,for this case is obtained according to the following relation :

$$T_{un} = T_i + \frac{2}{3}(T_{o-} T_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

$$T_{un}(cooling/summer) = 24.5 + \frac{2}{3}(30 - 24.5) = 28.2°C$$

Where (T_i) is the inside design temperature of the conditioned space , and (T_o) is the outside air temperature. Thus , the temperature difference (ΔT) , across the wall separating the conditioned and the unconditioned spaces is given by :

$$\Delta T = \frac{2}{3}(T_o - T_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.4)$$

b) Adjacent space having unusual heat sources:

Such as kitchens ,boiler rooms ,etc. For this case , $5°C$ or $10°C$ are added to the outside design temperature when the heat gain of the wall is computed .

$$T_{un} = T_O + 5°C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

$$= 30 + 5 = 35°C$$

c) Heating season with adjacent room unheated :

For this case , the temperature difference across the separating wall is taken as one-half the temperature difference between the inside space and the outside air when the heat loss through the wall of the adjacent room is calculated :

$$\Delta T_{adj} = 0.5(T_i - T_o) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.6)$$

$$\Delta T_{adj}(heating/winter) = 0.5(24.5 - 4) = 10.25°C$$

d) Ground floors directly on the ground :

The ground temperature needed for the calculation of the heat loss through such floors is taken 5 to $10°C$ above the outside air temperature ,Alternatively ,some arbitrary temperature difference between the inside space and the ground may be assumed .

2.3 Overall heat Transfer Coefficient :

The overall heat transfer coefficient is a measure of the overall ability of a series of conductive and convective barriers to transfer heat .

To calculate the heat gain from walls, ceiling, ground and doors, one need to calculate the value of overall heat transfer coefficient (U) for each one of them.

The values of (U)is depends on the kind of material that content in walls ,ceiling .

$$U_{ov.} = \frac{1}{R_{th.}} = \frac{1}{\left[R_i + \sum_{j=1}^{n}\sum R_{(cond.)} + R_o\right]} = \frac{1}{\left[\left(\frac{1}{h_{out}}\right) + \left(\frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3}\right) + \left(\frac{1}{h_{in}}\right)\right]} \quad \ldots(2.7)$$

The Unit of Overall Heat Transfer **(U)** is $W/m^2.°K$

Table (2.4): Overall heat Transfer Coefficient

Type of construction		Thickness [m]	U (W/ m².°C)
Ext. Wall		0.35	0.86
Inn. Wall		0.14	2.64
Un-con. wall		0.30	2.36
Ceiling between floor		0.40	0.833
Ceiling last floor	With brick	0.51	0.89
	Without brick	0.51	0.97
Floor		0.37	2.14
Window		-----	3.50
Door Out steel		-----	5.80
Door Inn. 50 mm wood		0.045	2.70

2.3.1 Sample Calculation for Heating loads for Director Room 1:

1-Heating loads calculation :

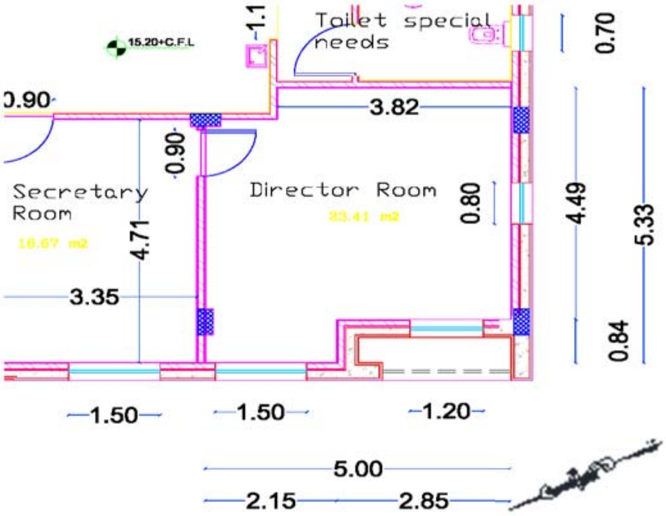

Figure (2.2) :The Director room 1 dimensions

Calculate the heat loss from the Director room 1 at the last floor as a sample :

The height of the room = 3 m

The height of the window = 1.5 m

The height of the door= 2 m

Heat loss through ceiling ($\dot{Q}_c$) :

Because of its construction, the ceiling is divided into two areas which are area A_1 and area A_2.

The area A_1 is equal to:

$$A_1 = \frac{4}{5} A_c \quad \text{...(2.8)}$$

$$= \frac{4}{5}(23.41) = 18.73 \text{ m}^2$$

And the area A_2 is equal to:

$$A_2 = \frac{1}{5} A_c \quad \text{...(2.9)}$$

$$= \frac{1}{5}(22.5) = 4.68 \text{ m}^2$$

$$\dot{Q}_c = U_C \times A_C \times (T_{i-}T_o) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2.10)$$

$=(U_1A_1 + U_2A_2)\times(T_i - T_o)$

$\dot{Q}_c = (0.89 \times 18.73 + 0.97 \times 4.68)(24.5 - 4)$

$\dot{Q}_c = 428.22$ W.

Heat loss through walls ($\dot{Q}_w$) :

The external wall area is :

$A_{w,ex} = [(5.33\times3.0)+(5.0\times3.0)]-[1.5(0.8+1.2+1.5)] = 25.74\ m^2$

$\dot{Q}_{w,ex} = (U_{w,ex}\times A_{w,ex})\times(T_i - T_o)$

$= (0.86\times 25.74)(24.5-4) = 453.79$ W

There are one space beside the director room1 is unconditioned, so heat loss from unconditioned walls :

The unconditioned temperature is calculate by equation (2.6) :

$T_{un.} = 0.5 (T_i - T_o)$

$= 0.5 (24.5 - 4) = 10.25$ °C

The unconditioned area is :

$A_{w,un.} = (3.82\times 3.0) = 11.46 m^2$

$\dot{Q}_{w,un.} = ((U_{un.} = U_{in)} \times A_{w,un.})(T_i - T_{un.}) = (2.64\times11.46)(24.5-10.25)$

$= 431.12$ W

Now, the total heat loss from walls is :

$\dot{Q}_{w,tot} = \dot{Q}_{w,ex} + \dot{Q}_{w,un.} = 453.97 + 431.12 = 885$ W

Heat loss through windows ($\dot{Q}_g$):

there are three windows at the two external wall

$A_{wind.} = 1.5(1.5+1.2+0.8) = 5.25 m^2$

$\dot{Q}_g = U_g A_g (T_i - T_o)$

$= (3.5)(5.25)(24.5-4) = 376.69$ W

Heat loss through internal door ($\dot{Q}_d$) :

$\dot{Q}_d = U_d A_d (T_i - T_{i.}) = (2.7)(2\times.9)(24.5-24.5)$

= 0.0 W with the same temperature

Heat loss through floor($\dot{Q}_f$) :

$\dot{Q}_f = U_f \times A_f (T_{adj} - T_{i.})$

$= (2.14) \times (23.41) \times (29 - 24.5) = 225.44$ W

Heat loss through infiltration ($\dot{Q}_{inf}$) :

The total heat load due to infiltration is given by the equation

$\dot{Q}_{inf.,g} = \frac{\dot{V}f}{vo} (h_i - h_o)$ ……………………………………………………(2.10)

$= \rho_o \dot{V}f\ (h_i - h_o)$, while $\rho_o = 1/vo$

Where:

hi: Inside enthalpy of infiltrated air in(kJ/kg)

ho: Outside enthalpy of infiltrated air in (kJ/kg)

$\dot{V}f$: The volumetric flow rate of infiltrated air in (m^3/s)

vo : Specific volume in(m^3/kg)

$\dot{V}f = K \times L\ [0.613\ (S_1 \times S_2 \times V_O)^2\ ]^{2/3}$

Where :

K = the infiltration air coefficient.

L: the crack length in meter.

S_1: factor that depends on the topography of the location of the building

S_2: coefficient that depends on the height of the building.

V_O: measured wind speed (m/s)

The value of K, S_1 and S_2 is obtained from Appendix A of Tables (2.6), (2.7) and (2.8) respectively. K =0.43 , S_1 =1 , S_2 =0.79 , V_O= 1.4 (m/s) from Palestinian code .

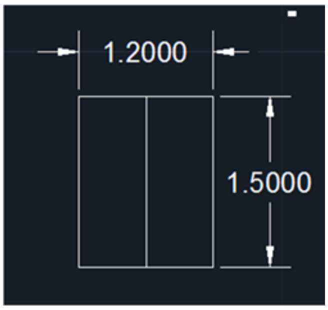

Figure (2.3): One sample of Sliding window

The window is sliding as shown in Figure (2.3) ,then L for three windows with different dimension:

L = [(2×1. 5) + (3×1.5)]+ [(2×1. 2) + (3×1.5)]+ [(2×0.8) + (3×1.5)] = 20.5 m

Therefore ;

$\dot{V}f$ = (0.43) (20.5) $\left[0.613(1.0 \times 0.79 \times 1.4)^2\right]^{2/3}$

= 7.2756 m^3/h = 2.021× 10^{-3} m^3/s

From the psychometric figure (2.1) human comfort chart can obtain the following moist air properties that correspond to the given inside and outside design conditions :

v_o = 0.79 m^3/kg , h_i = 42 kJ/kg , h_o = 13kJ/kg

ρ_o = 1/ v_o = 1.27 kg / m^3

The total heat loss due to infiltration is calculated by equation (2.10) as follows:

Through window :

$\dot{Q}_{inf.,g} = \rho_o \dot{V}f\ (h_i - h_o)$

= (1.27)(2.021× 10^{-3})(42 – 13) = 0.0744kW= 74.43 W

$\dot{Q}_{inf.,tot} = \dot{Q}_{inf.,g}$ = 74.43 W

The total heat loss from the director room 1 is

$\dot{Q}_{tot} = \dot{Q}_{w,tot} + \dot{Q}_c + \dot{Q}_g + \dot{Q}_d + \dot{Q}_{inf.}$

$= 885 + 428.22 + 225.44 + 376.69 + 74.43$

$= 1989.78$ W

Take the safety factor of 10 % for each space of the residence to cover the miscellaneous and emergency heating loads then :

$\dot{Q}_{tot} = 1989.78 \times 1.1 = 2188.76$ [W]=2.19 [kW]

Sample Room(1):

Inside Design Condition : **$T_i = 24.5C$, $\varphi_i = 35\%$**

Outside Design Condition : **$T_o = 4$ C , $\varphi_o = 72\%$**

Table (2.5) Summary of heating loads calculations:

	Area (m^2)	U ($W/m^2.°C$)	($T_i - T_o$) °C	Q_{Loss} (W)
Walls				
$Wall_{in}$, un con.	11.46	2.64	(24.5-10.25) =14.25	432.12
$Wall_{out}$	25.74	0.86	(24.5-4) = 20.5	453.79
Ceiling	Aceiling=23.41 (m^2)	U1=0.89	(24.5-4) = 20.5	428.22
	A1=18.7m^2	U2=0.97		
	A2=4.68m^2			
Floor	23.41	2.14	(29-24.5) = 4.5	225.44
Windows	5.25	3.5	(24-4) = 20	376.69
Doors				
$Door_{in}$	1.8	2.7	(24.5-24.5) =0	—
Infiltration				
Infiltration Windows	—	—	—	74.43
Infiltration Doors	—	—	—	—
			Q_{Loss} (W)	1989.78
	Q[W]loss * Safety Factor (10%)	2188.76	Q $loss$ [kW]	2.19

2.3.2 Sample Calculation for Cooling loads for Director Room 1:

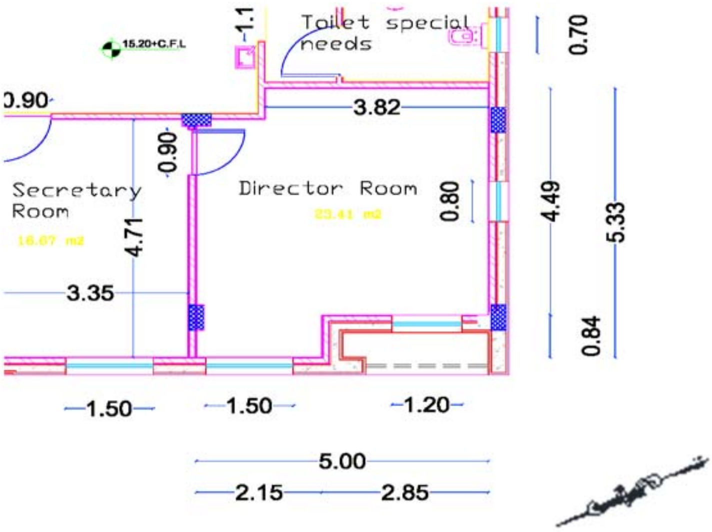

Figure (2.4) :The Director room 1 dimensions

CLTD Values :

$(CLTD)_{corr.}$= (CLTD + LM) k + (25.5 - Tin) + (To,m - 29.4) f…………..(2.11)

Where:
CLTD: cooling load temperature difference, ˚C
LM: latitude correction factor.
k: color adjustment factor.
Tin: inside comfort design temperature, ˚C
f: attic or roof fan factor.
To,m: outdoor mean temperature,°C

F=1 there is no attic or roof fan

K=1 for dark color walls

The values of LM (latitude correction factor) is obtained from (Appendix A) Table (2.10) .

For Hebron city: Latitude: 31°31′45″ N

Solar time = 12 hours in summer (from Palestinian code)

Then the $CLTD_{sunlit\ roof}$=13 °

DR = $T_{ave,max}$-$T_{ave,min}$ = (29.1-17.7)=11.4 °C

$T_{o,m}$= $T_o - \frac{DR}{2}$ = T_o-5.7 = 30 - 5.7 = 24.3 °C

Where

$T_{o,m}$ is the outdoor mean temperature.

DR : the daily range temperature which equals to the difference between the average maximum and average minimum daily temperatures for the warmest month of the summer season .

$T_{ave.max.}$ = 29.1 °C , $T_{ave.\ min.}$ = 17.7 °C from Palestinian code in July

Where: $T_{ave,max}$ and $T_{ave,min}$ is the average maximum and average minimum daily temperatures for the warmest month of the summer season .

Table (2.6):Value of CLTD corr. for the sunlit roof by solar effect :

Type	LM	CLTD (°C)	$CLTD_{corr}$ (°C)
Horizontal Roofs	0.5	13	9.4
North wall	0.5	5	1.4
South wall	-1.6	6	0.3
East wall	0	10	5.9
West wall	0	8	3.9
NE	0.5	8	4.4
NW	0.5	7	3.4
SE	-0.5	9	4.4
SW	-0.5	8	4.5
NNE, NNW	0.5	_	_
ENE , WNW	0	_	_
ESE , WSW	-0.5	_	_
SSE , SSW	-1.6	_	_

For 12 hr solar time of the external walls we get the CLTD values .

CLTD corr. for the sunlit roof :

$$(CLTD)_{corr.\ sunlit\ roof} = (CLTD + LM)\ k + (25.5 - T_{in}) + (T_{o,m} - 29.4)\ f$$

$$= (13+0.5)\times 1 + (25.5-24.5) + (24.3-29.4)\times 1$$

$$= 9.4\ °C$$

Table (2.7) the value of CLTD corr. (°C) by Solar Transmission:

Glass windows direction	LM	CLF	SHG W/m2	SC	CLTD (°C)	CLTD corr. (°C)
N	0.5	0.7	126	0.82	5	1.4
E	0	0.39	678	0.82	5	0.9
S	-1.6	0.52	227	0.82	5	0.3
W	0	0.14	678	0.82	5	0.9
NE	0.5	0.33	527	0.82	5	1.4
SE	-0.5	0.51	473	0.82	5	0.4
SW	-0.5	0.23	473	0.82	5	0.4
NW	0.5	0.17	527	0.82	5	1.4

Where CLF is the cooling load factor for glass windows (medium construction) without interior shading from table (2.15) .

LM: from table (2.10), SHG: from table (2.12), CLTD : from table (2.11) .

Cooling Loads :

1. **Infiltration** :

Using Crackage method :

$$\dot{Q}_{inf.,g} = \frac{\dot{V}f}{vo} (h_o - h_i) \quad (2.15)$$

Where:

hi: Inside enthalpy of infiltrated air in(kJ/kg)

ho: Outside enthalpy of infiltrated air in (kJ/kg)

$\dot{V}f$: The volumetric flow rate of infiltrated air in (m^3/s)

$$\dot{V}f = K \times L \left[0.613\, (S_1 \times S_2 \times V_O)^2\right]^{2/3} \quad (2.16)$$

Where:

K = the infiltration air coefficient.

L: the crack length in meter.

S_1: factor that depends on the topography of the location of the building

S_2: coefficient that depends on the height of the building.

V_O: measured wind speed (m/s)

The value of k, S1 and S2 is obtained from Appendix A ,Tables (2.6), (2.7) and (2.8) respectively. K =0.43 , S_1 =1.0 , $S2$ =0.79 , V_O= 1.4 (m/s) from Palestinian code .

And the window is sliding:

L = [(2×1. 5) + (3×1.5)]+ [(2×1. 2) + (3×1.5)]+ [(2×0.8) + (3×1.5)] = 20.5 m

Therefore ;

$\dot{V}f$ = K × L [0.613 $(S_1 \times S_2 \times V_O)^2$]$^{2/3}$

$\dot{V}f$ = (0.43) (20.5) [0.613(1 × 0.79 × 1.4)^2]$^{2/3}$ =7.2756 m3/h = 2.021×10^{-3} [m^3/s]

$\dot{Q}_{nf.,g} = \frac{\dot{V}f}{vo}(h_o - h_i) = (2.021 * 10^{-3})/0.88\ (68.5 - 45)$ = 0.0539 [kW] = 53.94W.

2. Ventilation:

From Table (2.20) the minimum outside air requirements for mechanical ventilation for the areas of office space =10 L/s/p .

$\dot{V}v$ = 10 * 3 person = 30 L/s = 0.030 m^3/s

$\dot{m}_v = \frac{\dot{V}v}{\dot{V}o} = \frac{0.030}{0.88}$ = 0.034 Kg/s .

$\dot{Q}_{vn.} = \dot{m} \times Cp_{air} \times (T_{out} - T_{in})$ = 0.034*1.005*(30-24.5) =0.1879 [kW] =187.93W.

Now for the South West inner wall:

There is a part of this wall near to conditioned space at the same temperature(secretary room1) ,so

$\dot{Q} = U*A*\Delta T$ = 0.0 W

And there is another wall unconditioned space so :

$A_{uncon.,wall}$= (3.82 × 3.0) = 11.46 m^2

$\dot{Q}_{un\ con.,wall\ SE} = U_{uncon.,wall} \times A \times (\Delta T_{adj,cooling})$= 2.64 × (11.46)× 28.2 = 853.17 W

$\dot{Q}$ from the north wall(secretary room1)= $U_{inn,wall}*A*(\Delta T_{adj,cooling})$ = 2.64*(11.76)*0.0= 0.0 W (Because there is another conditioned space at the same temperature) .

For the South West wall:

$A_{SW,window} = [(0.8 \times 1.5)] = 1.2\ m^2$

$A_{SW\ wall} = (5.33 \times 3.0) = 15.99\ m^2$

$\dot{Q}_{SW,\ wall} = U_{outer\ wall} \times A \times CLTD_{corr} = 0.86 \times 15.99 \times 4.5 = 61.88\ W$

$A_{NW,window} = [(1.2 \times 1.5)+(1.5 \times 1.5) = 4.05\ m^2$

$A_{NW,\ wall} = (5.0 \times 3.0) = 15 m^2$

$\dot{Q}_{NW,\ wall} = U_{outer\ wall} \times A \times CLTD_{corr} = 0.86 \times 15.0 \times 3.4 = 43.86\ W$

$\dot{Q}_{SW\ window} = \dot{Q}_{solar\ effect} + \dot{Q}_{solar\ transmission}$

$\dot{Q}_{solar\ effect,\ SW} = U_{window} \times A_w \times CLTD_{corr,\ sw} = 3.5 \times 1.2 \times 0.4 = 1.7\ W$

$\dot{Q}_{solar\ transmission,\ SW} = A \times SHG \times SC \times CLF = 1.2 \times 473 \times 0.82 \times 0.51 = 237.37\ W$

$\dot{Q}_{SW,\ window} = 1.7 + 237.37 = 239\ W$

For the NW wall :

$A_{NW,window} = 4.05\ m^2$

$A_{NW,wall} = 15\ m^2$

$\dot{Q}_{wall\ ,NW} = U_{outer\ wall} \times A \times CLTD_{corr} = 0.86 \times 15 \times 3.4 = 43.86\ W$

$\dot{Q}_{solar\ effect,\ NW} = U_{window} \times A_w \times CLTD_{corr,w} = 3.5 \times 4.05 \times 1.4 = 19.85\ W$

$\dot{Q}_{solar\ transmission,\ NW} = A \times SHG \times SC \times CLF = 4.05 \times 527 \times 0.82 \times 0.17 = 297.5\ W$

$\dot{Q}_{NW,\ window} = 19.85 + 297.5 = 317\ W$

For ground and ceiling :

$\dot{Q}_{ground} = U_g \times A \times (T_g - T_i) = 2.14 \times 23.41 \times (26-24.5) = 75\ W$

$U_{1,C} = 0.89\ [W/m^2.°C]$

$A_{1,C} = \frac{4}{5} \times 23.41 = 18.73\ m^2$

$U_{2,C} = 0.97\ [W/m^2.°C]$

$A_{2,C} = \frac{1}{5} \times 23.41 = 4.7\ m^2$

$\dot{Q}_{ceiling}$ = (U_{1c}×A_1 + U_{2c}×A_2)× $CLTD_{corr,roof}$ = [(0.89×18.73) + (0.97×4.7)× 9.4 =199.5W

Heat gain due to lights :

P_{light/m^2}= 30 W/m^2

CLF_{LT} = 0.82 FOR 10 hours of operation from table (2.17) Appendix A .

$\dot{Q}_{Lt} = \frac{P}{m2}$ *A*CLF_{LT} = 30*23.41*0.82 = 575.88 W

Heat gain due to occupants :

Total heat gain = 145 W/person

Sensible heat gain = 87 W/person

CLF_{oc} = 0.85 for 10 hours in space from table (2.18) .

$\dot{Q}_{oc.sensible}$ = No.of persons * $\frac{P\ sen}{person}$*CLF_{oc} = 3*87*0.85 = 221.85 [W]

$\dot{Q}_{oc.latent}$ = No.of persons * $\frac{P\ lat}{person}$ = 3*(145-87) = 174 [W]

$\dot{Q}_{oc.,\ tot}$ = 221.85 + 174 = 395.85 W

Table (2.8) External Cooling Loads : Conduction due to (ΔT):

Surface	Area [m^2]	U [W/m^2. °C]	ΔT [°C]	$\dot{Q}$ [W]
South West Wall	15.99	0.89	5.5	78.3
North West Wall	15	0.89	5.5	73.4
Roof Ceiling	23.41	U1=0.89,U2=0.97	5.5	75
SE uncond. wall	11.46	2.64	3.7	853.2
			Total	1079.9

i)Transmitted heat gains :

Table (2.9) : Transmitted heat gains:

Surface	Area (m^2)	SHG (W/m^2)	SC	CLF	$\dot{Q}$ (W)
SW Glass	1.2	473	0.82	0.23	237.37
NW Glass	4.05	527	0.82	0.17	297.5
				Total	534.87

ii) Conduction due to CLTD :

Table (2.10) Conduction due to (CLTD):

Surface	Area (m^2)	CLTD (°C)	LM	$CLTD_{corr}$ (°C)	$\dot{Q}$ (W)
SW wall	15.99	8	-0.5	3.4	61.9
SW Glass window	1.2	5	-0.5	0.4	1.7
NW wall	15	7	0.5	3.4	43.86
NW Glass Window	4.05	5	0.5	1.4	19.85
Ceiling	23.41	13	0.5	9.4	199.5
				Total	326.81

2) Internal Cooling loads :

Table (2.11) Internal Cooling Loads:

Item	$\dot{Q}$ (W)
Lights	575.88
Occupants	395.85
Total	971.73

3) Infiltration:

Table (2.12): The value of Infiltration :

item	$\dot{Q}$ (W)
Infiltration	53.94
Total	53.94

4) ventilation :

Table (2.13) : The value of Ventilation:

item	$\dot{Q}$ (W)
Ventilation	187.93
Total	187.93

Multiply the final result with Factor Of Safety for this room (F.O.S) 10%

$\dot{Q}_{Total\ room} = \sum\dot{Q} \times$ F.O.S

=[1079.9+534.87+326.81+971.73+53.94+187.93]×1.1

= 3155.2×1.1 = 3470.7 **W**

= 3.5 **kW** = 1 **Ton Refrigerant**

Ventilation Load Summary for Toilet and kitchen is listed in the following table:

Table (2.14) : Ventilation for twenty four Toilets and eight Kitchens :

Unit Type	Area (m^2)	$\dot{Q}$ vent. (kW)	$\dot{Q}$ vent (kW) with 1.1 F.O.S	Number Of Unit	Total Of $\dot{Q}$ Vent. (kW)
Kitchen	7.63	0.075	0.083	8	0.664
Toilet	17	0.188	0.207	24	4.968
			SUM Total		5.632

The Total ventilation loads = 5.6 [kW]

2.4 Estimation Of Heating and Cooling loads :

Heating and Cooling Loads for each Floors is listed in the following table:

Table (2.15):Summary heating and cooling loads:

Floors	Area (m^2)	$\dot{Q}$ heating [kW]with Safety Factor	$\dot{Q}$ cooling [kW] with Safety Factor
First	282	67.86	54.17
Second	278	66.86	53.39
Third	278	66.86	53.39
Fourth	278	71.1	57.65
Total	1116	272.68	218.6

2.5 Variable Refrigerant Flow System

2.5.1 Overview

The primary function of all air-conditioning systems is to provide thermal comfort for building occupants. There are a wide range of air conditioning systems available, starting from the basic window-fitted units to the small split systems, to the medium scale package units, to the large chilled water systems, and currently to the variable refrigerant flow (VRF) systems.

Variable refrigerant flow (VRF) is an air conditioning system configuration where there is one outdoor condensing unit and multiple indoor units. The term variable refrigerant flow refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and configurations connected to a single condensing unit. The arrangement provides an individualized comfort control, and simultaneous heating and cooling in different zones.

Currently widely applied in large buildings especially in Japan and Europe, these systems are just starting to be introduced in the U.S. The VRF technology/system was developed and designed by Daikin Industries, Japan who named and protected the term variable refrigerant volume (VRV) system so other manufacturers use the term VRF "variable refrigerant flow". In essence both are same.

2.5.2 Variable Refrigerant Flow description

VRF systems are similar to the multi-split systems which connect one outdoor section to several evaporators. VRF systems continually adjust the flow of refrigerant to each indoor evaporator. The control is achieved by continually varying the flow of refrigerant through a pulse modulating valve (PMV) whose opening is determined by the microprocessor receiving information from the thermostat sensors in each indoor unit. The indoor units are linked by a control wire to the outdoor unit which responds to the demand from the indoor units by varying its compressor speed to match the total cooling and/or heating requirements.

VRF systems promise a more energy-efficient strategy (estimates range from 11% to 17% less energy compared to conventional units) at a some what higher cost.

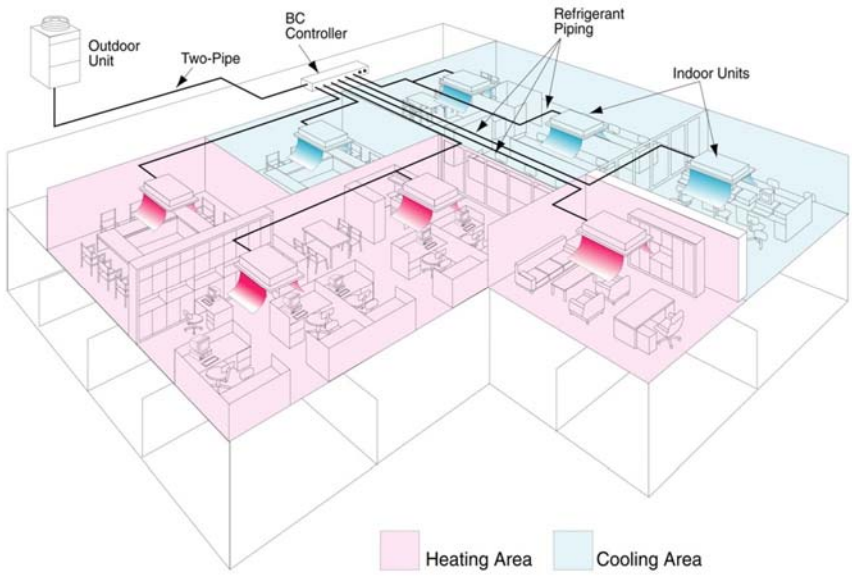

Figure (2.5) : VRF System with multiple indoor evaporator units

The modern VRF technology uses an inverter-driven scroll compressor and permits as many as 48 or more indoor units to operate from one outdoor unit (varies from manufacturer to manufacturer). The inverter scroll compressors are capable of changing the speed to follow the variations in the total cooling/heating load as determined by the suction gas pressure measured on the condensing unit. The capacity control range can be as low as 6% to 100%.

Refrigerant piping runs of more than 200 ft are possible, and outdoor units are available in sizes up to 286,600 Btu/ h = (84 kW).

A schematic VRF arrangement is indicated below:

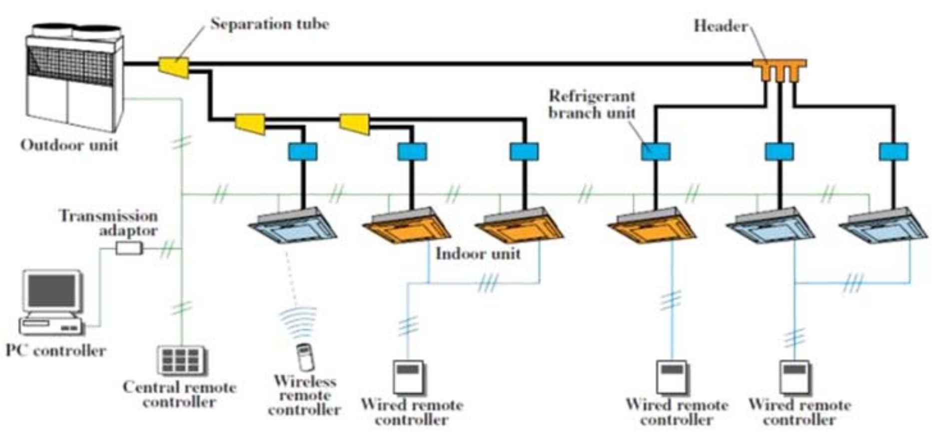

Figure (2.6) : A schematic VRF arrangement

VRF systems are engineered systems and use complex refrigerant and oil control circuitry. The refrigerant pipe-work uses a number of separation tubes and/or headers (refer schematic figure above).

A separation tube has 2 branches whereas a header has more than 2 branches. Either of the separation tube or header, or both, can be used for branches. However, the separation tube is never provided after the header because of balancing issues.

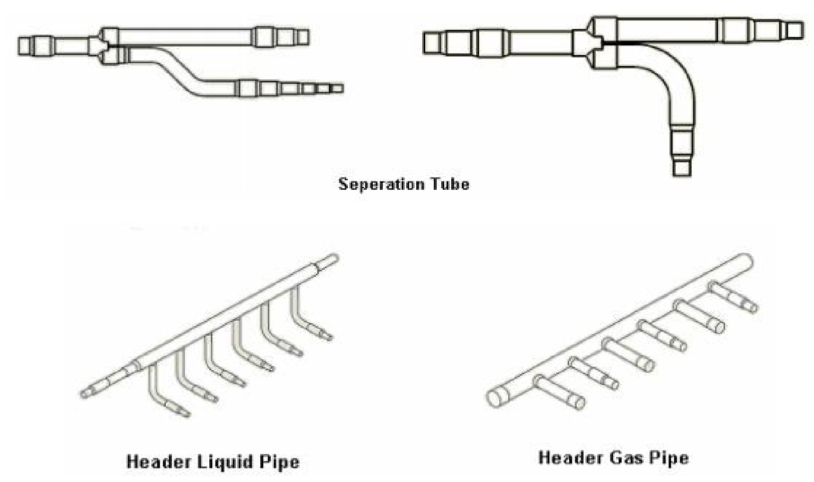

Figure (2.7) : Separation and header tubes

2.5.3 Design considerations for VRF system

Deciding what HVAC system best suits your application will depend on several variables such as building characteristics, cooling and heating load requirements, peak occurrence, simultaneous heating and cooling requirements, fresh air needs, accessibility requirements, minimum and maximum outdoor temperatures, sustainability, and acoustic characteristics.

Building Characteristics :

VRF systems are typically distributed systems – the outdoor unit is kept at a far off location like the top of the building or remotely at grade level and all the evaporator units are installed at various locations inside the building. Typically the refrigerant pipe-work (liquid and suction lines) is very long, running in several hundreds of feet in length for large multi-story buildings. Obviously, the long pipe lengths will introduce pressure losses in the suction line and, unless the correct diameter of pipe is selected, the indoor units will be starved of refrigerant resulting in insufficient cooling to the end user. So it is very important to make sure that the pipe sizing is done properly, both for the main header pipe as well as the feeder pipes that feed each indoor unit. The maximum allowable length varies among different manufacturers; however the general guidelines are as follows:

- The maximum allowable vertical distance between an outdoor unit and its farthest indoor unit is 164 ft.
- The maximum permissible vertical distance between two individual indoor units is 49 ft.
- The maximum overall refrigerant piping lengths between outdoor and the farthest indoor unit is up to 541 ft.

Note: The longer the lengths of refrigerant pipes, the more expensive the initial and operating costs.

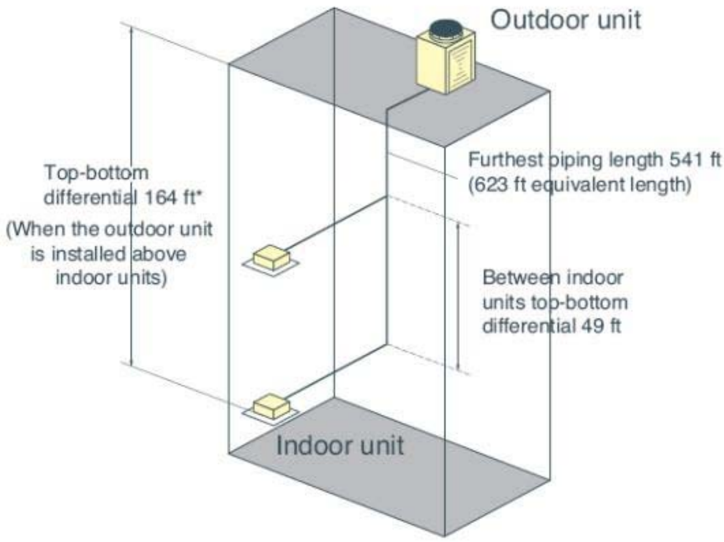

Figure (2.8) : Design limits in VRF system

<u>Sustainability</u>

One attractive feature of the VRF system is its higher efficiency compared to conventional units. Cooling power in a VRF system is regulated by means of adjusting the rotation speed of the compressor which can generate an energy saving around 30%.

A VRF system permits easy future expansion when the conditions demand. Over sizing however, should be avoided unless a future expansion is planned.

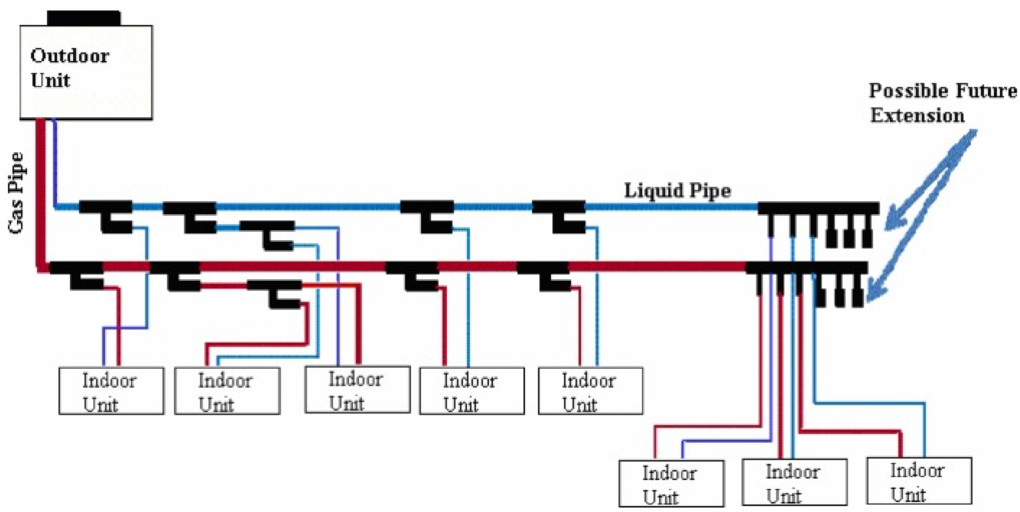

Figure (2.9) : Pipe work schematic

Other sustainability factors include:

- Use of non-ozone depleting environment-friendly refrigerants such as R 410a .
- Opting for heat pump instead of electrical resistance heating in areas demanding both cooling and heating .
  Heat pumps offer higher energy efficiency.

Simultaneous Heating and Cooling

Some manufacturers offer a VRF system with heat recovery feature which is capable of providing simultaneous heating and cooling. The cost of a VRF-HR is higher than that of a normal VRF heat pump unit and therefore its application should be carefully evaluated.

More economical design can sometimes be achieved by combining zones with similar heating or cooling requirements together. For example, the areas that may require simultaneous heating and cooling are the parametric and interior zones. Parametric areas with lot of glazing and exposure especially towards west and south will have high load variations. A VRF heat pump type system is capable of providing simultaneous heating and cooling exceeding 6 tons cooling requirement.

Using VRF heat pump units for heating and cooling can increase building energy efficiency. The designer must evaluate the heat output for the units at the outdoor design temperature. Supplemental heating with electric resistors shall be considered only when the heating capacity of the VRF units is below the heating capacity required by the application. Even though supplemental heating is considered, the sequence of operation and commissioning must specify and prevent premature activation of supplemental heating.

First Costs

The installed cost of a VRF system is highly variable, project dependent, and difficult to pin down. Studies indicate that the total installed cost of a VRF system is estimated to be 5% to 20% higher than air or water cooled chilled water system, water source heat pump, or rooftop DX system providing equivalent capacity. This is mainly due to long refrigerant piping and multiple indoor evaporator exchanges with associated controls. Building owners often have no incentive to accept higher first costs, even if the claimed payback period is short, as the energy savings claims are highly unpredictable.

2.6 Advantages of VRF system :

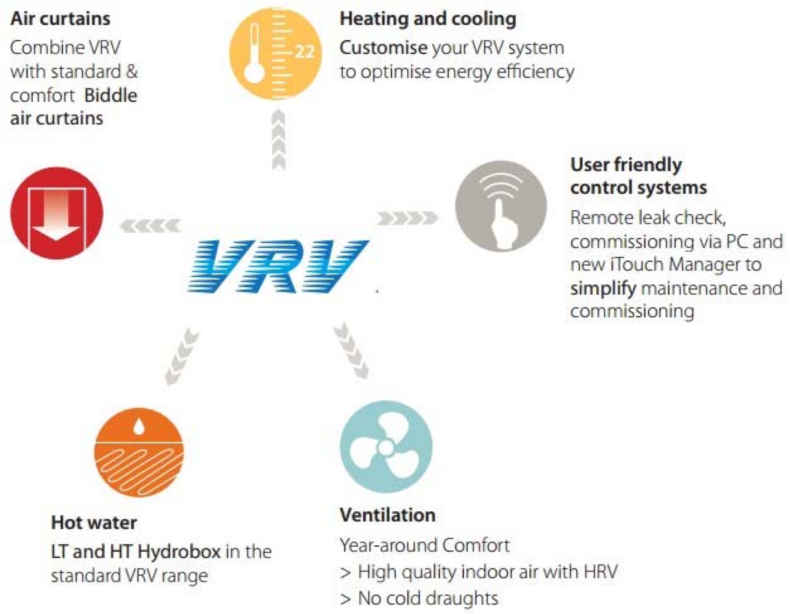

Figure (2.10) : VRV provides a total solution for integrated climate control

VRF systems have several key benefits, including:

1. **Installation Advantages**.

VRF systems are lightweight and modular. Each module can be transported easily and fits into a standard elevator.

2. **Design Flexibility.**

A single condensing unit can be connected to many indoor units of varying capacity (e.g., 0.5 to 4 tons [1.75 to 14 kW]) and configurations (e.g., ceiling recessed, wall mounted, floor console). Current products enable up to 20 indoor units to be supplied by a single condensing unit. Modularity also makes it easy to adapt the HVAC system to expansion or reconfiguration of the space, which may require additional capacity or different terminal units.

3. **Maintenance and Commissioning.**

VRF systems with their standardized configurations and sophisticated electronic controls are aiming toward near plug-and-play commissioning.

4. **Comfort.**

Many zones are possible, each with individual set point control. Because VRF systems use variable speed compressors with wide capacity modulation capabilities, they can maintain precise temperature control, generally within ±1°F (±0.6°C), according to manufacturers' literature.

5. **Energy Efficiency**.

The energy efficiency of VRF systems derives from several factors. The VRF essentially eliminates duct losses, which are often estimated to be between (10-20) percent of total airflow in a ducted system. VRF systems typically include two to three compressors, one of which is variable speed, in each condensing unit, enabling wide capacity modulation. This approach yields high part-load efficiency, which translates into high seasonal energy efficiency, because HVAC systems typically spend most of their operating hours in the range of 40% to 80% of maximum capacity.

6. **Refrigerant piping**

Runs of more than 200 feet (60.96 m) are possible and outdoor units are available in sizes up to 268,000 Btu/ h (84 kW).

2.7 Selection units

This section talks about selection of outdoor and indoor units of VRF system, depending on the “Samsung VRF catalogue”, since this company product is existing in Hebron.

Outdoor and indoor units are selected according to the thermal load of the building.

Outdoor unit

It was chosen three outdoor units with capacity of individual is 60.508 TR DVM S (New)HP Compact (Module) , Cooling capacity = 212.8 kW , Heating capacity = 239.4 kW .

Table (2.16): Outdoor units (Heat Pump)

Outdoor Unit Name	Dimension (Mm)	Capacity HP	Cooling [kW]	Heating [kW]	No.
AM300KXVAGH/TK	1295*1795*765	30	84	94.5	1
AM240KXVAGH/TK	1295*1795*765	24	67.2	75.6	1
AM220KXVAGH/TK	1295*1795*765	22	61.6	69.3	1
	Total	76	212.8	239.4	3

<u>Indoor unit</u>

In this project there are three types of indoor units selected, which are split , cassette and mini cassette units. The split unit is used for bedrooms, and the cassette units are used for reception and restaurant , and mini cassette units are used for passages and breakfast hall .

The figure below shows the three types of selected units:

Figure (2.11) : Spilt , Cassette S, Mini cassette and 360 cassette of Indoor Units

The selected Outdoor and Indoor units for the building are listed in the tables below:

Table (2.17): Bill of Quantity of Outdoor and Indoor units for All Floors :

Outdoor				Unit			
Fl	**Name**	**Model name**	**Quantity**	**Fl**	**Name**	**Model name**	**Quan.**
Roof	Outdoor	AM220KXVAGH/TK	1	4F	3RD-ROOM-01	AM090KN4DEH/TK	3
				4F	3RD-ROOM-02	AM045KN4DEH/TK	1
				4F	3RD-ROOM-04	AM045FNNDEH/TK	2
				4F	3RD-ROOM-05	AM036FNNDEH/TK	1
				4F	3RD-ROOM-07	AM028FNNDEH/TK	2
				4F	3RD-ROOM-06	AM022FNTDEH/TK	1
				4F	3RD-ROOM-08	AM045FN4DEH/TK	1
				3F	2ND-ROOM-01_1	AM071KN4DEH/TK	4
				3F	2ND-ROOM-02	AM022FNQDEH/TK	2
		AM240KXVAGH/TK	1	3F	2ND-ROOM-03	AM056FNNDEH/TK	1
				3F	2ND-ROOM-04	AM036FNNDEH/TK	3
				3F	2ND-ROOM-06	AM112FNMDEH/TK	1
				3F	2ND-ROOM-12	AM045FNNDEH/TK	1
				3F	2ND-ROOM-14	AM090FNMDEH/TK	1
				2F	1ST-ROOM-01_1	AM071KN4DEH/TK	5
				2F	1ST-ROOM-03	AM036FNNDEH/TK	2
				2F	1ST-ROOM-03	AM045FN4DEH/TK	2
				2F	1ST-ROOM-05	AM112FNMDEH/TK	1
		AM300KXVAGH/TK	1	2F	1ST-ROOM-06	AM022FNQDEH/TK	2
				2F	1ST-ROOM-11	AM090FNMDEH/TK	1
				1F	GR-ROOM-01_1	AM071KN4DEH/TK	2
				1F	GR-ROOM-02	AM056KN4DEH/TK	3
				1F	GR-ROOM-03	AM036FNNDEH/TK	2
				1F	GR-ROOM-05	AM022FNQDEH/TK	1
				1F	GR-ROOM-06	AM056FN4DEH/TK	1
				1F	GR-ROOM-08	AM045FN4DEH/TK	2
				1F	GR-ROOM-10	AM022FNTDEH/TK	1
				1F	GR-ROOM-11	AM112FNMDEH/TK	1
Total of Outdoor Units			3	Total of Indoor Units			50

Table (2.18): Outdoor And Indoor Nominal Capacity [kW]

Name	Model name	ID Type	Nominal Capacity Cooling [kW]	Nominal Capacity Heating [kW]	Dimension [Mm]	Qty.
3RD-ROOM-01	AM090KN4DEH/TK	360 Cassette	9	10	947x281x947	3
3RD-ROOM-02	AM045KN4DEH/TK	360 Cassette	4.5	5	947x281x947	1
3RD-ROOM-04	AM045FNNDEH/TK	4Way CASSETTE (600 x 600)	4.5	5	575x250x575	2
3RD-ROOM-05	AM036FNNDEH/TK	4Way CASSETTE (600 x 600)	3.6	4	575x250x575	1
3RD-ROOM-07	AM028FNNDEH/TK	4Way CASSETTE (600 x 600)	2.8	3.2	575x250x575	
3RD-ROOM-06	AM022FNTDEH/TK	Neo Forte	2.2	2.5	825x285x189	1
3RD-ROOM-08	AM045FN4DEH/TK	4Way Cassette S	4.5	5	840x204x840	1
2ND-ROOM-01_1	AM071KN4DEH/TK	360 Cassette	7.1	8	947x281x947	4
2ND-ROOM-02	AM022FNQDEH/TK	Neo Forte	2.2	2.5	825x285x189	2
2ND-ROOM-03	AM056FNNDEH/TK	4Way CASSETTE (600 x 600)	5.6	6.3	575x250x575	1
2ND-ROOM-04	AM036FNNDEH/TK	4Way CASSETTE (600 x 600)	3.6	4	575x250x575	3
2ND-ROOM-06	AM112FNMDEH/TK	MSP Duct	11.2	12.5	1150x320x480	1
2ND-ROOM-12	AM045FNNDEH/TK	4Way CASSETTE (600 x 600)	4.5	5	947x281x947	1
2ND-ROOM-14	AM090FNMDEH/TK	MSP Duct	9	10	1150x260x480	1
1ST-ROOM-01_1	AM071KN4DEH/TK	360 Cassette	7.1	8	947x281x947	5
1ST-ROOM-03	AM036FNNDEH/TK	4Way CASSETT E (600 x 600)	3.6	4	575x250x575	2
1ST-ROOM-03	AM045FN4DEH/TK	4Way Cassette S	4.5	5	840x204x840	2
1ST-ROOM-05	AM112FNMDEH/TK	MSP Duct	11.2	12.5	1150x320x480	1
1ST-ROOM-06	AM022FNQDEH/TK	Neo Forte	2.2	2.5	825x285x189	2
1ST-ROOM-11	AM090FNMDEH/TK	MSP Duct	9	10	1150x260x480	1
GR-ROOM-01_1	AM071KN4DEH/TK	360 Cassette	7.1	8	947x281x947	2
GR-ROOM-02	AM056KN4DEH/TK	360 Cassette	5.6	6.3	947x281x947	3
GR-ROOM-03	AM036FNNDEH/TK	4Way CASSETTE (600 x 600)	3.6	4	575x250x575	2
GR-ROOM-05	AM022FNQDEH/TK	Neo Forte	2.2	2.5	825x285x189	1
GR-ROOM-06	AM056FN4DEH/TK	4Way Cassette S	5.6	6.3	840x204x840	1
GR-ROOM-08	AM045FN4DEH/TK	4Way Cassette S	4.5	5	840x204x840	2
GR-ROOM-10	AM022FNTDEH/TK	Neo Forte	2.2	2.5	825x285x189	1
GR-ROOM-11	AM112FNMDEH/TK	MSP Duct	11.2	12.5	1150x320x480	1

2.8 Mechanical Ventilation :

Ventilation is the process of supplying and removing air by natural or mechanical means to and from a building. The design of a building's ventilation system should meet the minimum requirements of the building (Ventilating Systems) regulations.

There are two ways for Ventilation:

- "Natural ventilation" covers uncontrolled inward air leakage through cracks, windows, door ways and vents (infiltration) as well as air leaving a room (exfiltration) through the same routes. Natural ventilation is strongly affected by weather conditions and is often unreliable.
- Mechanical or forced ventilation is provided by air movers or fans in the wall, roof or air conditioning system of a building. It promotes the supply or exhaust air flow in a controllable manner.

The air flow rate into a room space, for general mechanical supply and extract systems, is usually expressed in:

1. Air changes per hour
2. An air flow rate per person
3. An air flow rate per unit floor area

An air change per hour (ACH) is the most frequently used basis for calculating the required airflow. Air changes per hour are the number of times in one hour an equivalent room volume of air will be introduced into, or extracted from the room space.

Table (2.19) : Ventilation rate

Room	Volume(m^3)	Ventilating Rate	
		(L/s)	(CFM)
Kitchen	22.92	63.5	134.6
Man Toilet	9.67	26.8	56.4
Woman Toilet	9.67	26.8	56.4
Handicapped toilet	13.69	37.9	80.4

Type of suction fan is TOSHEPA WALL VENTILATOR VRH-30S1which have the following specifications :

- AC 220 V/ 50 Hz.
- Plastic body and blades.
- 2 directions .
- Easy for cleaning.
- Safety back window.
- More than 5000 working

Chapter Three

Plumbing System

3.1 Introduction

Plumbing is the art and science of installing pipes in buildings, fixtures and other appurtenances for bringing in the water supply and removing liquid and waterborne wastes. Plumbing systems are one of the most important parts of building design because it's prevent transmission of disease, hygiene, remove the dirty water and etc.

Plumbing includes many systems in buildings, the figure below shows the details of the plumbing systems.

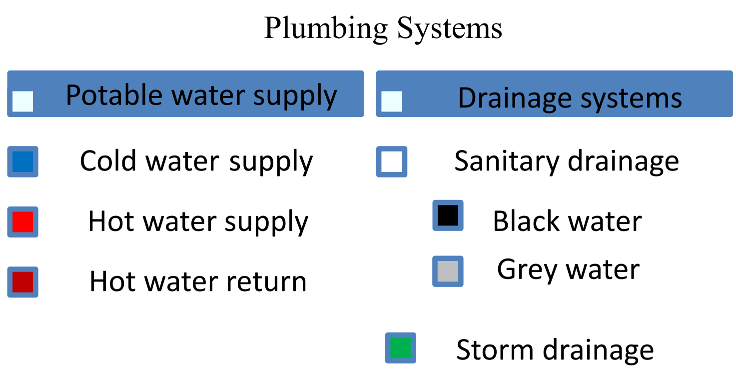

Figure (3.1): Plumping systems types

Grey water treatment which means all wastewater that is discharged from a building excluding black water. This includes water from lavatories and kitchen sinks.

The main purpose of grey water recycling and treatment is to substitute the precious drinking water in applications which do not require drinking water quality ; with grey water recycling it is possible to reduce the amounts of fresh water consumption as well as wastewater production in addition to reducing the water bills.

In water treatment the main process is using the sand filter to achieve the required percentage of recycled water.

3.2 Water supply system

3.2.1 Overview

There are two types of water distribution systems for buildings:

1. Up feed distribution system.
2. Down feed distribution system.

The system that we will be use to this building is Down feed distribution system.

the system which operates by pumping the water from the city main or suction tank at the ground floor to a roof tank from which the fixture units are fed .

The design of main water supply for the building needs to take into consideration the actual and anticipated future consumption. Moreover , size of water main pipe, and required pressure of water are essential .

3.2.2 Calculations of hot and cold water supply systems :

To determine the pipe size for cold and hot water supply system , the water supply fixture unit (WSFU) for each fixture unit must be determined and total fixture unit on each piping run out be calculated, the minimum flow pressure required at the critical fixture unit must be determined.

There is one fixture unit (kitchen sink) (WSFU) as follow:

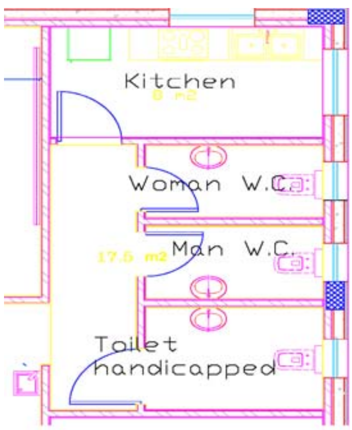

Figure (3.2): Sample WSFU

1. kitchen sink: is a fixture unit needs cold and hot water supplies as shown in Table A(3.3) the value Fixture Units of the kitchen sink for a public use is (4) , while the daily use is not too much will take the private use Fixture Units (2).

   Or hot water only was needed then this value should be multiplied by (3/4), so the demand of the kitchen sink will be as follow:

   a. (2) WSFU for both hot and cold water demand.
   b. (3/4)×2 WSFU for hot or cold water only.

2. Water closet: is a fixture unit needs cold supplies , the value of Fixture Units of the Water closet for General use is (5).

3. Lavatory: is a fixture unit needs cold and hot water supplies , the value Fixture Units of the lavatory for General use is (2) , while if cold or hot water only was needed then this value should be multiplied by (3/4), so the demand of the Toilet will be as follow:

   a. Fixture Units (2) for both hot and cold water demand.
   b. (3/4)×2 Fixture Units for hot or cold water only .

Table (3.1): The Fixture Unit load

Fixture unit	No. Of Fixture	WSFU	WSFU cold water	WSFU hot water	No. of FU hot ,cold
Kitchen Sink	1	$\frac{3}{4}\times 2$	1.5	1.5	2
Lavatory (general)	3	$\frac{3}{4}\times 2$	4.5	4.5	6
Water Closet (cleaning)	3	2	6	0	6
∑ WSFU	7	---	12	6	14

The amount of water supply fixture unit cold water is 12 fixture unit load so we use the Table A(3.3) for estimating demand to calculate the required amount of water which is equal (9.2) gallon per minute (gpm) by using the interpolation.

Table (3.2): The load of Fixture Units and Demand (gpm)

No. Of Floors	Zone	Load, WSFU			Demand, (gpm)		
		Cold water	Hot water	Hot , Cold water	Cold water	Hot water	Hot , Cold water
Ground	B	12	6	14	9.2	5	10.4
First	B	12	6	14	9.2	5	10.4
Second	A	12	6	14	9.2	5	10.4
	B	12	6	14	9.2	5	10.4
Third	A	12	6	14	9.2	5	10.4
	B	12	6	14	9.2	5	10.4
Fourth	A	12	6	14	9.2	5	10.4
	B	12	6	14	9.2	5	10.4
Total	--	96	48	112	73.6	40	83.2

3.2.3 Pipe size calculations:

Using Down feed distribution system where the water from the gravity tank on the roof serves the floor below by gravity system .

In this system , the static pressure will be the main pressure , and the equation of flow will be :

Static pressure=Friction head loss+ Minimum flow pressure…….……........…(3.1)

- Using the Table A(3.1) Minimum pressure required by typical plumbing fixture and the (kitchen sink) is the critically fixture unit, the minimum flow pressure is (8)psi.

static pressure = $8\text{m} \times \left(\frac{1\text{ft}}{0.3048\text{m}}\right) \times \left(0.433\frac{\text{Psi}}{1\text{ft}}\right) = 11.36 \text{ Psi}$

Friction Head Loss $=$ Static pressure - Min. Flow Pressure

$$= 11.36 - 8 = 3.36\ Psi$$

Equivalent Length = $35 \text{ m} \times \left(\frac{1\text{ft}}{0.305\text{m}}\right) = 114.829\text{ft}$

TEL = $114.829 \times 1.5 = 172.2\text{ft}$

Then :

$$friction\ head\ loss = \frac{\Delta P}{TEL} = \frac{3.36\ psi \times 100}{(172.2) \times 100ft} = 1.95\ Psi/100ft$$

Table (3.3): Size of cold water pipes

GPM	Pipe size (in)	GPM	Pipe size (in)	GPM	Pipe size (in)
0→2	1/2"	78→140	3"	3601→4200	14"
3→4	3/4"	141→280	4"	4201→5500	16"
5→7.5	1"	281→500	5"	5501→7000	18"
8→16	1-1/4"	501→800	6"	7001→9000	20"
17→24	1-1/2"	801→1700	8"	9001→13000	24"
25→48	2"	1701→2500	10"	Water pipe sizing	
49→77	2-1/2"	2501→3600	12"		

It possible to choose the pipes size from above Table (3.3) , or by using the chart from figure (3.1) Appendix B of Friction Head Loss for Water in commercial Steel Pipe (Schedule 40) .

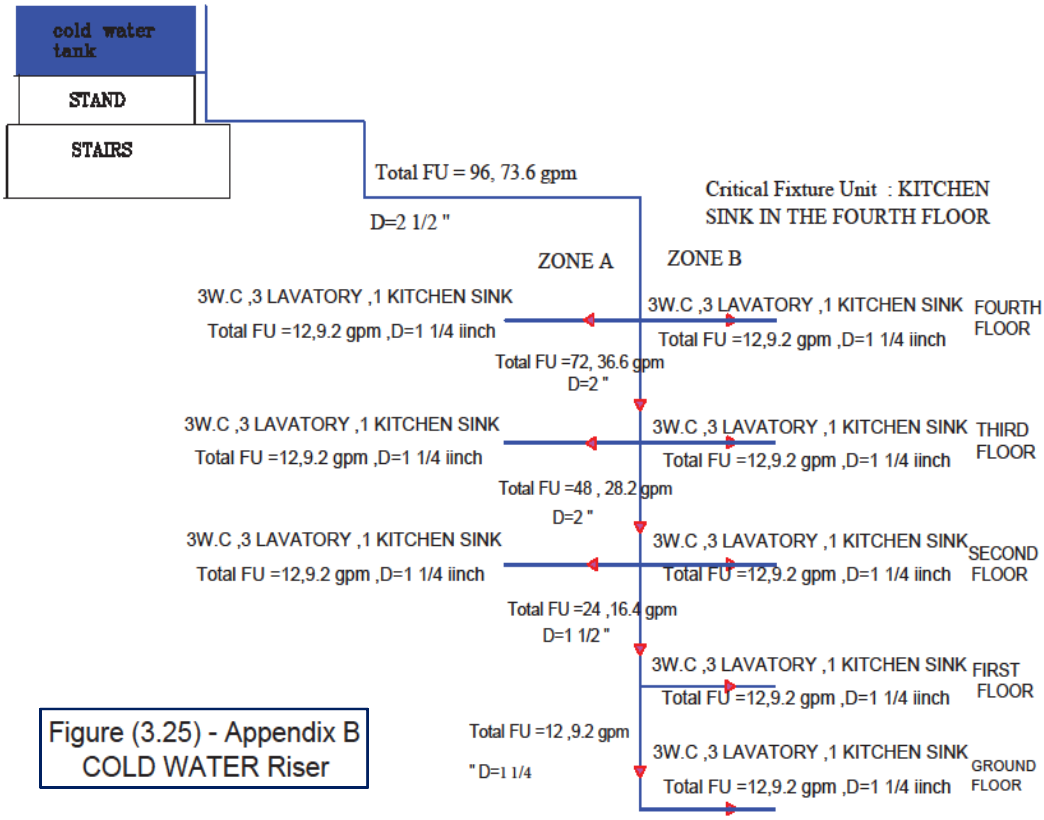

Figure (3.3): Cold Water Riser

*See the (figure 3.25 in Appendix B) Cold water Riser

Table (3.4) : The total calculation for The Risers

No. Of Floor	ZONE A		ZONE B	
	Total no. Of FU For cold	Total no. Of FU for hot	Total no. Of FU For cold	Total no. Of FU for hot
Ground	0	0	12	6
First	0	0	12	6
Second	12	6	12	6
Third	12	6	12	6
Fourth	12	6	12	6
∑ WSFU	36	18	60	30
∑ WSFU for cold	96 fu	=73.6 gpm	= 16.7 m³/h	= 4.64 l/s
∑ WSFU for hot	48 fu	=40 gpm	= 9.08 m³/h	= 2.52 l/s

Convert from gpm to m³/hr

∑ WSFU for cold water Riser = $\left(73.6\,\frac{\text{galon}}{\text{minute}}\right) \times \left(0.227124707\,\frac{\text{m}^3}{\text{hr}}\right)$
$=16.7\text{m}^3/\text{h}$

∑ WSFU for hot = $\left(40\,\frac{\text{galon}}{\text{minute}}\right) \times \left(0.227124707\,\frac{\text{m}^3}{\text{hr}}\right) = 9.08\text{m}^3/\text{h}$

The total amount of water required which is 73.6 gpm about 16.7 m³/h for cold water Riser and 40 gpm about 9 m^3/h for hot water supply Riser .

Table (3.5) : Properties of cold water Riser

Riser with two zone	WSFU	GPM	Diameter[Inch]	Velocity [fps]
	96	73.6	2 1/2	4

Table (3.6) : Properties of hot water riser

Riser with two zone	WSFU	GPM	Diameter[Inch]	Velocity [fps]
	48	40	2	3

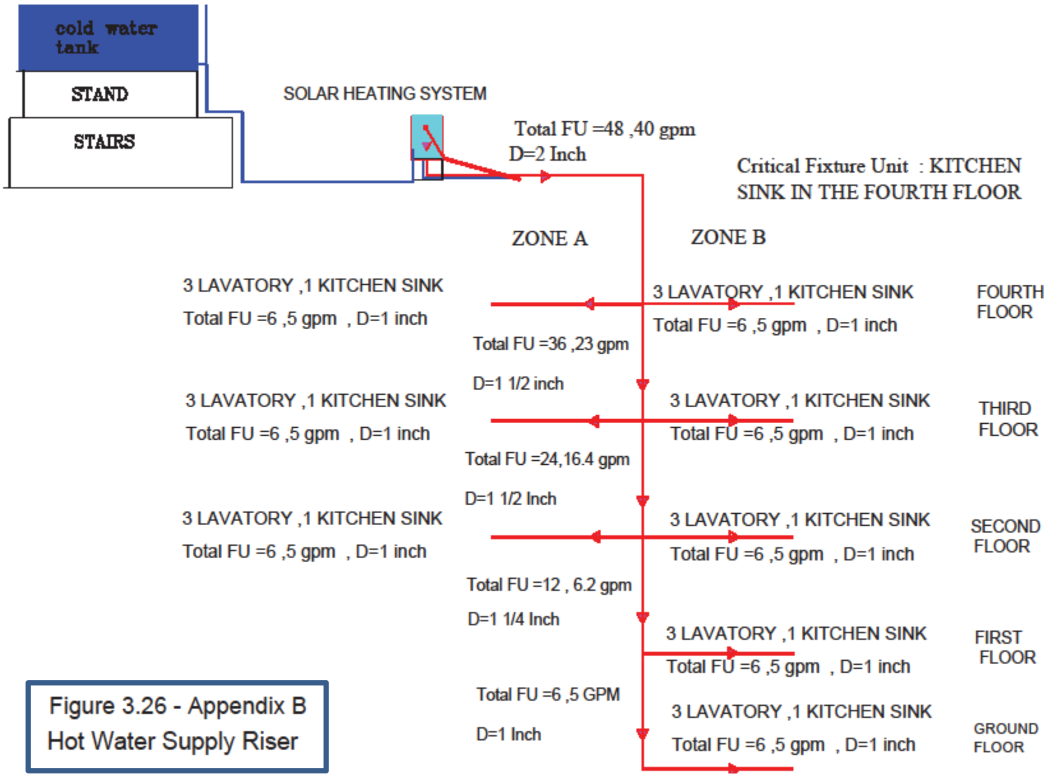

Figure (3.4): Hot Water Risers and Solar Heating System

*See the (figure 3.26 in Appendix B) Hot water Supply Riser .

The total water supply fixture unit for cold water risers equal 96 WSFU and for hot water risers equal 48 WSFU.

The total demand for cold water equals (73.6) gpm and the total demand for hot water equals (40) gpm .

The friction loss is 1.95 Psi/100ft

So the pipe diameter of the main pump is 2 1/2" and the velocity is 4 fps.

3.3 Hot Water System Recirculation :

When do not use hot water, the water in any Pipes will lose heat and you must be work of Cycling a certain amount of water, Even this water remains valid for use. To find this amount must know the rate of heat loss in pipes, and get it from the following Table:

Table (3.7) : Approximate insulated piping heat loss and surface Temperature :

Nominal Pipe size (In.)	Insulation Thickness (In.)	Heat Loss (Btu/h/linear ft)	Surface Temperature (°F)
1/2	1	8	68
3/4	1	10	69
1	1	10	69
1 1/4	1	13	70
1 1/2	1	13	69
2 or less	1/2ª	24 or less	74
2	1	16	70
2 1/2	1 1/2	12	67
3	1 1/2	16	68
4	1 1/2	19	69
6	1 1/2	27	69
8	1 1/2	32	69
10	1 1/2	38	69

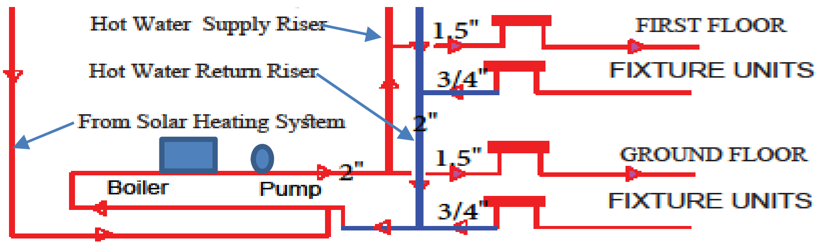

Figure (3.5): Hot Water System Recirculation

3.3.1. Calculation for Return pipes diameter :

Recirculating systems are usually provided when piping run is about 100 ft long.

The types of recirculation systems :

1. Thermo siphon recirculation system .
2. Forced circulation system : (low and long buildings) controlled pump is used .

Choose the second system to provide maximum hot water demand immediately at required temperature .

Recirculation system includes :

- Hot water supply piping
- Hot water return piping
- Circulating pumps
- Balance valves
- Shut off valves
- Check valves
- Controls for the pumps

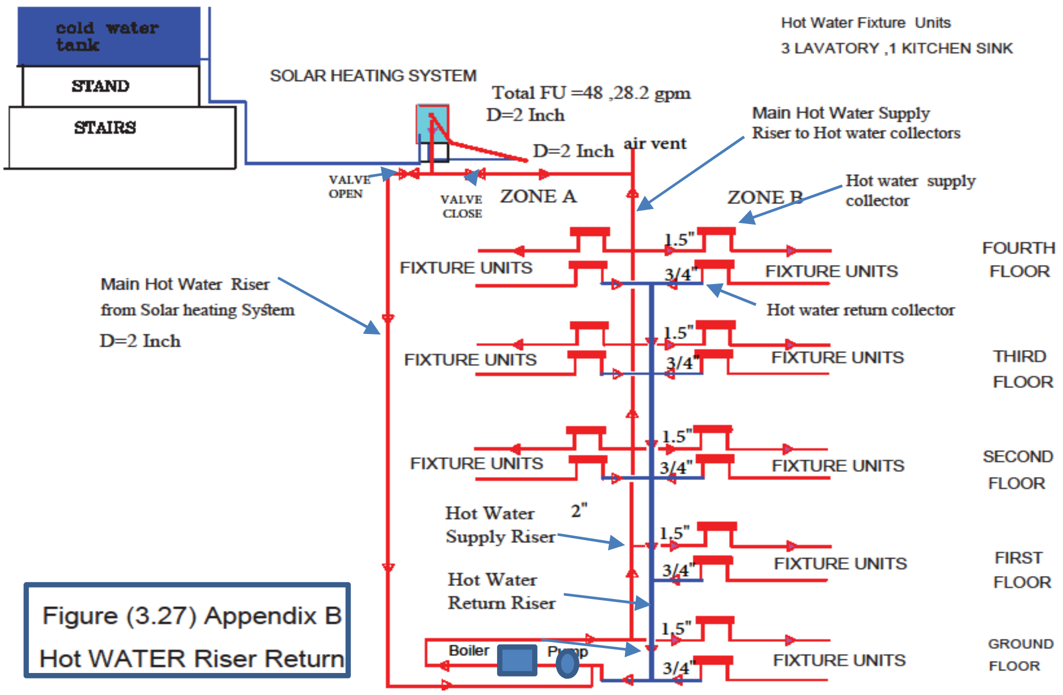

Figure (3.6): Up feed Hot Water System with Heater at Bottom of System

*See Figure (3.27) at Appendix B (Hot Water Riser Return)

1. Return pipe diameter=1/2 supply pipe diameter
2. Heat loss(return)=2/3 Heat loss(supply):

Heat loss(supply)=EL*Heat loss.

Heat loss from Table:(3.6)=16 btu/hr for dimeter 2".

EL for riser (1)=3.35+(3.85*4)+(20)= 38.75/0.3048 = 127.13 ft.

127.13 ft *16 btu/h/ft linear =2034.12 btu/h

Heat loss(return)=2/3 *2034.12=1356 btu/h

Total heat losses =2034.12+1356=3390 btu/h

By using this equation:

10,000 btu/h Heat loss=1GPM(circulated pump)

circulated pump=0.3390 GPM

Table (3.8) : Properties of Riser (Recirculation)

Section No.	EL [ft]	Supply Diam. Inch	Return in Diam. Inch	Heat Loos supply [Btu/h]	Heat Loss return [Btu/h]	Total heat loss [Btu/h]	Circulated pump [GPM]
Main Riser	127	2	2	127*16=2032	2023*2/3=1354.6	3390	0.3390
Section A-4th level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
Section B-4th level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
Section A-3rd level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
Section B-3rd level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
Section A-2nd level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
Section B-2nd level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
Section B-1st level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
Section B-Gr.level	52	1.5	3/4	52*13=676	676*2/3=450.66	1126.66	0.1127
				∑TOTAL		12390.94	1.2394

3.4 Selections :

3.4.1 Selection for cold water pump :

In order to choose the details of the required water pump we have to determine two main conditions, the amount of total flow rate of demand water and the total head:-

1. **Flow rate determination**:

According to the previews calculation and equation estimation, the total flow rate for the riser is 73.6 gpm, so by converting 73.6 gpm equal to 16.7 [m^3/h].

2. **Head estimation**

According to the previews calculation and equation estimation the head is 34 psi & equal 2.3 Bar, Adding 1 bar for fittings losses the value is almost 3.3 bar .

Pump selection

Using (dp-select) software and with filling data into brackets as follow :

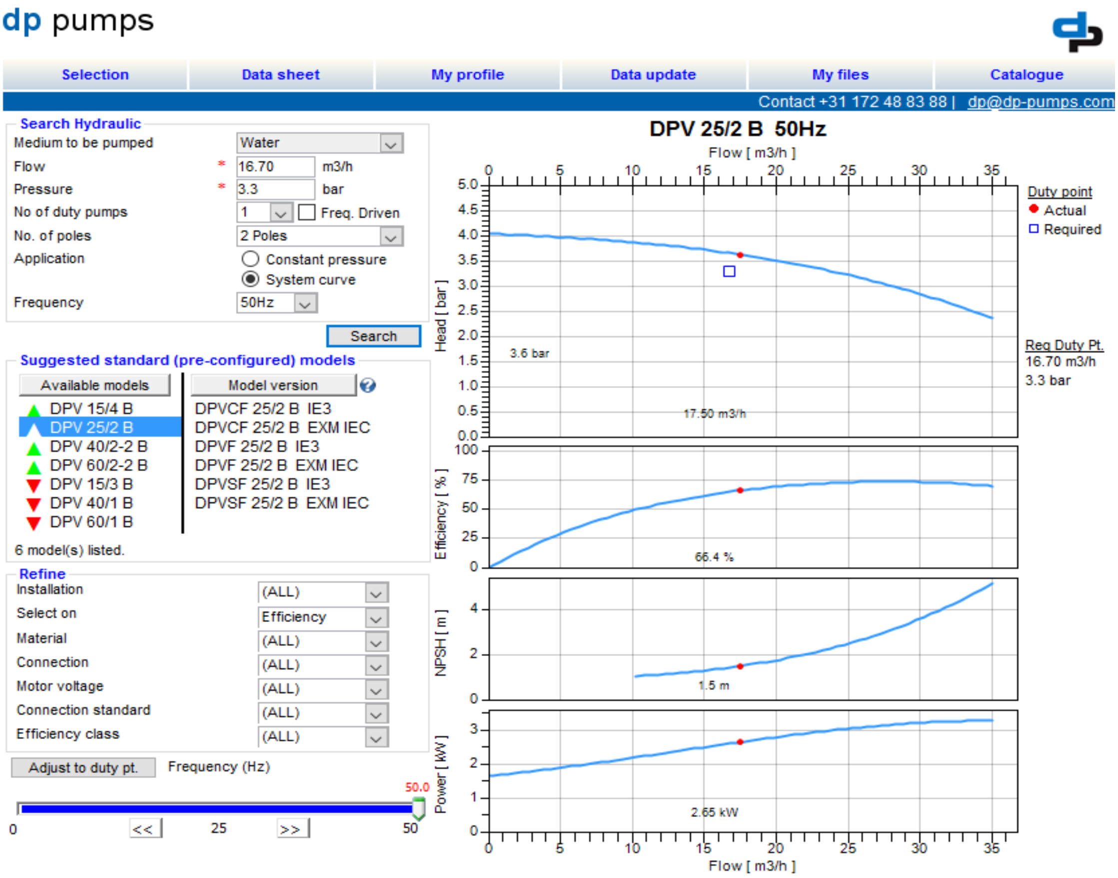

Figure (3.7) : Pump data

The pump model selected “DPV 25/2 B”.

The characteristic curves of this pump as follow :

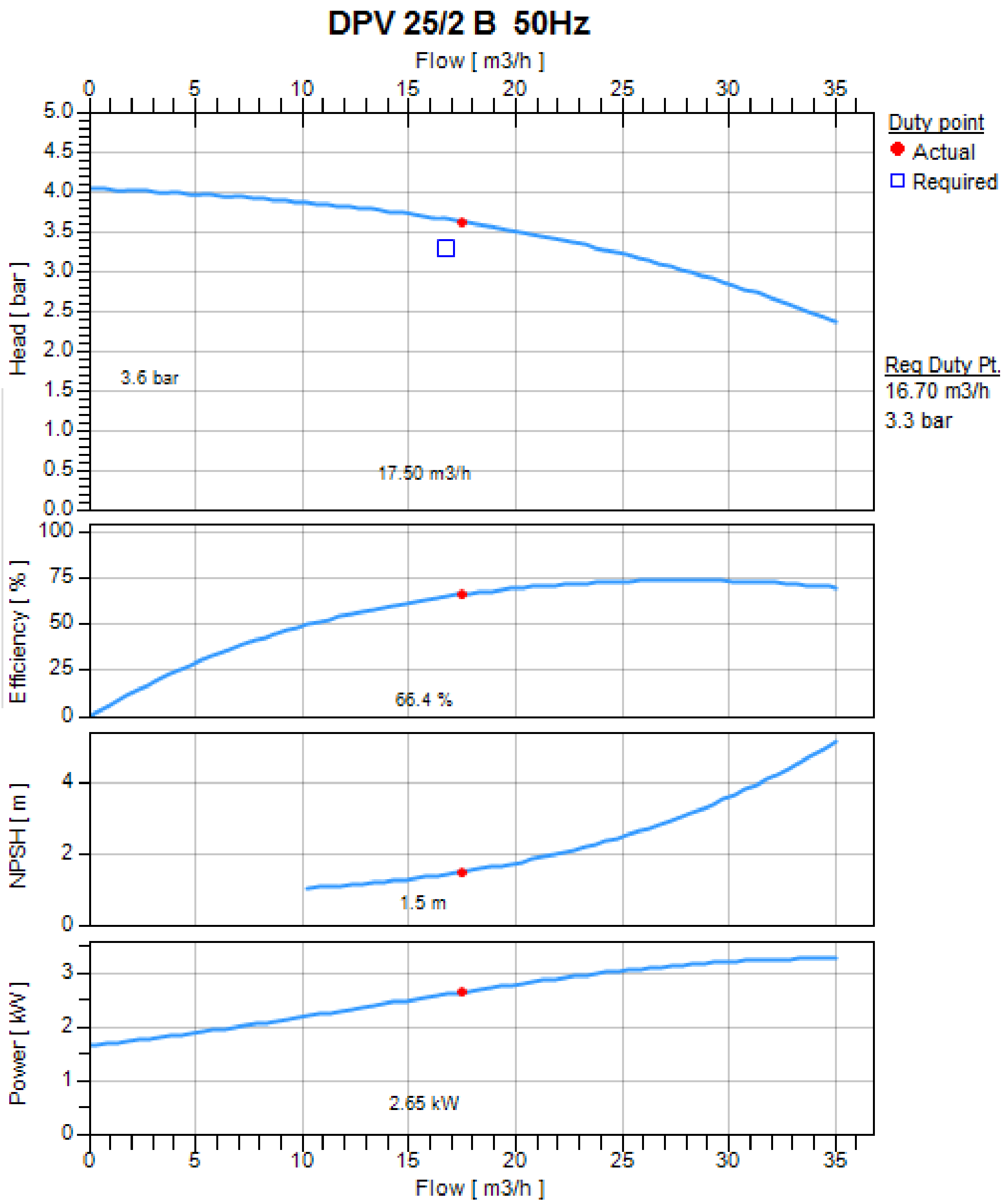

Figure (3.8) : Pump Characteristic Curves

3.4.2 Selection for cold water tank :

The main condition in choosing the size of water tank to limit the size with the daily use of demand and number of storage day .

Size Water Tank=Number of people in the building ×Daily consumption for each person× Number of storage day ……………..(3.2)

1. Number of people in the building :

From Table ( ) ASHRAE 62 Estimated maximum occupancy P/1000ft^2 or 100 m^2 is (7) with building application of offices .

$$\text{Number of people in the building} = \frac{\text{Area Of Building}}{\text{Maximum Area Occupy by one person}} \quad \text{... (3.3)}$$

$$= \frac{2000}{14} = 143 \text{ person}$$

2. Daily consumption for each person :

   From the Uniform Plumbing Code (UPC) is 20 Gallons per day per employee .

From the Egypt Code :

$$Q_{AV(Sewerage)} = (0.8 - 0.9) Q_{AV(WATER)}$$

Substitute the sewerage quantities equal of water quantities .

Number of storage day depending on the average schedule distribution program in Hebron about 15 day .

Size Water Tank=143×20× 15=42900 Gallons =162 m^3

When the number of peoples increase by full occupancy about 250 person

Size Water Tank=250×20× 15=75000 Gallons =284 m^3

3.4.3 Selection for boiler

The types of Hot Water Heaters :

1. Instantaneous water heaters (tank less water heaters) ;Atmor,Gas boiler :
   Units that heat water only when hot water faucet opens or other fixture demands hot water ,They are referred to as tank-less heaters because they do not use any sort of storage tank.
2. Tank type water heater:

Are the most common used units .Their advantages are that they makes or provide a large quantity of heated water available upon demand .

the second system of tank type heater use it in this project because need to compensate the hot water demand.

Use Table (A3.9) to calculate the size of the boiler :

Total Daily consumption =number of person ×Hot water per person (gal/day)

=254 ×2 =508 (gal/day)

Maximum hourly demand =maximum hourly demand portion of daily use ×Total

=1/5×508 =101.6 (gal/hr)

Duration of peak load = 2 (hour)

Total peak load =2 hr×101.6 gal/hr =203.2 (gal)

Storage capacity = 1/5×Total =1/5×508 =101.6 (gal)

Convert from gallon to liter to get the size of boiler tank (theoretical calculation:

1 galon = 3.78 liter , 101.6 galon =384.04 liter

Heat capacity = 1/6 ×508 =84.66 (gal)

$$Recovery\ Rate = \frac{total\ peak\ load - (3/4\ \times\ average\ capacity)}{Duration\ of\ peak\ load}$$

$$= \frac{203.2 - (3/4\ \times\ 101.6)}{2} = 63.5\ galon$$

The value of 63.5 (galon) should be filled at storage tank when be consumed .

And be less than the value of storage capacity .

$\text{Heater Capacity} = (\text{GPH} \times \Delta\text{T})/410$ [Kw]

where:

$\dot{Q}$: boiler capacity. [kW]

$\Delta\text{T} = 70\text{F} =$ difference in temperature between water entering heater and leaving the heater.

Make up water temperature $= 50\text{F}$

$\text{Heater Capacity} = (101.6 \times 70)/410 = 17.34$ [Kw]

3.4.4 Selection for hot water central Tank size :

In the case of cold water calculation where calculate the demand load gpm by fixture load , but in the case of hot water central use the hot water demand per fixture for type of offices (Gallons of water per hour per fixture).

Table (3.9): Fixture Units loads (gph)

Fixture unit	No. of fixture	Office building (GPH)	GPH for sum. Of fixture
Kitchen Sink	1	20	20
Lavatory (general)	3	6	18
Total	4	---	38

In the table follow show the total calculations for all floors of water demand per fixture .

Table (3.10): The hot water demand per fixture for all floor (gph)

No. Of Floors	Zone	Demand, (gph)		
		Kitchen Sink	lavatory	Total
Ground	B	20	18	38
First	B	20	18	38
Second	A	20	18	38
	B	20	18	38
Third	A	20	18	38
	B	20	18	38
Fourth	A	20	18	38
	B	20	18	38
Total	--	160	144	304

The demand factor for the building type offices is =0.3

The storage capacity factor is = 2

$$Probable \max demand = Possible \max demand \times Demand\ Factor$$

$$= 304 \times 0.3 = 91.2\ GPH$$

$$Storage\ Tank\ Capacity = GPH \times Demand\ Factor \times Storage\ Factor \ldots.(3.4)$$

$= 304 \times 0.3 \times 2 = 182.4$ Gallon $= 0.69\ m^3$=690 liter

Table (3.11) Hot-Water Demand per Fixture for Various Types of Buildings

(Gallons of water per hour per fixture calculated a final temperature of 140°F

	Apartment House	Club	Gymnasium	Hospital	Hotel	Industrial Plant	Office Building	Private Residence	School	YMCA
1. Basin, private lavatory	2	2	2	2	2	2	2	2	2	2
2. Basin, public lavatory	4	6	8	6	8	12	6	—	15	8
3. Bathtub[c]	20	20	30	20	20	—	—	20	—	30
4. Dishwasher[a]	15	50-150	—	50-150	50-200	20-100	—	15	20-100	20-100
5. Foot basin	3	3	12	3	3	12	—	3	3	12
6. Kitchen sink	10	20	—	20	30	20	20	10	20	20
7. Laundry, stationary tub	20	28	—	28	28	—	—	20	—	28
8. Pantry sink	5	10	—	10	10	—	10	5	10	10
9. Shower	30	150	225	75	75	225	30	30	225	225
10. Service sink	20	20	—	20	30	20	20	15	20	20
11. Hydrotherapeutic shower				400						
12. Hubbard bath				600						
13. Leg bath				100						
14. Arm bath				35						
15. Sitz bath				30						
16. Continuous-flow bath				165						
17. Circular wash sink				20	20	30	20		30	
18. Semicircular wash sink				10	10	15	10		15	
19. DEMAND FACTOR	0.30	0.30	0.40	0.25	0.25	0.40	0.30	0.30	0.40	0.40
20. STORAGE CAPACITY FACTOR[b]	1.25	0.90	1.00	0.60	0.80	1.00	2.00	0.70	1.00	1.00

Note. Data sources predate low-flow fixtures and appliances.
[a]Dishwasher requirements should be taken from this table or from manufacturers' data for model to be used, if known.
[b]Ratio of storage tank capacity to probable maximum demand/h. Storage capacity may be reduced where unlimited supply of steam is available from central street steam system or large boiler plant.
[c]Whirlpool baths require specific consideration based on capacity. They are not included in the bathtub category.

See the technical specification of boiler from Catalogue

3.5 Sanitary drainage system

3.5.1 Drainage system Definition:

The "Sanitary" drainage system carries away the contaminated fluids and solids created at the fixture . The drainage systems of sanitary black water to be treated and remove from the system , but storm and grey water treated and use it again in the system .

3.5.2 Drainage system components:

The main components of drainage system are:

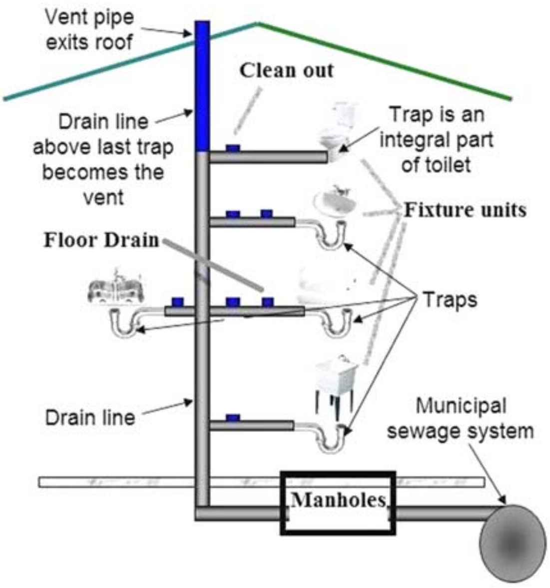

Figure (3.9): Drainage system components

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

- Accessories

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.

3.5.3 Sanitary drainage

3.5.3.1 Design procedure and pipe sizing

Pipe size is calculated by using a concept of fixture units (DFU) instead of using gpm of 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 as for water supply to add DFU of various fixtures to obtain the maximum expected drainage flow. Drainage pipes sized for a particular number of drainage fixture units, according to Tables (3.11), (3.12), (3.14), (3.15) . 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%)
- For pipes of diameter ≥ 4" the minimum slope is 1/8”/ft (1%)

Design procedure:

1. Calculation of the number of DFU for each branch by using Table (A3.12)
2. Calculation of the number of DFU for each stack
3. Choosing the branch pipe diameter by using Table (A3.14)
4. Choosing the stack pipe diameter .
5. Comparing the stack pipe diameter with branch diameter
6. Choosing the building drain pipe diameter by using Table (3.15)

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 Table A(3.11).

3.5.3.2 Black Water pipe sizing :

The following figure and tables shows the sizing of stacks:

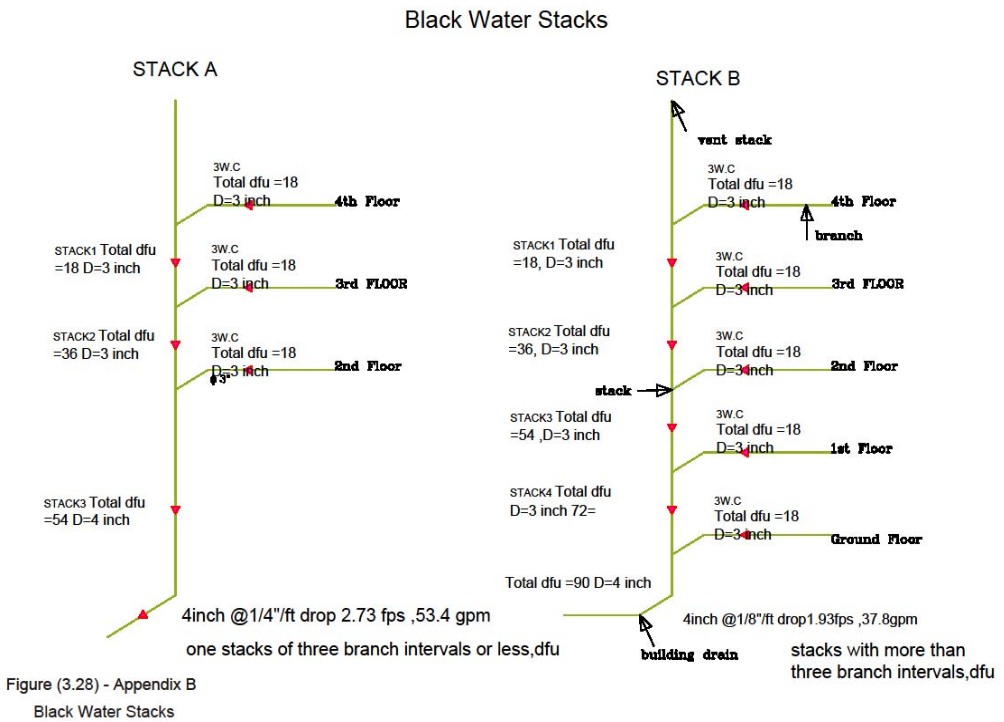

Figure (3.10): Black Water Stacks

*See Figure (3.28) at Appendix B (Black Water Stacks)

Table (3.12) : Sizing stack A of black water

Stack A	Total dfu values	Diameter (inch)
Branch of Fourth floor	18	3
Stack between Fourth and third floor	18	3
Branch of third floor	18	3
Stack between third and second floor	36	3
Branch of second floor	18	3
Stack between second and first floor	54	4

Table (3.13) : Sizing stack B of black water

Stack B	Total dfu values	Diameter (inch)
Branch of Fourth floor	18	3
Stack between Fourth and third floor	18	3
Branch of third floor	18	3
Stack between third and second floor	36	3
Branch of second floor	18	3
Stack between second and first floor	54	3
Branch of first floor	18	3
Stack between first and ground floor	72	3
Branch of ground floor	18	3
From ground floor to building drain	90	4

Table (3.14) :Sizing of black water stacks and building drain.

Stack	Total Dfu	Diam. (in)	Diam. building drain	Slope %	Velocity ft/s
A	54	4	4	1/8	1.93
B	90	4	4	1/4	2.73

Stack A: one stack of three branch Intervals.

Stack B: one stack with more than three branch Intervals.

3.5.3.3 Grey Water pipe sizing :

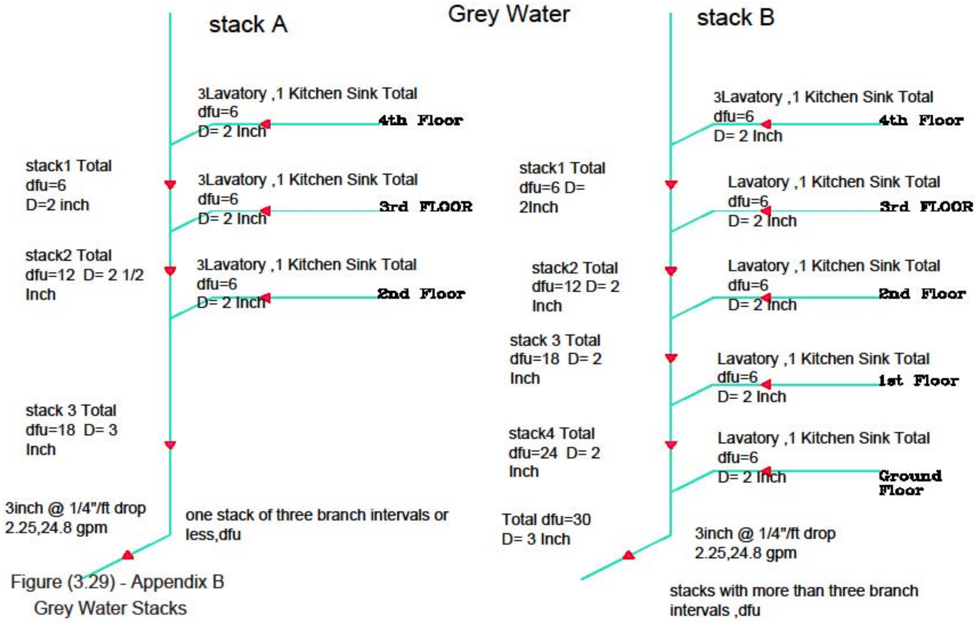

Figure (3.11): Gray Water Stacks

*See Figure (3.29) at Appendix B (Grey Water Stacks)

Table (3.15) : Sizing stack B of Grey water

Stack B	Total dfu value	Diameter (inch)
Branch of Fourth floor	6	2
Stack between Fourth and third floor	6	2
Branch of third floor	6	2
Stack between third and second floor	12	2
Branch of second floor	6	2
Stack between second and first floor	18	2
Branch of first floor	6	2
Stack between first and ground floor	24	2
Branch of ground floor	6	2
From ground floor to building drain (stack)	30	3

Table (3.16) : Sizing stack A of Grey water

Stack A	Total dfu value	Diameter (inch)
Branch of Fourth floor	6	2
Stack between Fourth and third floor	6	2
Branch of third floor	6	2
Stack between third and second floor	12	2
Branch of second floor	6	2
Stack between second and first floor	18	3

Table (3.17) : Sizing of Grey water stacks and building drain.

stack	Total dfu	Diameter of stack (in)	Diam. building drain	Slope %	Velocity ft/s
A	18	3	3	1/4	2.25
B	30	3	4	1/4	2.25

Stack A: one stack of three branch Interval.

Stack B: one stack with more than three branch Interval.

3.6 Manhole design

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

This project contains three types of manhole, which is:

- Sanitary manhole for black water .
- Sanitary manhole for gray water .
- Storm Water

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 50 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.

Table (3.18) : Diameter of the manhole according to their depth

Depth	Diameter
70-80	60
80-140	80
140-250	100
250-∞	125

3.6.1 Manhole calculation

Using the following equations to size manholes (depth ,invert level and diameter of manholes by the standards of civil works):

- Depth: (M2 = M1 + (Slope × Distance) + 5 + Level Difference) in cm……(3.5)
- 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:

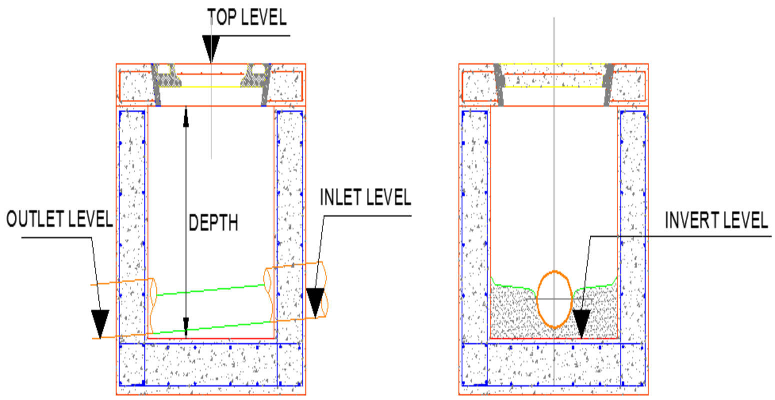

Figure 3.12: Manholes details

The result calculation of the grey water and black water manholes is listed in the tables below:

Table (3.19):Black water manholes

Manh. No.	Top level (m)	Invert level (m)	Outlet level (m)	Depth cm	Dia. (cm)	Cover Type
M01	-0.30	-0.80	-0.45	50	60	Concrete
M02	-0.30	-0.88	-0.53	58	60	Concrete
M03	-0.30	-1.075	-0.725	77.5	60	Concrete
M04	-0.30	-1.24	-0.89	94	80	Concrete
M05	-0.30	-0.80	-0.45	50	60	Concrete

Table (3.20):Gray water manholes

Manh. No.	Top level (m)	Invert level (m)	Outlet level (m)	Depth cm	Dia. (cm)	Cover Type
M01	-0.30	-0.80	-0.45	50	60	Concrete
M02	-0.30	-0.87	-0.52	57	60	Concrete
M03	-0.30	-0.945	-0.595	64.5	60	Concrete
M04	-0.30	-1.155	-0.805	85.5	80	Concrete
M05	-0.30	-0.80	-0.45	50	60	Concrete
M06	-0.30	-0.88	-0.53	58	60	Concrete
M07	-0.30	-1.00	-0.65	70	60	Concrete
M08	-0.30	-1.10	-0.75	80	80	Concrete
M09	-0.30	-1.55	-1.2	1.25	80	Concrete
M10	-0.30	-1.55	-1.2	1.25	80	Concrete
M11	-0.30	-1.55	-1.2	1.25	80	Concrete

From the last Manhole to grey water septic tank , install filter and pump to rise the grey water to Roof tank (of grey water) to feed the water closet flush tank.

3.7 Storm drainage

Every structure shall be provided with a storm drainage system that will conduct storm water from roofs and all paved areas into an approved sewer system . the storm water drainage system within or on a building must be completely separate from the sanitary drainage system.

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 roof area of this building is 400 m^2 ,and therefore needs 4" FD.

Table (3.21):Storm Water Manholes

Manh. No.	Top level (m)	Invert level (m)	Outlet level (m)	Depth cm	Dia. (cm)	Cover Type
M01	-0.30	-0.80	-0.45	50	60	Concrete
M02	-0.30	-0.86	-0.51	56	60	Concrete
M03	-0.30	-0.80	-0.45	50	60	Concrete
M04	-0.30	-1.02	-0.67	72	60	Concrete
M05	-0.30	-1.14	-0.79	84	80	Concrete
M06	-0.30	-1.21	-0.86	91	80	Concrete
M07	-0.30	-1.55	-1.20	1.25	80	Concrete
M08	-0.30	-1.55	-1.20	1.25	80	Concrete

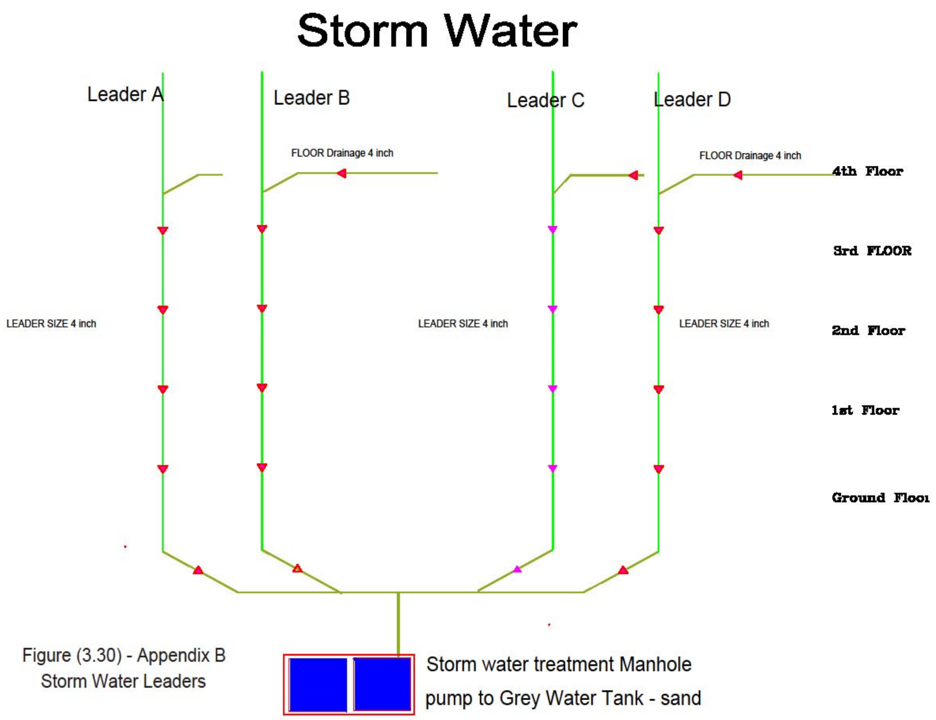

Figure (3.13): Storm Water Leader

*See Figure (3.30) at Appendix B (Storm Water Leaders)

Chapter Four

Fire Fighting System

4.1 Introduction

A fire fighting system is probably the most important of the building services, as its aim is to protect human life and property, strictly in that order. fire fighting systems and equipment vary depending on the age, size, use and type of building construction.

4.2 Types of fire fighting system

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

4.2.1 Fire extinguishers

Fire extinguishers are provided for a 'first attack' fire fighting 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.

The principle fire extinguisher types currently available include:

Figure 4.1 : Fire extinguishers

4.2.2 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.

Figure 4.2: Fire hose reel

4.2.3 Fire hydrant 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 fire fighting process.

Fire hydrants are for the sole use of trained fire fighters (which includes factory fire fighting 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.

Figure 4.3: Fire Hydrant System

4.2.4 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.

4.3 Select the most effective type :

After the identification of the fire systems now the best performance for the building and offices l is hose reel and extinguisher.

The number of hose reels to be used in building is 6 fire hose reels for all floors .

4.4 Pipe size calculation:

The fire hose reel system is to be used, so the pipe size for this system will be calculated as follows:

The minimum flow rate for single cabinet = 23 (l/min). Then :

Table 4.1:Pipe schedule - standpipes and supply piping

Total Accumulated Flow		Total Distance of Piping from Farthest Outlet		
L/min	gpm	<15.2 m (<50 ft)	15.2–30.5 m (50–100 ft)	>30.5 m (>100 ft)
379	100	2	2½	3
382–1893	101–500	4	4	6
1896–2839	501–750	5	5	6
2843–4731	751–1250	6	6	6
4735	1251 and over	8	8	8

Note: For SI units, 3.785 L/min = 1 gpm; 0.3048 m = 1 ft.

Then the table (4.1) is to be used to calculate the pipe size by follow the next procedure. First, the total flow rate is determined which is 575 l/min for our calculation sample. Then the total distance of piping from farthest outlet is to be chosen. Finally, the intersection between the two values in table (4.2) will give the size of pipe supply, which is equal to 4".

Then to determine the outlet pipe size from pipe supply to hose connection For this building.

The selection diameter is (2 in.) hose stations to supply water for use primarily by the building occupants or by the fire department during initial response.

4.5 Fire fighting pumps

Continuous water and pumping station supply should always be available and ready to fight fire, the following three pumps should be connected to a suction header (from water tank), and discharge header (to fire fighting network).

Pumping should be included :

1. Electrical fire fighting pump.
2. Diesel Fire fighting Pump,(Stand-by pump). Diesel pump works if:
    - The electrical pump is out of service, or if there is a lack of electricity.
    - The electrical pump is working but can’t satisfy system water requirements.
3. Jockey Pump: work to make up the system pressure in case of leakage or during the first seconds of fire.

Pump that used in building made by PEERLESS PUMP
Company. Mode: Peerless-J-J65F.
(See Cataloge).

References

References

1. Ronald L.Howell, Principles of Heating Ventilating and Air Conditioning 6th edition, ASHRAE, USA, 2009.
2. M.A.A.A M. Ashamed, Heating and Air Conditioning for Residential Buildings, National Library Department, Jordan, 2007.
3. J. F. Krieger, Handbook of Heating, Ventilation, and Air Conditioning, Boca Raton, CRC.Press LLC, Florida, 2001.
4. Mohammad A. Hammed, Heating and Air conditioning 3rd edition, Jordan, 1996.
5. Brain L.Olsen , Plumbing System 2nd edition,Missouri Group, USA, 1982.
6. Palestinian code.

Books:

1. Heating and air conditioning for residential buildings.
2. Heat Transfer a Practical Approach, 2 edition.
3. Fundamentals of Heat and Mass Transfer, 5 edition.
4. Heating Ventilation and Air Conditioning Analysis and Design, 4 edition.
5. Introduction to environmental engineering, fourth edition.

Websites:

1. (Water pump), dp-@dp- pumps.com
2. (Fire pump), www.groundfos.com
3. (Fire catalog),www.normteknik.com.tr
4. VRF (Daikin), http://www.daikin.com/products/ac/
5. VRF (Samsung), http://samsungdvm-s.com/
6. Manhole design, http://www.sewerhistory.org/grfx/components/mholes1.htm

7. "HVAC". *Merriam–Webster Dictionary*. Retrieved 2015-01-12.

8. Duttle, Marsha (January 1990). "NM State greywater advice". New Mexico State University. Retrieved 23 January 2010.

9. Dr. Allen V. Barker; Jean E. English (Sep 2011). "Recycling Gray Water for Home Gardens". University of Massachusetts. Archived from the original on September 1, 2012.

10. City of Fort Lauderdale (April 2011). "Fire-Rescue - Special Operations Command". fortlauderdale.gov.
11. http://www.nfpa.org/codes-and-standards/document-information
12. https://engineeringtoolbox.com

Appendix A

TABLE A(2.1) Thermophysical Properties of Gases at Atmospheric Pressure[a]

T (K)	ρ (kg/m^3)	c_p (kJ/kg · K)	$\mu \cdot 10^7$ (N · s/m^2)	$\nu \cdot 10^6$ (m^2/s)	$k \cdot 10^3$ (W/m · K)	$\alpha \cdot 10^6$ (m^2/s)	Pr
Air							
100	3.5562	1.032	71.1	2.00	9.34	2.54	0.786
150	2.3364	1.012	103.4	4.426	13.8	5.84	0.758
200	1.7458	1.007	132.5	7.590	18.1	10.3	0.737
250	1.3947	1.006	159.6	11.44	22.3	15.9	0.720
300	1.1614	1.007	184.6	15.89	26.3	22.5	0.707
350	0.9950	1.009	208.2	20.92	30.0	29.9	0.700
400	0.8711	1.014	230.1	26.41	33.8	38.3	0.690
450	0.7740	1.021	250.7	32.39	37.3	47.2	0.686
500	0.6964	1.030	270.1	38.79	40.7	56.7	0.684
550	0.6329	1.040	288.4	45.57	43.9	66.7	0.683
600	0.5804	1.051	305.8	52.69	46.9	76.9	0.685
650	0.5356	1.063	322.5	60.21	49.7	87.3	0.690
700	0.4975	1.075	338.8	68.10	52.4	98.0	0.695
750	0.4643	1.087	354.6	76.37	54.9	109	0.702
800	0.4354	1.099	369.8	84.93	57.3	120	0.709
850	0.4097	1.110	384.3	93.80	59.6	131	0.716
900	0.3868	1.121	398.1	102.9	62.0	143	0.720
950	0.3666	1.131	411.3	112.2	64.3	155	0.723
1000	0.3482	1.141	424.4	121.9	66.7	168	0.726
1100	0.3166	1.159	449.0	141.8	71.5	195	0.728
1200	0.2902	1.175	473.0	162.9	76.3	224	0.728
1300	0.2679	1.189	496.0	185.1	82	238	0.719
1400	0.2488	1.207	530	213	91	303	0.703
1500	0.2322	1.230	557	240	100	350	0.685
1600	0.2177	1.248	584	268	106	390	0.688
1700	0.2049	1.267	611	298	113	435	0.685
1800	0.1935	1.286	637	329	120	482	0.683
1900	0.1833	1.307	663	362	128	534	0.677
2000	0.1741	1.337	689	396	137	589	0.672
2100	0.1658	1.372	715	431	147	646	0.667
2200	0.1582	1.417	740	468	160	714	0.655
2300	0.1513	1.478	766	506	175	783	0.647
2400	0.1448	1.558	792	547	196	869	0.630
2500	0.1389	1.665	818	589	222	960	0.613
3000	0.1135	2.726	955	841	486	1570	0.536

Table 2.2 Inside film resistance, R_i.

Element	Heat Direction	Material Type	R_i m²·°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 2.3 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, m²·°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 2.4 Overall Heat Transfer Coefficient for Windows, W/m²·°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 2.5 Overall heat transfer coefficients for wood and metal doors, W/m²·°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 2.6 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 2.7 Values of the factor S_1

№	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 2.8 Values of the factor S_2

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

TABLE 2.9 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 2.10 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 2.11 Approximate CLTD values for light, medium, and heavy weight construction walls, °C.

Solar Time	Wall construction											
	Light				Medium				Heavy			
	N	E	S	W	N	E	S	W	N	E	S	W
8:00	—	16	—	—	—	—	—	—	—	—	—	—
9:00	—	20	—	—	—	6	—	—	—	—	—	—
10:00	—	21	2	—	—	11	—	—	—	—	—	—
11:00	—	18	7	—	—	14	—	—	—	3	—	—
12:00	—	12	12	—	—	15	—	—	—	5	—	—
13:00	2	9	15	5	—	14	5	—	—	7	—	—
14:00	3	7	16	13	—	12	9	1	—	8	—	—
15:00	3	7	14	21	1	10	11	6	—	8	1	—
16:00	4	6	11	27	2	9	12	12	—	8	3	—
17:00	4	5	7	30	2	8	11	17	—	8	5	3
18:00	5	3	4	27	3	7	9	22	—	8	6	7
19:00	2	1	1	17	3	5	7	23	—	7	6	10
20:00	—	—	—	6	3	3	5	20	1	7	6	12

TABLE 2.12 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 2.13 Shading coefficient (SC) for glass windows without interior shading.[1]

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, W/m²·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

TABLE 2.14 Shading coefficient (SC) for glass windows with interior shading.

Type of Glass	Nominal Thickness, mm	Type of Interior Shading				
		Venetian Blinds		Roller Shade		
				Opaque		Translucent
		Medium	Light	Dark	White	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	—	—	—	—

TABLE 2.15 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

TABLE 2.16 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

TABLE 2.17 Cooling load factor $(CLF)_{Lt}$, for lights.[3]

Number of hours after lights are turned On	Fixture X[c] hours of operation 10	16	Fixture Y[c] hours of operation 10	16
0	0.08	0.19	0.01	0.05
1	0.62	0.72	0.76	0.79
2	0.66	0.75	0.81	0.83
3	0.69	0.77	0.84	0.87
4	0.73	0.80	0.88	0.89
5	0.75	0.82	0.90	0.91
6	0.78	0.84	0.92	0.93
7	0.80	0.85	0.93	0.94
8	0.82	0.87	0.95	0.95
9	0.84	0.88	0.96	0.96
10	0.85	0.89	0.97	0.97
11	0.32	0.90	0.22	0.98
12	0.29	0.91	0.18	0.98
13	0.26	0.92	0.14	0.98
14	0.23	0.93	0.12	0.99
15	0.21	0.94	0.09	0.99
16	0.19	0.94	0.08	0.99
17	0.17	0.40	0.06	0.24
18	0.15	0.36	0.05	0.20

TABLE 2.18 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

TABLE 2.19 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 2.20 Minimum outside air requirements for mechanical ventilation

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	—

Appendix B

Table 3.1 Minimum Pressure Required by Typical Plumbing Fixtures

Fixture Type	*Minimum Pressure, psi*
Sink and tub faucets	8
Shower	8
Water closet—tank flush	8
Flush valve—urinal	15
Flush valve—siphon jet bowl	
floor-mounted	15
wall-mounted	20
Flush valve—blowout bowl	
floor-mounted	20
wall-mounted	25
Garden hose	
5/8-in. sill cock	15
3/4-in. sill cock	30
Drinking fountain	15

Source. EPA Manual of Individual Water Supply System, 1975 and manufacturers' data.

Table 3.2 Recommended Flow Rates for Typical Plumbing Fixtures

Fixture Type	*Flow, gpm*
Lavatory	3
Sink	4.5
Bathtub	6
Laundry tray	5
Shower	3–10
Water closets	
tank type	3
flush valve[a]	15–40
Urinal flush valve	15
Garden hose	
5/8-in. sill cock	3 1/3
3/4-in. sill cock	5
Drinking fountain	3/4

Source. Data extracted from various sources.

[a]Wide range of flows; depends on flow pressure.

Table 3.3 Water Supply Fixture Units and Fixture Branch Sizes

Fixture[a]	*Use*	*Type of Supply Control*	*Fixture Units[b]*	*Min. Size of Fixture Branch[d] in.*
Bathroom group[c]	Private	Flushometer	8	—
Bathroom group[c]	Private	Flush tank for closet	6	—
Bathtub	Private	Faucet	2	1/2
Bathtub	General	Faucet	4	1/2
Clothes washer	Private	Faucet	2	1/2
Clothes washer	General	Faucet	4	1/2
Combination fixture	Private	Faucet	3	1/2
Dishwasher[f]	Private	Automatic	1	1/2
Drinking fountain	Offices, etc.	Faucet 3/8 in.	0.25	1/2
Kitchen sink	Private	Faucet	2	1/2
Kitchen sink	General	Faucet	4	1/2
Laundry trays (1–3)	Private	Faucet	3	1/2
Lavatory	Private	Faucet	1	3/8
Lavatory	General	Faucet	2	1/2
Separate shower	Private	Mixing valve	2	1/2
Service sink	General	Faucet	3	1/2
Shower head	Private	Mixing valve	2	1/2
Shower head	General	Mixing valve	4	1/2
Urinal	General	Flushometer	5	3/4[e]
Urinal	General	Flush tank	3	1/2
Water closet	Private	Flushometer	6	1
Water closet	Private	Flushometer/tank	3	1/2
Water closet	Private	Flush tank	3	1/2
Water closet	General	Flushometer	10	1
Water closet	General	Flushometer/tank	5	1/2
Water closet	General	Flush tank	5	1/2

Water supply outlets not listed above shall be computed at their maximum demand, but in no case less than the following values:

Fixture Branch[d]	*Number of Fixture Units* — *Private Use*	*General Use*
3/8	1	2
1/2	2	4
3/4	3	6
1	6	10

[a]For supply outlets likely to impose continuous demands, estimate continuous supply separately and add to total demand for fixtures.

[b]The given weights are for total demand. For fixtures with both hot and cold water supplies, the weights for maximum separate demands may be taken as three-quarters the listed demand for the supply.

[c]A bathroom group for the purposes of this table consists of not more than one water closet, one lavatory, one bathtub, one shower stall or one water closet, two lavatories, one bathtub or one separate shower stall.

[d]Nominal I.D. pipe size.

[e]Some may require larger sizes—see manufacturer's instructions.

[f]Data extracted from Code Table B.5.2.

Source. Reproduced with permission from The National Standard Plumbing Code, published by The National Association of Plumbing Heating Cooling Contractors.

Table 3.4 Table for Estimating Demand

Supply Systems Predominantly for Flush Tanks		Supply Systems Predominantly for Flushometers	
Load, WSFU[a]	*Demand, gpm*	*Load, WSFU*[a]	*Demand, gpm*
6	5	—	—
10	8	10	27
15	11	15	31
20	14	20	35
25	17	25	38
30	20	30	41
40	25	40	47
50	29	50	51
60	33	60	55
80	39	80	62
100	44	100	68
120	49	120	74
140	53	140	78
160	57	160	83
180	61	180	87
200	65	200	91
225	70	225	95
250	75	250	100
300	85	300	110
400	105	400	125
500	125	500	140
750	170	750	175
1000	210	1000	218
1250	240	1250	240
1500	270	1500	270
1750	300	1750	300
2000	325	2000	325
2500	380	2500	380
3000	435	3000	435
4000	525	4000	525
5000	600	5000	600
6000	650	6000	650
7000	700	7000	700
8000	730	8000	730
9000	760	9000	760
10,000	790	10,000	790

[a]Water Supply Fixture Units

Source. Reproduced with permission from The National Standard Plumbing Code, published by The National Association of Plumbing Heating Cooling Contractors.

Fixture	*Riser A or B* — *Load per Fixture, WSFU*	*No. of Fixtures*	*Total Load, WSFU*
Urinal, general	5	6	30
Flush valve water closet, general	10	15	150
Lavatory, general	2	12	24
Sink, private	3	2	6
Total WSFU per riser			210
Total WSFU risers A and B			420

Table 3.5 Demand at Individual Water Outlets

Type of Outlet	*Demand, gpm*
Ordinary lavatory faucet	2.0
Self-closing lavatory faucet	2.5
Sink faucet, 3/8 or 1/2 in.	4.5
Sink faucet, 3/4 in.	6.0
Bath faucet, 1/2 in.	5.0
Shower head, 1/2 in.	5.0
Laundry faucet, 1/2 in.	5.0
Ballcock in water closet flush tank	3.0
1-in. flush valve (25-psi flow pressure)	35.0
1-in. flush valve (15-psi flow pressure)	27.0
3/4-in. flush valve (15-psi flow pressure)	15.0
Drinking fountain jet	0.75
Dishwashing machine (domestic)	4.0
Laundry machine (8 or 16 lb)	4.0
Aspirator (operating room or laboratory)	2.5
Hose bibb or sill cock (1/2 in.)	5.0

Source. Data reproduced with permission from National Standard Plumbing Code, published by the National Association of Plumbing, Heating, Cooling Contractors.

$$H_{fr} = K\frac{LV^2}{d} \qquad \textbf{(9.1)}$$

where

- H_{fr} is the friction head,
- f is the dimensionless coefficient of friction of the pipe's interior wall,
- K is a constant that depends on the units used,
- L is the total equivalent pipe length, including fittings, and
- d is the pipe diameter.

It is not necessary or even useful to attempt to compute the friction mathematically since charts such as those shown in Figures 9.5–9.7 are readily available.

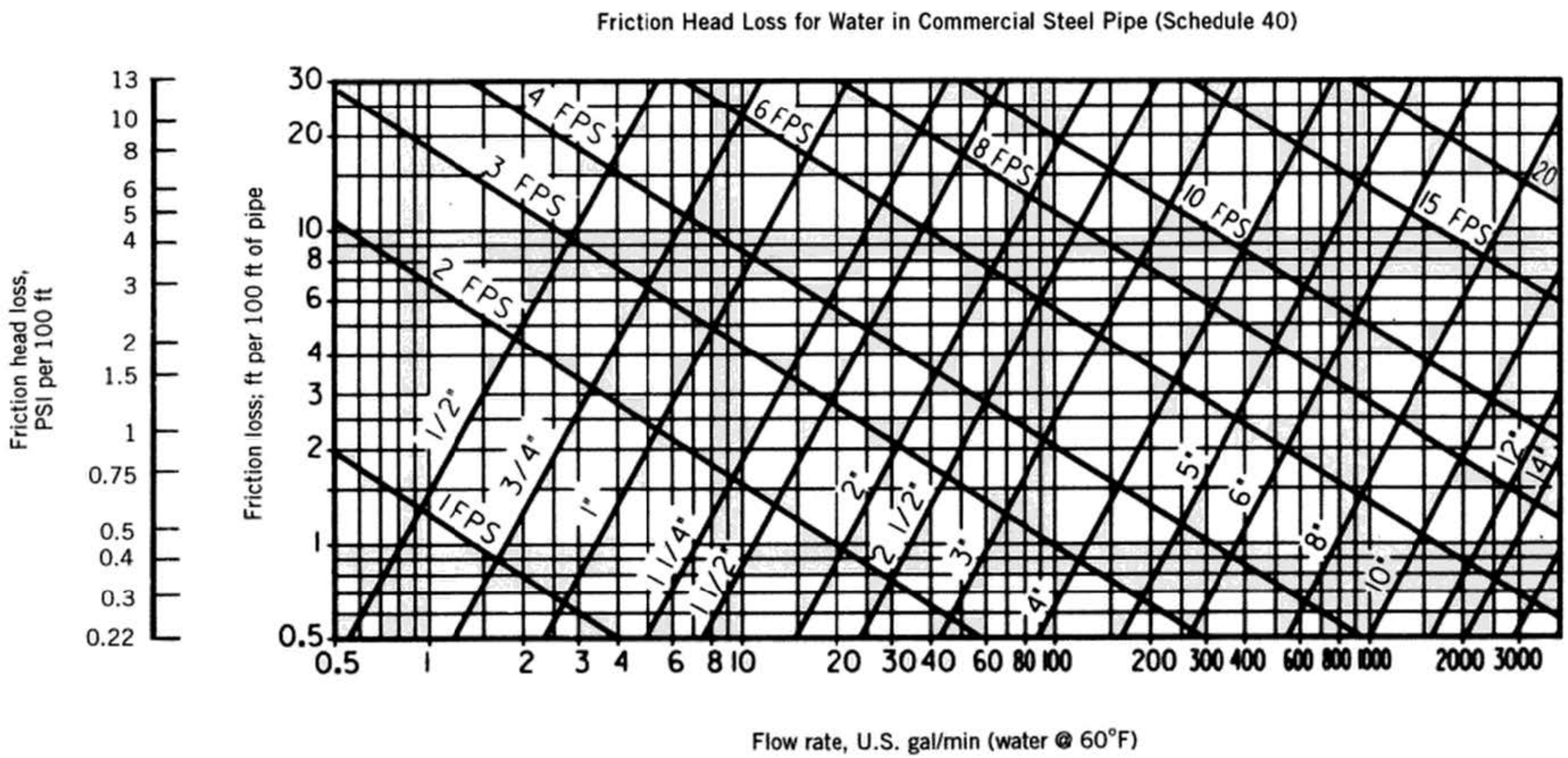

figure 3.1 **Chart of friction head loss in Schedule 40 black iron or steel pipe, for water at 60°F, in feet of water and psi per 100 ft of equivalent pipe length. Pipe sizes are nominal. (Reprinted by permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia, from the 1993 *ASHRAE Handbook—Fundamentals.*)**

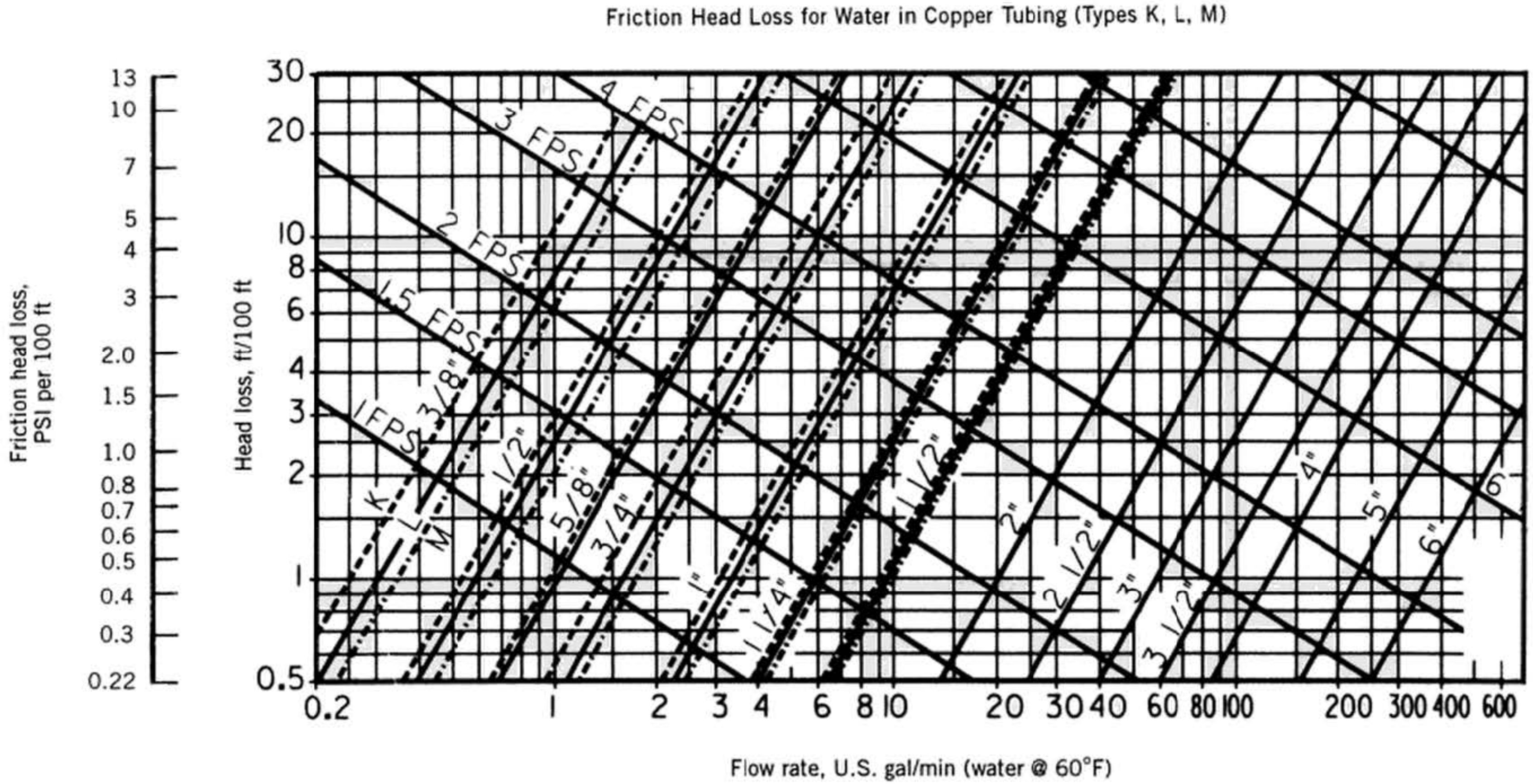

figure 3.2 **Chart of friction head loss in copper pipe and tubing for water at 60°F, in feet of water and psi per 100 ft of equivalent pipe length. Pipe and tubing sizes are nominal. (Reprinted by permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia, from the 1993 *ASHRAE Handbook—Fundamentals.*)**

Friction Head Loss for Water in Plastic Pipe (Schedule 80)

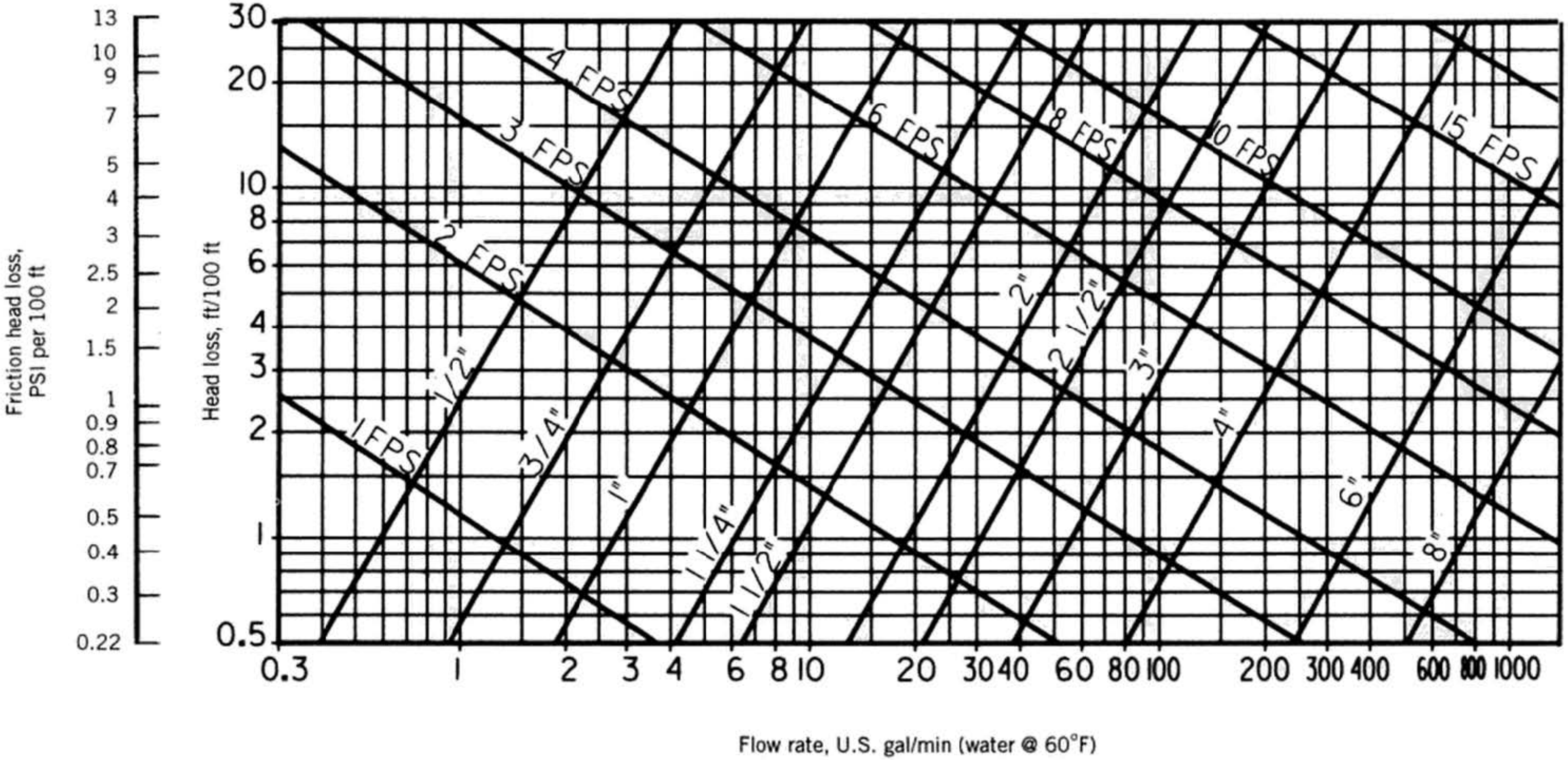

figure 3.3 Chart of friction head loss in Schedule 80 plastic pipe for water at 60°F, in feet of water and psi per 100 ft of equivalent pipe length. Pipe sizes are nominal. (Reprinted by permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia, from the 1993 *ASHRAE Handbook—Fundamentals.*)

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Table 3.6(a) Flow (gpm), Velocity (*V*, fps) and Friction Head Loss (*H*, ft of water) for Schedule 40 Thermoplastic Pipe Per 100 ft of Equivalent Length

	Pipe Size																					
	½ in.		*¾ in.*		*1 in.*		*1¼ in.*		*1½ in.*		*2 in.*		*2½ in.*		*3 in.*		*4 in.*		*6 in.*		*8 in.*	
Flow, gpm	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*
1	1.1	1.2	1.3	1.0																		
2	2.3	4.2	3.2	5.6																		
5	5.6	22.9	4.4	10.4	1.9	1.7	1.1	0.4														
7	7.9	42.7	6.3	20.2	2.7	3.1	1.6	0.8	1.1	0.4												
10	11.3	82.6	9.5	42.8	3.9	6.1	2.2	1.6	1.6	0.7												
15	16.9	175.0	12.6	73.0	5.8	12.9	3.3	3.3	2.4	1.6	1.5	0.5	1.0	0.2								
20			15.8	110.3	7.7	22.0	4.4	5.7	3.2	2.6	2.0	0.8	1.4	0.3								
25					9.6	33.2	5.5	8.6	4.0	4.0	2.4	1.2	1.7	0.5	1.1	0.2						
30					11.6	46.5	6.6	12.0	4.9	5.6	2.9	1.6	2.1	0.7	1.3	0.2						
35					13.5	61.9	7.7	15.9	5.7	7.5	3.4	2.2	2.4	0.9	1.5	0.3						
40					15.4	79.3	8.8	20.4	6.5	9.5	3.9	2.8	2.7	1.2	1.8	0.4	1.0	0.1				
45							9.9	25.4	7.3	11.9	4.4	3.5	3.1	1.5	2.0	0.5	1.2	0.1				
50							11.0	30.9	8.1	14.4	4.9	4.2	3.4	1.8	2.2	0.6	1.3	0.2				
60							13.3	43.3	9.7	20.2	5.9	5.9	4.1	2.5	2.7	0.9	1.5	0.2				
70							15.5	57.5	11.3	26.9	6.8	7.9	4.8	3.3	3.1	1.2	1.8	0.3				
75									12.1	30.6	7.3	8.9	5.1	3.8	3.3	1.3	1.9	0.3				
80									12.9	34.4	7.8	10.1	5.5	4.3	3.5	1.5	2.0	0.4				
90									14.5	42.9	8.8	12.5	6.2	5.3	4.0	1.8	2.3	0.5	1.0	0.1		
100									16.2	52.1	9.8	15.2	6.8	6.4	4.4	2.2	2.6	0.6	1.1	0.1		
125											12.2	23.0	8.5	9.7	5.5	3.4	3.2	0.9	1.4	0.1		
150											14.6	32.3	10.3	13.6	6.6	4.7	3.8	1.2	1.7	0.2		
175											17.1	43.0	12.0	18.1	7.7	6.3	4.5	1.7	2.0	0.2	1.1	0.1
200													13.7	23.2	8.8	8.0	5.1	2.1	2.3	0.3	1.3	0.1
250													17.1	35.0	11.0	12.1	6.4	3.2	2.8	0.4	1.6	0.1
300															13.2	17.0	7.7	4.5	3.4	0.6	1.9	0.2
350															15.5	22.6	8.9	6.0	3.9	0.8	2.3	0.2
400																	10.2	7.6	4.5	1.0	2.6	0.3
450																	11.5	9.5	5.1	1.3	2.9	0.3
500																	12.8	11.5	5.6	1.6	3.2	0.4
750																	19.2	24.5	8.4	3.3	4.9	0.9
1000																			11.2	5.6	6.5	1.5
1250																			14.0	8.5	8.1	2.2
1500																			16.8	12.0	9.7	3.1

Note: The figures have been rounded to one decimal place. For exact data refer to original source.
Source. Data extracted, with permission, from *Chemtrol Thermoplastic Piping Technical Manual.*

Table 3.6(b) Flow (gpm), Velocity (*V*, fps) and Friction Head Loss (*H*, ft of water) for Schedule 80 Thermoplastic Pipe Per 100 Ft. of Equivalent Length

	Pipe Size																					
Flow,	*1/2 in.*		*3/4 in.*		*1 in.*		*1 1/4 in.*		*1 1/2 in.*		*2 in.*		*2 1/2 in.*		*3 in.*		*4 in.*		*6 in.*		*8 in.*	
gpm	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*
1/4																						
1/2																						
3/4	1.1	1.3																				
1	1.5	2.2	0.8	0.5																		
3	4.4	17.1	2.4	3.7	1.4	1.0																
5	7.4	44.1	3.9	9.5	2.3	9.5	1.3	0.6														
7	10.3	82.3	5.5	17.6	3.3	5.0	1.8	1.2	1.3	0.5												
10	14.8	159.3	7.8	34.1	4.7	9.7	2.6	2.3	1.9	1.1	1.1	0.3										
15			11.8	72.3	7.0	20.4	3.9	4.9	2.8	2.2	1.7	0.6	1.2	0.3								
20			15.7	123.1	9.3	34.8	5.2	8.4	3.8	3.8	2.2	1.1	1.6	0.5	1.0	0.2						
25					11.7	52.6	6.5	12.6	4.7	5.7	2.8	1.6	1.9	0.7	1.2	0.2						
30					14.0	78.8	7.8	17.7	5.6	8.0	3.4	2.3	2.3	1.0	1.5	0.3						
35					16.3	98.2	9.1	23.6	6.6	10.7	3.9	3.0	2.7	1.3	1.7	0.4	1.0	0.1				
40							10.4	30.2	7.5	13.7	4.5	3.9	3.1	1.6	2.0	0.5	1.1	0.1				
45							11.7	37.5	8.4	17.1	5.0	4.4	3.5	2.0	2.2	0.7	1.3	0.2				
50							13.0	45.6	9.4	20.7	5.6	5.9	3.9	2.5	2.5	0.8	1.4	0.2				
60							15.6	69.9	11.3	29.0	6.1	8.2	4.7	3.4	3.0	1.2	1.7	0.3				
70									13.1	38.6	7.8	10.9	5.5	4.6	3.5	1.5	2.0	0.4				
75									14.1	43.9	8.4	12.4	5.8	5.2	3.7	1.7	2.1	0.5				
80									15.0	49.5	8.9	14.0	6.2	5.8	4.0	2.0	2.3	0.5	1.0	0.1		
90									16.9	61.5	10.1	17.4	7.0	7.3	4.5	2.5	2.6	0.6	1.1	0.6		
100											11.2	21.2	7.8	8.8	5.0	3.0	2.9	0.8	1.3	0.1		
125											14.0	32.0	9.7	13.3	6.2	4.5	3.6	1.2	1.6	0.2		
150											16.7	44.9	11.7	18.7	7.5	6.3	4.3	1.6	1.9	0.2	1.1	0.1
175													13.6	24.9	8.7	8.4	5.0	2.2	2.2	0.3	1.3	0.1
200													15.6	31.9	10.0	10.7	5.7	2.8	2.5	0.4	1.4	0.1
250															12.5	16.2	7.1	4.2	3.1	0.6	1.8	0.1
300															14.9	22.7	8.6	5.9	3.8	0.8	2.1	0.2
350															17.4	30.3	10.0	7.8	4.4	1.1	2.5	0.3
400																	11.4	10.0	5.0	1.4	2.9	0.4
450																	12.9	12.4	5.6	1.7	3.2	0.4
500																	14.3	15.1	6.3	2.0	3.6	0.5
750																	21.4	31.9	9.4	4.3	5.4	1.1
1000																			12.5	7.4	7.1	1.9
1250																			15.7	11.1	8.9	2.8
1500																					10.7	4.0

Note: The figures have been rounded to one decimal place.
Source. Data extracted, with permission, from *Chemtrol Thermoplastic Piping Technical Manual.*

Table 3.7 Equivalent Length of Plastic Pipe (ft) for Standard Plastic Fittings

Type Fitting	Size Fitting, in. ½	¾	1	1¼	1½	2	2½	3	4	6	8
90° Standard elbow	1.6	2.1	2.6	3.5	4.0	5.5	6.2	7.7	10.1	15.2	20.0
45° Standard elbow	0.8	1.1	1.4	1.8	2.1	2.8	3.3	4.1	5.4	8.1	10.6
90° Long radius elbow	1.0	1.4	1.7	2.3	2.7	4.3	5.1	6.3	8.3	12.5	16.5
90° Street elbow	2.6	3.4	4.4	5.8	6.7	8.6	10.3	12.8	16.8	25.3	33.3
45° Street elbow	1.3	1.8	2.3	3.0	3.5	4.5	5.4	6.6	8.7	13.1	17.3
Square corner elbow	3.0	3.9	5.0	6.5	7.6	9.8	11.7	14.6	19.1	28.8	37.9
Standard tee											
with flow thru run	1.0	1.4	1.7	2.3	2.7	4.3	5.1	6.3	8.3	12.5	16.5
with flow thru branch	4.0	5.1	6.0	6.9	8.1	12.0	14.3	16.3	22.1	32.2	39.9

Source. Data extracted, with permission, from *Chemtrol Thermoplastic Piping Technical Manual.*

Table 3.8 Sizing Tables Based on Velocity Limitation

	V=4 fps				V=8 fps			
	Column A		Column B		Column A		Column B	
Nominal Size,[a] in.	Flow, gpm	Load,[a] WSFU	Load,[b] WSFU	Friction,[c] psi/100 ft	Flow, gpm	Load,[a] WSFU	Load,[b] WSFU	Friction,[d] psi/100 ft
(a) Copper and Brass Pipe, Standard Pipe Size (Schedule 40) (Smooth)								
½	3.8			6.8	7.7	10		24
¾	6.6	8		5.0	13.2	18		18
1	11.0	15		3.7	22.1	34		13.3
1¼	18.3	27		2.7	36.6	70	21	9.7
1½	25.1	40	10	2.3	50.1	125	51	8.2
2	41.6	92	31	1.7	83.2	290	165	6.1
2½	61.2	180	80	1.3	122.4	490	390	4.9
3	91.8	330	210	1.1	183.6	850	810	3.9
4	156.7	680	620	0.8	313.4	1900	1900	2.8
(b) Copper Water Tube, Type M (Smooth)								
⅜	2.0			9.6	3.9			34
½	3.2			6.4	6.3	8		26
¾	6.4	8		5.0	12.9	18		18
1	10.9	15		3.6	21.8	34		13
1¼	16.3	24		2.9	32.6	60	15	10
1½	22.8	35		2.4	45.6	110	38	8.5
2	38.6	80	26	1.8	77.2	270	140	6.2
2½	59.5	170	70	1.4	119.0	470	360	5.0
3	84.9	300	170	1.1	169.9	750	730	4.0
4	149.3	625	575	0.8	296.7	1750	1750	2.8
(c) Copper Water Tube, Type L (Smooth)								
⅜	1.8			11.0	3.6			39
½	2.9			8.1	5.8	7		29
¾	6.0	7		5.3	12.1	17		19
1	10.3	14		4.0	20.6	30		14
1¼	15.7	23		3.0	31.3	55	15	11
1½	22.2	35		2.5	44.4	100	36	8.7
2	38.8	80	26	1.8	77.2	270	140	6.2
2½	59.5	170	70	1.4	119.0	470	360	5.0
3	84.9	300	170	1.1	169.9	750	730	4.0
4	149.3	625	575	0.8	298.7	1750	1750	2.8
(d) Copper Water Tube, Type K (Smooth)								
⅜	1.6			11.0	3.2			36
½	2.7			8.2	5.4	6		30
¾	5.4	6		5.6	10.9	15		20
1	9.7	13		4.1	19.4	29		14
1¼	15.2	24		3.1	30.4	55	15	12
1½	21.5	33		2.6	43.0	97	35	9.0
2	38.8	80	26	1.8	77.2	270	140	6.2
2½	59.5	170	70	1.4	119.0	470	360	5.0
3	84.9	300	170	1.1	169.9	750	730	4.0
4	149.3	625	575	0.8	298.7	1750	1750	2.8

Table 3.9 Estimated Hot Water Demand

Building Type	*Hot Water[a] per Person, gal/day*	*Maximum Hourly Demand, Portion of Daily Use, gal*	*Duration of Peak Load, hr*	*Storage Capacity, Portion of Daily Use, gal*	*Heating Capacity, Portion of Daily Use, gph*
Residences, apartments, hotels[b]	20–40	1/7	4	1/5	1/7
Office buildings	2–3	1/5	2	1/5	1/6
Factory buildings	5	1/3	1	2/5	1/8

[a] at 140°F.

[b] Allow additional 15 gal per dishwasher and 40 gal per domestic clothes washer.

Source. From Ramsey and Sleeper, *Architectural Graphic Standards*, 8th ed., 1989, reprinted by permission of John Wiley & Sons.

Table 3.10 Runout Pipe Size According to Number and Size of Outlets Supplied

Minimum Pipe Size, in.	*Maximum Number of 3/8-in. Outlets*	*Maximum Number of 1/2-in. Outlets*	*Maximum Number of 3/4-in. Outlets*
1/2	3	1	—
3/4	4	3	1
1	15	8	3

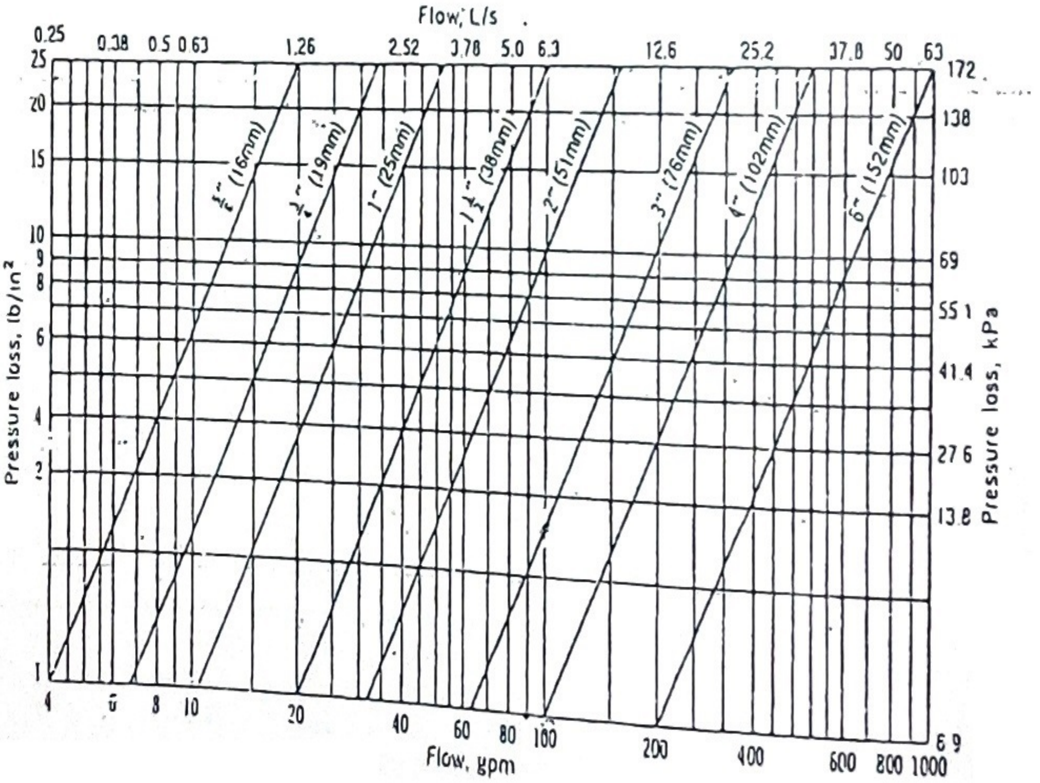

figure 3.4 Pressure loss (friction head loss) in disk-type water meters .
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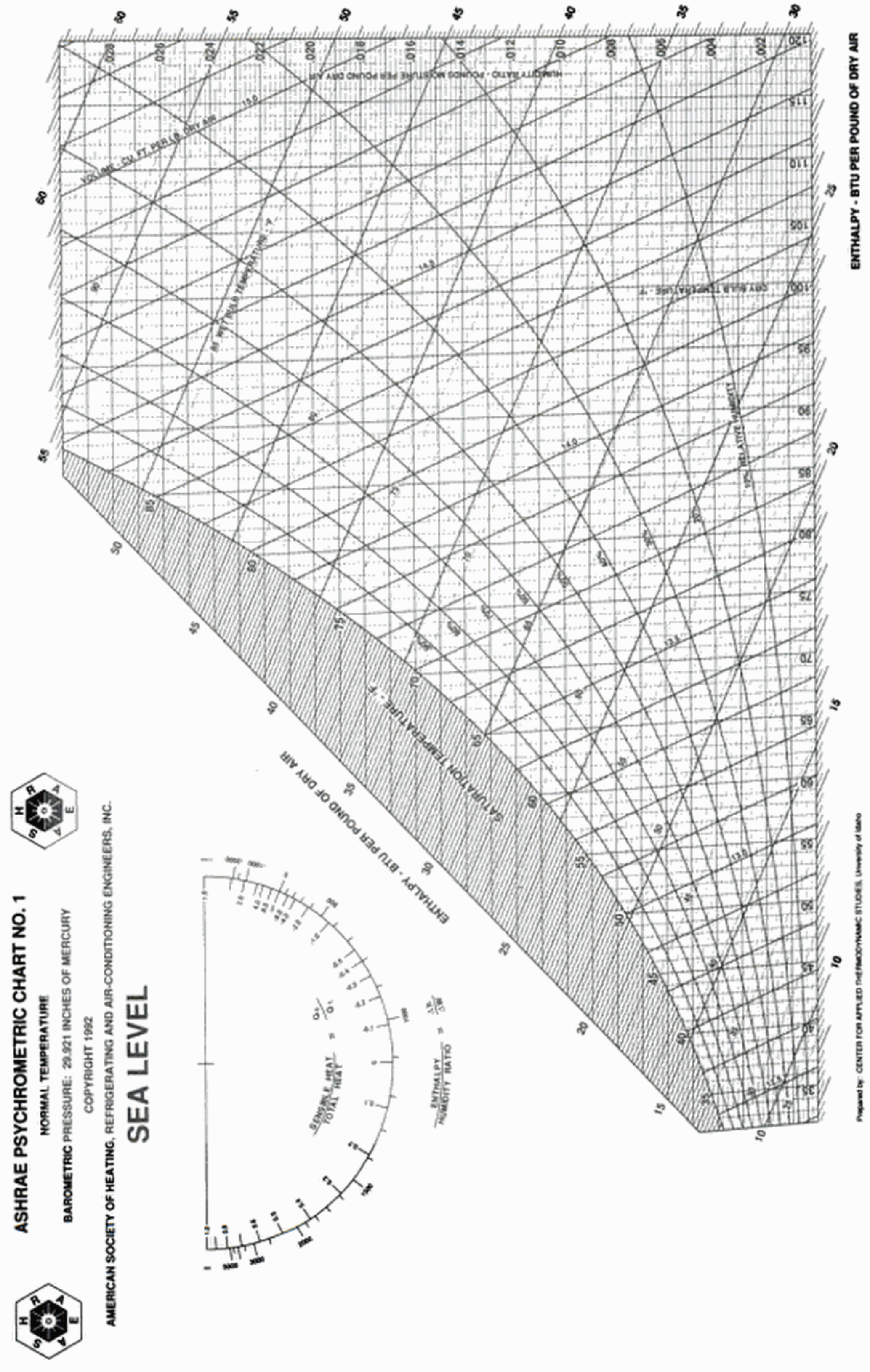

(b)

figure 3.5 ASHREA PSYCHROMETRIC CHART

Figure 2.19*(b)*.

Table 3.11 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*	*Velocity, fps*
1 1/4							3.40	1.78
1 3/8					3.13	1.34	4.44	1.90
1 1/2					3.91	1.42	5.53	2.01
1 5/8					4.81	1.50	6.80	2.12
2					8.42	1.72	11.9	2.43
2 1/2			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

[a]Computed from the Manning Formula for 1/2-full pipe, $n = 0.015$.
[b]Half full means filled to a depth equal to one-half the inside diameter.

Note: For 1/4 full, multiply discharge by 0.274 and multiply velocity by 0.701. For 1/3 full, multiply discharge by 0.44 and multiply velocity by 0.80. For 3/4 full, multiply discharge by 1.82 and multiply velocity by 1.13. For full, multiply discharge by 2.00 and multiply velocity by 1.00. For smoother pipe, multiply discharge and velocity by 0.015 and divide by n value of smoother pipe.

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Table 3.12 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)	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	½
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 1¼ in. or less	1
trap size 1½ in.	2
trap size 2 in.	3
trap size 2½ 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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Table 3.13 Minimum Size of Nonintegral Traps

Plumbing Fixture	*Trap Size in.*
Bathtub (with or without overhead shower)	1½
Bidet	1¼
Clothes washing machine standpipe	2
Combination sink and wash (laundry) tray	1½
Combination sink and wash (laundry) tray with food waste grinder unit[a]	1½
Combination kitchen sink, domestic, dishwasher, and food waste grinder	1½
Dental unit or cuspidor	1¼
Dental lavatory	1¼
Drinking fountain	1¼
Dishwasher, commercial	2
Dishwasher, domestic (nonintegral trap)	1½
Floor drain	2
Food waste grinder, commercial	2
Food waster grinder, domestic	1½
Kitchen sink, domestic, with food waste grinder unit	1½
Kitchen sink, domestic	1½
Kitchen sink, domestic, with dishwasher	1½
Lavatory, common	1¼
Lavatory (barber shop, beauty parlor or surgeon's)	1½
Lavatory, multiple type (wash fountain or wash sink)	1½
Laundry tray (1 or 2 compartments)	1½
Shower stall or drain	2
Sink (surgeon's)	1½
Sink flushing rim type (flush valve supplied)	3
Sink (service type with floor outlet trap standard)	3
Sink (service trap with P trap)	2
Sink, commercial (pot, scullery, or similar type)	2
Sink, commercial (with food grinder unit)	2

[a]Separate trap required for wash tray and separate trap required for sink compartment with food waste grinder unit.

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Table 3.14 Horizontal Fixture Branches and Stacks

Diameter of Pipe, in.	*Maximum Number of Fixture Units That May Be Connected to*			
	Any Horizontal Fixture Branch,[a] dfu	*One Stack of Three Branch Intervals or Less, dfu*	*Stacks with More Than Three Branch Intervals*	
			Total for Stack, dfu	*Total at One Branch Interval, dfu*
1½	3	4	8	2
2	6	10	24	6
2½	12	20	42	9
3	20[b]	48[b]	72[b]	20[b]
4	160	240	500	90
5	360	540	1100	200
6	620	960	1900	350
8	1400	2200	3600	600
10	2500	3800	5600	1000
12	3900	6000	8400	1500
15	7000			

[a]Does not include branches of the building drain.
[b]Not more than two water closets or bathroom groups within each branch interval nor more than six water closets or bathroom groups on the stack.

Note: Stacks shall be sized according to the total accumulated connected load at each story or branch interval and may be reduced in size as this load decreases to a minimum diameter of half of the largest size required.

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Table 3.15 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

[a]On site sewers that serve more than one building may be sized according to the current standards and specifications of the Administrative Authority for public sewers.
[b]Not over two water closets or two bathroom groups, except that in single family dwellings, not over three water closets or three bathroom groups may be installed.

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Table 3.16 Maximum Length of Trap Arm

Diameter of Trap Arm, in.	*Distance—Trap to Vent, ft*
1¼	3.5
1½	5
2	8
3	10
4	12

Note: This table has been expanded in the "Length" requirements to reflect expanded application of the wet venting principles. See Section 10.8 d. Slope shall not exceed ¼ in./ft.

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Table 3.17 Size and Length of Vents

Size of Soil or Waste Stack, in.	*Fixture Units Connected*	*Diameter of Vent Required, in.:* 1¼	1½	2	2½	3	4	5	6	8
		Maximum Length of Vent, ft								
1½	8	50	150							
2	12	30	75	200						
2	20	26	50	150						
2½	42		30	100	300					
3	10		30	100	100	600				
3	30			60	200	500				
3	60			50	80	400				
4	100			35	100	260	1000			
4	200			30	90	250	900			
4	500			20	70	180	700			
5	200				35	80	350	1000		
5	500				30	70	300	900		
5	1100				20	50	200	700		
6	350				25	50	200	400	1300	
6	620				15	30	125	300	1100	
6	960					24	100	250	1000	
6	1900					20	70	200	700	
8	600						50	150	500	1300
8	1400						40	100	400	1200
8	2200						30	80	350	1100
8	3600						25	60	250	800
10	1000							75	125	1000
10	2500							50	100	500
10	3800							30	80	350
10	5600							25	60	250

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Table 3.18 Size of Roof Gutters[a]

	Maximum Projected Roof Area for Gutters	
	1/16-in. Slope[c]	
Diameter of Gutter,[b] in.	*ft²*	*gpm*
3	170	7
4	360	15
5	625	26
6	960	40
7	1380	57
8	1990	83
10	3600	150

[a]This table is based upon a maximum rate of rainfall of 4 in./hr. Where maximum rates are more or less than 4 in./hr, the figures for drainage area shall be adjusted by multiplying by 4 and dividing by the local rate in inches per hour. See Figure 10.44.

[b]Gutters other than semicircular may be used provided they have an equivalent cross-sectional area.

[c]Capacities given for slope of 1/16 in./ft shall be used when designing for greater slopes.

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Table 3.19 Size of Vertical Conductors and Leaders

Diameter of Conductor or Leader, in.	*Design Flow in Conductor, gpm*	*Allowable Projected Roof Area at Various Rates of Rainfall, ft²*				
		1 in./h	*2 in./h*	*4 in./h*	*5 in./h*	*6 in./h*
2	23	2176	1088	544	435	363
2½	41	3948	1974	987	790	658
3	67	6440	3220	1610	1288	1073
4	144	13,840	6920	3460	2768	2307
5	261	25,120	12,560	6280	5024	4187
6	424	40,800	20,400	10,200	8160	6800
8	913	88,000	44,000	22,000	17,600	14,667

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Table 3.20 Size of Horizontal Storm Drains

Diameter of Conductor or Leader, in.	*Design Flow in Conductor, gpm*	*Allowable Projected Roof Area at Various Rates of Rainfall, ft²*				
		1 in./h	*2 in./h*	*4 in./h*	*5 in./h*	*6 in./h*
		Slope 1/16 in./ft				
2						
3						
4						
5	100	9600	4800	2400	1920	1600
6	160	15,440	7720	3860	3088	2575
8	340	32,720	16,360	8180	6544	5450
10	620	59,680	29,840	14,920	11,936	9950
12	1000	96,000	48,000	24,000	19,200	16,000
		Slope 1/8 in./ft				
2						
3	34	3290	1645	822	658	550
4	78	7520	3760	1880	1504	1250
5	139	13,360	6680	3340	2672	2230
6	222	21,400	10,700	5350	4280	3570
8	478	46,000	23,000	11,500	9200	7670
10	860	82,800	41,400	20,700	16,560	13,800
12	1384	133,200	66,600	33,300	26,640	22,200
15	2473	238,000	119,000	59,500	47,600	39,670
		Slope 1/4 in./ft				
2	17	1632	816	408	326	272
3	48	4640	2320	1160	928	775
4	110	10,600	5300	2650	2120	1770
5	196	18,880	9440	4720	3776	3150
6	314	30,200	15,100	7550	6040	5035
8	677	65,200	32,600	16,300	13,040	10,870
10	1214	116,800	58,400	29,200	23,360	19,470
12	1953	188,000	94,000	47,000	37,600	31,335
15	3491	336,000	168,000	84,000	67,200	56,000
		Slope 1/2 in./ft				
2	24	2304	1152	576	461	384
3	68	6580	3290	1644	1316	1100
4	156	15,040	7520	3760	3008	2510
5	278	26,720	13,360	6680	5344	4450
6	445	42,800	21,400	10,700	8560	7130
8	956	92,000	46,000	23,000	18,400	15,330
10	1721	165,600	82,800	41,400	33,120	27,600
12	2768	266,400	133,200	66,600	53,280	44,400
15	4946	476,000	238,000	119,000	95,200	79,330

Notes: Tables 10.9 and 10.10 are based on the rainfall rates shown. Local practice of the Administrative Authority should be consulted for the value to use for a particular place. For rainfall rates other than those shown, the allowable roof area is determined by dividing the value given above in the 1-in. column by the specified local rate. For conductors and leaders, the design flow rates are based on the pipes flowing between one-third, and one-half full. For rectangular leaders, the area shall be equal to the area of the circular pipe, provided the ratio of the sides of the leader does not exceed 3 to 1. For horizontal drains, the design flow rates are based on the pipes flowing full. See Figure 10.44.

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Table 3.21 Capacity of Septic Tanks[a]

Single Family Dwellings, Number of Bedrooms	Multiple Dwelling Units or Apartments—One Bedroom Each, Number of Units	Other Uses, Maximum Fixture Units Served	Minimum Septic Tank Capacity in gal
1–3		20	1000
4	2	25	1200
5 or 6	3	33	1500
7 or 8	4	45	2000
	5	55	2250
	6	60	2500
	7	70	2750
	8	80	3000
	9	90	3250
	10	100	3500

[a] Septic tanks sizes in this table include sludge storage capacity and the connection of domestic food waste disposal units without further volume increase.

Notes: Extra bedroom: 150 gal each. Extra dwelling units over 10: 250 gal each. Extra fixture units over 100: 25 gal/fixture unit.

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Table 3.22 Sewage Flows According to Type of Establishment

Type of Establishment	*Quantity*
Schools (toilets & lavatories only)	15 gal/day per person
Schools (toilets, lavatories, & cafeteria)	25 gal/day per person
Schools (toilets, lavatories, cafeteria & showers)	35 gal/day per person
Day workers at schools & offices	15 gal/ day per person
Day camps	25 gal/day per person
Trailer parks or tourist camps (with built-in bath)	50 gal/day per person
Trailer parks or tourist camps (with central bathhouse)	35 gal/day per person
Work or construction camps	50 gal/day per person
Public picnic parks (toilet wastes only)	5 gal/day per person
Public picnic parks (bathhouse, showers & flush toilets)	10 gal/day per person
Swimming pools & beaches	10 gal/day per person
Country clubs	25 gal/locker
Luxury residences & estates	150 gal/day per person
Rooming houses	40 gal/day per person
Boarding houses	50 gal/day per person
Hotels (with private baths—2 persons per room)	100 gal/day per person
Boarding schools	100 gal/day per person
Factories (gallons per person per shift—exclusive of industrial wastes)	25 gal/day per person
Nursing homes	75 gal/day per person
General hospitals	150 gal/day per person
Public institutions (other than hospitals)	100 gal/day per person
Restaurants (toilet & kitchen wastes per unit of serving capacity)	25 gal/day per person
Kitchen wastes from hotels, camps, boarding houses, etc., serving three meals per day	10 gal/day per person
Motels	50 gal/bed space
Motels with bath, toilet, and kitchen wastes	60 gal/bed space
Drive-in theaters	5 gal/car space
Stores	400 gal/toilet room
Service stations	10 gal/vehicle served
Airports	3–5 gal/passenger
Assembly halls	2 gal/seat
Bowling alleys	75 gal/lane
Churches (small)	3–5 gal/sanctuary seat
Churches (large with kitchens)	5–7 gal/sanctuary seat
Dance halls	2 gal/day per person
Laundries (coin-operated)	400 gal/machine
Service stations	1000 gal (first bay)
	500 gal (each additional bay)
Subdivisions or individual homes	75 gal/day per person
Marinas (flush toilets)	36 gal/fixture/hr
Urinals	10 gal/fixture/hr
Wash basins	15 gal/fixture/hr
Showers	150 gal/fixture/hr

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Table 3.23 Required Absorption Area in Seepage Pits for Each 100 gal of Sewage per Day

Time for 1-in. Drop, min	*Effective Absorption Area, ft²*
1	32
2	40
3	45
5	56
10	75
15	96
20	108
25	139
30	167

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Table 3.24 Tile Lengths for Each 100 gal of Sewage per Day

Time for 1-in. Drop, min	*Tile Length (ft) for Trench Widths of*		
	1 ft	*2 ft*	*3 ft*
1	25	13	9
2	30	15	10
3	35	18	12
5	42	21	14
10	59	30	20
15	74	37	25
20	91	46	31
25	105	53	35
30	125	63	42

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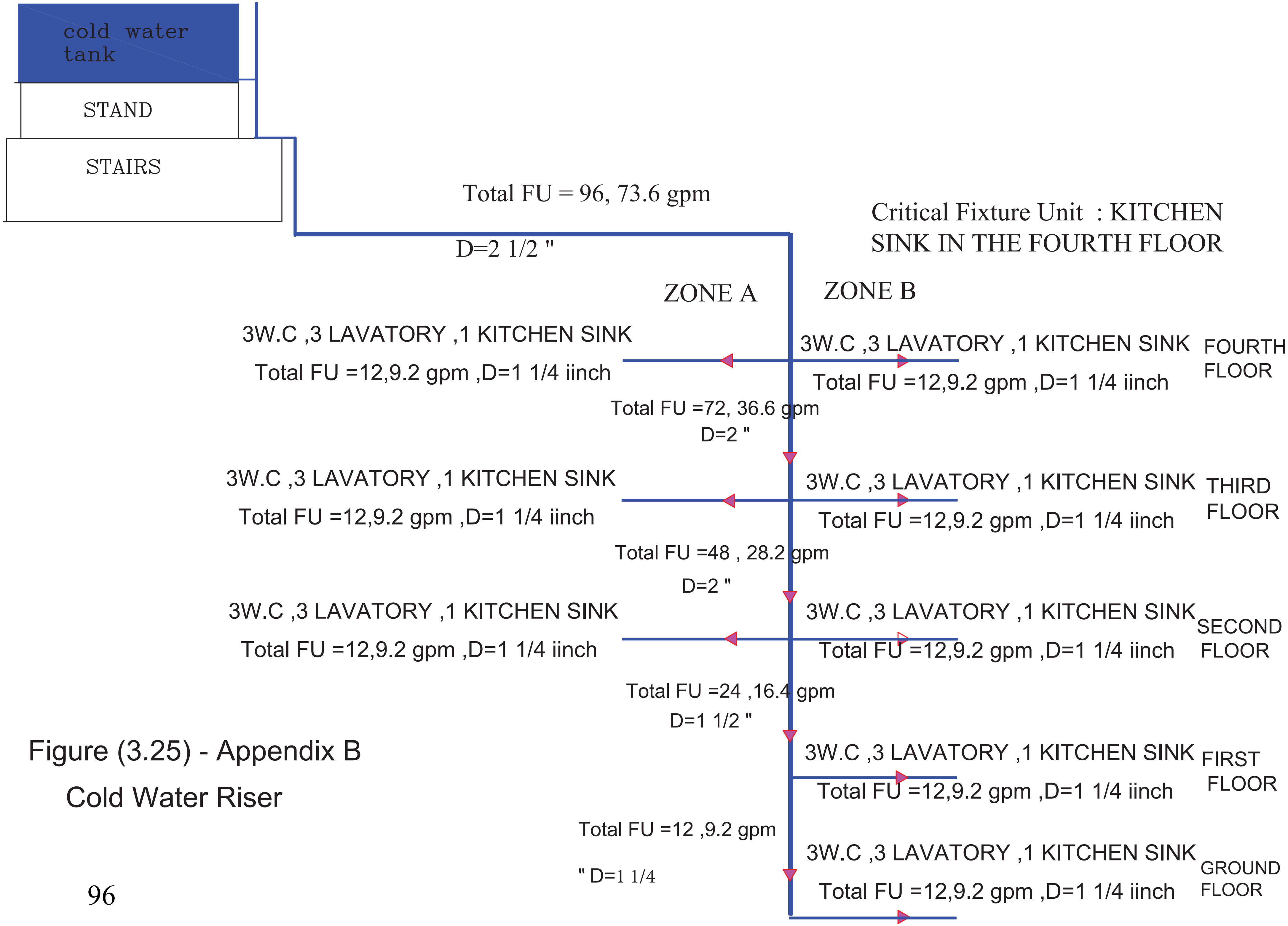


Figure (3.25) - Appendix B

Cold Water Riser

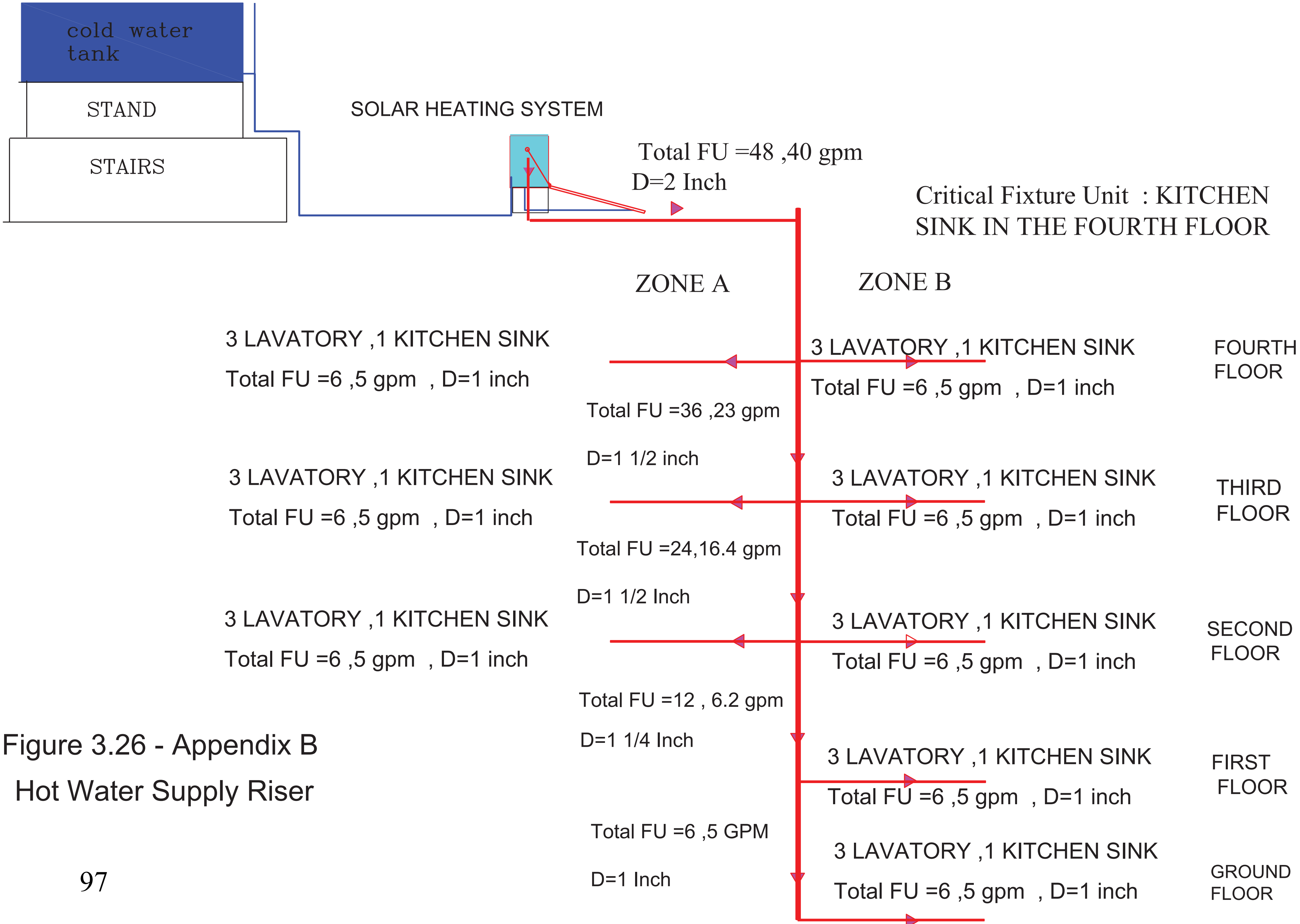


Figure 3.26 - Appendix B
Hot Water Supply Riser

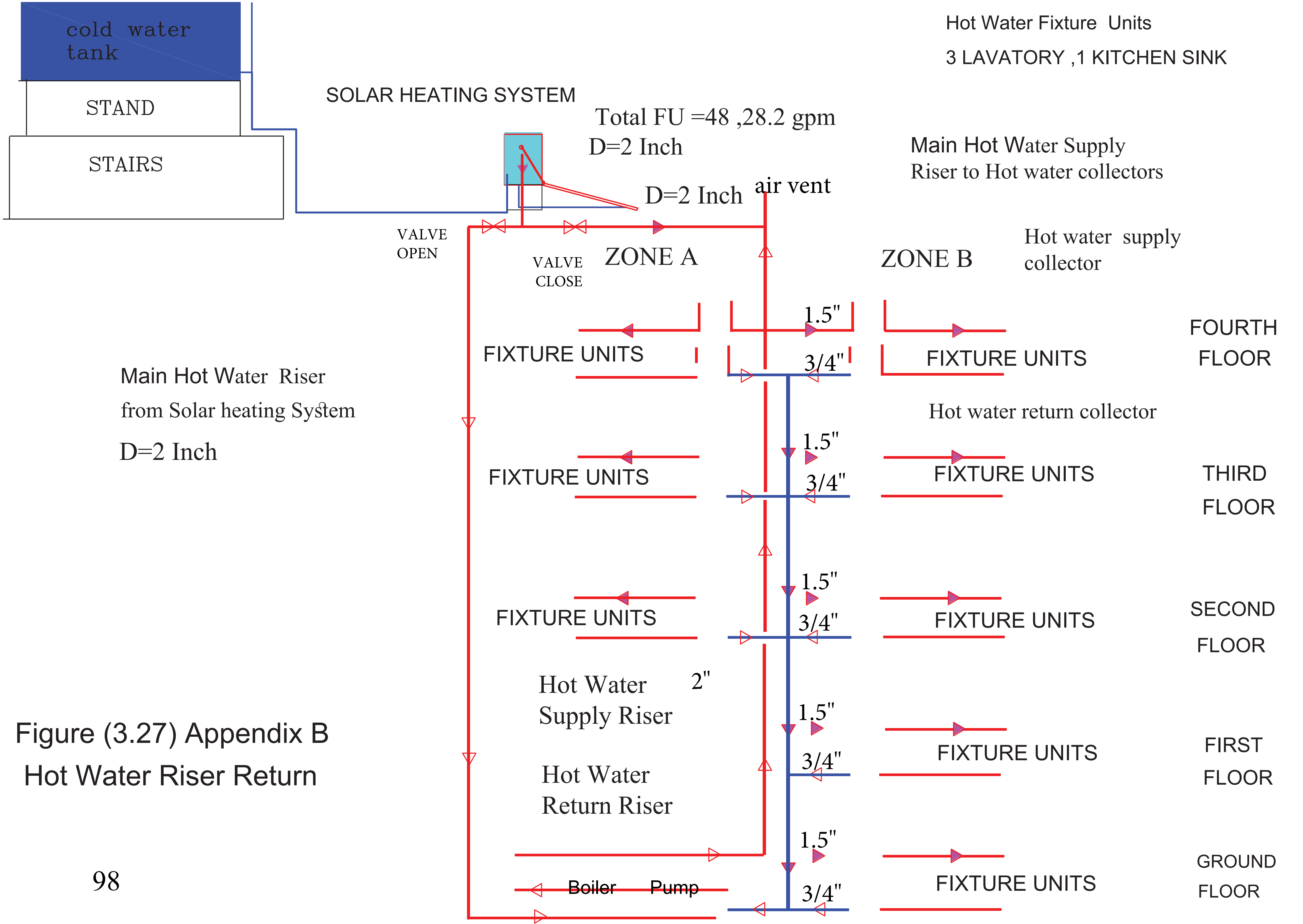


Figure (3.27) Appendix B
Hot Water Riser Return

BLACK WATER

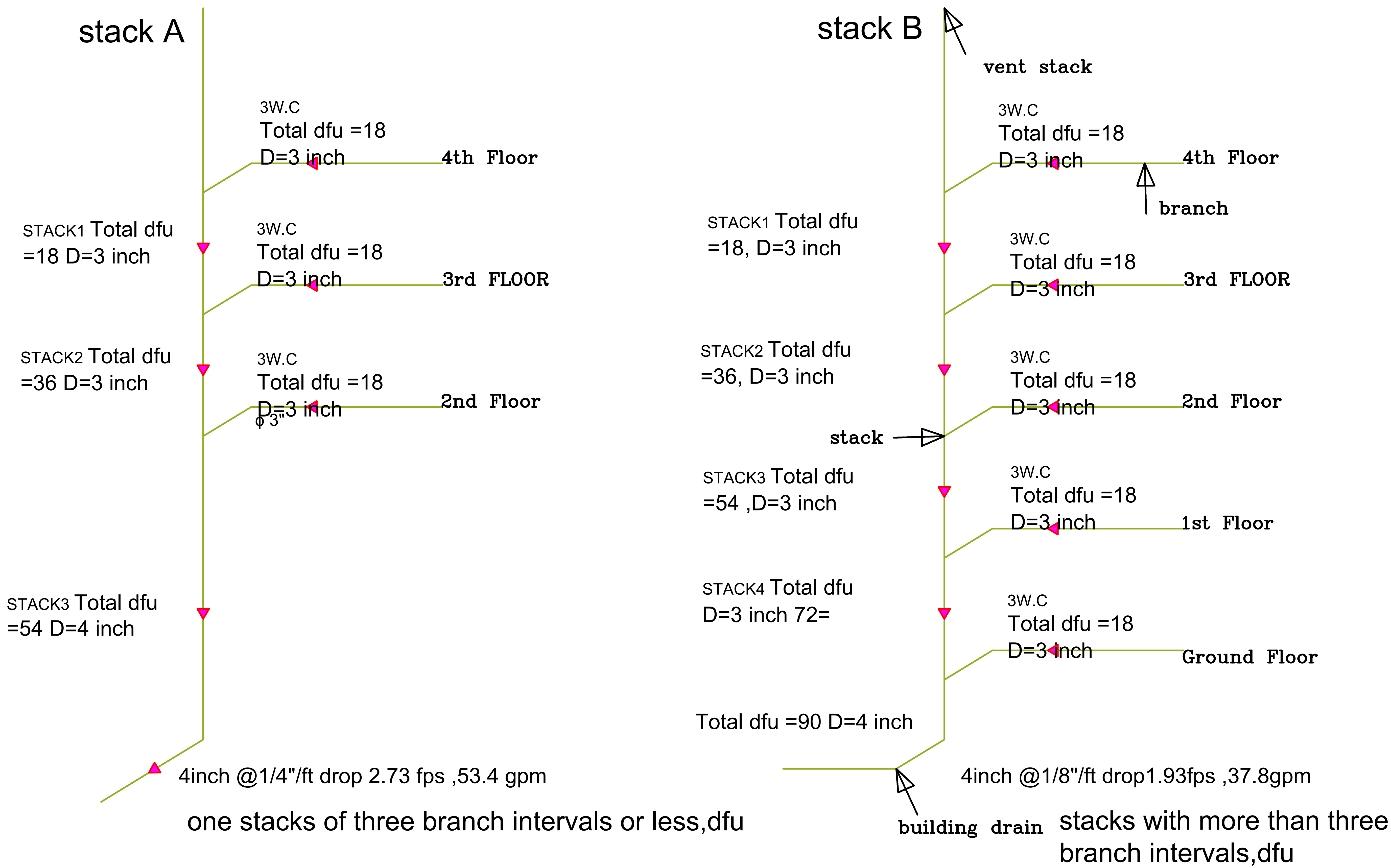


Figure (3.28) - Appendix B

Black Water Stacks

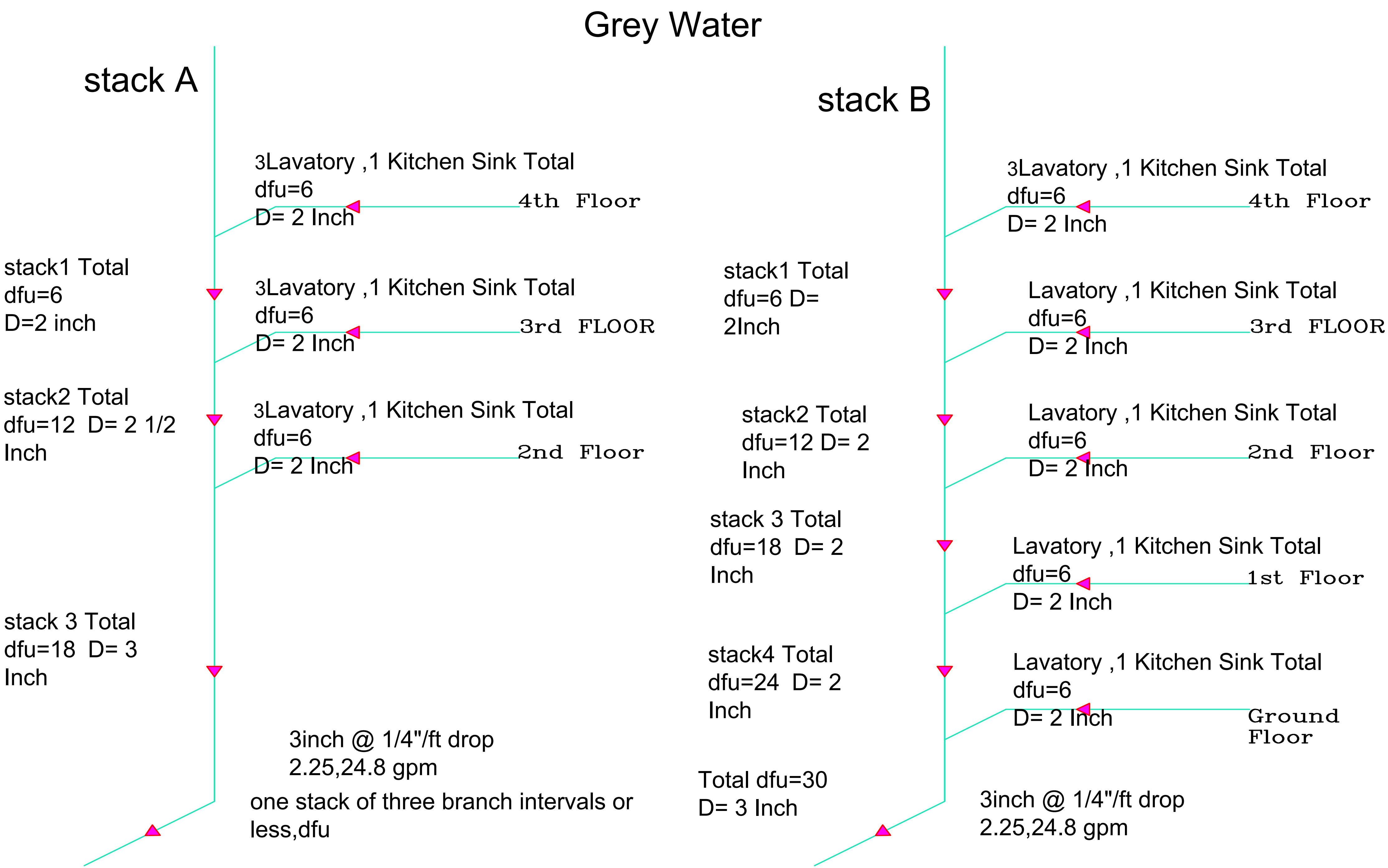


Figure (3.29) - Appendix B
Grey Water Stacks

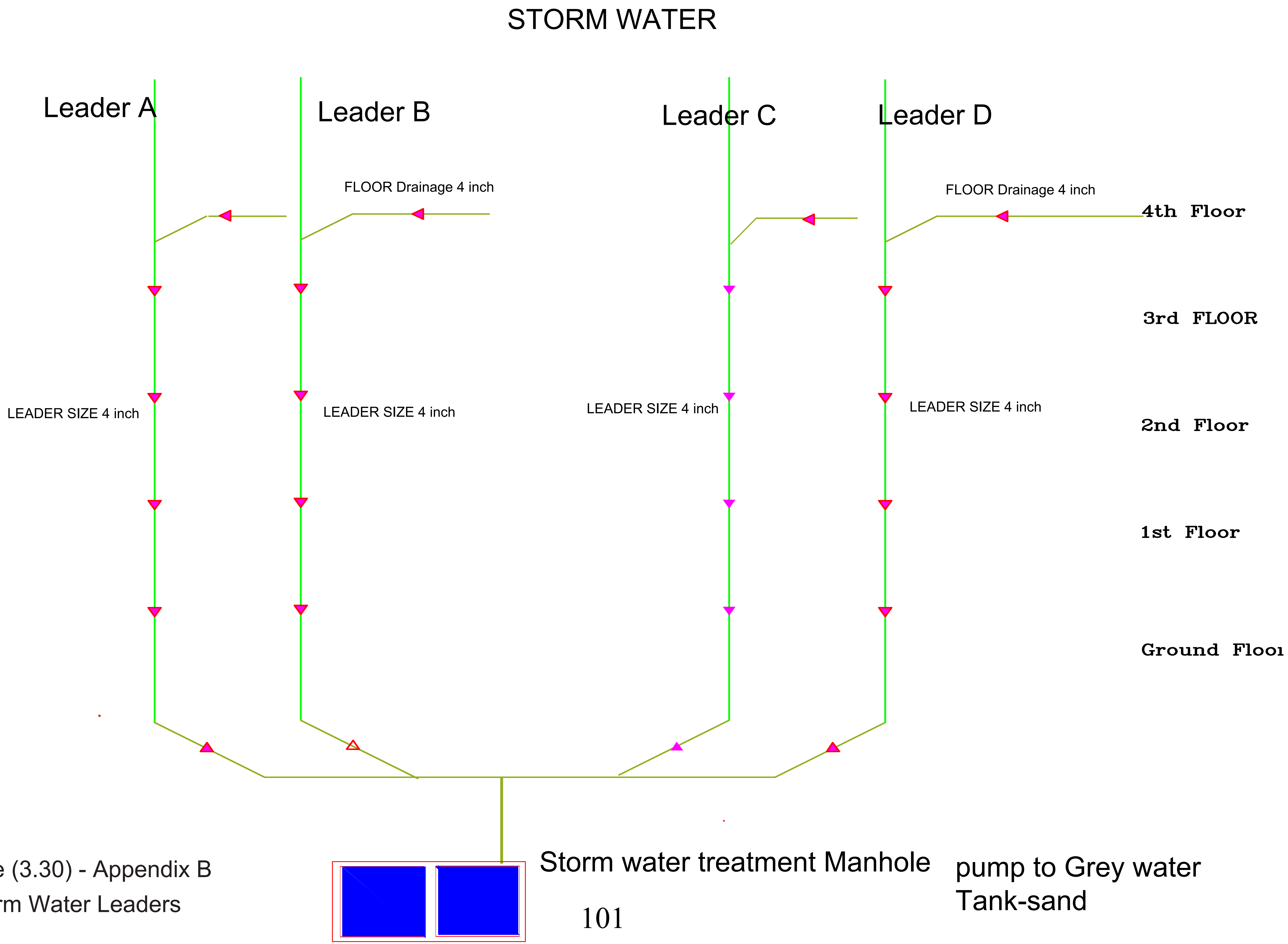


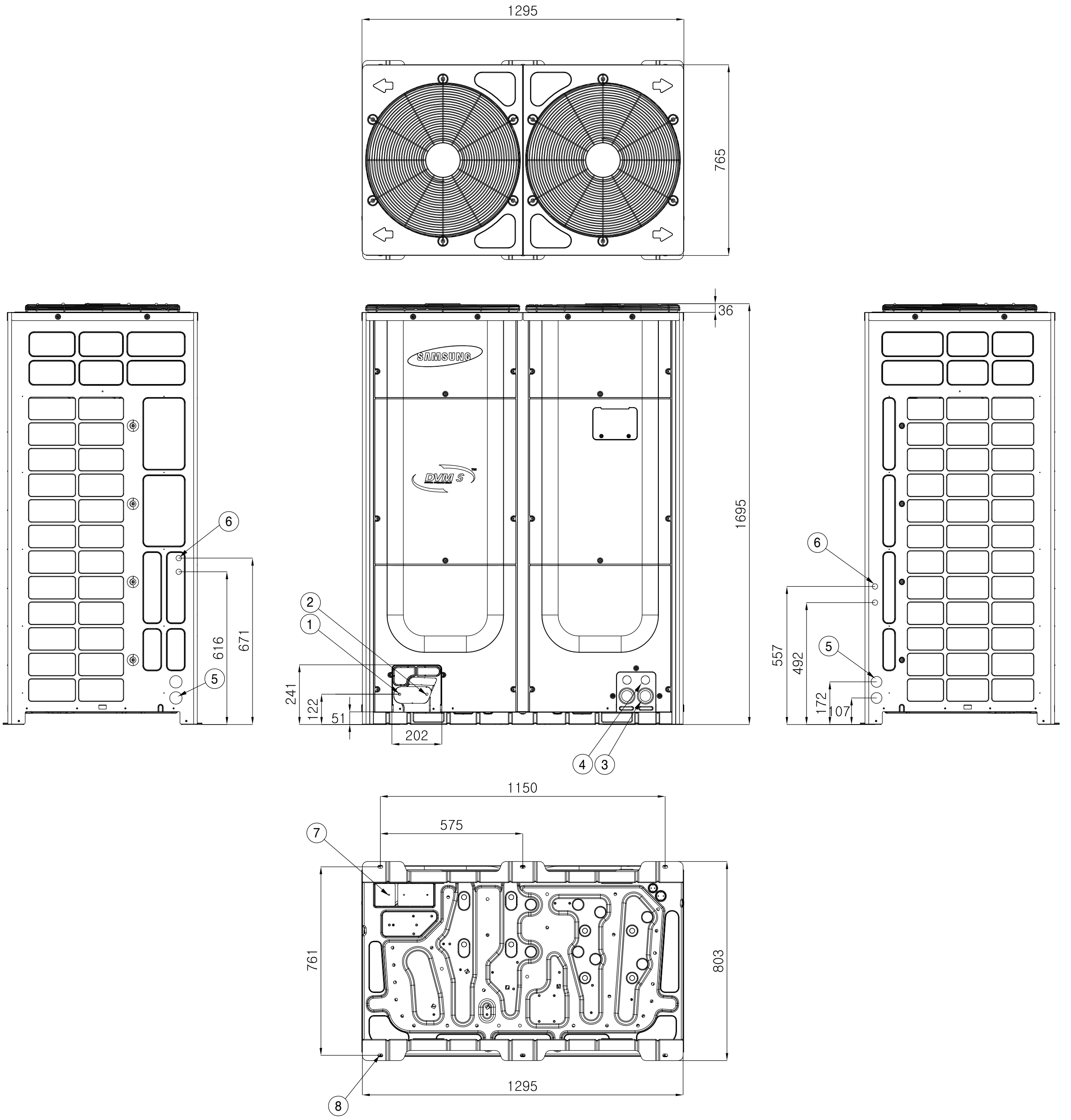
Figure (3.30) - Appendix B
Storm Water Leaders

Catalogue

6-1. Heat Pump

2) AM140/160/180/200/220FXVAGH✳✳✳

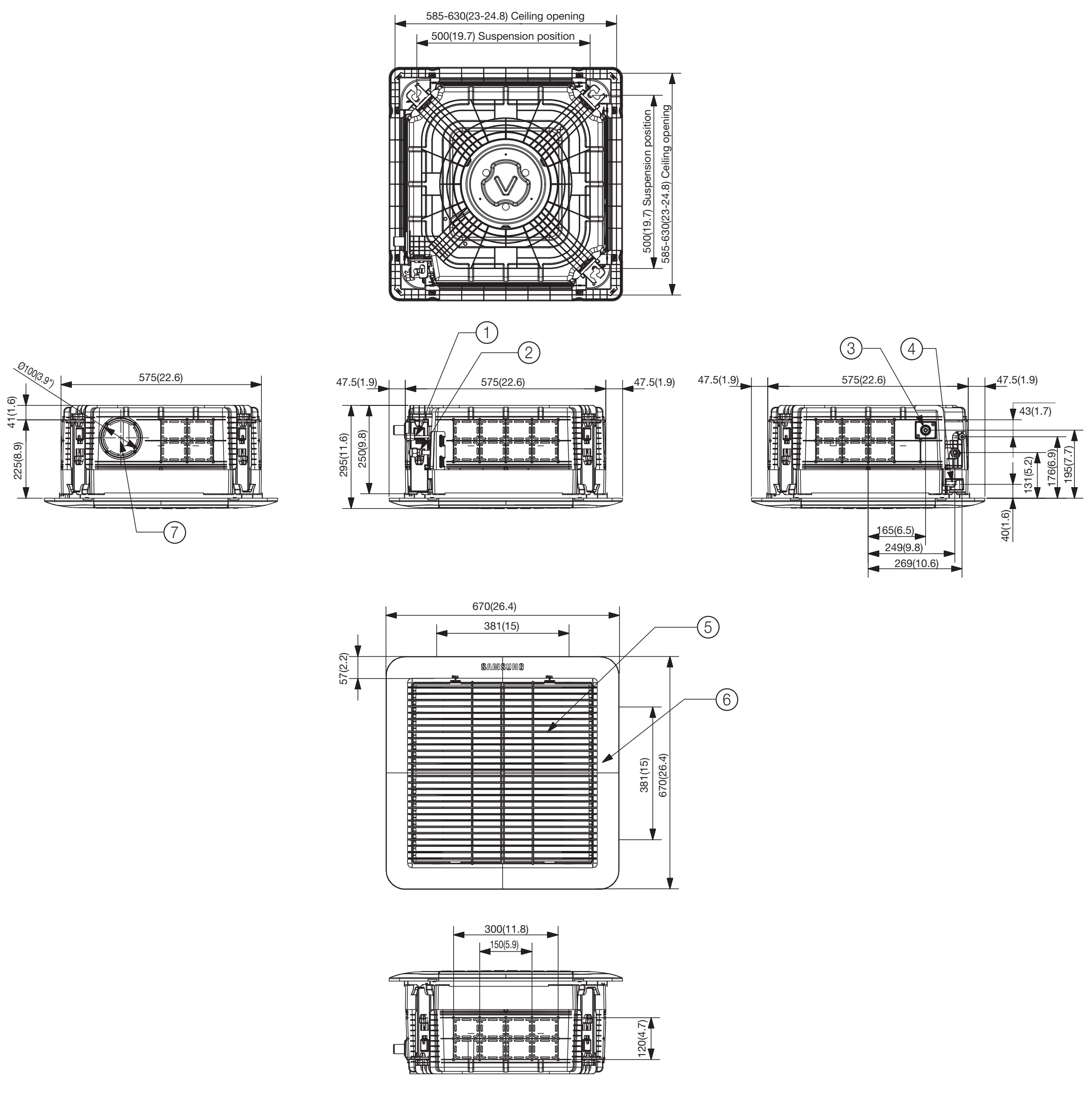
Unit : mm



No.	Name	Description	No.	Name	Description
①	Gas Ref. Pipe	-	⑤	Power Wiring Conduit	4 - Ø43.7
②	Liquid Ref. Pipe	-	⑥	Communication Wiring Conduit	8 - Ø22.0
③	Power Wiring Conduit	2 - Ø43.7	⑦	Knock-out Hole for Ref. Piping	178 x 76
④	Communication Wiring Conduit	2 - Ø34.5	⑧	Anchor Bolt Hole	4 - Ø12

2-3. Dimensional drawing

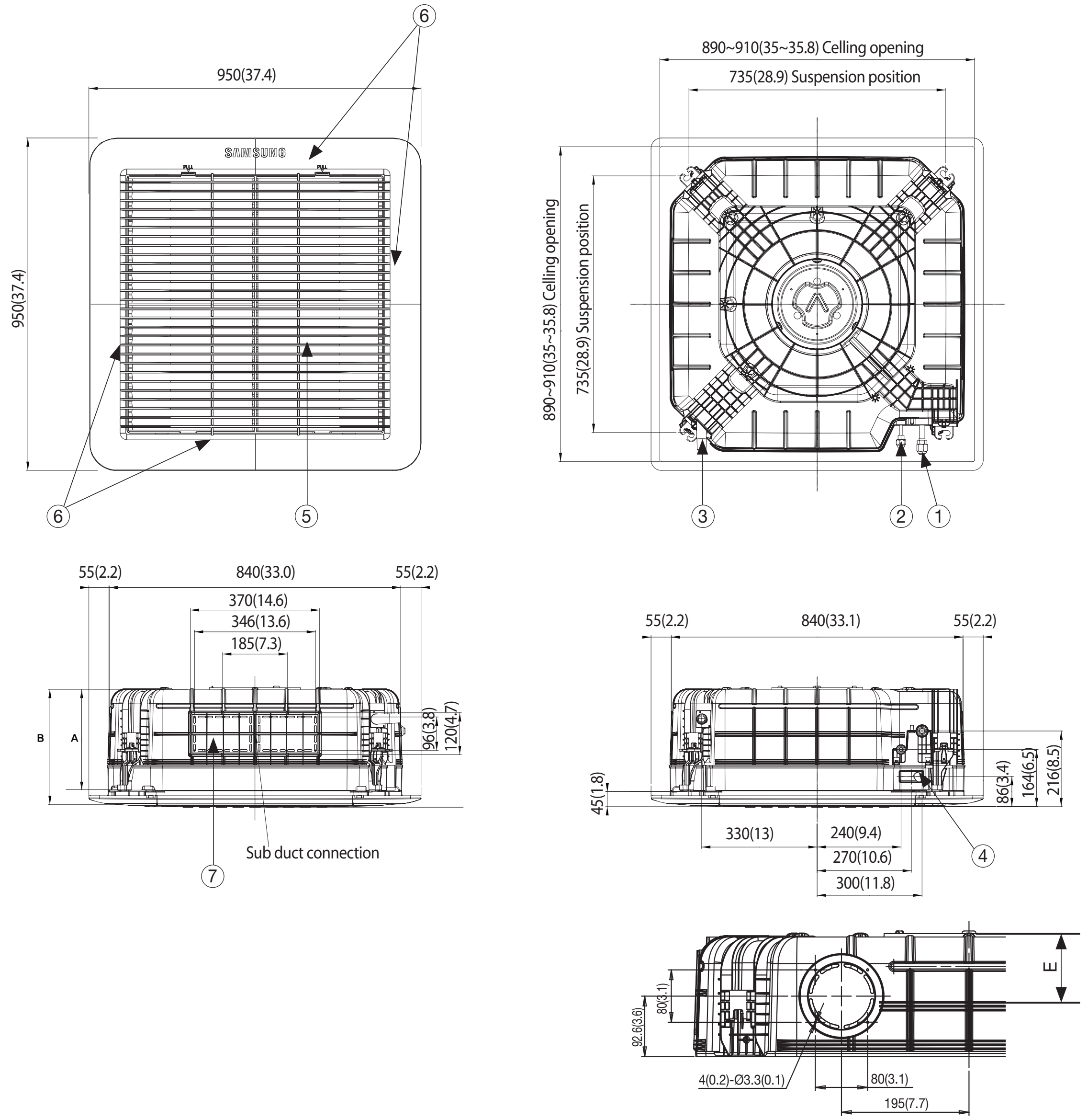
Unit: mm(inch)



No.	Name	Description			
		9.5 MBH	12.0 MBH	18.0 MBH	20.0 MBH
①	Liquid pipe connection	Ø6.35(1/4") Flare			
②	Gas pipe connection	Ø12.70(1/2") Flare			
③	Drain pipe connection	VP25 (OD 32, ID 25)/VP25 (OD 1 1/4", ID 1")			
④	Conduit for power supply & communication wiring	-			
⑤	Air inlet grille	-			
⑥	Air outlet louver	-			
⑦	Fresh air intake	Ø100(3.9")			

3-3 . Dimensional drawing

Unit: mm(inch)

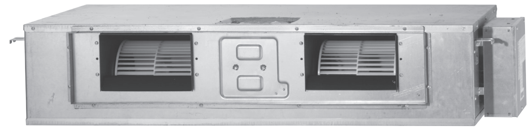


No.	Name	Description					
		9MBH	18MBH	24MBH	30MBH	36MBH	48MBH
①	Liquid pipe connection	Ø6.35(1/4") Flare			Ø9.52(3/8") Flare		
②	Gas pipe connection	Ø12.70(1/2") Flare			Ø15.88(5/8") Flare		
③	Drain pipe connection	VP25 (OD 32, ID 25)/VP25 (OD 1 1/4", ID 1")					
④	Conduit for power supply & communication wiring	-					
⑤	Air inlet grille	-					
⑥	Air outlet louver	-					
⑦	Sub-Duct	-					

		Description	
		9/18/24 MBH	30/36/48 MBH
A	mm(inch)	204(8.0)	288(11.3)
B	mm(inch)	253(10.0)	337(13.3)

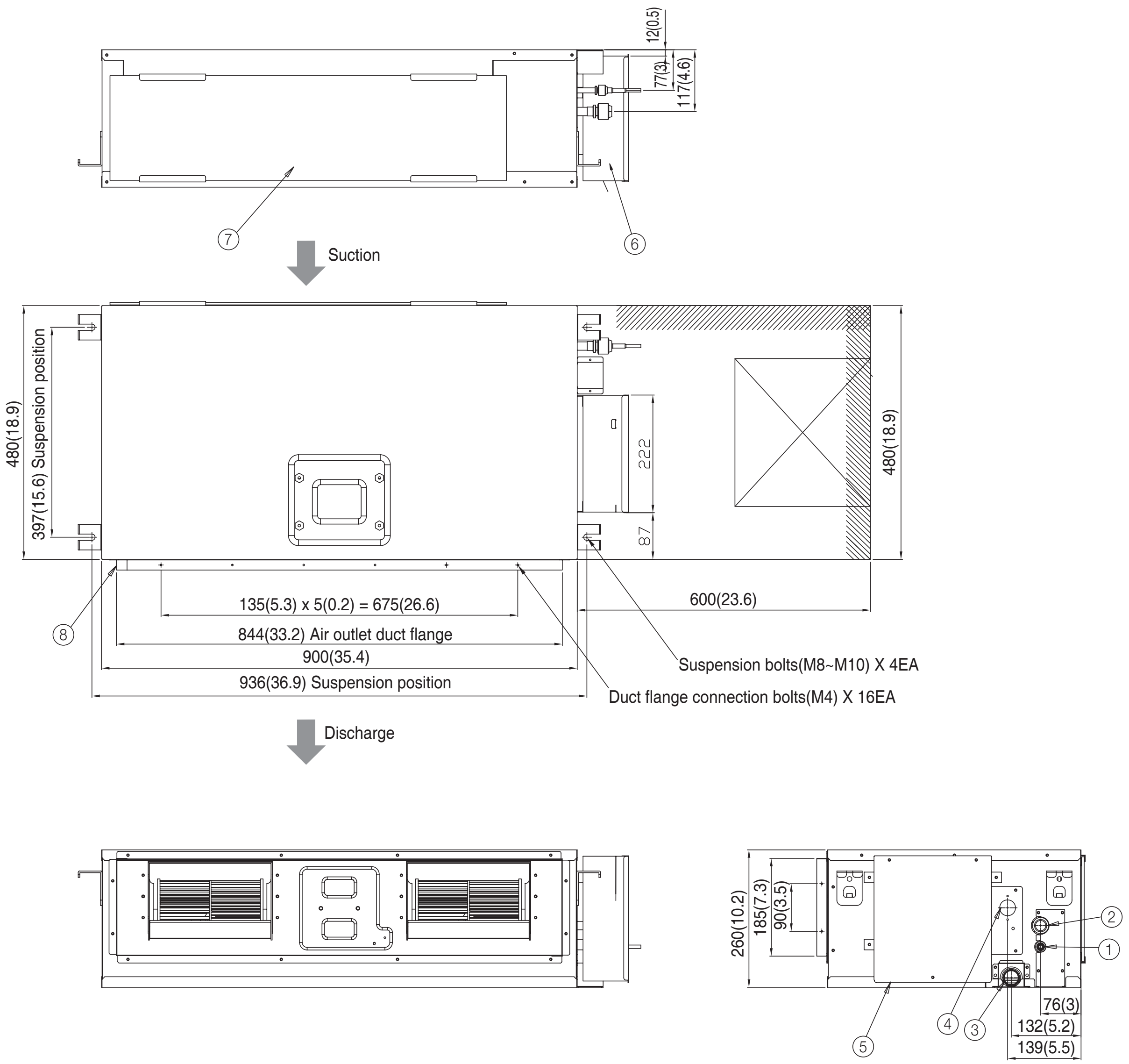
5 MSP(Middle static pressure) duct

5-3. Dimensional drawing



1) AM018/024FNMDCH✳✳✳

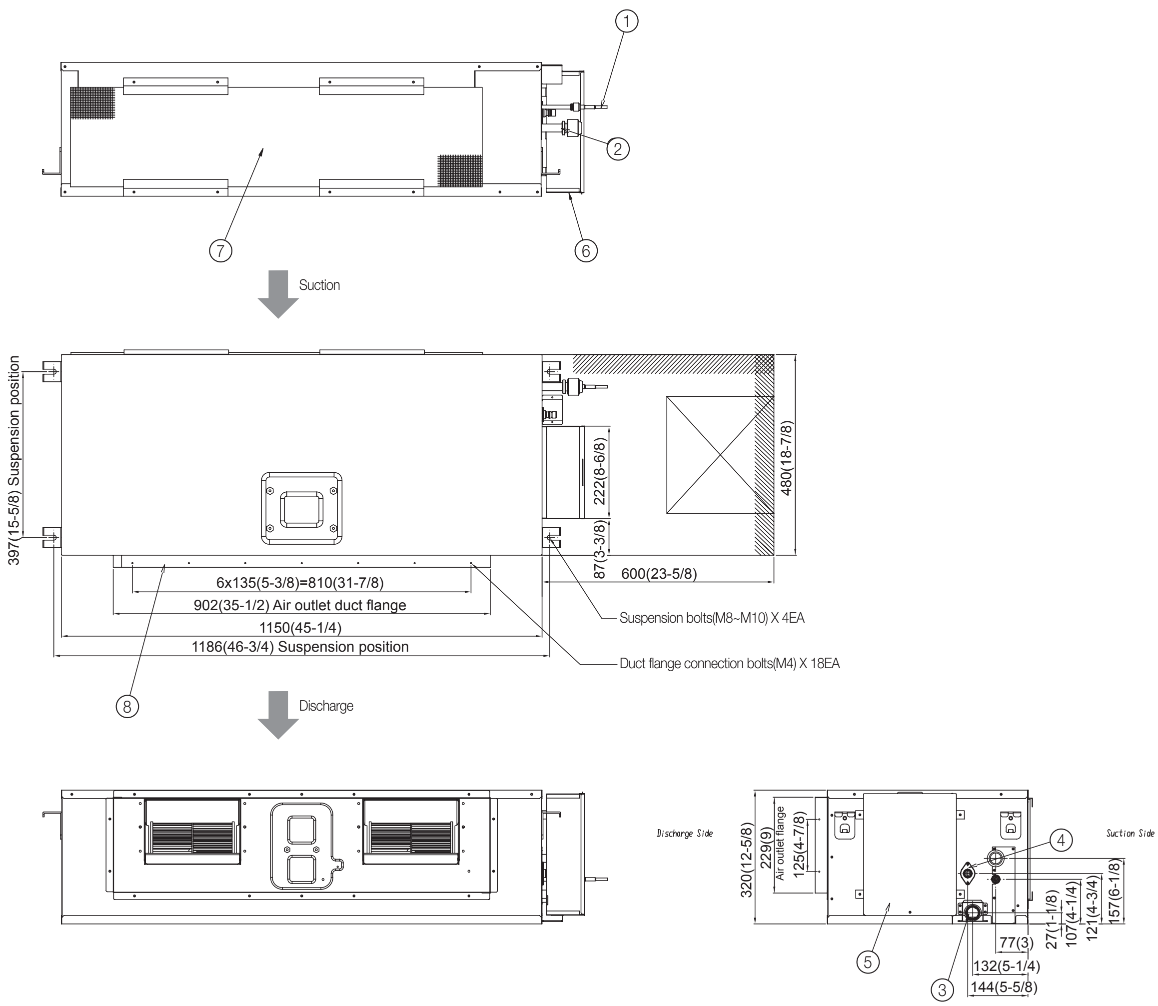
Unit: mm(inch)



No.	Name	Description	
		18MBH	24MBH
①	Liquid pipe connection	Ø6.35(1/4") Flare	Ø9.52(3/8") Flare
②	Gas pipe connection	Ø12.70(1/2") Flare	Ø15.88(5/8") Flare
③	Drain pipe connection without optional drain pump kits	VP25 (OD 32, ID 25) / VP25 (OD 1 1/4", ID 1")	
④	Drain pipe connection with optional drain pump kits	VP25 (OD 32, ID 25) / VP25 (OD 1 1/4", ID 1")	
⑤	Control unit	-	
⑥	Conduit for power supply & communication wiring	-	
⑦	Return air side	-	
⑧	Air outlet duct flange	-	

2) AM030/036FNMDCH✳✳✳

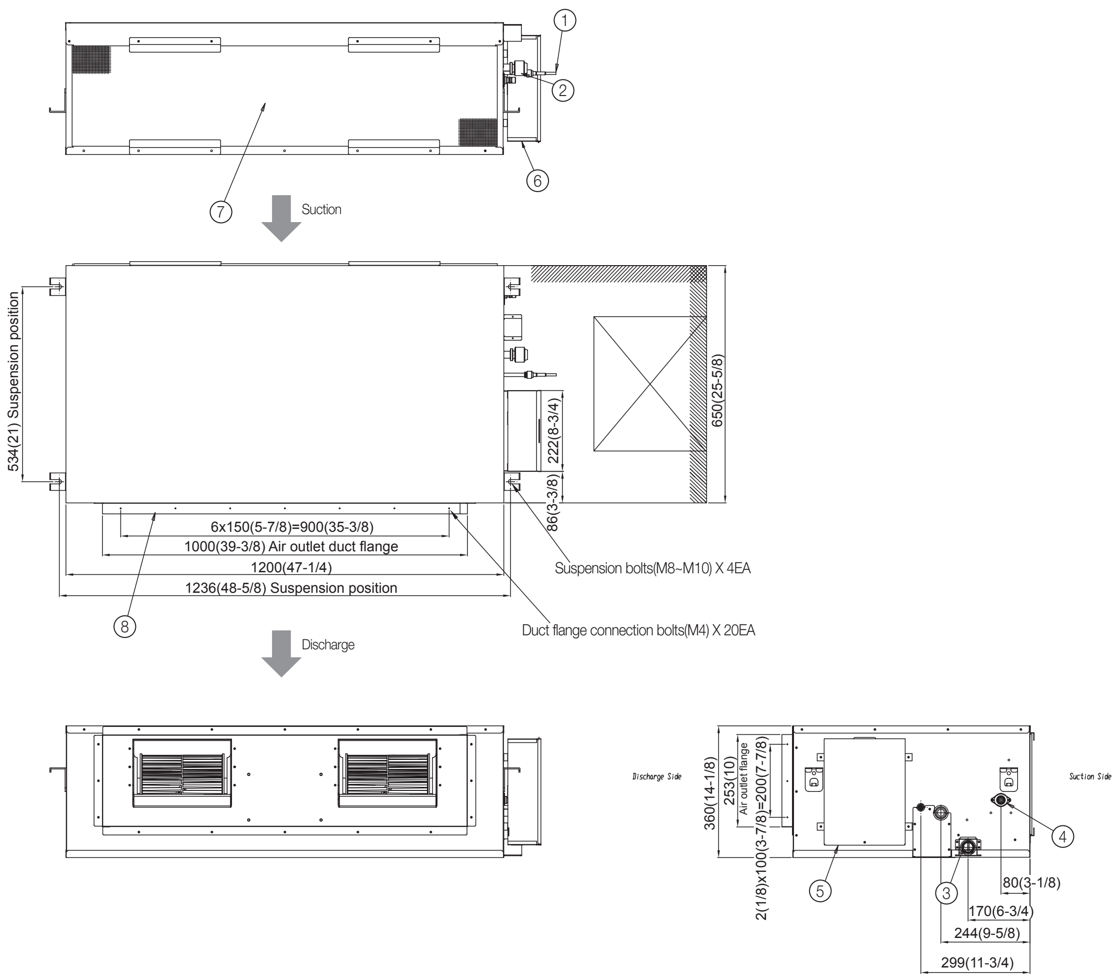
Unit: mm(inch)



No.	Name	Description	
		30.0 MBH	36.0 MBH
①	Liquid pipe connection	Ø9.52(3/8") Flare	
②	Gas pipe connection	Ø15.88(5/8") Flare	
③	Drain pipe connection without optional drain pump kits	VP25 (OD 32, ID 25) / VP25 (OD 1 1/4", ID 1")	
④	Drain pipe connection with optional drain pump kits	VP25 (OD 32, ID 25) / VP25 (OD 1 1/4", ID 1")	
⑤	Control unit	-	
⑥	Conduit for power supply & communication wiring	-	
⑦	Return air side	-	
⑧	Air outlet duct flange	-	

5-3. Dimensional drawing

3) AM048FNMDCH✳✳✳ Unit: mm(inch)

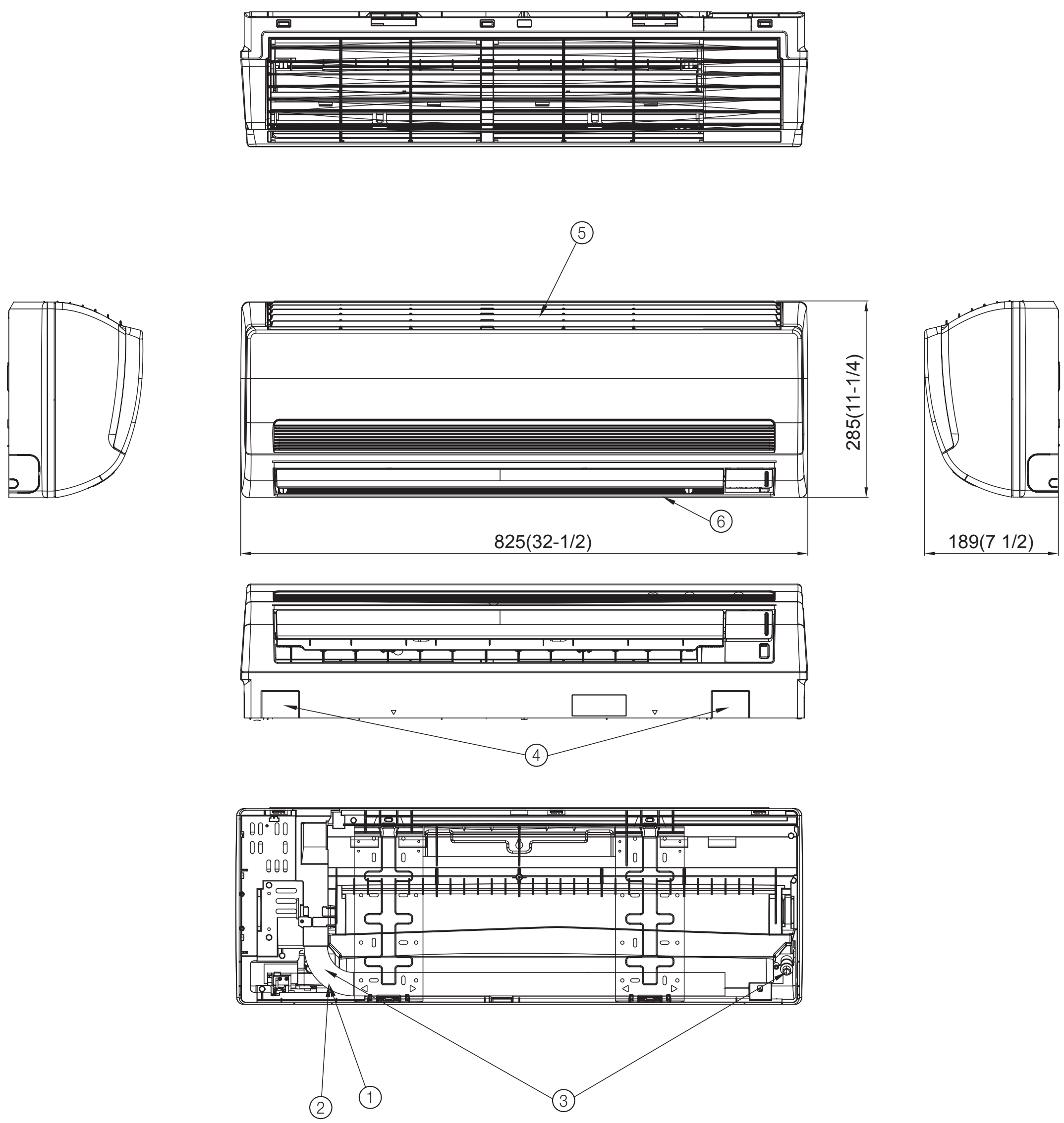


No.	Name	Description
		48.0 MBH
①	Liquid pipe connection	Ø9.52(3/8") Flare
②	Gas pipe connection	Ø15.88(5/8") Flare
③	Drain pipe connection without optional drain pump kits	VP25 (OD 32, ID 25) / VP25 (OD 1 1/4", ID 1")
④	Drain pipe connection with optional drain pump kits	VP25 (OD 32, ID 25) / VP25 (OD 1 1/4", ID 1")
⑤	Control unit	-
⑥	Conduit for power supply & communication wiring	-
⑦	Return air side	-
⑧	Air outlet duct flange	-

8-3. Dimensional drawing

1) AM007/009/012FNTDCH✳✳✳

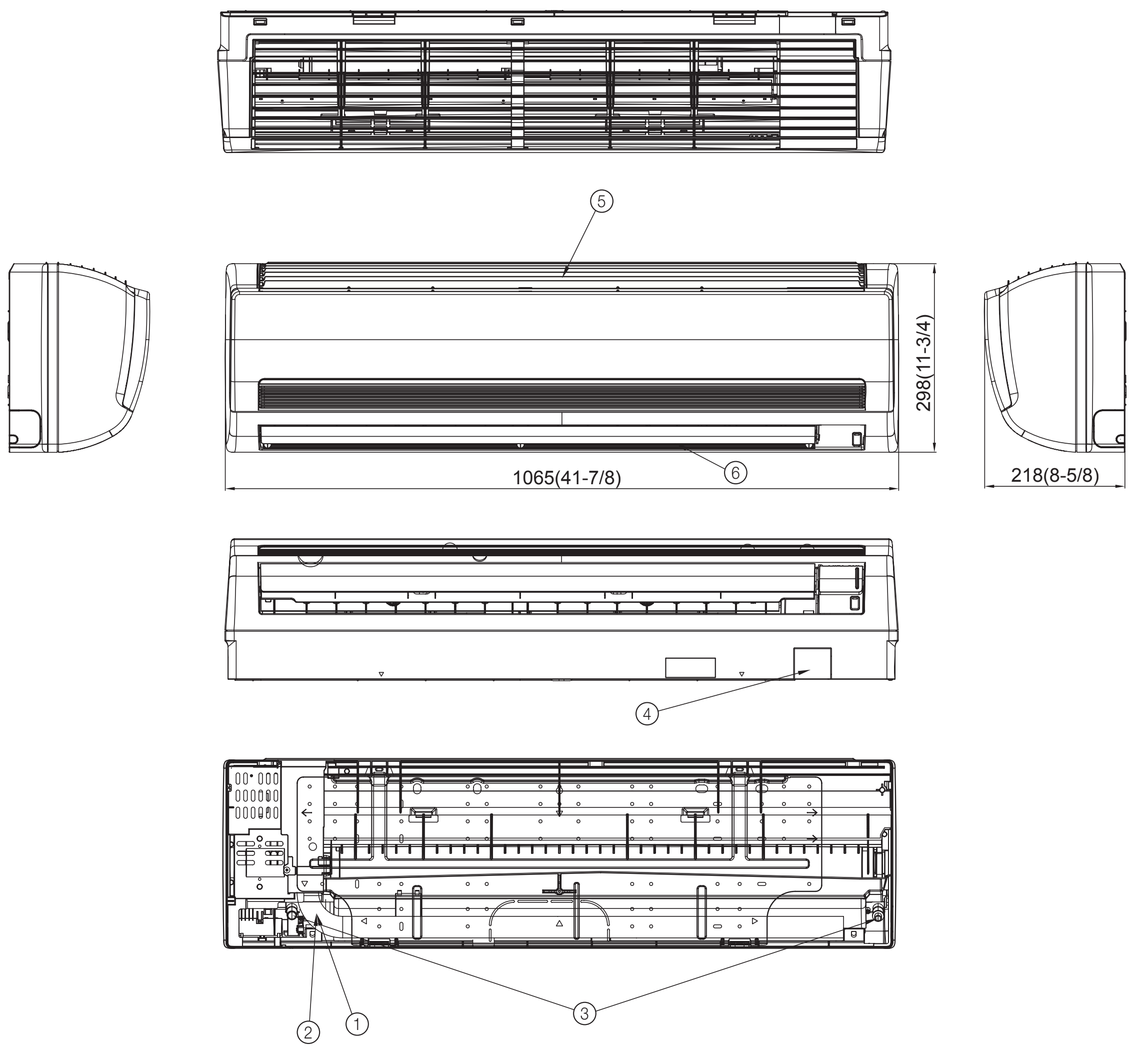
Unit:mm(inch)



No.	Name	Description		
		7.5 MBH	9.5 MBH	12.0 MBH
①	Liquid pipe connection	Ø6.35 (1/4") Flare		
②	Gas pipe connection	Ø12.70 (1/2") Flare		
③	Drain pipe connection	ID 18 hose / ID 11/16" hose		
④	Conduit for power supply & communication wiring	-		
⑤	Air inlet grille	-		
⑥	Air outlet louver	-		

2) AM018/020/024FNTDCH✳✳✳

Unit : mm(inch)

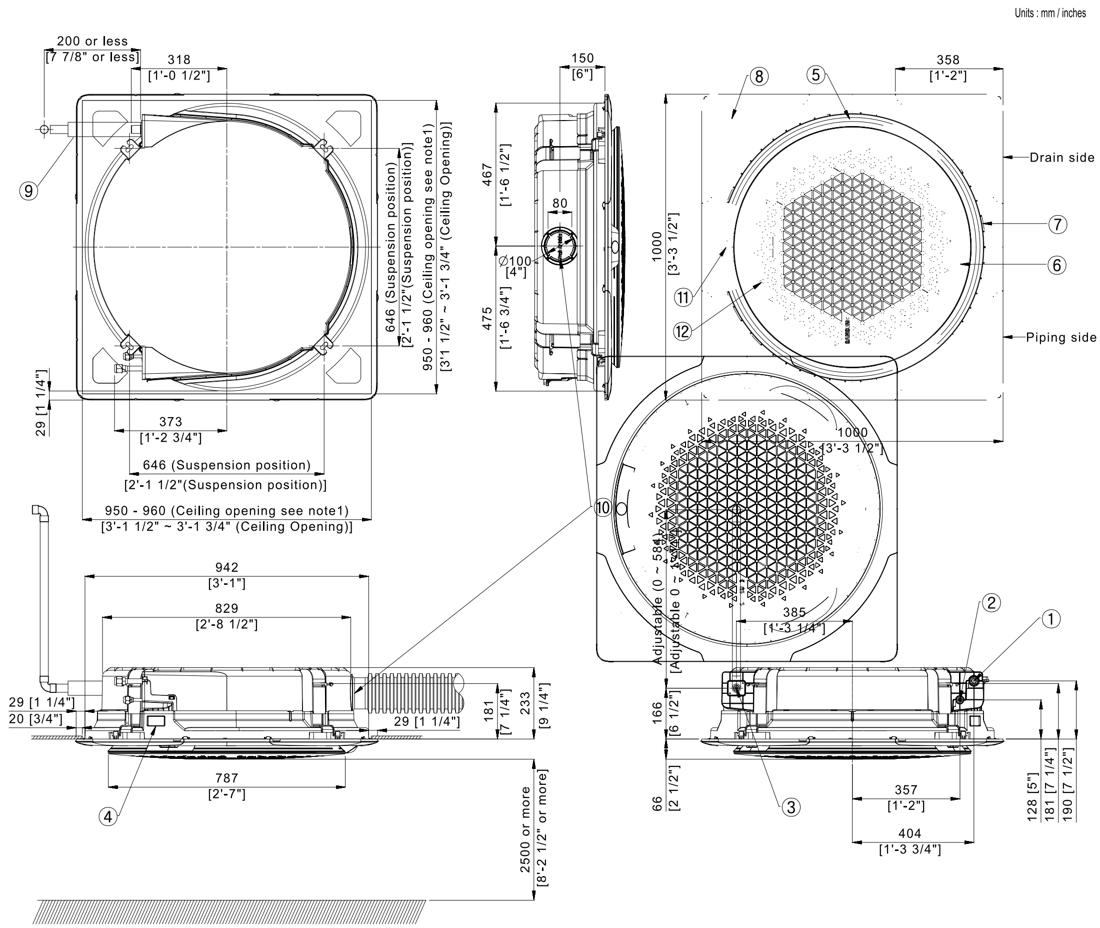


No.	Name	Description		
		18.0 MBH	20.0 MBH	23.2 MBH
①	Liquid pipe connection	Ø6.35 (1/4") Flare		Ø9.52 (3/8") Flare
②	Gas pipe connection	Ø12.70 (1/2") Flare		Ø15.88 (5/8") Flare
③	Drain pipe connection	ID 18 hose / ID 11/16" hose		
④	Conduit for power supply & communication wiring	-		
⑤	Air inlet grille	-		
⑥	Air outlet louver	-		

3 Dimensional drawing

360 CST (Square)

AM009KN4DCH/AA, AM012KN4DCH/AA, AM018KN4DCH/AA, AM024KN4DCH/AA



Note

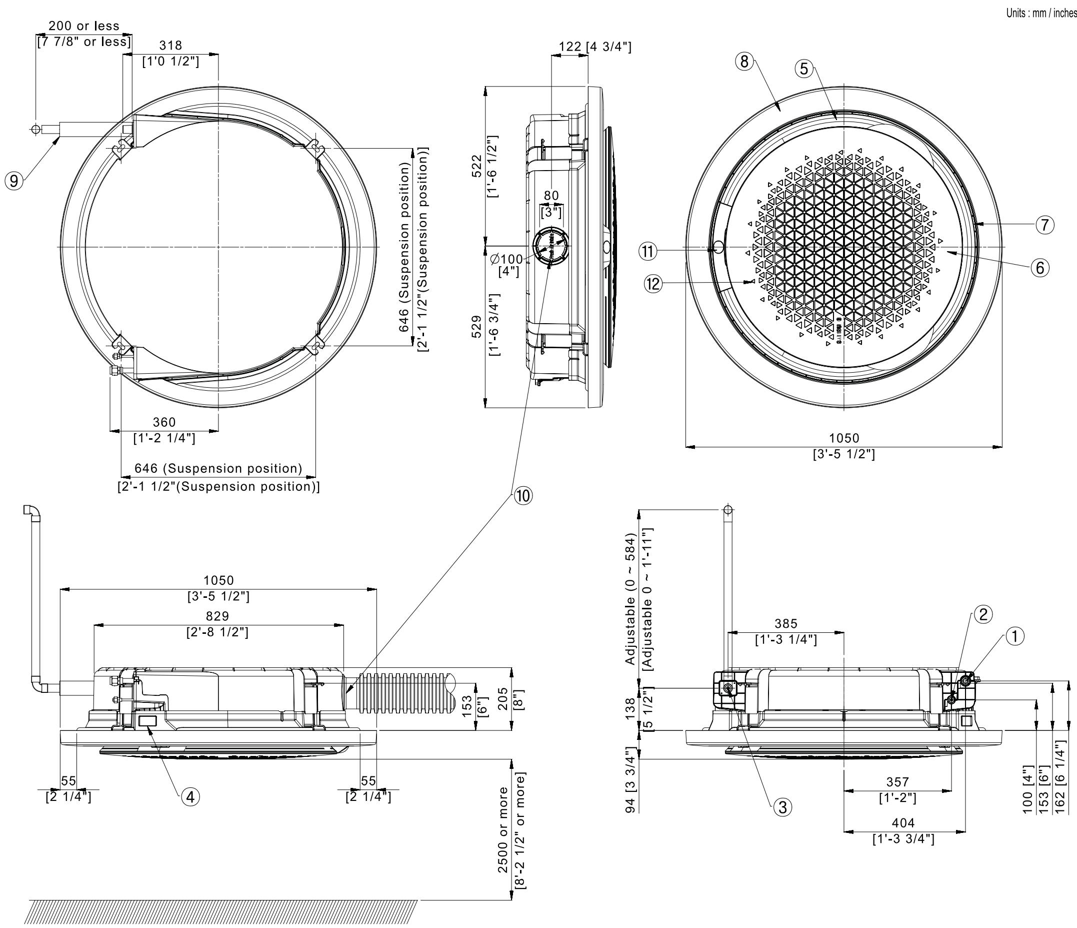
1. Make sure the spacing between the ceiling and the cassette is no more than 10mm[3/8"].
2. When the conditions exceed 30℃[86°F] and RH 80% in the ceiling or fresh air is inducted into the ceiling, and additional insulation is required (polyethylene foam, thickness 10mm[3/8"] or more)
3. **Square panel code : PC4NUDMAN (White), PC4NBDMAN (Black)**

- Weight [lbs] : 7.94 (Net), 13.23 (Shipping) - Dimensions (W x H x D) [inch] : 39.37 x 2.60 x 39.37 (Net), 43.03 x 3.35 x 42.64 (Shipping)

Table of descriptions			
1	Refrigerant gas pipe	7	Suction rim for Booster fan
2	Refrigerant liquid pipe	8	Decoration cover
3	Condensate drain	9	Drain hose
4	Power & Comm. wiring conduits	10	Fresh air intake knock out hole
5	Air discharge opening	11	Display window
6	Air suction grille	12	Infrared receiver

360 CST (Circle)

AM009KN4DCH/AA, AM012KN4DCH/AA, AM018KN4DCH/AA, AM024KN4DCH/AA



Note

1. Make sure the spacing between the ceiling and the cassette is no more than 10mm[3/8"].
2. When the conditions exceed 30℃[86°F] and RH 80% in the ceiling or fresh air is inducted into the ceiling, and additional insulation is required (polyethylene foam, thickness 10mm[3/8"] or more)
3. **Circular panel code : PC4NUNMAN (White), PC4NBNMAN (Black)**
   - Weight [lbs] : 5.95 (Net), 11.24 (Shipping)   - Dimensions (W x H x D) [inch] : 41.34 x 3.70 x 41.34 (Net), 43.03 x 3.35 x 42.64 (Shipping)
   ※ When installing the circular panel on the ceiling, make sure to install 2 or more inspection holes for the maintenance.
   (For further information, please refer to the installation manual.)
4. The circular panel is by default available in exposed installation.
5. Make inspection holes on the ceiling for easier installation and maintenance, as shown in the following table.
   (The size of an inspection hole must be at least 450 mm x 450 mm.)
6. A suspended ceiling structure can substitute for the inspection holes.

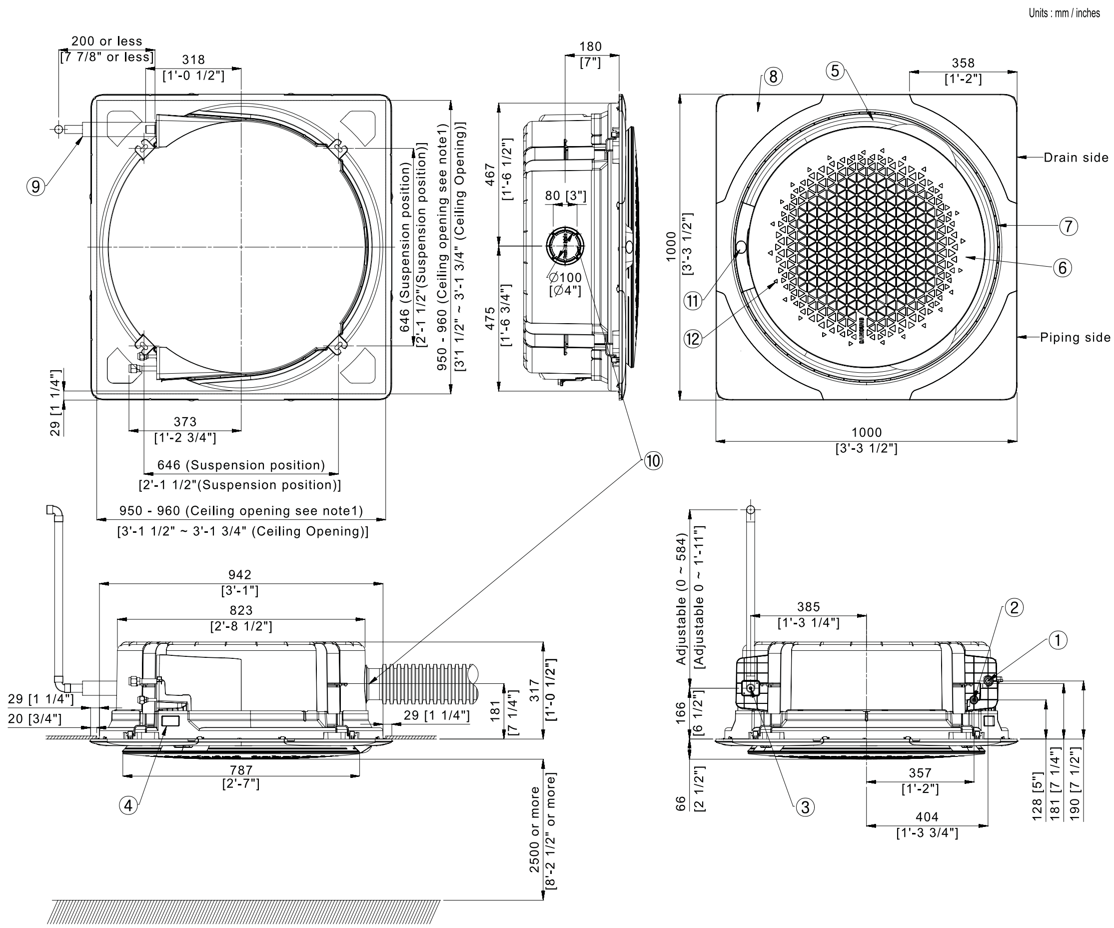
Category	Inspection hole		
	Recessed installation		Exposed installation
	Integrated	Suspended	
Square panel	1 ea	-	
Circular panel	2 ea		

Table of descriptions			
1	Refrigerant gas pipe	7	Suction rim for Booster fan
2	Refrigerant liquid pipe	8	Decoration cover
3	Condensate drain	9	Drain hose
4	Power & Comm. wiring conduits	10	Fresh air intake knock out hole
5	Air discharge opening	11	Display window
6	Air suction grille	12	Infrared receiver

3 Dimensional drawing

360 CST (Square)

AM030KN4DCH/AA, AM036KN4DCH/AA, AM048KN4DCH/AA



Note

1. Make sure the spacing between the ceiling and the cassette is no more than 29mm[1 1/4"]. Max ceiling opening : 960mm[3'-1 3/4"]
2. When the conditions exceed 30℃ and RH 80% in the ceiling or fresh air is inducted into the ceiling, and additional insulation is required (polyethylene foam, thickness 10mm[3/8"] or more)
3. **Square panel code : PC4NUDMAN (White), PC4NBDMAN (Black)**

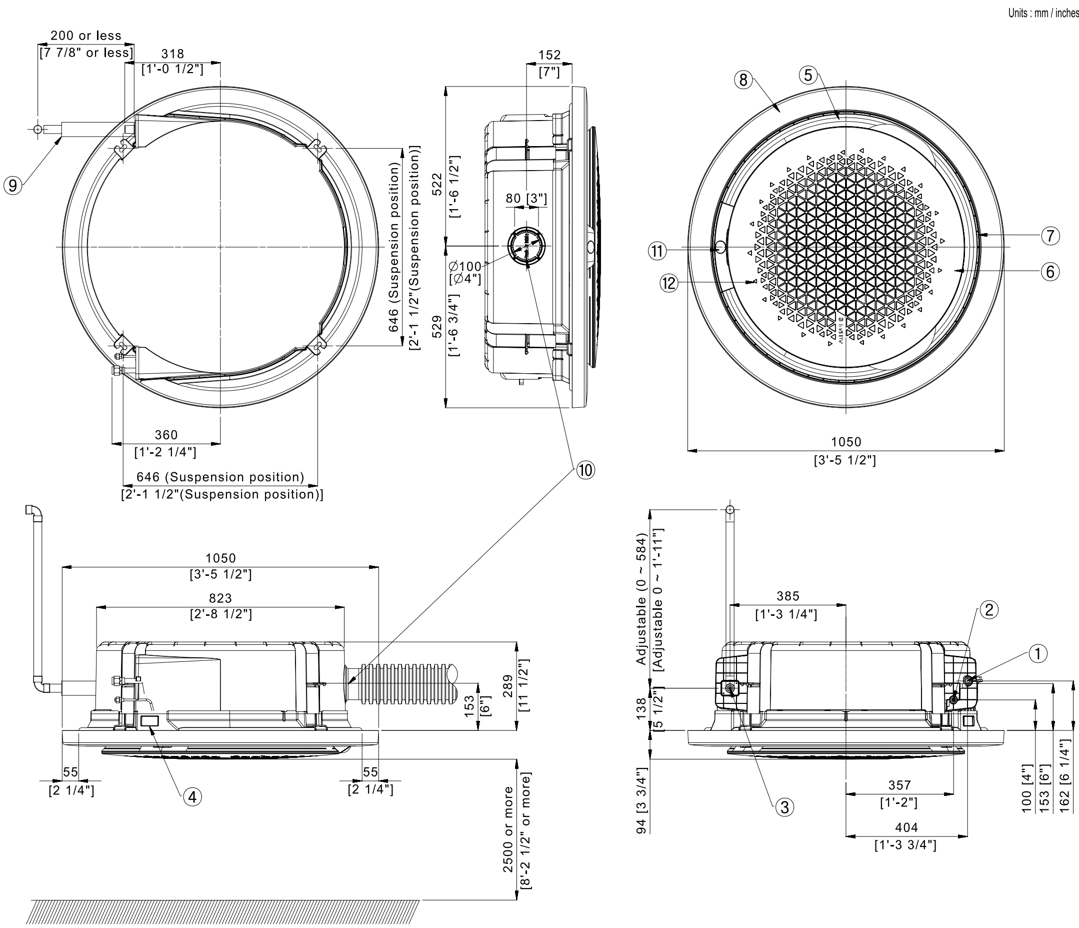
- Weight [lbs] : 7.94 (Net), 13.23 (Shipping) - Dimensions (W x H x D) [inch] : 39.37 x 2.60 x 39.37 (Net), 43.03 x 3.35 x 42.64 (Shipping)

Table of descriptions			
1	Refrigerant gas pipe	7	Suction rim for Booster fan
2	Refrigerant liquid pipe	8	Corner decoration cover
3	Condensate drain	9	Drain hose
4	Power & Comm. wiring conduits	10	Fresh air intake knock out hole
5	Air discharge opening	11	Display window
6	Air suction grille	12	Infrared receiver

3 Dimensional drawing

360 CST (Circle)

AM030KN4DCH/AA, AM036KN4DCH/AA, AM048KN4DCH/AA



Note

1. Make sure the spacing between the ceiling and the cassette is no more than 10mm[3/8"].
2. When the conditions exceed 30℃[86°F] and RH 80% in the ceiling or fresh air is inducted into the ceiling, and additional insulation is required (polyethylene foam, thickness 10mm[3/8"] or more)

3. Circular panel code : PC4NUNMAN (White), PC4NBNMAN (Black)

- Weight [lbs] : 5.95 (Net), 11.24 (Shipping) - Dimensions (W x H x D) [inch] : 41.34 x 3.70 x 41.34 (Net), 43.03 x 3.35 x 42.64 (Shipping)

※ When installing the circular panel on the ceiling, make sure to install 2 or more inspection holes for the maintenance. (For further information, please refer to the installation manual.)

4.The circular panel is by default available in exposed installation.
5. Make inspection holes on the ceiling for easier installation and maintenance, as shown in the following table.
(The size of an inspection hole must be at least 450 mm x 450 mm.)
6. A suspended ceiling structure can substitute for the inspection holes.

Category	Inspection hole		
	Recessed installation		Exposed installation
	Integrated	Suspended	
Square panel	1 ea	-	
Circular panel	2 ea		

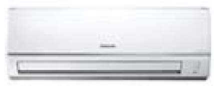
Table of descriptions			
1	Refrigerant gas pipe	7	Suction rim for Booster fan
2	Refrigerant liquid pipe	8	Decoration cover
3	Condensate drain	9	Drain hose
4	Power & Comm. wiring conduits	10	Fresh air intake knock out hole
5	Air discharge opening	11	Display window

Model	Model type	-	DVM S(NEW)
	Model name	-	AM220KXVAGH/TK
	Power supply	Ø,#,V,Hz	3,4,380-415,50Hz
	Image	-	
Nominal capacity	Cooling	kW	61.6
	Heating	kW	69.3
Simulated capacity	Cooling	kW	-
	Heating	kW	-
Power Input	Cooling	kW	17.3521
	Heating	kW	16.6988
Current Input	Cooling	A	27.8
	Heating	A	26.8
Airflow		CMM	290.00
Sound pressure		dB(A)	65
Piping	Liquid Pipe	mm	15.88
	Gas Pipe	mm	28.58
	H.P. Gas pipe	mm	-
Power cable		mm2	-
Communication cable		mm2	0.75 ~ 1.5
MCCB		A	63
Refrigerant	Type	-	R410A
	Refrigerant amount	kg	8.400
Dimensions & Weight	Weight	kg	285.000
	Dimensions	mm	1295x1695x765
Temp. range	Cooling	°C	-5 ~ 48
	Heating	°C	-25 ~ 24
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	DVM S(NEW)
	Model name	-	AM240KXVAGH/TK
	Power supply	Ø,#,V,Hz	3,4,380-415,50Hz
	Image	-	
Nominal capacity	Cooling	kW	67.2
	Heating	kW	75.6
Simulated capacity	Cooling	kW	-
	Heating	kW	-
Power Input	Cooling	kW	17.0992
	Heating	kW	17.4194
Current Input	Cooling	A	27.4
	Heating	A	27.9
Airflow		CMM	340.00
Sound pressure		dB(A)	66
Piping	Liquid Pipe	mm	15.88
	Gas Pipe	mm	34.92
	H.P. Gas pipe	mm	-
Power cable		mm2	-
Communication cable		mm2	0.75 ~ 1.5
MCCB		A	63
Refrigerant	Type	-	R410A
	Refrigerant amount	kg	12.500
Dimensions & Weight	Weight	kg	333.000
	Dimensions	mm	1295x1795x765
Temp. range	Cooling	°C	-5 ~ 48
	Heating	°C	-25 ~ 24
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	DVM S(NEW)
	Model name	-	AM300KXVAGH/TK
	Power supply	Ø,#,V,Hz	3,4,380-415,50Hz
	Image	-	
Nominal capacity	Cooling	kW	84
	Heating	kW	94.5
Simulated capacity	Cooling	kW	-
	Heating	kW	-
Power Input	Cooling	kW	22.7027
	Heating	kW	20.5882
Current Input	Cooling	A	36.4
	Heating	A	33
Airflow		CMM	340.00
Sound pressure		dB(A)	69
Piping	Liquid Pipe	mm	19.05
	Gas Pipe	mm	34.92
	H.P. Gas pipe	mm	-
Power cable		mm2	-
Communication cable		mm2	0.75 ~ 1.5
MCCB		A	80
Refrigerant	Type	-	R410A
	Refrigerant amount	kg	14.000
Dimensions & Weight	Weight	kg	350.000
	Dimensions	mm	1295x1795x765
Temp. range	Cooling	°C	-5 ~ 48
	Heating	°C	-25 ~ 24
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	Neo Forte
	Model name	-	AM022FNQDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	2.2
	Cooling (SH)	kW	1.5
	Heating	kW	2.5
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	25
	Heating	W	25
Current Input	Cooling	A	0.16
	Heating	A	0.16
Airflow	H/M/L	CMM	7.80 / 6.80 / 5.80
	ESP	mmAq	-
Sound pressure		dB(A)	26 / 31
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	ID 18 HOSE
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	8.300
	Dimensions	mm	825x285x189
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	Neo Forte
	Model name	-	AM022FNTDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	2.2
	Cooling (SH)	kW	1.5
	Heating	kW	2.5
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	25
	Heating	W	25
Current Input	Cooling	A	0.16
	Heating	A	0.16
Airflow	H/M/L	CMM	7.80 / 6.80 / 5.80
	ESP	mmAq	-
Sound pressure		dB(A)	26 / 30
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	ID 18 HOSE
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV NOT INCLUDED
Dimensions & Weight	Weight	kg	8.000
	Dimensions	mm	825x285x189
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	4Way CASSETTE (600 x 600)
	Model name	-	AM028FNNDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	2.8
	Cooling (SH)	kW	2
	Heating	kW	3.2
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	18
	Heating	W	18
Current Input	Cooling	A	0.17
	Heating	A	0.17
Airflow	H/M/L	CMM	10.00 / 8.50 / 7.50
	ESP	mmAq	-
Sound pressure		dB(A)	26 / 33
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	12.000
	Dimensions	mm	575x250x575
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	4Way CASSETTE (600 x 600)
	Model name	-	AM036FNNDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	3.6
	Cooling (SH)	kW	2.5
	Heating	kW	4
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	20
	Heating	W	20
Current Input	Cooling	A	0.19
	Heating	A	0.19
Airflow	H/M/L	CMM	10.50 / 9.50 / 8.00
	ESP	mmAq	-
Sound pressure		dB(A)	26 / 34
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	12.000
	Dimensions	mm	575x250x575
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

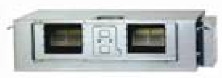
Model	Model type	-	4Way CASSETTE (600 x 600)
	Model name	-	AM045FNNDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	4.5
	Cooling (SH)	kW	3.46
	Heating	kW	5
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	23
	Heating	W	23
Current Input	Cooling	A	0.22
	Heating	A	0.22
Airflow	H/M/L	CMM	11.50 / 10.20 / 9.00
	ESP	mmAq	-
Sound pressure		dB(A)	32 / 36
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	12.000
	Dimensions	mm	575x250x575
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	4Way CASSETTE (600 x 600)
	Model name	-	AM056FNNDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	5.6
	Cooling (SH)	kW	4.2
	Heating	kW	6.3
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	28
	Heating	W	28
Current Input	Cooling	A	0.27
	Heating	A	0.27
Airflow	H/M/L	CMM	13.00 / 11.00 / 9.50
	ESP	mmAq	-
Sound pressure		dB(A)	33 / 39
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	12.000
	Dimensions	mm	575x250x575
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	4Way Cassette S
	Model name	-	AM045FN4DEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	4.5
	Cooling (SH)	kW	3.1
	Heating	kW	5
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	32
	Heating	W	32
Current Input	Cooling	A	0.22
	Heating	A	0.22
Airflow	H/M/L	CMM	14.50 / 13.50 / 12.50
	ESP	mmAq	-
Sound pressure		dB(A)	30 / 33
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	15.500
	Dimensions	mm	840x204x840
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	4Way Cassette S
	Model name	-	AM056FN4DEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	5.6
	Cooling (SH)	kW	3.9
	Heating	kW	6.3
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	32
	Heating	W	32
Current Input	Cooling	A	0.22
	Heating	A	0.22
Airflow	H/M/L	CMM	15.00 / 14.00 / 13.00
	ESP	mmAq	-
Sound pressure		dB(A)	30 / 33
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	15.500
	Dimensions	mm	840x204x840
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	MSP Duct
	Model name	-	AM090FNMDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	9
	Cooling (SH)	kW	6.9
	Heating	kW	10
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	240
	Heating	W	240
Current Input	Cooling	A	1.3
	Heating	A	1.3
Airflow	H/M/L	CMM	19.50 / 18.00 / 16.50
	ESP	mmAq	6
Sound pressure		dB(A)	34 / 40
Piping	Liquid Pipe	mm	9.52
	Gas Pipe	mm	15.88
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	34.000
	Dimensions	mm	1150x260x480
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	MSP Duct
	Model name	-	AM112FNMDEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	11.2
	Cooling (SH)	kW	8.3
	Heating	kW	12.5
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	260
	Heating	W	260
Current Input	Cooling	A	1.17
	Heating	A	1.17
Airflow	H/M/L	CMM	27.00 / 25.00 / 23.00
	ESP	mmAq	8
Sound pressure		dB(A)	38 / 41
Piping	Liquid Pipe	mm	9.52
	Gas Pipe	mm	15.88
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.50
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	36.000
	Dimensions	mm	1150x320x480
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	360 Cassette
	Model name	-	AM045KN4DEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	4.5
	Cooling (SH)	kW	3.1
	Heating	kW	5
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	26
	Heating	W	26
Current Input	Cooling	A	0.18
	Heating	A	0.18
Airflow	H/M/L	CMM	14.50 / 13.50 / 12.50
	ESP	mmAq	-
Sound pressure		dB(A)	29 / 33
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.5
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	21.000
	Dimensions	mm	947x281x947
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	360 Cassette
	Model name	-	AM056KN4DEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	5.6
	Cooling (SH)	kW	3.9
	Heating	kW	6.3
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	30
	Heating	W	30
Current Input	Cooling	A	0.21
	Heating	A	0.21
Airflow	H/M/L	CMM	16.00 / 14.50 / 13.50
	ESP	mmAq	-
Sound pressure		dB(A)	29 / 34
Piping	Liquid Pipe	mm	6.35
	Gas Pipe	mm	12.70
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.5
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	21.000
	Dimensions	mm	947x281x947
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	360 Cassette
	Model name	-	AM071KN4DEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	7.1
	Cooling (SH)	kW	5
	Heating	kW	8
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	34
	Heating	W	34
Current Input	Cooling	A	0.25
	Heating	A	0.25
Airflow	H/M/L	CMM	18.00 / 16.00 / 14.00
	ESP	mmAq	-
Sound pressure		dB(A)	30 / 36
Piping	Liquid Pipe	mm	9.52
	Gas Pipe	mm	15.88
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.5
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	21.000
	Dimensions	mm	947x281x947
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

Model	Model type	-	360 Cassette
	Model name	-	AM090KN4DEH/TK
	Power supply	Ø,#,V,Hz	1,2,220-240,50Hz
	Image	-	
Nominal capacity	Cooling	kW	9
	Cooling (SH)	kW	6.3
	Heating	kW	10
Simulated capacity	Cooling	kW	-
	Cooling (SH)	kW	-
	Heating	kW	-
Power Input	Cooling	W	55
	Heating	W	55
Current Input	Cooling	A	0.42
	Heating	A	0.42
Airflow	H/M/L	CMM	22.00 / 18.50 / 16.00
	ESP	mmAq	-
Sound pressure		dB(A)	32 / 40
Piping	Liquid Pipe	mm	9.52
	Gas Pipe	mm	15.88
	Drain	mm	VP25 (OD 32,ID 25)
Power cable		mm2	1.5 ~ 2.5
Communication cable		mm2	0.75 ~ 1.5
Refrigerant	Type	-	R410A
	Control	-	EEV INCLUDED
Dimensions & Weight	Weight	kg	21.000
	Dimensions	mm	947x281x947
Design condition (Cooling)	Outdoor(DB)	°C	34.9
	Indoor(WB)	°C	19
Design condition (Heating)	Outdoor(DB)	°C	1.8
	Indoor(DB)	°C	15

7. Branch kit

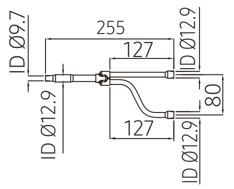
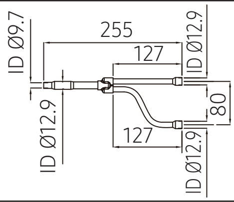
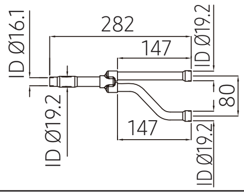
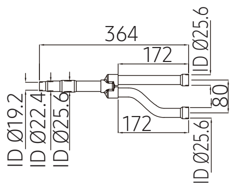
In door joint

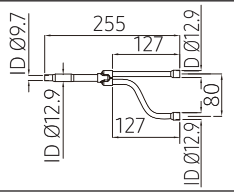
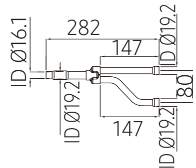
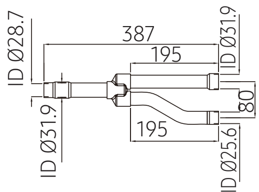
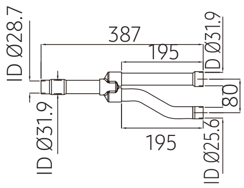
7.1. Y-joint

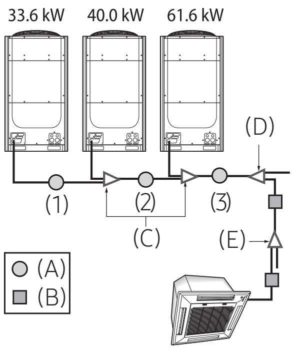
Model	Total indoor unit's capacities
MXJ-YA1509M	15.0 kW (51 MBH) and below
MXJ-YA2512M	Over 15.0~40.0 kW (51~136 MBH) and below
MXJ-YA2812M	Over 40.0~45.0 kW (136~154 MBH) and below
MXJ-YA2815M	Over 45.0~70.3 kW (154~240 MBH) and below
MXJ-YA3419M	Over 70.3~98.4 kW (240~336 MBH) and below
MXJ-YA4119M	Over 98.4~135.2 kW (336~461 MBH) and below
MXJ-YA4422M	Over 135.2 kW (461 MBH)

Dimensional drawing

(Unit : mm)

Port \ Model	MXJ-YA1509M	MXJ-YA2512M
Liquid side	 ① x 2 EA	 ① x 2 EA
Gas side	 ② x 2 EA	 ③ x 2 EA ⑧ x 2 EA

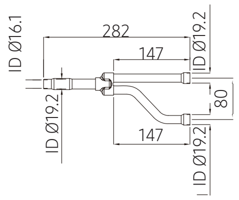
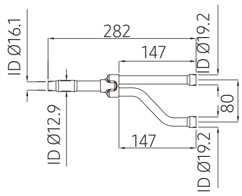
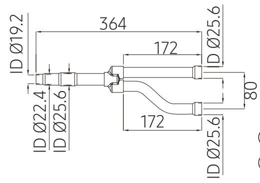
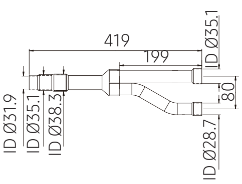
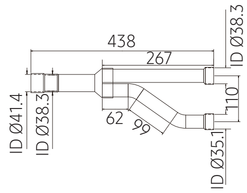
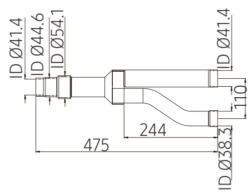
Port \ Model	MXJ-YA2812M	MXJ-YA2815M
Liquid side	 ① x 2 EA	 ② x 2 EA
Gas side	 ③ x 1 EA ⑦ x 1 EA	 ③ x 1 EA ⑦ x 1 EA



- First branch joint (D)
  Make a selection according to outdoor unit capacity.
- Branch joint (E)
  Select a branch joint according to the sum of indoor unit capacity which will be connected after the branch. However, if the size of the pipe between branch joints (E) is bigger than the size of the pipe connected to the outdoor unit (D), apply the pipe size (D).

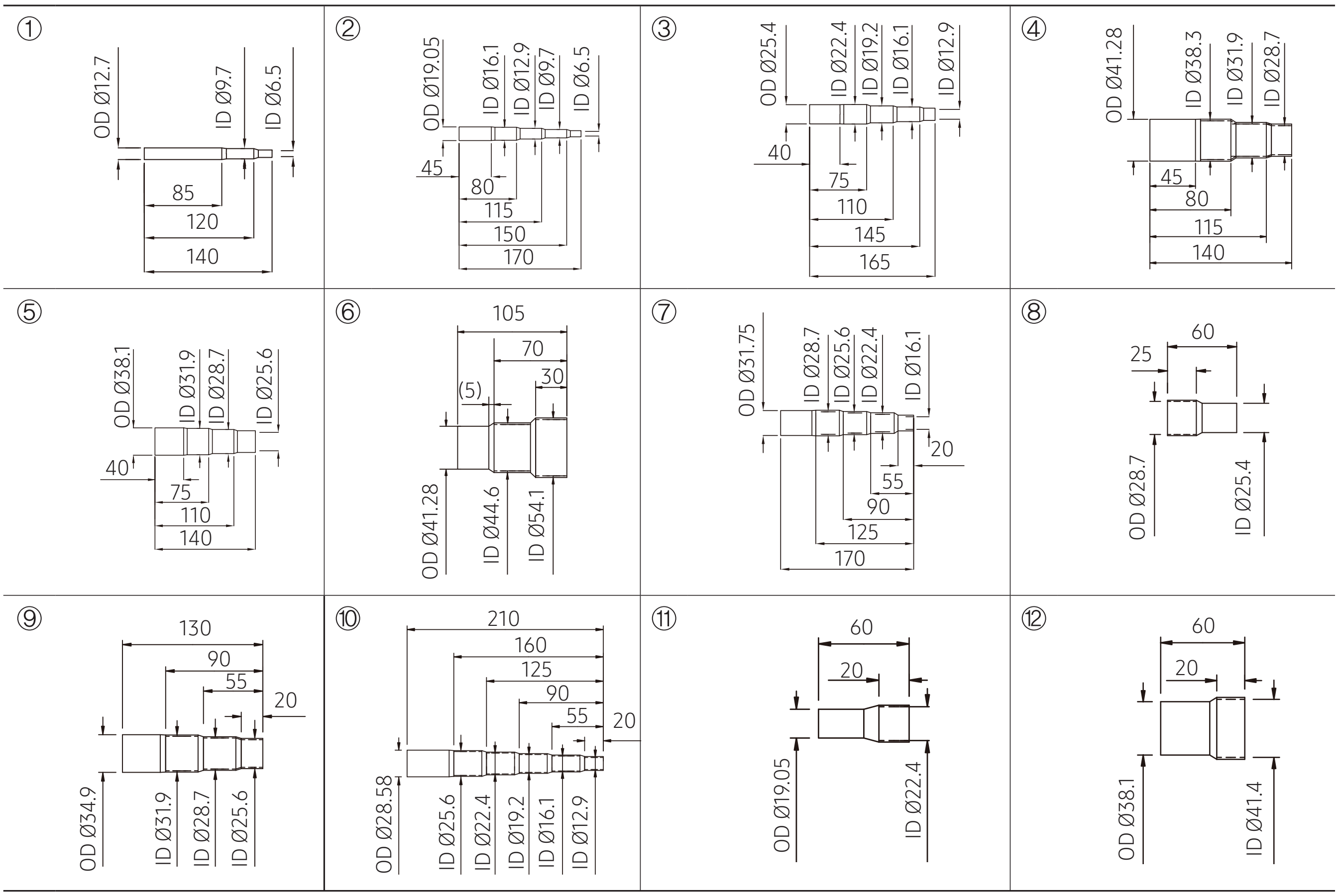
7. Branch kit

(Unit : mm)

Port \ Model	MXJ-YA3419M	MXJ-YA4119M	MXJ-YA4422M
Liquid side	 ② x 2 EA ⑪ x 2 EA	 ② x 2 EA ⑪ x 2 EA	 ① x 1 EA ③ x 2 EA
Gas side	 ⑨ x 1 EA ⑩ x 1 EA ⑫ x 1 EA	 ③ x 1 EA ⑤ x 1 EA ⑨ x 1 EA ⑫ x 1 EA	 ③ x 1 EA ④ x 1 EA ⑤ x 1 EA ⑥ x 1 EA

Reducer

(Unit : mm)



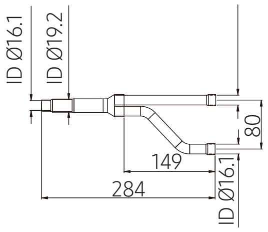
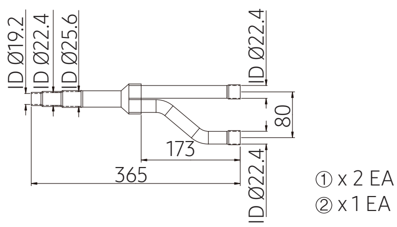
7. Branch kit

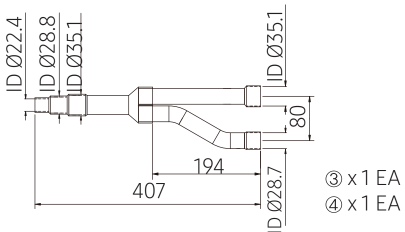
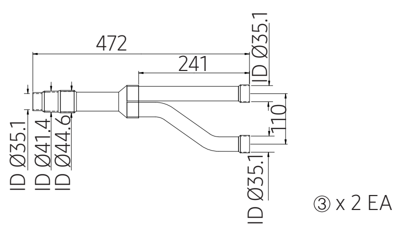
7.2. Y-joint for HR (High pressure gas)

Model	Total indoor unit's capacities
MXJ-YA1500M	22.4 kW (76 MBH) and below
MXJ-YA2500M	Over 22.4~70.3 kW (76~240 MBH) and below
MXJ-YA3100M	Over 70.3~ 135.2 kW (240~461 MBH) and below
MXJ-YA3800M	Over 135.2 kW (461 MBH)

Dimensional drawing

(Unit : mm)

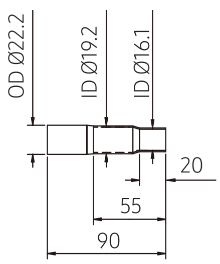
MXJ-YA1500M	MXJ-YA2500M
	

MXJ-YA3100M	MXJ-YA3800M
	

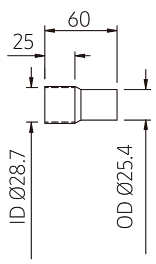
Reducer

(Unit : mm)

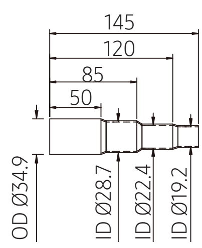
①



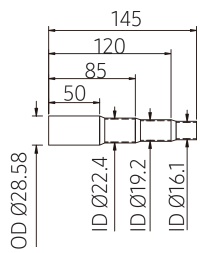
②



③



④



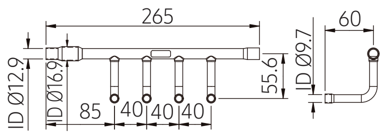
7. Branch kit

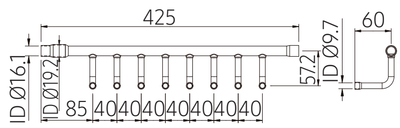
7.3. Header joint

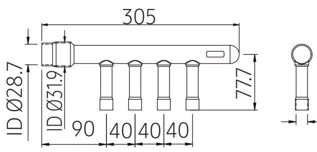
Model	Total indoor unit's capacities	The maximum quantity of connection
MXJ-HA2512M	45.0 kW(154 MBH) and below	4
MXJ-HA3115M	70.3 kW(240 MBH) and below	8
MXJ-HA3819M	Over 70.3 kW (240 MBH)	8

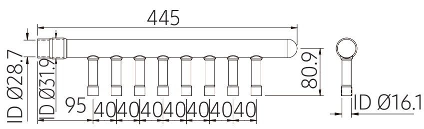
Dimensional drawing

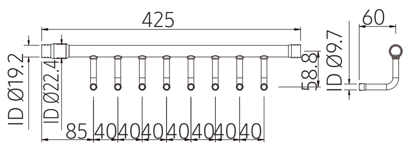
(Unit : mm)

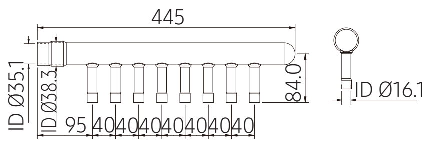
<table>
<tr><th>Port \ Model</th><th>MXJ-HA2512M</th><th>MXJ-HA3115M</th></tr>
<tr><td>Liquid side</td><td>

① x 4 EA ② x 1 EA ⑦ⓐ x 1 EA</td><td>

① x 8 EA ④ x 1 EA ⑦ⓑ x 1 EA</td></tr>
<tr><td>Gas side</td><td>

③ x 4 EA ⑤ x 1 EA ⑧ x 1 EA</td><td>

③ x 8 EA ⑥ x 1 EA ⑧ x 2 EA</td></tr>
<tr><th>Port \ Model</th><th colspan="2">MXJ-HA3819M</th></tr>
<tr><td>Liquid side</td><td colspan="2">

① x 8 EA ⑦ⓒ x 1 EA</td></tr>
<tr><td>Gas side</td><td colspan="2">

③ x 8 EA ⑧ x 2 EA</td></tr>
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Reducer

(Unit : mm)

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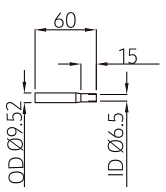
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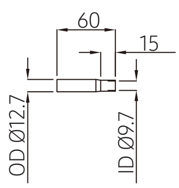
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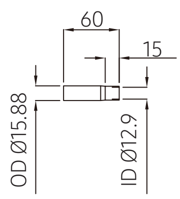
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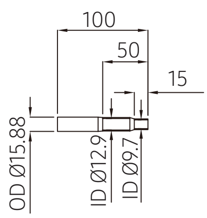
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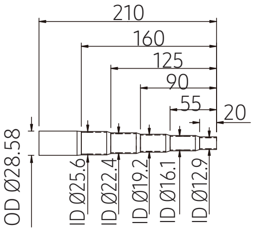
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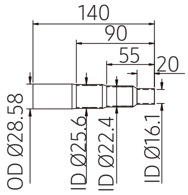
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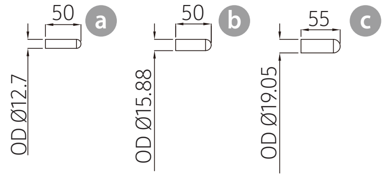
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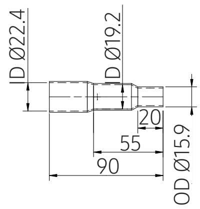
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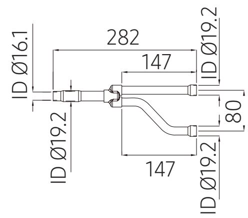
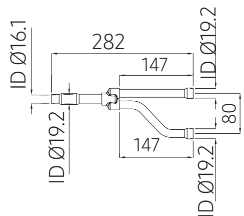
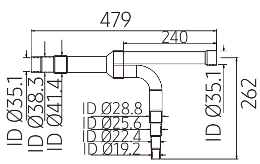
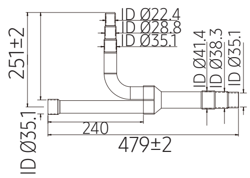
7. Branch kit

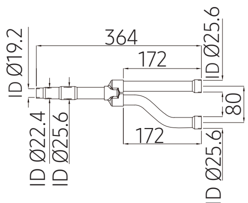
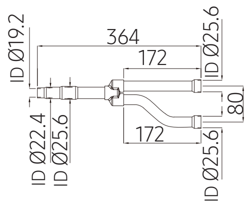
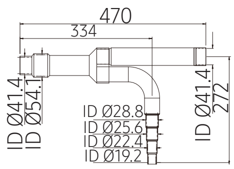
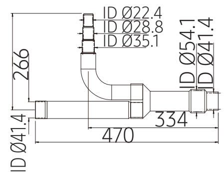
7.4. Out door joint

Model	Total indoor unit's capacities
MXJ-TA3819M	Below 135.2 kW (48HP, 461.3 MBH)
MXJ-TA3419M	
MXJ-TA4422M	Above 140.2 kW (50HP, 478.4 MBH)
MXJ-TA4122M	

Dimensional drawing

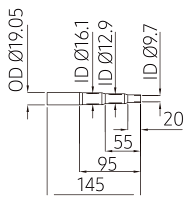
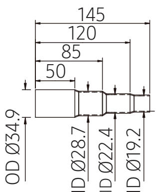
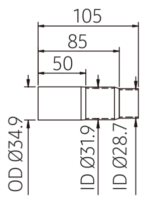
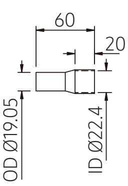
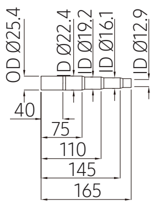
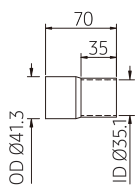
(Unit : mm)

Port \ Model	MXJ-TA3819M	MXJ-TA3419M
Liquid side	 ① x 2 EA ④ x 1 EA	 ① x 2 EA ④ x 1 EA
Gas side	 ② x 1 EA ③ x 1 EA	 ② x 1 EA ③ x 1 EA

Port \ Model	MXJ-TA4422M	MXJ-TA4122M
Liquid side	 ⑤ x 2 EA	 ⑤ x 2 EA
Gas side	 ⑥ x 1 EA	 ⑥ x 1 EA

Reducer

(Unit : mm)

①	②	③
		
④	⑤	⑥
		

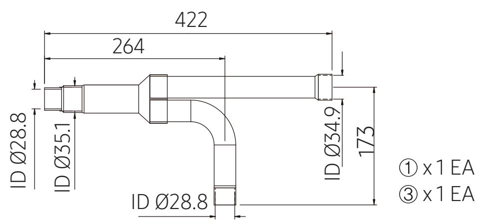
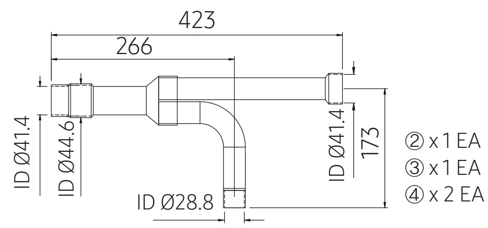
7. Branch kit

7.5. Out door joint for HR (High pressure gas)

Model	Total indoor unit's capacities
MXJ-TA3100M	Below 135.2 kW(48HP, 461.3MBH)
MXJ-TA3800M	Above 140.2 kW(50HP, 478.4 MBH)

Dimensional drawing

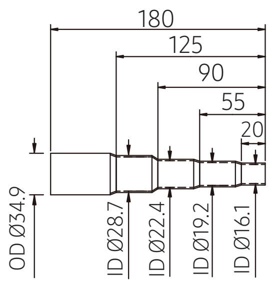
(Unit : mm)

MXJ-TA3100M	MXJ-TA3800M
	

Reducer

(Unit : mm)

①



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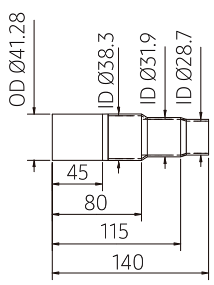

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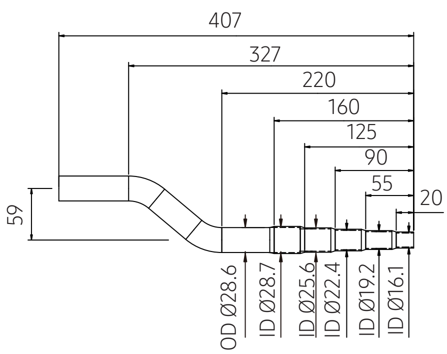

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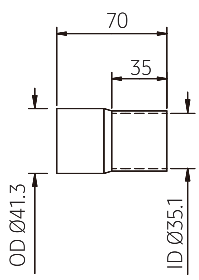

V2B1

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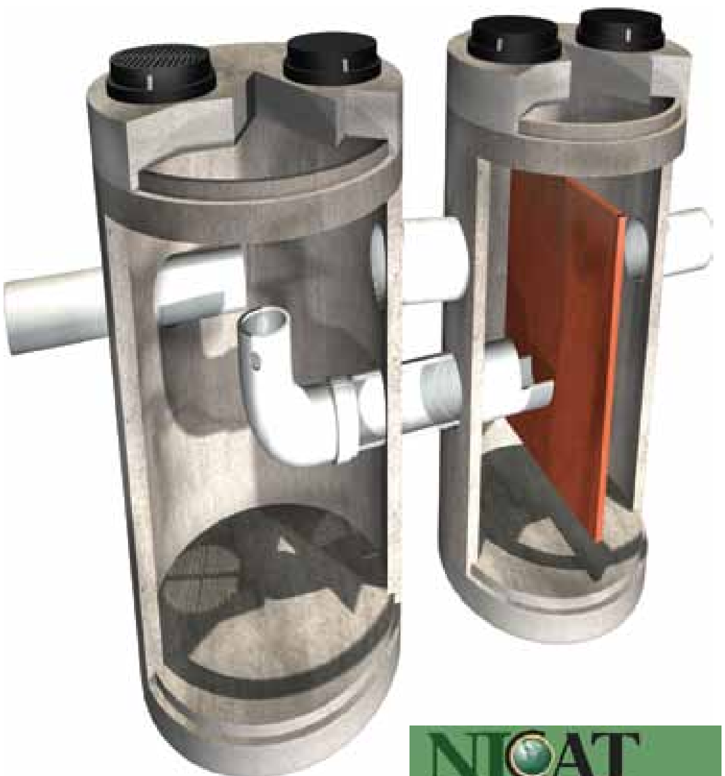
Hydrodynamic Separator aka Sand/Grit/Oil/Water Separator



V2B1 Sizing Chart

Based on removal of 80% TSS at 110 Microns.

V2B1 MODEL NUMBER	D1 DIA (ft.)	D2 DIA (ft.)	MIN. DEPTH BELOW INLET INVERT (ft.)	TREATMENT RATE (cfs)	MAX.INLET PIPE DIA. (in.)
2	4	4	3.5	1.54	12
3	4	5	3.5	1.97	16
4	5	5	4.5	2.40	21
6	6	5	4.5	2.93	24
7	6	6	4.5	3.46	24
8	7	6	4.5	4.08	30
9	7	5	4.5	3.55	30
10	8	5	4.5	4.27	36
11	8	6	4.5	4.80	36
12	8	7	4.5	5.42	36
13	8	8	5.0	6.14	36
14	10	5	5.0	6.00	42
15	10	6	5.0	6.53	42
16	10	7	5.0	7.15	42
17	10	8	5.0	7.87	42
18	10	10	5.5	9.60	42
19	12	5	5.0	8.11	48
20	12	6	5.0	8.64	48
21	12	7	5.5	9.26	48
22	12	10	5.5	11.71	48
25	12	8	5.5	9.98	48
40	12	12	5.5	13.47	48
50	16	10	6.0	17.09	72
60	20	10	6 0	24 00	80

Note: Some diameter sizes may not be available from some affiliates.

V2B1 Properties

- NJCAT Verified
- Constructed with local materials (manhole, pipe, etc.)
- Swirl technology in the first chamber
- Patented center draw
- 2 manhole configuration
- Baffle wall (floatable collection) in the second chamber

Benefits

- Shallower Manholes
- Ease of maintenance
- No inserts means autonomy
- Each V2B1 design is unique to the site conditions
- Design includes shop drawings, specifications, maintenance schedule and back-water analysis.

About the V2B1

The V2B1's unique standard pre-cast concrete, two-manhole design helps you meet the EPA goal of 80% TSS removal efficiency.
The inlet manhole has a tangential mounted inlet pipe that creates a swirl flow pattern, which improves flow distribution and reduces turbulence, thus enhancing sedimentation settling. The environment 21 "Center Withdrawal Elbow Pipe" conveys flow to the outlet manhole where floatable debris is retained by using an underflow baffle wall. All environment 21 products are designed with ease of maintenance in mind. The V2B1 has access openings to all stages of the separation process and has a direct and unobstructed access to the sump. The V2B1 is ideal for all sites requiring a hydrodynamic separator especially those with unique site scenarios involving other utilities.

Let ENV 21 do the work for you.

ENV 21 will size, design and provide you with the appropriate product to fit your project and your budget. We will provide you with shop drawings, specifications, installation details, back-water analysis, and a maintenance schedule. We even offer maintenance agreements with maintenance performed according to the recommended schedule.

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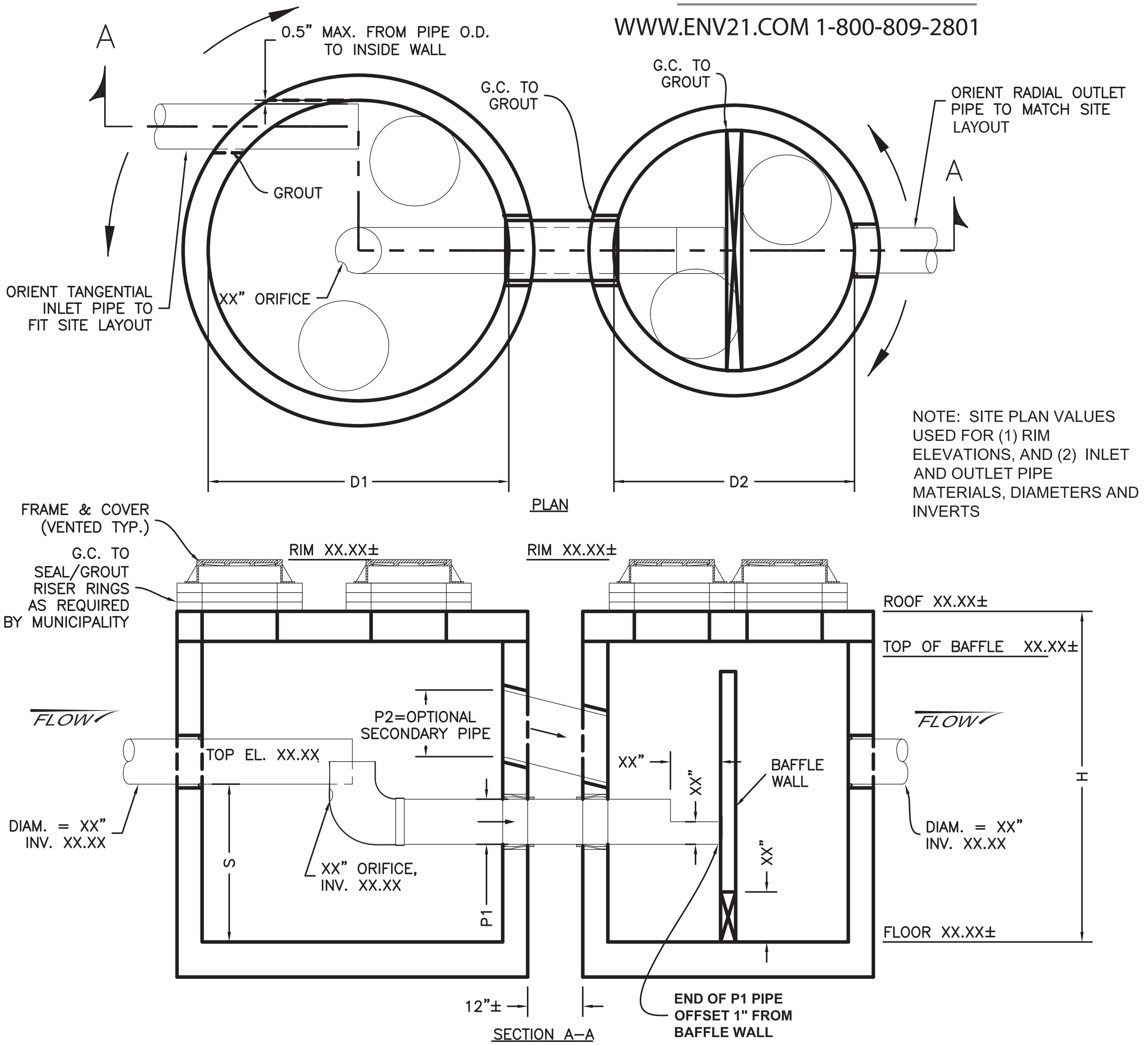
V2B1



NOTE: SITE PLAN VALUES USED FOR (1) RIM ELEVATIONS, AND (2) INLET AND OUTLET PIPE MATERIALS, DIAMETERS AND INVERTS

V2B1 SIZING TABLE					
V2B1 MODEL #	IMPERVIOUS AREA, ACRES	D1 (ft.)	D2 (ft.)	H (ft.)	S (ft.)
3	0.3 -1.3	4	5	7±	4.1±
4	1.3-2.0	5	5	7±	4.4±
6	2.0-3.0	6	5	8±	4.7±
9	3.0-4.0	7	5	8±	4.9±
11	4.0-5.3	8	6	9±	5.1±
17	5.3-8.3	10	8	10±	5.5±
25	8.3-11.7	12	8	11±	5.9±

Not to Scale

GENERAL NOTE:
MANHOLE DESIGN SPECIFICATIONS CONFORM TO LASTEST A.S.T.M. C478 SPEC. FOR PRECAST REINFORCED CONCRETE MANHOLE SECTIONS.
DESIGN LOADING: AASHTO HS20-44

MANUFACTURING NOTES:
1) DESIGN OF INTERNAL PVC PIPING PROVIDED TO LICENSED MANUFACTURER BY ENVIRONMENT 21, LLC.
2) LOCATION AND SIZE OF MANHOLE OPENINGS MAY BE ADJUSTED BY LICENSED MANUFACTURER.

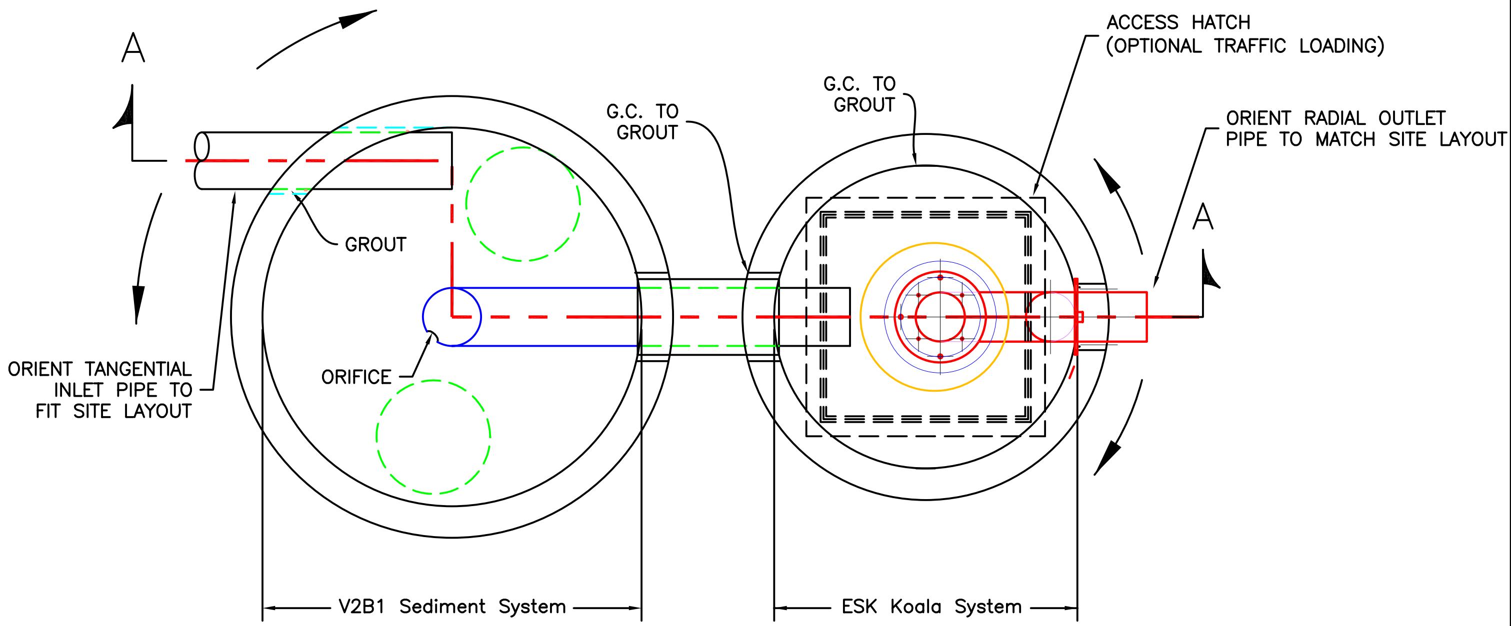
ESK Koala Oil/Water Separator

environment 21 Global Stormwater Solutions

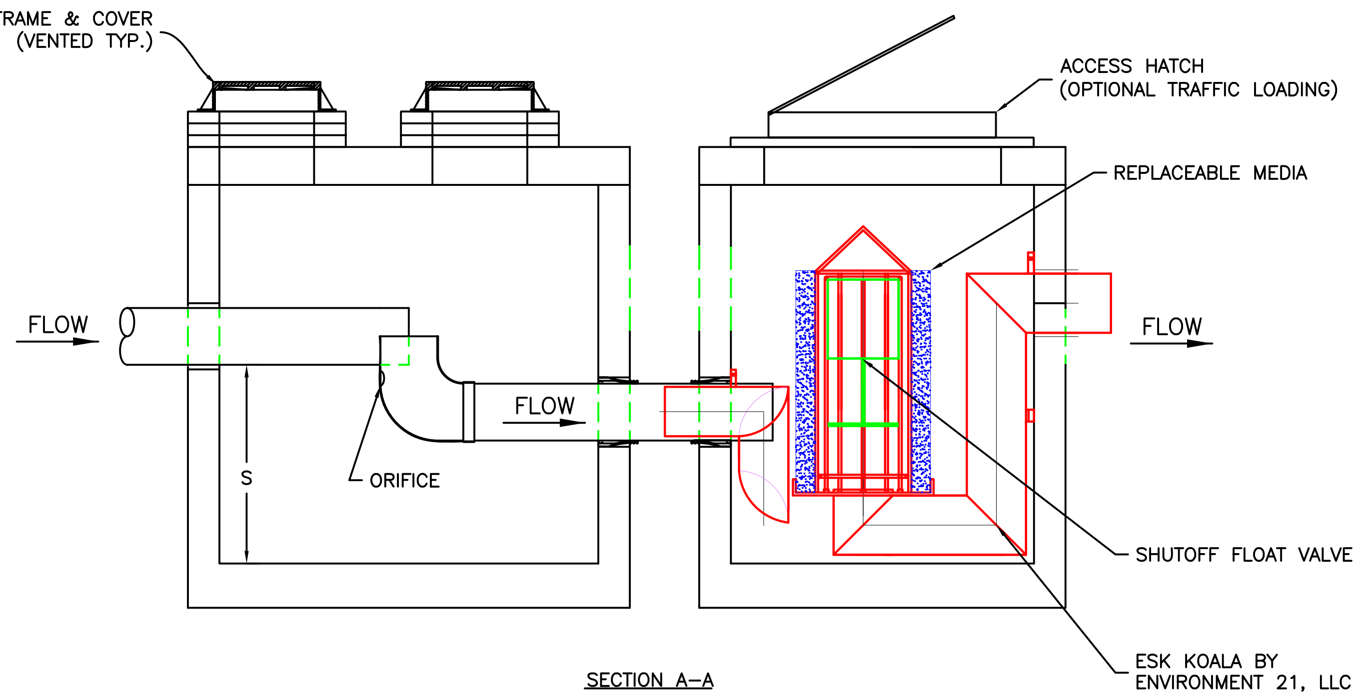
CALL: 1-800-809-2801

NOTES:
1) RAINFALL INTENSITY USED FOR TREATMENT FLOW = 0.80–1.0 IN/HR
2) MAXIMUM OPERATING LOSS APPROXIMATELY 0.8 FT

MANUFACTURING NOTES:
1) ALL INTERNAL COMPONENTS SHOULD BE SUPPLIED AND INSTALLED BY A LICENSED ENVIRONMENT 21 MANUFACTURER
2) LOCATION AND SIZE OF MANHOLE OPENINGS MAY BE ADJUSTED BY LICENSED MANUFACTURER.
3) V2B1 SEDIMENT SYSTEM IS RECOMENDED BUT NOT REQUIRED.
4) CONNECT MANHOLES WITH BOOTED CONNECTIONS.



PLAN



SECTION A–A

GENERAL NOTES:
MANHOLE DESIGN SPECIFICATIONS CONFORM TO LATEST A.S.T.M. C478 SPEC. FOR PRECAST REINFORCED CONCRETE MANHOLE SECTIONS.
DESIGN LOADING: AASHTO HS20–44

PROPRIETARY INFORMATION: PATENTS PENDING - ALL RIGHTS TO ENVIRONMENT 21, LLC.

O:\ENV21\Stormwater Treatment\ENV21 PRODUCTS\Coalescing Oil Separator\ESK\Marketing\V2B1 ESK Std Drawing.dwg

Electric Resistance Boiler

MODELS: S, CR, WB, HSB AND IWH 12-3,375 kW • 208-600V

Features

Compact, economical units that deliver maximum output with minimum space requirements. Ideal for new boiler applications or as a replacement unit to upgrade existing installations.

Steam boiler models S, CR and HSB, along with hot water boiler model WB, take up less floor area and fit through smaller openings than large conventional units do. The instantaneous hot water boilers (IWH Model), are also designed for a compact floor plan.

The electric boiler is one of the many products Cleaver-Brooks offers to meet your boiler room needs. Performance and reliability in a small package.

Why an Electric Boiler?

Cleaver-Brooks electric boilers are designed for heavy-duty commercial and industrial heating needs. They serve as either a primary or supplementary source of both hot water and steam. These immersion element boilers are quiet, flame-free and compact. Electric boilers completely eliminate the need for stacks and emission control. Cleaver-Brooks electric water boilers use resistance elements as a source of heat while keeping water volume as low as possible to allow close control and rapid response.

Advantages

COMPACT DESIGN

The smaller footprint reduces the overall boiler room space requirement.

NO STACK OR FUEL REQUIREMENTS

The unit can be located anywhere in the building and the exterior of the building is not compromised with an unsightly stack, which is particularly helpful in tall or high-rise buildings.

Typical Applications

Universities and Schools

Hospitals and Clinics

Commercial Buildings

EMISSIONS

Electric boilers are 100% local emission-free. This is beneficial in meeting the total emissions of a given project site, or in areas where fuel combustion emissions are limited.

QUIET OPERATION

Elimination of combustion noise and minimal moving parts results in extremely quiet operation.

HIGH EFFICIENCY

The electric boiler will provide nearly 100% efficiency at all operating points.

EASE OF MAINTENANCE

The absence of higher-maintenance combustion equipment and the use of solid state control devices reduce the complexity and number of moving parts. Electric elements are very accessible and easily replaceable, either individually or in flange-mounted groups.

LOWER OPERATING COST

For areas affected by allocations or interruptions of natural gas and costly oil supplies, electric boilers provide a dependable source of steam or hot water. Electric boilers offer a clean alternative to fossil fuels, allowing users to take advantage of lower energy rates during daily or seasonal off-peak periods.

Low Emissions, Compact, Quiet

QUALITY CONSTRUCTION

ISO 9001:2001 certified manufacturing processes ensure the highest compliance with manufacturing standards.

Each unit is tested and certified in accordance with UL or cUL and a label is affixed attesting to meeting the latest requirements for packaged electric boilers.

PROGRESSIVE SEQUENCING MODULATION

By individually controlling the heating elements with solid-state digital step controllers, only the amount of electrical energy required in response to the system demand is used. In addition, virtually a full range of input control is available with optional solid-state analog current controllers that reduce on/off cycling while providing unprecedented load tracking and, thus, reduced operating costs.

Standard Features

Boiler:

- ASME code vessel
- UL listed
- Integral steel frame
- Incoloy 800 heating elements
- Fiberglass insulation
- ASME pressure relief valves

Trim:

- Proportional Pressure (temperature on WB and IWH) control on most sizes
- Manual reset high pressure (temperature and WB and IWH) control
- Auxiliary low-water cutoff (low-water cutoff on WB and IWH)
- Auxiliary auto high water Cutoff
- Pilot Light: Control power on, low water, high pressure (temperature on WB & IWH)

Electrical Equipment:

- 200,000 AIC rated fuses
- Contactors rated at 500,000 cycles
- Control circuit step-down transformer
- Customer connection terminal strip
- Primary lugs
- Connection Lugs

Model S

Model HSB

Model WB

Model IWH

Model CR

PRODUCT OPTIONS

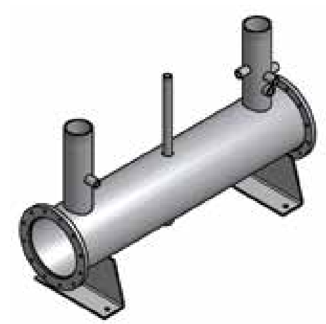
Product Type	Model	Vessel Diameter (inches)	Output (kW)	Design Pressure (PSIG)
Hot Water Boilers	WB	12	12-288	160, 200 & 250
		20	300-576	
		24	510-1,200	
		36	1,224-2,160	
		42	1,830-3,360	
Vertical Steam Boilers	S	12	12-48	15, 150, 200 & 250
		16	15-141	
		20	135-281	
		24	210-480	
		30	440-720	
		36	750-1031	
		42	1,020-1,688	
		48	1,380-2,250	
Vertical Steam Boilers with Condensate Return Tank and Pump	CR	12	12-56	15, 150, 200 & 250
		16	15-164	
		20	135-281	
		24	210-563	
Horizontal Steam Boilers	HSB	42	1,560-3,375	15, 150, 200 & 250
Instantaneous Water Heater	IWH	6	15-30	160
		8	45-240	
		10	210-360	

ELECTRIC BOILER VESSEL DIAGRAMS

Model WB

Model HSB

Models S and CR



Model IWH

CleaverBrooks®

Packaged Boiler Systems
221 Law Street • Thomasville, GA 31792 USA
800.250.5883 • info@cleaverbrooks.com
cleaverbrooks.com

Electric Resistance Boilers Steam or Hot Water

Standard Equipment - Water Boilers

Equipment described below is for the standard hot water electric boilers offering:

A. **Model WB Boiler**

1. The Model WB boiler is designed and constructed in accordance with the A.S.M.E. Code; UL listed, and are mounted on an integral steel frame. Fiberglass insulation (2" thickness) is covered with a preformed, sectional steel painted jacket, factory installed.
2. Trim and Controls:
    a. Manual Reset High Temperature Cutoff.
    b. Probe Low Water Cutoff, auto reset.
    c. Aux. Auto High Temperature Cutoff.
    d. For WB models:
        - 1-Step: (1) on/off temperature switch.
        - 2-Step: (2) on/off temperature switch.
        - 3-Step: (1) 3-stage electronic temperature control.
        - 4-Step: (1) 4-stage electronic temperature control.
        - 5-Step+: Solid state electronic proportional temperature control with progressive step control with adjustable span and inter-stage time delay.
    e. Bottom drain valve.
    f. A.S.M.E Pressure Relief Valve(s).
    g. WB models with 1-2 steps: Separate Pressure and temperature gauge.
    h. WB models with 3 or more steps: Separate Pressure Gauge and Digital Temperature Readout.
3. Electric Equipment
    a. Main Control Panel with panel door key lock.
    b. Lugs for the primary power supply, top of panel ingress as standard.
    c. Fuses for each contactor, 200,000 Amps interrupting capacity (AIC).
    d. Contactors duty rated @ 500,000 cycles.
    e. Pilot lights for “Control Power On”, “High Pressure”, “Low Water”, and “Steps”.
    f. 75 watts per square inch (WSI) "Incoloy- 800" heating elements.
    g. Control Circuit Step-down Transformer with primary and secondary fuses and secondary control power switch.
    h. Terminal strip for control wiring and external customer connections.

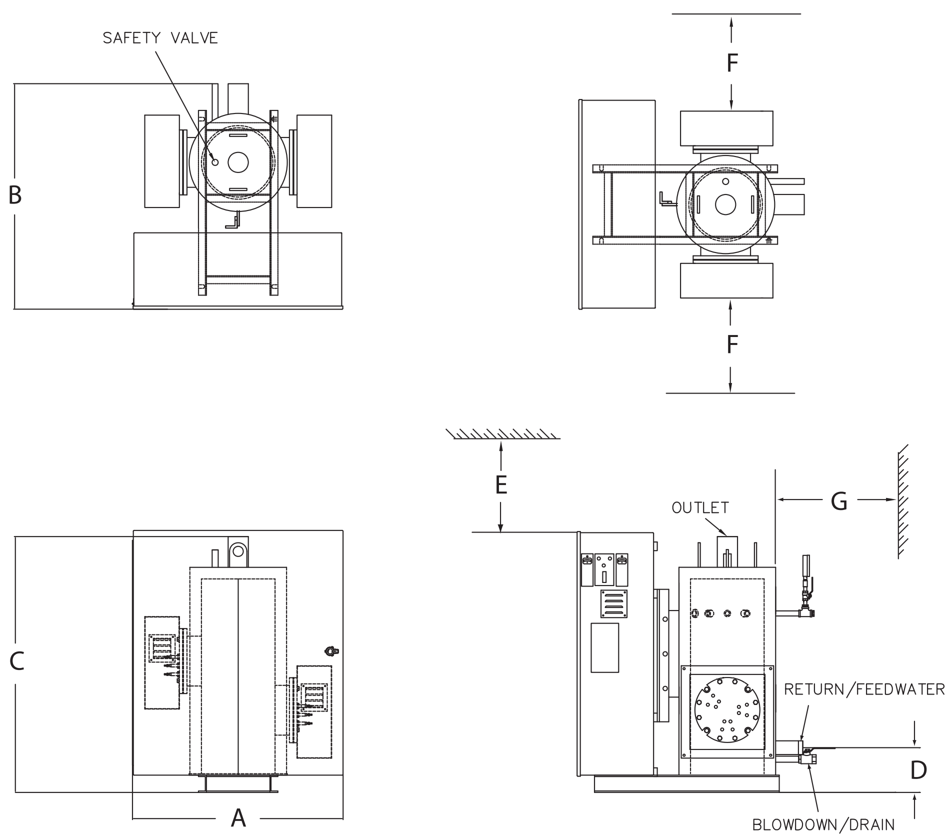
Table 1. Standard product offering

Product Type	Boiler Model	Output (kW)	Element Density (W/sq in)	Water Content (gallons)	Design Pressure (psig)	Notes
Hot water boilers	WB	12 - 3360	75	16 - 500	160, 200, 250[A]	1
Steam boilers	S	12 - 2250	67 or 78@600V	16 - 595	15, 150, 200, 250	1
	CR	12 - 563	67 or 78@600V	16 - 115	15, 150, 200, 250	1, 2
	HSB	1560 - 3375	75	180 - 790	15, 150, 200, 250	1
Instantaneous Water Heaters	IWH	15 - 360	75	135 - 360[B]	160	1

Notes: 1. Heating elements are of Incolloy-800 construction
2. Model CR identical to Model S but has integral condensate return tank and pump.

A. Model WB design pressure above 160 psig voids UL label.

B. 'Water content' not applicable. Flow rate in GPM is listed.



MODEL NO	CONNECTION SIZE (NPT)			DIMENSIONS (IN.)				CLEARANCES			APPROXIMATE WEIGHTS (LBS.)	
				WIDTH	DEPTH	HEIGHT†	INLET	TOP	SIDES	REAR	SHIPPING	OPERATING
	SUPPLY	RETURN	DRAIN	A	B	C	D	E	F	G		
WB-120	2	2	3/4	25	36	45	8	12	16	12	450	580
WB-121	3	3	3/4	32	36	45	8	12	16	12	500	630
WB-122	3	3	3/4	32	36	61	8	12	16	12	800	1005
WB-201	4 *	4 *	1-1/4	38	44	71	19	18	16	18	1400	2040
WB-202	4 *	4 *	1-1/4	38	48	71	19	18	16	18	1500	2140
WB-241	6 *	6 *	1-1/2	44	54	75	21	18	25	18	2200	3200
WB-242	6 *	6 *	1-1/2	48	60	75	21	18	25	18	2400	3400
WB-243	6 *	6 *	1-1/2	48	60	83	21	18	25	18	2800	3980
WB-361	6 *	6 *	1-1/2	56	74	75	24	24	30	24	3300	5260
WB-362	8 *	8 *	1-1/2	60	74	92	24	24	30	24	3600	6220
WB-363	8 *	8 *	2	72	76	104	24	24	30	36	4200	7280
WB-421[A]	10 *	10 *	2	76	76	104	24	24	33	36	5800	9300
WB-422[A]	10 *	10 *	2	76	95	111	24	24	33	36	6500	10500

NOTES: †Dimensional heights are for the boiler only. Control panel size varies based on the number of steps and optional equipment.

A.These models normally supplied with 2 control cabinets for 2 power supplies.

*These are flange connections; 150# ANSI.

Figure 1. Model WB Dimensions

Table 15. Model WB Max Flow Ratings Sheet 1 of 2

Model #	Rated kW	System Temperature Drop ^{0}F							
		10	20	30	40	50	60	70	80
		Maximum Flow Rate in GPM							
WB-120	12	8.2	4.5	3	2	1.75	1.5	1.25	1
	18	12.4	6.5	4.5	3.2	2.6	2	1.75	1.6
	24	16.5	8	5.5	4.1	3.2	2.75	2.3	2.1
	30	20.5	10.3	6.75	5.1	4.1	3.4	3	2.6
	36	24.5	12.25	8.2	6.2	4.9	4.1	3.5	3.1
	45	30.9	15.7	10.3	7.7	6.3	5.1	4.4	3.9
	54	37	18.4	12.3	9.2	7.4	6.1	5.3	4.6
	60	41	20.5	13.5	10.3	8.2	6.8	5.8	5.1
	72	49.5	24.2	16.5	12.3	9.8	8.2	7	6.1
WB-121	90	61.5	30.5	20.5	15.4	12.3	10.3	8.8	7.7
	108	73.6	37	24.7	18.5	14.8	12.3	10.6	9.2
	126	86	43	28.7	21.6	17.3	14.4	12.3	10.8
	144	98	49.2	32.9	24.6	19.7	16.5	14.1	12.3
WB-122	162	110.5	55.5	37	27.7	22.2	18.5	15.9	13.7
	180	122.6	61.5	41	30.8	24.6	20.5	17.6	15.4
	198	135.5	67.5	45	33.9	27.1	22.6	19.4	16.9
	216	148	74	49.3	37	29.6	24.6	21.1	18.5
	234	160	80	53.4	40	32	26.7	22.9	20
	252	172	86	57.5	43.1	34.5	28.8	24.6	21.6
	270	184.3	92.4	61.6	46.2	37	30.8	26.4	23.2
	288	196	98.5	65.7	49.3	39.5	32.9	28.2	24.6
WB-201	324	222	111	74	55.5	44.4	37	31.7	27.7
	360	246.5	123	82.2	61.6	49.3	41.1	35.2	30.8
	396	271	135.5	90.4	67.8	54.2	45.2	38.7	33.9
	432	296	148	98.6	74	59.2	49.3	42.3	37
WB-202	468	320	160.3	106.8	80.1	64.1	53.4	45.8	40
	504	345	172.5	115	86.3	69	57.5	49.3	43.2
	540	370	185	123.3	92.5	74	61.6	52.8	46.2
	576	394	197	131.5	98.6	79	65.7	56.4	49.3
WB-241	600	411	205.5	137	102.7	82.2	68.5	58.7	51.4
	630	431	215.5	143.8	107.9	86.3	71.9	61.6	53.9
	660	452	226	150.7	113	90.4	75.3	64.6	56.5
	690	472	236	157.5	118.2	94.5	78.8	67.5	59.1
	720	493	246.4	164.4	123.3	98.6	82.2	70.5	61.6
WB-242	750	514	257	171.2	128.4	102.7	85.6	73.4	64.2
	780	534	267	178.1	133.6	106.8	89	76.3	66.8
	810	555	277.5	185	138.7	110.9	92.5	79.2	69.3
	840	575	287.5	191.8	143.8	115.1	95.9	82.2	71.9
	870	596	298	198.6	150	119.2	99.3	85.1	74.5
	900	615	308	205.5	154.1	123.3	102.7	88.1	77
	930	637	318.5	212.3	159.2	127.4	106.2	91	79.6
	960	657	328.5	219.2	164.4	131.5	109.6	93.9	82.2

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Fire Fighting units with bore hole (submersible) pumps

Required components

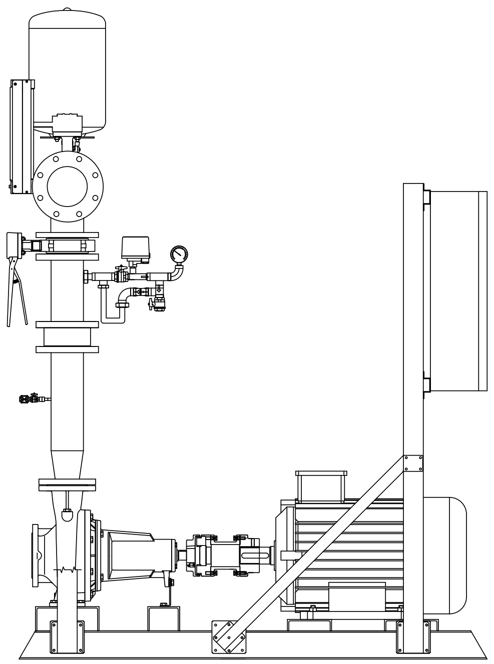
Hydraulic diagram

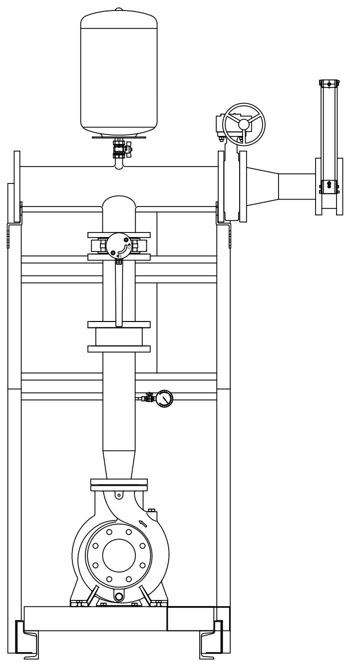
3.1

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Electric main pump module

“E” series





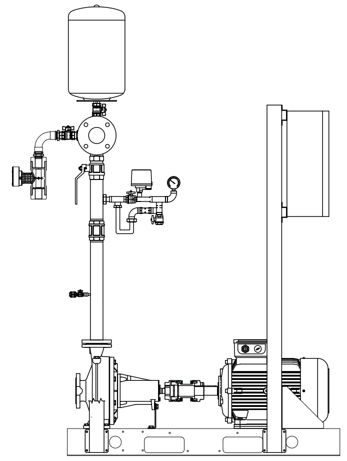
Fire fighting unit according to standard EN 12845, consists of 1 electric main pump module:

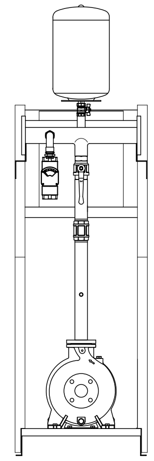
Main centrifugal pump “back pull-out” type in according to EN 733 (formerly DIN 24255) axial suction and radial discharge, cast iron pump casing, mechanical seal, coupling performed by means of flexible coupling spacer with three-phase asynchronous electric motor. The fire fighting unit is complete with a main electric pump mounted on a painted steel base and electrically wired to the electrical control panel installed on board skid (for power ≥ 160 kW the electric panel of the main pump is supplied loose cabinet metal size = WxHxD mm 800x1800x430 and its wiring with the group will be at the customer). The standard supply of the Fire unit Series “E” does not include either the suction valve or suction eccentric enlargement of the main pump, which must be ordered separately (suction reducing eccentric be sized according to the directions of the standard EN 12845).

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Electric main pump module

“E” series





Units with capacity from m³/h 0 up to m³/h 96

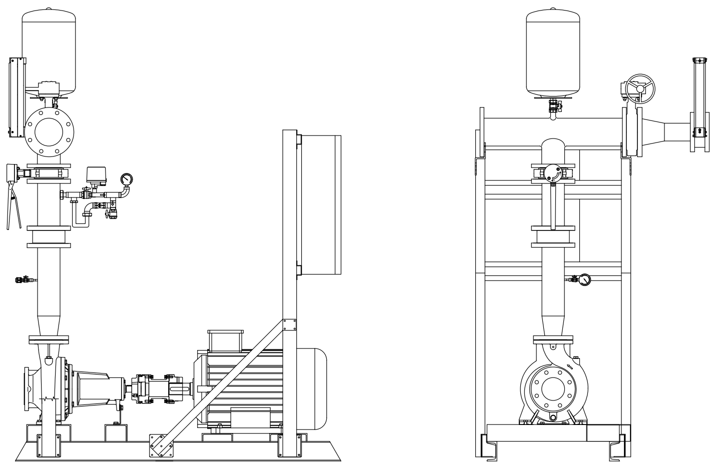
Code	Model	Electric Power (kW)	Q= CAPACITY OF EACH SERVICE PUMP																		
			m³/h 0	7,2	9	14,4	18	21,6	24	27	28,8	30	36	43,2	50,4	54	60	72	84	90	96
			l/m 0	120	150	240	300	360	400	450	480	500	600	720	840	900	1000	1200	1400	1500	1600
			H= Total head (m.c.a.)																		
700.001	E-L32-200/188-4	3	44	41	40	35	32*	27	24	20											
700.002	E-L32-200/204-5,5	4	54	51	45	45	42	37*	34	30	27	26									
700.003	E-S32-200N/206-7,5	5.5	54			51	49	46	44*	40	36	35									
700.004	E-S32-200N/219-10	7.5	63			62	61	60	57*	54	52	50	36								
700.005	E-L32X-250/256-15	11	86			74	71	66*	63	59											
700.006	E-C32-250/225-20	15	69				69	68	67	65	63	62*	53								
700.007	E-C32-250/235-20	15	77				76	75	74	73	71	70*	61								
700.008	E-C32-250/255-25	18.5	89				89	88	87	85	84	83	75*	60							
700.009	E-C32-250/264-25	18.5	96				95	94	92	91	89	88	80*	64							
700.010	E-S40-200/190-10	7.5	46				44	43	41	40	39	38*	33	26	20						
700.011	E-L40-200/209-10	7.5	57				54	52	51	50	49	48	46*	41							
700.012	E-S40-200/212-12,5	9.2	58				58	56	55	54	53	52	47*	41	35						
700.013	E-L40-250/233-15	11	72				68	65	64	63	62	61	57	52*	44						
700.014	E-L40-250/251-20	15	85				80	78	77	75	74	73	70	65*	56	53					
700.015	E-S40-250N/240-25	18.5	81						79	78	77	76	75	69	68*	65	61	51			
700.016	E-S40-250N/255-30	22	95						89	88	87	86	84	80	76*	74	69	55			
700.017	E-S40-250N/259-40	30	98						92	91	91,5	90	87	81	79*	76	71	59			
700.018	E-L50-200/197-15	11	51									48	47	45	42	41	38*	33	26		
700.019	E-L50-200/209-15	11	58									55	54	53	50	49	43*	40	33	29	
700.020	E-L50-250/224-20	15	68										64	63	60	59	56*	50	41		
700.021	E-L50-250/237-25	18.5	77										73	72	70	68	66	60*	52	47	
700.022	E-L50-250/250-30	22	86										83	81	79	78	75	70*	61	57	52
700.023	E-C50-250/255-40	30	95										92	90,5	88	86	83*	72	50	36	
700.024	E-C50-250/264-50	37	104										101	99	96	94	91	83*	61	54	26
700.025	E-CH50-315/291-75	55	118										114	113	110	108	106	98*	82	74	
700.026	E-CH50-315/308-100	75	132										129	127	125	123	122	116	106*	100	90

Tolerances in table: ISO 9906 Annex A (performance at the outlet of the pump)
Gray boxes: NPSH ≥ 5m (possible installation only with positive suction head)
* maximum efficiency point

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Electric main pump module

“E” series



Units with capacity from m³/h 66 up to m³/h 360

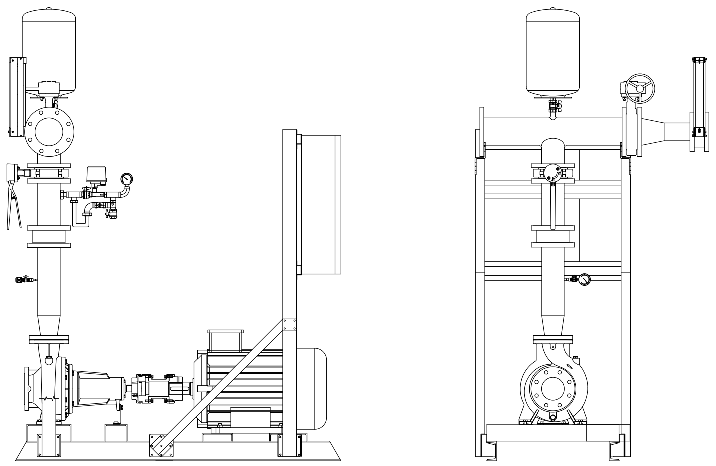
Code	Model	Electric Power (kW)	Q= CAPACITY OF EACH SERVICE PUMP													
			m³/h 0	66	72	90	108	120	150	180	210	240	270	300	330	360
			l/m 0	1100	1200	1500	1800	2000	2500	3000	3500	4000	4500	5000	5500	6000
			H= Total head (m.c.a.)													
700.027	E-L65-200/187-20	15	45	44	43	40*	37	34								
700.028	E-S65-200N/192-30	22	50	50	48	46*	43	40	30	15						
700.029	E-L65-200/198-25	18.5	52	51	51	48	45*	42								
700.030	E-L65-200/210-30	22	59	59	58	55	52*	50								
700.031	E-S65-200N/215-40	30	65	64	64	61	58*	55	46	34						
700.032	E-L65-250/241-40	30	76	74	73	69	64*	61								
700.033	E-L65-250/258-50	37	90	87	86	83	78*	75								
700.034	E-S65-250N/222-40	30	70	68	67	65	62*	59	51							
700.035	E-S65-250N/245-60	45	83	82	82	79	76	73*	65							
700.036	E-S65-250N/255-60	45	92	92	91	89	85	83*	74	65						
700.037	E-S65-250N/259-75	55	95	94	93	92	88	85*	76	69						
700.038	E-S65-315R/273-75	55	101	100	99	96	93*	90	84							
700.039	E-S65-315R/282-100	75	112	111	110	108	105*	103	96	87						
700.040	E-L80-200/189-30	22	48				45	44	38*	32						
700.041	E-L80-200/207-40	30	60				58	57	52*	46	40					
700.042	E-L80-250/225-50	37	71				67	65	58*	49						
700.043	E-L80-250/238-60	45	80				78	76	70*	62						
700.044	E-L80-250/256-75	55	92				91	90	84	76*	68					
700.045	E-L80X-250/270-100	75	112				108	106	101	94*	83					
700.046	E-C80-200/205-60	45	58					56	53	50*	46	42				
700.047	E-C80-200/214-75	55	64					62	60	57	53*	49				
700.048	E-C80-250/235-75	55	75					70	68	64*	57	44	30			
700.049	E-C80-250/255-100	75	89					85	84	80	75*	68	56	38		
700.050	E-C80-250/264-100	75	106					90	89	87	83*	76	66	52		
700.051	E-S80-250/269-150	110	102					102	100	98	95	92*	88	85	82	77
700.052	E-S80-315R/302-150	110	117					115	113	112	108*	103	90			

Tolerances in table: ISO 9906 Annex A (performance at the outlet of the pump)
Gray boxes: NPSH ≥ 5m (possible installation only with positive suction head)
* maximum efficiency point

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Electric main pump module

“E” series



Units with capacity from m³/h 150 up to m³/h 750

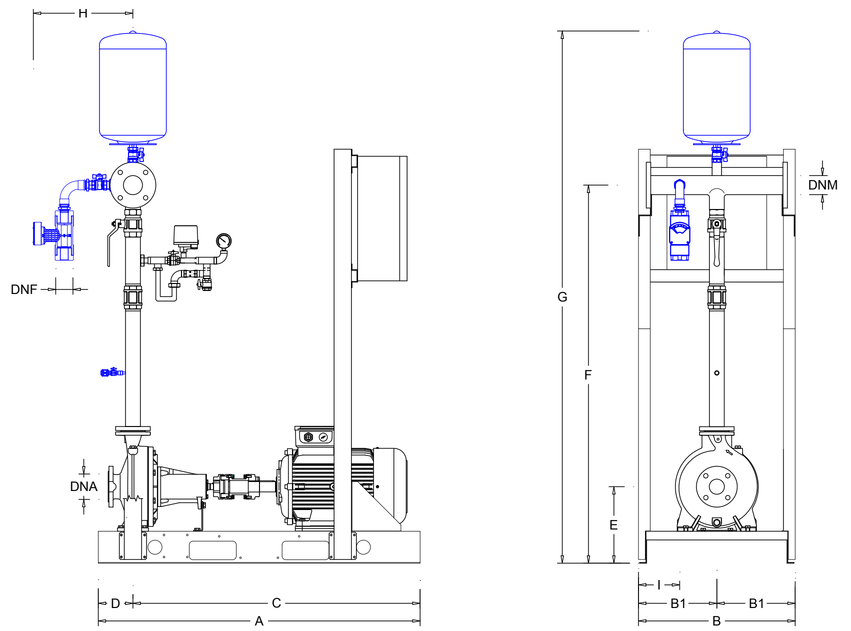
Code	Model	Electric Power (kW)	Q= CAPACITY OF EACH SERVICE PUMP																
			m³/h 0	150	180	210	240	270	300	330	360	390	420	480	540	600	650	700	750
			l/m 0	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	8000	9000	10000	10833	11667	12500
			H= Total head (m.c.a.)																
700.053	E-L100-200/192-40	30	49	45	42	38*	34	30	24										
700.054	E-L100-200/203-50	37	56	52	50	46	42*	38	33	26									
700.055	E-L100-250/221-60	45	69	65	59	56*	50	45	35										
700.056	E-L100-250/235-75	55	79	75	72	69	64*	56	50										
700.057	E-L100-250/254-100	75	92	89	86	84	80	75*	67										
700.058	E-L100-250/267-125	90	103	100	98	95	90	85*	80										
700.059	E-S100-200/219-75	55	62,5	60	59	57,5	55	52,5	49*	43	37,5								
700.060	E-S100-250/233-100	75	68	67	64	61	57	55*	49	43	30								
700.061	E-S100-250/250-100	75	80	79	77	75	72	69	64*	59	53								
700.062	E-S100-250/265-125	90	95	92	90	88	86	84	80*	75	70								
700.063	E-S100-250/269-150	110	97	95	94	92	90	86	83*	78	74								
700.064	E-CH100-315/291-150	110	117	114	111	108	102	96*	87	74									
700.065	E-CH100-315/308-180	132	131	130	128	124	120	115	106*	96	84								
700.066	E-L125-200/206-60	45	47					38	36	34	32	30*	28	22					
700.067	E-L125-200/216-75	55	57					49	47	45	42	40	38*	31	22				
700.068	E-CH125-250/222-100	75	59					55	53	50*	47	43							
700.069	E-L125-270/224-100	75	65					59	56	55	53	50*	48	47	35				
700.070	E-L125-270/237-125	90	75					70	68	65	65	61	60*	54	45	36			
700.071	E-L125-270/253-150	110	88					82	80	78	76	74	71	66*	57	46			
700.072	E-CH125-250/264-180	132	91					90	88	86	84	81	77*	72	62				
700.073	E-L125-270/266-180	132	97					91	90	87	86	84	81	76*	70	60			
700.074	E-CH125-250/278-218	160	102					101	100	99	97	95	93	87*	80	71			
700.075	E-S125-315R/302-272	200	124				118	117	115	112	109*	105	102	90					
700.076	E-S150-315R/257-218	160	70						68	67	66	64	62	58	52*	47	42	35	
700.077	E-S150-315R/266-218	160	85						82	81	80	78	76	72	68*	62	56	50	
700.078	E-S150-315R/280-272	200	97						94	93	92	90	88	85	80*	75	70	62	53
700.079	E-S150-315R/290-340	250	107						106	105	103	102	101	97	95*	90	85	80	75

Tolerances in table: ISO 9906 Annex A (performance at the outlet of the pump)
Gray boxes: NPSH ≥ 5m (possible installation only with positive suction head)
* maximum efficiency point

Dimensions - Fire fighting units Series "E"

Fire fighting units with horizontal pumps back pull-out type

1 Electric main pump module



Units with capacity from m³/h 0 up to m³/h 96

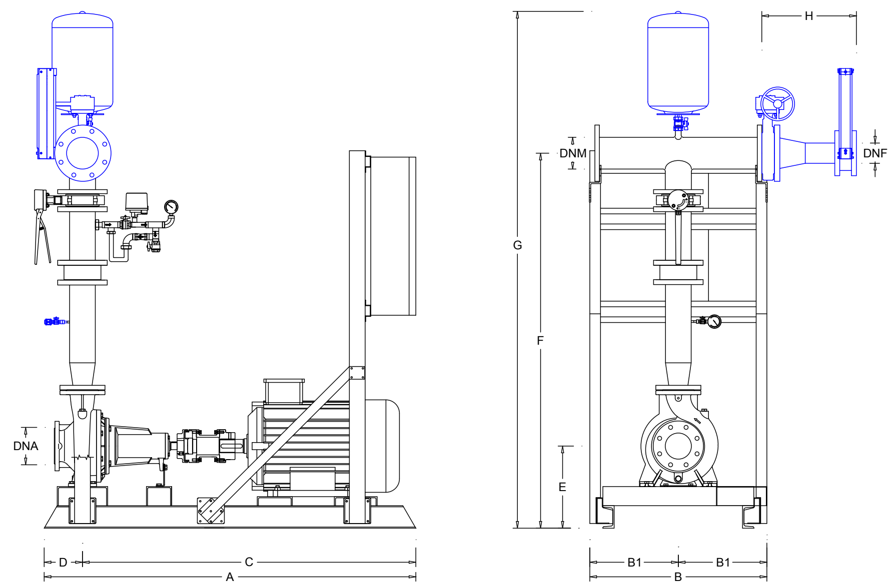
Fire Fighting Unit		Flow meter kit	Connections			Dimensions (mm)									
Code	Model		DNA	DNM	DNF	A	B	B1	C	D	E	F	G	H	I
700.001	E- L32-200/188-4	KA-32-32	DN50	DN65	1 ¼"	1300	633	316,5	1160	140	290	1428*	2050*	405*	150
700.002	E- L32-200/204-5,5														
700.003	E- S32-200/206-7,5														
700.004	E-S32-200N/219-10														
700.005	E-L32X-250/256-15										310	1533*	2155*		
700.006	E-C32-250/225-20											1493*	2115*		
700.007	E-C32-250/235-20														
700.008	E-C32-250/255-25	KA-40-40			1 ½"										
700.009	E-C32-250/264-25											1527*	2150*		
700.010	E-S40-200/190-10	KA-40-40	DN65	DN65	1 ½"	1300	633	316,5	1160	140	290	1428*	2050*	405*	150
700.011	E-L40-200/209-10														
700.012	E-S40-200/212-12,5														
700.013	E-L40-250/233-15										310	1533*	2155*		
700.014	E-L40-250/251-20											1493*	2115*		
700.015	E-S40-250N/240-25	KA-50-50			2"							1527*	2150*		
700.016	E-S40-250N/255-30														
700.017	E-S40-250N/259-40										330				
700.018	E-L50-200/197-15	KA-50-50	DN65	DN80	2"	1300	633	316,5	1160	140	290	1503	2125	405*	150
700.019	E-L50-200/209-15	KB1-65-65			DN65							1563	2185	432	
700.020	E-L50-250/224-20	KA-50-50			2"						310	1548	2170	405*	
700.021	E-L50-250/237-25	KB1-65-65			DN65							1582	2187	432	
700.022	E-L50-250/250-30														
700.023	E-C50-250/255-40	KA-50-50			2"	1650	786	393	1480	170	340	1605	2232	405*	
700.024	E-C50-250/264-50	KB1-65-65			DN65									432	
700.025	E-CH50-315/291-75					1800			1630		390	1665	2292		
700.026	E-CH50-315/308-100					1900					420				

* Tolerance of ± 50 mm
blue components: optional available on request

Dimensions - Fire fighting units Series "E"

Fire fighting units with horizontal pumps back pull-out type

1 Electric main pump module



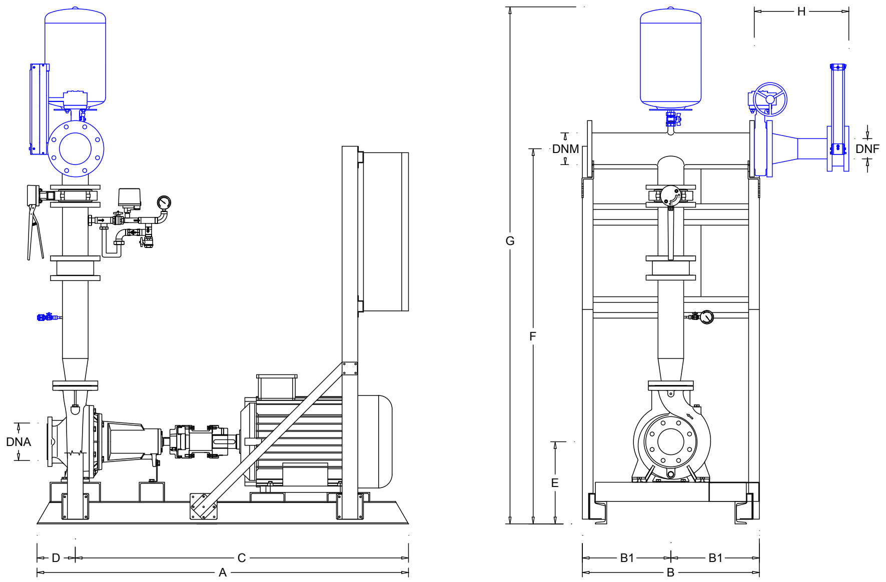
Units with capacity from m³/h 66 up to m³/h 360

Fire Fighting Unit		Flow meter kit	Connections			Dimensions (mm)								
Code	Model		DNA	DNM	DNF	A	B	B1	C	D	E	F	G	H
700.027	E-L65-200/187-20	KB2-100-65	DN80	DN100	DN65	1300	633	316.5	1160	140	310	1581	2216	397
700.028	E-S65-200N/192-30	KB2-100-80			DN80							1615	2233	402
700.029	E-L65-200/198-25	KB2-100-65			DN65									397
700.030	E-L65-200/210-30													
700.031	E-S65-200N/215-40	KB2-100-80			DN80	1650	786	393	1480	170	340	1600	2217	402
700.032	E-L65-250/241-40	KB2-100-65			DN65						360	1644	2262	397
700.033	E-L65-250/258-50													
700.034	E-S65-250N/222-40	KB2-100-80			DN80									402
700.035	E-S65-250N/245-60													
700.036	E-S65-250N/255-60													
700.037	E-S65-250N/259-75					1800			1630		390			
700.038	E-S65-315R/273-75											1699	2317	
700.039	E-S65-315R/282-100										420			
700.040	E-L80-200/189-30	KB2-125-80	DN100	DN125	DN80	1358	633	316.5	1160	140	310	1684	2315	426
700.041	E-L80-200/207-40	KC-125-100			DN100	1650	786	393	1480	170	365	1667	2298	420
700.042	E-L80-250/225-50	KB2-125-80			DN80						340	1717	2348	426
700.043	E-L80-250/238-60													
700.044	E-L80-250/256-75	KC-125-100			DN100	1800			1630		390			420
700.045	E-L80X-250/270-100										420	1832	2463	
700.046	E-C80-200/205-60					1650			1480		365	1667	2298	
700.047	E-C80-200/214-75					1800			1630		340			
700.048	E-C80-250/235-75										390	1717	2348	
700.049	E-C80-250/255-100										420			
700.050	E-C80-250/264-100											1832	2463	
700.051	E-S80-250/269-150					2200	1046	523	2015	185	475	1857	2488	
700.052	E-S80-315R/302-150											1892	2523	

* Tolerance of ± 50 mm
blue components: optional available on request

Dimensions - Fire fighting units Series “E”

Fire fighting units with horizontal pumps back pull-out type
1 Electric main pump module



Units with capacity from m³/h 150 up to m³/h 750

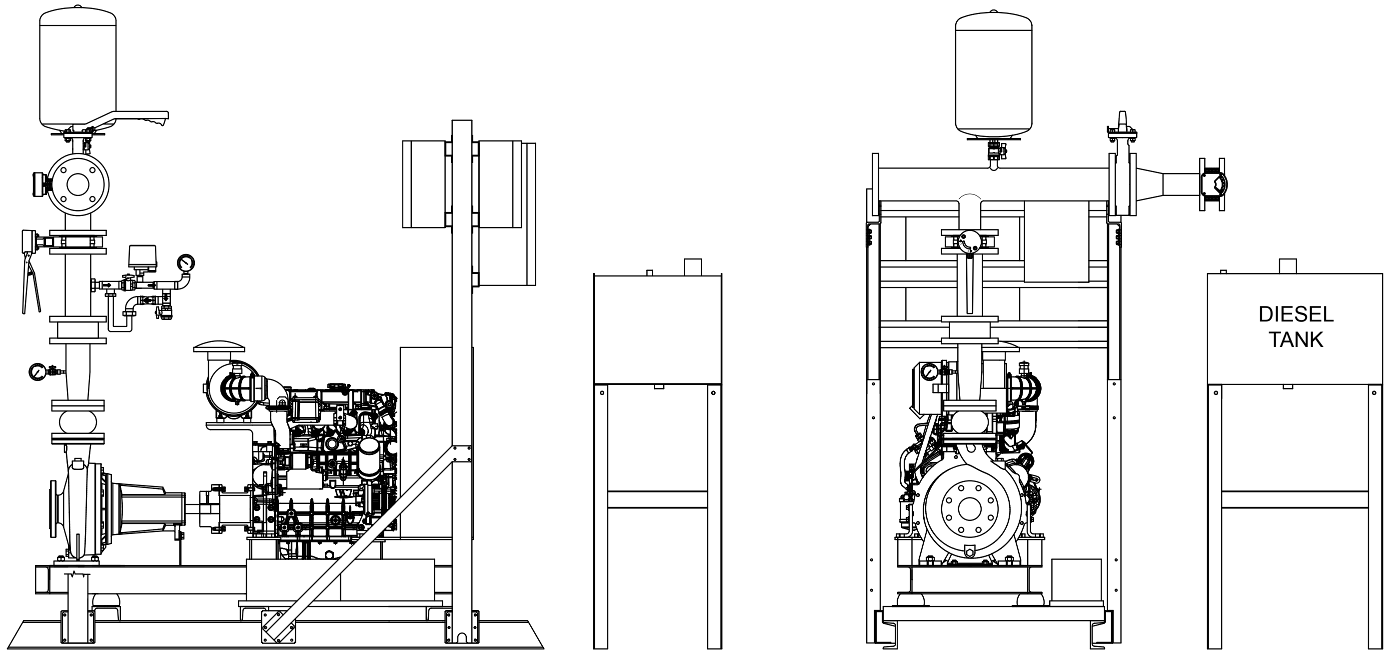
Fire Fighting Unit		Flow meter kit	Connections			Dimensions (mm)								
Code	Model		DNA	DNM	DNF	A	B	B1	C	D	E	F	G	H
700.053	E-L100-200/192-40	KC-150-125	DN125	DN150	DN125	1650	786	393	1480	170	340	1776	2421	472
700.054	E-L100-200/203-50													
700.055	E-L100-250/221-60										365	1801	2446	
700.056	E-L100-250/235-75					1800			1630		390			
700.057	E-L100-250/254-100										420	1881	2526	
700.058	E-L100-250/267-125													
700.059	E-S100-200/219-75										390	1776	2421	
700.060	E-S100-250/233-100										420	1801	2446	
700.061	E-S100-250/250-100											1881	2526	
700.062	E-S100-250/265-125													
700.063	E-S100-250/269-150					2150	1046	523	1965	185	475			
700.064	E-CH100-315/291-150											1941	2586	
700.065	E-CH100-315/308-180													
700.066	E-L125-200/206-60	KC-200-150	DN150	DN200	DN150	1800	786	393	1630	170	390	1957	2652	536
700.067	E-L125-200/216-75													
700.068	E-CH125-250/222-100	KC-200-125			DN125						420	1997	2692	
700.069	E-L125-270/224-100	KC-200-150			DN150							2077	2772	
700.070	E-L125-270/237-125	KC-200-200			DN200									438
700.071	E-L125-270/253-150					2150	1046	523	1965	185	475	2117	2792	
700.072	E-CH125-250/264-180	KC-200-150			DN150							2077	2772	536
700.073	E-L125-270/266-180	KC-200-200			DN200									438
700.074	E-CH125-250/278-218					2200			2015					
700.075	E-S125-315R/302-272	KC-200-150			DN150						505	2107	2802	536
700.076	E-S150-315R/257-218	KC-250-200	DN200	DN250	DN200	2200	1046	523	2015	185	505	2290	2992	636
700.077	E-S150-315R/266-218													
700.078	E-S150-315R/280-272													
700.079	E-S150-315R/290-340													

* Tolerance of ± 50 mm
blue components: optional available on request

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Diesel main motorpump module

“D” Series



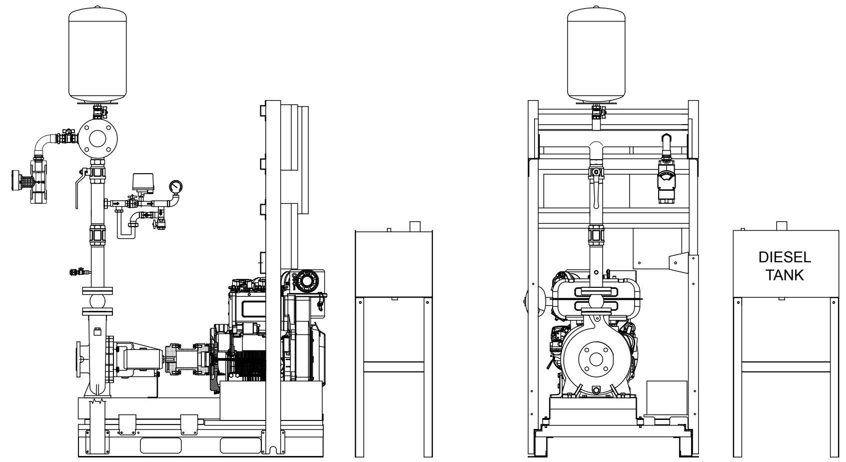
Fire fighting unit according to standard EN 12845, consists of 1 diesel main motorpump module:

Main centrifugal pump “back pull-out” according to EN 733 (formerly DIN 24255) axial suction and radial discharge, cast iron pump casing, mechanical seal, coupling performed by means of flexible coupling spacer with diesel engine fitted in compliance with EN 12845. The fire fighting unit is complete with a main pump mounted on a painted steel base, electrically wired to the electrical control panel installed on board skid. The standard supply of the Fire unit series “D” does not include either the suction valve or suction eccentric enlargement of the main pump or elastic vibration compensator, which must be ordered separately (suction reducing eccentric be sized according to the directions of the standard EN 12845). Diesel tank included, provided on a separate pedestal.

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Diesel main motorpump module

“D” Series



Units with capacity from m³/h 0 up to m³/h 96

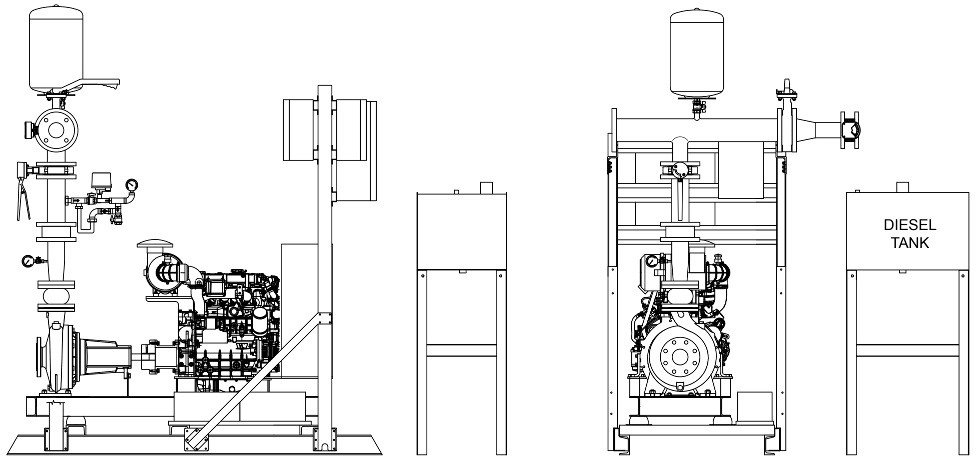
Code	Model	Diesel Power kW	Q= CAPACITY OF EACH SERVICE PUMP																		
			m³/h 0	7,2	9	14,4	18	21,6	24	27	28,8	30	36	43,2	50,4	54	60	72	84	90	96
			l/m 0	120	150	240	300	360	400	450	480	500	600	720	840	900	1000	1200	1400	1500	1600
			H= Total head (m.c.a.)																		
700.080	D-L32-200/188-5,8	4.26	44	41	40	35	32*	27	24	20											
700.081	D-L32-200/204-5,8	4.26	54	51	45	45	42	37*	34	30	27	26									
700.082	D-S32-200N/206-8,4	6.18	54			51	49	46	44*	40	36	35									
700.083	D-S32-200N/219-14,4	10.59	63			62	61	60	57*	54	52	50	36								
700.084	D-L32X-250/256-14,4	10.59	86			74	71	66*	63	59											
700.085	D-C32-250/225-18,5	13.60	69				69	68	67	65	63	62*	53								
700.086	D-C32-250/235-24	17.65	77				76	75	74	73	71	70*	61								
700.087	D-C32-250/255-24	17.65	89				89	88	87	85	84	83	75*	60							
700.088	D-C32-250/264-27	19.8	96				95	94	92	91	89	88	80*	64							
700.089	D-S40-200/190-8,4	6.18	46				44	43	41	40	39	38*	33	26	20						
700.090	D-L40-200/209-14,4	10.59	57				54	52	51	50	49	48	46*	41							
700.091	D-S40-200/212-14,4	10.59	58				58	56	55	54	53	52	47*	41	35						
700.092	D-L40-250/233-18,5	13.60	72				68	65	64	63	62	61	57	52*	44						
700.093	D-L40-250/251-24	17.65	85				80	78	77	75	74	73	70	65*	56	53					
700.094	D-S40-250N/240-27	19.8	81						79	78	77	76	75	69	68*	65	61	51			
700.095	D-S40-250N/255-36	26.47	95						89	88	87	86	84	80	76*	74	69	55			
700.096	D-S40-250N/259-36	26.47	98						92	91	91,5	90	87	81	79*	76	71	59			
700.097	D-L50-200/197-14,4	10.59	51									48	47	45	42	41	38*	33	26		
700.098	D-L50-200/209-18,5	13.60	58									55	54	53	50	49	43*	40	33	29	
700.099	D-L50-250/224-24	17.65	68										64	63	60	59	56*	50	41		
700.100	D-L50-250/237-27	19.8	77										73	72	70	68	66	60*	52	47	
700.101	D-L50-250/250-36	26.47	86										83	81	79	78	75	70*	61	57	52
700.102	D-C50-250/255-42,6	31.3	95										92	90,5	88	86	83*	72	50	36	
700.103	D-C50-250/264-42,6	31.3	104										101	99	96	94	91	83*	61	54	26
700.104	D-CH50-315/291-65,3	48	118										114	113	110	108	106	98*	82	74	
700.105	D-CH50-315/308-89,8	66	132										129	127	125	123	122	116	106*	100	90

Tolerances in table: ISO 9906 Annex A (performance at the outlet of the pump)
Gray boxes: NPSH ≥ 5m (possible installation only with positive suction head)
* maximum efficiency point

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Diesel main motorpump module

“D” Series



Units with capacity from m³/h 66 up to m³/h 360

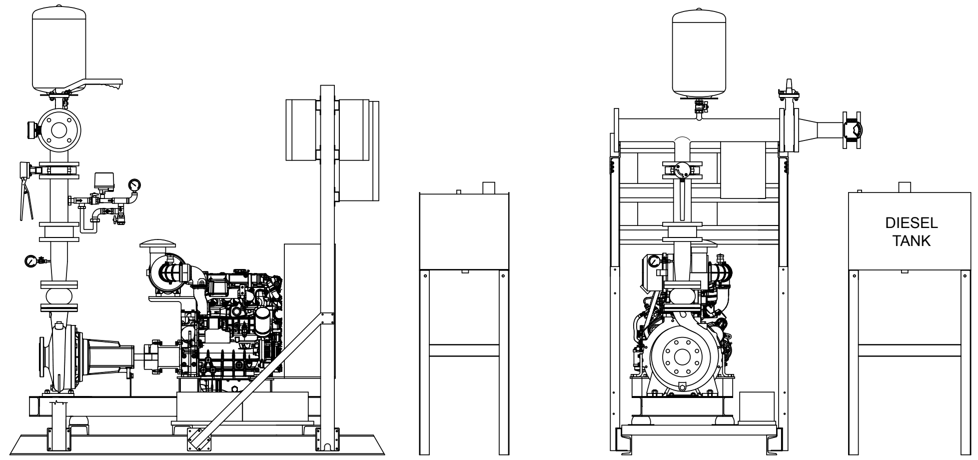
Code	Model	Diesel Power kW	Q= CAPACITY OF EACH SERVICE PUMP													
			m³/h 0	66	72	90	108	120	150	180	210	240	270	300	330	360
			l/m 0	1100	1200	1500	1800	2000	2500	3000	3500	4000	4500	5000	5500	6000
			H= Total head (m.c.a.)													
700.106	D-L65-200/187-24	17.65	45	44	43	40*	37	34								
700.107	D-S65-200N/192-36	26.47	50	50	48	46*	43	40	30	15						
700.108	D-L65-200/198-27	19.8	52	51	51	48	45*	42								
700.109	D-L65-200/210-36	26.47	59	59	58	55	52*	50								
700.110	D-S65-200N/215-42,6	31.3	65	64	64	61	58*	55	46	34						
700.111	D-L65-250/241-42,6	31.3	76	74	73	69	64*	61								
700.112	D-L65-250/258-50	37	90	87	86	83	78*	75								
700.113	D-S65-250N/222-42.6	31.3	70	68	67	65	62*	59	51							
700.114	D-S65-250N/245-65,3	48	83	82	82	79	76	73*	65							
700.115	D-S65-250N/255-65,3	48	92	92	91	89	85	83*	74	65						
700.116	D-S65-250N/259-65,3	48	95	94	93	92	88	85*	76	69						
700.117	D-S65-315R/273-89,8	66	101	100	99	96	93*	90	84							
700.118	D-S65-315R/282-89,8	66	112	111	110	108	105*	103	96	87						
700.119	D-L80-200/189-36	26.47	48				45	44	38*	32						
700.120	D-L80-200/207-42,5	31.3	60				58	57	52*	46	40					
700.121	D-L80-250/225-50	37	71				67	65	58*	49						
700.122	D-L80-250/238-65,3	48	80				78	76	70*	62						
700.123	D-L80-250/256-89,8	66	92				91	90	84	76*	68					
700.124	D-L80X-250/270-133,4	98.1	112				108	106	101	94*	83					
700.125	D-C80-200/205-65,3	48	58					56	53	50*	46	42				
700.126	D-C80-200/214-65,3	48	64					62	60	57	53*	49				
700.127	D-C80-250/235-65,3	48	75					70	68	64*	57	44	30			
700.128	D-C80-250/255-89,8	66	89					85	84	80	75*	68	56	38		
700.129	D-C80-250/264-133,4	98.1	106					90	89	87	83*	76	66	52		
700.130	D-S80-250/269-177,5	130.5	102					102	100	98	95	92*	88	85	82	77
700.131	D-S80-315R/302-177,5	130.5	117					115	113	112	108*	103	90			

Tolerances in table: ISO 9906 Annex A (performance at the outlet of the pump)
Gray boxes: NPSH ≥ 5m (possible installation only with positive suction head)
* maximum efficiency point

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Diesel main motorpump module

“D” Series



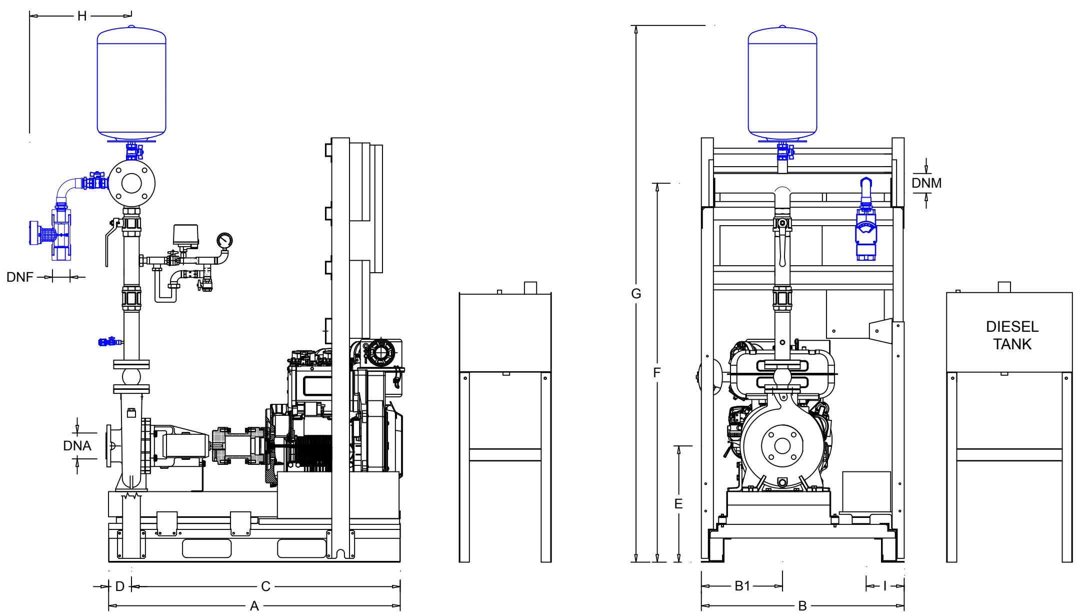
Units with capacity from m³/h 150 up to m³/h 750

Code	Model	Diesel Power kW	Q= CAPACITY OF EACH SERVICE PUMP																
			m³/h 0	150	180	210	240	270	300	330	360	390	420	480	540	600	650	700	750
			l/m 0	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	8000	9000	10000	10833	11667	12500
			H= Total head (m.c.a.)																
700.132	D-L100-200/192-42,6	31.3	49	45	42	38*	34	30	24										
700.133	D-L100-200/203-50	37	56	52	50	46	42*	38	33	26									
700.134	D-L100-250/221-65,3	48	69	65	59	56*	50	45	35										
700.135	D-L100-250/235-89,8	66	79	75	72	69	64*	56	50										
700.136	D-L100-250/254-133,4	98.1	92	89	86	84	80	75*	67										
700.137	D-L100-250/267-133,4	98.1	103	100	98	95	90	85*	80										
700.138	D-S100-200A/219-89,8	66	62,5	60	59	57,5	55	52,5	49*	43	37,5								
700.139	D-S100-250CD/233-89,8	66	68	67	64	61	57	55*	49	43	30								
700.140	D-S100-250B/250-133,4	98.1	80	79	77	75	72	69	64*	59	53								
700.141	D-S100-250AB/265-133,4	98.1	95	92	90	88	86	84	80*	75	70								
700.142	D-S100-250A/269-133,4	98.1	97	95	94	92	90	86	83*	78	74								
700.143	D-CH100-315/291-177,5	130.5	117	114	111	108	102	96*	87	74									
700.144	D-CH100-315/308-177,5	130.5	131	130	128	124	120	115	106*	96	84								
700.145	D-L125-200/206-65,3	48	47					38	36	34	32	30*	28	22					
700.146	D-L125-200/216-89,8	66	57					49	47	45	42	40	38*	31	22				
700.147	D-CH125-250/222-89,8	66	59					55	53	50*	47	43							
700.148	D-L125-270/224-133,4	98.1	65					59	56	55	53	50*	48	47	35				
700.149	D-L125-270/237-133,4	98.1	75					70	68	65	65	61	60*	54	45	36			
700.150	D-L125-270/253-177,5	130.5	88					82	80	78	76	74	71	66*	57	46			
700.151	D-CH125-250/264-177,5	130.5	91					90	88	86	84	81	77*	72	62				
700.152	D-L125-270/266-177,5	130.5	97					91	90	87	86	84	81	76*	70	60			
700.153	D-CH125-250/278-200,7	147.6	102					101	100	99	97	95	93	87*	80	71			
700.154	D-S125-315R/302-242	177.3	124				118	117	115	112	109*	105	102	90					
700.155	D-S150-315R/257-242	177.3	70						68	67	66	64	62	58	52*	47	42	35	
700.156	D-S150-315R/266-242	177.3	85						82	81	80	78	76	72	68*	62	56	50	
700.157	D-S150-315R/280-272	199.8	97						94	93	92	90	88	85	80*	75	70	62	53
700.158	D-S150-315R/290-302	221.4	107						106	105	103	102	101	97	95*	90	85	80	75

Tolerances in table: ISO 9906 Annex A (performance at the outlet of the pump)
Gray boxes: NPSH ≥ 5m (possible installation only with positive suction head)
* maximum efficiency point

Dimensions - Fire fighting units Series “D”

Fire fighting units with horizontal pumps back pull-out type
1 Diesel main motorpump module



Units with capacity from m³/h 0 up to m³/h 96

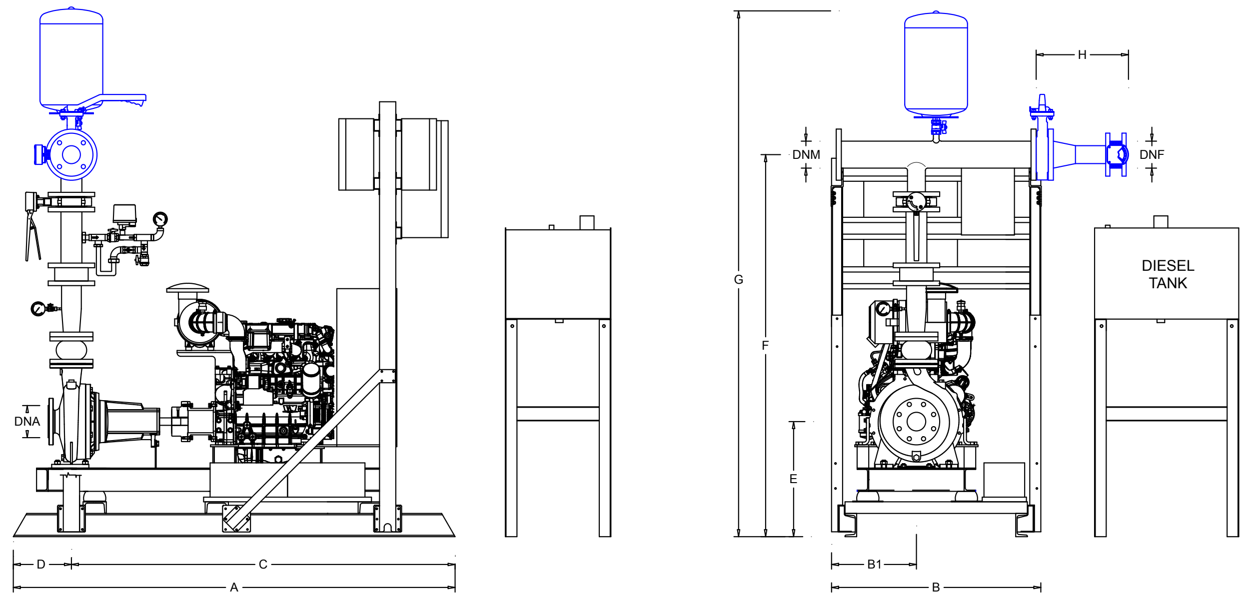
Fire Fighting Unit		Flow meter kit	Connections			Dimensions (mm)										Diesel Tank model
Code	Model		DNA	DNM	DNF	A	B	B1	C	D	E	F	G	H	I	
700.080	D-L32-200/188-5,8	KA-32-32	DN50	DN65	1 ¼”	1150	800	305	1060	90	438	1428*	2050*	405*	150	TK1
700.081	D-L32-200/204-5,8															
700.082	D-S32-200N/206-8,4															
700.083	D-S32-200N/219-14,4															
700.084	D-L32X-250/256-14,4										458	1493*	2115*			TK2
700.085	D-C32-250/225-18,5										498	1533*	2155*			
700.086	D-C32-250/235-24							320			458	1493*	2115*			
700.087	D-C32-250/255-24	KA-40-40			1 ½”											
700.088	D-C32-250/264-27					1480		305	1360							
700.089	D-S40-200/190-8,4	KA-40-40	DN65	DN65	1 ½”	1150	800	305	1160	90	438	1428*	2050*	405*	150	TK1
700.090	D-L40-200/209-14,4															
700.091	D-S40-200/212-14,4															
700.092	D-L40-250/233-18,5										498	1533*	2155*			TK2
700.093	D-L40-250/251-24							320			458	1493*	2115*			
700.094	D-S40-250N/240-27	KA-50-50			2”	1480		305	1360							
700.095	D-S40-250N/255-36										492	1527*	2150*			TK3
700.096	D-S40-250N/259-36															
700.097	D-L50-200/197-14,4	KA-50-50	DN65	DN80	2”	1150	800	305	1060	90	438	1503	2125	405*	150	TK1
700.098	D-L50-200/209-18,5	KB1-65-65			DN65						498	1563	2185	432		TK2
700.099	D-L50-250/224-24	KA-50-50			2”			320			458	1548	2170	495*		
700.100	D-L50-250/237-27	KB1-65-65			DN65	1480		305	1360					432		
700.101	D-L50-250/250-36										492	1582	2187			TK3
700.102	D-C50-250/255-42,6	KA-50-50			2”	1900	900	345	1650	250	515	1605	2232	405*		
700.103	D-C50-250/264-42,6	KB1-65-65			DN65									432		
700.104	D-CH50-315/291-65,3							365			520	1665	2292			TK4
700.105	D-CH50-315/308-89,8															TK5

* Tolerance of ± 50 mm
blue components: optional available on request

Dimensions of fuel tanks on p. 61

Dimensions - Fire fighting units Series “D”

Fire fighting units with horizontal pumps back pull-out type
1 Diesel main motorpump module



Units with capacity from m³/h 66 up to m³/h 360

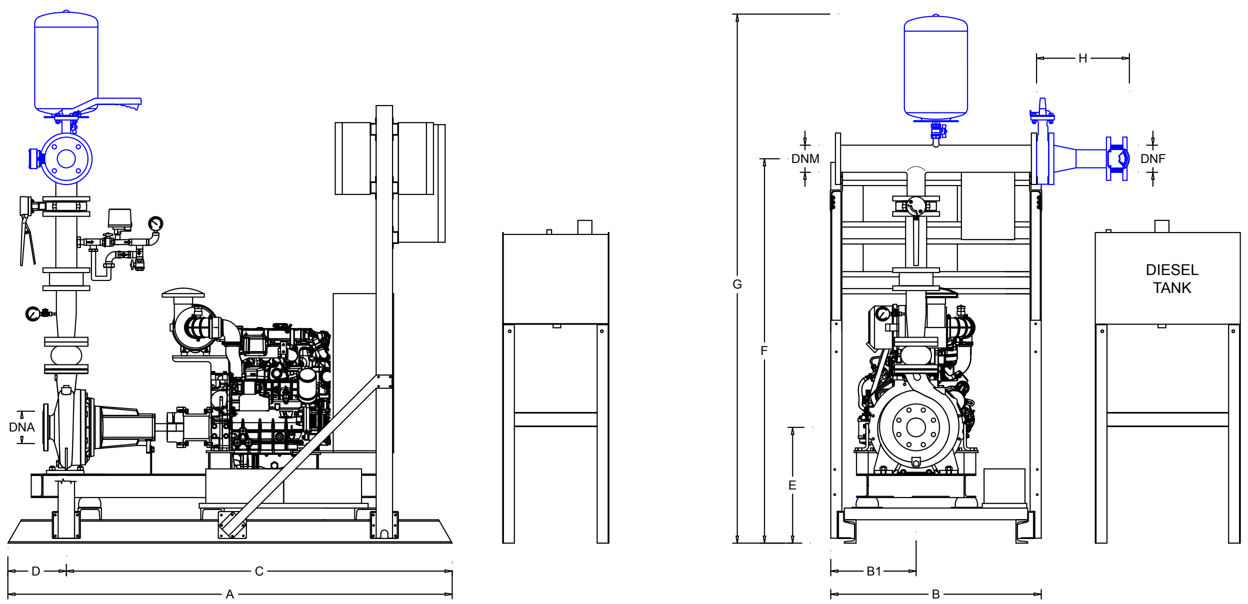
Fire Fighting Unit		Flow meter kit	Connections			Dimension (mm)									Diesel Tank model
Code	Model		DNA	DNM	DNF	A	B	B1	C	D	E	F	G	H	
700.106	D-L65-200/187-24	KB2-100-65	DN80	DN100	DN65	1330	800	320	1060	90	458	1581	2216	397	TK2
700.107	D-S65-200N/192-36	KB2-100-80			DN80	1480		305	1360		492	1615	2233	402	TK3
700.108	D-L65-200/198-27	KB2-100-65			DN65						458	1581	2216	397	TK2
700.109	D-L65-200/210-36										492	1615	2233		TK3
700.110	D-S65-200N/215-42,6	KB2-100-80			DN80	1900	900	365	1650	250	475	1600	2217	402	TK3
700.111	D-L65-250/241-42,6	KB2-100-65			DN65						495	1644	2262	397	
700.112	D-L65-250/258-50														
700.113	D-S65-250N/222-42.6	KB2-100-80			DN80									402	
700.114	D-S65-250N/245-65,3														TK4
700.115	D-S65-250N/255-65,3														
700.116	D-S65-250N/259-65,3														
700.117	D-S65-315R/273-89,8					2000			1750		520	1699	2317		TK5
700.118	D-S65-315R/282-89,8														
700.119	D-L80-200/189-36	KB2-125-80	DN100	DN125	DN80	1505	800	305	1360	90	492	1684	2315	426	TK3
700.120	D-L80-200/207-42,5	KC-125-100			DN100	1900	900	365	1650	250	475	1667	2298	420	
700.121	D-L80-250/225-50	KB2-125-80			DN80						495	1717	2348	426	
700.122	D-L80-250/238-65,3														TK4
700.123	D-L80-250/256-89,8	KC-125-100			DN100									420	TK5
700.124	D-L80X-250/270-133,4					2350	1250	495	2190	160	610	1832	2463		TK6
700.125	D-C80-200/205-65,3					1900	900	365	1650	250	475	1667	2298		TK4
700.126	D-C80-200/214-65,3														
700.127	D-C80-250/235-65,3										495	1717	2348		
700.128	D-C80-250/255-89,8														TK5
700.129	D-C80-250/264-133,4					2350	1250		2190	160	610	1832	2463		TK6
700.130	D-S80-250/269-177,5							495			635	1857	2488		TK7
700.131	D-S80-315R/302-177,5											1892	2523		

* Tolerance of ± 50 mm
blue components: optional available on request

Dimensions of fuel tanks on p. 61

Dimensions - Fire fighting units Series “D”

Fire fighting units with horizontal pumps back pull-out type
1 Diesel main motorpump module



Units with capacity from m³/h 150 up to m³/h 750

Fire Fighting Unit		Flow meter kit	Connections			Dimensions (mm)									Diesel Tank model
Code	Model		DNA	DNM	DNF	A	B	B1	C	D	E	F	G	H	
700.132	D-L100-200/192-42,6										495	1776	2421		TK3
700.133	D-L100-200/203-50					1900	900	365	1650	250					
700.134	D-L100-250/221-65,3										520	1801 1801	2446 2446		TK4
700.135	D-L100-250/235-89,8														TK5
700.136	D-L100-250/254-133,4					2350	1250	495	2190	160	600	1881	2526		TK6
700.137	D-L100-250/267-133,4														
700.138	D-S100-200A/219-89,8	KC-150-125	DN125	DN150	DN125	1900	900	365	1650	250	495	1776	2421	472	TK5
700.139	D-S100-250CD/233-89,8										520	1801	2446		
700.140	D-S100-250B/250-133,4										600	1881	2526		TK6
700.141	D-S100-250AB/265-133,4														
700.142	D-S100-250A/269-133,4					2350	1250	495	2190	160					
700.143	D-CH100-315/291-177,5										625	1941	2586		TK7
700.144	D-CH100-315/308-177,5														
700.145	D-L125-200/206-65,3	KC-200-150			DN150							1957	2652		TK4
700.146	D-L125-200/216-89,8					1900	900	365	1650	250	545			536	TK5
700.147	D-CH125-250/222-89,8	KC-200-125			DN125							1997	2692		
700.148	D-L125-270/224-133,4	KC-200-150			DN150						625	2077	2772		TK6
700.149	D-L125-270/237-133,4	KC-200-200	DN150	DN200	DN200									438	
700.150	D-L125-270/253-177,5					2350			2190		665	2117	2792		
700.151	D-CH125-250/264-177,5	KC-200-150			DN150		1250	495		160				536	TK7
700.152	D-L125-270/266-177,5	KC-200-200			DN200						625	2077	2772	438	
700.153	D-CH125-250/278-200,7					2500			2340						TK8
700.154	D-S125-315R/302-242	KC-200-150			DN150						655	2107	2802	536	
700.155	D-S150-315R/257-242														TK8
700.156	D-S150-315R/266-242	KC-250-200	DN200	DN250	DN200	2500	1250	495	2340	160	655	2290	2992	636	
700.157	D-S150-315R/280-272														TK9
700.158	D-S150-315R/290-302														TK10

* Tolerance of ± 50 mm
blue components: optional available on request

Dimensions of fuel tanks on p. 61

Interactive Catalog

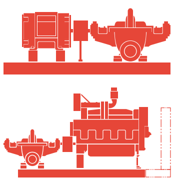
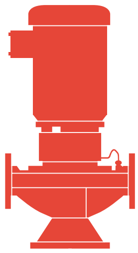
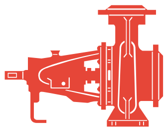
Peerless-J - J65F

Description	Vertical Diffuser Radial Split Case Single Suction Pump
Applications	Fire Pressure Maintenance
Markets	Fire Protection
Type	Peerless-J
Construction	Vertical Side Suction & Discharge Impellers Between Bearings
Casing	Multistage Diffuser Single Suction Vertical
Mounting	Floor Mounted
Sealing	Mechanical Seal

Documents

- Technical Data
- Dimensions
- Performance Curves

Peerless Fire Product Line Features and Specifications

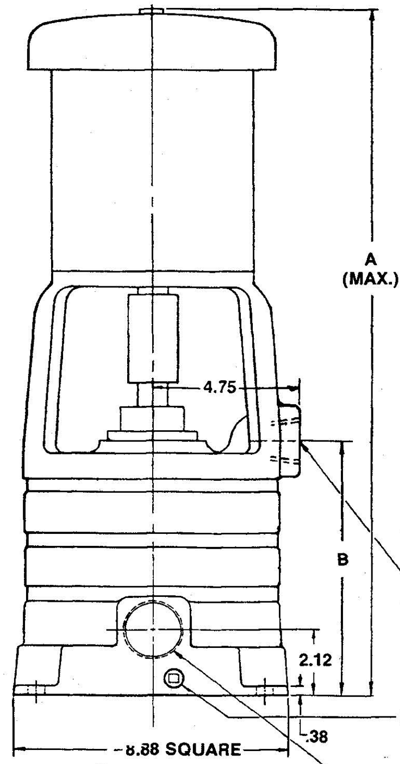
	 **Horizontal Fire Pumps, UL Listed, ULC Listed and FM Approved**	 **In-Line Fire Pumps, UL and ULC Listed**	 **End Suction Fire Pumps, UL Listed and FM Approved**	 **Vertical Fire Pumps UL Listed, ULC Listed and FM Approved**
Type	Horizontal centrifugal pumps with appropriate fittings for providing water supply to fire protection systems in buildings, plants and yards. Types AF, ADF, AEF, TUF, TUTF.	Compact in-line centrifugal fire pumps with appropriate fittings for providing water supply to fire protection systems in buildings, plants and yards. Type PVF.	End suction centrifugal fire pumps with appropriate fittings for providing water supply to fire protection systems in buildings, plants and yards. Type UNF.	Vertical turbine pumps with appropriate fittings for providing water supply to fire protection systems in buildings, plants and yards.
Capacities	250 to 5,000 gpm (57 to 1,136 m^3/hr)	50 to 1,500 gpm (11 to 341 m^3/hr)	Up to 1,500 gpm (341 m^3/hr)	250 to 5,000 gpm (57 to 1,136 m^3/hr)
Head	92 to 1178 feet (28 to 359 meters)	Up to 406 feet (123 meters)	Up to 367 feet (112 meters)	92 to 1,176 feet (28 to 359 meters)
Pressure	Up to 640 psi (45 kg/cm^2, 4,414 kPa)	Up to 175 psi (12 kg/cm^2, 1,207 kPa)	Up to 159 psi (11.2 kg/cm^2, 1,096 kPa)	Up to 500 psi (35.15 kg/cm^2, 3,515 kPa)
Horsepower	Up to 800 hp (597 kW)	Up to 125 hp (93 kW)	Up to 210 hp (157 kW)	Up to 600 hp (448 kW)
Drives	Horizontal electric motors, and diesel engines	Vertical close coupled electric motors	Horizontal electric motors and diesel engines	Vertical electric motors and diesel engines with right angle gears
Liquids Pumped	Water.	Water.	Water.	Water.
Temperature	Ambient within the limits for satisfactory equipment operation.	Ambient within the limits for satisfactory equipment operation.	Ambient within the limits for satisfactory equipment operation.	Up to 115°F (46°C)
Materials of Construction	Cast iron, bronze fitted as standard. Optional materials available for sea water applications.	Cast iron, bronze fitted.	Cast iron, bronze fitted.	Cast iron, bronze fitted as standard. Optional materials available for sea water applications.

FM APPROVED c UL US LISTED

Peerless Pump Company
Indianapolis, IN 46207-7025

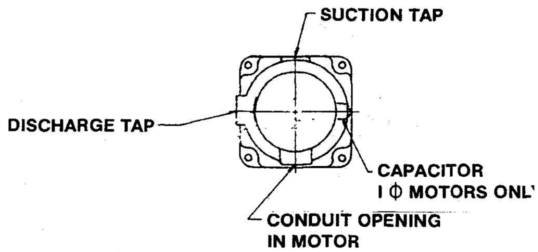
VERTICAL MULTISTAGE DIFFUSER PUMPS

Types J, TMUB, TMUAH

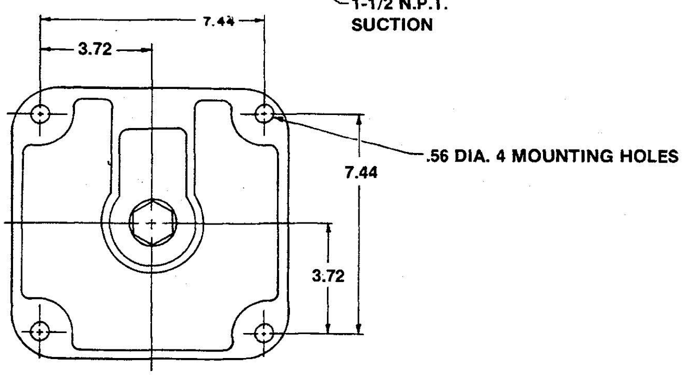


Unit Dimensions in Inches							
✓	Models	✓	Models	✓	No. of Stages	A	B
	1¼TMUB		J65E, J65F		2	30.50	8.66
	1¼TMUAH		J85E, J85F		3	32.44	10.59
-	-		J100G, J100H		4	34.38	12.52
-	-		J125G, J125H		5	38.00	14.44
-	-	-	-		6	39.94	16.37
-	-	-	-		7*	41.88	18.30
-	-	-	-		8*	43.81	20.22

* 50 Hertz 2900 rpm only



PUMP UNIT VIEWED FROM TOP

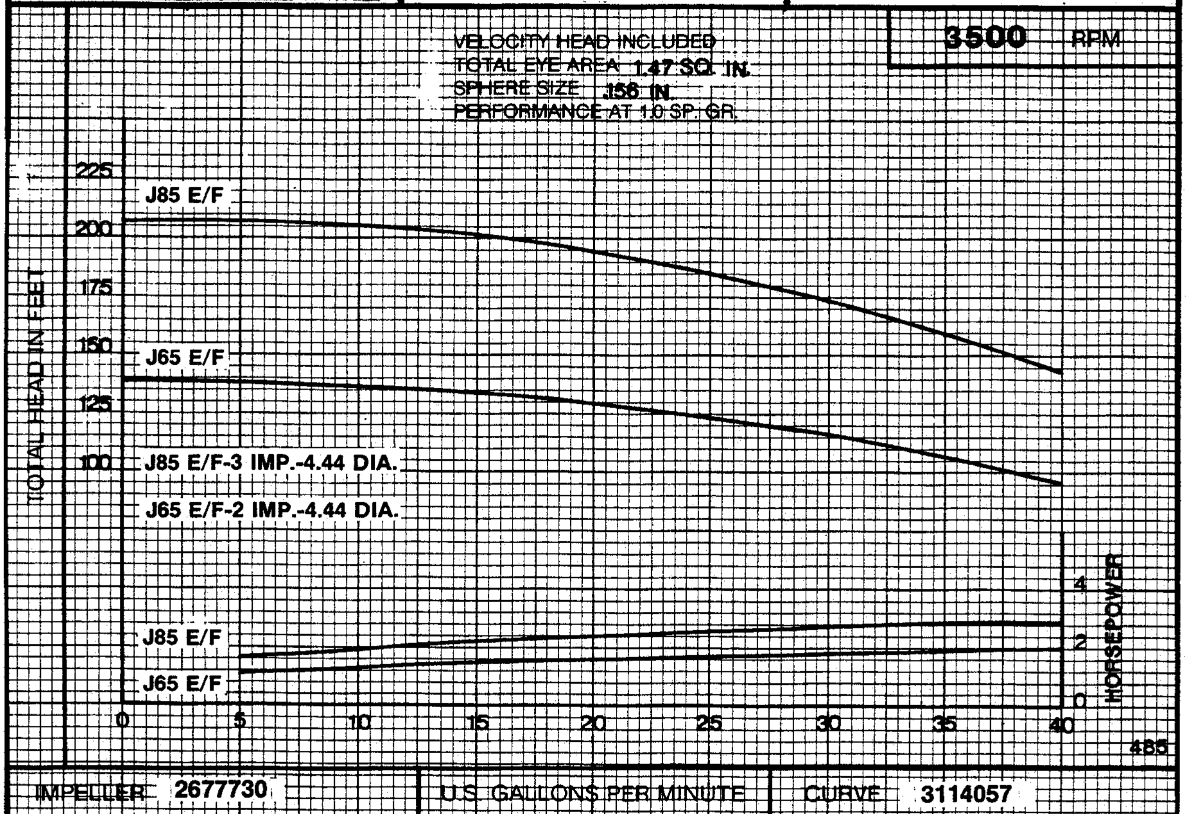


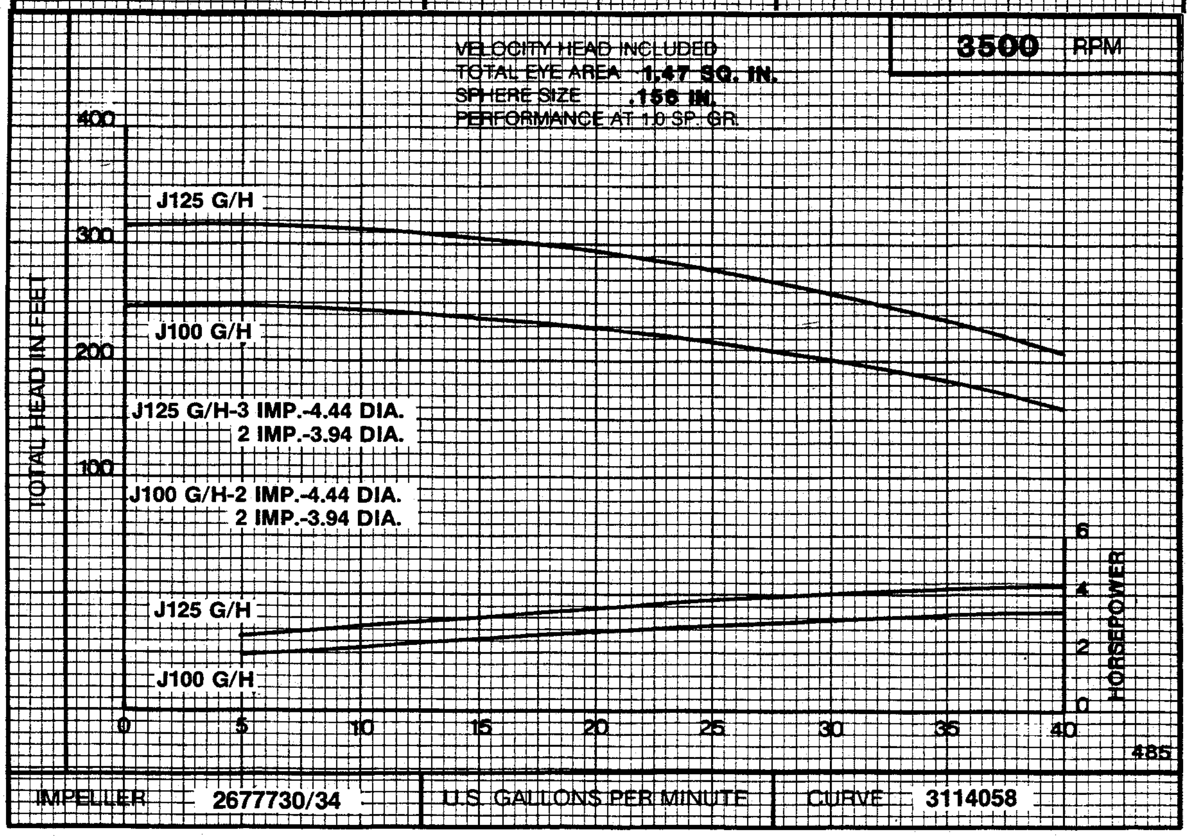
CUSTOMER ______ JOB NAME ______
P.O. NO. ______ ITEM NO. ______
S.O. NO. ______ SERIAL NO. ______
MOTOR MFR. ______ ENCL. ______ FRAME ______ H.P ______ VOLTS ______ PH. ______ HZ. ______
PUMP TYPE & SIZE ______ RPM ______ G.P.M. ______ TOTAL HD. FT. ______
CERTIFIED FOR ☐ APPROVAL ☐ CONSTRUCTION BY ______ DATE ______

Subject to change unless certified for construction.

DT 2898976
Rev. 10-94

Peerless Pump Company Indianapolis, IN 46207-7026	JOCKEY PUMPS Type J	SECTION 1840





SFR150 Series

المصنع السعودي لأجهزة الإطفاء
SAUDI FACTORY FOR FIRE EQUIPMENT

Fire Cabinet with Synthetic Hose Rack

Cabinets can be surface mounted, recesed or semi-recessed

Cabinet Made in CRCA steel or stainless steel with a thickness upto 2mm

Powder coated with an electrostatically applied, thermally fused at 200°c for elegant finish and protection from rust

Stainless steel cabinets are available with hairline finish or mirror finish; also with different sizes and various designs

Outer edges rolled over for safe handling and aesthetic apperance

Cabinet Door handles are stainless steel with chrome plated handle

1.5”ø x 30 meter length of hose rack, one piece construction of 16 gauge steel rack

Automatic release mechanism allows valve to be opened without release of water until last fold of hose is removed

MODEL	WIDTH	HEIGHT	DEPTH	SPECIFICATION
SFR150	650	850	160	Cabinets Made of Steel Synthetic Single Jacket Hose 1.5” x 100 feet long
SFR150S	650	850	160	Cabinets Made of Stainless Steel Synthetic Single Jacket Hose 1.5” x 100 feet long
SFR200E	750	850	180	Cabinets Made of Steel Synthetic Single Jacket Hose 1.5” x 100 feet long and (1) Extinguisher
SFR200ES	750	850	180	Cabinets Made of Stainless Steel Synthetic Single Jacket Hose 1.5” x 100 feet long and (1) Extinguisher
SFR200EV	750	940	200	Cabinets Made of Steel Synthetic Single Jacket Hose 1.5” x 100 feet long and (1) Extinguisher and (1) 2.5”Valve
SFR200EVS	750	940	200	Cabinets Made of Stainless Steel Synthetic Single Jacket Hose 1.5” x 100 feet long and (1) Extinguisher and (1) 2.5”Valve

Note: All dimensions are in ‘mm’

Standard Dry Chemical

Technical Information

Canadian Part Numbers are shown in parentheses. V/B = Vehicle Bracket Included.

Model	2.5 STD V/B	5.5 STD	5.5 STD V/B	10 STD	20S STD
Pt. # Alum. Valve	13415 (13490)	11014 (11090)	13514 (13581)	11840 (11890)	12220 (12290)
Agent Capacity	2.5 lb. (1.13 kg)	5.5 lb. (2.5 kg)	5.5 lb. (2.5 kg)	10 lb. (4.54 kg)	20 lb. (9.07 kg)
UL/ULC Rating	10-B:C	40-B:C	40-B:C	40-B:C	120-B:C
Temperature Range	-65° to 120°F (-54° to 49°C)				
Discharge Time	9 sec	14 sec	14 sec	14 sec	28 sec
Discharge Range ft (m)	9-15 (2.7-4.6)	12-18 (3.7-5.5)	12-18 (3.7-5.5)	15-21 (4.6-6.4)	15-21 (4.6-6.4)
Operating Pressure	100 psi (689 kPa)	195 psi (1344 kPa)	195 psi (1344 kPa)	195 psi (1344 kPa)	195 psi (1344 kPa)
Mounting Type	Vehicle	Wall	Vehicle	Wall	Wall
USCG Approval	Type B:C Size I	Type B:C Size I	Type B:C Size I	Type B:C Size II	Type B:C Size III
Ship Weight	5.5 lb. (2.5 kg)	10.5 lb. (4.8 kg)	10.75 lb. (4.9 kg)	18.25 lb. (8.3 kg)	33.5 lb. (15.2 kg)
Unit Height	14.75 in (37.5 cm)	16.375 in (41.6 cm)	16.375 in (41.6 cm)	21 in (53.3 cm)	21.25 in (53.8 cm)
Unit Width	4.875 in (12.4 cm)	7.25 in (18.4 cm)	7.25 in (18.4 cm)	7.75 in (19.7 cm)	8.75 in cm)
Unit Diameter	3.375 in (8.6 cm)	4.25 in (10.8 cm)	4.25 in (10.8 cm)	22.) 2 5.125 in (13 cm)	7.5 in (19.1 cm)

Standard (BC) Dry Chemical is a sodium bicarbonate based extinguishing agent that is suitable for use on Class B and Class C fires.

Typical Uses For flammable liquid hazards in public areas such as offices, classrooms, churches, parking garages, and hotel/motel assembly halls and guest areas. For flammable liquid hazards in businesses such as retail stores, light manufacturing facilities, research facilities, auto dealerships, vehicle/aircraft/marine service centers, and manufacturing processes such as painting, dipping, and coating.

Not recommended for use on sensitive electronic equipment.

Third Party Approvals For Peace Of Mind

LISTED LISTED DOT Compliant USCG Approved

WET HYDRANT

Model: SFH-50 Series

Wet Fire Hydrant is used in places where there is no danger of vehicle accidents or freezing atmospheres. It is better to be used in malls, shopping centers, colleges, hospitals etc.

Technical Features:

The hydrant material is cast iron. The entire hydrant is made by casting.

The 4” shell hydrant is made according to BS750 standard.

Two numbers of 2½” hydrant landing valves with cap and chain are provided with the hydrants.

The valves are of NST threads and normally PN20 rating.

(Other pressure ratings are available upon request).

DRY HYDRANT

Pillar Dry Type Fire Hydrants

150 SFH 800

150 SFH 1200

100 SFH 1200

100 SFH 800

DRY BARREL DESIGN eliminates damage to the Hydrant caused by freezing or corrosion of the upper part.

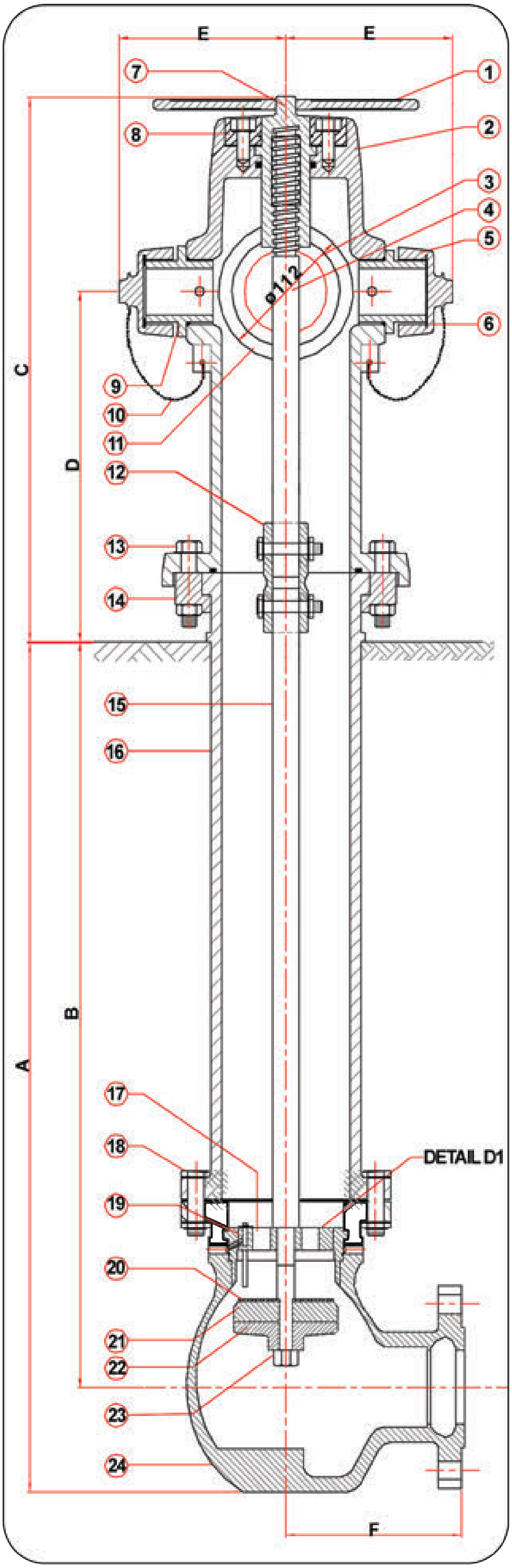
BREAK AWAY DESIGN to prevent accidents to the Hydrants, where only the upper part of the Flange will be broken upon impact .

Designed as per AWWA C502, which applies for the wall thickness, loss of head and hose connection plugs.

Simple rugged construction and easy to maintain.

Ductile Hydrants available upon request.

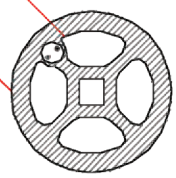
PILLAR DRY TYPE FIRE HYDRANTS SPECIFICATION



Model	A	B	C	D	E	F
100 SFH-800	895	800	610	400	200	190
100 SFH-1200	1295	1200	710	400	200	190
100 SFH-1500	1595	1500	710	400	200	190
150 SFH-800	895	800	690	470	220	240
150 SFH-1200	1295	1200	690	470	220	240
150 SFH-1500	1595	1500	690	470	220	240

Note:

- **All Dimensions in mm.**
- **Tolerance ±10 mm.**



D1

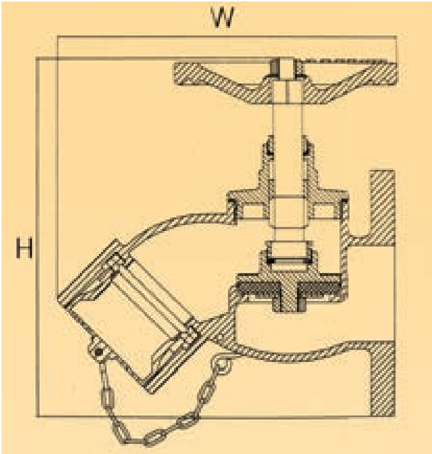
Item	Qty.	Item	Material
1	1	Handle	Gray casting
2	1	Body	Grey casting
3	1	Plummer coupling cap	Grey casting
4	1	Upper stem	Mild Steel
5	2	Coupling cap	Gery casting
6	2	Coupling gasket	3 THK Buna synthetic rubber
7	1	Operating unit	Gun metal
8	1	Cover	Gun metal
9	2	Coupling nipple	Gun metal 2 ½" NST
10	2	Coupling cap chain	M.S
11	1	Plummer coupling	Gun metal
12	1	Stem coupling	Grey casting
13	8	Claw bolt	Steel (M16 x 80 L.G)
14	9	Claw	Grey casting
15	1	Lower stem	Mild Steel
16	1	Spool or reel (Stand pipe)	Grey casting
17	1	Valve plate	Gun metal
18	8	Bottom bolt & nut	M16 x 70 LG. (HEX.) (Mild Steel)
19	1	Drain valve	Gun metal
20	1	Retainer plate	M.S
21	1	Rubber valve	Synthetic rubber
22	1	Bottom plate	Gray casting
23	1	Nut	M.S
24	1	Elbow	Grey casting

Option: Inner Parts can be stainless steel upon request.
Hydrant Body can be Ductile Iron upon request.

HOSE VALVE

Bib Nose

KM 635798

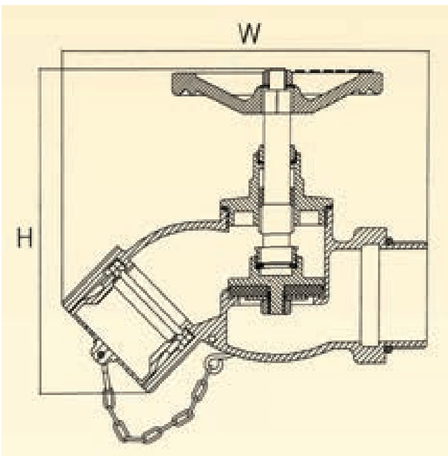


Flanged Inlet

Specification

Standard	Certificate to BS5041-1
Body	Copper alloy, Thickness ≥ 3mm
Handwheel	Grey cast iron alloy
Blank cap	Copper alloy
Inlet	Flanged or BSP Screwed
Outlet	Female instantaneous to BS336
Surface	Red or Yellow Painting
Test Pressure	22.5 bar
Fully open	4.5 Turns

MODEL	SIZE	H (mm)	W (mm)	Inlet	Outlet
SFD-K50-BLVF	DN50	240	225	165	BS336
SFD-K65-BLVF	DN65	250	225	185	BS336



Screwed Inlet

MODEL	SIZE	H (mm)	W (mm)	Inlet	Outlet
SFD-K65-BLVST	DN65	225	263	2.5”BSPT	BS336
SFD-K65-BLVS	DN65	225	263	2.5” BSP	BS336

Additional Accessories

PRESSURE REDUCING VALVE

MODEL: SF-PRV-X *(where X is the size and type)*

A pressure reducing valve is mainly used in a hose reel system to reduce the pressure at the inlet of the hose reel to the nominal working pressure.

MATERIAI: BRASS

WORKING PRESSURE: Inlet Pressure upto 20 Bar
Outlet Pressure between 1 to 4 Bar

AVAILABLE SIZES:

½” NPT | ¾” NPT | 1” BSP | 1” NPT | 1½” NPT | 2” BSP | 2” NPT

LOCK SHIELD VALVE

MODEL: SF-LSV

The lock shield valves are installed usually in the fire hose reel and the valve can be opened only by the key.

INLET: 1” F BSP
OUTLET: 1” F BSP
PRESSURE RATING: PN 20

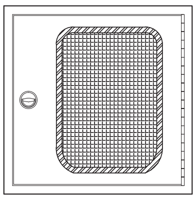
AIR RELEASE VALVE

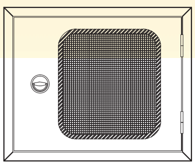
MODEL : SWR 103 - INLET : 20mm (3/4”) Ø BSP
MODEL : SWR 104 - 25mm (1”) Ø BSP

Air Release Valves are designed to vent entrained air that collects at high points in a pipeline. This valve continuously eliminates air from a system by releasing small quantities of air before large air pockets can occur in the system.

MATERIAL: COPPER ALLOY
TEST PRESSURE: 350 PSI

BREECHING INLET CABINET





CABINET: MILD STEEL, STAINLESS STEEL
GLASS: WIRE MESHED REINFORCEMENT
FINISH: RED
INSTALLATION: WALL RECESS MOUNTED
LETTERING: ANY LANGUAGE

MODEL	H (mm)	W (mm)	D (mm)
SDR 096 (2 Way Breeching Inlet Cabinet)	460	575	300
SDR 116 (4 Way Breeching Inlet Cabinet)	600	600	300

Eclipse 100 & 150

- Wall or Ceiling mountable
- Integral back draft shutter mechanism
- Meets current Building Regulations Approved Document F
- 100mm and 150mm size options
- Fixing kits available
- Fan IP44 rated -100mm
- Fan IPX4 rated -150mm

Bathroom Ventilation

The Eclipse range of circular axial fans is designed to be installed in kitchens and bathrooms. Its simple design provides an unobtrusive fitting that is sympathetic with most interiors.

Models

ECLIPSE 100X

Single speed 100mm bathroom/toilet fan with back draught shutter.

Model	Stock Ref
100X	427310

ECLIPSE 100XP

Single speed 100mm bathroom/toilet fan with pullcord and back draught shutter.

Model	Stock Ref
100XP	427281

ECLIPSE 100XT

Single speed 100mm bathroom toilet fan with integral adjustable overrun timer (5-30 minutes) and back draught shutter.

Model	Stock Ref
100XT	427282

ECLIPSE 150X

Single speed 150mm kitchen fan with back draught shutter.

Model	Stock Ref
150X	427283

ECLIPSE 150XP

Single speed 150mm Kitchen fan with pullcord and shutter.

Model	Stock Ref
150XP	427313

Accessories

Model	Stock Ref
Bezel Chrome 100mm	436480
Bezel Silver 150mm	436483

Wall Kit

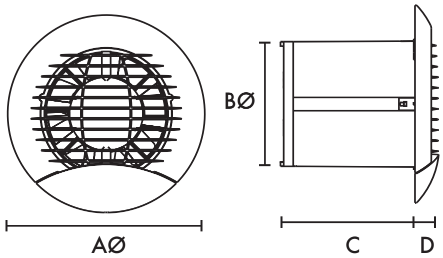
Wall fixing hole for 150mm Ø165mm.

Model	Stock Ref
Wall Kit White	140902
Wall Kit Brown	140903

Wall fixing hole for 100mm Ø117mm.

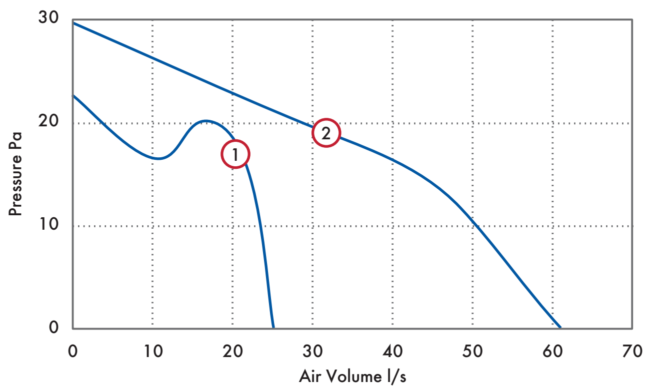
Model	Stock Ref
Wall Kit White	254102
Wall Kit Brown	254100

Dimensions (mm)



Model	A	B	C	D
Eclipse 100	157	99	107	19
Eclipse 150	201	144	123	19

Performance Guide



		Extract Performance			dB(A)
Model	Curve Ref	m^3/h	l/s	Watts	@ 3m
Eclipse 100	1	90	25	14	38
Eclipse 150	2	220	61	16	45

Tested at 240V 50Hz

Cooker Hoods

- A choice of three styles for domestic applications
- Wall, ceiling or cabinet fixed
- Compatible with flat ducting or aluminium flexible ducting
- All models are provided with a charcoal filter and washable grease filter as standard
- All models are fitted with mains lead, built-in lighting and choice of 3 speeds

Kitchen Ventilation

Vent-Axia offers a range of cooker hoods for the removal of cooking odours and steam at source in the domestic kitchen. Each model is designed to provide the extraction levels necessary to comply with Building Regulation requirements for kitchens with ducted outlets plus models that provide higher outputs for busier kitchens.

A choice of styles is available to include wall, or cabinet fixed models to provide integrated ventilation in any modular fitted kitchen from a terraced galley kitchen to the most extensive layouts. Models are available that can re-circulate or extract with the use of ducting.

The Building Regulations for the mechanical ventilation of kitchens with open-able windows in dwellings require that extractor hoods should be capable of extracting at a rate of 30 l/s (108m^3/h).

When used with ducting, the resistance of the entire system should be considered so that the required performance is achieved. Extractor hoods should not be sited where ambient temperatures are likely to exceed +50°C.

Models

Genova

A white cooker hood with 'flip front' glass visor and rear spigot design to be wall-mounted or mounted beneath a top cabinet. Offering three speeds with extract rates of 100/160/220m^3/h.

Model	Stock Ref
Genova	120801

Rimini/Milano/Roma

The Rimini (500mm width), Milano (600mm width) and Roma (900mm width) are stainless steel chimney cooker hoods with an extending chimney to fit varying ceiling heights. Offering three speeds with extract rates of 340/420/460m^3/h.

Model	Stock Ref
Rimini	427166
Milano	120841
Roma	120851

Dimensions (mm)

Model	W	D	H
Genova	600	470	150
Napoli	600	275	400
Rimini	500	500	1115
Milano	600	500	1115
Roma	900	500	1115

Extractor hoods are not suitable for use above an eye level grill. Must be mounted between 760mm and 900mm above the hob.

In-Line Pumping Power Turbo-Flow WIS Series

The WIS Series Turbo-Flow In-Line Circulation Pumps utilize the latest technology for a wide range of HVAC water systems and industrial applications. **The WIS Series is avalible in horizontal or vertical in-line mounting configurations** with optional vibration mount isolators. Wastecorp's WIS Series is designed for maintenance-free quiet operation. You can always count on the WIS Series and benefit from low life-cycle costs. These rugged heavy-duty cast iron pumps are engineered for easy maintenance, as the entire rotation element is removable without disturbing piping or the pump casing.

INDUSTRY USE AND APPLICATIONS:

Industry	Plumbing Application(s)
General Water Supply	Circulation of cooling and heating building systems, water booster service, boiler feed, general circulation service
Agriculture/Food/Beverage	Irrigation, water supply, food processing, beverage processing, fertilizers
Manufacturing	Pulp and paper, pharmaceutical, paper mills, refrigeration and cooling tower service
Chemical/Mining	Chemical plants, refineries, petroleum circulation,

Fluid Transfer

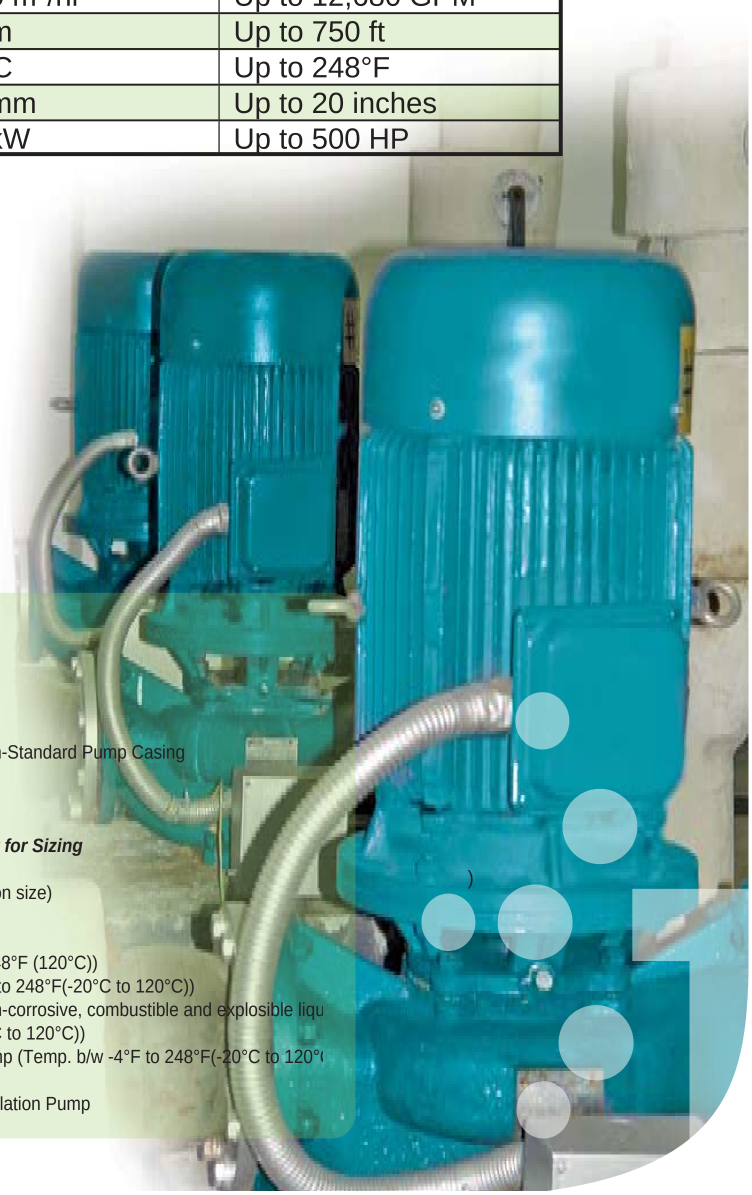
Any type of thin, clean, non-aggressive and non-explosive liquids or oils that are virtually free or contain negligible amounts of non-dissolving solids. Specific pump models will accommodate liquid temperatures up to 250°F (120°C). (See specific models below for more information.)

FLUID TRANSFER

WIS Series	Fluid Transfer Characteristics
WIS	Pure water or other liquids with similar physical characteristics (Temp. under 80°C or 176°F) [Wide density range of 0.6 to 1.3 S.G]
WIS-H	Hot Water Pump (Temp. under 120°C or 248°F)
WIS-C	Chemical Pump (Temp. under 120°C or 248°F)
WIS-XPO	Explosion-Proof Oil Pump (non-corrosive) (Temp. under 120°C or 248°F)
WIS-XPC	Explosion-Proof Chemical Pump (Temp. under 120°C or 248°F)

SPECIFIC TECHNICAL DATA

Technical Data	(50Hz Motors)	(60 Hz Motors)
Max. Capacity	Up to 2,400 m^3/hr	Up to 12,680 GPM
Max. Head	Up to 160 m	Up to 750 ft
Max. Temperatures	Up to 120°C	Up to 248°F
Max. Connection Size	Up to 500 mm	Up to 20 inches
Max. Motor/Power	Up to 250 kW	Up to 500 HP



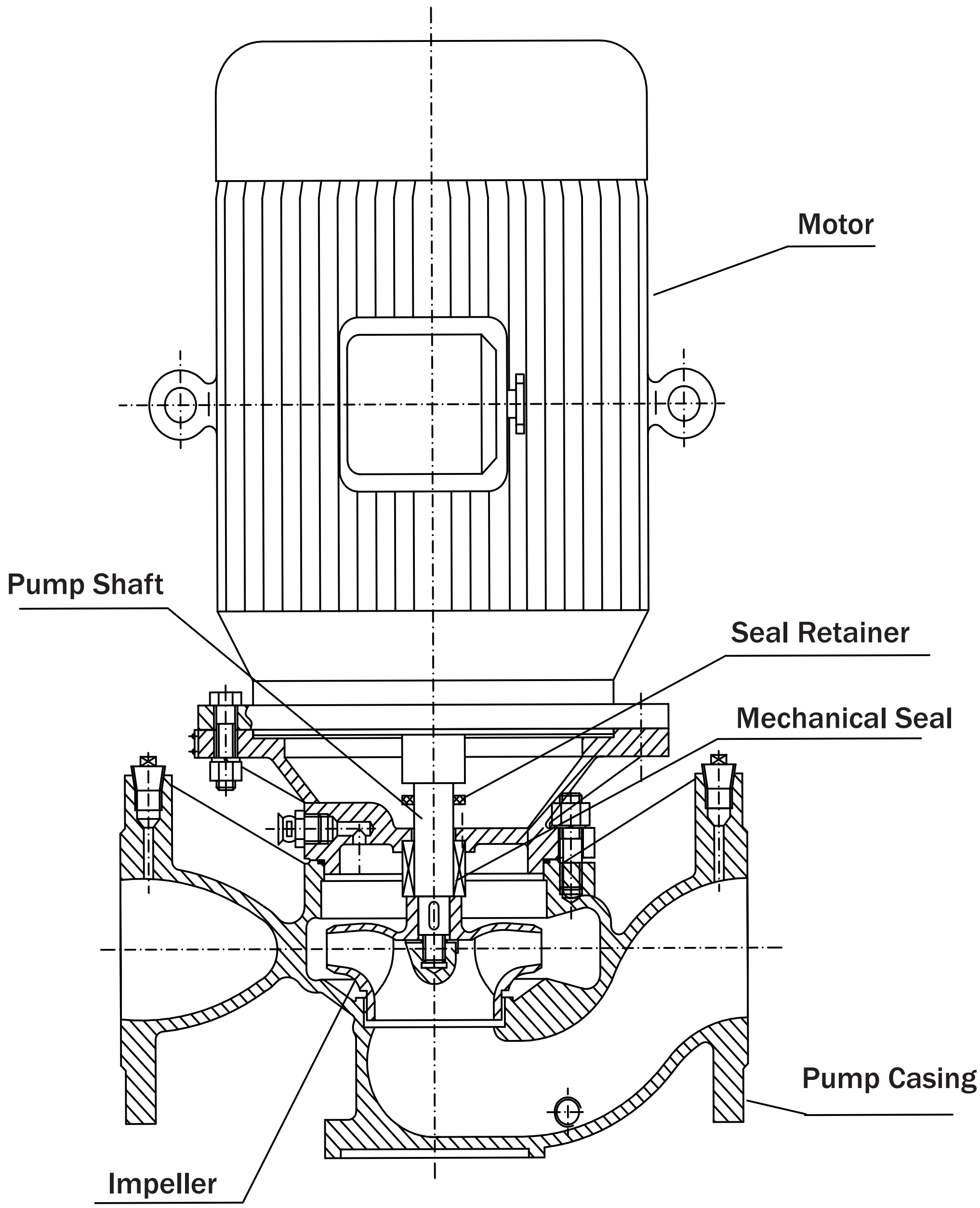
How to select your model:

WIS- H- 200- ? (A) (I)

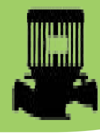
- (I) → Non-Standard Impeller and Non-Standard Pump Casing
- (A) → Trimmed Impeller
- ? → Impeller Size (***Contact Factory for Sizing***
- 200- → Pump Size (based on connection size)
- H- → **Application Specific Model:**
  - H = Hot Water Pump (Temp. under 248°F (120°C))
  - C = Chemical Pump (Temp. b/w -4°F to 248°F(-20°C to 120°C))
  - XPO = Explosion-Proof Oil Pump (non-corrosive, combustible and explosible liqu (Temp. b/w -4°F to 248°F(-20°C to 120°C))
  - XPC = Explosion-Proof Chemical Pump (Temp. b/w -4°F to 248°F(-20°C to 120°(
- WIS- → Wastecorp Vertical In-line Circulation Pump

Wastecorp Turbo Flow WIS Series
Vertical In-line Circulation/ Booster Pumps

WIS Series In-Line Circulation Pumps Cutaway

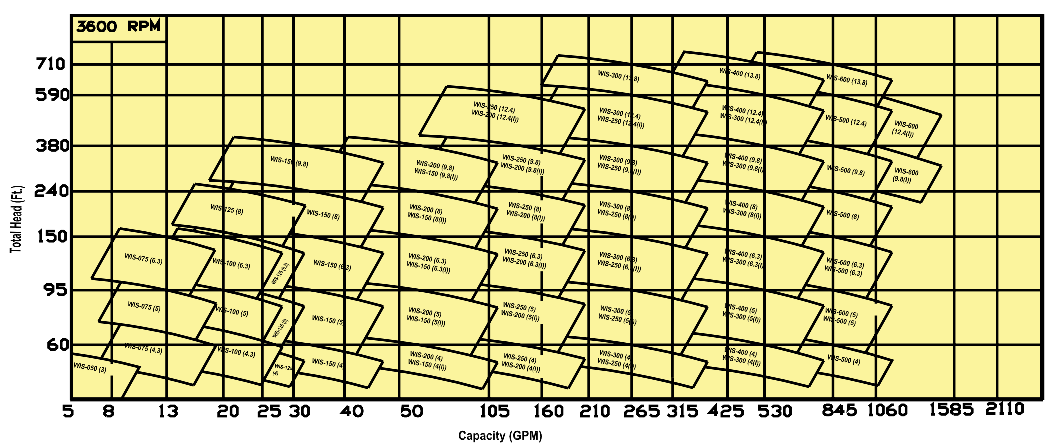


Turbo Flow

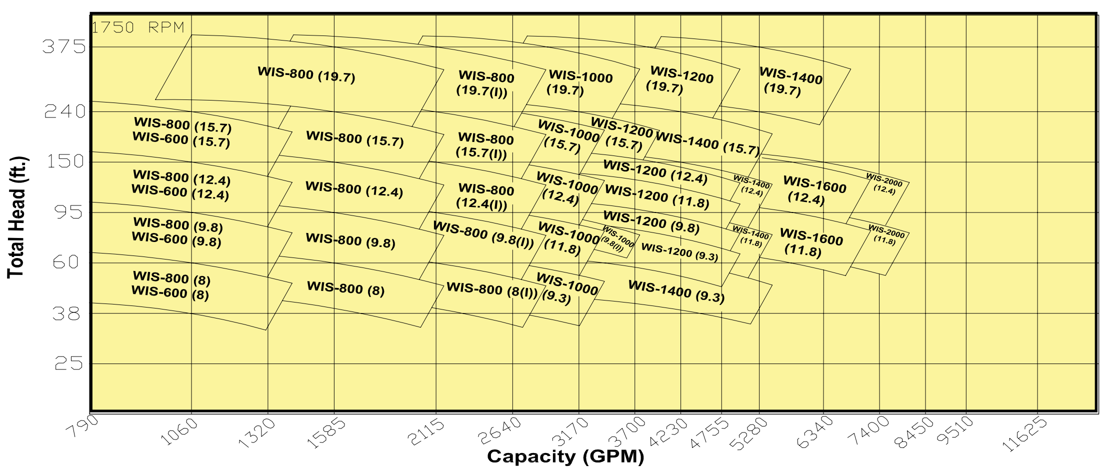


Wastecorp Turbo Flow WIS Series VerticalIn-line Circulation/ Booster Pump Pump Curves at 60 Hz

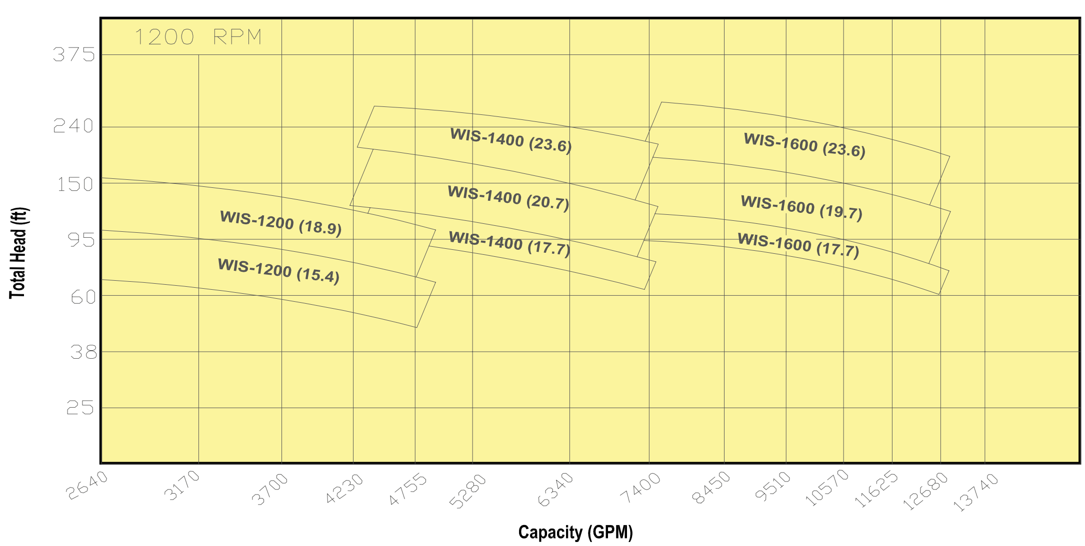
60 Hz @ 3600 RPM



60 Hz @ 1750 RPM



60 Hz @ 1200 RPM



Wastecorp Turbo Flow WIS Series
In-line Circulation Booster Pump
Overview of Performance Range Using 60 Hz Motors[2]

WIS Series In-Line Circulation Pumps Overview of Pump Performance (Utilizing 60 Hz / 3600 RPM Motors)

WIS SERIES MODELS	Pump Size[1]	Suction & Discharge Conn. Size		Max. Capacity		Max. Head		Max. Impeller OD Size[3]		Max. Power		Max. Weight	
	(inch)	DN (mm)	NPS (inch)	(m3/hr)	(GPM)	(m)	(ft)	(mm)	(inch)	(kW)	(HP)	(kg)	(lb)
WIS-050	1/2 x 1/2 x 3	15	0.50	2	11	12	40	80	3	0.3	0.4	20	44
WIS-075	3/4 x 3/4 x 6	20	0.75	4	17	48	156	160	6	2.6	3.5	38	84
WIS-100	1 x 1 x 6	25	1	6	27	48	156	160	6	3	3	44	97
WIS-125	1-1/4 x 1-1/4 x 8	32	1.25	8	34	76	250	200	8	5	7	68	150
WIS-150	1-1/2 x 1-1/2 x 10	40	1.50	20	86	118	387	250	10	19	25	125	276
WIS-200	2 x 2 x 12	50	2	40	174	184	605	315	12	52	70	330	728
WIS-250	2-1/2 x 2-1/2 x 12	65	2.50	78	343	184	605	315	12	78	104	375	827
WIS-300	3 x 3 x 14	80	3	156	687	225	737	350	14	130	174	680	1,499
WIS-400	4 x 4 x 14	100	4	156	687	225	737	350	14	156	209	680	1,499
WIS-500	5 x 5 x 12	125	5	230	1,014	192	628	315	12	156	209	720	1,587
WIS-600	6 x 6 x 16	150	6	288	1,268	230	756	400	16	190	255	990	2,183

WIS Series In-Line Circulation Pumps Overview of Pump Performance (Utilizing 60 Hz / 1750 RPM Motors)

WIS SERIES MODELS	Pump Size[1]	Suction & Discharge Conn. Size		Max. Capacity		Max. Head		Max. Impeller OD Size[3]		Max. Power		Max. Weight	
	(inch)	DN (mm)	NPS (inch)	(m3/hr)	(GPM)	(m)	(ft)	(mm)	(inch)	(kW)	(HP)	(kg)	(lb)
WIS-600	6 x 6 x 16	150	6	312	1,374	76	250	400	16	78	104	520	1,146
WIS-800	8 x 8 x 20	200	8	624	2,747	122	402	500	20	228	306	1,250	2,756
WIS-1000	10 x 10 x 20	250	10	804	3,540	125	411	500	20	276	371	1,250	2,756
WIS-1200	12 x 12 x 20	300	12	1,080	4,755	122	402	500	20	432	579	1,685	3,715
WIS-1400	14 x 14 x 16	350	14	1,152	5,072	79	260	400	16	276	371	1,950	4,299
WIS-1600	16 x 16 x 12	400	16	1,560	6,868	53	172	315	12	228	306	1,740	3,836
WIS-2000	20 x 20 x 12	500	20	1,740	7,661	50	163	315	12	276	371	2,070	4,564

WIS Series In-Line Circulation Pumps Overview of Pump Performance (Utilizing 60 Hz / 1200 RPM Motors)

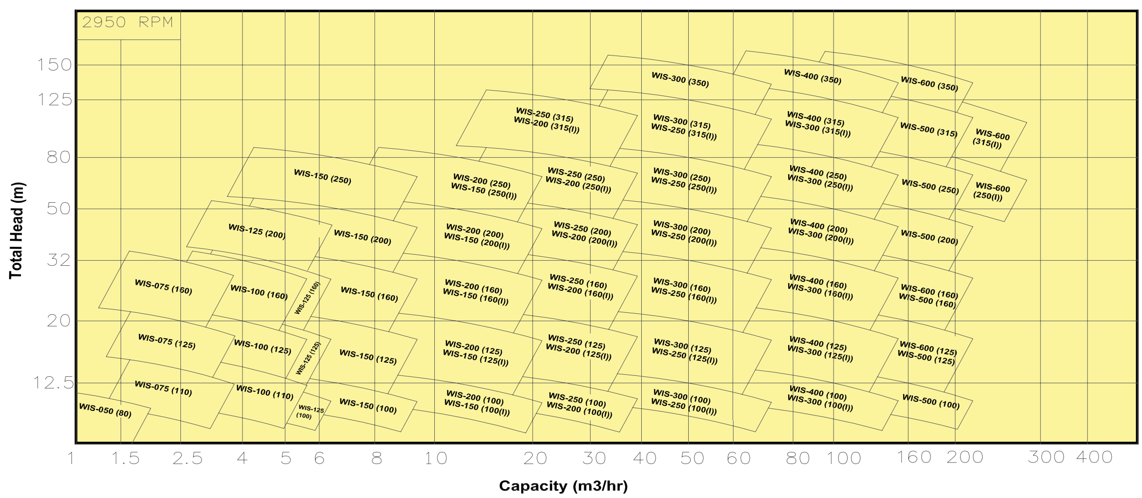
WIS SERIES MODELS	Pump Size[1]	Suction & Discharge Conn. Size		Max. Capacity		Max. Head		Max. Impeller OD Size[3]		Max. Power		Max. Weight	
	(inch)	DN (mm)	NPS (inch)	(m3/hr)	(GPM)	(m)	(ft)	(mm)	(inch)	(kW)	(HP)	(kg)	(lb)
WIS-1200	12 x 12 x 19	300	12	1,080	4,755	45	146	480	19	130	174	1,500	3,307
WIS-1400	14 x 14 x 24	350	14	1,680	7,397	76	250	600	24	432	579	2,750	6,063
WIS-1600	16 x 16 x 20	400	16	2,880	12,680	49	161	500	20	432	579	2,980	6,570

NOTES:

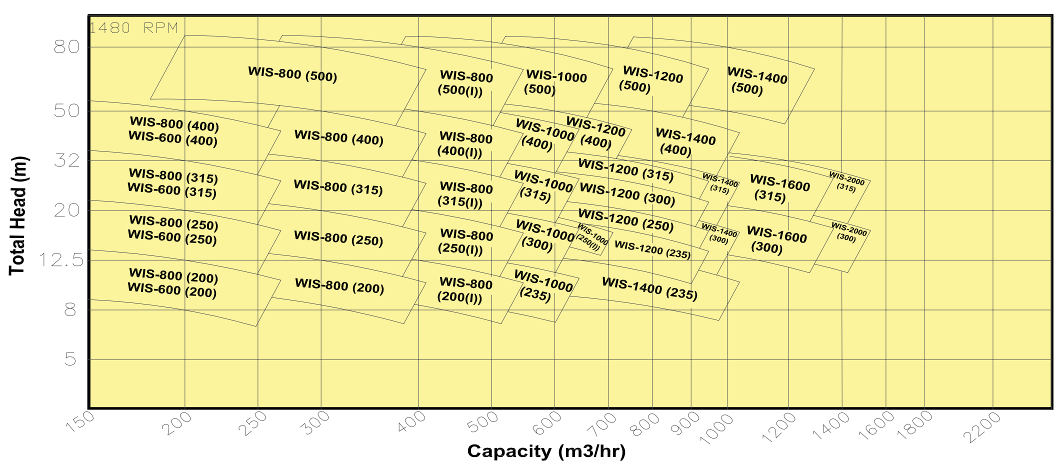
1. Please contact the factory for proper model selection for your application.
2. This is a general overview of the performance for this series of Turbo-Flow pumps.
3. Optional impeller sizes are available, including trimmed impeller sizes. Contact factory for additional information.
4. Wastecorp. Pumps reserves the right to make revisions to its products, performance, dimensions and specifications, and related information, without notice.

Wastecorp Turbo Flow WIS Series
Vertical In-line Circulation/ Booster Pump
Pump Curves at 50 Hz

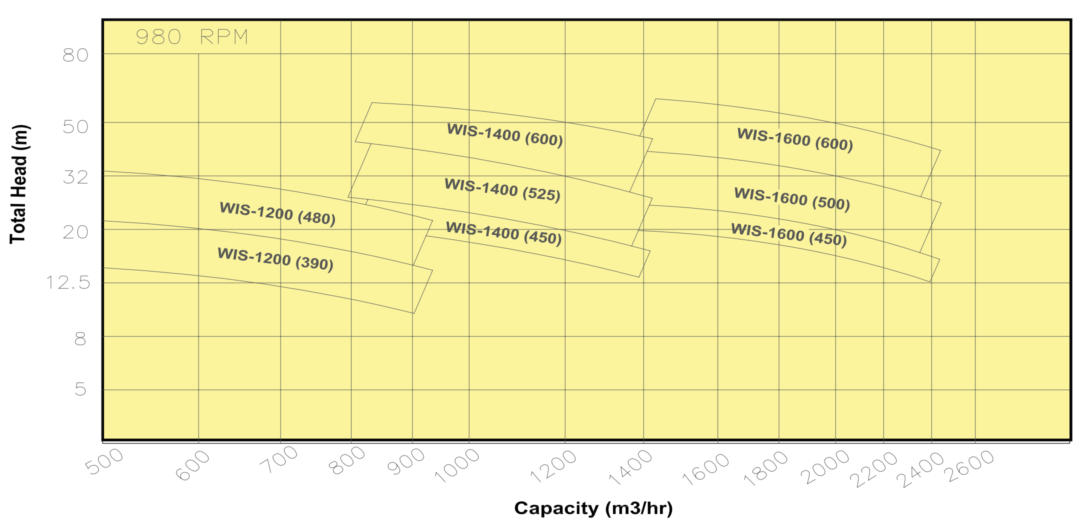
50 Hz @ 2950 RPM



50 Hz @ 1480 RPM



50 Hz @ 980 RPM



Wastecorp Turbo Flow WIS Series
Vertical In-line Circulation/ Booster Pumps
Overview of Performance Range Using 50 Hz Motors[2]

WIS Series In-Line Circulation Pumps Overview of Pump Performance (Utilizing 50 Hz / 2900 RPM Motors)

WIS SERIES MODELS	Pump Size[1]	Suction & Discharge Conn. Size		Max. Capacity		Max. Head		Max. Impeller OD Size[3]		Max. Power		Max. Weight	
	(mm)	DN (mm)	NPS (inch)	(m3/hr)	(GPM)	(m)	(ft)	(mm)	(inch)	(kW)	(HP)	(kg)	(lb)
WIS-050	15 x 15 x 80	15	0.50	2	9	9	28	80	3	0	0	20	44
WIS-075	20 x 20 x 160	20	0.75	3	15	33	108	160	6	2	2	38	84
WIS-100	25 x 25 x 160	25	1	5	23	33	108	160	6	2	2	44	97
WIS-125	32 x 32 x 200	32	1.25	7	29	53	174	200	8	3	4	68	150
WIS-150	40 x 40 x 250	40	1.50	16	72	82	269	250	10	11	15	125	276
WIS-200	50 x 50 x 315	50	2	33	145	128	420	315	12	30	40	330	728
WIS-250	65 x 65 x 315	65	2.50	65	286	128	420	315	12	45	60	375	827
WIS-300	80 x 80 x 350	80	3	130	572	156	512	350	14	75	101	680	1,499
WIS-400	100 x 100 x 350	100	4	130	572	156	512	350	14	90	121	680	1,499
WIS-500	125 x 125 x 315	125	5	192	845	133	436	315	12	90	121	720	1,587
WIS-600	150 x 150 x 400	150	6	240	1,057	160	525	400	16	110	148	990	2,183

WIS Series In-Line Circulation Pumps Overview of Pump Performance (Utilizing 50 Hz / 1480 RPM Motors)

WIS SERIES MODELS	Pump Size[1]	Suction & Discharge Conn. Size		Max. Capacity		Max. Head		Max. Impeller OD Size[3]		Max. Power		Max. Weight	
	(mm)	DN (mm)	NPS (inch)	(m3/hr)	(GPM)	(m)	(ft)	(mm)	(inch)	(kW)	(HP)	(kg)	(lb)
WIS-600	150 x 150 x 400	150	6	260	1,145	53	174	400	16	45	60	520	1,146
WIS-800	200 x 200 x 500	200	8	520	2,289	85	279	500	20	132	177	1,250	2,756
WIS-1000	250 x 250 x 500	250	10	670	2,950	87	285	500	20	160	215	1,250	2,756
WIS-1200	300 x 300 x 500	300	12	900	3,963	85	279	500	20	250	335	1,685	3,715
WIS-1400	350 x 350 x 400	350	14	960	4,227	55	180	400	16	160	215	1,950	4,299
WIS-1600	400 x 400 x 315	400	16	1,300	5,724	37	120	315	12	132	177	1,740	3,836
WIS-2000	500 x 500 x 315	500	20	1,450	6,384	35	113	315	12	160	215	2,070	4,564

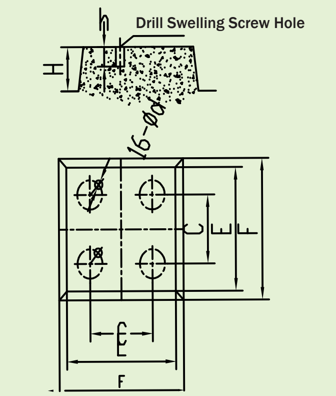
WIS Series In-Line Circulation Pumps Overview of Pump Performance (Utilizing 50 Hz / 980 RPM Motors)

WIS SERIES MODELS	Pump Size[1]	Suction & Discharge Conn. Size		Max. Capacity		Max. Head		Max. Impeller OD Size[3]		Max. Power		Max. Weight	
	(mm)	DN (mm)	NPS (inch)	(m3/hr)	(GPM)	(m)	(ft)	(mm)	(inch)	(kW)	(HP)	(kg)	(lb)
WIS-1200	300 x 300 x 480	300	12	900	3,963	31	102	480	19	75	101	1,500	3,307
WIS-1400	350 x 350 x 600	350	14	1,400	6,164	53	174	600	24	250	335	2,750	6,063
WIS-1600	400 x 400 x 500	400	16	2,400	10,567	34	112	500	20	250	335	2,980	6,570

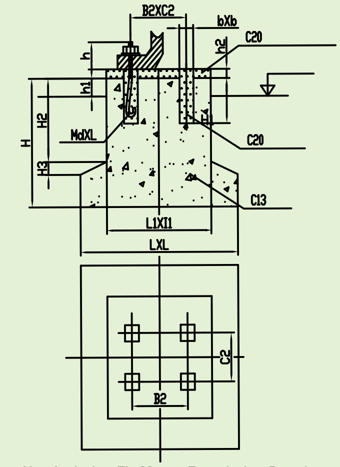
NOTES:

1. Please contact the factory for proper model selection for your application.
2. This is a general overview of the performance for this series of Turbo-Flow pumps.
3. Optional impeller sizes are available, including trimmed impeller sizes. Contact factory for additional information.
4. Wastecorp. Pumps reserves the right to make revisions to its products, performance, dimensions and specifications, and related information, without notice.

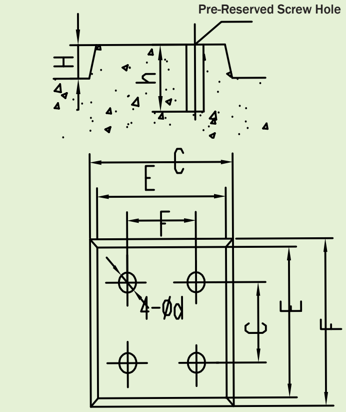
WIS Series In-Line Circulation Pumps Dimensional Drawing



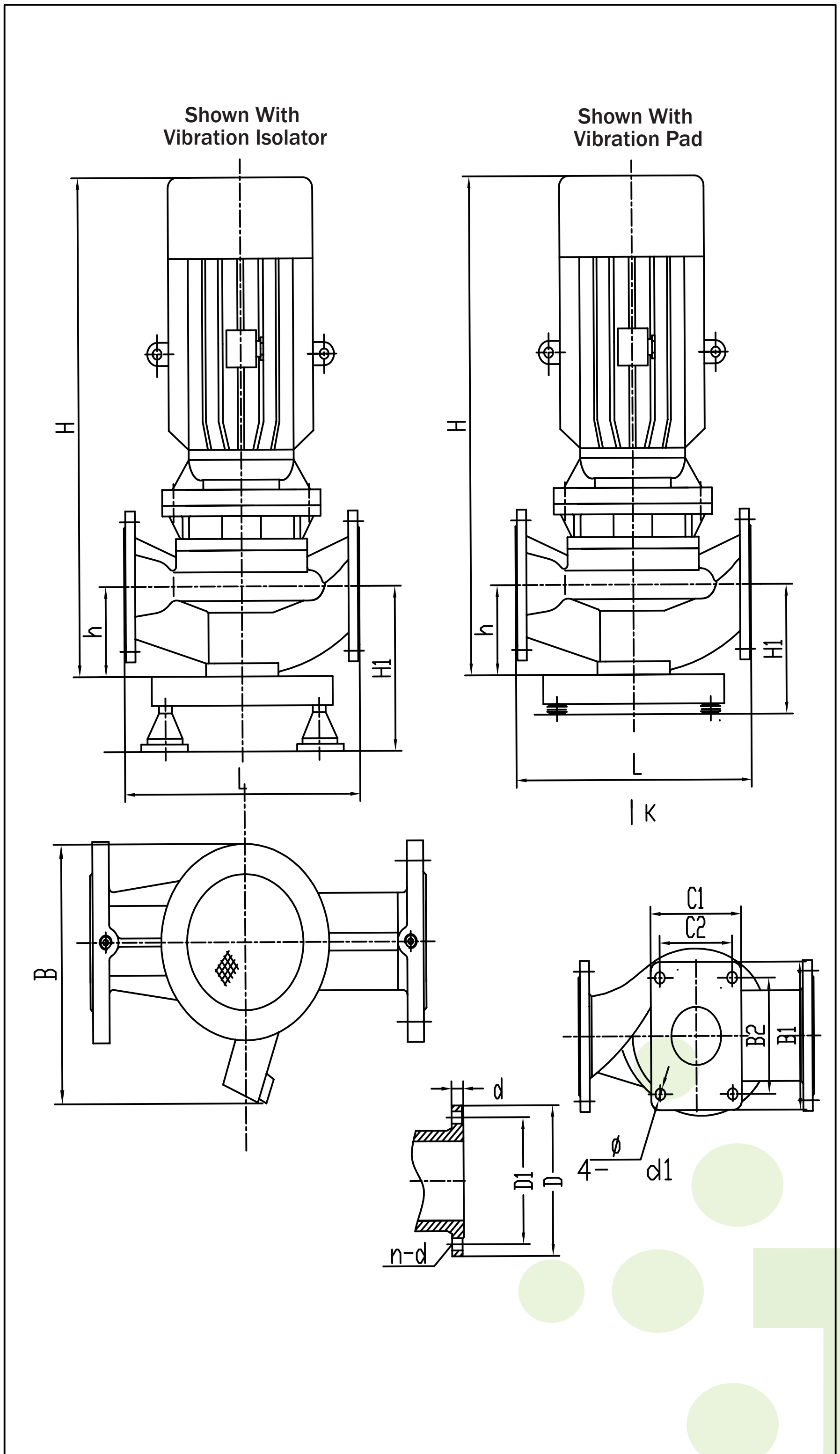
Flexible Joint Foundation Drawing



Non Isolation Fix Mount Foundation Drawing



Rigid Joint Foundation Drawing



WIS Series In-Line Circulation Pumps General Pump Dimensions (Metric)

WIS SERIES MODELS	MAX. PUMP DIMENSIONS[1] (mm)					MAX. FOOT DIMENSIONS[2] (mm)					FLANGE DIMENSIONS (mm)						ISOLATION SELECTION & DIMENSION[3]				
METRIC																	Vibration Isolation Pad		Vibration Isolator		Connection Board
	L	B	H	h	DN (Φ)	d1 (Φ)	B_1	C_1	B_2	C_2	DN (Φ)	D (Φ)	D_1 (Φ)	No. of Holes (n)	Hole Size d (Φ)	b	Max. Type	Max. H_1 (mm)	Max. Type	Max. H_1 (mm)	Max. Type
WIS-050	180	134	333	40	1/2	12	90	65	70	45	-	-	-	-	-	-	SD41-0.5	60	-	-	-
WIS-075	300	258	425	70	3/4	12	130	90	100	60	-	-	-	-	-	-	SD41-0.5	90	-	-	-
WIS-100	300	258	440	70	25	12	130	90	100	60	25	115	85	4	14	16	SD41-0.5	90	-	-	-
WIS-125	340	288	531	90	32	14	160	110	130	80	32	140	100	4	19	18	SD41-0.5	165	-	-	SLS-2
WIS-150	440	433	732	100	40	18	200	140	160	100	40	150	110	4	19	18	SD41-0.5	185	JG2-2	220	SLS-3
WIS-200	550	475	935	130	50	18	220	160	180	120	50	165	125	4	19	20	SD41-1.5	205	JG2-2	250	SLS-4
WIS-250	580	525	1080	140	65	22	280	200	220	160	65	185	145	4	19	20	SD61-1.5	215	JG3-2	282	SLS-6
WIS-300	630	700	1260	160	80	22	280	200	220	160	80	200	160	8	19	22	SD61-1.5	240	JG3-2	302	SLS-6
WIS-400	680	700	1325	180	100	22	320	230	280	200	100	220	180	8	19	24	SD62-2.0	278	JG3-2	322	SLS-10
WIS-500	695	700	1390	200	125	22	360	310	300	250	125	250	210	8	19	26	SD62-1.0	298	JG3-2	342	SLS-12
WIS-600	820	899	1610	225	150	22	360	310	300	250	150	285	240	8	23	26	SD62-1.5	323	JG4-2	413	SLS-12
WIS-800	1100	899	1990	280	200	22	370	300	300	250	200	340	295	12	23	30	SD62-1.5	378	JG3-2	422	SLS-12
WIS-1000	1270	899	1880	350	250	26	500	400	450	350	250	405	355	12	28	32	SD62-1.5	448	JG4-2	538	SLS-16
WIS-1200	1420	1055	2015	400	300	26	550	480	480	430	300	460	410	12	28	32	SD63-2.0	501	JG4-2	588	SLS-18
WIS-1400	1700	1055	2050	460	350	26	550	480	480	430	350	520	470	16	28	36	SD62-4.0	548	JG4-2	638	SLS-18
WIS-1600	1750	1055	2095	480	400	26	550	500	480	430	400	580	525	16	31	38	SD62-4.0	578	JG4-2	668	SLS-18
WIS-2000	1500	927	1985	425	500	26	550	480	480	430	500	715	650	20	34	42	SD62-2.5	523	JG4-2	613	SLS-18

WIS Series In-Line Circulation Pumps General Pump Dimensions (Imperial)

WIS SERIES MODELS	MAX. PUMP DIMENSIONS[1] (inches)					MAX. FOOT DIMENSIONS[2] (inches)					FLANGE DIMENSIONS (inches)						ISOLATION SELECTION & DIMENSION[3]				
IMPERIAL																	Vibration Isolation Pad		Vibration Isolator		Connection Board
	L	B	H	h	DN (Φ)	d1 (Φ)	B_1	C_1	B_2	C_2	DN (Φ)	D (Φ)	D_1 (Φ)	No. of Holes (n)	Hole Size d (Φ)	b	Max. Type	Max. H_1 (inches)	Max. Type	Max. H_1 (inches)	Max. Type
WIS-050	7	5	13	2	0.50	15/32	4	3	3	2	-	-	-	-	-	-	SD41-0.5	2	-	-	-
WIS-075	12	10	17	3	0.75	15/32	5	4	4	2	-	-	-	-	-	-	SD41-0.5	4	-	-	-
WIS-100	12	10	17	3	1	15/32	5	4	4	2	1	5	3	4	9/16	5/8	SD41-0.5	4	-	-	-
WIS-125	13	11	21	4	1.25	9/16	6	4	5	3	1.25	6	4	4	3/4	23/32	SD41-0.5	6	-	-	SLS-2
WIS-150	17	17	29	4	1.5	23/32	8	6	6	4	1.5	6	4	4	3/4	23/32	SD41-0.5	7	JG2-2	9	SLS-3
WIS-200	22	19	37	5	2	23/32	9	6	7	5	2	6	5	4	3/4	25/32	SD41-1.5	8	JG2-2	10	SLS-4
WIS-250	23	21	43	6	2.5	7/8	11	8	9	6	2.5	7	6	4	3/4	25/32	SD61-1.5	8	JG3-2	11	SLS-6
WIS-300	25	28	50	6	3	7/8	11	8	9	6	3	8	6	8	3/4	7/8	SD61-1.5	9	JG3-2	12	SLS-6
WIS-400	27	28	52	7	4	7/8	13	9	11	8	4	9	7	8	3/4	15/16	SD62-2.0	11	JG3-2	13	SLS-10
WIS-500	27	28	55	8	5	7/8	14	12	12	10	5	10	8	8	3/4	1 1/32	SD62-1.0	12	JG3-2	13	SLS-12
WIS-600	32	35	63	9	6	7/8	14	12	12	10	6	11	9	8	29/32	1 1/32	SD62-1.5	13	JG4-2	16	SLS-12
WIS-800	43	35	78	11	8	7/8	15	12	12	10	8	13	12	12	29/32	1 3/16	SD62-1.5	15	JG3-2	17	SLS-12
WIS-1000	50	35	74	14	10	1-1/64	20	16	18	14	10	16	14	12	1 3/32	1 1/4	SD62-1.5	18	JG4-2	21	SLS-16
WIS-1200	56	42	79	16	12	1-1/64	22	19	19	17	12	18	16	12	1 3/32	1 1/4	SD63-2.0	20	JG4-2	23	SLS-18
WIS-1400	67	42	81	18	14	1-1/64	22	19	19	17	14	20	19	16	1 3/32	1 13/32	SD62-4.0	22	JG4-2	25	SLS-18
WIS-1600	69	42	82	19	16	1-1/64	22	20	19	17	16	23	21	16	1 7/32	1 1/2	SD62-4.0	23	JG4-2	26	SLS-18
WIS-2000	59	36	78	17	20	1-1/64	22	19	19	17	20	28	26	20	1 11/32	1 21/32	SD62-2.5	21	JG4-2	24	SLS-18

Notes:

1 Pump dimensions vary depending on impeller size. Contact factory for actual dimensions for your pump.

2 Installation dimensions vary depending on impeller and motor size. Contact factory for actual dimensions for your pump.

3 Vibration pad dimensions vary depending on Motor Size. Contact factory for actual dimensions for your pump.