MEP KEY

By – AHMED M. SHUHAYB

هذا العمل خالص لوجه الله تعالى

فضلا وليس امرا

نسألكم الدعاء لوالدي رحمه الله وقراءة الفاتحة

JULY 1, 2023

ASEC OFFICE BIM ENGINEERING
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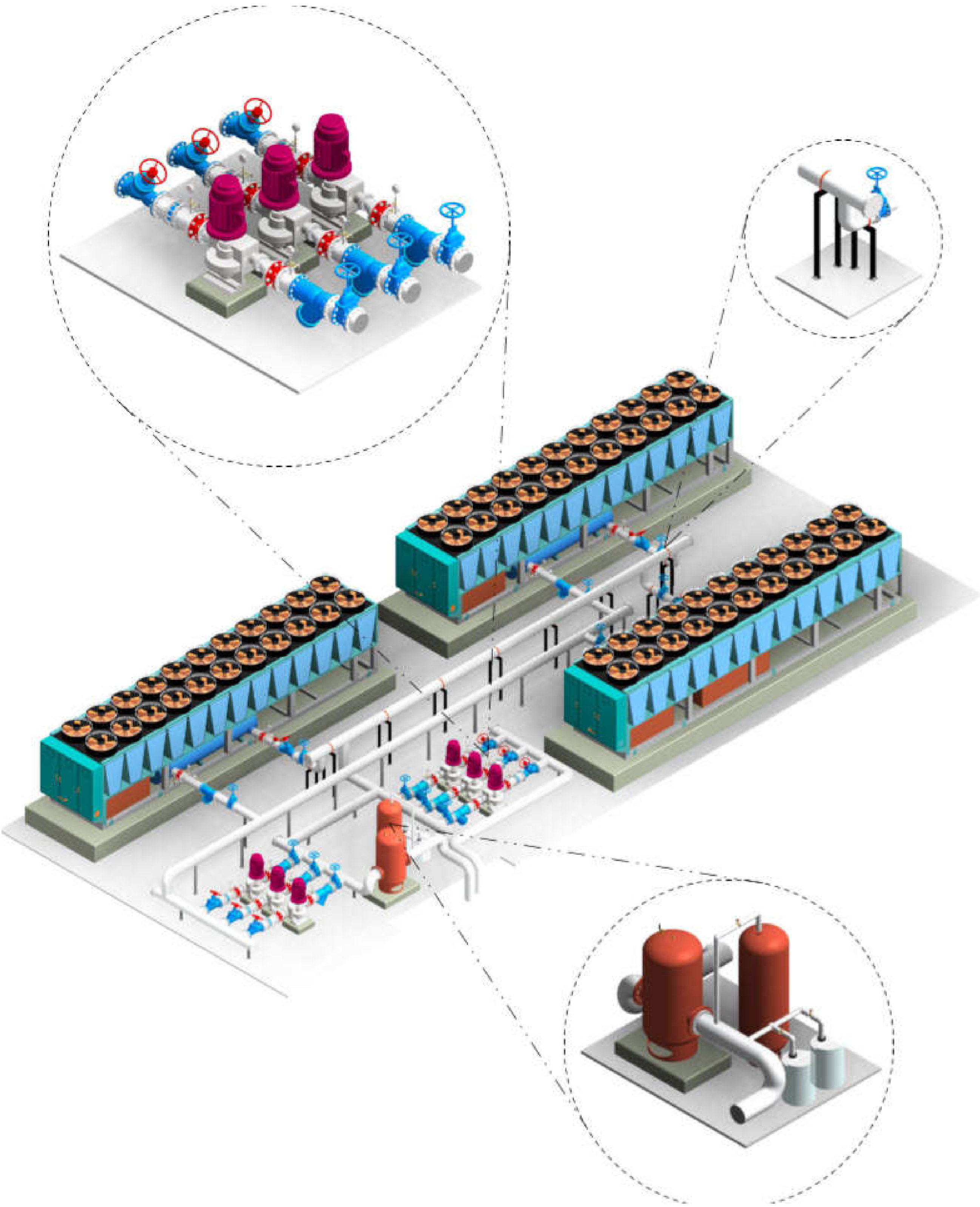
HVAC NOTES

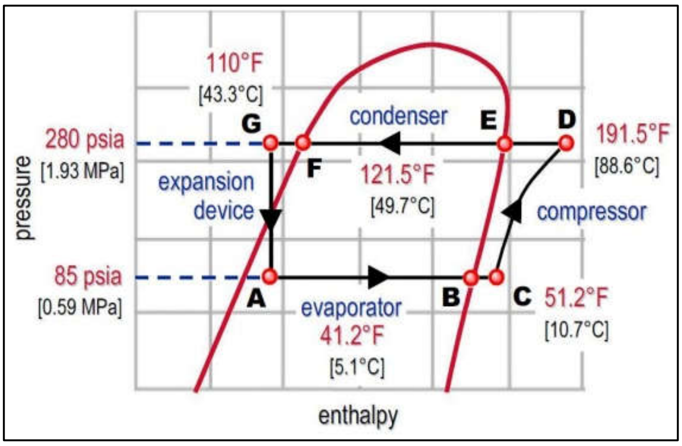


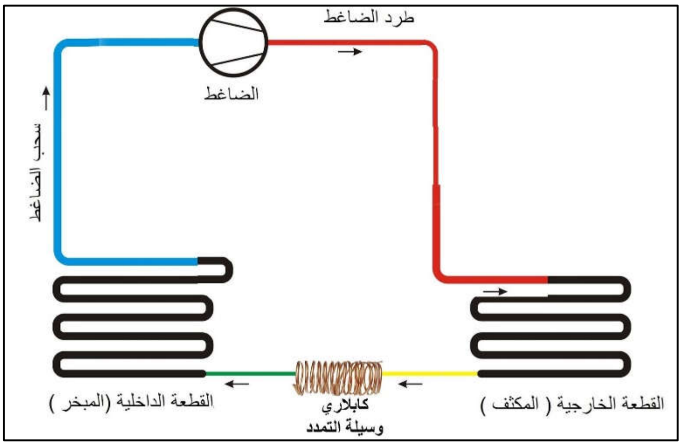
HVAC Basics

1- <u>Heating and Ventilation Air Conditioning</u>

- Temperature: 24±2 °C
- Humidity: 50±5%
- Fresh: 5:20 % from Supply Air
- Velocity: 50 FPM
- Filtration
- NC
- Distribution

2- <u>Refrigeration Cycle</u>





3- <u>AC Types</u>

- **INDOOR UNIT:**

وحدة مكونة من مبخر (ملف التبريد) – مروحة – فلتر
مسئولة عن تبريد الهواء بشكل مباشر- تقوم بتوصيلها بوحدة خارجية مسئولة عن تبريد ملف التبريد
مصدر تبريد ملف التبريد يكون فريون في أنظمة DX او مياه في أنظمة Chilled

- HI-Wall Split
- Ceiling Suspended
- Floor Standing
- Cassette
- Fan Coil Unit or Concealed
- AHU

- **OUTDOOR UNIT:**

هي الوحدة المسئولة عن انتاج مائع التبريد المسئول عن تبريد ملف التبريد

- DX Unit (Condensing Unit) — عبارة عن مكثف – ضاغط – صمام تمدد
- VRF (VRV) Unit — عبارة عن مكثف – ضاغط – صمام تمدد
- Chiller (Air Cooled – Water Cooled) — عبارة عن مكثف – ضاغط – صمام تمدد – مبخر

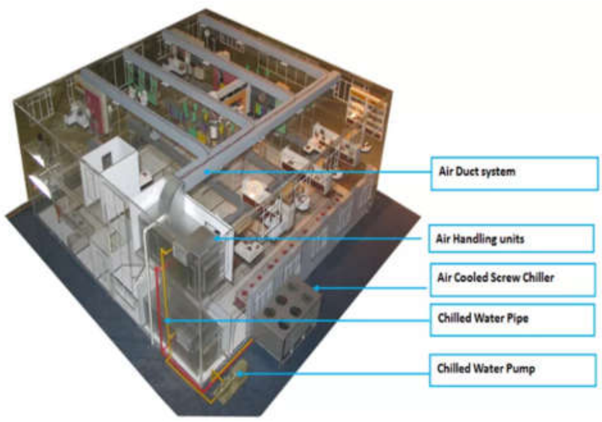
- DX Unit: يتم توصيل كل وحدة داخلية بوحدة خارجية يعني لو عندك داخل المبني 20 وحدة داخلية يبقي عندك 20 وحدة خارجية ويتم التوصيل باستخدام مواسير نحاس بداخلها فريون بمقاسات مختلفة حسب الحمل التبريد ومتطلبات المصنع ويكون لها طول محدد لذلك لا يفضل ان يكون فيه مسافات طويلة.

- VRF: يتم توصيل أكثر من وحدة داخلية بوحدة واحدة خارجية ولكن ليها حد أكثر يعني مش Unlimited ولكل بكل تأكيد بتوفر مساحة خارجية لتقليل عدد الوحدات الخارجية وبتوفر استهلاك الكهرباء ويتم التوصيل باستخدام مواسير نحاس بداخلها فريون ولها القدرة انها تمشي لمسافات طويلة.

- Chiller: يتم توصيل كل الوحدات الداخلية بالوحدة الخارجية ويكون الشيلر له رنج واسع من الاحمال الحرارية ويتم التوصيل باستخدام مواسير حديد Seamless Black steel وليس مواسير نحاس.

➢ DX System:

➢ Chilled Water System:



➢ VRF System:

➢ Package Unit:

وحدة تكييف مكونة من:

مبخر – مروحة – فلاتر

ضاغط – مكثف – صمام التمدد

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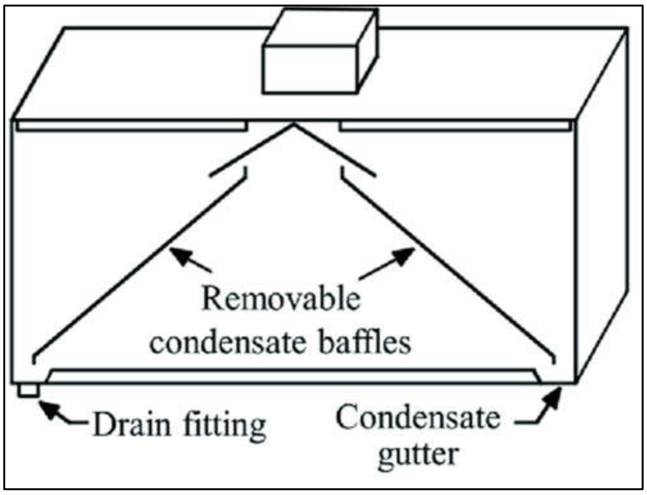
Ventilation System

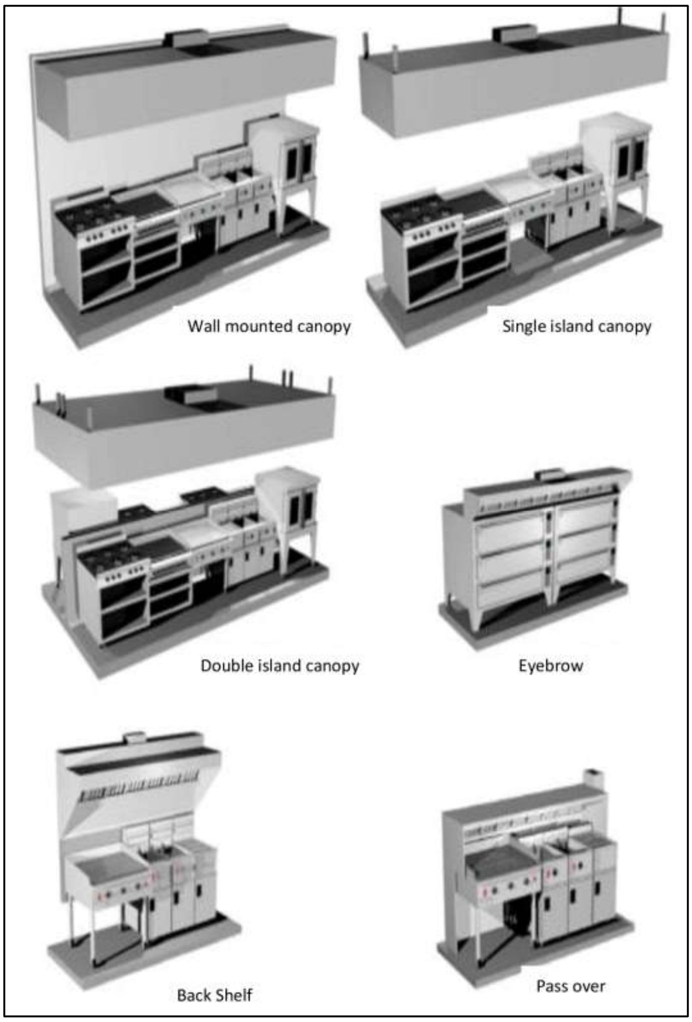
- Mechanical Ventilation
  - $\text{CFM} = \frac{\text{ACHx Volume (m}^3)}{1.7}$ الحمامات والمطابخ والمخازن والجراجات
  - $\text{CFM} = \frac{\text{ACHx Volume (Ft}^3)}{60}$
  - $\text{CFM} = \frac{\text{H(Btu/min)}}{\acute{\rho}(0.071)\text{x}C_p(0.24)\text{x}\Delta T(20°f)}$ غرفة المولدات والمحركات

Space	ACH	Space	ACH
Toilet	10:12	Car Park	4:6 - 10
Kitchen	15:20	Store	4:6

- Central Kitchen Ventilation
  - Hood Types
    - Wall Mounted Canopy
    - Single Island Canopy
    - Double Island Canopy
    - Eyebrow
    - Back shelf
    - Condensate

Light	Medium	Heavy	Extra Heavy
200°	200°	315°	370°
- Ovens - Steamers - Cheese Melters	- Hot Top/Element Ranges - Griddles - Fryers - Pasta Cookers - Conveyor Ovens (Pizza) - Rotisseries	- Open Burner Gas Ranges - Broilers - Wok Ranges	- Appliance using solid fuels e.g. wood, charcoal, briquettes
50 FPM	85 FPM	150 FPM	185 FPM





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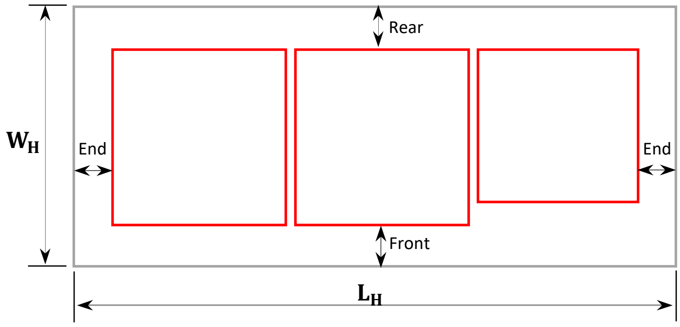
➢ Hood Dimension

Type of Hood	End Overhang	Front Overhang	Rear Overhang
Wall-mounted canopy	6 in. to 12 in. (15-30 cm)	12 in (30 cm)	--
Single island canopy	6 in. to 12 in. (15-30 cm)	12 in. (30 cm)	12 in. (30 cm)
Double island canopy	6 in. to 12 in. (15-30 cm)	12 in. (30 cm)	12 in. (30 cm)
Eyebrow	0 in.	12 in. (30 cm)	--
Backshelf or Pass-over	0 to 3 in. (72 mm)	--	Front set back 6 in. to 12 in. (15-30 cm) in from the front of the cooking surface



➢ Hood Flow Rate

$$Q_{Ex} = L_H x\, CFM/Ft$$
$$Q_{Fr} = 0.8 : 0.95\ x\ Q_{Ex}$$

Ashrae- St 90.1

Hood Type	Extra Heavy Duty		Heavy Duty		Medium Duty		Light Duty	
	cfm/ft	L/s.m	cfm/ft	L/s.m	cfm/ft	L/s.m	cfm/ft	L/s.m
Wall-mounted canopy	385	597	280	434	210	325	140	217
Single island canopy	490	760	420	651	350	542	280	434
Double island canopy (per side)	385	597	280	434	210	325	175	271
Eyebrow Non-canopy	N/A	N/A	N/A	N/A	175	271	175	271
Backshelf / pass-over	N/A	N/A	280	434	210	325	210	325

Egyptian Code

Hood Type	Extra Heavy Duty		Heavy Duty		Medium Duty		Light Duty	
	cfm/ft	L/s.m	cfm/ft	L/s.m	cfm/ft	L/s.m	cfm/ft	L/s.m
Wall-mounted canopy	550	852	400	619	300	464	200	310
Single island canopy	700	1084	600	929	500	774	400	619
Double island canopy (per side)	550	852	400	619	300	464	250	387
Eyebrow Non-canopy	N/A	N/A	N/A	N/A	250	387	250	387
Backshelf / pass-over	N/A	N/A	400	619	300	464	300	464

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- Correction Factor According to Hood Type
    - Wall Mounted Canopy x 1
    - Single Island Canopy x 1.2
    - Double Island Canopy x 1.15

- Pressure Drop Through Hood
    - Light Cooking = 0.3 Inwg
    - Medium Cooking = 0.4 Inwg
    - Heavy Cooking = 0.6 Inwg

- Exhaust / Fresh Neck

يتم تحديد عدد الفتحات بحيث يتم توزيع عمليه السحب والفرش على طول الهود

$\mathbf{W \times H = CFM_{Ex,Fr}/V_{900FPM}}$

يتم فرض قيمة Hبحيث تكون في الفرش حوالي من 15 الي 30 سم

يتم فرض قيمة Hبحيث تكون في السحب حوالي من 20 الي 40 سم

وبمعلومية قيمة CFMوقيمة السرعة خلال الفتحة لا تتجاوز 900 FPM وعمل فرض لقيمة Hبالتالي تحصل على قيمة W

- Example:
    Hot Line Length = 3 m, Width= 0.9 m, Medium Cooking – In Center Kitchen

Island Single Canopy

- L_H = End Overhang + Hot Line Length + End Overhang = 0.15 + 3 + 0.15 = 3.3 m =10.8 Ft
- W_H = Rear Overhang + Hot Line Width + Front Overhang = 0.3 + 0.9 + 0.3 = 1.5 m
- H_H = Hood Height (50: 60 cm)

- $Q_{Ex} = L_H \text{x} \, CFM/Ft$ = 10.8 x 500 x 1.2 = 6,500 CFM
- $Q_{Fr} = 0.8{:}\,0.95 \text{ x } Q_{Ex}$ = 0.85 x 6,500 = 5,500 CFM

- No-Ex- Neck = 3
- One Neck - 2150 CFM
- $\mathbf{W \times H = CFM_{Ex,Fr}/V_{900FPM}}$ - $\mathbf{W \times H} = 2150/900$ = 2.4 Ft² = 2230 cm²
- W = 2230/40 = 55 cm
- W x H = 50 x 40 cm x 3 Neck

- No-Fr- Neck = 4
- One Neck - 1,375 CFM
- $\mathbf{W \times H = CFM_{Ex,Fr}/V_{900FPM}}$ - $\mathbf{W \times H} = 1{,}375/900$ = 1.5 Ft² = 1393cm²
- W = 1393/25 = 55 cm
- W x H = 55 x 25 cm x 4 Neck

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Hospital Requirements

➢ HOSPITAL SPACES

ما يتم تطبيقه بالفعل		ASHRAE ST.170		اعتبارات عامة			ASEC
G	F	E	D	C	B	A	
Equip	**ACH_T**	**ACH_T**	**ACH_F**	**كل الهواء المطرود يتم التخلص منه مباشرة**	**مسموح بتدوير الهواء داخل الغرفة**	**الضغط**	**اسم الغرفة**
FAHU 100%	20:25	20	4	NR	NO	+	غرفة العمليات
FAHU 100%	20:25	20	4	NR	NO	+	الولادة القيصرية
NR	6	6	2	NR	NR	NR	الولادة الطبيعية
FAHU 100%	10:12	6	2	NR	NO	+	الافاقة والانعاش
FAHU 100%	10:12	6	2	NR	NO	+	طرق العمليات
FAHU 100%	10:12	6	2	NR	NO	+	العناية المركزية
FAHU 100%	10:12	6	2	NR	NO	+	الحضانات
FAHU 100%	10:12	6	2	NR	NO	+ or -	غرف العزل
FAHU 100%	10:12	6	2	YES	NR	-	المعامل وبنك الدم
FAHU 100%	12	12	2	YES	NR	-	الفرز
NR	10:12	6	2	NR	NR	+	المناظير- العلوي
FAHU 100%	10:12	6	2	NR	NO	+	المناظير- السفلي
FAHU 100%	15	15	3	NR	NO	+	اشعة – الجراحة والقسطرة
NR	10	6	2	NR	NR	-	الغسيل الكلوي
NR	6	6	2	NR	NR	NR	غرف الإقامة
							مخازن الادوية
							الصيدلية
							أماكن الانتظار
							الاشعة – الرنين
							عيادات الكشف
							UPS/IT
EX-FAN	10	6	NR	YES	NO	-	غرفة الكهرباء
EX, FR-FAN	10	10	2	YES	NO	-	المطبخ والمغسلة
EX-FAN	10	10	NR	YES	NO	-	المخازن والحمامات
FAHU 100%	10	6	2	YES	NO	-	استلام المواد غير المعقمة
FAHU 100%	10	4	2	NR	NO	+	مخزن معقم – منطقة العمل

➢ B: مسموح بعملية التدوير باستخدام جهاز تكييف داخل الغرفة بدون استخدام فلتر هيبا اذا كان مكتوب NOفبالتالي غير مسموح باستخدام أي جهاز تكييف الا وحدة المناولة وحدة الباكدج بشرط ان تكون مزودة بفلتر هيبا بالإضافة الي الفلاترالاخري

➢ C: هل الهواء المطرود من الغرفة يمكن إعادة استخدامه مرة اخري ام لا بمعني من الممكن ان يتم استخدامه في HEAT RECOVERY اما إذا كان مكتوب YESمعناها لا يجوز استخدام هواء الغرفة دي مرة اخري مثل هواء الحمامات والمطبخ

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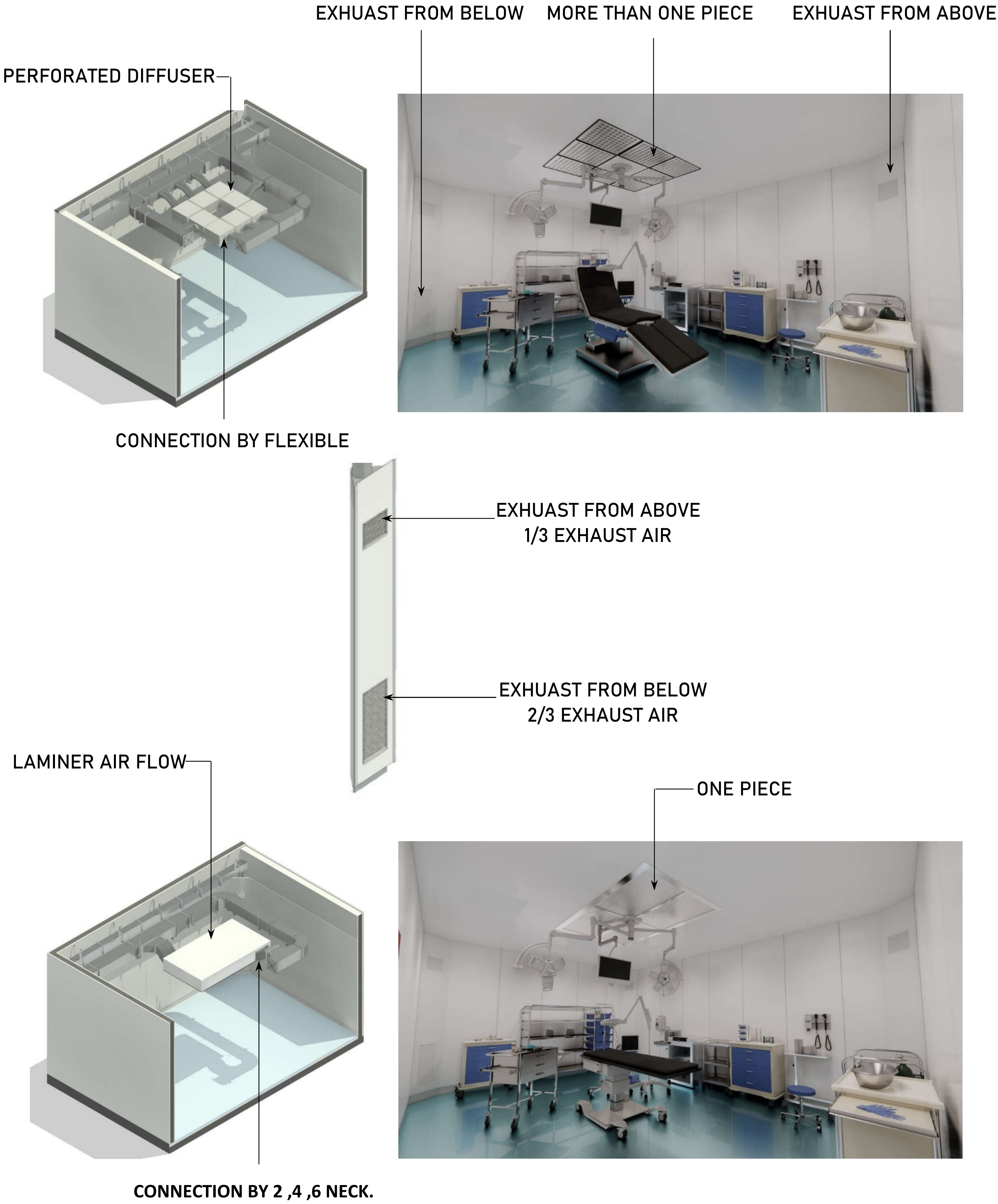

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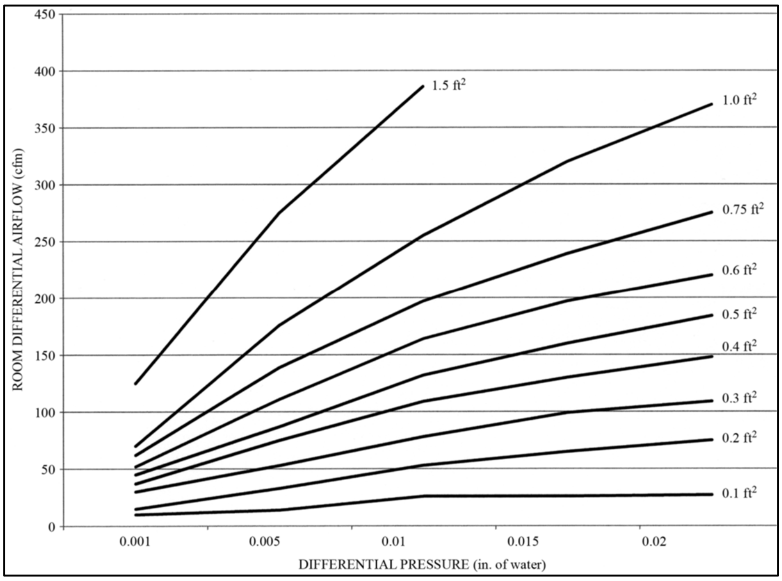
CALCULATION

- $CFM_{ex} > CFM_{sup} \rightarrow -ve$
- $CFM_{sup} > CFM_{ex} \rightarrow +ve$
- $CFM_{sup} = \frac{ACH * V}{1.7}$
- $CFM_{ex} = CFM_{sup} \pm \Delta CFM$
- $\Delta CFM = 2610 * A_L * \sqrt{\Delta P}$



Part Number	Style Code	Nominal Size (Feet)	Actual Size Inches (H x W x D)	Rated Airflow (SCFM) 100 FPM	Std. Pkg. Qty	Ship. Wt. Lbs/Box (± 7%)	Cubic Ft.	Cell Sides	Media Pack
99.99% Scanned (H)									
577-890-004	43A89A2T2H0	2 x 1	24 x 12 x 2¾	165	1	18.0	0.7	2¾ (89)	2" (A)
577-890-005	14A89A2T2H0	2 x 2	24 x 24 x 2¾	350	1	21.0	1.4	2¾ (89)	2" (A)
577-890-007	46A89A2T2H0	2 x 3	24 x 36 x 2¾	540	1	24.0	2.0	2¾ (89)	2" (A)
577-890-008	17A89A2T2H0	2 x 4	24 x 48 x 2¾	725	1	28.0	2.7	2¾ (89)	2" (A)
99.9995% on 0.1 to 0.2 micron - Laser Tested and Scan Tested (M)									
579-890-004	43E89A2T2M0	2 x 1	24 x 12 x 2¾	165	1	18.0	#N/A	2¾ (89)	2" (A)
579-890-005	14E89A2T2M0	2 x 2	24 x 24 x 2¾	350	1	21.0	1.4	2¾ (89)	2" (A)
579-890-007	46E89A2T2M0	2 x 3	24 x 36 x 2¾	540	1	24.0	3.3	2¾ (89)	2" (A)
579-890-008	17E89A2T2M0	2 x 4	24 x 48 x 2¾	725	1	28.0	2.7	2¾ (89)	2" (A)
99.99% Efficient on 0.3 micron - Scan Tested (H)									
577-590-004	43A59B2T2H0	2 x 1	24 x 12 x 3¾	165	1	19.0	0.9	3¾ (59)	3" (B)
577-590-005	14A59B2T2H0	2 x 2	24 x 24 x 3¾	350	1	24.0	1.7	3¾ (59)	3" (B)
577-590-007	46A59B2T2H0	2 x 3	24 x 36 x 3¾	540	1	26.0	1.7	3¾ (59)	3" (B)
577-590-008	17A59B2T2H0	2 x 4	24 x 48 x 3¾	725	1	31.0	3.4	3¾ (59)	3" (B)

لتحديد ابعاد الفلتر المناسب ومعرفة أقصى قيمة من الهواء تخرج من خلال الفلتر.

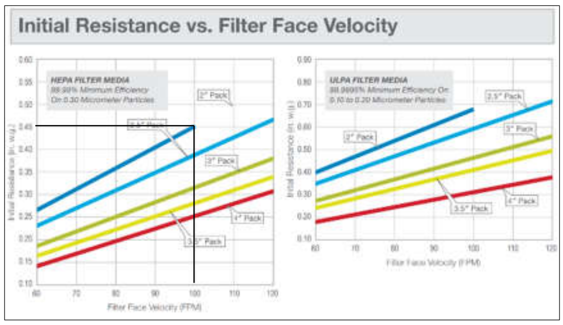
c) Plenum Neck Size=250 mm DIA, Module Size=600x600 mm

Air flow in CFM	220	325	440	550	650	760
Air flow in m³/sec	0.104	0.154	0.208	0.26	0.307	0.359
Neck velocity in m/sec.	2	3	4	5	6	7
P_s loss in mm H_2O	0.698	1.609	2.93	4.193	5.342	6.605
Throw in meters	0.5-1.7	1.1-2.3	1.8-3.2	2.6-4.1	3.1-4.9	3.7-6.1
NC	19	30	37	43	48	56

PERFORATED DIFFUSER

لدية القدرة على انه يطلع قيم مختلفة من الهواء، ولكن بكون مقيد بالفلتر ومقيد بالسرعة ومسافة القذف فنحاول نختار اقل حاجه ممكنة.

لتحديد قيمة الفقد في الضغط خلال الفلتر.



TECHNICAL DATA						
Type	Size in mm (L x W)	Height in mm	Particulate air filter H14	Flow rate at v=0.24 m/s	Pressure loss at v=0.24 m/s	Connecting supports
FFD 12/24	1303 x 2385 mm	at least. 250 mm	4 pcs	2480 m³/h	approx. 60 Pa	2 pcs
FFD 14/24	1455 x 2385 mm	at least. 250 mm	6 pcs	2790 m³/h	approx. 60 Pa	2 pcs
FFD 16/24	1607 x 2385 mm	at least. 250 mm	6 pcs	3090 m³/h	approx. 60 Pa	2 pcs
FFD 18/24	1759 x 2385 mm	at least. 250 mm	6 pcs	3400 m³/h	approx. 60 Pa	2 pcs
FFD 20/24	1929 x 2385 mm	at least. 250 mm	8 pcs	3740 m³/h	approx. 60 Pa	2 pcs
FFD 22/24	2233 x 2385 mm	at least. 250 mm	8 pcs	4350 m³/h	approx. 60 Pa	2 pcs
FFD 24/24	2385 x 2385 mm	at least. 250 mm	8 pcs	4650 m³/h	approx. 60 Pa	2 pcs
FFD 14/26	1455 x 2537 mm	at least. 300 mm	6 pcs	2965 m³/h	approx. 60 Pa	2 pcs
FFD 16/26	1607 x 2537 mm	at least. 300 mm	6 pcs	3290 m³/h	approx. 60 Pa	2 pcs
FFD 20/26	1929 x 2537 mm	at least. 300 mm	8 pcs	4230 m³/h	approx. 60 Pa	2 pcs
FFD 26/26	2537 x 2537 mm	at least. 300 mm	8 pcs	5560 m³/h	approx. 60 Pa	4 pcs

LAF

يتم اختيار أبعاده بناء على قيمة الهواء اللي تخرج من خلاله وتحديد عدد التوصيلات مع الداكت والفقد في الضغط خلاله.

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Heat Loads

Manual Load According to CLTD

STEPS FOR COOLING AND HEATING LOAD CALCULATION MANUAL تم الاستعانة بجدول

Load Type	Equation	Note	Table No
Wall	Q= A x U x CLTD	CLTD=(CLTD+LM) x K +(78 $-T_R$) + ($T_o - 85$)	1.1.3, 1.1.4, 1.1.5
Roof		A – Area	يتم حساب المساحة باستخدام الرسم المعماري
Door		U – Overall Heat Transfer	1.1.1, 1.1.2
Glass	Q= A x U x ΔT	U – Overall Heat Transfer	1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5
Solar Glass	Q= A x SHGF x CLF x SC	SHGF = Solar Heat Gain Factor	1.2.6
		CLF = Cooling Load Factor	1.2.7, 1.2.8
		SC = Shading Factor	1.2.9, 1.2.10, 1.2.11, 1.2.12, 1.2.13, 1.2.14
Light	Q=3.41 x q x F_ax F_S x A x CLF	CLF = Cooling Load Factor	2.1.1, 2.1.2, 2.1.3, 2.1.4
		Q = Lighting Power Densities	2.1.5
People	Q_S = N x $q_S/Peson$ x CLF	$q_S/Person$, $q_L/Peson$	2.2.2
	Q_L = N x $q_L/Peson$	CLF = Cooling Load Factor	2.2.1
Miscellaneous	Q_S = Sensible x CLF	CLF = Cooling Load Factor	2.2.3, 2.2.4
	Q_L = Latent	Sensible, Latent	2.2.5, 2.2.6, 2.2.7
Elec.Equip	Q= Constant x F_Lx CLF	Constant A, B, C	2.2.9
		F_L , Standard Motor	2.2.10
		CLF = Cooling Load Factor	2.2.4
Partition	Q= A x U x ΔT	Wall, Door, Floor, Window, Ceiling	بين حيز مكيف وحيز غير مكيف غير معرض للشمس
Infiltration	Q_S = 1.08 x CFM x ΔT	$CFM = \frac{Volume \times N_a}{60}$	3.1.2
	Q_L = 4840 x CFM x Δω		الحجم يتم وضعة وحدة القدم المكعب
Ventilation	Q_S = 1.08 x CFM x ΔT	$CFM = \frac{CFM}{Person}$ x N. Person + $\frac{CFM}{Aera}$ x Area	3.1.1
	Q_L = 4840 x CFM x Δω		

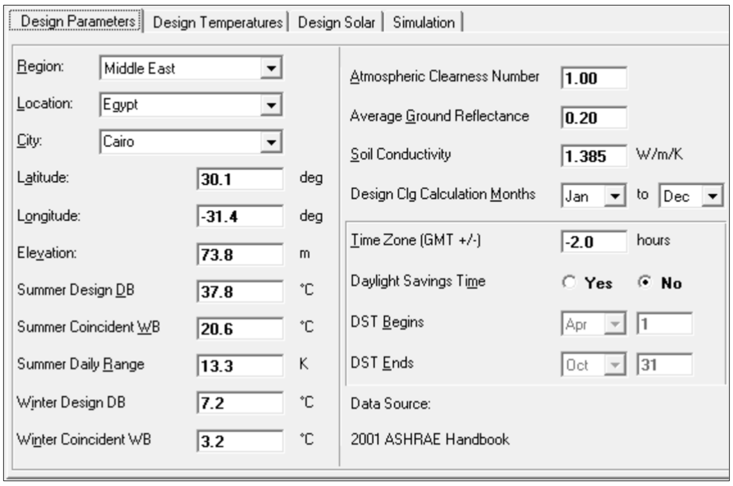
- بعد الانتهاء من عمل الحسابات الحرارية باستخدام برنامج الهاب يفضل عمل تقرير مختصر للنتائج
- يفضل عمل مقارنة بين نتائج الهاب ونتائج الحمل بناء على Rule of Thumb

Rule of Thumb

- Large, Perimeter - Offices, Commercial: 22.5 – 27.5 m^2/Ton
- Large, Interior - Offices, Commercial: 30 – 35 m^2/Ton
- Small - Offices, Commercial: 32.5 – 37.5 m^2/Ton
- Banks, Court Houses, Municipal Buildings, Town Halls: 20 – 25 m^2/Ton
- Computer Rooms: 5 – 15 m^2/Ton
- Restaurants: 10 – 25 m^2/Ton
- Hospital Patient Rooms, Nursing Home Patient Rooms: 25 – 30 m^2/Ton
- Operation Room, ICU: According to Air Change per Hour
- Malls, Shopping Centers: 15 – 35 m^2/Ton
- Supermarkets: 25 – 35 m^2/Ton

System Name	Space Name	Area	Out In	R-Thumb	Air $Flow_S$	Air $Flow_F$	Air $Flow_{EX}$	Total Load HAP	Selection Catalog
00 – 01 – FCU	00 – 01 – OFFICE	20 m^2	Out	0.9 TR	350 CFM	35 CFM	-	0.8 TR	FCU –M 12
00 – 01 – AHU	00 – 02 – OR	40 m^2	Out	10 TR	1400 CFM	1400 CFM	1200 CFM	10 TR	AHU –M 10
00 – 02 – AHU	00 – 03 – OFFICE	22 m^2	IN	0.7 TR	300 CFM	30 CFM	-	2.4 TR	AHU –M30
	00 – 04 – OFFICE	21 m^2	IN	0.7 TR	300 CFM	30 CFM	-		
	00 – 05 – OFFICE	24 m^2	IN	0.9 TR	300 CFM	30 CFM	-		

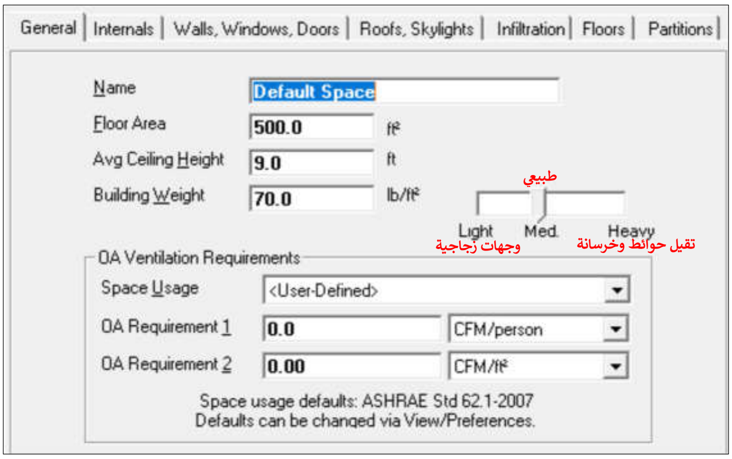
WEATHER



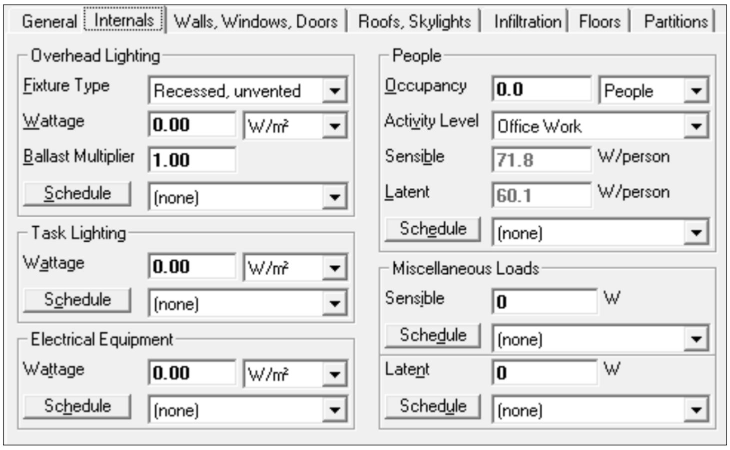
- ادخال المنطقة
- ادخال البلد
- ادخال المدينة
- درجة الحرارة الجافة وهي تتراوح في رنج 42:44 C
- درجة الحرارة الرطبة وهي تتراوح في رنج 26:28 C

يتم الحصول على مدخلات الطقس من خلال النشرة الجوية للبلد او من موقع
ASHRAE METO INFO

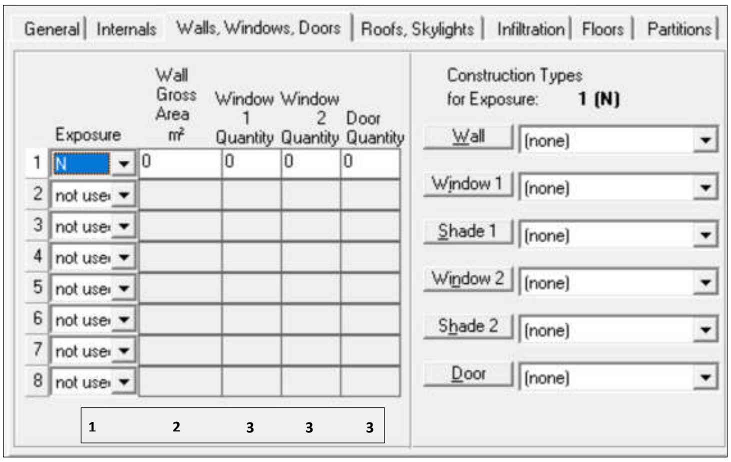
SPACE INPUT



- اسم الغرفة ويفضل لما تجي تسمي الغرفة يكون نمط ثابت 00-01-OFFICE
- مساحة الغرفة
- الارتفاع حتى منسوب السقف مستعار وفي حالة عدم وجود سقف مستعار يكون الارتفاع حتى السقف الخرساني
- نظام الهواء النقي
  - إذاكان نظام الهواء يكون هواء راجع فإن نسبة الهواء النقي حوالي من 5 الي 20 % من الهواء السبلاي أو حسب قيم Ashrae 62.1
  - إذاكان نظام الهواء السبلاي توتال فرش فإن نسبة الهواء النقي تكون 100 %
- ملحوظة في حالة التعامل بنسبة مؤية يتم إدخالها في خانة واحدة فقط OA Requirement 1



- تتراوح من 8 الي 12 وات لكل متر مربع حسب التطبيق
- لا تنس وضع جدول عمل لمواعيد التشغيل ونلاحظ ان عند حساب الحمل الحراري يتم الحساب على الساعة الاسوأ وغالبا يكون جدول عمل واحد للإضاءة والأشخاص والمعدات
- تتراوح من 20 الي 50 وات لكل متر مربع حسب التطبيق
- يتم تحديد عدد الأشخاص بناء على الفرش المعماري أو فرض هندسي مقبول
- يتم تحديد نشاط الأشخاص حسب طبيعة التطبيق وغالبا نفضل ان يكون نشاط متوسط
- هي أحمال المطبخ من معدات بوتاجاز، وأفران، وقلاية، وخلافة.. ويتم الحصول على قيم الاحمال من خلال المانول ولكن الأفضل من خلال الداتا شيت للمعدات من المورد

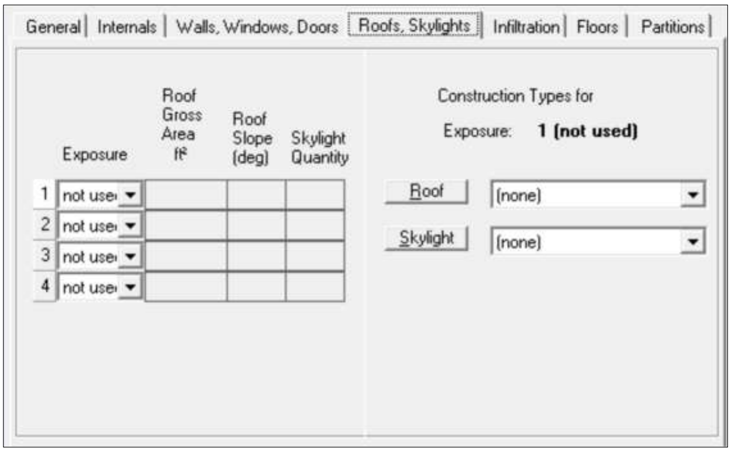


1- لابد من تحديد اتجاه الحائط المعرض للشمس
2- تقوم بإدخال مساحة الحائط بالكامل بما تشمله من شبابيك وابواب
3- تقوم بإدخال عدد الأبواب والشبابيك

- مكونات الحائط والابواب والشبابيك طبقا للمكونات المعمارية وفي حالة عدم توضيح لك المكونات تقوم بفرضها طبقا للمنطق الهندسي، ولكن يفضل الرجوع للمعماري لان وجود عازل من عدمه مؤثر في تحديد الحمل الحراري بدقة
- **ملحوظة:** لو عندك حوائط زجاج فأنت قدامك حل من اثنين
  الأول: هو أنك تعمل كل حيطة زجاج تعمل ليها شباك بنفس مساحة الحيطة
  الثاني: تعمل شباك واحد مساحة 1 متر مربع وبعد كدة تدخل المساحة كعدد شبابيك

SPACE INPUT

يتم ادخال قيمة السقف الخرساني في حالة الدور الأخير فقط وذلك عندما يكون السقف الخرساني معرض للشمس اما لو كان الدور غير معرض فلا تكون بإدخال أي قيم هنا

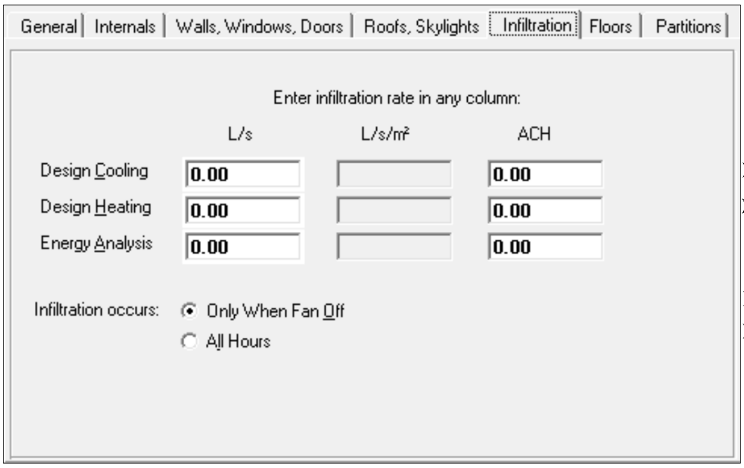


- يتم ادخال المساحة الكلية للسقف الخرساني
- اتجاه السقف الخرساني ويكون اتجاه H
- في بعض التطبيقات مثل المولات يكون السقف الخرساني اغلبه زجاج وبالتالي فانت بتدخل عدد Skylight كأنك تتعامل مع شباك بالضبط بس الشباك في السقف

- قم بإدخال مكونات السقف الخرساني بما فيه من خرسانة وتحديد وعازل ام لا ودة طبعا بتحصل عليه من المهندس الانشائي

اما بخصوص Skylight تتعامل معاكأنه بالضبط شباك زجاج

مدخلات Infiltrationتكون مؤثرة في حالة كانت الغرفة ضغطها سالب اما في حالة كان الغرفة ضغطها موجب او متعادل فالتالي لا يحدث تسريب Infiltration

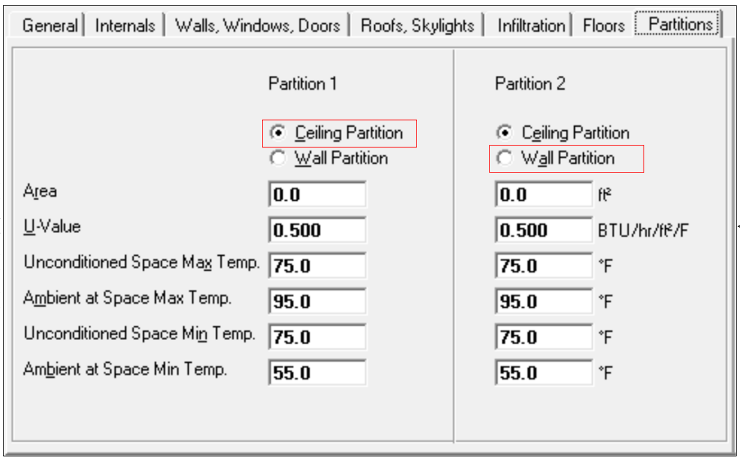


- قيمة التسريب في حالة الصيف تكون حواليACH=0.8
- قيمة التسريب في حالة الشتاء تكون حواليACH=1.2

- في حالة ضغط الغرفة موجب ويكون وقتها قيمة التسريب غير مؤثر
- في حالة ضغط الغرفة سالب ويكون وقتها قيمة التسريب مؤثر

Floor:

- تحتها مكيف فبالتالي لا يوجد حمل حراري
- تحتها غير مكيف فتتعامل معاها كأنها بارتشن بالضبط ودة أغلب الشغل
- تكون في منسوب الشارع
- تكون تحت منسوب الشارع ودة في حالات البدروم



- مساحة السقف المستعار
- بناء على قيمة المكونات المعمارية للسقف المستعار
- درجة حرارة المكان غير المكيف وتكون في رنج 75:95 F
- درجة حرارة الوسط الخارجي وتكون في رنج 100:115 F

- مساحة الحوائط والابواب والشبابيك
- بناء على مكونات الحوائط والابواب والشبابيك الموجودة بين الغرفة واي وسط غير مكيف

عندي مشكلة في حالة لو عندي أكثر من بارتشن زي حائط وباب وشباك فنلاحظ ان كل مكون منهم مختلف المكونات وبالتالي مختلف في قيمة U- طيب انا مينفعش اجمع مساحات مختلفة U

ريح نفسك وأعمل الحركة دي تحط قيمة U=1 و تضرب قيمة A x U لكل حائط او باب او شباك وتجمعهم وتحطهم في خانة A

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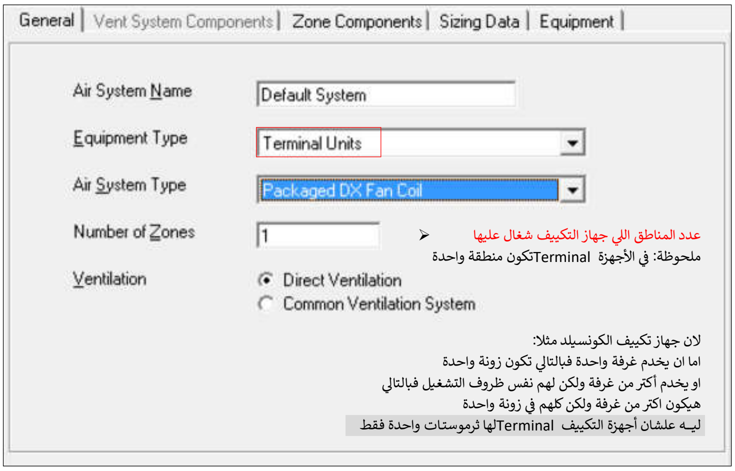
SYSTEM INPUT

أي جهاز تكييف هجيبه في المشروع لازم أعمل ليه سيستم علشان أعرف الحمل الحراري بتاعه وكمية الهواء.. الخ



اسم النظام هو اسم جهاز التكييف ويفضل لما تجي تسمى الغرفة يكون نمط ثابت 00-01-FCU

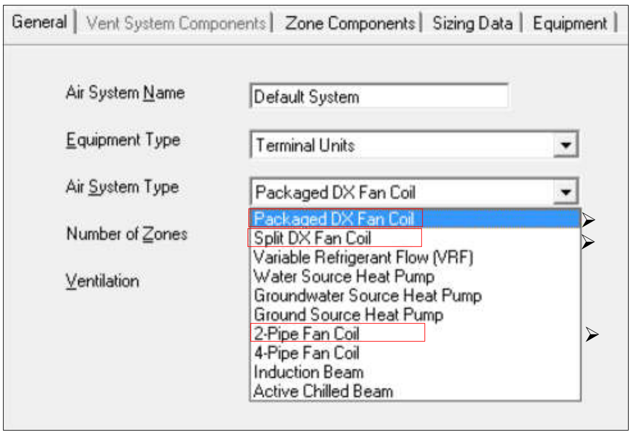
نوع أجهزة التكييف: ركز معايا هنا يقصد توصيف جهاز التكييف اللي مسؤول عن تبريد الهواء

- Undefined لو انت لسه لم تأخذ القرار نوع الجهاز أيه
- Packaged Rooftop وحدة باكدج تبريد المكثف بالهواء
- Packaged Vertical وحدة باكدج تبريد المكثف بالماء باستخدام برج تبريد
- Chilled AHU وحدة مناولة هواء مائع تبريد ملف التبريد ماء من الشيلر
- Split AHU وحدة مناولة هواء مائع تبريد ملف التبريد فريون من وحدة DX او VRF
- Terminal وحدات تكييف منفصلة زي جهاز تكييف الشباك والاسبلت و الكونسيلد والفان كويل يونت ... الخ

ملحوظة لازم تأخذ بالك منها كل أجهزة التكييف ما عدا Terminal Unit يتم عمل خلط بين الهواء الراجع والهواء النقي داخل جهاز التكييف باستخدام Mixing Box

لذلك في حالة وحدات Terminal Unit بيسألك انت عاوز نظام التهوية

- Direct Ventilation معناها ان نظام التهوية يدخل بشكل طبيعي من خلال فتحة شباك او باب او فتحة في الحيطة ولكن حركة الهواء تتم بشمل طبيعي
- Common Ventilation معناها ان نظام التهوية تتم باستخدام مصدر خارجي مثل مروحة فرش او عن طريق FAHU وحدة مناولة عادية خالص ولكن توتال فرش

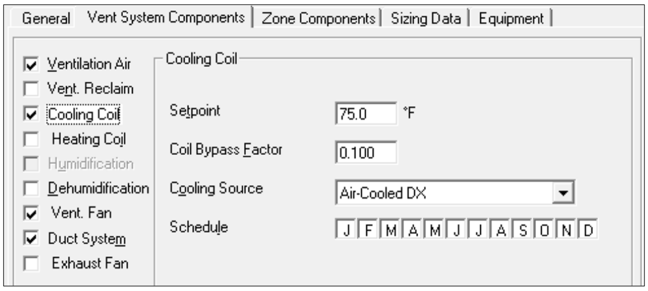


جهاز تكييف شباك

جهاز تكييف اسبلت

حائطي – سقفي – كاست - كونسيلد

جهاز تكييف فان كويل
بارد فقط
ومصدر التبريد ماء من الشيلر

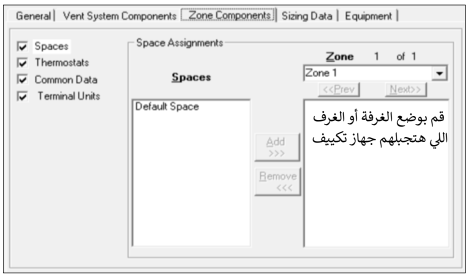


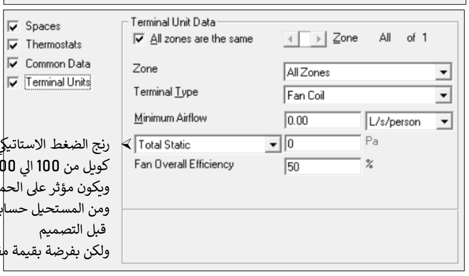
Vent System Components

لا تفعل الا في حالة كان مصدر الهواء الفرش Common Ventilation

في حالة كان مصدر الهواء الفرش من خلال وحدة مناولة هواء فتقوم بتفعيل Cooling Coil وضبط درجة حرارة هواء الارسال للهواء الفرش حوالي 24 درجة سليزية

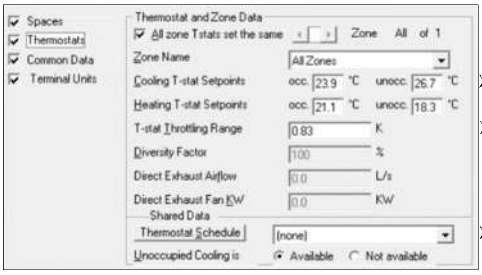
عند طباعة التقرير للنظام فلاحظ ان اول صفحة في التقرير تمثل حمل الهواء الفرش وليس حمل جهاز التكيف للغرفة – شوفت انا نبهت عليك اهو وبرضو مش هتاخد بالك





رنج الضغط الاستاتيكي الكلي لفان كويل من 100 الي 200 باسكال ويكون مؤثر على الحمل الحراري ومن المستحيل حسابه بدقة قبل التصميم ولكن بفرضه بقيمة مقبولة

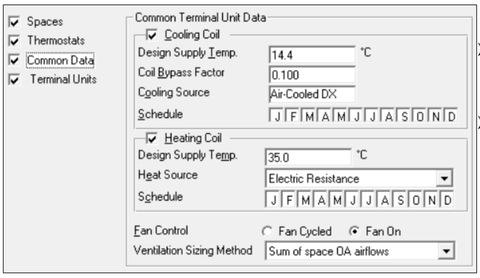
غير مؤثرة في حالة حساب الغرف العادية، ولكن مهمه في حالة الغرف العمليات والعناية... ويتم ضبطها على ACH



درجة حرارة الغرفة في حالة تواجد اشخاص

الفرق بين فصل الجهاز وتشغيله

جدول العمل من نوع Fan



درجة حرارة هواء الارسال وتكون في رنج 12:16 درجة لأجهزة Chilled

درجة حرارة هواء الارسال وتكون في رنج 10:12 درجة لأجهزة DX

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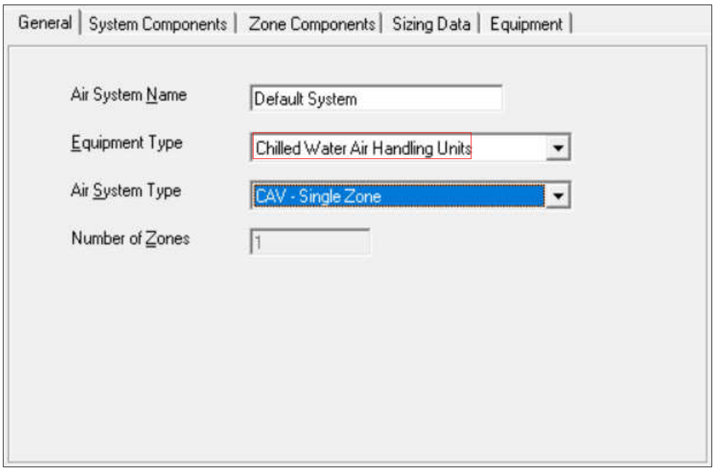
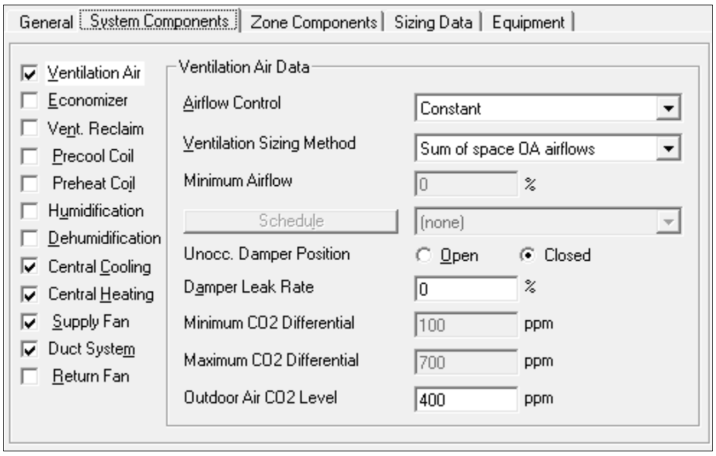
SYSTEM INPUT

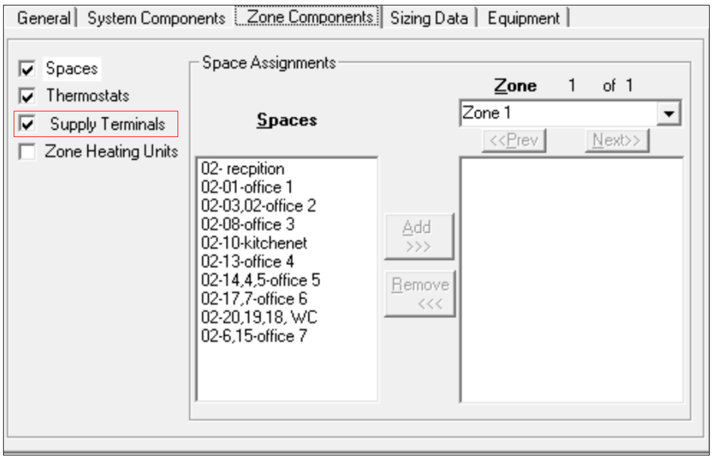


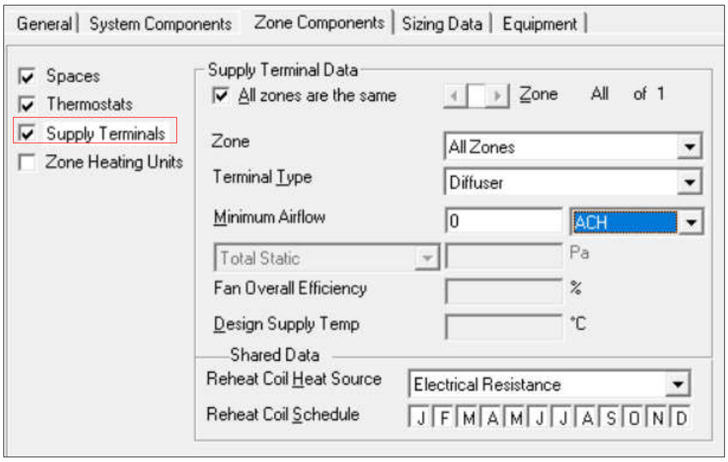
- عدد المناطق اللي جهاز التكييف شغال عليها

ملحوظة: في وحدات المناولة من الممكن ان يكون اكتر من زونة على نفس الجهاز فيه حالة كان Air System Type من النوع VAV وبالتالي يكون مروحة من النوع Variable لان عند دخول كل منطقة نركب VAV وطالما ركبنا VAV يبقي معها الثرموستات

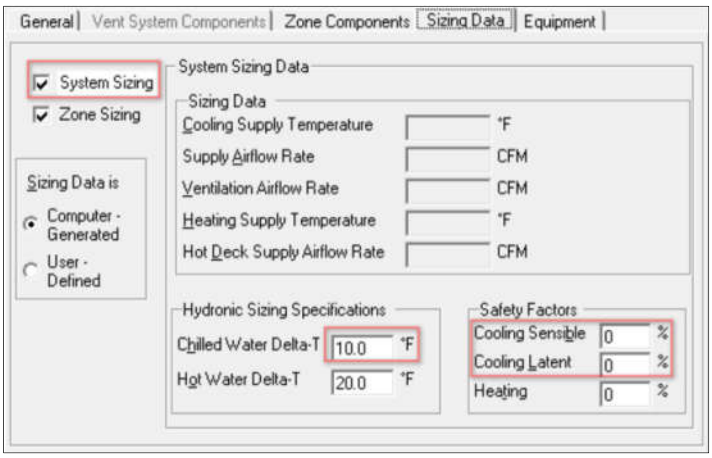


- Damper Leak – Heat Gain – Duct Loss = 2:5 %
- Central Cooling: 10:12 C – DX Type, 12:16 C – Chilled
- Supply Fan:
  - Total Static= 700:1000 Pa
  - من المستحيل حساب الضغط الاستاتيكي للمروحة الا بعد تصميم الداكت ولكن لازم تفرضها فرض منطقي علشان ليها تأثير على الحمل الحراري





- ركز علشان شرحنا الصورتين دول سابقا، ولكن مع نظام Terminalوكان فيه اختلاف في المسميات فقط، ولكن نفس الكونسبت
- Supply Terminal هنا تلاقي فيها Minimum Airflow في حالة غرف العمليات والعناية وخلافة بتدخل عدد مرات تغير الهواء من خلال Ashrae St-170 علشان البرنامج يقارن بين الحمل العادي والحمل الناتج من عدد مرات تغير الهواء



- Safety Factor: 5:10%

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Equipment Selection

➢ Selection of Chiller

- Chiller Type – Air or Water Cooled
- Performance Data – TR © Ambient Temperature
- Pressure Drop – Evaporator and Condenser

- Water Cooled
  - ✓ Leaving Temperature Evaporator – 5:7 °C
  - ✓ Entering Temperature Condenser – 30 °C

- Air Cooled
  - ✓ Leaving Temperature Evaporator – 5:7 °C
  - ✓ Ambient Temperature – 40:46 °C
- Brand
  - ✓ Trane
  - ✓ York
  - ✓ Carrier
  - ✓ Drek

➢ Selection of FCU

- CFM From HAP Report
- Entering Water Temperature Evaporator – 5:7 °C
- Entering Air Temperature Dry Bulb – 25: 30 °C
- Entering Air Temperature Wet Bulb – 17: 21 °C
- Select Total Load
- Pressure Drop Evaporator
- Pressure Dorp Fan
- Brand
  - ✓ Carrier
  - ✓ Volta
  - ✓ Saiver

➢ Selection of AHU

- CFM From HAP Report
- Entering Water Temperature Evaporator – 5:7 °C
- Entering Air Temperature Dry Bulb – 28:44 °C
- Entering Air Temperature Wet Bulb – 17: 21 °C
- Select Total Load
- Pressure Drop Evaporator
- Pressure Dorp Fan
- Brand
  - ✓ Carrier
  - ✓ Volta
  - ✓ Saiver

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Air Terminals

كل اللي انت عاوز مخرج هواء يطلع كمية الهواء اللي انت عازوها، ولكن عن سرعة مقبولة ومعامل ضوضاء مقبول ومسافة القذف مقبولة

- السرعة المقبولة: في حدود 500 الي 750 قدم للدقيقة طبقا للتطبيق ممكن تزيد او تقل، ولكن اغلب التطبيقات في الرنج الحالي.
- معامل الضوضاء: يتراوح من 25 الي 40، ولكن حسب التطبيق وموضح في بداية أغلب الكتالوجات
- مسافة القذف: تختلف حسب التوزيع للمخارج

لوقيمة Tتساوي 0.9 M تكون المسافة بين المخرجين 1.2 الي 1.4 متر، لوقيمة Tتساوي 1.2 M تكون المسافة بين المخرجين 1.5 الي 1.8 متر
لوقيمة Tتساوي 1.8 M تكون المسافة بين المخرجين 2.4 الي 2.7 متر، لوقيمة Tتساوي 2.1 M تكون المسافة بين المخرجين 3 الي 3.2 متر
لوقيمة Tتساوي 2.4 M تكون المسافة بين المخرجين 3.4 الي 3.6 متر، لوقيمة Tتساوي 2.7 M تكون المسافة بين المخرجين 3.8 الي 4 متر
لوقيمة Tتساوي 3 M بالتالي تكون المسافة بين المخرجين 4.2 الي 4.5 متر

Square – Round Diffuser

Air Flow	Outlet Velocity	ΔP	T_{50}	Neck Size Square	Outlet Velocity	ΔP	T_{50}	Neck Size Round
50 CFM	500 FPM	0.02 Inwg	3 Ft – 0.9 M	6 x 6"	300 FPM	0.02 Inwg	3 Ft – 0.9 M	φ6"
100 CFM	500 FPM	0.02 Inwg	4 Ft – 1.2 M	9 x 9"	500 FPM	0.04 Inwg	5 Ft – 1.5 M	φ6"
150 CFM	400 FPM	0.02 Inwg	5 Ft – 1.5 M	12 x 12"	400 FPM	0.03 Inwg	5 Ft – 1.5 M	Φ8"
	700 FPM	0.03 Inwg	5 Ft – 1.5 M	9 x 9"				
200 CFM	500 FPM	0.02 Inwg	5 Ft – 1.5 M	12 x 12"	600 FPM	0.06 Inwg	7 Ft – 2.1 M	Φ8"
250 CFM	600 FPM	0.02 Inwg	6 Ft – 1.8 M	12 x 12"	700 FPM	0.08 Inwg	7 Ft – 2.1 M	Φ8"
300 CFM	500 FPM	0.02 Inwg	6 Ft – 1.8 M	15 x 15"	600 FPM	0.06 Inwg	9 Ft – 2.7 M	Φ10"
350 CFM	550 FPM	0.02 Inwg	7 Ft – 2.1 M	15 x 15"	650 FPM	0.06 Inwg	9 Ft – 2.7 M	Φ10"
400 CFM	700 FPM	0.03 Inwg	9 Ft – 2.7 M	15 x 15"	700 FPM	0.06 Inwg	9 Ft – 2.7 M	Φ10"
	400 FPM	0.02 Inwg	7 Ft – 2.1 M	18 x 18"	500 FPM	0.04 Inwg	9 Ft – 2.7 M	Φ12"
450 CFM	500 FPM	0.02 Inwg	8 Ft – 2.4 M	18 x 18"	600 FPM	0.06 Inwg	10 Ft – 3 M	Φ12"
					400 FPM	0.03 Inwg	8 Ft – 2.4 M	Φ14"
500 CFM	600 FPM	0.02 Inwg	9 Ft – 2.7 M	18 x 18"	500 FPM	0.04 Inwg	10 Ft – 3 M	Φ14"
600 CFM	600 FPM	0.03 Inwg	10 Ft – 3 M	18 x 18"	600 FPM	0.06 Inwg	11 Ft – 3.3 M	Φ14"
					400 FPM	0.03 Inwg	10 Ft – 3 M	Φ16"

Linear Bar Grill

Width	Outlet Velocity	ΔP	T_{50}	CFM/M
4"	600:800 FPM	0.02:0.03 Inwg	16 Ft	250:300 CFM
6"	600:800 FPM	0.02:0.03 Inwg	20 Ft	400:550 CFM
8"	600:800 FPM	0.02:0.03 Inwg	22 Ft	475:625 CFM

Linear Slot Diffuser

Slot	Outlet Velocity	ΔP	T_{50}	CFM/M
2	600:1000 FPM	0.02:0.06 Inwg	11:15 Ft	100:150 CFM
3	600:1000 FPM	0.02:0.06 Inwg	12:18 Ft	150:200 CFM
4	600:1000 FPM	0.02:0.06 Inwg	13:22 Ft	150:300 CFM

Swirl Diffuser

Air Flow CFM	Outlet Velocity FPM	ΔP	T_{50} Ft	Neck Size
100 - 150	500 -700	0.04 - 0.07	6 - 7	6x6"- φ6"
200 - 250	600 -700	0.07 - 0.09	7 - 8	8x8"- φ8"
300 - 400	600 -700	0.14 - 0.15	10 - 11	10x10"- φ10"
450 - 550	600 -700	0.19 - 0.27	13 - 14	12x12"- φ12"

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Perforated Diffuser

Air Flow	Outlet Velocity	ΔP	Neck Size Round	Neck Size Square
50	300 FPM	0.01 Inwg	Ø4"	6 x 6"
100	300 FPM	0.01 Inwg	Ø6"	8 x 8"
150	300 FPM	0.01 Inwg	Ø6"	10 x 10"
200	300: 500 FPM	0.01: 0.05 Inwg	Ø8"	10 x 10"
250	300 FPM	0.01 Inwg	Ø10"	12 x 12"
300	300: 400 FPM	0.01: 0.03 Inwg	Ø10"	12 x 12"
350	300: 400 FPM	0.01: 0.03 Inwg	Ø10"	12 x 12"
400	300 FPM	0.01 Inwg	Ø12"	16 x 16"
450	300 FPM	0.01 Inwg	Ø12"	16 x 16"
500	300 FPM	0.01 Inwg	Ø12"	18 x 18"

Jet Diffuser

Air Flow	No. Jet	ΔP - INWG	T	L	Neck Size
500	2,3	0.1,0.04	30,20	35,30	Φ8"
	1	0.09	40	46	Φ10"
	1	0.04	37	42	Φ12"
600	2,3,4	0.13,0.06,0.04	38,30,26	44,35,30	Φ8"
	1,2	0.13,0.03	50,26	58,30	Φ10"
	1	0.06	47	54	Φ12"
700	2,3,4	0.18,0.09,0.05	40,35,29	46,40,33	Φ8"
	1,2	0.18,0.0	60,37	69,42	Φ10"
	1	0.08	50	58	Φ12"
	1	0.06	40	46	Φ14"
800	3,4	0.1,0.06	38,32	44,37	Φ8"
	1,2	0.24,0.06	60,37	69,42	Φ10"
	1	0.1	57	65	Φ12"
	1	0.08	47	54	Φ14"
900	3,4	0.13,0.08	40,35	46,40	Φ8"
	2	0.08	40	46	Φ10"
	1	0.13	60	69	Φ12"
	1	0.1	50	58	Φ14"
1000	3,4	0.16,0.1	48,37	55,43	Φ8"
	2,3	0.09,0.04	47,33	54,38	Φ10"
	1,2	0.16,0.04	70,40	80,46	Φ12"
	1	0.12	57	65	Φ14"
1200	3,4	0.24,0.13	50,42	58,48	Φ8"
	2,3	0.13,0.06	52,40	60,46	Φ10"
	1,2	0.23,0.06	80,47	92,54	Φ12"
	1	0.18	67	77	Φ14"

Eyeball

	50 FPM			100 FPM			200 FPM		
	30'	60'	100'	30'	60'	100'	30'	60'	100'
Φ6"	75	175	250	175	350	500	350		
Φ8"	100	225	300	225	450	650	450	875	
Φ10"	150	275	400	275	550	825	550	1100	
Φ12"	175	350	550	350	700	1050	700	1400	2100
Φ16"	250	475	700	475	925	1400	925	1850	2800

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Duct Design

➢ Duct Design

- **Duct Size**

  - ✓ Width, Height – Aspect Ratio (1:4)
  - ✓ CFM
  - ✓ Pressure Drop (0.06: 0.15 Inwg)
  - ✓ Velocity
    - FCU (800: 900 FPM)
    - AHU (1200: 1500 FPM)
    - Exhaust Fan (1600: 2000 FPM)
    - Fresh Fan (1400: 1800 FPM)

- **External Static Pressure**

  - ✓ The hardest path, not the longest ,it is often the longest.
  - ✓ ESP = Critical Path x $\frac{\Delta P}{L}$ + Fitting Losses + Accessories Losses
    - Reducer – 1: 3 Pa
    - Take off – 10:20 Pa
    - Elbow – 1: 8 Pa
    - Volume Damper – 5 Pa
    - Machine Connection – 15 Pa
    - Air Terminal – 2:8 Pa
    - Insect Screen – 10 Pa
    - Sand trap – 100 Pa
    - Flexible Duct – 10 Pa

- **Duct Thickness, according to – Max Width, ESP**

Gauge	Thickness	Max Width
26	0.55 mm	Up to 12”
24	0.7 mm	13 to 30”
22	0.85 mm	31 to 54”
20	1 mm	55 to 84”
18	1.25 mm	85” to Over

- **Duct Hanger**

Distance Between Hangers (m)	Angle Dimension (mm)	Rod Diameter (mm)	Max Width (Inch)
3	25x25x2	8	Up to 20
2.5	35x35x2.5	10	21 to 32
2.5	35x35x3	10	33 to 40
2	40x40x3	12	41 to 60
1.5	50x50x5	12	61 to Over

- **Duct Mass**
  - ✓ M= 2(W+H) L*T*ρ W, H, L, T – (m), ρ – ($\frac{Kg}{m^3}$)
  - ✓ M= 0.4(W+H) L*T W, H – (Inch), L – (m), T – (mm)

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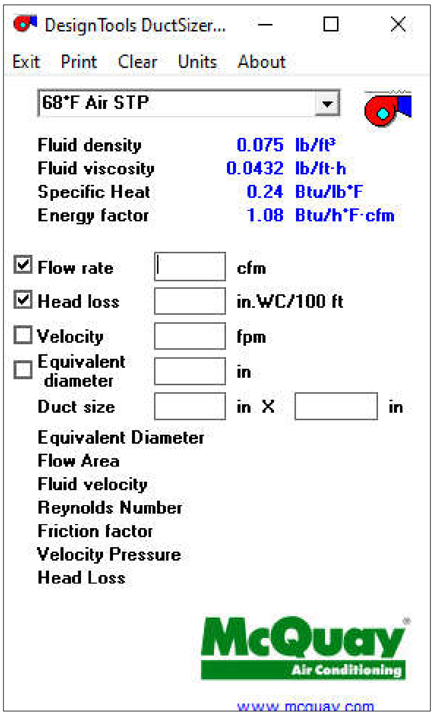
- Duct Insulation
  - ✓ Area= 2(W+H) L — W, H, L – (m)
  - ✓ Area= 0.5(W+H) L — W, H – (Inch), L – (m)

- Duct Cladding
  - ✓ Area= 2(W'+H') L
    - W'=W+2*Insulation Thickness
    - H'=H+2* Insulation Thickness

    W, H, L – (m)
  - ✓ Area= 0.5(W'+H') L
    - W'=W+2*Insulation Thickness
    - H'=H+2* Insulation Thickness

    W, H – (Inch), L – (m)



➢ Duct Types
- Rectangle
- Round
- Ovel

➢ Duct Material
- Galvanized
- Stainless Steel
- Black Steel
- Aluminum
- Fabric - Microbe-X, Sedona-Mx
- PID – Duct

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Pipe Design

➢ Pipe Design

- Pipe Size

  ✓ $\text{GPM} = \frac{\text{TR}\times 24}{\Delta T}$
  ✓ Pressure Drop (Max 10ft/100ft) – (Ideal 4ft/100ft)
  ✓ Velocity (Range 2:10 FPS) – (Ideal 4 FPS)

Flow Rang (GPM)		Pipe Size (Inch)	Pressure Drop (Ft/100Ft)
From	To		
0	2	½	0 – 4
3	4	¾	2.5 – 4
5	7	1	2 – 4
8	16	1.25	1.25 – 4
17	24	1.5	2 – 4
25	48	2	1.5 – 4
49	77	2.5	2 – 4
78	140	3	1.5 – 4
141	280	4	1.25 – 4
281	500	5	1.5 – 4
501	800	6	1.25 – 4
801	1700	8	1 – 4
1701	2500	10	1.25 – 2.75

Table 23.4.3.1.1 Equivalent Schedule 40 Steel Pipe Length Chart

	Fittings and Valves Expressed in Equivalent Feet (Meters) of Pipe														
	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.	3½ in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.
Fittings and Valves	(15 mm)	(20 mm)	(25 mm)	(32 mm)	(40 mm)	(50 mm)	(65 mm)	(80 mm)	(90 mm)	(100 mm)	(125 mm)	(150 mm)	(200 mm)	(250 mm)	(300 mm)
45° elbow	—	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	3 (0.9)	3 (0.9)	4 (1.2)	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.4)	13 (4)
90° standard elbow	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	7 (2.1)	8 (2.4)	10 (3)	12 (3.7)	14 (4.3)	18 (5.5)	22 (6.7)	27 (8.2)
90° long-turn elbow	0.5 (0.2)	1 (0.3)	2 (0.6)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	5 (1.5)	6 (1.8)	8 (2.4)	9 (2.7)	13 (4)	16 (4.9)	18 (5.5)
Tee or cross (flow turned 90°)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	8 (2.4)	10 (3)	12 (3.7)	15 (4.6)	17 (5.2)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	50 (15.2)	60 (18.3)
Butterfly valve	—	—	—	—	—	6 (1.8)	7 (2.1)	10 (3)	—	12 (3.7)	9 (2.7)	10 (3)	12 (3.7)	19 (5.8)	21 (6.4)
Gate valve	—	—	—	—	—	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Swing check*	—	—	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.4)	14 (4.3)	16 (4.9)	19 (5.8)	22 (6.7)	27 (8.2)	32 (9.3)	45 (13.7)	55 (16.8)	65 (20)

- Pump Head
  ✓ The hardest path, not the longest ,it is often the longest.
  ✓ $H_P = H_s + H_R + H_F$ $H_s = \text{Zero}\,, H_R = \text{Zero}$

$H_P =$ Critical Path x $\frac{4ft}{100ft}$ + Equivalent lengths of fitting x $\frac{4ft}{100ft}$ + Cooling Coil Pressure Losses (AHU, FCU, Chiller)

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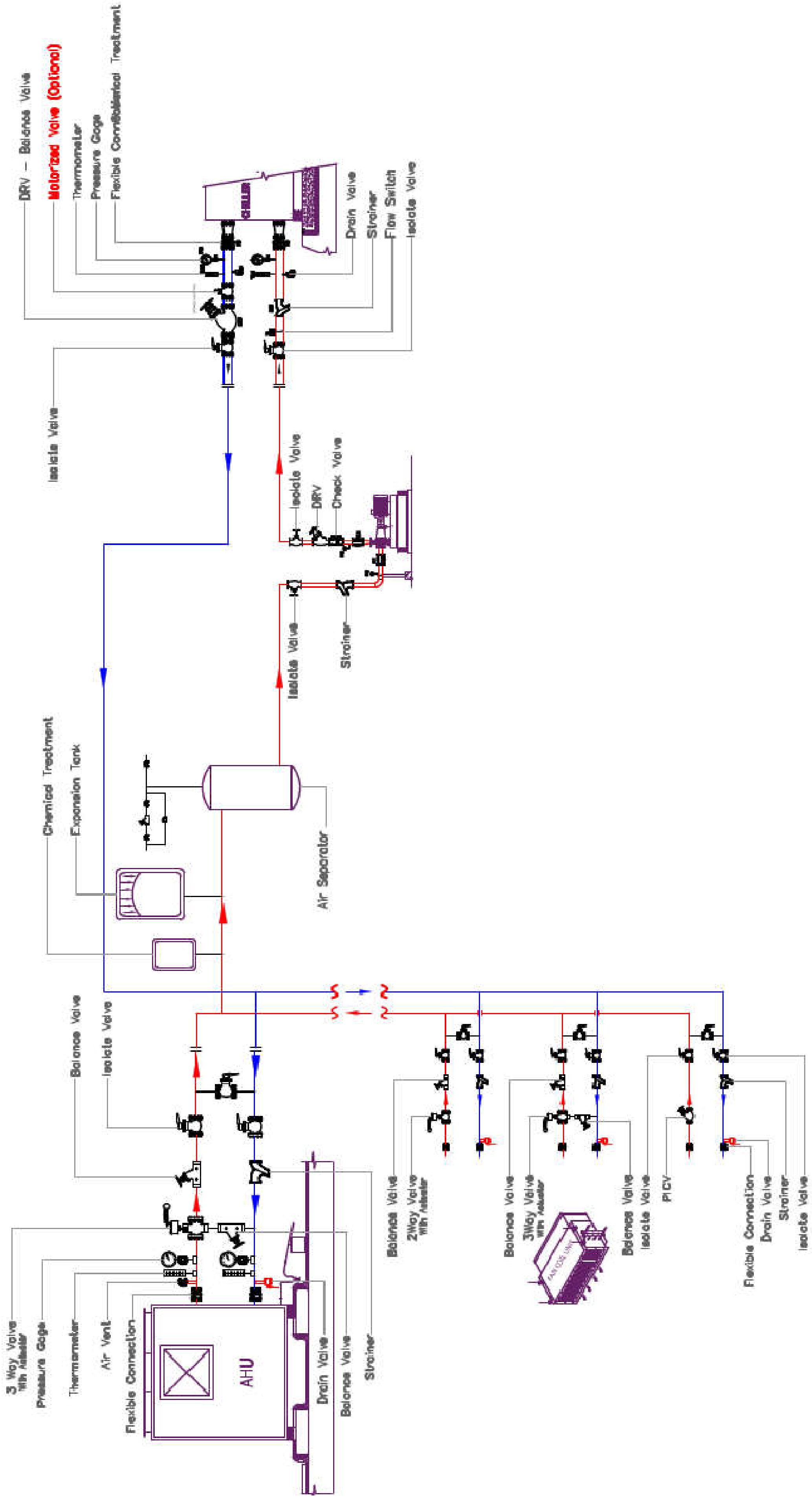
➢ Hook Up



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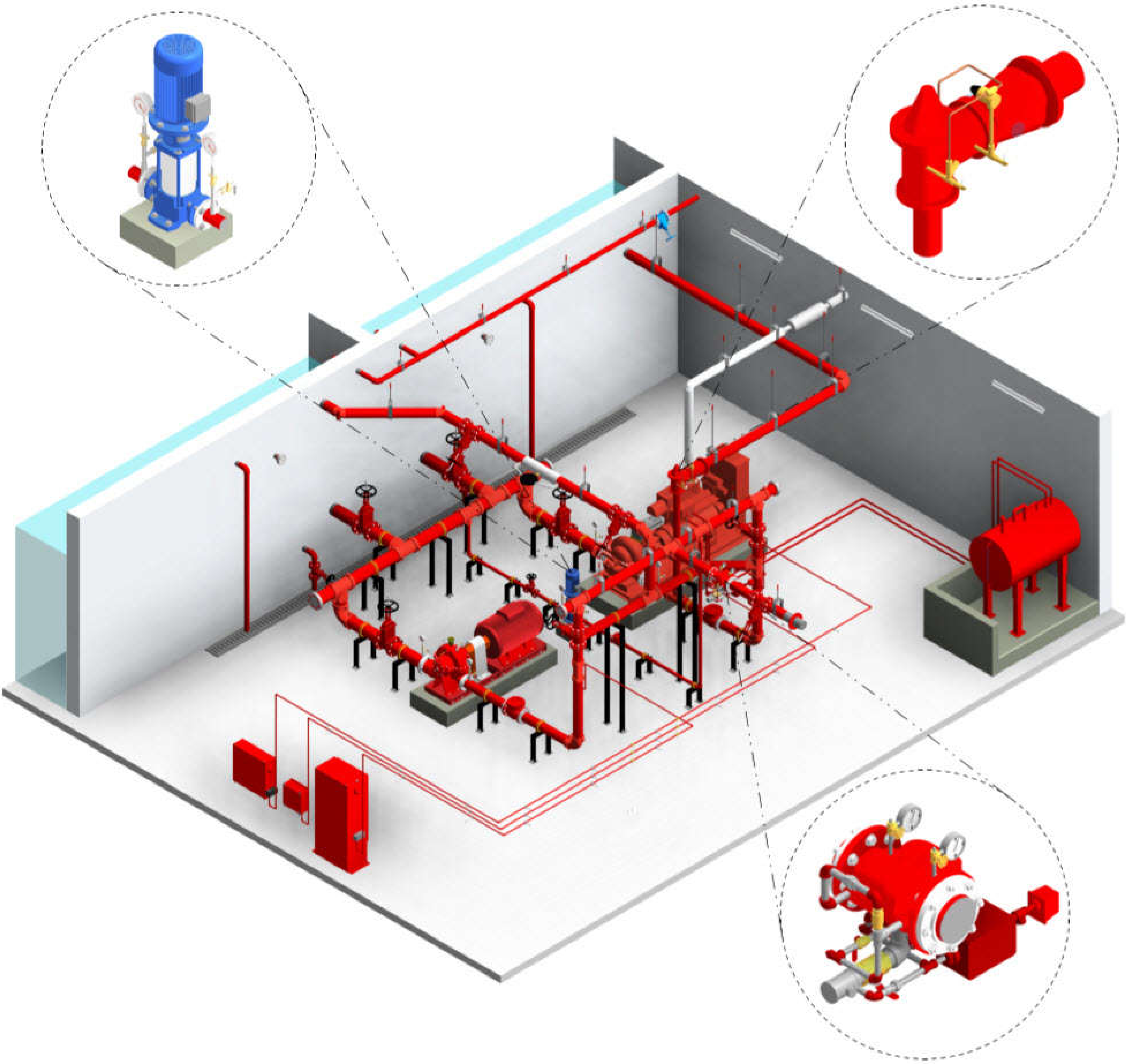
FIREFIGHTING NOTES



The Main Firefighting Systems

- Water system
  - Manual
    - Hose Cabinet
    - Fire Hydrant
    - Fire Extinguishers
  - Automatic
    - Sprinkler System
    - Spray System
    - Water Mist System
- Gas system
  - Manual
    - Fire Extinguishers
  - Automatic
    - Co_2 Network
    - FM200 Network
    - Novec 1230
    - Aerosol
- Foam system
  - Manual
    - Fire Extinguishers
  - Automatic
    - Foam Network

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Pipe In Firefighting

- Pipe Types
  - Seamless Black steel شبكة المياه الرطبة والجافة تكون مضغوطة نيتروجين
  - ERW
  - CPVC
  - HDPE شبكة المياه المدفونة
  - Galvanized شبكة الصرف او نظام الرشاشات الجافة
  - Copper
  - UPVC شبكة الصرف

  Bending pipe
    - All pipe (R=12D) and (D) is the pipe diameter
    - In black steel (D = 2" ↓ → R = 6D)
    - In black steel (D = 2.5" ↑ → R = 5D)
- Hanger

Table 9.2.2.1(b) Maximum Distance Between Hangers (m)

	Nominal Pipe Size (mm)											
	20	25	32	40	50	65	80	90	100	125	150	200
Steel pipe except threaded lightwall	NA	3.7	3.7	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Threaded lightwall steel pipe	NA	3.7	3.7	3.7	3.7	3.7	3.7	NA	NA	NA	NA	NA
Copper tube	2.4	2.4	3.0	3.0	3.7	3.7	3.7	4.6	4.6	4.6	4.6	4.6
CPVC	1.7	1.8	2.0	2.1	2.4	2.7	3.0	NA	NA	NA	NA	NA
Ductile-iron pipe	NA	NA	NA	NA	NA	NA	4.6	NA	4.6	NA	4.6	4.6

Table 9.1.2.1 Hanger Rod Sizes

Pipe Size		Diameter of Rod	
in.	mm	in.	mm
Up to and including 4	100	⅜	10
5 6 8	125 150 200	½	12
10 12	250 300	⅝	16

Table 9.1.4.5.1 Minimum Bolt or Rod Size for Steel

Pipe Size		Size of Bolt or Rod	
in.	mm	in.	mm
Up to and including 4	100	⅜	10
5 6 8	125 150 200	½	12
10	250	⅝	15
12	300	¾	20

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Nominal Diameter of Pipe Being Supported – Schedule 40 Steel												
Span (ft)	1	1.25	1.5	2	2.5	3	3.5	4	5	6	8	10
1.5	0.08	0.09	0.09	0.1	0.11	0.12	0.14	0.15	0.18	0.22	0.30	0.41
2.0	0.11	0.11	0.12	0.13	0.15	0.16	0.18	0.20	0.24	0.29	0.40	0.55
2.5	0.14	0.14	0.15	0.16	0.17	0.18	0.20	0.21	0.25	0.30	0.43	0.56
3.0	0.16	0.17	0.18	0.20	0.22	0.25	0.27	0.30	0.36	0.43	0.60	0.82
3.5	0.19	0.20	0.21	0.23	0.26	0.29	0.32	0.35	0.42	0.51	0.70	0.96
4.0	0.22	0.23	0.24	0.26	0.29	0.33	0.36	0.40	0.48	0.58	0.80	1.10
4.5	0.25	0.26	0.27	0.29	0.33	0.37	0.41	0.45	0.54	0.65	0.90	1.23
5.0	0.27	0.29	0.30	0.33	0.37	0.41	0.45	0.49	0.60	0.72	1.00	1.37
5.5	0.30	0.31	0.33	0.36	0.40	0.45	0.50	0.54	0.66	0.79	1.10	1.51
6.0	0.33	0.34	0.36	0.39	0.44	0.49	0.54	0.59	0.72	0.87	1.20	1.64
6.5	0.36	0.37	0.40	0.42	0.48	0.54	0.59	0.64	0.78	0.94	1.31	1.78
7.0	0.38	0.40	0.43	0.46	0.52	0.58	0.63	0.69	0.84	1.01	1.41	1.92
7.5	0.41	0.43	0.46	0.49	0.55	0.62	0.68	0.74	0.90	1.08	1.51	2.06
8.0	0.44	0.46	0.49	0.52	0.59	0.66	0.72	0.79	0.96	1.16	1.61	2.19
8.5	0.47	0.48	0.52	0.56	0.63	0.70	0.77	0.84	1.02	1.23	1.71	2.33
9.0	0.49	0.51	0.55	0.59	0.66	0.74	0.81	0.89	1.08	1.30	1.81	2.47
9.5	0.52	0.54	0.58	0.62	0.70	0.78	0.86	0.94	1.14	1.37	1.91	2.60
10.0	0.55	0.57	0.61	0.65	0.74	0.82	0.90	0.99	1.20	1.45	2.01	2.74
10.5	0.58	0.60	0.64	0.69	0.77	0.86	0.95	1.04	1.26	1.52	2.11	2.88
11.0	0.60	0.63	0.67	0.72	0.81	0.91	0.99	1.09	1.32	1.59	2.21	3.01
11.5	0.63	0.66	0.70	0.75	0.85	0.95	1.04	1.14	1.38	1.66	2.31	3.15
12.0	0.66	0.68	0.73	0.78	0.88	0.99	1.08	1.19	1.44	1.73	2.41	3.29
12.5	0.69	0.71	0.76	0.82	0.92	1.03	1.13	1.24	1.5	1.81	2.51	3.43
13.0	0.71	0.74	0.79	0.85	0.96	1.07	1.17	1.29	1.56	1.88	2.61	3.56
13.5	0.74	0.77	0.82	0.88	0.99	1.11	1.22	1.34	1.62	1.95	2.71	3.70
14.0	0.77	0.80	0.85	0.91	1.03	1.15	1.26	1.39	1.68	2.02	2.81	3.84
14.5	0.80	0.83	0.88	0.95	1.07	1.19	1.31	1.43	1.74	2.1	2.91	3.97
15.0	0.82	0.86	0.91	0.98	1.10	1.24	1.35	1.48	1.8	2.17	3.01	4.11
15.5	0.85	0.88	0.94	1.01	1.14	1.28	1.4	1.53	1.86	2.24	3.11	4.25
16.0	0.88	0.91	0.97	1.05	1.18	1.32	1.44	1.58	1.92	2.31	3.21	4.39

- 1.5 m – Distance between two Hanger
- Ɵ 10" – Diam Rod
- Modules = 0.37
- Trapeze Hanger
    - 2.5"x2.5"x0.25"
    - 2"

Table 9.1.1.7.1(b) Available Section Modulus of Common Trapeze Hangers (in.^{3})

Pipe		Modulus (in.^{3})	Angles (in.)	Modulus (in.^{3})
in.	mm			
Schedule 10				
1	25	0.12	1½ × 1½ × 3/16	0.10
1¼	32	0.19	2 × 2 × ⅛	0.13
1½	40	0.26	2 × 1½ × 3/16	0.18
2	50	0.42	2 × 2 × 3/16	0.19
2½	65	0.69	2 × 2 × ¼	0.25
3	80	1.04	2½ × 1½ × 3/16	0.28
3½	90	1.38	2½ × 2 × 3/16	0.29
4	100	1.76	2 × 2 × 5/16	0.30
5	125	3.03	2½ × 2½ × 3/16	0.30
6	150	4.35	2 × 2 × ⅜	0.35
			2½ × 2½ × ¼	0.39
			3 × 2 × 3/16	0.41
Schedule 40				
1	25	0.13	3 × 2½ × 3/16	0.43
1¼	32	0.23	3 × 3 × 3/16	0.44
1½	40	0.33	2½ × 2½ × 5/16	0.48
2	50	0.56	3 × 2 × ¼	0.54
2½	65	1.06	2½ × 2 × ⅜	0.55
3	80	1.72	2½ × 2½ × ⅜	0.57
3½	90	2.39	3 × 3 × ¼	0.58
4	100	3.21	3 × 3 × 5/16	0.71
5	125	5.45	2½ × 2½ × ½	0.72
6	150	8.50	3½ × 2½ × ¼	0.75
			3 × 2½ × ⅜	0.81
			3 × 3 × ⅜	0.83
			3½ × 2½ × 5/16	0.93
			3 × 3 × 7/16	0.95
			4 × 4 × ¼	1.05
			3 × 3 × ½	1.07
			4 × 3 × 5/16	1.23
			4 × 4 × 5/16	1.29
			4 × 3 × ⅜	1.46
			4 ×4 × ⅜	1.52
			5 × 3½ × 5/16	1.94
			4 × 4 × ½	1.97
			4 × 4 × ⅝	2.40
			4 × 4 × ¾	2.81
			6 × 4 × ⅜	3.32
			6 × 4 × ½	4.33
			6 × 4 × ¾	6.25
			6 × 6 × 1	8.57

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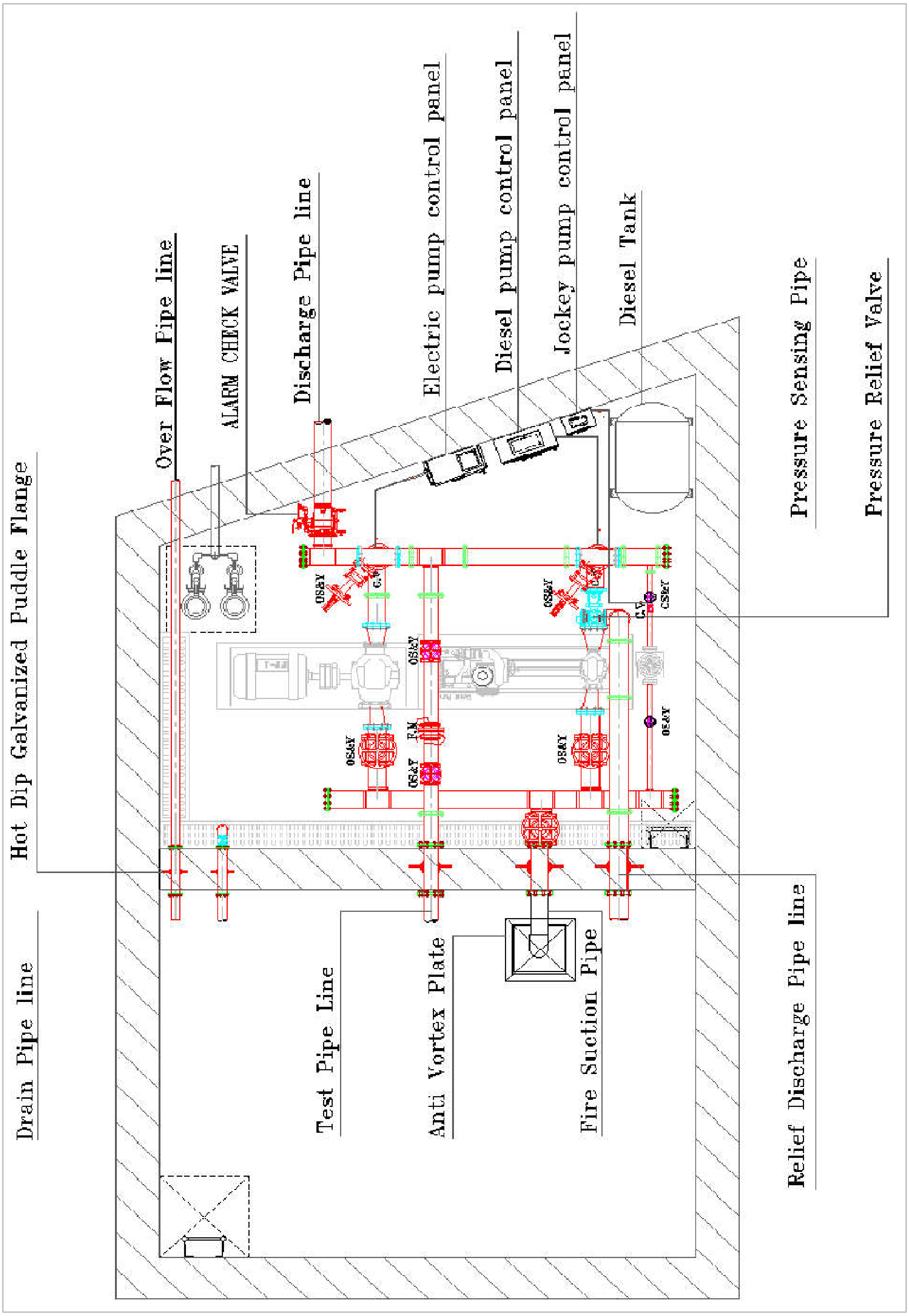
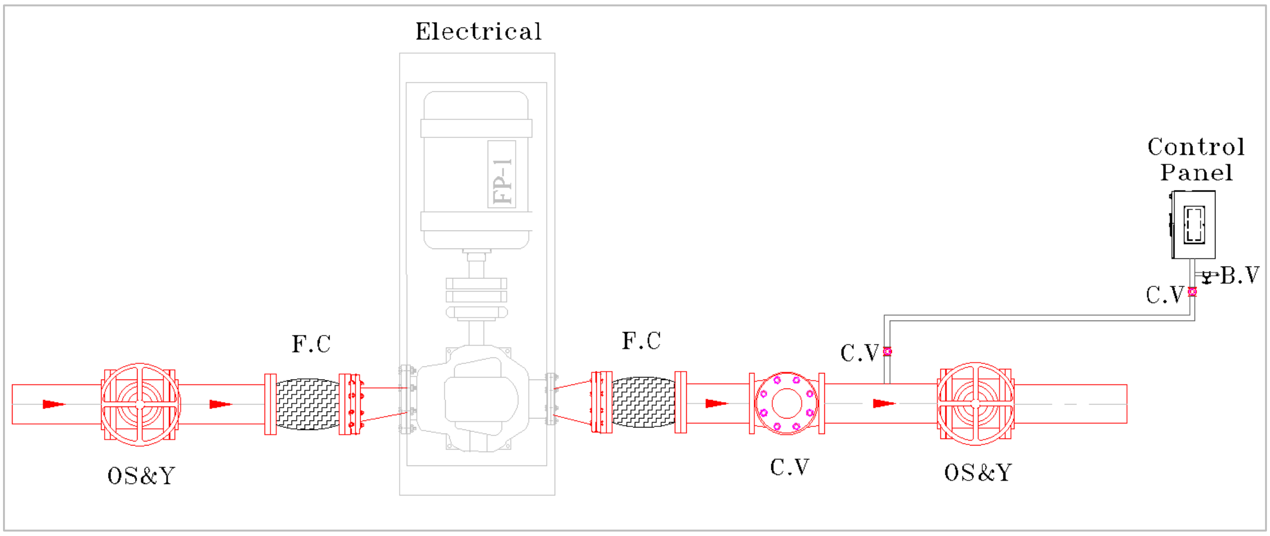
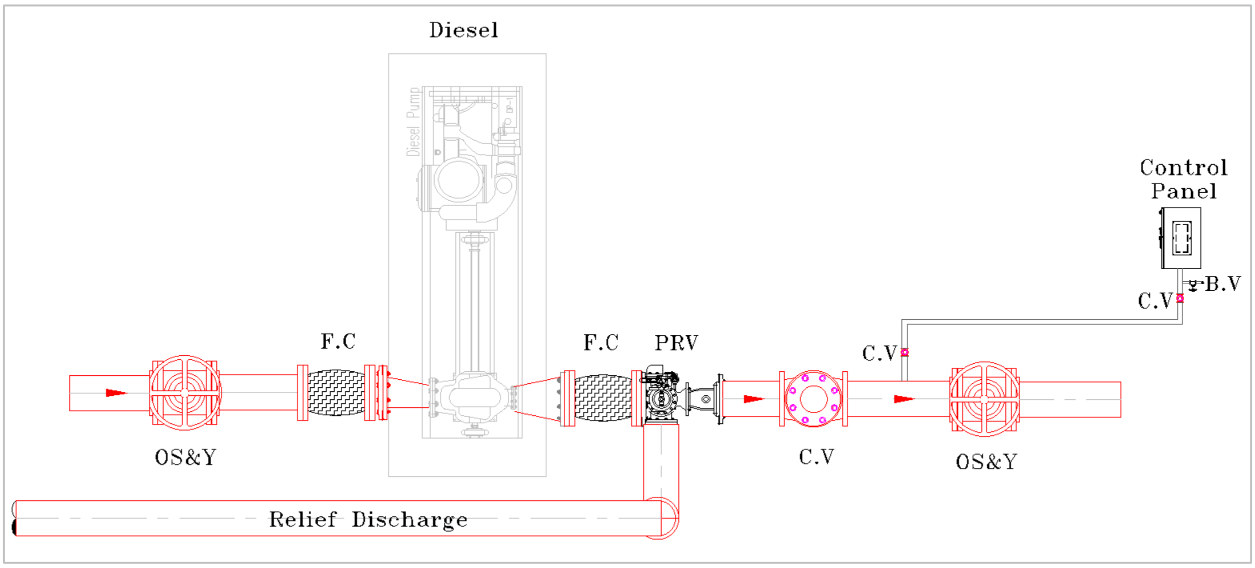
Pump Room



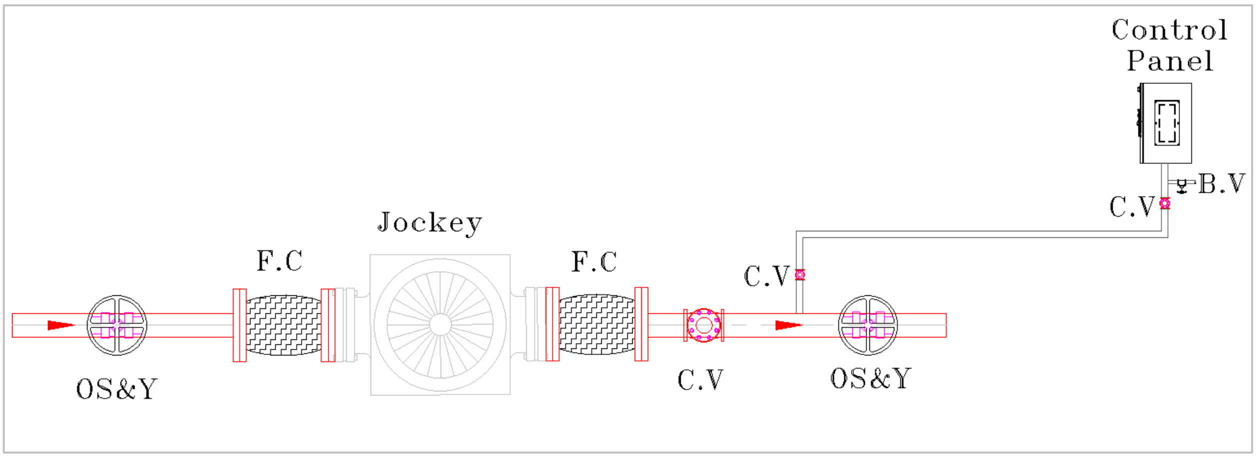
- ## Electrical Pump



- ## Diesel Pump



- ## Jockey Pump



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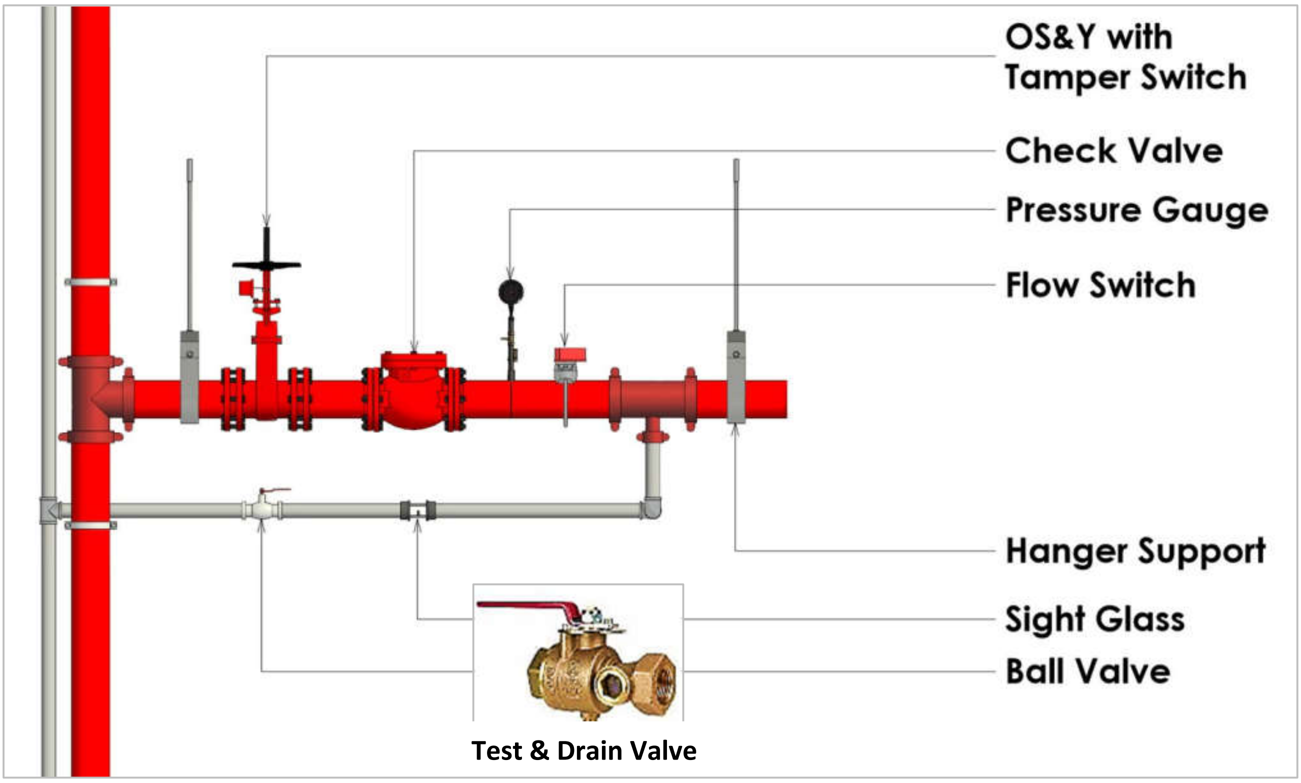
Zone Control Station



- <u>Siamese Connection</u>

  - Min Size 2.5", 250 GPM.
  - Shall not be less than 18 " or more than 48 " above grade.

- <u>Fire Extinguishers</u>

  - Dry Powder, Wet Chemical, Co_2
  - Lowest height from the ground = 10 cm
  - The maximum height if the extinguisher weight is 18 Kg or less = 1.53 m
  - The maximum height if the extinguisher weight is more than 18 Kg= 1.07 m

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- **Hose Cabinet**

  - Class1

    - Hose Rack
    - 2.5"
    - 250 GPM
    - Min Pressure 6.9 Bar
    - Max Pressure 12.1 Bar
    - Reinforced Cloth

  - Class2

    - Hose Reel
    - 1" :1.5"
    - 100 GPM
    - Min Pressure 4.5 Bar
    - Max Pressure 6.9 Bar
    - Rubber

  - Class3

    - Min Pressure 6.9 Bar
    - Max Pressure 6.9 Bar
    - 100 GPM,250 GPM
    - 1.5" ,2.5"
    - Reinforced Cloth
    - Rubber

- **Travel Distance**

  - 39.7 m for Non SPK for 2.5 "
  - 61 m for SPK for 2.5 "
  - 39.7 m for SPK 1.5 "
  - 36.6 m for SPK 1 "

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- Pressure Relief Valve -PRV

  - Total Pressure = C * P-Shut Off + P-Static
  - If total pressure ≤ 12.1 (not required PRV)
  - If total pressure > 12.1 (required PRV)

  Where:

  - P-Static →location of pump and tank غالبا يوضع بصفر الا في حالة لوكان منسوب التانك مختلف مع المضخة
  - C→ constant (in case governor =1) (in case no governor =1.21)

- Pressure Reducing Valve -PRV
  - يتم تركيبة قبل دخل الزون او الصناديق او أي مكون في الشبكة في حالة كان ضغط الشبكة اعلي من 12.1 بار

- Firefighting Tank
  - Capacity Tank = GPM (According Calc.) x Time (30 :90 According Hazard)

Table 5.7.4 Minimum Size of Drain Pipe

Tank Capacity		Nominal Pipe Diameter	
L	gal	mm	in.
1900 to 2850	500 to 750	75	3
2851 to 3800	751 to 1000	100	4
3801 to 9500	1001 to 2500	125	5
9501 to 15,000	2501 to 4000	150	6
>15,000	>4000	200	8

Table 13.5.13.5(B) Size of Overflow Pipes

Liquid Surface Area		Overflow Pipe Diameter, Minimum	
ft²	m²	in.	mm
<75	<7	3	75
75 to 150	7 to 14	4	100
150 to 225	14 to 21	5	125
225 to 325	21 to 30	6	150

Table 13.2.3.4 Required Vent Diameter

Tank Capacity		Vent Diameter	
L	gal	mm	in.
Up to 1040	Up to 275	38	1½
1040 to 2500	275 to 660	51	2
2501 to 3410	661 to 900	64	2½
3411 to 4165	901 to 1100	76	3

Table 8.16.2.4.2 Drain Size

Riser or Main Size [in. (mm)]	Size of Drain Connection [in. (mm)]
Up to 2 (50)	¾(20) or larger
2½(65), 3 (80), 3½(90)	1¼(32) or larger
4 (100) and larger	2 (50) or larger

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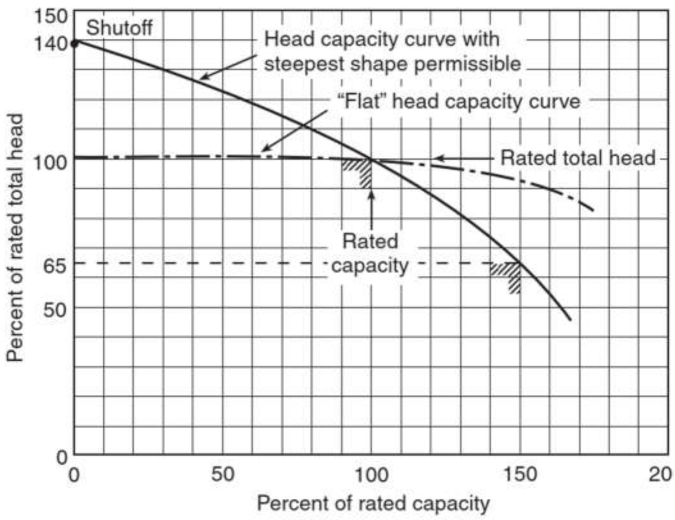
Table 4.27(a) Summary of Centrifugal Fire Pump Data (U.S. Customary)

Pump Rating (gpm)	Minimum Pipe Sizes (Nominal) (in.)						
	Suction[a,b,c]	Discharge[a]	Relief Valve	Relief Valve Discharge	Meter Device	Number and Size of Hose Valves	Hose Header Supply
25	1	1	¾	1	1¼	1 — 1½	1
50	1½	1¼	1¼	1½	2	1 — 1½	1½
100	2	2	1½	2	2½	1 — 2½	2½
150	2½	2½	2	2½	3	1 — 2½	2½
200	3	3	2	2½	3	1 — 2½	2½
250	3½	3	2	2½	3½	1 — 2½	3
300	4	4	2½	3½	3½	1 — 2½	3
400	4	4	3	5	4	2 — 2½	4
450	5	5	3	5	4	2 — 2½	4
500	5	5	3	5	5	2 — 2½	4
750	6	6	4	6	5	3 — 2½	6
1000	8	6	4	8	6	4 — 2½	6
1250	8	8	6	8	6	6 — 2½	8
1500	8	8	6	8	8	6 — 2½	8
2000	10	10	6	10	8	6 — 2½	8
2500	10	10	6	10	8	8 — 2½	10
3000	12	12	8	12	8	12 — 2½	10
3500	12	12	8	12	10	12 — 2½	12
4000	14	12	8	14	10	16 — 2½	12
4500	16	14	8	14	10	16 — 2½	12
5000	16	14	8	14	10	20 — 2½	12

7.3.4.2 The suction strainer shall have a free area of at least four times the area of the suction connections, and the openings shall be sized to restrict the passage of a 0.5 in. (12.7 mm) sphere.

8.5.5* Suction Strainer.

8.5.5.1 Pumps shall be equipped with a removable and cleanable suction strainer installed at least 10 pipe diameters from the pump suction inlet.



الشروط الواجب توافرها في مضخات الحريق: -

- ان تعطى ال Q، H المرادان.
- يجب عند اختيارها لابد ان تكون في الجزء الأوسط للمنحنى لتعطى اكبر كفاءه.
- عند زياده ال Qبمقدار 150 % ان لا يقل ال Hعن 65 % من قيمته الأصلية.
- Shut down pressureلا يزيد عن 140 %
- ان تكون المضخة خضعت للاختبار

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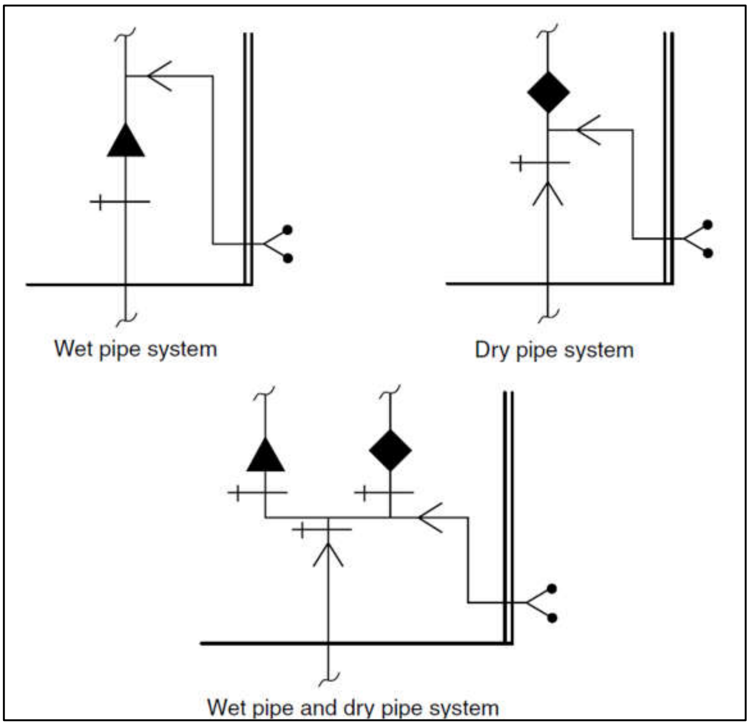
➢ Hazard Classifications

- Light Hazard
- Ordinary Hazard (Group 1)
- Ordinary Hazard (Group 2)
- Extra Hazard (Group 1) (Eh1)
- Extra Hazard (Group 2) (Eh2)

➢ Fire Sprinkler System Types - Alarm Check Valve

- Wet System
- Dry System
- Preaction System
  - Single Interlock – حساس فقط
  - Double Interlock – حساس ورشاش
  - Non-Interlock – حساس او رشاش
- Deluge System

مكان تركيب وصلة الدفاع المدني بالنسبة ل ACV



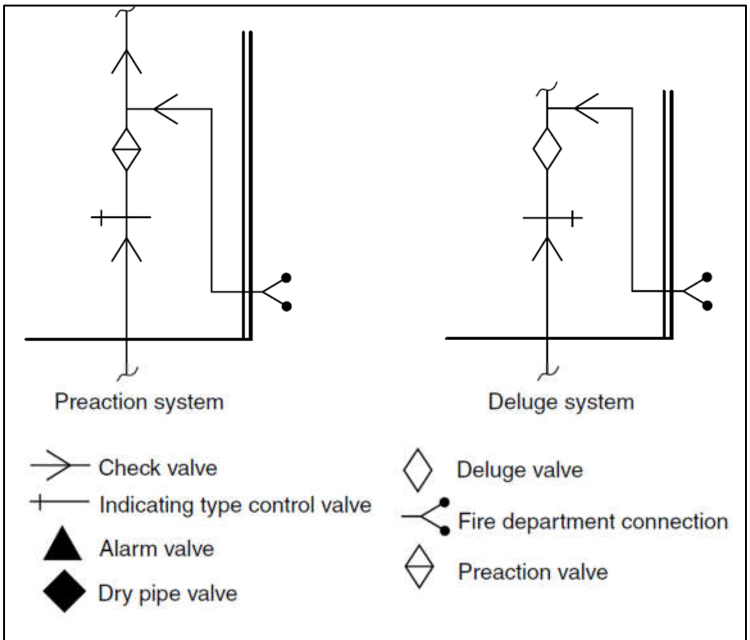


FIGURE A.8.16.1.1 Examples of Acceptable Valve Arrangements.

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الاعتبارات التصميمية للرشاشات

Pendent and Upright

Type	Hazard	Max Area	Max Spacing	Min Spacing	Max Wall	Min Wall
Standard	Light	18 m²	4.6 m	1.8 m	2.3 m	10 cm
	Ordinary	12 m²	4.6 m		2.3 m	
	Extra	8.4 m²	3.7 m		1.85 m	
Extended	Light	37 m²	6.1 m	2.4 m	3 m	
	Ordinary	37 m²	6.1 m		3 m	
	Extra	18.2 m²	4.3 m		2.1 m	
CMSA	غير قابل / راكات	12.1 m²	3.7 m	1.8 m	1.85 m	
	قابل بدون عوارض	12.1 m²	3.7 m	1.8 m	1.85 m	
	قابل بعوارض / راكات	9.3 m²	3 m	1.8 m	1.5 m	
ESFR	Up to 9.1 m	9.3 m²	3.7 m	1.8 m	1.85 m	
	Over 9.1 m	9.3 m²	3 m	1.8 m	1.5 m	

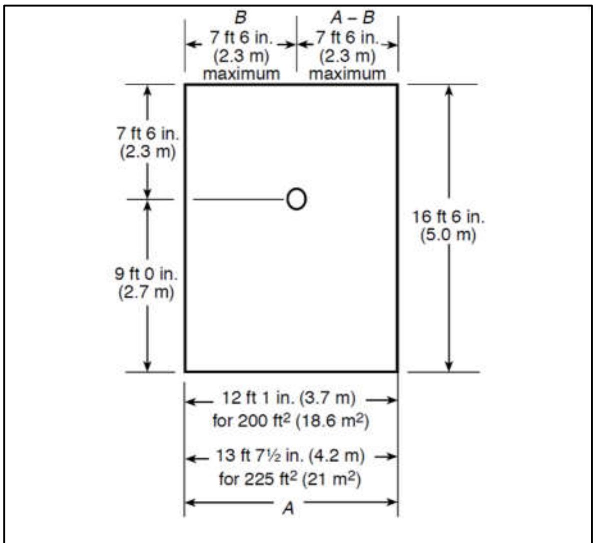


FIGURE A.8.6.3.2.4(a) Small Room Provision — One Sprinkler.

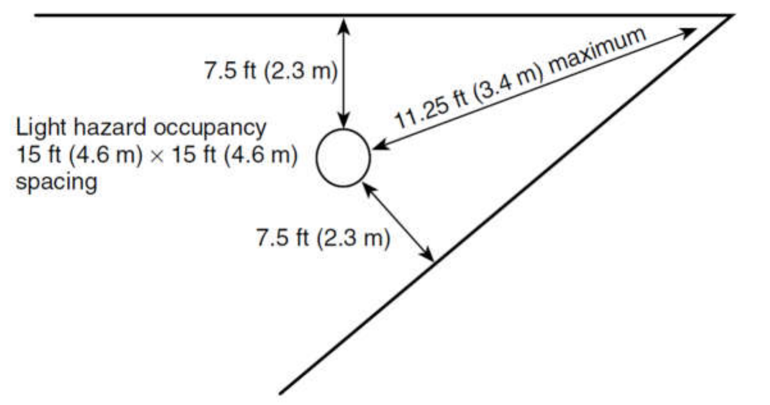


FIGURE A.8.6.3.2.3 Maximum Distance from Walls.

Side Wall

Type	Hazard	Area	Max- S	Max- L	Max- W	Min - W
Standard	Light – N -Com	18 m²	4.3 m	4.3 m	2.1 m	10 cm
	Light - Com	11 m²	4.3 m	3.7 m	1.85 m	
	Ordinary – N- Com	9.3 m²	3 m	3 m	1.5 m	
	Ordinary – Com	7.4 m²	3 m	3 m	1.5 m	
Extended	Light – N -Com	37 m²	8.5 m	4.3 m	2.1 m	
	Ordinary – N- Com	37 m²	7.3 m	4.3 m	2.1 m	

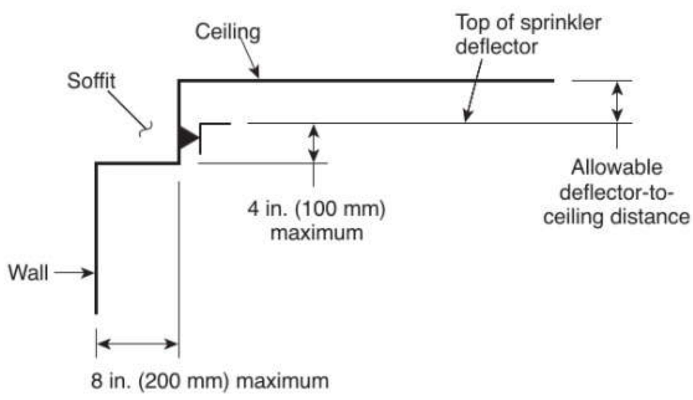


FIGURE A.10.3.5.1.3.2 Location Sidewalls with Respect to Soffits — Sidewall in Soffit.

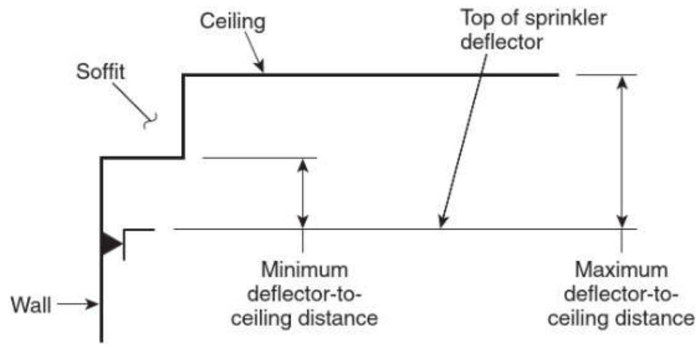
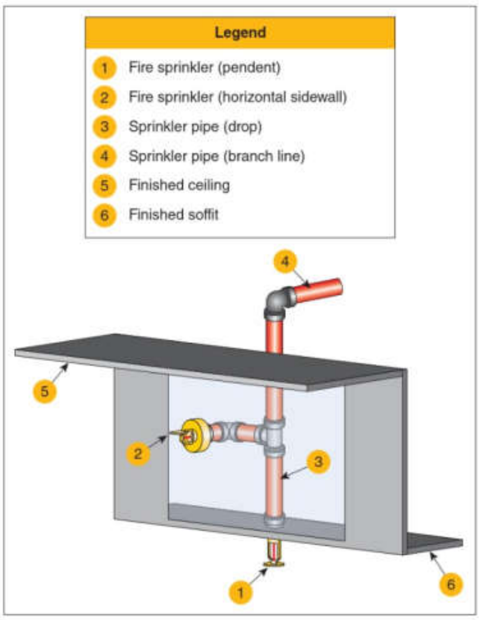


FIGURE A.10.3.5.1.3.3 Location Sidewalls with Respect to Soffits — Sidewall Under Soffit.

8.7.4.1.4.1 Where soffits exceed more than 8 in. (200 mm) in width or projection from the wall, pendent sprinklers shall be installed under the soffit.

8.7.4.1.4.2 Sidewall sprinklers shall be permitted to be installed in the face of a soffit located directly over cabinets, without requiring additional sprinklers below the soffit or cabinets, where the soffit does not project horizontally more than 12 in. (300 mm) from the wall.

8.7.4.1.4.3 Where sidewall sprinklers are more than 36 in. (900 mm) above the top of cabinets, the sprinkler shall be permitted to be installed on the wall above the cabinets where the cabinets are no greater than 12 in. (300 mm) from the wall.



➢ Sprinkler Calc.

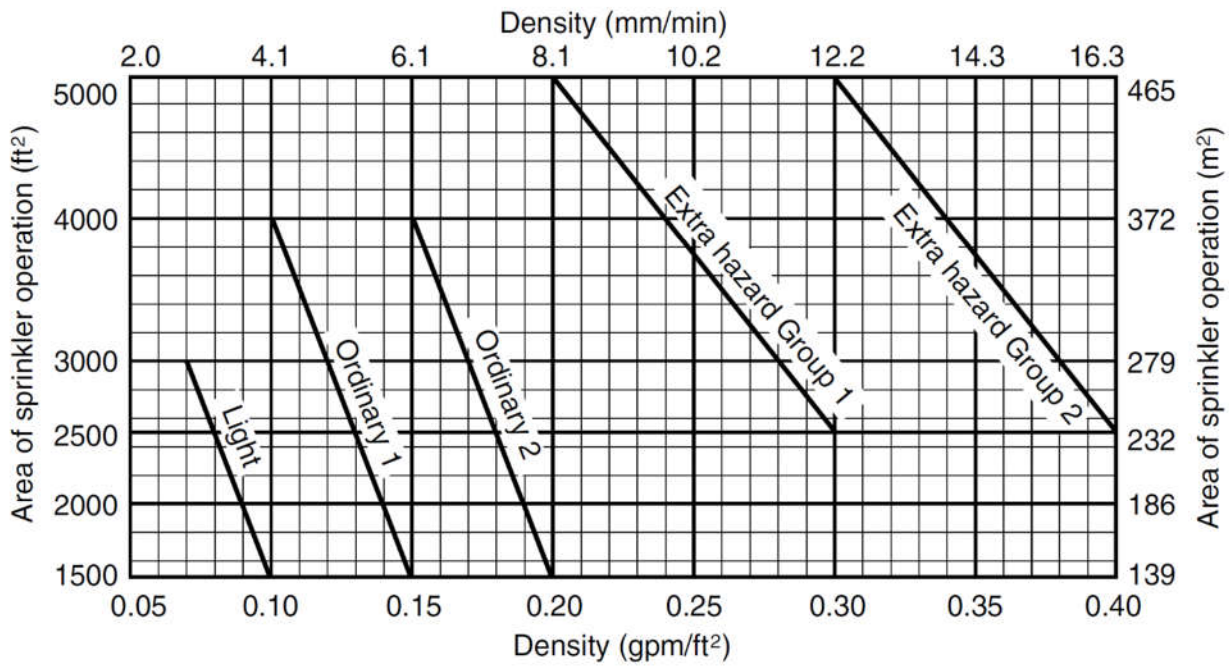


FIGURE 11.2.3.1.1 Density/Area Curves.

- Hazard Classification
- Density = 0.1, 0.15, 0.2 gpm/ft²
- Area of sprinkler operation =1500 ft²
- No. of Sprinkler in space (N_r) = A_r / A_s
- No. of sprinkler in Operation (N_s) = D_a / A_s
- Number of Sprinkler on Branch line (N_b) = $1.2\sqrt{D_a}$ / S
- Q_s= N_s x Flow per sprinkler
- Flow per sprinkler= D_d / A_s
- Q= $K\sqrt{P}$

  K= 5.6, 8, … According to Ceiling Height – FM $_{Global}$, P not less than 7 psi

- Q_T =Q_s + Hose Allowance
- H_P = H_s + H_R + H_F

Table 10.1.2.1.1 Hose Stream Allowance and Water Supply Duration Requirements for Occupancy Protection Systems

Occupancy	Hose Stream Allowance gpm	Hose Stream Allowance Lpm	Minimum Duration (minutes)
Light hazard	100	378	30
Ordinary hazard	250	946	60–90*
Residential up to 4 stories	Not applicable	Not applicable	30
Residential one- and two-family dwellings	Not applicable	Not applicable	10

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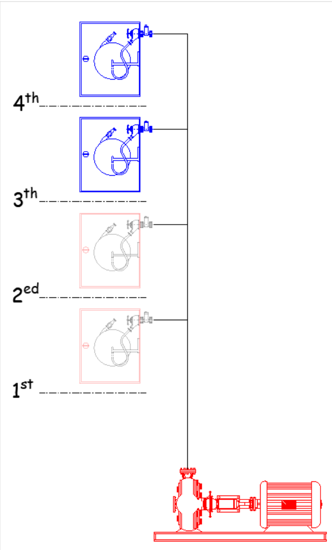
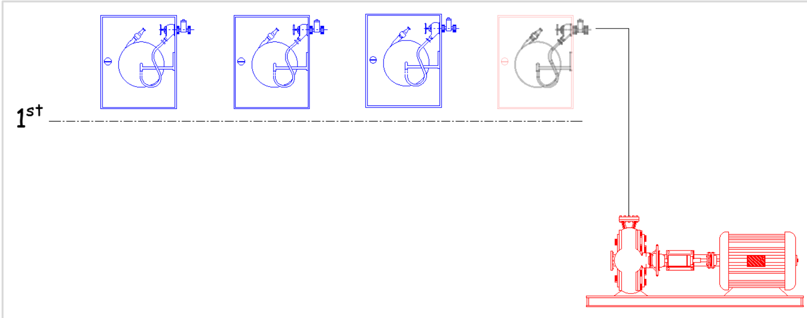
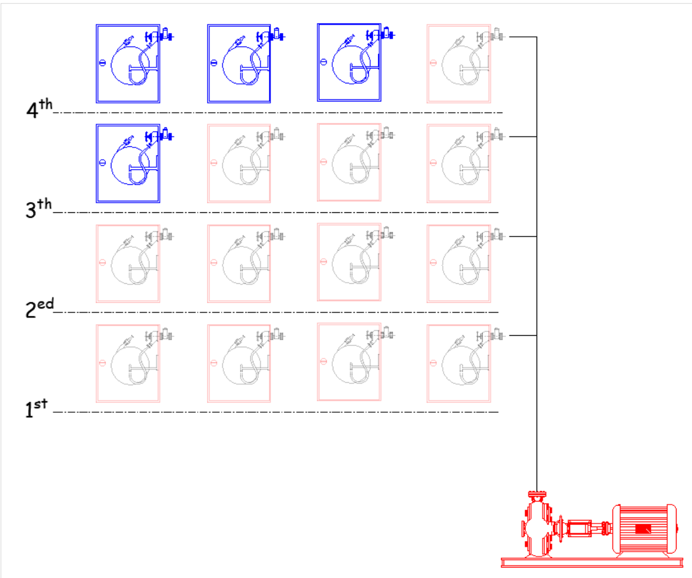
➢ Hose Cabinet Calc.



Vertical Riser - Q=500 gpm, H_R =6.9 Bar



Horizontal Riser - Q=750 gpm, H_R =6.9 Bar



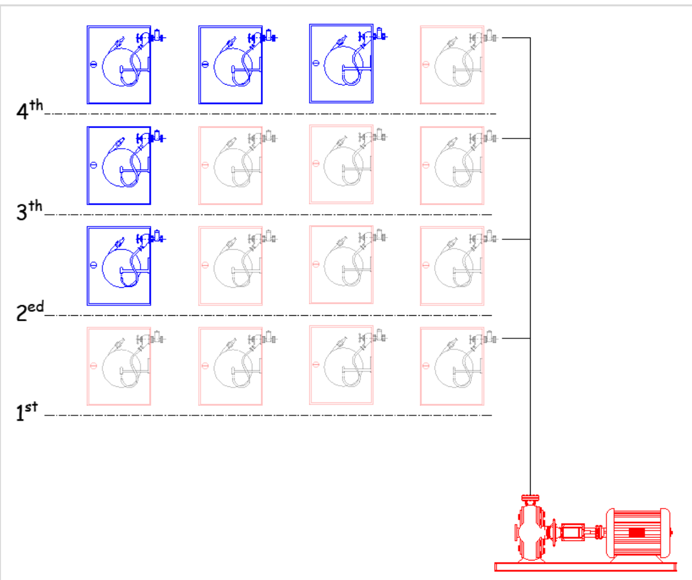
Vertical Riser

Many Hoses in floor

Sprinklers and Hoses

Q=1000 gpm, H_R =6.9 Bar

Vertical Riser



Many Hoses in floor

Non-Sprinklers and Hoses Only

Q=1250 gpm, H_R =6.9 Bar

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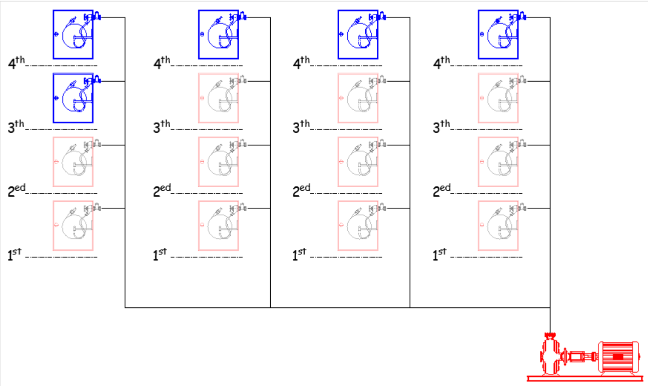
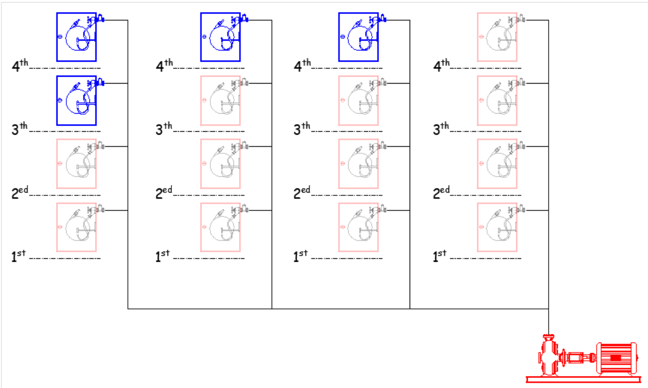
➢ عند أخذ الصندوق من الصاعد الثاني ممكن تأخذه من أي دور وليس الأبعد



Area ≤ 80,000 ft^2

Non-Sprinklers and Hoses Only

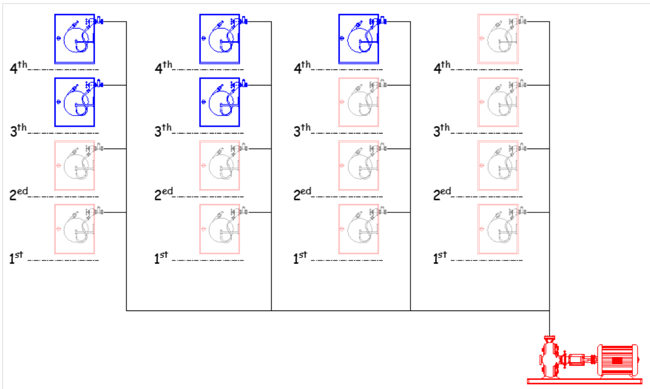
Q=1250 gpm, H_R =6.9 Bar



Area ≤ 80,000 ft^2

Sprinklers and Hoses

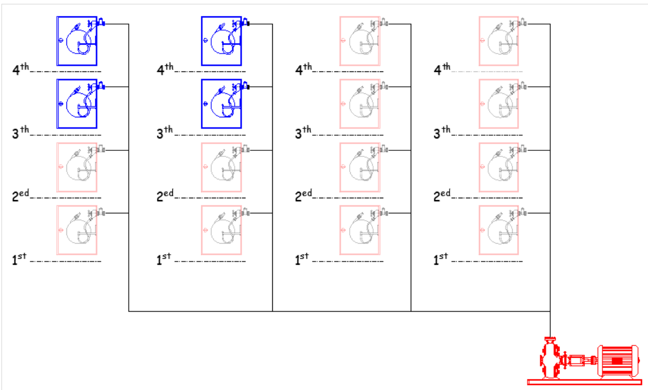
Q=1000 gpm, H_R =6.9 Bar



Area > 80,000 ft^2

Non-Sprinklers and Hoses Only

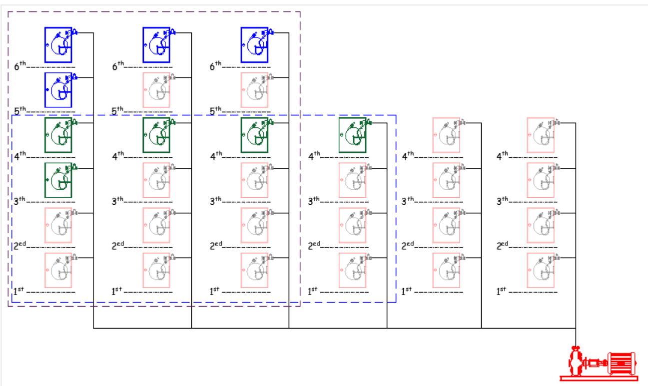
Q=1250 gpm, H_R =6.9 Bar



Area > 80,000 ft^2

Sprinklers and Hoses

Q=1000 gpm, H_R =6.9 Bar



2 Part – High and Low

Area ≤ 80,000 ft^2

Non-Sprinklers – Hoses Only

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Pipe Schedules Methods

Table 23.7.2.2.1 Light Hazard Pipe Schedules

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in. (32 mm)	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in. (40 mm)	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in.(50 mm)	12 sprinklers
2½ in. (65 mm)	30 sprinklers	2½ in. (65 mm)	40 sprinklers
3 in. (80 mm)	60 sprinklers	3 in. (80 mm)	65 sprinklers
3½ in. (90 mm)	100 sprinklers	3½ in. (90 mm)	115 sprinklers
4 in. (100 mm)	See Section 8.2	4 in. (100 mm)	See Section 8.2

Table 23.7.2.4 Number of Sprinklers Above and Below Ceiling

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in.(25 mm)	2 sprinklers
1¼ in. (32 mm)	4 sprinklers	1¼ in. (32 mm)	4 sprinklers
1½ in. (40 mm)	7 sprinklers	1½ in. (40 mm)	7 sprinklers
2 in. (50 mm)	15 sprinklers	2 in. (50 mm)	18 sprinklers
2½ in. (65 mm)	50 sprinklers	2½ in. (65 mm)	65 sprinklers

Table 23.7.3.4 Ordinary Hazard Pipe Schedule

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in. (32 mm)	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in. (40 mm)	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in. (50 mm)	12 sprinklers
2½ in. (65 mm)	20 sprinklers	2½ in. (65 mm)	25 sprinklers
3 in. (80 mm)	40 sprinklers	3 in. (80 mm)	45 sprinklers
3½ in. (90 mm)	65 sprinklers	3½ in. (90 mm)	75 sprinklers
4 in. (100 mm)	100 sprinklers	4 in. (100 mm)	115 sprinklers
5 in. (125 mm)	160 sprinklers	5 in. (125 mm)	180 sprinklers
6 in. (150 mm)	275 sprinklers	6 in. (150 mm)	300 sprinklers
8 in. (200 mm)	See Section 8.2	8 in. (200 mm)	See Section 8.2

Table 23.7.3.5 Number of Sprinklers — Greater Than 12 ft (3.7 m) Separations

Steel		Copper	
2½ in. (65 mm)	15 sprinklers	2½ in (65 mm)	20 sprinklers
3 in. (80 mm)	30 sprinklers	3 in. (80 mm)	35 sprinklers
3½ in. (90 mm)	60 sprinklers	3½ in. (90 mm)	65 sprinklers

Table 23.7.3.7 Number of Sprinklers Above and Below a Ceiling

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	4 sprinklers	1¼ in. (32 mm)	4 sprinklers
1½ in. (40 mm)	7 sprinklers	1½ in. (40 mm)	7 sprinklers
2 in. (50 mm)	15 sprinklers	2 in. (50 mm)	18 sprinklers
2½ in. (65 mm)	30 sprinklers	2½ in. (65 mm)	40 sprinklers
3 in. (80 mm)	60 sprinklers	3 in. (80 mm)	65 sprinklers

23.7.4* Extra Hazard Occupancies. Extra hazard occupancies shall be hydraulically calculated.

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➢ Gas Calc.

- **CO_2 - Mass**

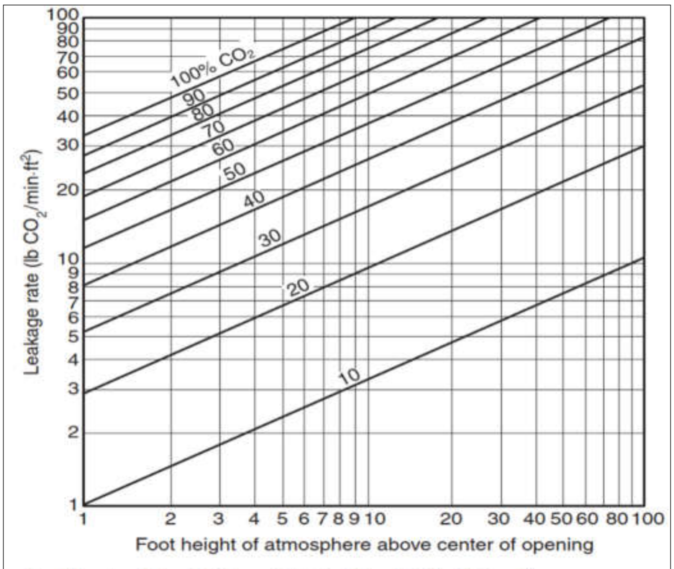
 = Flooding Factor x Volume x Conversion Factor + Fan Leakage (1 min) + Leakage Rate

Δ Table 5.3.3(b) Volume Factors and Flooding Factors (SI Units)

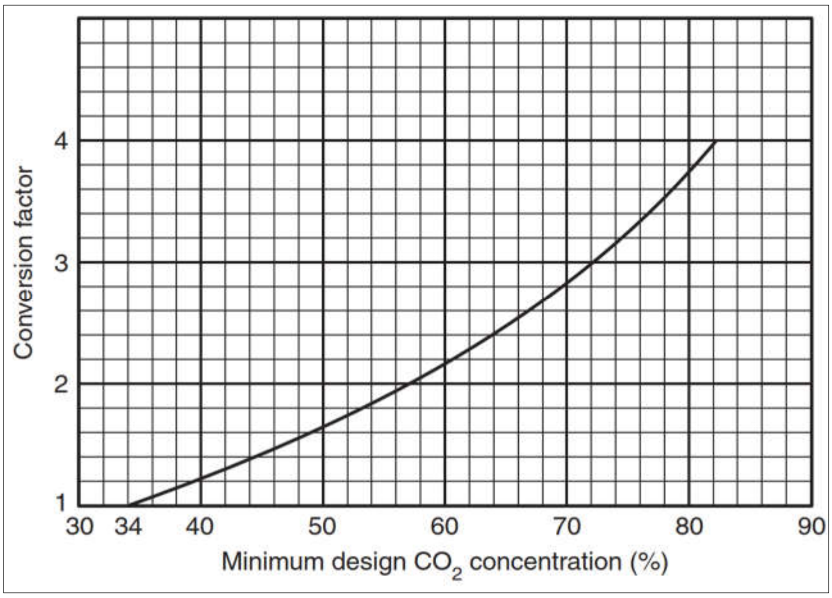
(A)	(B)		(C)
Volume of Space (m^3)	Volume Factor ($m^3/kg\ CO_2$)	Flooding Factor ($kg\ CO_2/m^3$)	Calculated Quantity (kg) (Not Less Than)
Up to 3.96	0.86	1.15	—
3.97–14.15	0.93	1.07	4.5
14.16–45.28	0.99	1.01	15.1
45.29–127.35	1.11	0.90	45.4
127.36–1415.0	1.25	0.80	113.5
Over 1415.0	1.37	0.74	1135.0

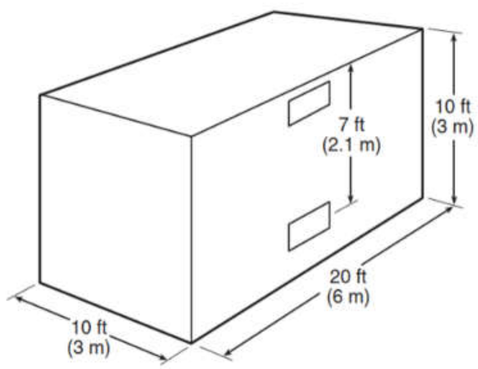
Δ Table 5.4.2.1 Volume Factors and Flooding Factors for Specific Hazards

Design Concentration (%)	Volume Factors		Flooding Factors		Specific Hazards
	$ft^3/lb\ CO_2$	$m^3/kg\ CO_2$	$lb\ CO_2/ft^3$	$kg\ CO_2/m^3$	
50	10	0.62	0.100	1.60	Dry electrical hazards in general [spaces less than 2000 ft^3 (56.6 m^3)]
50	12	0.75	0.083 (200 lb minimum)	1.33 (91 kg minimum)	Dry electrical hazards in general [spaces greater than 2000 ft^3 (56.6 m^3)]
65	8	0.50	0.125	2.00	Record (bulk paper) storage, ducts, covered trenches
75	6	0.38	0.166	2.66	Fur storage vaults, dust collectors



For SI units, 1 ft = 0.305 m; 1 lb/min·ft² = 4.89 kg/min·m².





Applications where temperature of the enclosure Above 200°F (93°C)

For each additional 5°F above 200°F - 1 % increase in the calculated total quantity of carbon dioxide shall be provided.

Applications where temperature of the enclosure below 0°F (−18°C)

For each 1°F below 0°F - 1 % increase in the calculated total quantity of carbon dioxide shall be provided

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- FM_{200} – Mass

W = Room Volume X Flooding Factor C_f X Design Factor C_{alt}

W= V/S x (C/100-C)

- V = Net Hazard Volume [m³]
- S = Specific vapor volume [m³/kg]
- S = 0.1269 + 0.0005131 x T (at sea level!)
- C = Concentration [%]

Table 5.5.3.3 Atmospheric Correction Factors

Equivalent Altitude		Enclosure Pressure (Absolute)		Atmospheric Correction Factor
ft	km	psi	mm Hg	
-3,000	-0.92	16.25	840	1.11
-2,000	-0.61	15.71	812	1.07
-1,000	-0.30	15.23	787	1.04
0	0.00	14.70	760	1.00
1,000	0.30	14.18	733	0.96
2,000	0.61	13.64	705	0.93
3,000	0.91	13.12	678	0.89
4,000	1.22	12.58	650	0.86
5,000	1.52	12.04	622	0.82
6,000	1.83	11.53	596	0.78
7,000	2.13	11.03	570	0.75
8,000	2.45	10.64	550	0.72
9,000	2.74	10.22	528	0.69
10,000	3.05	9.77	505	0.66

Δ Table A.5.4.2.2(b) Class A Flame Extinguishing and Minimum Design Concentrations Tested to UL 2166 and UL 2127

Agent	Class A MEC	Class A Minimum Design Concentration	Class C Minimum Design Concentration
FK-5-1-12	3.3	4.5	4.5
HFC-125	6.7	8.7	9.0
HFC-227ea	5.2	6.7	7.0
HFC-23	15.0	18.0	20.3
IG-541	28.5	34.2	38.5
IG-55	31.6	37.9	42.7
IG-100	31.0	37.2	41.9

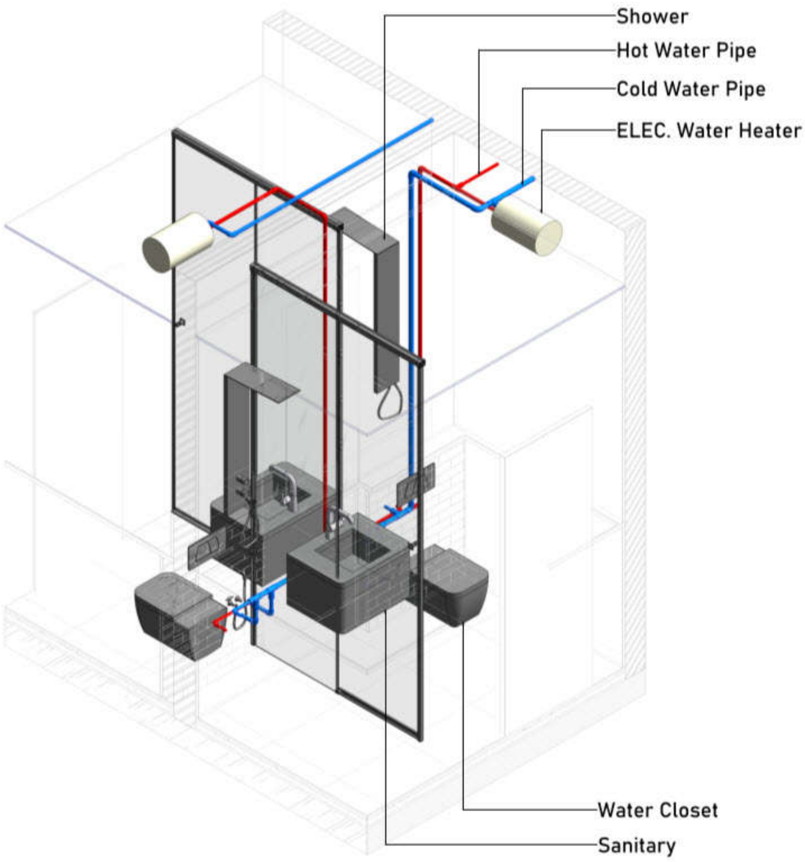
Δ Table A.5.5.1(j) HFC-227ea Total Flooding Quantity (SI Units)[a]

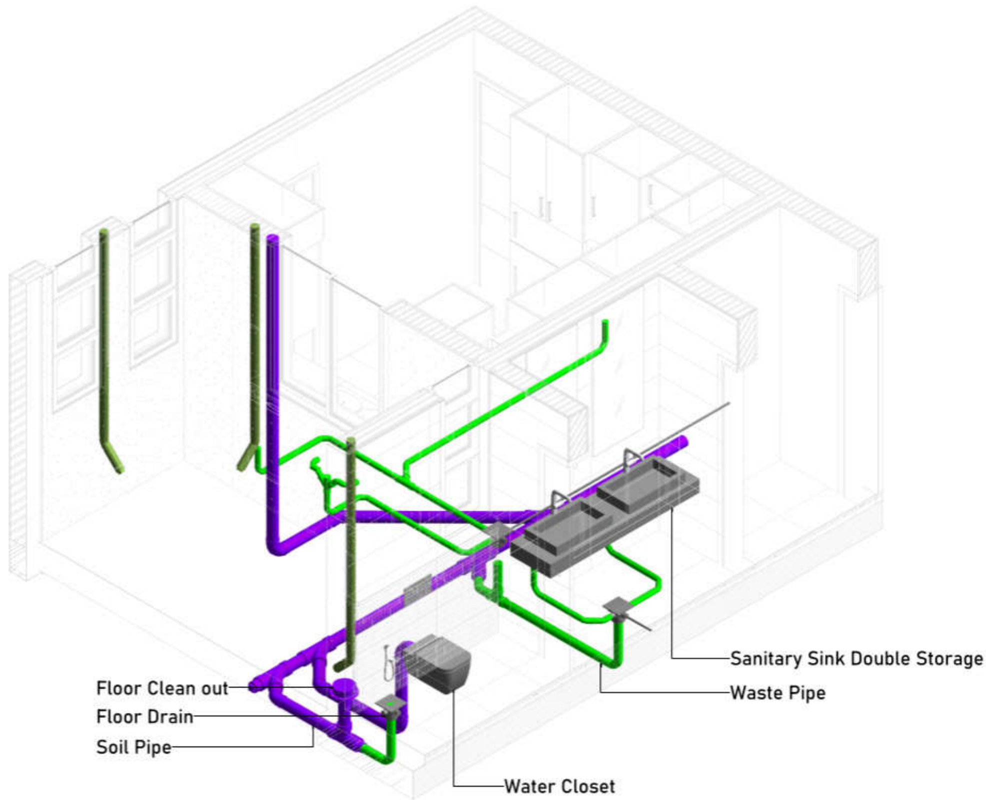
Temp (t) (°C)[c]	Specific Vapor Volume (s) (m³/kg)[d]	Weight Requirements of Hazard Volume, W/V (kg/m³)[b] Design Concentration (% per Volume)[e]									
		6	7	8	9	10	11	12	13	14	15
−10	0.1215	0.5254	0.6196	0.7158	0.8142	0.9147	1.0174	1.1225	1.2301	1.3401	1.4527
−5	0.1241	0.5142	0.6064	0.7005	0.7987	0.8951	0.9957	1.0985	1.2038	1.3114	1.4216
0	0.1268	0.5034	0.5936	0.6858	0.7800	0.8763	0.9748	1.0755	1.1785	1.2839	1.3918
5	0.1294	0.4932	0.5816	0.6719	0.7642	0.8586	0.9550	1.0537	1.1546	1.2579	1.3636
10	0.1320	0.4834	0.5700	0.6585	0.7490	0.8414	0.9360	1.0327	1.1316	1.2328	1.3264
15	0.1347	0.4740	0.5589	0.6457	0.7344	0.8251	0.9178	1.0126	1.1096	1.2089	1.3105
20	0.1373	0.4650	0.5483	0.6335	0.7205	0.8094	0.9004	0.9934	1.0886	1.1859	1.2856
25	0.1399	0.4564	0.5382	0.6217	0.7071	0.7944	0.8837	0.9750	1.0684	1.1640	1.2618
30	0.1425	0.4481	0.5284	0.6104	0.6943	0.7800	0.8676	0.9573	1.0490	1.1428	1.2388
35	0.1450	0.4401	0.5190	0.5996	0.6819	0.7661	0.8522	0.9402	1.0303	1.1224	1.2168
40	0.1476	0.4324	0.5099	0.5891	0.6701	0.7528	0.8374	0.9230	1.0124	1.1029	1.1956
45	0.1502	0.4250	0.5012	0.5790	0.6586	0.7399	0.8230	0.9080	0.9950	1.0840	1.1751
50	0.1527	0.4180	0.4929	0.5694	0.6476	0.7276	0.8093	0.8929	0.9784	1.0660	1.1555
55	0.1553	0.4111	0.4847	0.5600	0.6369	0.7156	0.7960	0.8782	0.9623	1.0484	1.1365
60	0.1578	0.4045	0.4770	0.5510	0.6267	0.7041	0.7832	0.8641	0.9469	1.0316	1.1183
65	0.1604	0.3980	0.4694	0.5423	0.6167	0.6929	0.7707	0.8504	0.9318	1.0152	1.1005
70	0.1629	0.3919	0.4621	0.5338	0.6072	0.6821	0.7588	0.8371	0.9173	0.9994	1.0834
75	0.1654	0.3859	0.4550	0.5257	0.5979	0.6717	0.7471	0.8243	0.9033	0.9841	1.0668
80	0.1679	0.3801	0.4482	0.5178	0.5890	0.6617	0.7360	0.8120	0.8898	0.9694	1.0509
85	0.1704	0.3745	0.4416	0.5102	0.5803	0.6519	0.7251	0.8000	0.8767	0.9551	1.0354
90	0.1730	0.3690	0.4351	0.5027	0.5717	0.6423	0.7145	0.7883	0.8638	0.9411	1.0202

Δ Table A.5.5.1(b) FK-5-1-12 Total Flooding Quantity (SI Units)[a]

Temp (t) (°C)[c]	Specific Vapor Volume (s) (m³/kg)[d]	Weight Requirements of Hazard Volume, W/V (kg/m³)[b] Design Concentration (% by Volume)[e]							
		3	4	5	6	7	8	9	10
−20	0.0609140	0.5077	0.6840	0.8640	1.0479	1.2357	1.4275	1.6236	1.8241
−15	0.6022855	0.4965	0.6690	0.8450	1.0248	1.2084	1.3961	1.5879	1.7839
−10	0.0636570	0.4859	0.6545	0.8268	1.0027	1.1824	1.3660	1.5337	1.7455
−5	0.0650285	0.4756	0.6407	0.8094	0.9816	1.1575	1.3372	1.5209	1.7087
0	0.0664000	0.4658	0.6275	0.7926	0.9613	1.1336	1.3096	1.4895	1.6734
5	0.0677715	0.4564	0.6148	0.7766	0.9418	1.1106	1.2831	1.4593	1.6395
10	0.0691430	0.4473	0.6026	0.7612	0.9232	1.0886	1.2576	1.4304	1.6070
15	0.0705145	0.4386	0.5909	0.7464	0.9052	1.0674	1.2332	1.4026	1.5757
20	0.0718860	0.4302	0.5796	0.7322	0.8879	1.0471	1.2096	1.3758	1.5457
25	0.0732575	0.4222	0.5688	0.7184	0.8713	1.0275	1.1870	1.3500	1.5167
30	0.0746290	0.4144	0.5583	0.7052	0.8553	1.0086	1.1652	1.3252	1.4888
35	0.0760005	0.4069	0.5482	0.6925	0.8399	0.9904	1.1442	1.3013	1.4620
40	0.0773720	0.3997	0.5385	0.6802	0.8250	0.9728	1.1239	1.2783	1.4361
45	0.0787435	0.3928	0.5291	0.6684	0.8106	0.9559	1.1043	1.2560	1.4111
50	0.0801150	0.3860	0.5201	0.6570	0.7967	0.9395	1.0854	1.2345	1.3869
55	0.0814865	0.3795	0.5113	0.6459	0.7833	0.9237	1.0671	1.2137	1.3636
60	0.0828580	0.3733	0.5029	0.6352	0.7704	0.9084	1.0495	1.1936	1.3410
65	0.0842295	0.3672	0.4947	0.6249	0.7578	0.8936	1.0324	1.1742	1.3191
70	0.0856010	0.3613	0.4868	0.6148	0.7457	0.8793	1.0158	1.1554	1.2980
75	0.0869725	0.3556	0.4791	0.6052	0.7339	0.8654	0.9998	1.1372	1.2775
80	0.0883440	0.3501	0.4716	0.5958	0.7225	0.8520	0.9843	1.1195	1.2577
85	0.0897155	0.3447	0.4644	0.5866	0.7115	0.8390	0.9692	1.1024	1.2385
90	0.0910870	0.3395	0.4574	0.5778	0.7008	0.8263	0.9547	1.0858	1.2198
95	0.0924585	0.3345	0.4507	0.5692	0.6904	0.8141	0.9405	1.0697	1.2017
100	0.0938300	0.3296	0.4441	0.5609	0.6803	0.8022	0.9267	1.0540	1.1842

PLUMBING NOTES





Water Tank Calc.

من خلال الجدول التالي تقدر تحصل على احتياج المبني من المياه

Capacity= No of Capita X Demand/Capita X Storage Days

No	Building Type	Total Water	Hot Water	Total Water	Hot Water	Total Water	Hot Water
01	Apartment (Per Apartment)	150	75				
02	Residence (Per Residence)	250	125	100-400	30-240	60	25
03	Dormitories	65	20				
04	Office Building (Per Worker)	20	3	45-70	10		
05	Industrial Plant (Per Worker)	35	15	20-100	5-20	35	
06	School Without Cafeteria or Shower	15	2	50	7	20	8
07	School With Cafeteria Without Shower	20	4	75	15		
08	School With Cafeteria and Shower	25	10	100	40		
09	Hospital (Per Bed)	300	125	600	300	225	
10	Cafeteria or Restaurant (Per Meal)	10	4	35	15	15	
11	Place of Assembly	3	0.5	50	7		
12	Hotels (Per Room)	75	50	100-240	40-160	175	40
12.1	4 Star			600-800	250-350		
12.2	5 Star			1100	450		
13	Swimming Pools			40	10		
14	Nursing Homes (Per Bed)	75	30				
15	Airports (Per Passenger)	5	1	20	4		
16	Commercial Laundry (Per Pound of Wash)	3.5	2	35	35		
17	Hospital Laundry (Per Bed)			180	100		
18	Hotel Laundry (Per Bed)			130	75		
19	Garage			30	-		
Unit		Gal/Day		Lit/Day		Gal/Day	
Source		Practical Guide		Egyptian Code		ASPE	

Table 7.3.1.2 Occupant Load Factor

Use	(ft^2/person)[a]	(m^2/person)[a]
Assembly Use		
Concentrated use, without fixed seating	7 net	0.65 net
Less concentrated use, without fixed seating	15 net	1.4 net
Bench-type seating	1 person/18 linear in.	1 person/455 linear mm
Fixed seating	Use number of fixed seats	Use number of fixed seats
Waiting spaces	See 12.1.7.2 and 13.1.7.2.	See 12.1.7.2 and 13.1.7.2.
Kitchens	100	9.3
Library stack areas	100	9.3
Library reading rooms	50 net	4.6 net
Swimming pools	50 (water surface)	4.6 (water surface)
Swimming pool decks	30	2.8
Exercise rooms with equipment	50	4.6
Exercise rooms without equipment	15	1.4
Stages	15 net	1.4 net
Lighting and access catwalks, galleries, gridirons	100 net	9.3 net
Casinos and similar gaming areas	11	1
Skating rinks	50	4.6
Business Use (other than below)	150	14
Concentrated Business Use[f]	50	4.6
Airport traffic control tower observation levels	40	3.7
Collaboration rooms/ spaces ≤450 ft^2 (41.8 m^2) in area[f]	30	2.8
Collaboration rooms/ spaces >450 ft^2 (41.8 m^2) in area[f]	15	1.4
Day-Care Use	35 net	3.3 net
Detention and Correctional Use	120	11.1
Educational Use		
Classrooms	20 net	1.9 net
Shops, laboratories, vocational rooms	50 net	4.6 net
Health Care Use		
Inpatient treatment departments	240	22.3
Sleeping departments	120	11.1
Ambulatory health care	150	14
Industrial Use		
General and high hazard industrial	100	9.3
Special-purpose industrial	NA	NA
Mercantile Use		
Sales area on street floor[b,c]	30	2.8
Sales area on two or more street floors[c]	40	3.7

Table 7.3.1.2 *Continued*

Use	(ft^2/person)[a]	(m^2/person)[a]
Sales area on floor below street floor[c]	30	2.8
Sales area on floors above street floor[c]	60	5.6
Floors or portions of floors used only for offices	See business use.	See business use.
Floors or portions of floors used only for storage, receiving, and shipping, and not open to general public	300	27.9
Mall structures[d]	Per factors applicable to use of space[e]	
Residential Use		
Hotels and dormitories	200	18.6
Apartment buildings	200	18.6
Board and care, large	200	18.6
Storage Use		
In storage occupancies	NA	NA
In mercantile occupancies	300	27.9
In other than storage and mercantile occupancies	500	46.5

للحصول على
عدد الأشخاص المتوقعين
داخل المبني بناء على المساحة

TABLE 606.5.7
SIZE OF DRAIN PIPES FOR WATER TANKS

TANK CAPACITY (gallons)	DRAIN PIPE (inches)
Up to 750	1
751 to 1,500	$1^1/_2$
1,501 to 3,000	2
3,001 to 5,000	$2^1/_2$
5,000 to 7,500	3
Over 7,500	4

For SI: 1 inch = 25.4 mm, 1 gallon = 3.785 L.

TABLE 606.5.4
SIZES FOR OVERFLOW PIPES FOR WATER SUPPLY TANKS

MAXIMUM CAPACITY OF WATER SUPPLY LINE TO TANK (gpm)	DIAMETER OF OVERFLOW PIPE (inches)
0 – 50	2
50 – 150	$2^1/_2$
150 – 200	3
200 – 400	4
400 – 700	5
700 – 1,000	6
Over 1,000	8

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m.

للحصول على
قطر ماسورة الصرف
قطر ماسورة Overflow
الخاصة بالتانك

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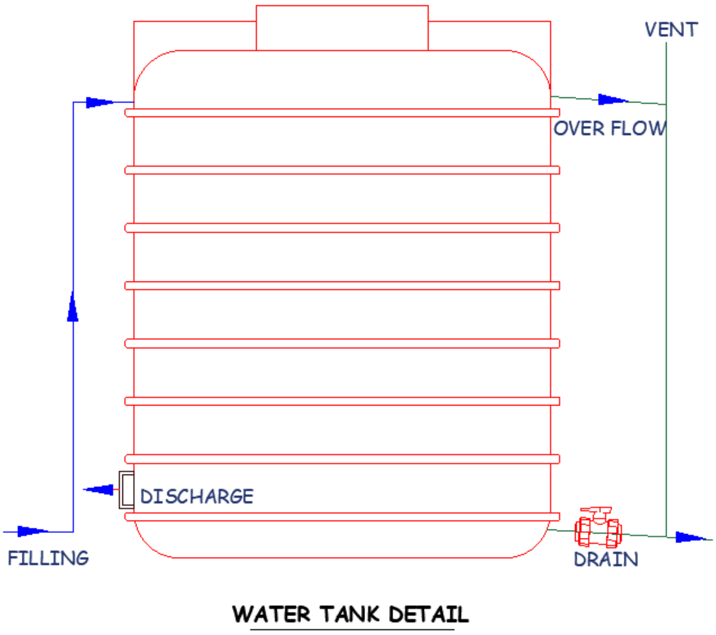


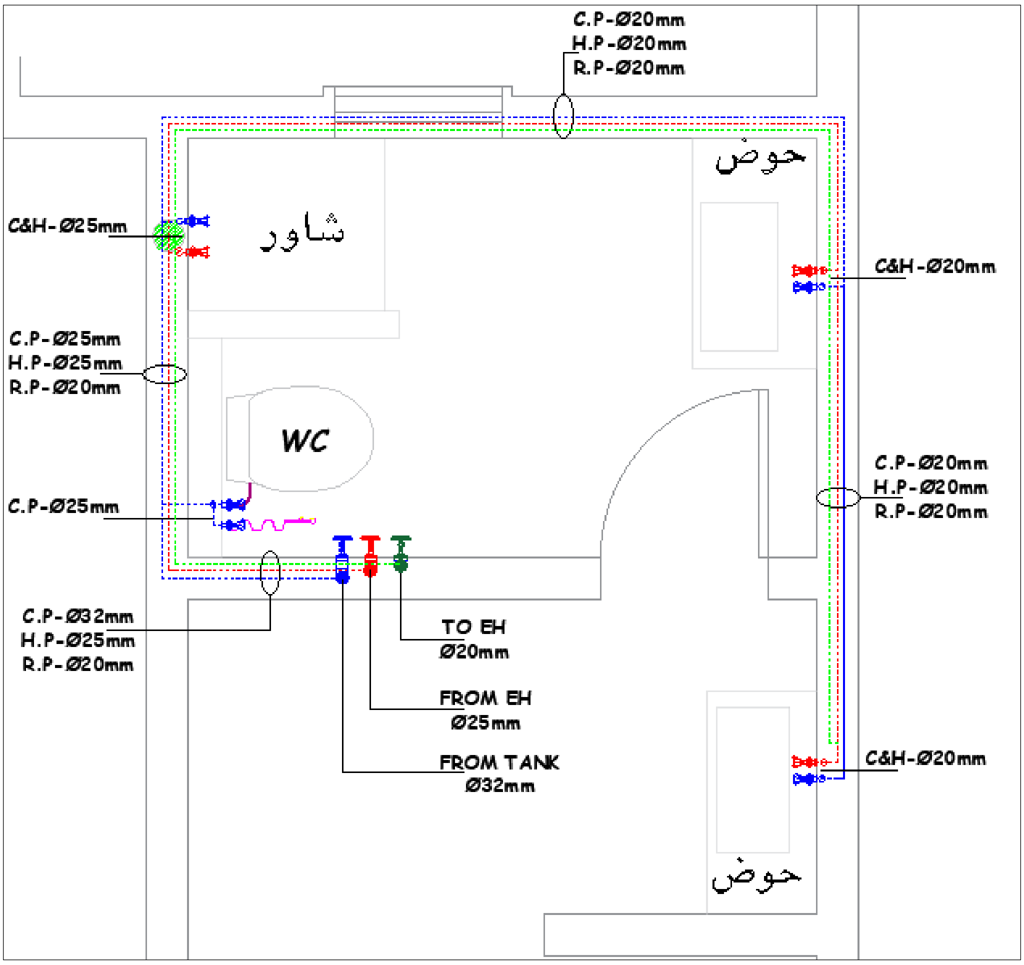
شوية حسابات لازم تأخذ بالك منها:

I. الخزان الأرضي في مشاريع الخليج يتم تصميمه انه يكفي 7 أيام
II. الخزان الأرضي في المشاريع الكبيرة زي المستشفيات والمولات يتم تصميمة من يومين الى ثلاثة أيام
III. الخزان العلوي يتم تصميمة انه يكفي المبنى لمدة يوم واحد

المضخات:

i. مضخات رفع (Lifting Pump) للتانك العلوي
Q(GPM)= Tank Capacity / Time (4:8 Hr.)
ولكن يتم حساب الزمن على ساعتين فقط لسرعة الملىء
ii. يتم حساب ماسورة Filling بناء على العلاقة بين الـ GPM، Table 1.1
iii. يتم حساب ماسورة Overflow بناء على العلاقة بين GPM، Table 606.5.4
iv. يتم حساب ماسورة Drain بناء على العلاقة بين Gallon، Table 606.5.7
v. يتم حساب ماسورة Discharge بناء على العلاقة بين الـ WSFU وتحويلها الى GPM وبعدها تدخل بمعلومة GPM تجيب القطر من Table 1.1
vi. مضخات (Booster Pump) التي تخدم الأدوار القريبة من التانك
يتم حساب Q بناء على WSFU للأدوار العلوية وتحويلها الى GPM

Domestic Water Calc.



أحد حمامات الفيلا السكنية

مصدر المياه الباردة خزان علوي

مصدر المياه الساخنة سخان مركزي

1. Bathtub and Shower
   $WSFU_C$=1, $WSFU_H$=1, $WSFU_T$=1.4
2. Lavatory
   $WSFU_C$=0.5, $WSFU_H$=0.5, $WSFU_T$=0.7
3. Water Closet
   $WSFU_C$=2.2, $WSFU_T$=2.2

$WSFU_{CT}$=4.2----- GPM=8.0 ---Ø=1.25"
$WSFU_{HT}$=2------- GPM=5.0 ---Ø=1.00"

طبقا للجدول Table 1.1 تلاحظ ان المفروض دي الاقطار، ولكن انا قررت اقلل الأقطار شوية علشان في المشروع حمامات كثير وبالتالي الأفضل اقلل اقطار الرئيسية ودة يتسبب في رفع الفقد في الضغط شوية صغيرين وانا أصلا جايب مضخة بوستر اعلي المبنى ضغطها مناسب معايا يبقي ساعتها لازم يبقي عندك سينس هندسي علشان لازم اقلل التكلفة شوية لو في ايدك وكان اختياري كدة

$WSFU_{CT}$=4.2----- GPM=8.0 ---Ø=1.00"
$WSFU_{HT}$=2------- GPM=5.0 ---Ø=0.75"

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تحديد أقطار مواسير المياه الباردة والساخنة

- تحديد قيمة WSFU
- تحويل قيمة WSFU الي GPM
- تحديد القطر المناسب بناء على GPM

ملحوظة:

- اقطار المواسير المياه PPR او UPVC تكون اقطار خارجية لو كانت بالملي وتكون اقطار اسمية لو كانت بالبوصة

Flow Range (GPM)		Pipe Size (Inch)	Pressure Drop Range (Of Water/100ft)
0	2	0.5	0 – 4
3	4	0.75	2.5 – 4
5	7.5	1	2 – 4
8	16	1.25	1.25 – 4
17	24	1.5	2 – 4
25	48	2	1.5 – 4
49	77	2.5	2 – 4
78	140	3	1.5 – 4
141	280	4	1.25 – 4
281	500	5	1.5 – 4
501	800	6	1.25 – 4
801	1700	8	1 – 4
1701	2500	10	1.25 – 2.75
2501	3600	12	1.25 – 2.25

Table - 1.1

Nominal (Inch)	Nominal (mm)	Out Diameter (mm)
0.5"	15	20
0.75"	20	25
1"	25	32
1.25"	32	40
1.5"	40	50
2	50	63
2.5"	63	75
3"	75	90
4"	100	110
5"	125	125
6"	150	160
8"	200	200
10"	250	250
12"	300	315

Table - 1.2

TABLE E103.3(2)
LOAD VALUES ASSIGNED TO FIXTURES[a]

FIXTURE	OCCUPANCY	TYPE OF SUPPLY CONTROL	LOAD VALUES, IN WATER SUPPLY FIXTURE UNITS (wsfu)		
			Cold	Hot	Total
Bathroom group	Private	Flush tank	2.7	1.5	3.6
Bathroom group	Private	Flushometer valve	6.0	3.0	8.0
Bathtub	Private	Faucet	1.0	1.0	1.4
Bathtub	Public	Faucet	3.0	3.0	4.0
Bidet	Private	Faucet	1.5	1.5	2.0
Combination fixture	Private	Faucet	2.25	2.25	3.0
Dishwashing machine	Private	Automatic	—	1.4	1.4
Drinking fountain	Offices, etc.	$^3/_8$" valve	0.25	—	0.25
Kitchen sink	Private	Faucet	1.0	1.0	1.4
Kitchen sink	Hotel, restaurant	Faucet	3.0	3.0	4.0
Laundry trays (1 to 3)	Private	Faucet	1.0	1.0	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2.0
Service sink	Offices, etc.	Faucet	2.25	2.25	3.0
Shower head	Public	Mixing valve	3.0	3.0	4.0
Shower head	Private	Mixing valve	1.0	1.0	1.4
Urinal	Public	1" flushometer valve	10.0	—	10.0
Urinal	Public	$^3/_4$" flushometer valve	5.0	—	5.0
Urinal	Public	Flush tank	3.0	—	3.0
Washing machine (8 lb)	Private	Automatic	1.0	1.0	1.4
Washing machine (8 lb)	Public	Automatic	2.25	2.25	3.0
Washing machine (15 lb)	Public	Automatic	3.0	3.0	4.0
Water closet	Private	Flushometer valve	6.0	—	6.0
Water closet	Private	Flush tank	2.2	—	2.2
Water closet	Public	Flushometer valve	10.0	—	10.0
Water closet	Public	Flush tank	5.0	—	5.0
Water closet	Public or private	Flushometer tank	2.0	—	2.0

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SIZING PIPE	SUPPLY SYSTEM PREDOMINANTLY FOR FLUSH TANK			SIZING PIPE	SUPPLY SYSTEM PREDOMINANTLY FOR FLUSH VALVE		
	Load	Demand			Load	Demand	
Inch Nominal	WSFU	GPM	Ft^3/M	Inch Nominal	WSFU	GPM	Ft^3/M
0.50	0.5	2	0.032		_	_	_
0.75	1	3	0.041				
1	2	5	0.068		_	_	_
	3	6.5	0.869		_	_	_
1.25	4	8	1.069		_	_	_
	5	9.4	1.266	1.25	5	15	2.005
	6	10.7	1.430	1.5	6	17.4	2.326
	7	11.8	1.577		7	19.8	2.646
	8	12.8	1.711		8	22.2	2.968
	9	13.7	1.831		9	24.6	3.289
	10	14.6	1.952	2	10	27	3.609
	11	15.4	2.059		11	27.8	3.716
	12	16	2.139		12	28.6	3.823
	13	16.5	2.206		13	29.4	3.930
1.5	14	17	2.273		14	30.2	4.037
	15	17.5	2.339		15	31	4.144
	16	18	2.906		16	31.8	4.241
	17	18.4	2.460		17	32.6	4.358
	18	18.8	2.513		18	33.4	4.465
	19	19.2	2.567		19	34.2	4.572
	20	19.6	2.620		20	35	4.679
	25	21.5	2.874		25	38	5.080
	30	23.3	3.115		30	42	5.614
2	35	24.9	3.329		35	44	5.882
	40	26.3	3.516		40	46	6.149
	45	27.7	3.703		45	48	6.417
	50	29.1	3.890	2.5	50	50	6.684
	60	32	4.278		60	54	7.219
	70	35	4.679		70	58	7.753
	80	38	5.080		80	61.2	8.181
	90	41	5.481		90	64.3	8.596
	100	43.5	5.815		100	67.5	9.023
	120	48	6.417		120	73	9.759
2.5	140	52.5	7.018		140	77	10.293
	160	57	7.620	3	160	81	10.828
	180	61	8.154		180	85.5	11.430
	200	65	8.689		200	90	12.031
	225	70	9.358		225	95.5	12.766
	250	75	10.026		250	101	13.502
3	275	80	10.694		275	104.5	13.970
	300	85	11.363		300	108	14.437
	400	105	14.036		400	127	16.977
	500	124	16.576		500	143	19.116
4	750	170	22.726	4	750	177	23.661
	1000	208	27.805		1000	208	27.805
	1250	239	31.950		1250	239	31.950
	1500	269	35.960		1500	269	35.960
5	1750	297	39.703	5	1750	297	39.703
	2000	325	43.446		2000	325	43.446
	2500	380	50.798		2500	380	50.798
	3000	433	57.883		3000	433	57.883
6	4000	525	70.182	6	4000	525	70.182
	5000	593	79.272		5000	593	79.272

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Hot Water Calc.

➢ السخانات الفردية:

- تستخدم في الوحدات السكنية الصغيرة والمشاريع المتوسطة
- السخان له سعات مختلفة (30,50,80,100,150) لتر حسب المتوافرة في السوق ونظام التشغيل كهرباء
- السخان (6,10) لتر ونظام التشغيل غاز
- السخان الفوري (6,10) لتر وبيكون استهلاك الكهرباء فيه مرتفع

Heater Capacity (Lit)	Electrical Load (KW)
30	1.2
50	1.5
80	2
100	3
150	4

Application	Usage Factor
Hospital, Hotel	0.5
Residential	0.33
Office	0.25

للسخان الفوري فقط

Power Input (KW) = (ρ (1000) x Flow (lit/s) x C_P (4.18) x ΔT_{50c} x UF / Efficiency (0.95))/1000

السخان الفوري يتم حساب Flow بناء على مجموع $WSFU_H$ وتحويلها إلى GPM ولا تنسى تحويل الوحدة للتعويض في القانون بـ Lit/S بالضرب 0.063x

Table 16-3 Hot Water Demand per Fixture for Various Types of Buildings
(Gallons of water per hour per fixture, calculated at a final temperature of 140°F)

	Apartment House	Club	Gymnasium	Hospital	Hotel	Industrial Plant	Office Building	Private Residence	School	Y.M.C.A.
1. Basins, private lavatory	2	2	2	2	2	2	2	2	2	2
2. Basins, public lavatory	4	6	8	6	8	12	6	-	15	8
3. Bathtubs	20	20	30	20	20	-	-	20	-	30
4. Dishwashers	15	50-150	-	50-150	50-200	20-100	-	15	20-100	20-100
5. Foot basins	3	3	12	3	3	12	-	3	3	12
6. Kitchen sink	10	20	-	20	30	20	20	10	20	20
7. Laundry, stationary tubs	20	28	-	28	28	-	-	20	-	28
8. Pantry sink	5	10	-	10	10	-	10	5	10	10
9. Showers	30	150	225	75	75	225	30	30	225	225
10. Slop sink	20	20	-	20	30	20	20	15	20	20
11. Hydro-therapeutic showers				400						
12. Hubbard baths				600						
13. Lap baths				100						
14. Arm baths				35						
15. Sitz baths				30						
16. Continuous-flow baths				165						
17. Circular wash sinks				20	20	30	20		30	
18. Semi-circular wash sinks				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*	1.25	0.90	1.00	0.60	0.80	1.00	2.00	0.70	1.00	1.00

* Ratio of storage tank capacity to probable maximum demand per hour. Storage capacity may be reduced where an unlimited supply of steam is available from a central street steam system or large boiler plant.

من خلال الجدول السابق نحصل علي قيمة GPH خاص بالسخانات الفردية ويستخدم مع السخانات المركزية.

مثال: فيلا سكنية يحتوي على WC و2 حوض وشاور

- ➢ Max_{GPH} = No. Fixture x GPH = (2x2) + (1x30) = 32 GPH
- ➢ $Probable_{GPH}$ = Max_{GPH} x D.F
- ➢ Heater Capacity $_{Individual}$ = $Probable_{GPH}$ x S.C.F = 32 x 0.3 x 1.25 = 12Gal x 3.78 = (50 Lit)
- ➢ Heater Capacity $_{Central}$ = ($Probable_{GPH}$ x S.C.F)/0.7
- ➢ Power Input (KW) = (ρ (1000) x $Probable_{GPH}$ (lit/s) x C_P (4.18) x ΔT_{50c} / Efficiency (0.95))/1000

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➢ السخانات المركزية:

➢ <u>Based On Daily Use</u>

- Daily Demand = Demand per Person/Day x No. of Person
- $Probable_{GPH}$ = Daily Demand x Max. Hr. Demand
- Storage Tank Capacity = Daily Demand x Storage Capacity in Relation to Day Use /0.7
- Power Input (KW) = (ρ (1000) x $Probable_{GPH}$ (lit/s) x CP (4.18) x ΔT_{50c} / Efficiency (0.95))/1000

Table 16-2 Estimated Hot Water Demand Characteristics for Various Types of Buildings

Type of Building	Hot Water Required per Person	Max. Hourly Demand in Relation to Day's Use	Duration of Peak Load Hours	Storage Capacity in Relation to Day's Use	Heating Capacity in Relation to Day's Use
Residences, apartments, hotels, etc.[a, b]	20–40 gal/day[c]	1/7	4	1/5	1/7
Office buildings	2–3 gal/day[c]	1/5	2	1/5	1/6
Factory buildings	5 gal/day[c]	1/3	1	2/5	1/8
Restaurants			(See text)		

a Daily hot water requirements and demand characteristics vary with the type of hotel. The better class hotel has a relatively high daily consumption with a low peak load. The commercial hotel has a lower daily consumption but a high peak load.
b The increasing use of dishwashers and laundry machines in residences and apartments requires additional allowances of 15 gal/dishwasher and 40 gal/laundry washer.
c At 140°F.

➢ <u>By Hunter Curves</u>

- Storage Tank Capacity = Demand per Person/Day x No. of Person = (1 Gal/P x 20 Person) =20 Gal
- $Probable_{GPH}$ = Recovery Capacity x No. of Person = 0.175 GPH_P x 20 Person = 3.5 GPH
- Power Input (KW) = (ρ (1) x $Probable_{GPH}$ (lit/s) x CP (4.18) x ΔT_{50c} / Efficiency (0.95)) = 0.9 KW

Figure 16-5 Apartments

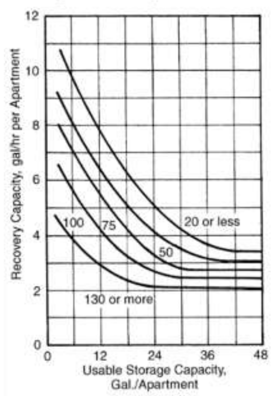


Figure 16-6 Office Buildings

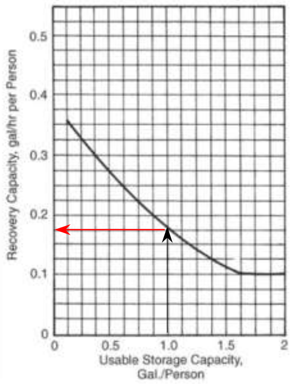


Figure 16-7 Nursing Homes

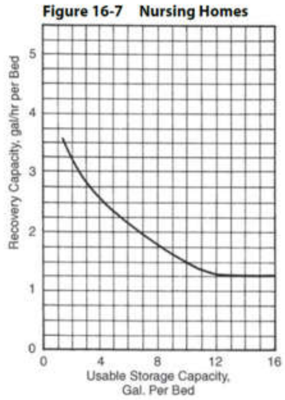


Figure 16-8 Motels

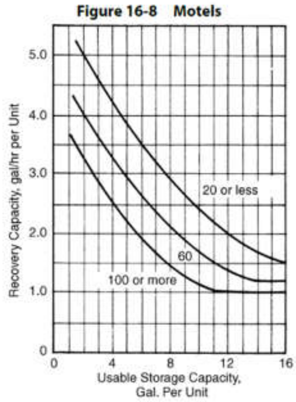


Figure 16-9 Food Service

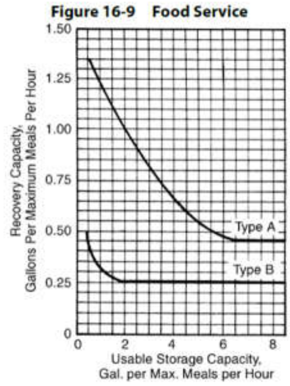


Figure 16-10 Elementary Schools

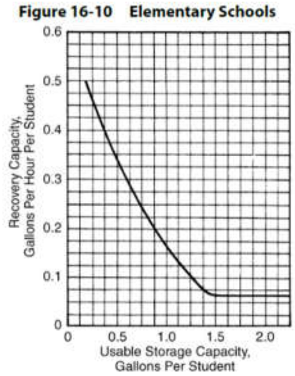


Figure 16-11 High Schools

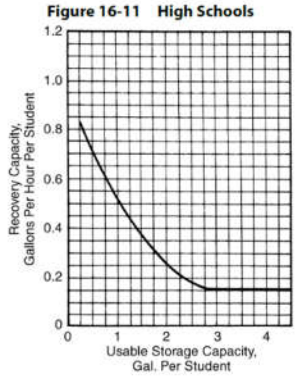
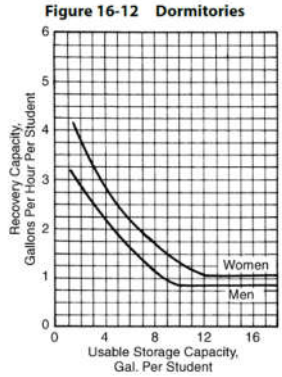


Figure 16-12 Dormitories



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- تصميم راجع المياه الساخن

Table 17-1 Piping Heat Loss (Btu/hr. Per Lineal Ft. For 140°F. Water Temp and 70°F. Room Temp.)

Nominal Pipe Size	Insulated Pipe (½" Fiberglass)	Bare Pipe Sched. 40 Steel	Bare Pipe Brass, Copper, T.P.	Bare Pipe Type K Copper
½"	15	35	26	19
¾"	17	43	32	26
1"	19	53	38	32
1¼"	21	65	46	39
1½"	25	73	53	46
2"	28	91	65	58
2½"	32	108	75	68
3"	38	129	90	81
4"	46	163	113	103
5"	55	199	138	127
6"	63	233	161	149
8"	80	299	201	188

- تصميم مضخة التدوير Q,H

An Allowance of 1 GPM is Assigned for Each Group of 20 Hot Water Fixtures.
or
1GPM = 10,000 Btu/hr.

$Q_{\text{Circulation Pump}}$ = Total Heat Loss $_{(\text{Btu/hr.})}$/10,000

- Total Heat Loss = Heat Loss Supply + Heat Loss Return
- Heat Loss Return = 2/3 Heat Loss Supply
- Total Heat Loss = 5/3 Heat Loss Supply

ببساطة شديدة اعمل حصر لشبكة المياه الساخنة بالكامل كل ماسورة حسب القطر بتاعها وبعدها انظر قيمة الفقد الحراري
وبعدها عوض في القانون السابق نحصل على قيمة مضخة التدوير

- HP = H $_{\text{Losses for longest path}}$
  = (L_{Pipe} + $L_{\text{equivalent}}$) x $\Delta P/L_{4Ft/100Ft}$

- تصميم قطر ماسورة الراجع

✓ **الطريقة الاولي (الاسهل)**
قطر ماسورة الراجع نص قطر ماسورة السبلاي
لا يقل قطر صاعد ماسورة الراجع عن 0.75"

✓ **الطريقة الثانية (الاصعب)**
بمعلومية الفقد في الحرارة في ماسورة السبلاي
تقدر تعوض في القانون هذا:

- Total Heat Loss = 5/3 Heat Loss Supply

وبعدها تقدر تعوض في قانون هذا نحصل علىGPM في كل ماسورة على حدي

- Q_{GPM}= Total Heat Loss $_{(\text{Btu/hr.})}$/10,000

ثم نحصل على القطر من خلال الجدول التالي

½ in. = 1.8 gpm	2 in. = 34.6 gpm
¾ in. = 3.5 gpm	2½ in. = 56 gpm
1 in. = 6.6 gpm	3 in. = 93 gpm
1¼ in. = 12.4 gpm	4 in. = 181 gpm
1½ in. = 18.3 gpm	

التوصيف النهائي:

- معدل التدفق للمضخة
- الضغط الخاص بالمضخة
- اقطار ماسورة الراجع

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- **تصميم مواسير المياه المثلجة:**

نحتاج المياه المثلجة في بعض التطبيقات وخاصة المصانع الغذائية
وبالتالي نحتاج الى الشيلر ونحتاج الى مضخة تدوير وتانك تخزين تعتبر نفس فكرة المياه الساخنة، ولكن بالعكس

Table 20-2 Drinking Water Requirements

Type of Service	Delivered Water Temp., °F	Gal/ Person/Hr	Waste and Consumption/ Person/Hr, oz (liquid)	Consumption Only/Person/Hr, oz (liquid)	People Served/Gal
Office (cup)	45–50	0.033	4.2	4.2	30
Office (bubbler)	45–50	0.083	10.5	4.2	12
Light mfg.	45–50	0.143	18.3	7.32	7
Heavy mfg.	50–55	0.20	25.6	10.24	5
Hot heavy mfg.	55–60	0.25	32.0	12.8	4
Restaurant[a]	40–45	0.1 gal/person			
Cafeteria[a]	40–45	0.083 gal/person			
Soda fountain	40–45	0.5 gal/seat			
Theater[a]	45–50	1.0 gal/100 seats continuous capacity			
Schools	45–50	same as office			
Hospitals					
A. Per bed	45–50	0.083 gal			
B. Per attendant	45–50	0.083 gal			
Hotels	45–50	0.08 gal/hr/room			
Public fountains, amusement parks, fairs, etc.	45–50	20–35 gal/hr			
Dept. stores, hotel and office building lobbies	45–50	4–5 gal/hr/fountain			

a Special consideration should be given to peak-load demands for this application.

Circulating Pump Capacity

See Table 20-6. Size the pump to circulate a minimum of 3 gpm per branch circuit or the gpm necessary to limit the temperature rise of the circulating water to a maximum of 5°, whichever is the greater value. The pump should be located in the return line to discharge into the cooler with the makeup water connection between the pump and the cooler.

Makeup Water Mixture

Calculate the temperature of the mixture of makeup water and circulating water. The quantity and temperature of this mixture are used as the specified capacity of the water-cooling unit.

Storage Tank

Size the storage tank for a capacity of 50% of the usage per hour.

Table 20-6 Circulating Pump Capacity

Pipe Size, in.	Room Temperature, °F		
	70	80	90
	GPH/100 ft		
½	8.0	11.1	14.3
¾	8.4	11.8	15.2
1	9.1	12.8	16.5
1¼	10.4	14.6	18.7
1½	11.2	15.7	20.2

Notes:
1. GPH/100 ft of pipe (including all branch lines) circulation rate to limit temperature rise to 5°F (water at 45°F).
2. Divide total gph by 60 to obtain gpm. Add 20% for safety factor.
3. For pump head figure longest branch only.
4. Install pump on the return line to discharge into the cooling unit.
5. Makeup connection should be between the pump and the cooling unit.
6. Btu = gal to be cooled × temp difference × 8.3

Table 20-3 Refrigeration Load

	Btu/Hr/Gal Cooled to 45°F					
Water inlet temp., °F	65	70	75	80	85	90
Btu/gal	167	208	250	291	333	374

Notes: Multiply load for 1 gal by total gph. Total Btu/hr is usage load (Table 20-2 × Table 20-3) plus Btu/hr from Tables 20-4 and 20-5 plus 15% safety factor.

Table 20-4 Circulating System Line Loss (Heat Gain) Approx. 1-In. Insulation

Pipe Size (in.)	Btu/Hr/100 Ft (45°F Circulating Water)			
	Btu/Hr/Ft/°F (Temp. Diff.)	Room Temperature, °F 70	80	90
½	0.110	280	390	500
¾	0.119	300	420	540
1	0.139	350	490	630
1¼	0.155	390	550	700
1½	0.174	440	610	790
2	0.200	500	700	900
2½	0.228	570	800	1030
3	0.269	680	940	1210

Table 20-5 Circulating Pump Heat Input

Motor H.P.	¼	⅓	½	¾	1	1½	2
Btu Hourly	636	850	1272	1908	2545	3816	5090

- **Circulation Pump Capacity**

  = 3 GPM / Branch or (Table 20-6) is the greater value
  HP= GPM x Head / 3960 x (Efficiency)$_{0.75:0.85}$

- **Usage Load**

  = [(5 Gal/Hr./Fountain x 10 Fountain x 250 Btu/Hr./Gal) (Table 20-2, Table 20-3)
  + Pipe Heat Gain (Table 20-4)
  + Circulation Pump Heat (Table 20-5)] x Safety Factor (1.15)

- **Storage Tank**

  = 5 Gal/Hr./Fountain x 10 Fountain x 0.5 per hour = ...Gal

- Sand Filter

A= Q/V

$D_{(mm)}$= $(4xQ/3.14xV)^{0.5}$x1000

V= 30: 50 m^3/hr./m^2

CODE	TYPE	Ø	CONNECTIONS	FLOW (m³/h) V=50m³/h/m²	QUARTZ SAND kg	FILTER AREA m²	DIMENSIONS H	M	PACKING	WEIGHT kg	VOLUME m³
MU-450-VT	Top	450	1½"	8	75	0.16	800	570	2	16.5	0.19
MU-550-VT	Top	550	1½"	12	125	0.22	840	610	2	21.1	0.23
MU-650-VT	Top	650	1½"	16	150	0.30	960	730	2	24.3	0.38
MU-450-VS	Side	450	1½"	8	75	0.16	670	590	2	16.5	0.19
MU-550-VS	Side	550	1½"	12	125	0.22	710	630	2	21.1	0.23
MU-650-VS	Side	650	1½"	16	150	0.30	830	660	2	24.3	0.38
MU-700-VS	Side	700	1½"	19	225	0.50	895	750	2	33	0.45
MU-800-VS	Side	800	2"	25	300	0.50	1030	900	2	41.5	0.67
MU-900-VS	Side	900	2"	30	400	0.64	1130	930	2	52.3	0.95
MU-1100-VS	Side	1100	Ø75	43	650	0.98	1310	990	1	115	1.84
MU-1200-VS	Side	1200	Ø90	56	1000	1.13	1430	1020	1	124	2.32

- Softener Filter

Get Total WSFU then Convert to GPM

Hardness = Inlet water hardness – Outlet water
Hardness = 350 – 75 = 275 ppm
275 ppm = 275/17.1 grain/gal = 16.1 grain/gal

Water usage per day = GPM x 60 Min x 24 Hr.
=32 x 60 x 24 = 46080 gal/day

Total grain/day = 16.1 x 46080 = 741888 grain/day

Resin volume required = grain/day x no. of days / resin capacity
= 741888 x 1 / 150000 = 4.9 ft^3 of resin = 0.14m^3
From Catalogue in (grain/ft^3 of resin)

Salt consumption per generation = resin volume x salt dosage
=4.9 x 15 lb/ft^3= 73.5 lb =33.5kg

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Drainage Design

من خلال الجدول التالي يمكننا الحصول على:

- قيمة DFU
- قيمة اقل قطر للصرف للوحدة الصحية

TABLE 709.1
DRAINAGE FIXTURE UNITS FOR FIXTURES AND GROUPS

FIXTURE TYPE	DRAINAGE FIXTURE UNIT VALUE AS LOAD FACTORS	MINIMUM SIZE OF TRAP (inches)
Automatic clothes washers, commercial[a,g]	3	2
Automatic clothes washers, residential[g]	2	2
Bathroom group as defined in Section 202 (1.6 gpf water closet)[f]	5	—
Bathroom group as defined in Section 202 (water closet flushing greater than 1.6 gpf)[f]	6	—
Bathtub[b] (with or without overhead shower or whirlpool attachments)	2	$1^1/_2$
Bidet	1	$1^1/_4$
Combination sink and tray	2	$1^1/_2$
Dental lavatory	1	$1^1/_4$
Dental unit or cuspidor	1	$1^1/_4$
Dishwashing machine[c], domestic	2	$1^1/_2$
Drinking fountain	$^1/_2$	$1^1/_4$
Emergency floor drain	0	2
Floor drains[h]	2[h]	2
Floor sinks	Note h	2
Kitchen sink, domestic	2	$1^1/_2$
Kitchen sink, domestic with food waste disposer, dishwasher or both	2	$1^1/_2$
Laundry tray (1 or 2 compartments)	2	$1^1/_2$
Lavatory	1	$1^1/_4$
Shower (based on the total flow rate through showerheads and body sprays)		
Flow rate:		
5.7 gpm or less	2	$1^1/_2$
Greater than 5.7 gpm to 12.3 gpm	3	2
Greater than 12.3 gpm to 25.8 gpm	5	3
Greater than 25.8 gpm to 55.6 gpm	6	4
Service sink	2	$1^1/_2$
Sink	2	$1^1/_2$
Urinal	4	Note d
Urinal, 1 gallon per flush or less	2[e]	Note d
Urinal, nonwater supplied	$^1/_2$	Note d
Wash sink (circular or multiple) each set of faucets	2	$1^1/_2$
Water closet, flushometer tank, public or private	4[e]	Note d
Water closet, private (1.6 gpf)	3[e]	Note d
Water closet, private (flushing greater than 1.6 gpf)	4[e]	Note d
Water closet, public (1.6 gpf)	4[e]	Note d
Water closet, public (flushing greater than 1.6 gpf)	6[e]	Note d

For SI: 1 inch = 25.4 mm, 1 gallon = 3.785 L, gpf = gallon per flushing cycle, gpm = gallon per minute.
a. For traps larger than 3 inches, use Table 709.2.
b. A showerhead over a bathtub or whirlpool bathtub attachment does not increase the drainage fixture unit value.
c. See Sections 709.2 through 709.4.1 for methods of computing unit value of fixtures not listed in this table or for rating of devices with intermittent flows.
d. Trap size shall be consistent with the fixture outlet size.
e. For the purpose of computing loads on building drains and sewers, water closets and urinals shall not be rated at a lower drainage fixture unit unless the lower values are confirmed by testing.

Table 704.1
Slope of Horizontal Drainage Pipe

Size (Inches)	Minimum Slope (In/Ft)	Minimum Slope (cm/m)	Minimum Slope (cm/m) Practical
2.5 or less	1/4	2	1
3: 6”	1/8	1	0.5
8 or Larger	1/16	0.5	0.5

TABLE 710.1(1)
BUILDING DRAINS AND SEWERS

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS CONNECTED TO ANY PORTION OF THE BUILDING DRAIN OR THE BUILDING SEWER, INCLUDING BRANCHES OF THE BUILDING DRAIN[a]			
	Slope per foot			
	1/16 inch	1/8 inch	1/4 inch	1/2 inch
1 1/4	—	—	1	1
1 1/2	—	—	3	3
2	—	—	21	26
2 1/2	—	—	24	31
3	—	36	42	50
4	—	180	216	250
5	—	390	480	575
6	—	700	840	1,000
8	1,400	1,600	1,920	2,300
10	2,500	2,900	3,500	4,200
12	3,900	4,600	5,600	6,700
15	7,000	8,300	10,000	12,000

For SI: 1 inch = 25.4 mm, 1 inch per foot = 83.3 mm/m.

a. The minimum size of any building drain serving a water closet shall be 3 inches.

TABLE 710.1(2)
HORIZONTAL FIXTURE BRANCHES AND STACKS[a]

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
	Total for horizontal branch	Stacks[b]		
		Total discharge into one branch interval	Total for stack of three branch Intervals or less	Total for stack greater than three branch intervals
1 1/2	3	2	4	8
2	6	6	10	24
2 1/2	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c

Table 12.8.1
Maximum Length of Trap Arm

Size Trap Arm	Length Trap Arm to Vent	Minimum Slope (cm/m)	Minimum Slope (cm/m) Practical
1.25”	105 cm	2	1
1.5”	150 cm	2	1
2”	240 cm	2	1
3”	300 cm	1	0.5
4”	360 cm	1	0.5

Condensate Drain Ac

Pipe Size (Inches)	Cooling Capacity (Ton)
0.75”	Less than 3 Tr
1”	3: 20 Tr
1.25”	20: 100 Tr
1.5”	100: 300 Tr
2”	300: 600 Tr

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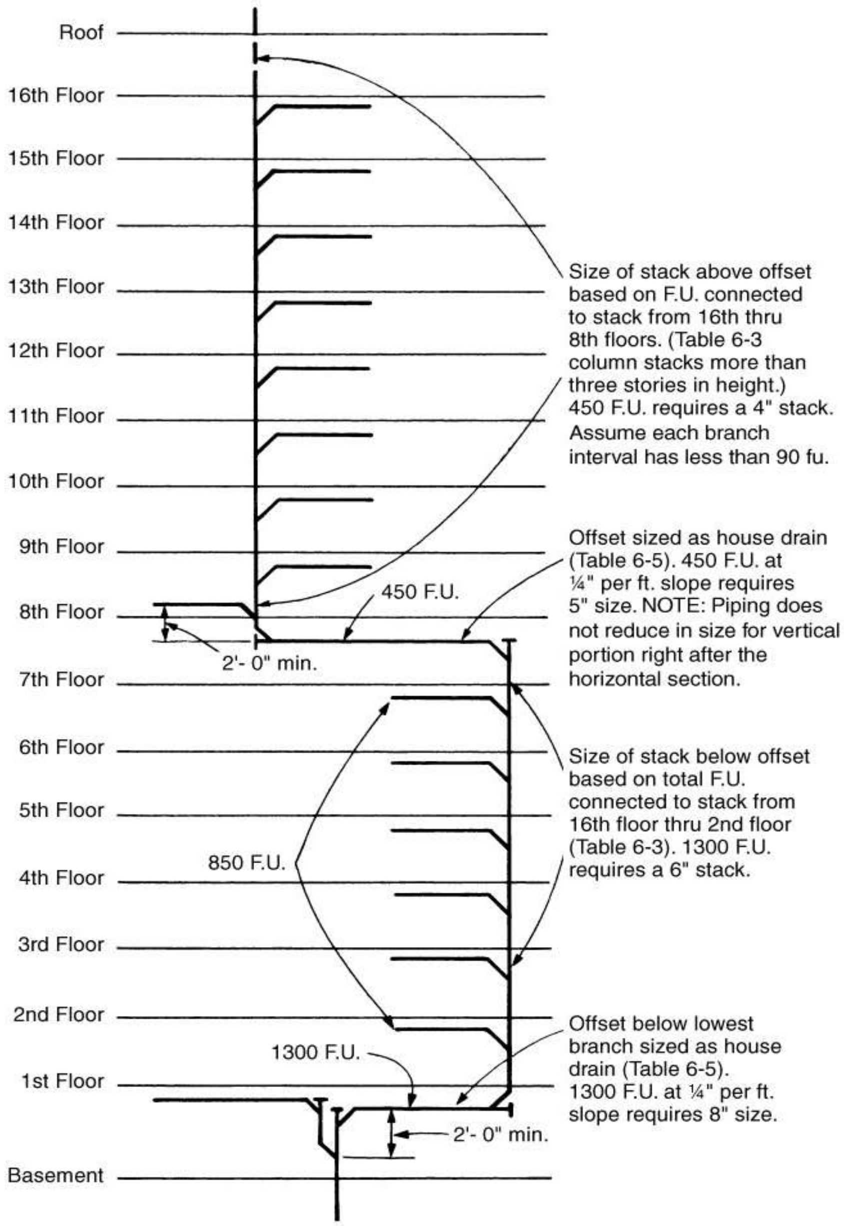
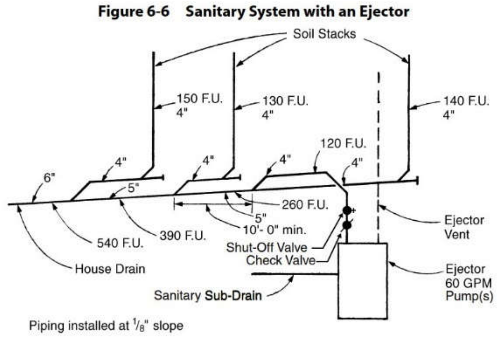
Figure 6-4 Procedure for Sizing an Offset Stack



الجدول التالي:

قطر ماسورة صرف Sump Pit معلومية GPM=2DFU

Figure 6-6 Sanitary System with an Ejector



PIPE (inches)	(gpm)
2	21
$2^1/_2$	30
3	46

For SI: 1 inch = 25.4 mm, 1 gallon per minute = 3.785 L/m.

Size and Length of Sump Vents
Table 12.14.2

GPM	Diameter of Vent (Inches)					
	1.25	1.5	2	2.5	3	4
10	NL	NL	NL	NL	NL	NL
20	270	NL	NL	NL	NL	NL
40	72	160	NL	NL	NL	NL
60	31	75	270	NL	NL	NL
80	16	41	150	380	NL	NL
100	<10	25	97	250	NL	NL
150	NP	<10	44	110	370	NL
200	NP	NP	20	60	210	NL
250	NP	NP	10	36	132	NL
300	NP	NP	<10	22	88	380
400	NP	NP	NP	<10	44	210
500	NP	NP	NP	NP	24	130

Velocity in Pipe - Min. (0.61m/s), Max. (2m/s)

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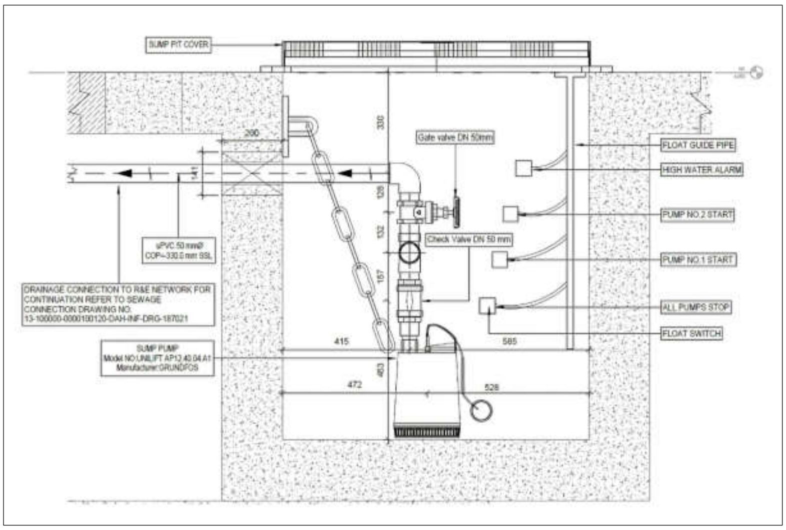
- ## Sump Pits Capacity

H1 = 30cm (Including suction depth)
H2 = 20cm
H3=H4= 0.5 x (Effective Volume/Sump Area)
Sump Area = Length x Width (1.5m²)
Min. Sump Length = Width = 1.2m
Effective Volume = 5 x Pump Flow
Pump Flow = Inlet Peak Flow/No. of duty pump
H5 = 20cm
H6 = 10cm
H7 = Inlet pipe invert level from F.F.L
Sump depth = Sum (H1:H7)



- ## Septic Tank Capacity

Figure 21-1 Precast Septic Tank

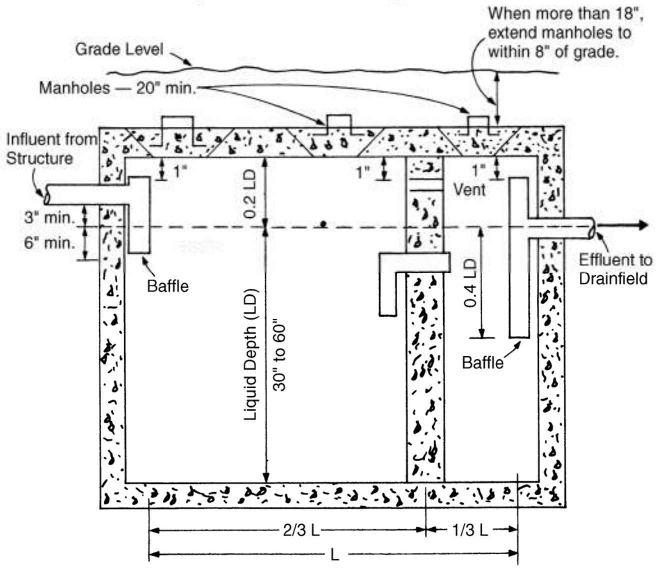


TABLE 21.1 Septic tank capacity for one- and two-family dwellings. *Copyright © 2009 by International Code Council, Inc. Reprinted with permission. All rights reserved.*

NUMBER OF BEDROOMS	SEPTIC TANK (gallons)
1	750
2	750
3	1,000
4	1,200
5	1,425
6	1,650
7	1,875
8	2,100

For SI: 1 gallon = 3.785 L.

Table 16.6.1
Capacity of Septic Tanks

Single Family Dwelling Number of Bedroom	Multiple Dwelling Units	Maximum Fixture Units	Minimum Septic Tank Capacity in Gallon
1 – 3		20	1000
4	2 units	25	1200
5 – 6	3	33	1500
7 – 8	4	45	2000
	5	55	2250
	6	60	2500
	7	70	2750
	8	80	3000
	9	90	3250
	10	100	3500

Extra Bedroom: 150 Gallon each
Extra Dwelling Units Over 10: 250 Gallon Each
Extra Fixture Unit Over 100: 25 Gallon Per Fixture Unit

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Interceptors

I. $Q_{gpm} = 0.75 \times V \times n / T$

V_{gallon}, حجم حلة الحوض
n, عدد الاحواض
T_{min}, زمن التصرف غالبا دقيقة واحدة

II. Q = No. Meals $_{per\ hour}$ x Waste Flow Rate x Retention Time x Storage Factor

Waste Flow Rate

8. Hospitals	250 (946.3) per bed
Kitchen waste only	25 (94.6) per bed
Laundry waste only	40 (151.4) per bed
9. Hotels (no kitchen waste)	60 (227.1) per bed (2 person)

15. Restaurants – cafeterias	20 (75.7) per employee
toilet	7 (26.5) per customer
kitchen waste	6 (22.7) per meal
add for garbage disposal	1 (3.8) per meal
add for cocktail lounge	2 (7.6) per customer
kitchen waste –	
disposable service	2 (7.6) per meal

Retention Time

- Commercial Kitchen - 2.5 Hr.
- Single Kitchen - 1.5 Hr.

Storage Factor

- Commercial Kitchen
  - ✓ 8Hr. Operation – 1
  - ✓ 16Hr. Operation – 2
  - ✓ 24Hr. Operation – 3
- Single Kitchen - 1.5

III. Q = No. Vehicle $_{per\ hour}$ x Waste Flow Rate x Retention Time x Storage Factor

Waste Flow Rate

14. Parks, mobile homes	250 (946.3) per space
picnic parks (toilets only)	20 (75.7) per parking space
recreational vehicles –	
without water hook-up	75 (283.9) per space
with water and sewer hook-up	100 (378.5) per space

Retention Time

- Sand Silt Oil - 2.0 Hr.

Storage Factor

- Auto Washers
  - ✓ Self-Serve – 1.5
  - ✓ Employee Operated – 2

IV. Q = No. Machines x2 Cycles $_{per\ hour}$ x Waste Flow Rate x Retention Time x Storage Factor

Waste Flow Rate

11. Laundries, self-service	
(minimum 10 hours per day)	50 (189.3) per wash cycle
Commercial	Per manufacturer's specifications

Retention Time

- Laundry - 2.0 Hr.

Storage Factor

- Laundries – 1.5

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- Neutralization Tank

Table 2-3 Acid Waste Neutralization Tank Sizes	
Number of Sinks	Tank Size, gal (L)
2	5 (18.9)
4	15 (56.8)
8	30 (113.6)
16	55 (208.2)
22	75 (283.9)
27	90 (340.7)
30	108 (408.8)
40	150 (567.8)
50	175 (662.4)
60	200 (757.0)
75	275 (1,040.9)
110	360 (1,362.6)
150	500 (1,898.5)
175	550 (2,081.8)
200	650 (2,460.3)
300	1,200 (4,542)
500	2,000 (7,570)
600	3000 (11,355)
Note: For commercial and industrial laboratories, the number of lab sinks should be multiplied by a 0.5 use factor.	

- IC and Manhole

IC – Inspection Chamber

مقاس غرفة التفتيش بالسنتمتر			عمق غرفة التفتيش
120x80	90x60	60x60	
سمك الحائط			
25	25	25	لغاية 50 سم
25	25	25	اكبر من 50 الي 85 سم
38	25	-	اكبر من 85 الي 120 سم
38	-	-	اكبر من 120 الي 150 سم

Maximum Distance Between Two Manhole

أكبر مسافة	قطر الخط
30 م	200 – 175
50 م	300 – 200
60 م	400 – 300
100 م	900 – 400
150 م	1200 – 900
200 م	اكبر من 1200

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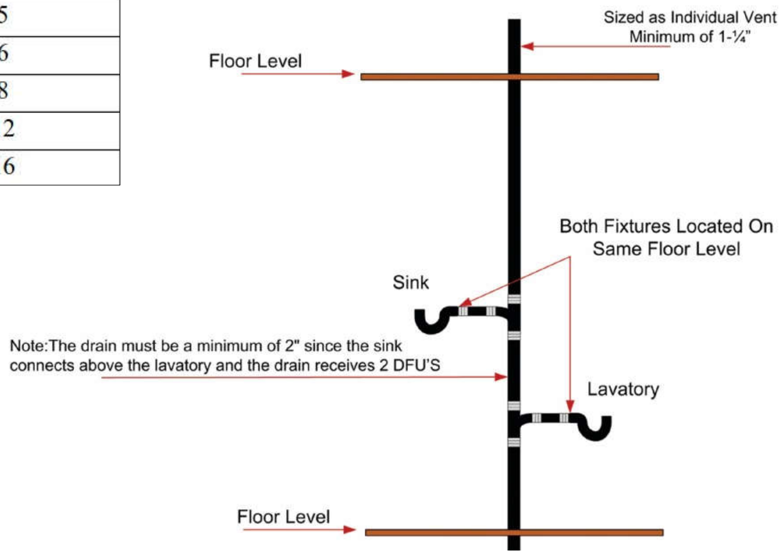
- Vent System Types

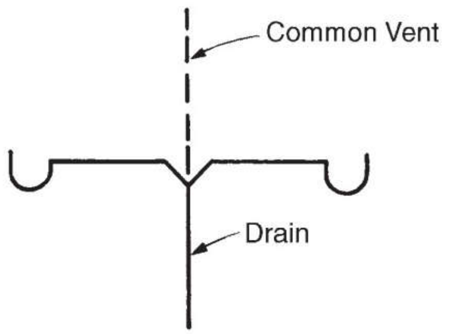
- Individual Vent

TABLE 909.1 MAXIMUM DISTANCE OF FIXTURE TRAP FROM VENT		
SIZE OF TRAP (inches)	SLOPE (inch per foot)	DISTANCE FROM TRAP (feet)
$1^1/_4$	$^1/_4$	5
$1^1/_2$	$^1/_4$	6
2	$^1/_4$	8
3	$^1/_8$	12
4	$^1/_8$	16



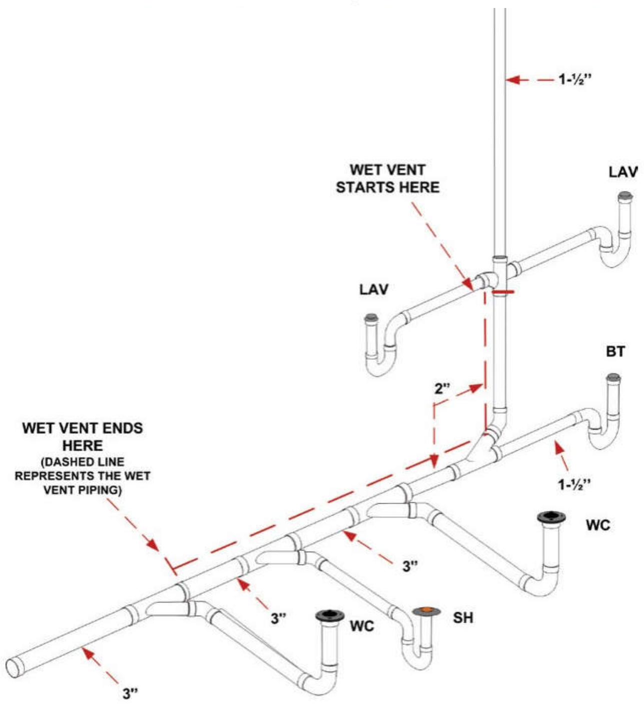
- Common Vent

TABLE 911.3 COMMON VENT SIZES	
PIPE SIZE (inches)	MAXIMUM DISCHARGE FROM UPPER FIXTURE DRAIN (dfu)
$1^1/_2$	1
2	4
$2^1/_2$ to 3	6



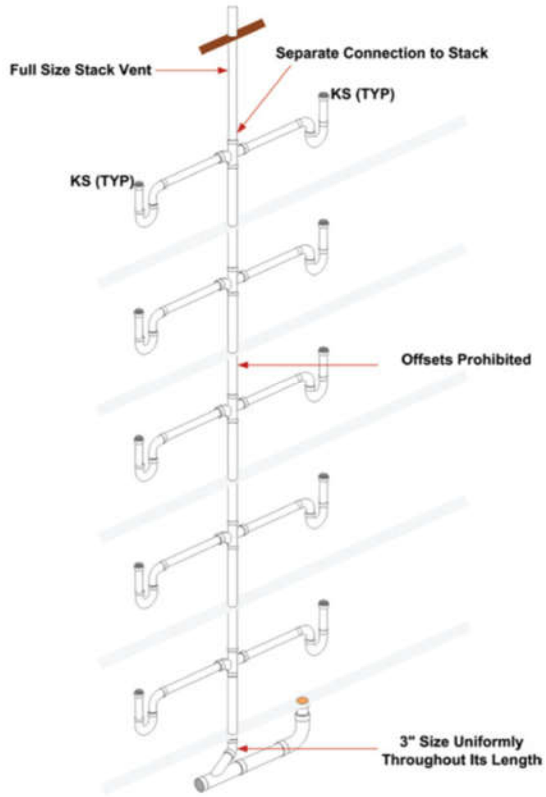
- Wet Vent

TABLE 912.3 WET VENT SIZE	
WET VENT PIPE SIZE (inches)	DRAINAGE FIXTURE UNIT LOAD (dfu)
$1^1/_2$	1
2	4
$2^1/_2$	6
3	12

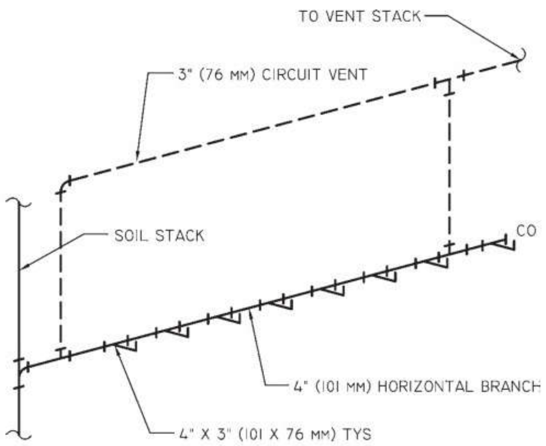


- Waste Vent

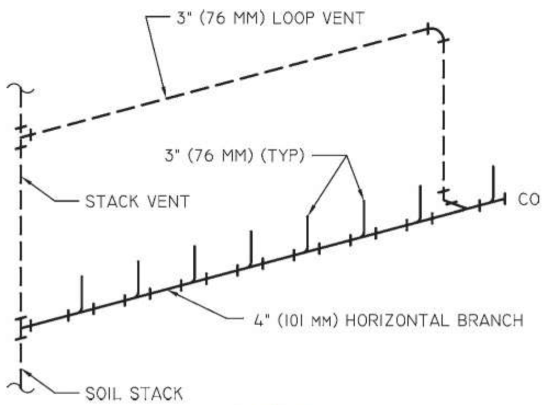
TABLE 913.4 WASTE STACK VENT SIZE		
STACK SIZE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)	
	Total discharge into one branch interval	Total discharge for stack
$1^1/_2$	1	2
2	2	4
$2^1/_2$	No limit	8
3	No limit	24
4	No limit	50
5	No limit	75
6	No limit	100

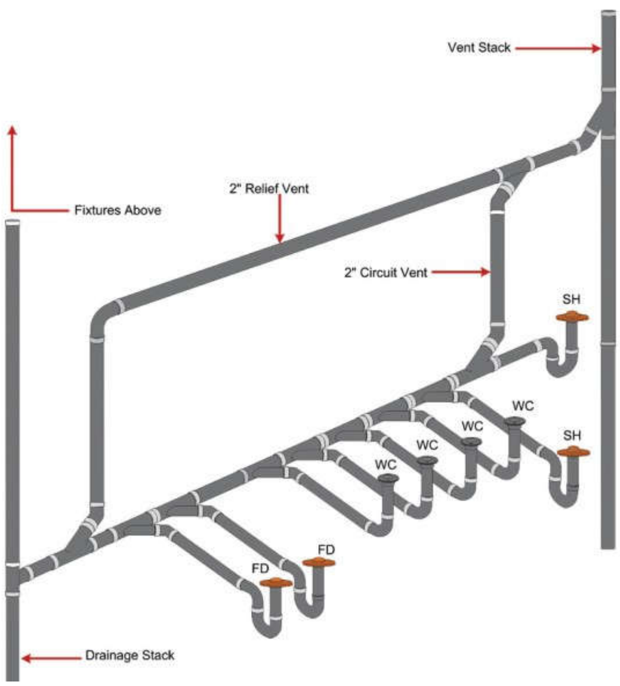


- Circuit Vent



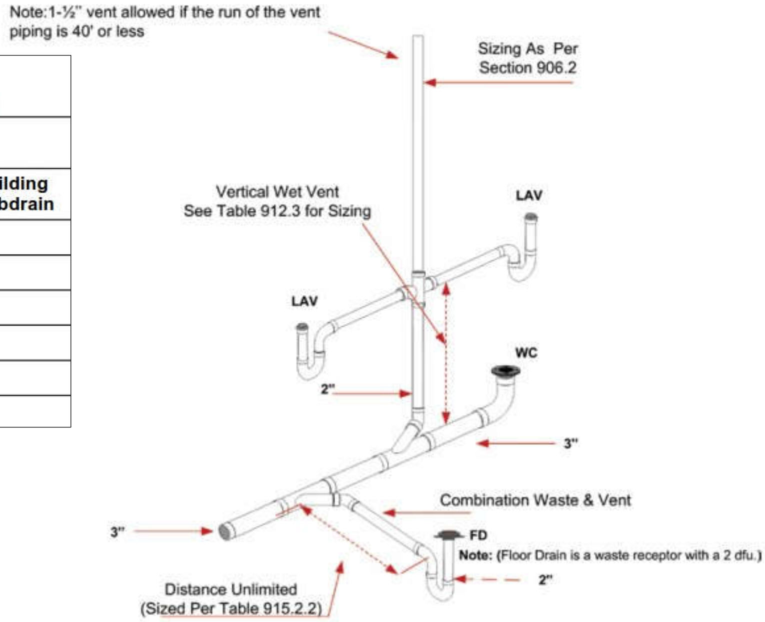
Circuit Vent



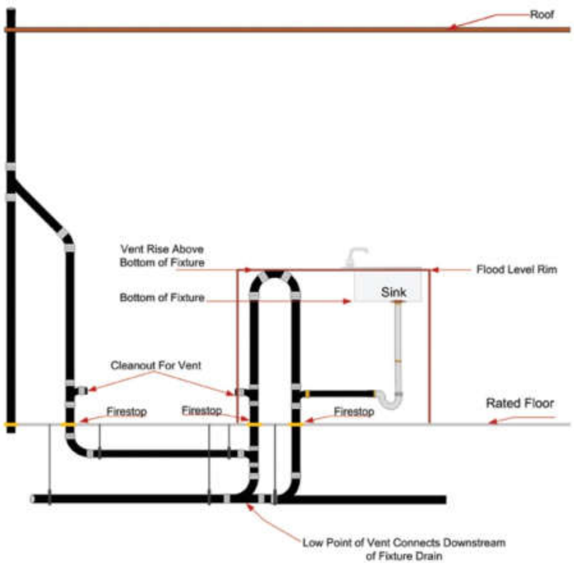


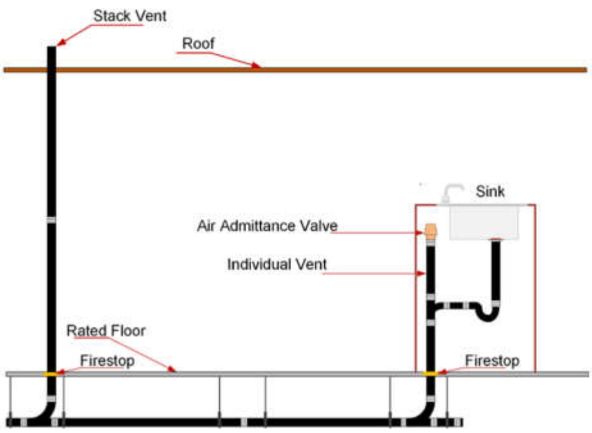
- Combination Waste and Vent

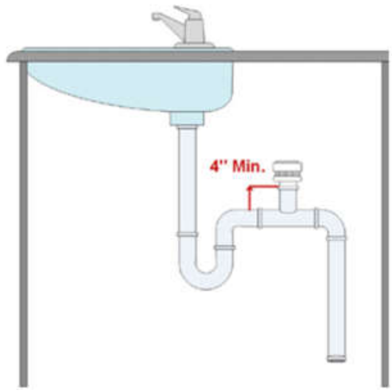
TABLE 915.2.2 SIZE OF COMBINATION WASTE AND VENT PIPE		
DIAMETER PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)	
	Connecting to a horizontal branch or stack	Connecting to a building drain or building subdrain
2	3	4
$2^1/_2$	6	26
3	12	31
4	20	50
5	160	250
6	360	575



- Island Vent







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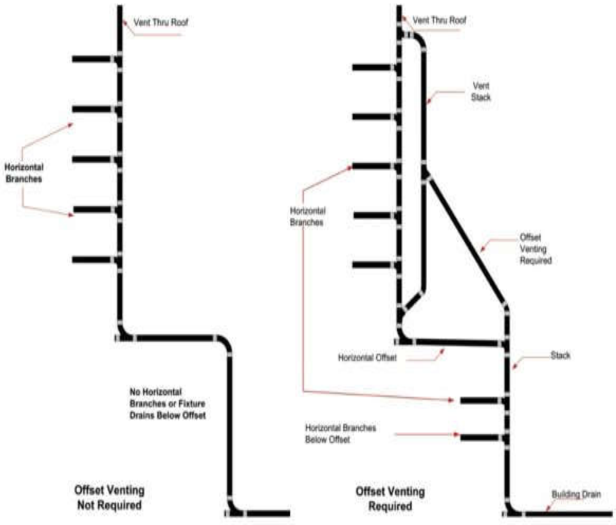
- Single Stack System

TABLE 917.2 SINGLE STACK SIZE			
STACK SIZE (inches)	MAXIMUM CONNECTED DRAINAGE FIXTURE UNITS		
	Stacks less than 75 feet in height	Stacks 75 feet to less than 160 feet in height	Stacks 160 feet and greater in height
3	24	NP	NP
4	225	24	NP
5	480	225	24
6	1,015	480	225
8	2,320	1,015	480
10	4,500	2,320	1,015
12	8,100	4,500	2,320
15	13,600	8,100	4,500



- Size and Developed Length of Stack Vents

Table 12.16 SIZE AND LENGTH OF VENTS										
Size of Fixture Drain, Drainge Stack, or Building Drain (inches)	Drainage Fixture Units Connected	Diameter of Vent Required (inches) for the Maximum Length of Vent (feet)								
		1-1/4"	1-1/2"	2"	2-1/2"	3"	4"	5"	6"	8"
1-1/4"	1	(1)								
1-1/2"	8	50	150							
2"	12	30	75	200						
2"	20	26	50	150						
3"	10		30	100	200	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					50	200	400	1300	
6"	620					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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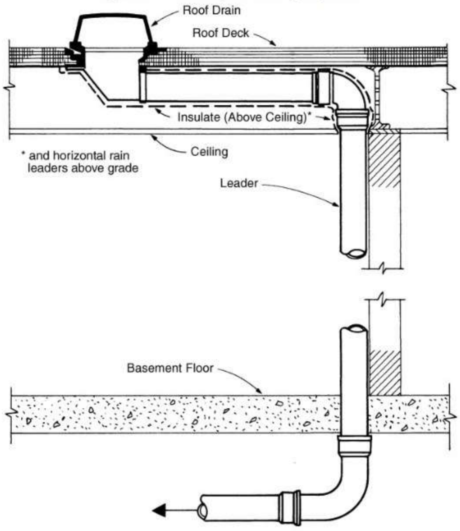
Storm Drainage Design

Q=CxIxAx0.0104

Figure 7-2 A Simple Drainage System



Roof Drain Vertical Leader Requirements for Horizontal Roof Areas at Various Rainfall Rate											
Leaders Pipe Size		Hourly Rainfall in Inches									
		1	$1^{1/2}$	2	$2^{1/2}$	3	4	5	6	7	8
		Roof Area Sq. Ft.									
2"	50	2,880	1,920	1,440	1,150	960	720	575	480	410	360
3"	82	8,880	5,860	4,400	3,520	2,930	2,200	1,760	1,470	1,260	1,100
4"	110	18,400	12,700	9,200	7,360	6,130	4,600	3,680	3,070	2,630	2,300
5"	125	34,600	23,050	17,300	13,840	11,530	8,650	6,920	5,765	4,945	4,325
6"	150	54,000	36,000	27,000	21,600	18,000	13,500	10,800	9,000	7,715	6,750
8"	200	116,000	77,400	58,000	46,400	38,680	29,000	23,200	19,315	16,570	14,500
Leaders Pipe Size		Hourly Rainfall in mm									
		25	40	50	65	75	100	125	150	175	200
		Roof Area Sq. mt.									
2"	50	268	178	134	107	89	67	53	45	38	33
3"	82	825	545	409	327	272	204	164	137	117	102
4"	110	1,710	1,180	855	684	570	428	342	285	244	214
5"	125	3,216	2,143	1,608	1,286	1,072	804	643	536	460	402
6"	150	5,019	3,346	2,510	2,008	1,673	1,255	1,004	837	717	627
8"	200	10,782	7,194	5,391	4,313	3,595	2,696	2,156	1,795	1,540	1,348

TABLE 1106.2
STORM DRAIN PIPE SIZING

PIPE SIZE (inches)	CAPACITY (gpm)				
	VERTICAL DRAIN	SLOPE OF HORIZONTAL DRAIN			
		$^1/_{16}$ inch per foot	$^1/_8$ inch per foot	$^1/_4$ inch per foot	$^1/_2$ inch per foot
2	34	15	22	31	44
3	87	39	55	79	111
4	180	81	115	163	231
5	311	117	165	234	331
6	538	243	344	487	689
8	1,117	505	714	1,010	1,429
10	2,050	927	1,311	1,855	2,623
12	3,272	1,480	2,093	2,960	4,187
15	5,543	2,508	3,546	5,016	7,093

TABLE 1106.6
HORIZONTAL GUTTER SIZING

GUTTER DIMENSIONS[a] (inches)	SLOPE (inch per foot)	CAPACITY (gpm)
$1^1/_2 \times 2^1/_2$	$^1/_4$	26
$1^1/_2 \times 2^1/_2$	$^1/_2$	40
4	$^1/_8$	39
$2^1/_4 \times 3$	$^1/_4$	55
$2^1/_4 \times 3$	$^1/_2$	87
5	$^1/_8$	74
$4 \times 2^1/_2$	$^1/_4$	106
$3 \times 3^1/_2$	$^1/_2$	156
6	$^1/_8$	110
3×5	$^1/_4$	157
3×5	$^1/_2$	225
8	$^1/_{16}$	172
8	$^1/_8$	247
$4^1/_2 \times 6$	$^1/_4$	348
$4^1/_2 \times 6$	$^1/_2$	494
10	$^1/_{16}$	331
10	$^1/_8$	472
5×8	$^1/_4$	651
4×10	$^1/_2$	1055

TABLE 1106.3
VERTICAL LEADER SIZING

SIZE OF LEADER (inches)	CAPACITY (gpm)
2	30
2×2	30
$1^1/_2 \times 2^1/_2$	30
$2^1/_2$	54
$2^1/_2 \times 2^1/_2$	54
3	92
2×4	92
$2^1/_2 \times 3$	92
4	192
$3 \times 4^1/_4$	192
$3^1/_2 \times 4$	192
5	360
4×5	360
$4^1/_2 \times 4^1/_2$	360
6	563
5×6	563
$5^1/_2 \times 5^1/_2$	563
8	1208
6×8	1208

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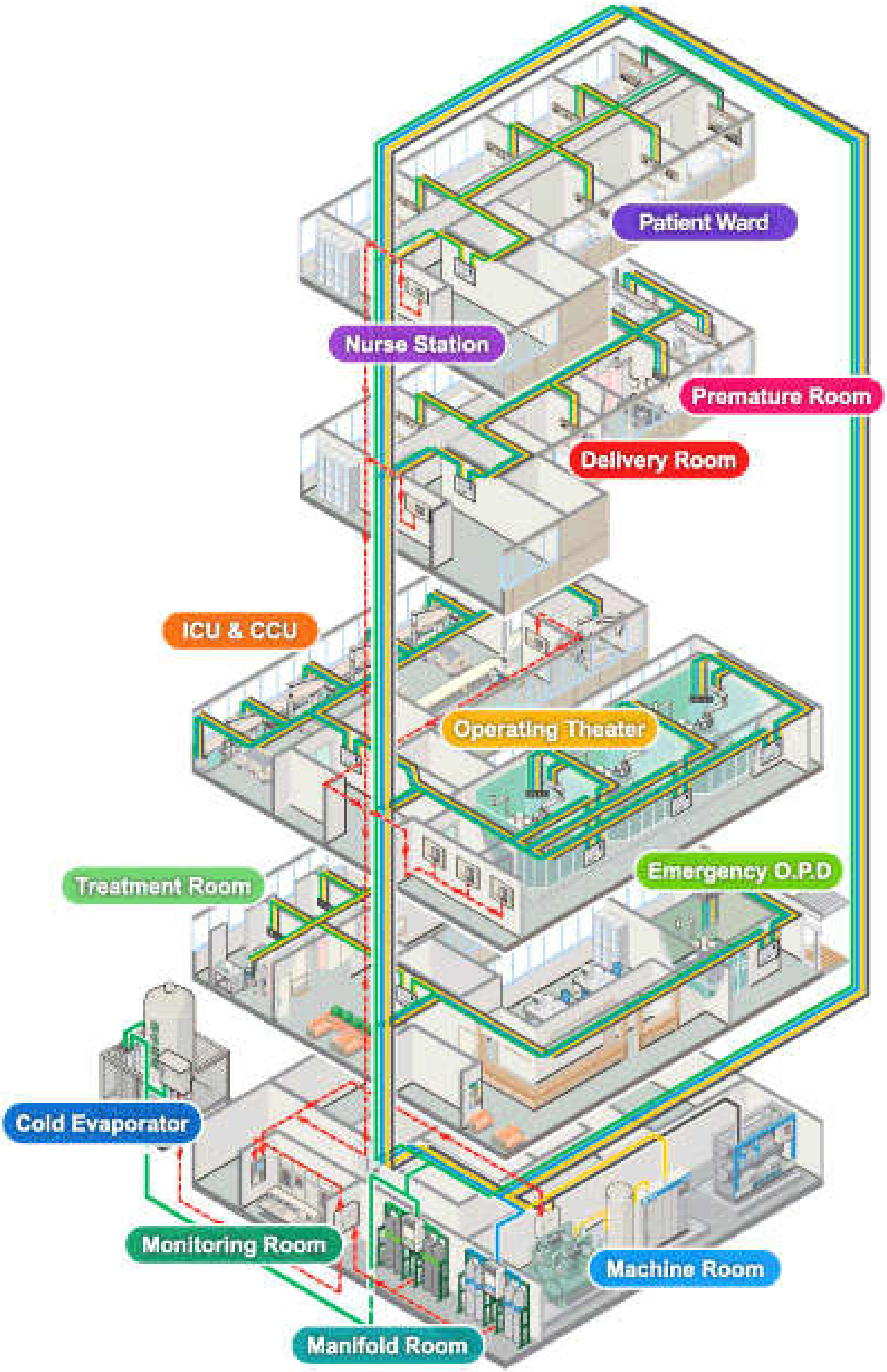
MEDICAL GAS NOTES



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MEDICAL GAS

- MEDICAL GAS:

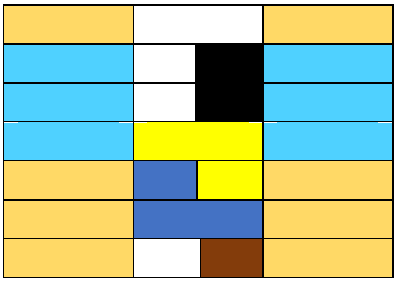
  - O_2 Oxygen
  - MA4 Medical Air
  - SA7 Surgical Air
  - MV Medical Vacuum
  - AGSS Anaesthetic Gas Scavenging Systems
  - N2O Nitrous Oxide
  - HE/O_2 Helium Oxygen

- GAS SOURCES:

SOURCE	O_2	MA4 / SA7	MV	AGSS	N2O
Primary	Fully Automatic Manifold	Duplex Compressor	Two Pumps Of A Triplex	Waste Anesthesia Gas Disposal (WAGD)	Fully Automatic Manifold Gas Cylinders
	Simplex, Duplex VIE	Two Compressors Of A Triplex Compressor			
	Liquid Cylinder PSA	Two Compressors Of A Quadruplex Compressor	Two Pumps Of A Quadruplex Pump		
Secondary	Manual Emergency Manifold	Automatic Manifold	Third Pumps Of A Triplex		Manual Emergency Manifold
	Automatic Manifold Second Vessel Duplex Vie	Third Compressor Of A Triplex Compressor			
	Automatic Manifold	Other Two Compressors Of A Quadruplex Compressor	Other Two Pumps Of A Quadruplex Pump		
Reserve	Automatic / Manual Manifold	Automatic Manifold	Portable Suction Equipment		Automatic / Manual Manifold

- PIPES SIZE:
  - Φ (12,15,22,28,35,42,54,67,76,108)
- COLOR CODE: HTM-02 A

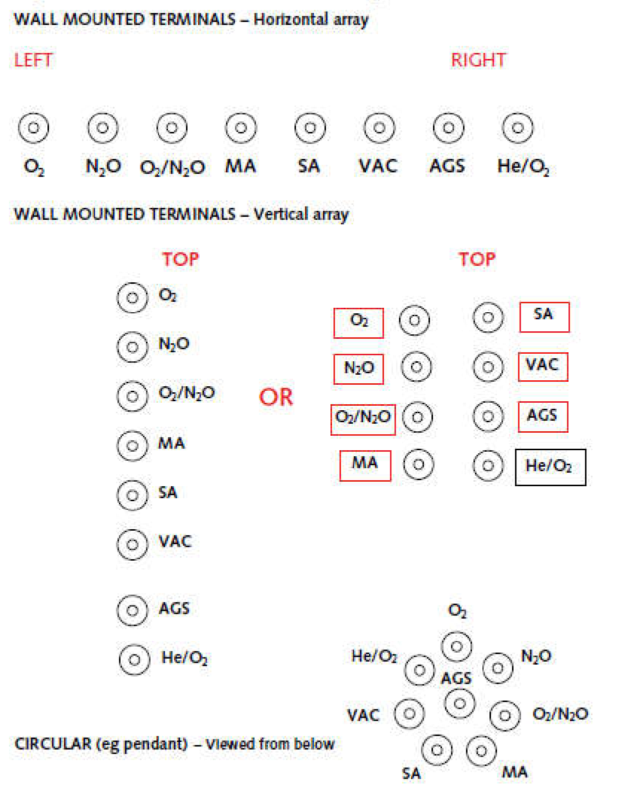
O_2
MA4
SA7
MV
AGSS
N2O
HE/O_2



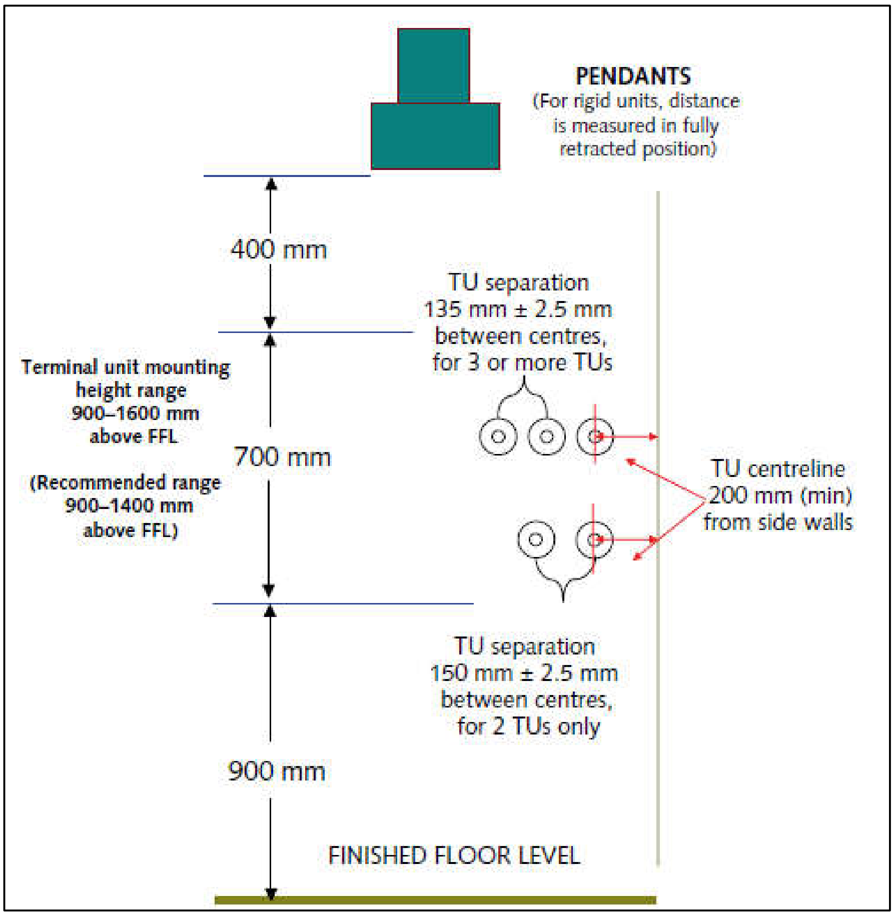
- PIPES SUPPORT:

Outside Diameter (mm)	Maximum interval between Supports (m)
Up to 15	1.5
22-28	2
35-54	2.5
> 54	3

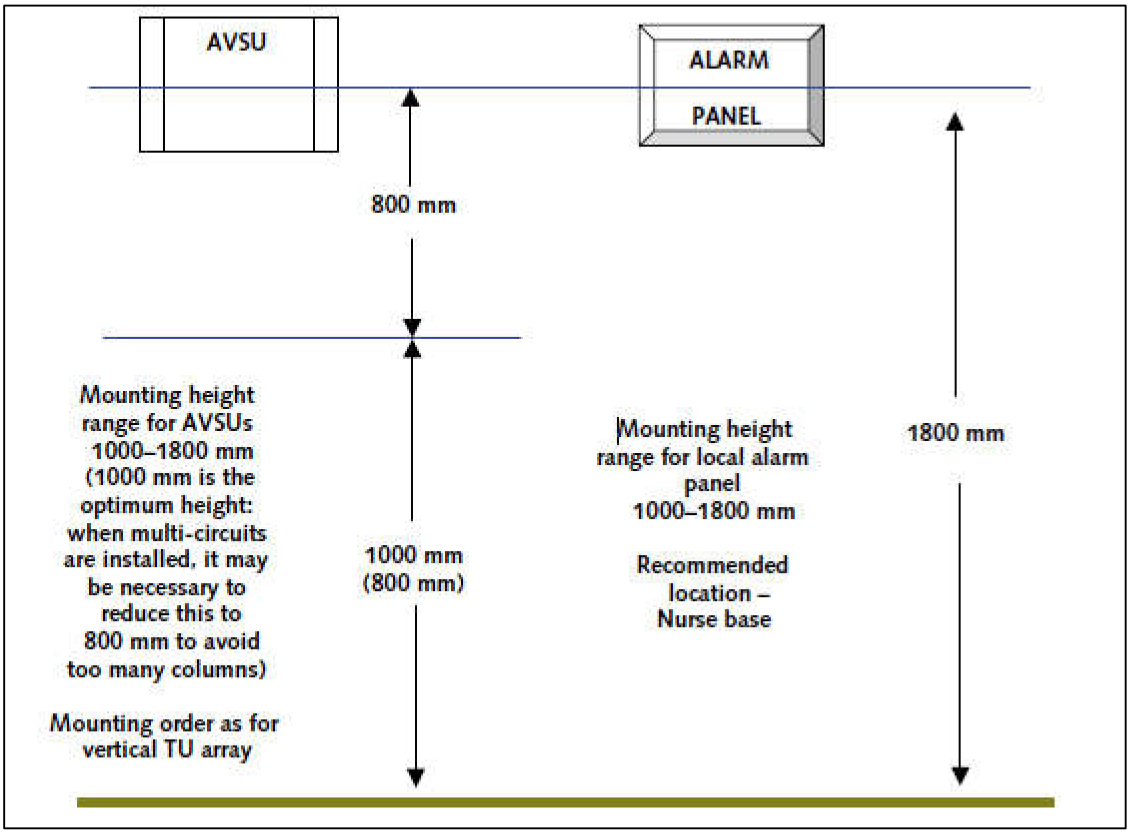
Figure 1 Terminal unit mounting order



- FIGURE 2 TERMINAL UNIT MOUNTING HEIGHTS:



- FIGURE 3 AVSU AND LOCAL ALARM PANEL MOUNTING HEIGHTS:



متطلبات الغازات للأقسام والغرف بالمستشفى

Department	القسم	O_2	N_2O	MA4	SA7	VAC	AGSS	AVSU
Accident and Emergency	قسم الطوارئ							1
Resuscitation room	غرفة الانعاش	2	2	2	-	2	2	2*
Treatment/Plaster room	غرفة العلاج الرئيسية	1	1	1	1	1	1	1
Post-anesthesia recovery	غرفة الافاقة من التخدير	2	-	2	-	2	-	2*
Treatment room/cubicle	غرفة تلقي العلاج	1	-	-	-	1	-	1
Operating department	قسم العمليات							1
Orthopedic	عمليات العظام	2	1	2	-	2	1	1
Neurosurgery	عمليات المخ والاعصاب	2	1	2	-	2	1	1
General surgery	الجراحة العامة	2	2	2	2	2	2	1
Post-anesthesia recovery	غرفة الافاقة من التخدير	2	-	2	-	2	-	2*
Equipment service room	غرفة أدوات الجراحة	1	1	1	1	1	1	1
Anesthetic room	غرفة التخدير	1	1	1	-	1	1	-
Maternity department	قسم الولادة							1
LDRP room	غرفة الولادة	1	-	-	-	2	-	1
Operating suite	جناح العمليات	1	1	1	-	1	1	1
In-patient accommodation	غرفة إقامة المرضي	1	-	-	-	1	-	1
Neonatal unit	وحدة العناية المركزية	2	-	2	-	2	-	2
Pediatrician	غرفة طبيب الأطفال	1	-	1	-	1	-	1
Nursery	غرفة التمريض	1	-	-	-	1	-	-
Obstetrician	غرفة اخصائي النساء والتوليد	-	-	-	-	2	-	1
Diagnostics department	قسم التشخيص							1
Special procedures room	غرفة الفحوصات الخاصة	1	1	1	-	1	1	1
Anesthetic room	غرفة التخدير	1	1	1	-	1	1	1
Holding and recovery	غرفة افاقة	1	-	1	-	1	-	1
Ultrasound	غرفة الموجات فوق الصوتية	1	-	-	-	1	-	1
Fluoroscopy	غرفة اشعة اكس	1	-	-	-	1	-	1
Urography	تصوير الجهاز البولي	1	-	-	-	1	-	1
Tomography	غرفة المناظير -مقطعي	1	-	-	-	1	-	1
MRI	الرنين المغناطيسي	1	1	1	-	1	1	1
Angiography	غرفة مناظير الاوعية الدموية	1	1	1	-	1	1	1
Endoscopy	غرفة مناظير الجهاز الهضمي	1	1	1	-	1	1	1
Single and multi-bedrooms	غرفة إقامة المرضي	1	-	1	-	1	-	1
Renal department	قسم الغسيل الكلوي							
Per dialysis station		1	-	1	-	1	-	
Per bed space		1	-	1	-	1	-	
Critical care area	قسم العناية المركزية							1
Per bed space	عناية مركزية	4	2	4	-	4	2	2*
CCU per bed space	عناية القلب	4	-	4	-	4	-	2*
HDU	العناية الحرجة	4	-	4	-	4	-	2*
Burns unit	وحدة الحروق	2	2	2	-	2	2	2*
Department	القسم	O_2	N_2O	MA4	SA7	VAC	AGSS	AVSU
Adult mental illness	قسم المخ والاعصاب							1

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ECT room	العلاج بالصدمات الكهربية	1	1	1	-	1	1	1
Post anesthesia recovery	غرفة الافاقة	1	-	1	-	1	-	1
Fracture Clinic	عيادات الكسور							
Plaster room	غرفة التجبير وعلاج الكسور	1	1	1	1	1	1	1
Oral surgery, orthodontic	جراحات الفم والاسنان							1
Consulting/treatment room	غرفة الكشف	1	1	1	1	1	1	1
Recovery room	غرفة الافاقة	1	-	-	1	1	-	1
Appliance laboratory	معمل معدات الجرحة	1	1	1	1	1	1	1
Sterile services department	قسم التعقيم							
Washroom	غرفة غسيل المعدات	-	-	1	1	-	-	
IAP room	غرفة فحص المعدات والتجميع والتغليف	1	-	1	1	-	-	1

Notes:

* Dual circuits.

† Dental vacuum only.

p = Project team option.

hp/lp = high-pressure and low-pressure alarms for oxygen, medical air and nitrous oxide

(1) Departmental AVSUs installed on the hospital street side of fire compartment doors.

(2) Installed immediately outside the room.

(4) In addition to the dual circuits, additional AVSUs will be required to sub-divide the number of terminal units controlled. This subdivision should be based on the layout of the accommodation; for example, if the recovery area is divided into several separate room/areas, each would have a separate sub-set (see Figures 4 and 5).

(5) This is intended to provide some flexibility and the exact number will depend on the total number of rooms within the department.

(6) If a high-dependency unit is included within general in-patient accommodation, a separate set of AVSUs should be provided for the unit. In addition to the departmental valves or the ward, an additional set will be required to control the single-bed, multi-bed, and treatment rooms.

(7) Department AVSUs may be required if the units are large and separate from, for example, the critical care area.

(8) Additional AVSUs may be required in a large unit: the aim should be to have about 8–12 rooms controlled by a set of valves – discretion is required to arrive at the logical number.

(9) Installed in reception area.

(10) Installed in the operating room in the "main panel" or within the room, or an anteroom, e.g., control room of an MRI device.

(11) Installed at the main staff base (nurses' station). (12) Installed in the room space with the AVSUs.
(13) Separate AVSUs will be required if endoscopy room is included.

Gas Source Volume Consumption

1- Oxygen - O_2

Q-Diversified Flow for Department, Qw - Diversified Flow for Ward

Table 13 Oxygen: design and diversified flows

Department	Design flow for each terminal unit (L/min)	Diversified flow *Q* (L/min)
In-patient accommodation (ward units):		
Single 4-bed rooms and treatment room	10	$Q_w = 10 + [(n-1)6/4]$
Ward block/department	10	$Q_d = Q_w[1 + (nW-1)/2]$
Accident & emergency:		
Resuscitation room, per trolley space	100	$Q = 100 + [(n-1)6/4]$
Major treatment/plaster room, per trolley space	10	$Q = 10 + [(n-1)6/4]$
Post-anaesthesia recovery, per trolley space	10	$Q = 10 + [(n-1)6/8]$
Treatment room/cubicle	10	$Q = 10 + [(n-1)6/10]$
Operating:		
Anaesthetic rooms	100	Q = no addition made
Operating rooms	100	$Q = 100 + (nT-1)10$
Post-anaesthesia recovery		$Q = 10 + (n-1)6$
Maternity:		
LDRP rooms:		
Mother	10	$Q = 10 + [(n-1)6/4]$
Baby	10	$Q = 10 + [(n-1)3/2]$
Operating suites:		
Anaesthetist	100	$Q = 100 + (nS-1)6$
Paediatrician	10	$Q = 10 + (n-1)3$
Post-anaesthesia recovery	10	$Q = 10 + [(n-1)3/4]$
In-patient accommodation:		
Single/multi-bed wards	10	$Q = 10 + [(n-1)6/6]$
Nursery, per cot space	10	$Q = 10 + [(n-1)3/2]$
Special care baby unit	10	$Q = 10 + (n-1)6$
Radiological:	100	$Q = 10 + [(n-1)6/3]$
All anaesthetic and procedures rooms		
Critical care areas	10	$Q = 10 + [(n-1)6]3/4$
Coronary care unit (CCU)	10	$Q = 10 + [(n-1)6]3/4$
High-dependency unit (HDU)	10	$Q = 10 + [(n-1)6]3/4$
Renal	10	$Q = 10 + [(n-1)6/4]$
CPAP ventilation	75	$Q = 75n \times 75\%$
Adult mental illness accommodation:		
Electro-convulsive therapy (ECT) room	10	$Q = 10 + [(n-1)6/4]$
Post-anaesthesia, per bed space	10	$Q = 10 + [(n-1)6/4]$
Adult acute day care accommodation:		
Treatment rooms	10	$Q = 10 + [(n-1)6/4]$
Post-anaesthesia recovery per bed space	10	$Q = 10 + [(n-1)6/4]$
Day patient accommodation (as "In-patient accommodation")		As "In-patient accommodation"
Oral surgery/orthodontic:		
Consulting rooms, type 1	10	$Q = 10 + [(n-1)6/2]$
Consulting rooms, types 2 & 3	10	$Q = 10 + [(n-1)6/3]$
Recovery room, per bed space	10	$Q = 10 + [(n-1)6/6]$
Out-patient:		
Treatment rooms	10	$Q = 10 + [(n-1)6/4]$
Equipment service rooms, sterile services etc	100	Residual capacity will be adequate without an additional allowance

n- number of beds, nS–number of operating suits, nW-number of wards, nT-number of theatres

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Annual O2 consumption = Q (L/min) x 60 x 10 (hr.) x 365 /1000= m³/year

6.21- The maximum potential daily demand should be based on the peak flow condition between 8.00 am and 6.00 pm

Gas Source	Annual Consumption (m³/year)
Manifold Gas Cylinder	Less Than 3000
Liquid Cylinder	From 3000: 40000
Bulk VIE	From 27500: 40000
PSA Plant	Far from Supplier

Primary Source

- Volume = Q (L/min) x 60 x 10 (hr.) x Storage days x NGF = Liter
  - Storage days
- 6.124- The 1997 edition of HTM 2022 defined a (fixed) VIE primary vessel capacity of 14 days' oxygen supply
  - NGF
    - 8:10%
- No. of cylinders = Volume / 6540 = Liters - Gas
- Liquid Volume = Gas Volume / 840 = Liters – Liquid

6.160 The table below provides a matrix for the calculation of primary reserve stock based upon distance from gas supplier and fitting of telemetry.

Kilometres from gas supply depot	No telemetry (no of days' stock)	Telemetry fitted (no of days' stock)
Up to 75	5	3
75–150	6	4
150–300	7	5
Over 300	8	6

Secondary Source

- Volume = Q (L/min) x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 6540 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

Third Source (Reserve)

- Volume = Q (L/min) High dependency areas x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 6540 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

High dependency areas

LDRP Mother Room - Critical Care Areas - Special Care Baby Unit - Pediatrician Room- Operating Room

Table 2-10 Exterior Bulk Oxygen-Storage Installation Criteria

Bulk Tank Separation Distances, ft (m)	Item
1 (0.30)	Building structure (except wood frame)
5 (1.52)	Property line
10 (3.05)	Parked vehicles, sidewalk, structure openings
15 (4.57)	All classes of flammable and combustible liquids stored below ground. Class III B liquid, 1000 gal (3785 L) or less, above-ground storage.
25 (7.62)	Solid slow-burning material, coal, lumber, etc., underground tank vent or fill openings. Above-ground flammable and combustible liquids, 1000 gal (3785 L) or less, except Class III B liquids.
35 (10.67)	Clearance for ventilation one side.
50 (15.24)	Public assembly area, open or enclosed. Wood-frame structure. Non-ambulatory patient area.
75 (22.86)	Liquefied hydrogen storage above ground. Clearance for ventilation one side.
25 (7.62)	1000 gal (3785 L) liquefied gas or 25,000 ft³ (700 m³) non-liquefied gas.
50 (15.24)	Over 1000 gal (3785 L) of liquefied gas or over 25,000 ft³ (700 m³) of non-liquefied gas.

Source: NFPA no. 50.

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2- Nitrous Oxide - N_2O

Table 15 Nitrous oxide: design and diversified flows

Department	Design flow for each terminal unit (L/min)	Diversified flow Q (L/min)
Accident & emergency: resuscitation room, per trolley space	10	$Q = 10 + [(n-1)6/4]$
Operating	15	$Q = 15 + (nT - 1)6$
Maternity: operating suites	15	$Q = 15 + (nS - 1)6$
Radiological: all anaesthetic and procedures rooms	15	$Q = 10 + [(n-1)6/4]$
Critical care areas	15	$Q = 10 + [(n-1)6/4]$
Oral surgery/orthodontic: consulting rooms, type 1	10	$Q = 10 + [(n-1)6/4]$
Other departments	10	No additional flow included
Equipment service rooms	15	No additional flow included

Primary Source

- Volume = Q (L/min) x 60 x 10 (hr.) x Storage days = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 8900 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2Day.]

6.160 The table below provides a matrix for the calculation of primary reserve stock based upon distance from gas supplier and fitting of telemetry.

Kilometres from gas supply depot	No telemetry (no of days' stock)	Telemetry fitted (no of days' stock)
Up to 75	5	3
75–150	6	4
150–300	7	5
Over 300	8	6

Secondary Source and Third Source

- Volume = Q (L/min) x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 8900 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

3- Nitrous Oxide/Oxygen Mixture -(N_2O/O_2)

Table 16 Nitrous oxide/oxygen mixtures – design and diversified flows

Department	Design flow for each terminal unit (L/min)	Diversified flow Q (L/min)
Maternity: <12 LDRP room(s), mother >12 LDRP rooms	275	$Q = 275 + [(n-1)6/2]$ $Q = 275 \times 2 + [(n-1)6/2]$
Other areas	20	$Q = 20 + [(n-1)10/4]$
Equipment service rooms	275	No additional flow included

Primary Source

- Volume = Q (L/min) x 60 x 10 (hr.) x Storage days = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 4740 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2Day.]

Secondary Source and Third Source

- Volume = Q (L/min) x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 4740 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

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4- Medical Air -MA4

Table 18 Medical air 400 kPa – design and diversified flows

Department	Design flow for each terminal unit (L/min)	Diversified flow Q (L/min)
In-patient accommodation (ward units):		
Single/multi-bed and treatment rooms[1]	20	$Q_w = 20 + [(n-1)10/4]$
Ward block/department	20	$Q_d = Q_w[1 + (nW-1)/2]$
Accident & emergency:		
Resuscitation room, per trolley space	40	$Q = 40 + [(n-1)20/4]$
Major treatment/plaster room, per trolley space	40	$Q = 40 + [(n-1)20/4]$
Post-anaesthesia recovery, per trolley space	40	$Q = 40 + [(n-1)40/4]$
Operating:		
Anaesthetic rooms	40	No additional flow included
Operating rooms	40	$Q = 40 + [(nT-1)40/4]$
Post-anaesthesia recovery	40	$Q = 40 + [(n-1)10/4]$
Maternity:		
LDRP rooms:	40	$Q = 40 + [(n-1)40/4]$
Baby[2]	40	$Q = 40 + [(n-1)40/4]$
Operating suites:		
Anaesthetist	40	$Q = 40 + [(nS-1)10/4]$
Post-anaesthesia recovery	40	$Q = 40 + [(n-1)40/4]$
Neonatal unit (SCBU)	40	$Q = 40n$
Radiological:		
All anaesthetic and procedures rooms	40	$Q = 40 + [(n-1)40/4]$
Critical care areas[3]	80	$Q = 80 + [(n-1)80/2]$
High-dependency units	80	$Q = 80 + [(n-1)80/2]$
Renal	20	$Q = 20 + [(n-1)10/4]$
Oral surgery/orthodontic:		
Major dental/oral surgery rooms	40	$Q = 40 + [(n-1)40/2]$
All other departments	40	No additional flow allowance to be made
Equipment service rooms	40	No additional flow included

Primary Source
- Compressor flow= Q (L/min)
- No. of compressors is 2 for even (Duplex or triplex or quadruplex)
- Air Vessel (Receiver) volume = Compressor flow (L/min) x 0.5 x 1 (minute)
- Use one duty receiver, if flow > 500L/min use two
- Using duplex dryer

Secondary Source
- Volume = Q (L/min) x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 6220 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

Third Source (Reserve)
- Volume = Q (L/min) High dependency areas x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 6220 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

➢ ملحوظة:
- في حالة كان النظام Triplex or Quadruplex يكون احد عدد 2 ضواغط أساسي والباقي يكون ثانوي
- ويكون المصدر الثالث أسطوانات على الاحتياج الكلي للهواء تكفي لعمل 4 ساعات

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5- Surgical Air -SA7

Table 20 Surgical air 700 kPa – design and diversified flows

Department	Design flow for each terminal unit (L/min)	Diversified flow Q (L/min)
Operating room (orthopaedic and neurosurgical operating rooms only): <4 operating rooms >4 operating rooms	 350 350	 $Q = 350 + [(n-1)350/2]$ $Q = 350 + [(n-1)350/4]$
Other departments, eg equipment workshops, fracture clinic	350	$Q = 350$
Equipment service rooms	350	No additional flow required

Table 19 Typical pressure and flow requirements for surgical tools

Type of tool	Pressure (kPa)	Flow (L/min)
Small air drill	600–700	200
Medullary reaming machine	600–700	350
Oscillating bone saw	600–700	300
Universal drill	600–700	300
Craniotome	620–750	300

Primary Source

- Compressor flow= Q (L/min) x Factor (0.33:0.66)
- No. of compressor is 1 for even (Simplex or Duplex)
- Air Vessel (Receiver) volume = from table according to design flow
- Use one duty receiver.
- Using Simplex dryer

Design flow (L/min)	Vessel size	Compressor output (L/min)
>500	1 × 200% design flow	0.33 × design flow
500–2000	2 × 66.6% design flow	0.66 × design flow
2000–3500	2 × 200% design flow	0.66 × design flow
3500–7000	3 × 33.3% design flow	0.5 × design flow

Secondary Source

- Volume = Q (L/min) x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 6220 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

Third Source (Reserve)

- Volume = Q (L/min) x 60 x 4 (hr.) = Liter
- No. of cylinders = Volume / Cylinder volume = Volume / 6220 (Liter)
- No. of cylinder banks = 2 (right & left) [Each bank 2hr.]

➢ ملحوظة:

- في حالة كان النظام Duplex يكون احد عدد 1 ضواغط أساسي والاخر يكون ثانوي

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6- Vacuum Air -VA

Table 21 Vacuum – design and diversified flows

Department	Design flow for each terminal unit (L/min)	Diversified flow Q (L/min)
In-patient accommodation:		
Ward unit	40	$Q = 40$
Multiple ward units	40	$Q_d = 40 + [(n-1)40/4]$
Accident & emergency:		
Resuscitation room, per trolley space	40	$Q = 40 + [(n-1)40/4]$
Major treatment/plaster room, per trolley space	40	$Q = 40 + [(n-1)40/4]$
Post-anaesthesia recovery, per trolley space	40	$Q = 40 + [(n-1)40/4]$
Treatment room/cubicle	40	$Q = 40 + [(n-1)40/8]$
Operating:		
Anaesthetic rooms	40	No additional flow included
Operating rooms:		
Anaesthetist	40	$Q = 40$
Surgeon	40	$Q = 40$
Operating suites	40	$Q_s = 80 + [(nS-1)80/2]$
Post-anaesthesia recovery	40	$Q = 40 + [(n-1)40/4]$
Maternity:		
LDRP rooms:		
Mother	40	$Q = 40 + [(n-1)40]/4$
Baby	40	No additional flow included
Operating suites:		
Anaesthetist	40	$Q = 40$
Obstetrician	40	$Q = 40$
Operating suites		$Q_s = 80 + [(nS-1)80/2]$
Post-anaesthesia recovery	40	$Q = 40 + [(n-1)40/4]$
In-patient accommodation:		
Ward unit comprising single, multi-bed and treatment room	40	$Q = 40$
Multi-ward units	40	$Q = 40 + [(n-1)40/2]$
Nursery, per cot space	40	No additional to be included
SCBU	40	$Q = 40 + [(n-1)40/4]$
Radiology/diagnostic departments:		
All anaesthetic and procedures rooms	40	$Q = 40 + [(n-1)40/8]$
Critical care areas	40	$Q = 40 + [(n-1)40/4]$
High-dependency units	40	$Q = 40 + [(n-1)40/4]$
Renal	40	$Q_d = 40 + [(n-1)40/4]$
Adult mental illness accommodation:		
ECT room	40	$Q = 40 + [(n-1)40/4]$
Post-anaesthesia, per bed space	40	$Q = 40 + [(n-1)40/4]$
Adult acute day care accommodation:		
Treatment rooms	40	$Q = 40 + [(n-1)40/4]$
Post-anaesthesia recovery per bed space	40	$Q = 40 + [(n-1)40/8]$
Day patient accommodation (as "In-patient accommodation")		As "In-patient accommodation"
Oral surgery/orthodontic:		
Consulting rooms, type 1	40	Dental vacuum only
Consulting rooms, types 2 & 3	40	Dental vacuum only
Recovery room, per bed space	40	$Q = 40 + [(n-1)40/8]$
Out-patient:		
Treatment rooms	40	$Q = 40 + [(n-1)40/8]$
Equipment service rooms, sterile services etc	40	Residual capacity will be adequate without an additional allowance

Primary Source and Secondary

- Pump flow= Q (L/min)
- Pump pressure = 60kpa
- Vessel volume = Pump flow (L/min) X 1 (minute)

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7- AGSS

Department	Design flow for each terminal unit (L/min)	Diversified flow Q (L/min)
Accident & emergency resuscitation room (per trolley space)	$V^{(1)}$	$Q = V + [(n-1)V/4]$
Operating departments	V	$Q = V + (nT-1)V$
Maternity operating suites	V	$Q = V + (nS-1)V$
Radiodiagnostic (all anaesthetic and procedures room)	V	$Q = V + [(n-1)V/4]$
Oral surgery/orthodontic consulting rooms (type 1)	V	$Q = V + [(n-1)V/4]$
Other departments	V	$Q = V + [(n-1)V/8]$

Note:

1. For the purpose of sizing the AGS disposal system pump, V is taken as either 130 L/min or 80 L/min (see paragraph 10.16).

Primary Source and Secondary

- Pump flow = Q (L/min)
- No. of vacuum pumps is two (One duty + One standby)

Notes:

If duplex pump selected one of them is duty and other is standby

if simplex pump selected another one shall be provided as standby

Table 10 Suggested sizes for gas sources

Source	Service	Number of cylinders	Cylinder size	Notes
Automatic manifold	Oxygen	2 x 10	J	Used as a stand-alone manifold or support for cryogenic system/PSA plant
	Medical air	2 x 10	J	Used as a stand-alone manifold or support for compressor plant
	Surgical air	2 x 6	J	
	Oxygen/nitrous oxide mixture	2 x 8	G	
	Nitrous oxide	2 x 6	G	
	Carbon dioxide	2 x 4	VF	
	Helium/oxygen	2 x 4	H	
	Nitrogen	2 x 6	W	
Manual manifold	Oxygen	2 x 2	J	As secondary supply for an automatic manifold system
	Medical air	2 x 2	J	
	Surgical air	2 x 1	J	
	Oxygen/nitrous oxide mixture	2 x 2	G	
	Nitrous oxide	2 x 2	G	
	Carbon dioxide	2 x 1	VF	
	Helium/oxygen	2 x 1	H	
	Nitrogen	2 x 2	W	

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Outlets and Pipes Sizing

1- French Standard Medical Gas Outlet

2- German Medical Gas Outlet

3- English Medical Gas Outlet

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Wall Mounted Outlets

Bed Head Unit Outlets

Multi Movement Electric Single Arm Pendant

Pressure Drop from Source to Outlet

Nominal Pressure	Plant Pressure	Pressure Safety	Alarm High	Alarm Low	Alarm Local	Minimum Pressure Outlet
4 bars	420 KPA	530 KPA	500 KPA	370 KPA	360 KPA	370 KPA
7 bars	850 KPA	1100 KPA	1050 KPA	650 KPA	650 KPA	700 KPA
-VA	60 KPA			48 KPA	37 KPA	40 KPA

A- 4 Bar Gases:

- Pressure at source of supply = 420 Kpa.
- Pressure at most remote outlet = 370 Kpa.
- Maximum pressure drop = 50 Kpa.
- Pressure drops from Source to Riser = 7 Kpa.
- Pressure drops through Riser = 7 Kpa.
- Pressure drops from Riser to most remote outlet = 7 Kpa.
- Pressure drops through Outlet = 21 Kpa.
- Total pressure drops in Piping = 42 Kpa.

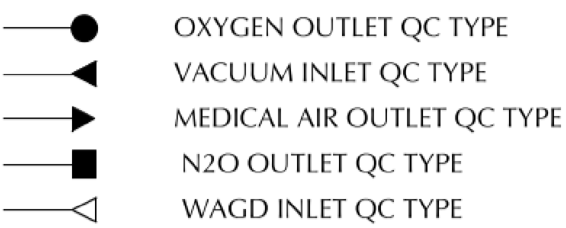
B- 7 Bar Gases:

- Pressure at source of supply = 850 Kpa.
- Pressure at most remote outlet = 700 Kpa.
- Maximum pressure drop = 150 Kpa.
- Pressure drops from Source to Riser = 40 Kpa.
- Pressure drops through Riser = 40 Kpa.
- Pressure drops from Riser to most remote outlet = 40 Kpa.
- Pressure drops through Outlet = 21 Kpa.
- Total pressure drops in Piping = 141 Kpa.

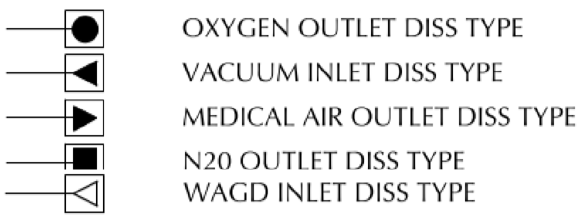
C- Vacuum Gases:

- Pressure at source of supply = 60 Kpa.
- Pressure at most remote outlet = 40 Kpa.
- Maximum pressure drop = 20 Kpa.
- Pressure drops from Source to Riser = 2.5:5 Kpa.
- Pressure drops through Riser = 2.5:5 Kpa.
- Pressure drops from Riser to most remote outlet = 5:10 Kpa.
- Total pressure drops in Piping = 15 Kpa.

(English Outlet)



(French Outlet)



Mono system (English Method – HTM)   Dual system (French Method – Afnor)

Table A2 Pipeline pressure loss: 400 kPa (4 bar) pipelines

British Standard Size Tube BS EN 1057: R250, Table X		Distance from source (m) at 400 kPa for 7, 14, 21 kPa (1, 2, 3 psi) pressure loss																
Outside Diameter (mm)	Pressure loss (kPa)	8	15	30	61	91	122	152	183	213	244	274	305	335	366	396	427	457
		Free air flow rate (L/min)																
12	7	311	209	141	95	75	64	56	50	46	43	40	37	35	34	32	31	30
	14	455	307	207	139	110	94	82	74	68	63	59	55	52	50	47	45	44
	21	564	382	258	174	138	117	103	93	85	78	73	69	65	62	59	57	55
15	7	579	391	263	177	140	119	105	94	86	80	75	70	66	63	60	58	56
	14	845	572	386	260	207	175	154	139	127	118	110	104	98	93	89	85	82
	21	1038	711	481	325	258	219	192	173	159	147	137	129	122	117	111	107	102
22	7	1677	1135	768	518	411	349	307	277	254	235	220	207	196	186	178	170	164
	14	2441	1656	1123	759	604	513	451	407	373	345	323	304	288	274	262	251	241
	21	3023	2053	1395	945	751	638	562	507	465	431	403	379	359	342	326	313	301
28	7	3363	2283	1547	1047	832	706	622	560	514	476	445	419	397	378	361	346	332
	14	4881	3320	2257	1530	1218	1035	912	823	754	699	653	615	583	555	530	508	488
	21	6034	4109	2800	1901	1514	1287	1135	1024	938	870	814	767	726	691	660	633	609
35	7	6023	4096	2783	1886	1500	1275	1124	1013	928	861	805	758	718	683	653	626	602
	14	8720	5943	4051	2752	2192	1865	1644	1483	1360	1261	1180	1111	1053	1002	957	918	883
	21	10758	7344	5018	3415	2723	2317	2044	1845	1692	1569	1468	1383	1310	1248	1192	1143	1099
42	7	10103	6883	4685	3180	2533	2154	1899	1713	1570	1456	1362	1283	1215	1157	1105	1060	1019
	14	14587	9963	6806	4633	3694	3145	2775	2504	2296	2130	1993	1878	1780	1694	1619	1553	1493
	21	17963	12290	8421	5743	4584	3904	3446	3112	2855	2648	2478	2335	2213	2107	2014	1932	1858
54	7	14974	10588	7487	5294	4323	3743	3348	3056	2830	2647	2496	2368	2257	2161	2076	2001	1933
	14	21176	14974	10588	7487	6113	5294	4735	4323	4002	3743	3529	3348	3192	3056	2937	2830	2734
	21	25935	18339	12968	9169	7487	6484	5799	5294	4901	4585	4323	4101	3910	3743	3597	3466	3348
76	7	37754	26696	18877	13348	10899	9438	8442	7706	7135	6674	6292	5969	5692	5449	5236	5045	4874
	14	53392	37754	26696	18877	15413	13348	11939	10899	10090	9438	8899	8442	8049	7706	7404	7135	6893
	21	65392	46239	32696	23119	18877	16348	14622	13348	12358	11560	10899	10339	9858	9438	9068	8738	8442

Table A3 Pipeline pressure loss: 700 kPa (7 bar) pipelines

British Standard Size Tube BS EN 1057: R250, Table X		Distance from source (m) at 700 kPa for 7, 14, 34 kPa (1, 2, 5 psi) pressure loss																
Outside Diameter (mm)	Pressure loss (kPa)	8	15	30	61	91	122	152	183	213	244	274	305	335	366	396	427	457
		Free air flow rate (L/min)																
12	7	408	276	186	125	99	84	74	67	61	56	53	50	47	45	43	41	39
	14	599	405	274	185	147	124	109	99	90	84	78	74	70	66	63	61	58
	34	979	664	450	304	242	205	181	163	149	138	129	122	115	110	105	100	96
15	7	759	514	347	234	186	158	139	125	114	106	99	93	88	84	80	77	74
	14	1112	754	510	345	274	232	205	184	169	156	146	138	130	124	118	114	109
	34	1811	1231	836	566	450	383	337	304	279	258	242	227	215	205	196	188	180
22	7	2192	1488	1009	682	542	460	406	366	335	310	290	273	259	246	235	225	217
	14	3198	2175	1478	1001	797	677	597	538	493	457	428	403	381	363	347	332	320
	34	5180	3533	2410	1638	1306	1111	980	884	811	752	704	663	628	598	571	548	527
28	7	4387	2984	2027	1374	1093	929	819	739	677	628	587	553	524	498	476	456	439
	14	6382	4351	2963	2013	1604	1364	1203	1086	995	923	863	813	771	734	701	672	646
	34	10290	7038	4816	3283	2620	2232	1970	1779	1632	1514	1417	1335	1266	1205	1152	1105	1063
35	7	7841	5345	3638	2470	1968	1674	1476	1332	1221	1132	1059	998	945	900	860	825	793
	14	11380	7775	5307	3612	2881	2453	2165	1954	1792	1662	1556	1466	1389	1323	1264	1212	1166
	34	18271	12528	8599	5876	4696	4003	3536	3194	2931	2720	2547	2401	2276	2168	2073	1988	1912
42	7	13128	8964	6113	4159	3316	2823	2490	2248	2061	1912	1789	1686	1598	1521	1454	1394	1341
	14	19010	13012	8901	6070	4847	4129	3646	3293	3021	2803	2624	2473	2344	2232	2134	2047	1969
	34	30392	20892	14381	9849	7881	6723	5942	5371	4930	4577	4286	4042	3833	3651	3491	3349	3223

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Table A4 Pipeline pressure loss: 1100 kPa (11 bar) pipelines

British Standard Size Tube BS EN 1057: R250, Table X		Distance from source (m) at 1100 kPa for 7, 14, 34 kPa (1, 2, 5 psi) pressure loss																
Outside Diameter (mm)	Pressure loss (kPa)	8	15	30	61	91	122	152	183	213	244	274	305	335	366	396	427	457
		Free air flow rate (L/min)																
12	7	487	356	252	177	144	124	112	102	94	88	84	79	75	72	69	67	65
	14	689	503	355	249	204	177	158	144	133	124	118	111	106	102	98	94	91
	34	1084	791	560	392	321	277	249	227	210	197	185	176	167	161	154	148	143
15	7	867	634	448	314	257	222	199	181	168	157	148	141	134	128	124	119	115
	14	1226	895	633	444	363	314	281	257	238	222	209	199	189	181	174	168	162
	34	1929	1409	996	698	572	494	443	403	373	350	330	313	298	285	275	264	256
22	7	2332	1703	1205	845	692	598	535	487	452	423	399	378	360	345	332	319	309
	14	3294	2405	1701	1193	977	844	755	689	638	597	562	534	509	487	468	451	436
	34	5185	3787	2678	1878	1537	1328	1189	1084	1005	939	886	840	801	767	737	710	686
28	7	4469	3263	2308	1618	1325	1145	1025	935	866	809	764	724	691	660	636	612	591
	14	6311	4608	3259	2286	1872	1616	1448	1320	1223	1143	1078	1022	976	933	897	864	835
	34	9935	7255	5130	3598	2946	2544	2279	2077	1926	1799	1698	1609	1535	1469	1412	1359	1315
35	7	7718	5636	3985	2795	2289	1976	1771	1614	1495	1397	1319	1250	1192	1141	1097	1056	1021
	14	10898	7959	5628	3947	3231	2791	2500	2279	2112	1973	1862	1765	1684	1611	1549	1492	1442
	34	17157	12530	8860	6213	5087	4394	3936	3587	3325	3107	2932	2779	2651	2537	2439	2348	2271
42	7	12550	9166	6481	4545	3721	3214	2879	2624	2432	2272	2144	2033	1940	1855	1784	1718	1661
	14	17724	12944	9152	6418	5255	4538	4066	3706	3435	3209	3029	2871	2739	2620	2519	2426	2345
	34	27902	20377	14409	10104	8273	7145	6401	5834	5407	5052	4768	4519	4312	4125	3966	3819	3692

Table A5 Pipeline pressure loss (vacuum)

British Standard Size Tube BS EN 1057: R250, Table X		Distance from source (m) at 59 kPa (450 mm Hg) for 1.3, 2.6, 3.9, 6.5 kPa (10, 20, 30, 50 mm Hg) pressure loss																
Outside Diameter (mm)	Pressure loss (kPa)	8	15	30	61	91	122	152	183	213	244	274	305	335	366	396	427	457
		Free air flow rate (L/min)																
12	1.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	2.6	47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	3.9	60	40	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	6.5	82	55	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15	1.3	59	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	2.6	89	59	40	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	3.9	113	76	51	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	6.5	153	103	69	46	–	–	–	–	–	–	–	–	–	–	–	–	–
22	1.3	173	116	78	52	41	–	–	–	–	–	–	–	–	–	–	–	–
	2.6	260	174	117	79	62	53	46	42	–	–	–	–	–	–	–	–	–
	3.9	330	222	149	100	79	67	59	53	49	45	42	40	–	–	–	–	–
	6.5	445	301	203	137	108	92	81	73	67	62	57	54	51	49	46	45	43
28	1.3	350	236	159	106	84	71	63	56	51	48	44	42	40	–	–	–	–
	2.6	525	353	238	160	127	107	94	85	78	72	67	63	60	57	54	52	50
	3.9	666	448	303	204	161	137	120	108	99	92	86	81	76	73	69	66	64
	6.5	900	607	412	278	220	187	164	148	135	125	117	110	104	99	95	91	87
35	1.3	637	427	288	193	153	130	114	102	94	87	81	76	72	69	65	63	60
	2.6	947	638	431	290	230	195	171	154	141	131	122	115	109	103	99	95	91
	3.9	1198	808	548	369	293	248	218	197	180	167	156	147	139	132	126	121	116
	6.5	1614	1091	743	503	399	339	298	269	246	228	213	200	190	180	172	165	158
42	1.3	1074	724	488	328	260	220	194	174	160	148	138	130	123	117	111	107	103
	2.6	1598	1079	731	493	391	331	291	262	240	222	208	196	185	176	168	161	155
	3.9	2016	1363	926	626	497	422	371	334	306	283	265	249	236	224	214	205	197
	6.5	2706	1833	1254	851	677	574	506	456	417	387	361	340	322	306	293	280	270
54	1.3	2191	1480	1001	674	535	453	399	359	329	304	284	268	253	241	230	220	212
	2.6	3246	2196	1493	1010	802	681	599	540	494	458	428	403	381	363	346	332	319
	3.9	4083	2766	1889	1281	1019	865	762	687	629	582	545	513	485	462	441	423	406
	6.5	5448	3699	2549	1737	1384	1176	1037	935	856	794	742	699	662	630	601	576	554
76	1.3	5521	3773	2563	1733	1377	1169	1029	927	849	786	735	692	655	623	595	570	548
	2.6	8070	5563	3807	2586	2058	1749	1541	1389	1273	1179	1103	1038	983	936	894	857	823
	3.9	10041	6968	4801	3274	2609	2219	1957	1765	1617	1499	1402	1320	1250	1190	1137	1090	1048
	6.5	13166	9233	6439	4421	3533	3009	2655	2396	2197	2037	1906	1796	1701	1619	1547	1483	1426
108	1.3	12874	9140	6543	4552	3732	3280	2879	2628	2433	2276	1919	2036	1941	1858	1785	1712	1641
	2.6	18207	12874	9235	6578	5274	4552	4071	3716	3441	3219	3035	2879	2745	2628	2525	2422	2325
	3.9	22494	15905	11374	8114	6509	5657	5030	4592	4251	3976	3750	3557	3391	3247	3119	2992	2870
	6.5	29238	20675	14708	10520	8445	7343	6538	5968	5526	5169	4873	4623	4408	4220	4055	3889	3730

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Example

Calculate the pressure drop in a 15 mm diameter pipe, 12 m in length, carrying medical air at a design flow rate of 800 L/min.

Solution

The pressure drop Δp across the pipe can be calculated from the formula:

$$\Delta p = \frac{\text{Measured length of pipe}}{\text{Nearest length of pipe from Table}} \times \left(\frac{\text{Design flow}}{\text{Nearest flow from Table}}\right)^2 \times \text{Pressure drop from Table}$$

From Table, the nearest length to 12 m is 15 m and the nearest flow rate to the design flow of 800 L/min is 711 L/min in the 15 m column, at which there is a pressure drop of 21 kPa across a 15 mm diameter, 15 m length of pipe.

Using these values, Equation gives a pressure drop across the 12 m pipe of:

$$\frac{12}{15} \times \left(\frac{800}{711}\right)^2 \times 21 = 21.3 \text{ KPA}$$

If this loss is unacceptable, use the next (higher) pipe size, that is 22 mm. The nearest flow rate to 800 L/min is now 1135 L/min, representing a pressure loss of 7 kPa over 15 m.

In this instance:

Δp = 2.8 kPa.

Table A6 Equivalent lengths for copper fittings

	6 mm	8 mm	10 mm	12 mm	15 mm	22 mm	28 mm	35 mm	42 mm	54 mm	76 mm
Ball valve	0.10	0.10	0.20	0.30	0.30	0.60	0.90	0.90	1.10	1.20	1.20
Tee (Thru')	0.12	0.15	0.18	0.21	0.32	0.42	0.54	0.70	0.82	1.05	1.56
Tee (Branch)	0.46	0.52	0.70	0.80	0.95	1.26	1.60	2.10	2.45	3.14	4.67
90° Elbow	0.17	0.20	0.25	0.33	0.47	0.63	0.80	1.05	1.23	1.58	2.36

Table A7 Equivalent lengths for ABS (acrylonitrile butadiene styrene) vacuum fittings

	40 mm	50 mm	70 mm	100 mm	125 mm
Tee (Thru')	0.95	1.23	1.65	2.20	2.56
Tee (Branch)	2.76	3.38	4.57	6.12	7.68
90° elbow	1.25	1.71	2.44	3.08	3.84