Carrier

United Technologies

turn to the experts



greenspeed

AQUAEDGE

PUREtec

19DV

Back-to-Back Centrifugal Liquid Chiller with PUREtec™ Refrigerant and Greenspeed™ Intelligence

19DV Two-stage: 600 - 800Ton (Air-conditioning Low voltage VFD)



Turn To The Experts

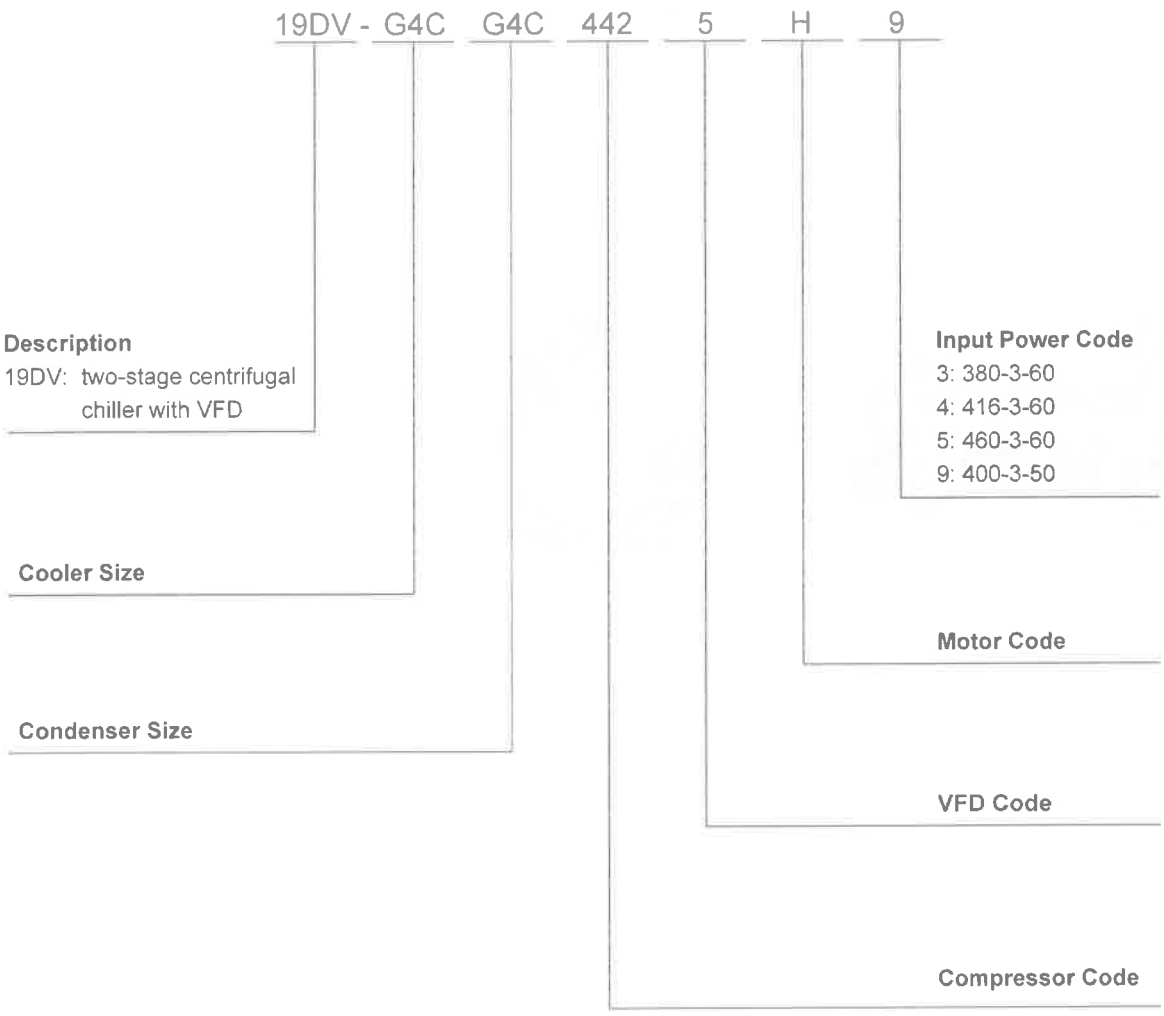


Inheriting a rich legacy of innovation including inventing modern air-conditioning, Carrier has been a global leader in innovations for Heating Ventilation Air Conditioning (HVAC) and refrigeration solutions. Carrier is a part of UTC Climate, Controls & Security, a unit of United Technologies Corp., a leading provider to the aerospace and building systems industries worldwide.

With a broad portfolio of advanced technical patent awards, our global R&D center in Shanghai develops innovative heat, ventilation and air-conditioning (HVAC) solutions.

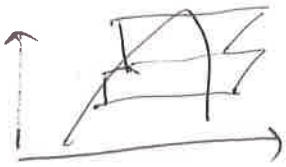


Model Number Nomenclature



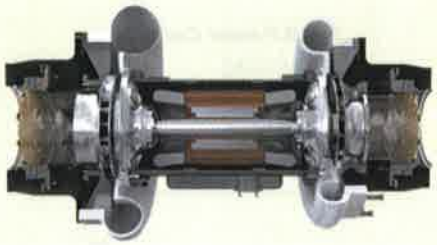
Cooling Capacity

19DV Two-stage: 600 - 800Ton (Air-conditioning Low voltage VFD)

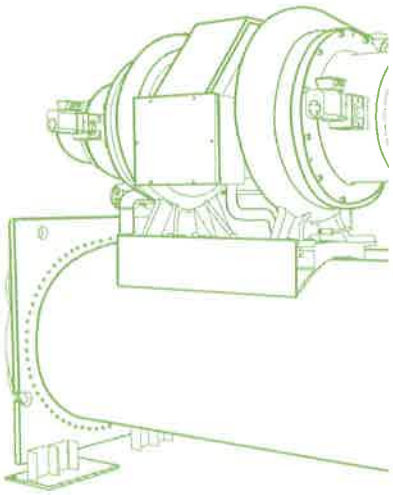


Reliable

- Advanced back-to-back two-stage compressor naturally balances both radial and axial thrust on shaft.
- Simple and robust ceramic bearing system enables refrigerant lubrication that doesn't request oil lubrication which is requested by conventional chillers. Customers won't be troubled by oil related failures as well as maintenance cost and efforts.
- High tier variable speed starter equipped with harmonic filter(optional), total harmonic distortion (THD) ≤5% and fully complies with IEEE519 standard.
- Swift restart - 19DV can restart within 30 seconds (with UPS) after power recovery and achieve to required cooling load more rapidly, especially reliable for data center application.







Efficient

- Carrier back-to-back two-stage compressor integrated with inter-stage economizer which improves both cooling capacity and efficiency.
- High speed direct drive motor reduces mechanical loss by 75% resulting from the removal of gear driven system.
- By application of refrigerant lubricated ceramic bearings, the efficiency decline by oil in heat exchangers is not existed in 19DV.
- Pioneer falling film evaporator is designed for low pressure refrigerant, which performs a significantly enhanced heat transfer efficiency by mitigating submergence effect especially at part load conditions.
- High performance tubing with internally and externally enhanced fins improves chiller efficiency by reducing overall resistance to heat transfer.
- Greenspeed™ variable speed control gives a moment-to-moment control of compressor speed to adapt building load changes perfectly, which ensures the chiller always operating efficiently at both full load and part load.
- 19DV chillers can achieve up to 7.0 full load COP and 11.8 IPLV at AHRI conditions.

AHRI

Water-Cooled Chillers
AHRI Standards 550/590



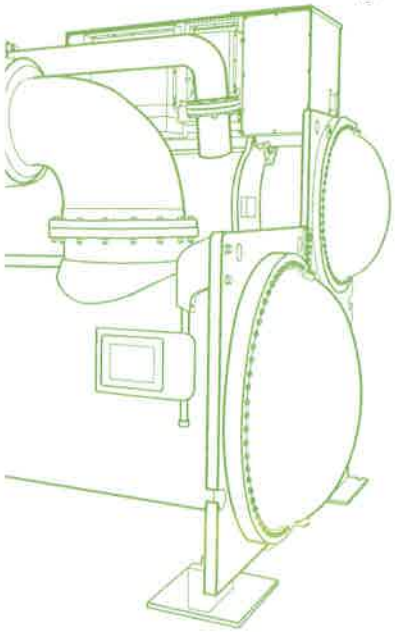


Sustainable

- R-1233zd(E) is new non-Ozone Depletion Substances, the ultra low Global Warming Potential of ~ 1, non-flammability and non-toxicity refrigerant that provides a safe and environmentally steward solution to centrifugal chillers.
- Carrier pioneer falling film evaporator design helps reduce the refrigerant charge significantly.
- The industry leading energy efficiency of 19DV chiller leads to lower electrical power consumption and significant reduction of related CO_2 emissions.

PUREtec R-1233zd(E)

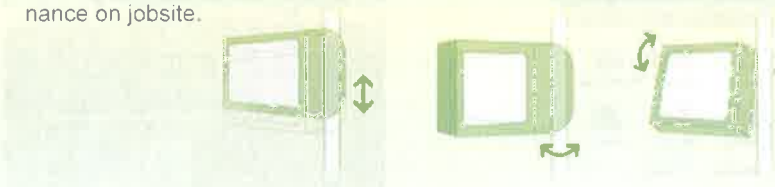
Quiet



- Refrigerant-cooled hermetic motor, no gear driven, optimized flow channel and 60% impeller speed of legacy design, all these features contribute to reduce refrigerant airflow noise.
- Greenspeed™ variable speed control adaptively turns down impeller speed at part load for better acoustic performance.
- 19DV chillers can meet 18001 standard recommended by Occupational Health and Safety Advisory Services (OHSAS).

Flexible

- System layout of 19DV chillers is well optimized and specific crescent shape economizer is designed to best leverage the space between evaporator and condenser that brings up to -15% smaller footprint versus legacy R-123 unit.
- Patented re-locatable control panel could be installed at any of the four corners of the chiller, which makes the layout of chillers more flexible to fit the site conditions.
- Bolt together modular design is ideal for retrofit project or installation in limited place.
- Miscellaneous optional offerings (such as marine water box) help to facilitate daily maintenance on jobsite.



Smart

- PIC5+ intelligent control - color touch screen, intuitive menu, animated component level interface, graphic trending, auto pushed alarm mail, smart password and more than 10 languages for choice.
- Multiple remote access methods present the users a flexible way to monitor and control the chillers.
- Carrier lifecycle data management system supports online data management and analysis, daily and key performance reports, prognostics and preventative maintenance, which will help the users continuously optimize the chiller and system operation.



CERTIFIED®
www.ahridirectory.org
and 551/591

Carrier PIC5+ Control System - Intelligent Colorful Touch Screen

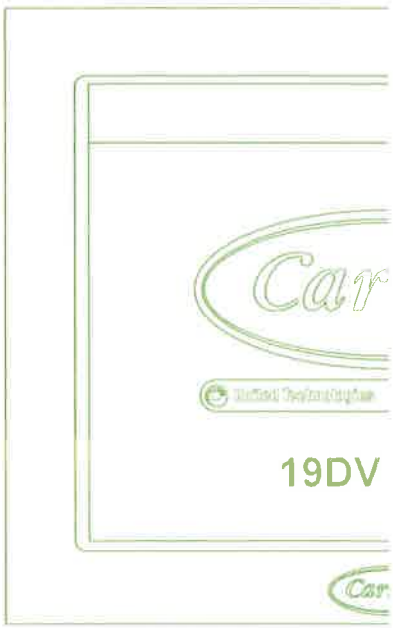
Carrier two-stage centrifugal chiller equips the latest PIC5+ control system with strong control and monitoring function during chiller operation. The control system applies a 10.4 inch high resolution touch screen, which can support more than ten language choices for customer, real time display of operation parameters with pictures makes it more human friendly and comfortable interface for operation. The control system simulates and monitors chiller operation, adjusts cooling or heating capacity according to load change and provides various protections during operation.

Reliable Start-up and Operation

- PIC5+ control system provides customer the smart password to avoid any setting change without authorization.
- When chiller receives start-up order, controller will conduct following pre-start safety checking, to ensure parameters like condensing pressure, bearing temperature, motor winding temperature, discharge temperature, evaporator saturated temperature and average line voltage etc. are normal.
- During chiller operation, except for the function of monitoring main operation parameters the control system also has capability to record and display trend curve, which is real time trend of key components during operation. It ensures effective and reliable operation of chiller by optimized intelligent and dynamic control algorithm.
- The control system has comprehensive protection during operation, such as surge protection, overvoltage and overcurrent protection, discharge temperature overheat protection, bearing temperature overheat protection, evaporator and condenser anti-freeze protection, low discharge superheat protection etc. in order to ensure chiller long time reliable operation.
- The optional envelope stability control is advanced parametric solution to control both chiller system and compressor to best balance the chiller efficiency and reliability. In real time, the controller optimizes compressor speed, guide vane position and stabilizer valve position to find the most efficient operating point throughout the operating range, without comprising the chiller stability.







Effective Failure Diagnostic

- The PIC5+ control system has failure diagnostic function and can be easily accessed via touch screen for detail chiller operation parameters. If control system detects failure the alarm will be initiated and related code will be recorded in alarm menu. The alarm records can be automatically saved by control system. Carrier service technician can read and delete alarm records by Carrier service/PCDCT tools.
- The control system has additional pre-diagnostic function. Different with diagnostic function, information displayed from this function is mainly for maintenance purpose. For an example, to inform customer periodically replace filter from this function.
- The control system has email alarm function. The control system can automatically send out an email with one or more alarm information to customer or service people through effective email address when alarm exists.

Flexible Interface and Connection

- The installation of Carrier colorful touch screen is very flexible. It greatly improves the convenience that customer can install touch screen at any corner of the chiller.
- The customer can not only directly operate on touch screen but also use the port to connect with BAS system. The control system facilitates various accesses, such as CCN to meet customer requirements. PIC5+ is compatible with Carrier i-Vu control network and integrated BACnet/IP protocol. PIC5+ also facilitates protocol such as native Modbus and converter for LonWorks to simplify the seamless connection with building automation systems.
- Carrier LDMS (Lifecycle Data Management System) is based on "Big Data Processing" and supports more value-added customer service such as online data management and analysis, daily and key performance reports, prognostics and preventative maintenance. The enhanced data management and analysis will help the users to achieve continuous optimization of the chiller and system operation.





Main Page

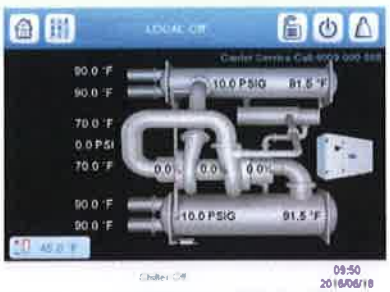
Control system main page operation and primary parameters monitored:

- Main page button
- Menu page button
- Log in/Language button
- Start-up/Stop page button
- Alarm menu button
- Setting point
- Chiller load percentage
- Inlet Guide Vane position percentage
- Condensing water pump status
- Chilled water pump status
- Condenser water inlet/outlet temperature
- Evaporator water inlet/outlet temperature
- Condenser saturated temperature and pressure
- Evaporator saturated temperature and pressure



Customer can easily read the primary information of chiller, components status and access to other interfaces from this page. They are:

- General parameter page
- Temperature/Pressure page
- Input/Output parameter page
- Water system parameter page
- Operation time
- Mode
- Graphic data trend



Air-conditioning (380V-3Ph-50Hz)

Model	Chiller				Chiller Line Amps	Evaporator		
	Cooling Capacity		Input Power	Full load COP		Flow Rate	Pressure Drop	Water Connection
	kW	Tons	kW	ikW/kW	A	l/s	kPa	mm
19DV-G24G234445B9	2110	600	321.2	0.1522	523	100.8	50.1	DN350
19DV-G24G244525D9	2462	700	377.9	0.1535	616	117.6	67.8	DN350
19DV-G44G444625D9	2813	800	434.8	0.1545	688	134.4	99.2	DN350

Model	Condenser			Footprint			Weight		
	Flow Rate	Pressure Drop	Water Connection	Length	Width	Height	Operating	Rigging (w/o Refrigerant)	Refrigerant Charge
	l/s	kPa	mm	mm	mm	mm	kg	kg	kg
19DV-G24G234445B9	117.0	55.4	DN250	4762	2508	2882	18440	15920	702
19DV-G24G244525D9	136.7	62.6	DN250	4762	2508	2882	18648	16078	700
19DV-G44G444625D9	156.3	90.8	DN250	5284	2508	2882	19528	16731	788

Air-conditioning (380V-3Ph-60Hz)

Model	Chiller				Chiller Line Amps	Evaporator		
	Cooling Capacity		Input Power	Full load COP		Flow Rate	Pressure Drop	Water Connection
	kW	Tons	kW	ikW/kW	A	l/s	kPa	mm
19DV-G24G234445B3	2110	600	321.2	0.1522	551	100.8	50.1	DN350
19DV-G24G244525D3	2462	700	377.9	0.1535	643	117.6	67.8	DN350
19DV-G44G444625D3	2813	800	434.8	0.1545	715	134.4	99.2	DN350

Model	Condenser			Footprint			Weight		
	Flow Rate	Pressure Drop	Water Connection	Length	Width	Height	Operating	Rigging (w/o Refrigerant)	Refrigerant Charge
	l/s	kPa	mm	mm	mm	mm	kg	kg	kg
19DV-G24G234445B3	117.0	55.4	DN250	4762	2508	2882	18440	15920	702
19DV-G24G244525D3	136.7	62.6	DN250	4762	2508	2882	18648	16078	700
19DV-G44G444625D3	156.3	90.8	DN250	5284	2508	2882	19528	16731	788

Notes:

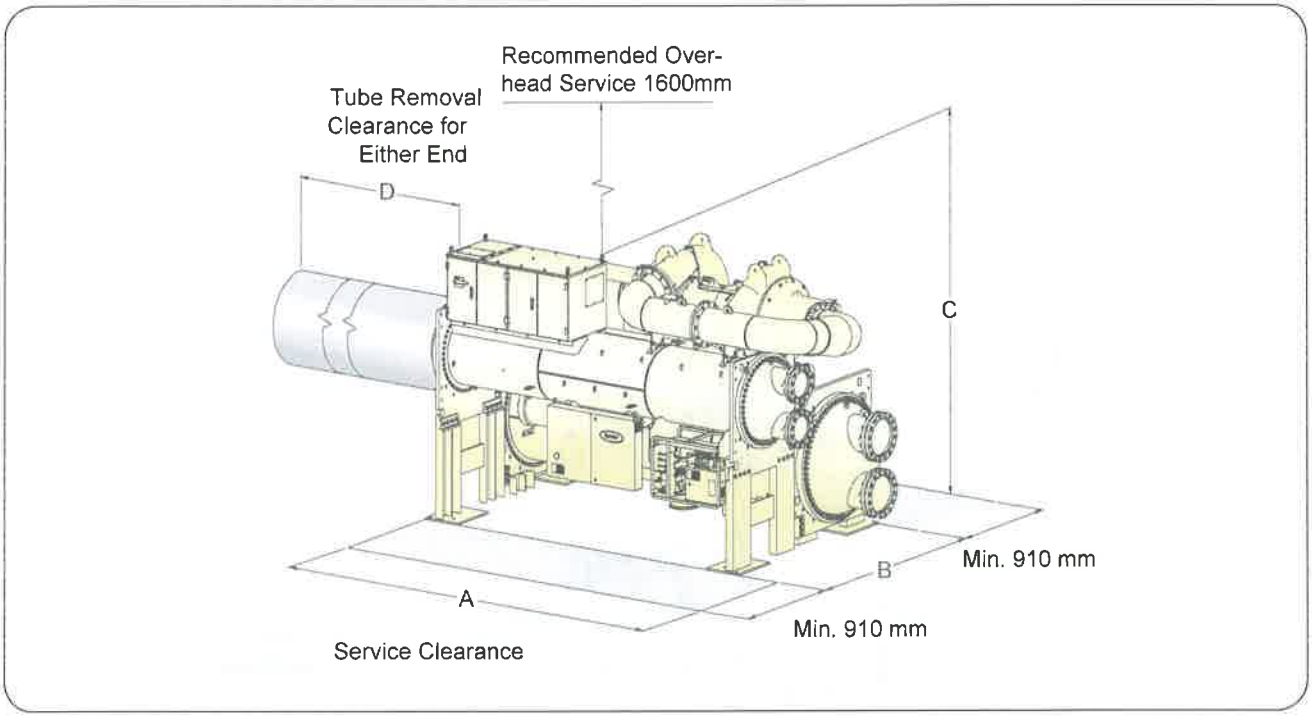
1. The above selections are based on entering/leaving chilled water temperature 12/7°C, entering/leaving cooling water temperature 32/37°C. evaporator fouling factor 0.0176 m²°C/kW and condenser fouling factor 0.044 m²°C/kW.
2. Carrier will select specific models using E-Cat on different requests for tonnage, lift, and efficiency. For details, please contact local agencies.
3. Standard evaporator and condenser water side pressure is 1.0MPa. For more requirements, please contact local agencies.
4. For more details or customized selections, please contact local agencies.

AHRI CERTIFIED® www.ahridirectory.org Water-Cooled Chillers AHRI Standards 550/590 and 551/591

Certified in accordance with the AHRI Water-Cooled Water-Chilling and Heat Pump Water-Heating Packages. Certification Program, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI). Certified units may be found in the AHRI Directory at www.ahndirectory.org

http://www.ahridirectory.org

19DV Chiller Dimensions



Evaporator Size	Condenser Size	A-Length for NIH Waterbox mm (2-Pass)	B-Width mm	C-Width mm	D-Tube Removal Space for Either End mm
G2A-G29	G2C-G29	4762	2508	2882	4267
G4A-G49	G4C-G49	5284	2508	2882	4877

Field Wiring Specifications (with VFD)

I. General

1.0 All field-supplied conductors, devices and the field-installation wiring, termination of conductors and devices must be in compliance with all applicable codes and job specifications.

1.1 The routing of field-installed conduit and conductors and location of field-installed devices must not interfere with equipment access or the reading, adjusting or servicing of any component.

1.2 Equipment installation and all starting and control devices must comply with details in equipment submittal drawings and literature.

1.3 Contacts and switches are shown in the position, which would de-energize the circuit and cause chiller shut down.

1.4 WARNING-Do not use aluminum conductors.

II. Power Wiring to VFD Starter

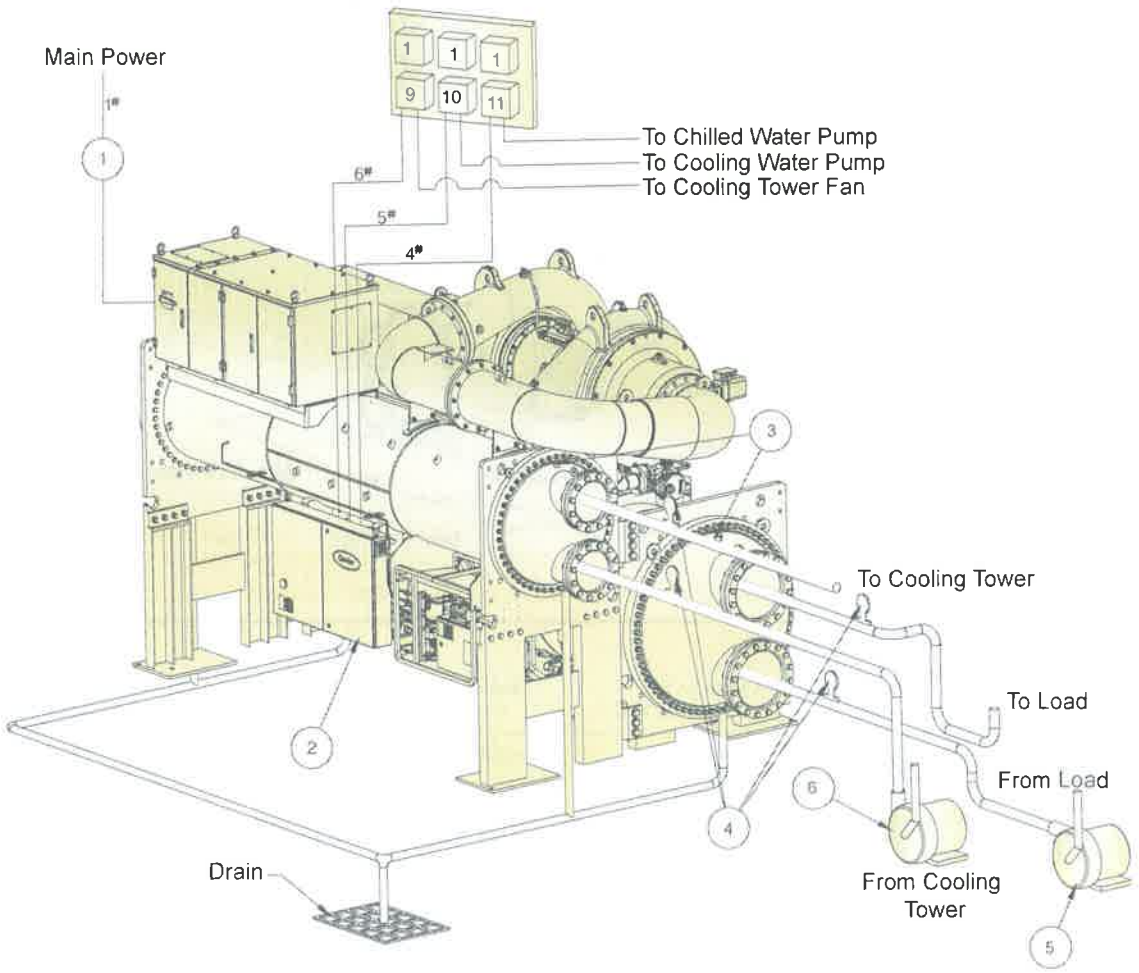
2.0 Provide a means of disconnecting power to starter. Fused disconnect is required on VFD.

2.1 Incoming power wire must be protected with metal jacket.

2.2 Line side power conductor rating must meet VFD nameplate voltage and chiller full load amps (minimum circuit ampacity).

2.3 VFD and controls must be grounded by using equipment grounding lugs provided inside unit mounted starter enclosure.

Typical Piping and Wiring (Unit Mounted VFD)



① Air switch ② Control box ③ Vent
④ Pressure gauges ⑤ Chilled water pump ⑥ Cooling water pump

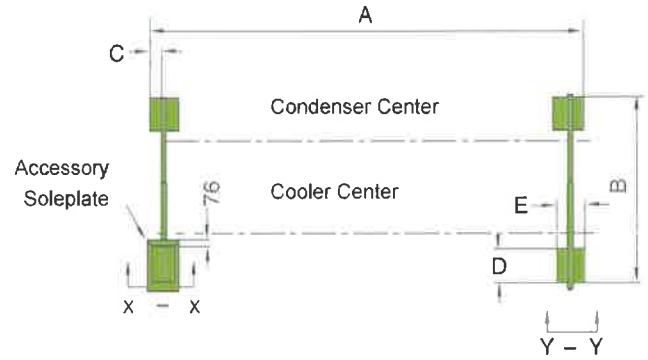
Line	Purpose	Specification
1#	Main power to Starter	50Hz or 60Hz low voltage AC power source: 3 phase, 1 grounding
4#	To cooling tower fan starter (option)	2 control lines (option)
5#	To cooling water pump starter (option)	2 control lines (option)
6#	To chilled water pump starter (option)	2 control lines (option)

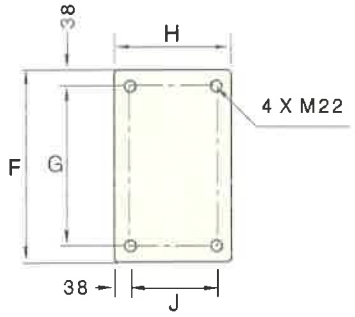
Piping and Wiring Requirements:

1. The installer must get all pipes and wires in place and mark the ends.
2. Filters must be installed in cooling water and chilled water pipes.
3. Thermometer (0-50 C) and pressure gauge (0~1Mpa or 2MPa) must be installed at inlet and outlet of the pipes.
4. The installer must install the relief valve vent to outdoors with a steel pipe(outer diameter 48mm, thickness 4mm).
5. It is suggested that an oxygen content monitor be installed in the machine room for safety. which will give an alarm when the oxygen content is less than 19.5%.
6. Input power shall be in compliance with Carrier applicable codes and job specifications. For more details or customized conditions, please contact local agencies.

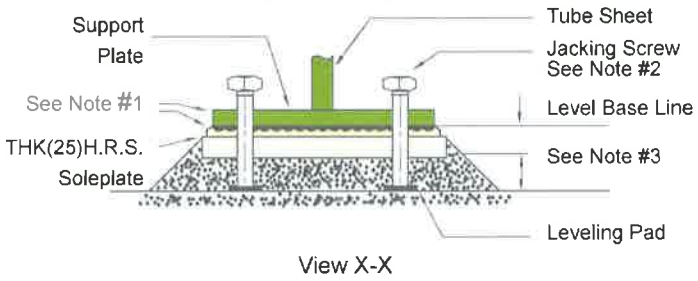
Types of Base Isolation

Location of Isolator

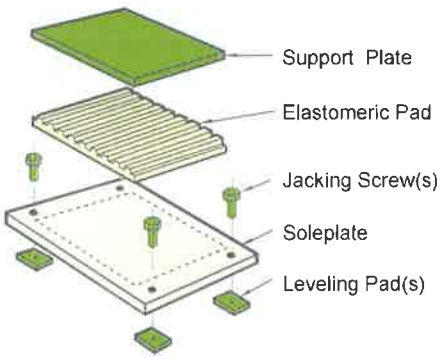




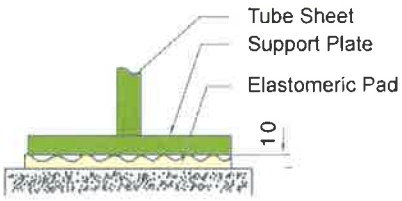
Standard Isolation



View X-X



Simplified Isolation



View Y-Y

Notes:

1. Accessory soleplate package includes 4 soleplates, 16 jacking screws, and 16 leveling pads.
2. Jacking Screws should be removed after the grout has set.
3. Thickness of grout varies, depending on the amount necessary to level chiller.

Evaporator/Condenser Size	A mm	B mm	C mm	D mm	E mm	F mm	G mm	H mm	J mm
G2A-G29/G2C-G29	3951	2508	102	559	406	711	635	432	356
G4A-G49/G4C-G49	4472	2508	102	559	406	711	635	432	356

improve buildings

Carrier improves the world around us; Carrier improves people's lives; our products and services improve building performance; our culture of improvement will not allow us to rest when it comes to the environment.

Carrier

United Technologies
Building & Industrial Systems

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Version:	CAT-AQUAEDGE-19DV_1612_01
Supersede:	
Effective Date:	Dec, 2016

Dedicated Outdoor Air System (DOAS) Sizing Summary for VRF System (Direct OA) 7am to 7p

Project Name: Manufacturing Office_CSL CSDC1 2017 03/06/2017
Prepared by: Carrier APO 11:51AM

Air System Information

Air System Name **VRF System (Direct OA) 7am to 7p**
Equipment Class ..... **TERM**
Air System Type ..... **VRF**
Number of zones **7**
Floor Area ..... **557.4** m²
Location ..... **Singapore, Singapore**

Sizing Calculation Information

Calculation Months ..... **Jan to Dec**
Sizing Data ..... **User-Modified**
Zone L/s Sizing ..... **Sum of space airflow rates**
Space L/s Sizing ..... **Individual peak space loads**

NOTE: No other data is applicable for a Terminal Units air system without a Dedicated Outdoor Air System (DOAS).

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Sizing Data ..... **User-Modified**

Zone L/s Sizing ..... **Sum of space airflow rates**
Space L/s Sizing ..... **Individual peak space loads**

Terminal Unit Sizing Data - Cooling

Zone Name	Total Coil Load (kW)	Sens Coil Load (kW)	Coil Entering DB / WB (°C)	Coil Leaving DB / WB (°C)	Water Flow @ 5.6 K (L/s)	Time of Peak Coil Load	Zone L/(s·m²)
1 Conference Room	5.5	4.0	24.1 / 17.4	11.0 / 10.4	-	Aug 1400	7.18
2 Asst Manager	2.4	1.9	24.0 / 16.8	11.0 / 10.4	-	Aug 0700	5.74
3 Manager	3.5	2.9	24.1 / 16.6	11.0 / 10.3	-	Aug 0700	6.46
4 General Perimeter	10.1	7.8	23.4 / 16.7	11.0 / 10.4	-	Aug 0700	5.33
5 Chief Engineer	2.9	2.4	23.7 / 16.4	11.0 / 10.3	-	Aug 0700	7.65
6 Engineering	7.5	6.0	23.4 / 16.5	11.0 / 10.4	-	Aug 0700	6.38
7 General Core Office	22.3	15.3	23.1 / 17.3	11.0 / 10.5	-	Aug 1400	3.59

Terminal Unit Sizing Data - Heating, Fan, Ventilation

Zone Name	Heating Coil Load (kW)	Heating Coil Ent/Lvg DB (°C)	Htg Coil Water Flow @11.1 K (L/s)	Fan Design Airflow (L/s)	Fan Motor (BHP)	Fan Motor (kW)	OA Vent Design Airflow (L/s)
1 Conference Room	0.0	-17.8 / -17.8	0.00	250	0.025	0.020	40
2 Asst Manager	0.0	-17.8 / -17.8	0.00	120	0.025	0.020	11
3 Manager	0.0	-17.8 / -17.8	0.00	180	0.025	0.020	13
4 General Perimeter	0.0	-17.8 / -17.8	0.00	520	0.025	0.020	54
5 Chief Engineer	0.0	-17.8 / -17.8	0.00	160	0.025	0.020	11
6 Engineering	0.0	-17.8 / -17.8	0.00	400	0.025	0.020	34
7 General Core Office	0.0	-17.8 / -17.8	0.00	1050	0.025	0.020	163

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (kW)	Time of Peak Sensible Cooling Load	Zone Heating Load (kW)	Zone Floor Area (m²)
1 Conference Room	2.8	Aug 1700	0.0	34.8
2 Asst Manager	1.3	Aug 1700	0.0	20.9
3 Manager	2.2	Aug 1700	0.0	27.9
4 General Perimeter	5.7	Dec 1700	0.0	97.5
5 Chief Engineer	1.9	Aug 1700	0.0	20.9
6 Engineering	4.5	Sep 1700	0.0	62.7
7 General Core Office	10.3	Aug 1800	0.0	292.6

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (kW)	Time of Peak Sensible Load	Air Flow (L/s)	Heating Load (kW)	Floor Area (m²)	Space L/(s·m²)
1 Conference Room							
1 Conference Room	1	2.8	Aug 1700	232	0.0	34.8	6.66
2 Asst Manager							
2 Asst. Mamager	1	1.3	Aug 1700	112	0.0	20.9	5.34
3 Manager							
3 Manager	1	2.2	Aug 1700	181	0.0	27.9	6.49

Zone Sizing Summary for VRF System (Direct OA) 7am to 7p

Project Name: Manufacturing Office_CSL CSDC1 2017 03/06/2017
Prepared by: Carrier APO 11:51AM

Zone Name / Space Name	Mult.	Cooling Sensible (kW)	Time of Peak Sensible Load	Air Flow (L/s)	Heating Load (kW)	Floor Area (m^2)	Space L/(s·m^2)
4 General Perimeter							
4 General Perimeter	1	5.7	Dec 1700	474	0.0	97.5	4.86
5 Chief Engineer							
5 Chief Engineer	1	1.9	Aug 1700	157	0.0	20.9	7.52
6 Engineering							
6 Engineering	1	4.5	Sep 1700	374	0.0	62.7	5.96
7 General Core Office							
7 General Core Office	1	10.3	Aug 1800	851	0.0	292.6	2.91

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 0700 COOLING OA DB / WB 26.9 °C / 24.6 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
ZONE LOADS	**Details**	**Sensible (W)**	**Latent (W)**	**Details**	**Sensible (W)**	**Latent (W)**
Window & Skylight Solar Loads	47 m²	1174	-	47 m²	-	-
Wall Transmission	194 m²	3510	-	194 m²	0	-
Roof Transmission	557 m²	4380	-	557 m²	0	-
Window Transmission	47 m²	793	-	47 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	5 m²	168	-	5 m²	0	-
Floor Transmission	557 m²	0	-	557 m²	0	-
Partitions	79 m²	191	-	79 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	9000 W	6472	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	2100 W	1837	-	0	0	-
People	64	2984	3845	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**21509**	**3845**	-	**0**	**0**
Zone Conditioning	-	38184	3845	-	0	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Exhaust Fan Load	0 L/s	0	-	0 L/s	0	-
Ventilation Load	327 L/s	1664	10117	327 L/s	-1752	0
Ventilation Fan Load	0 L/s	0	-	0 L/s	0	-
Space Fan Coil Fans	-	140	-	-	-140	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	-	**39988**	**13962**	-	**-1892**	**0**
Terminal Unit Cooling	-	39988	13951	-	-1892	0
Terminal Unit Heating	-	0	-	-	0	-
>> Total Conditioning	-	**39988**	**13951**	-	**-1892**	**0**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

1 Conference Room	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
	OCCUPIED T-STAT 21.0 °C			OCCUPIED T-STAT 18.3 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	6 m²	357	-	6 m²	-	-
Wall Transmission	22 m²	569	-	22 m²	0	-
Roof Transmission	35 m²	363	-	35 m²	0	-
Window Transmission	6 m²	151	-	6 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	35 m²	0	-	35 m²	0	-
Partitions	12 m²	43	-	12 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	563 W	482	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	131 W	123	-	0	0	-
People	12	708	721	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**2797**	**721**	-	**0**	**0**

2 Asst Manager	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
	OCCUPIED T-STAT 21.0 °C			OCCUPIED T-STAT 18.3 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	3 m²	214	-	3 m²	-	-
Wall Transmission	13 m²	341	-	13 m²	0	-
Roof Transmission	21 m²	218	-	21 m²	0	-
Window Transmission	3 m²	91	-	3 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	21 m²	0	-	21 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	338 W	289	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	79 W	74	-	0	0	-
People	2	118	120	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**1345**	**120**	-	**0**	**0**

3 Manager	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
	OCCUPIED T-STAT 21.0 °C			OCCUPIED T-STAT 18.3 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	8 m²	383	-	8 m²	-	-
Wall Transmission	31 m²	692	-	31 m²	0	-
Roof Transmission	28 m²	290	-	28 m²	0	-
Window Transmission	8 m²	211	-	8 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	28 m²	0	-	28 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	450 W	386	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	105 W	98	-	0	0	-
People	2	118	120	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**2179**	**120**	-	**0**	**0**

4 General Perimeter	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Dec 1700 COOLING OA DB / WB 27.2 °C / 23.1 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
	OCCUPIED T-STAT 21.0 °C			OCCUPIED T-STAT 18.3 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	13 m²	1132	-	13 m²	-	-
Wall Transmission	60 m²	1155	-	60 m²	0	-
Roof Transmission	98 m²	673	-	98 m²	0	-
Window Transmission	13 m²	187	-	13 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	5 m²	276	-	5 m²	0	-
Floor Transmission	98 m²	0	-	98 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	1575 W	1351	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	368 W	344	-	0	0	-
People	10	590	601	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**5710**	**601**	-	**0**	**0**

5 Chief Engineer	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
	OCCUPIED T-STAT 21.0 °C			OCCUPIED T-STAT 18.3 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	7 m²	492	-	7 m²	-	-
Wall Transmission	27 m²	521	-	27 m²	0	-
Roof Transmission	21 m²	218	-	21 m²	0	-
Window Transmission	7 m²	181	-	7 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	21 m²	0	-	21 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	338 W	289	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	79 W	74	-	0	0	-
People	2	118	120	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	1893	120	-	0	0

6 Engineering	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Sep 1700 COOLING OA DB / WB 31.0 °C / 25.4 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
	OCCUPIED T-STAT 21.0 °C			OCCUPIED T-STAT 18.3 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	10 m²	1356	-	10 m²	-	-
Wall Transmission	40 m²	790	-	40 m²	0	-
Roof Transmission	63 m²	631	-	63 m²	0	-
Window Transmission	10 m²	243	-	10 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	63 m²	0	-	63 m²	0	-
Partitions	12 m²	39	-	12 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	1013 W	868	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	236 W	221	-	0	0	-
People	6	354	360	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	4503	360	-	0	0

7 General Core Office	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1800 COOLING OA DB / WB 31.5 °C / 25.8 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C		
	OCCUPIED T-STAT 21.0 °C			OCCUPIED T-STAT 18.3 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	0 m²	0	-	0 m²	-	-
Wall Transmission	0 m²	0	-	0 m²	0	-
Roof Transmission	293 m²	3127	-	293 m²	0	-
Window Transmission	0 m²	0	-	0 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	293 m²	0	-	293 m²	0	-
Partitions	55 m²	195	-	55 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	4725 W	4097	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	1103 W	1037	-	0	0	-
People	30	1796	1802	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	10253	1802	-	0	0

TABLE 1.1.A. Component Loads For Space "1 Conference Room" In Zone "1 Conference Room"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C OCCUPIED T-STAT 21.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C OCCUPIED T-STAT 18.3 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(W)	(W)	Details	(W)	(W)
Window & Skylight Solar Loads	6 m²	357	-	6 m²	-	-
Wall Transmission	22 m²	569	-	22 m²	0	-
Roof Transmission	35 m²	363	-	35 m²	0	-
Window Transmission	6 m²	151	-	6 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	35 m²	0	-	35 m²	0	-
Partitions	12 m²	43	-	12 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	563 W	482	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	131 W	123	-	0	0	-
People	12	708	721	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	2797	721	-	0	0

TABLE 1.1.B. Envelope Loads For Space "1 Conference Room" In Zone "1 Conference Room"						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(m²)	(W/(m²·K))	Coeff.	(W)	(W)	(W)
E EXPOSURE						
WALL	22	1.321	-	569	-	0
WINDOW 1	6	2.612	0.486	151	357	0
H EXPOSURE						
ROOF	35	0.727	-	363	-	0

TABLE 2.1.A. Component Loads For Space "2 Asst. Mamager" In Zone "2 Asst Manager"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C OCCUPIED T-STAT 21.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C OCCUPIED T-STAT 18.3 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(W)	(W)	Details	(W)	(W)
Window & Skylight Solar Loads	3 m²	214	-	3 m²	-	-
Wall Transmission	13 m²	341	-	13 m²	0	-
Roof Transmission	21 m²	218	-	21 m²	0	-
Window Transmission	3 m²	91	-	3 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	21 m²	0	-	21 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	338 W	289	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	79 W	74	-	0	0	-
People	2	118	120	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	1345	120	-	0	0

TABLE 2.1.B. Envelope Loads For Space "2 Asst. Mamager" In Zone "2 Asst Manager"						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(m²)	(W/(m²·K))	Coeff.	(W)	(W)	(W)
E EXPOSURE						
WALL	13	1.321	-	341	-	0
WINDOW 1	3	2.612	0.486	91	214	0
H EXPOSURE						
ROOF	21	0.727	-	218	-	0

TABLE 3.1.A. Component Loads For Space "3 Manager" In Zone "3 Manager"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C OCCUPIED T-STAT 21.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C OCCUPIED T-STAT 18.3 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	**Details**	**(W)**	**(W)**	**Details**	**(W)**	**(W)**
Window & Skylight Solar Loads	8 m²	383	-	8 m²	-	-
Wall Transmission	31 m²	692	-	31 m²	0	-
Roof Transmission	28 m²	290	-	28 m²	0	-
Window Transmission	8 m²	211	-	8 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	28 m²	0	-	28 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	450 W	386	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	105 W	98	-	0	0	-
People	2	118	120	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**2179**	**120**	-	**0**	**0**

TABLE 3.1.B. Envelope Loads For Space "3 Manager" In Zone "3 Manager"						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(m²)	(W/(m²·K))	Coeff.	(W)	(W)	(W)
E EXPOSURE						
WALL	18	1.321	-	455	-	0
WINDOW 1	4	2.612	0.486	121	286	0
S EXPOSURE						
WALL	13	1.321	-	237	-	0
WINDOW 1	3	2.612	0.486	91	97	0
H EXPOSURE						
ROOF	28	0.727	-	290	-	0

TABLE 4.1.A. Component Loads For Space "4 General Perimeter" In Zone "4 General Perimeter"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Dec 1700 COOLING OA DB / WB 27.2 °C / 23.1 °C OCCUPIED T-STAT 21.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C OCCUPIED T-STAT 18.3 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(W)	(W)	Details	(W)	(W)
Window & Skylight Solar Loads	13 m²	1132	-	13 m²	-	-
Wall Transmission	60 m²	1155	-	60 m²	0	-
Roof Transmission	98 m²	673	-	98 m²	0	-
Window Transmission	13 m²	187	-	13 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	5 m²	276	-	5 m²	0	-
Floor Transmission	98 m²	0	-	98 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	1575 W	1351	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	368 W	344	-	0	0	-
People	10	590	601	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**5710**	**601**	-	**0**	**0**

TABLE 4.1.B. Envelope Loads For Space "4 General Perimeter" In Zone "4 General Perimeter"						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(m²)	(W/(m²·K))	Coeff.	(W)	(W)	(W)
S EXPOSURE						
WALL	60	1.321	-	1155	-	0
WINDOW 1	13	2.612	0.486	187	1132	0
DOOR GLASS	5	3.123	0.750	76	200	0
H EXPOSURE						
ROOF	98	0.727	-	673	-	0

TABLE 5.1.A. Component Loads For Space "5 Chief Engineer" In Zone "5 Chief Engineer"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1700 COOLING OA DB / WB 32.2 °C / 26.0 °C OCCUPIED T-STAT 21.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C OCCUPIED T-STAT 18.3 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	**Details**	**(W)**	**(W)**	**Details**	**(W)**	**(W)**
Window & Skylight Solar Loads	7 m²	492	-	7 m²	-	-
Wall Transmission	27 m²	521	-	27 m²	0	-
Roof Transmission	21 m²	218	-	21 m²	0	-
Window Transmission	7 m²	181	-	7 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	21 m²	0	-	21 m²	0	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	338 W	289	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	79 W	74	-	0	0	-
People	2	118	120	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**1893**	**120**	-	**0**	**0**

TABLE 5.1.B. Envelope Loads For Space "5 Chief Engineer" In Zone "5 Chief Engineer"						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(m²)	(W/(m²·K))	Coeff.	(W)	(W)	(W)
S EXPOSURE						
WALL	13	1.321	-	237	-	0
WINDOW 1	3	2.612	0.486	91	97	0
W EXPOSURE						
WALL	13	1.321	-	284	-	0
WINDOW 1	3	2.612	0.486	91	394	0
H EXPOSURE						
ROOF	21	0.727	-	218	-	0

TABLE 6.1.A. Component Loads For Space "6 Engineering" In Zone "6 Engineering"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Sep 1700 COOLING OA DB / WB 31.0 °C / 25.4 °C OCCUPIED T-STAT 21.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C OCCUPIED T-STAT 18.3 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	**Details**	**(W)**	**(W)**	**Details**	**(W)**	**(W)**
Window & Skylight Solar Loads	10 m²	1356	-	10 m²	-	-
Wall Transmission	40 m²	790	-	40 m²	0	-
Roof Transmission	63 m²	631	-	63 m²	0	-
Window Transmission	10 m²	243	-	10 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	63 m²	0	-	63 m²	0	-
Partitions	12 m²	39	-	12 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	1013 W	868	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	236 W	221	-	0	0	-
People	6	354	360	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**4503**	**360**	-	**0**	**0**

TABLE 6.1.B. Envelope Loads For Space "6 Engineering" In Zone "6 Engineering"						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(m²)	(W/(m²·K))	Coeff.	(W)	(W)	(W)
W EXPOSURE						
WALL	40	1.321	-	790	-	0
WINDOW 1	10	2.612	0.486	243	1356	0
H EXPOSURE						
ROOF	63	0.727	-	631	-	0

TABLE 7.1.A. Component Loads For Space "7 General Core Office" In Zone "7 General Core Office"						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1800 COOLING OA DB / WB 31.5 °C / 25.8 °C OCCUPIED T-STAT 21.0 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 22.8 °C / 16.1 °C OCCUPIED T-STAT 18.3 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	**Details**	**(W)**	**(W)**	**Details**	**(W)**	**(W)**
Window & Skylight Solar Loads	0 m²	0	-	0 m²	-	-
Wall Transmission	0 m²	0	-	0 m²	0	-
Roof Transmission	293 m²	3127	-	293 m²	0	-
Window Transmission	0 m²	0	-	0 m²	0	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	293 m²	0	-	293 m²	0	-
Partitions	55 m²	195	-	55 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	4725 W	4097	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	1103 W	1037	-	0	0	-
People	30	1796	1802	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	**10253**	**1802**	-	**0**	**0**

TABLE 7.1.B. Envelope Loads For Space "7 General Core Office" In Zone "7 General Core Office"						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(m²)	(W/(m²·K))	Coeff.	(W)	(W)	(W)
H EXPOSURE						
ROOF	293	0.727	-	3127	-	0

August DESIGN COOLING DAY, 0700

TABLE 1: SYSTEM DATA

Component	Location	Dry-Bulb Temp (°C)	Specific Humidity (kg/kg)	Airflow (L/s)	CO2 Level (ppm)	Sensible Heat (W)	Latent Heat (W)
Ventilation Air	Inlet	26.9	0.01869	327	400	1664	10117
Vent - Return Mixing	Outlet	-17.8	0.00000	0	0	-	-
Ventilation Fan	Outlet	-17.0	0.00000	0	0	0	
Zone Air	-	22.8	0.00813	2680	135	38184	3845
Return Plenum	Outlet	-17.8	0.00813	2680	135	0	-

Air Density x Heat Capacity x Conversion Factor: At sea level = 1.207; At site altitude = 1.205 W/(L/s-K)
Air Density x Heat of Vaporization x Conversion Factor: At sea level = 2947.6; At site altitude = 2942.0 W/(L/s)
Site Altitude = 15.8 m

TABLE 2: ZONE DATA

Component	Location	Dry-Bulb Temp (°C)	Specific Humidity (kg/kg)	Airflow (L/s)	CO2 Level (ppm)	Sensible Heat (W)	Latent Heat (W)
1 Conference Room (Cooling)							
Ventilation Air	-	-	-	40	-	-	-
Cooling Coil Inlet	-	24.0	0.00970	250	0	-	-
Cooling Coil Outlet	-	11.0	0.00764	250	0	3913	1515
Heating Coil Inlet	-	11.0	0.00764	250	0	-	-
Heating Coil Outlet	-	11.0	0.00764	250	0	0	-
Zone Air	-	23.3	0.00797	250	0	3718	-
2 Asst Manager (Cooling)							
Ventilation Air	-	-	-	11	-	-	-
Cooling Coil Inlet	-	24.0	0.00898	120	0	-	-
Cooling Coil Outlet	-	11.0	0.00757	120	0	1886	498
Heating Coil Inlet	-	11.0	0.00757	120	0	-	-
Heating Coil Outlet	-	11.0	0.00757	120	0	0	-
Zone Air	-	23.6	0.00798	120	0	1821	-
3 Manager (Cooling)							
Ventilation Air	-	-	-	13	-	-	-
Cooling Coil Inlet	-	24.1	0.00870	180	0	-	-
Cooling Coil Outlet	-	11.0	0.00754	180	0	2852	615
Heating Coil Inlet	-	11.0	0.00754	180	0	-	-
Heating Coil Outlet	-	11.0	0.00754	180	0	0	-
Zone Air	-	23.8	0.00790	180	0	2782	-
4 General Perimeter (Cooling)							
Ventilation Air	-	-	-	54	-	-	-
Cooling Coil Inlet	-	23.4	0.00917	520	0	-	-
Cooling Coil Outlet	-	11.0	0.00762	520	0	7758	2368
Heating Coil Inlet	-	11.0	0.00762	520	0	-	-
Heating Coil Outlet	-	11.0	0.00762	520	0	0	-
Zone Air	-	22.9	0.00806	520	0	7476	-
5 Chief Engineer (Cooling)							
Ventilation Air	-	-	-	11	-	-	-
Cooling Coil Inlet	-	23.7	0.00861	160	0	-	-
Cooling Coil Outlet	-	11.0	0.00755	160	0	2440	501
Heating Coil Inlet	-	11.0	0.00755	160	0	-	-
Heating Coil Outlet	-	11.0	0.00755	160	0	0	-
Zone Air	-	23.3	0.00786	160	0	2370	-
6 Engineering (Cooling)							
Ventilation Air	-	-	-	34	-	-	-
Cooling Coil Inlet	-	23.4	0.00886	400	0	-	-
Cooling Coil Outlet	-	11.0	0.00759	400	0	5986	1499
Heating Coil Inlet	-	11.0	0.00759	400	0	-	-
Heating Coil Outlet	-	11.0	0.00759	400	0	0	-

Component	Location	Dry-Bulb Temp (°C)	Specific Humidity (kg/kg)	Airflow (L/s)	CO2 Level (ppm)	Sensible Heat (W)	Latent Heat (W)
Zone Air	-	23.0	0.00795	400	0	5807	-
7 General Core Office (Cooling)							
Ventilation Air	-	-	-	163	-	-	-
Cooling Coil Inlet	-	23.0	0.00997	1050	0	-	-
Cooling Coil Outlet	-	11.0	0.00772	1050	0	15153	6955
Heating Coil Inlet	-	11.0	0.00772	1050	0	-	-
Heating Coil Outlet	-	11.0	0.00772	1050	0	0	-
Zone Air	-	22.2	0.00837	1050	0	14209	-

WINTER DESIGN HEATING

TABLE 1: SYSTEM DATA

Component	Location	Dry-Bulb Temp (°C)	Specific Humidity (kg/kg)	Airflow (L/s)	CO2 Level (ppm)	Sensible Heat (W)	Latent Heat (W)
Ventilation Air	Inlet	22.8	0.00864	327	400	1752	0
Vent - Return Mixing	Outlet	-17.8	0.00000	0	0	-	-
Ventilation Fan	Outlet	-17.8	0.00000	0	0	0	-
Zone Air	-	18.3	0.00864	2680	0	0	0
Return Plenum	Outlet	-17.8	0.00864	2680	0	0	-

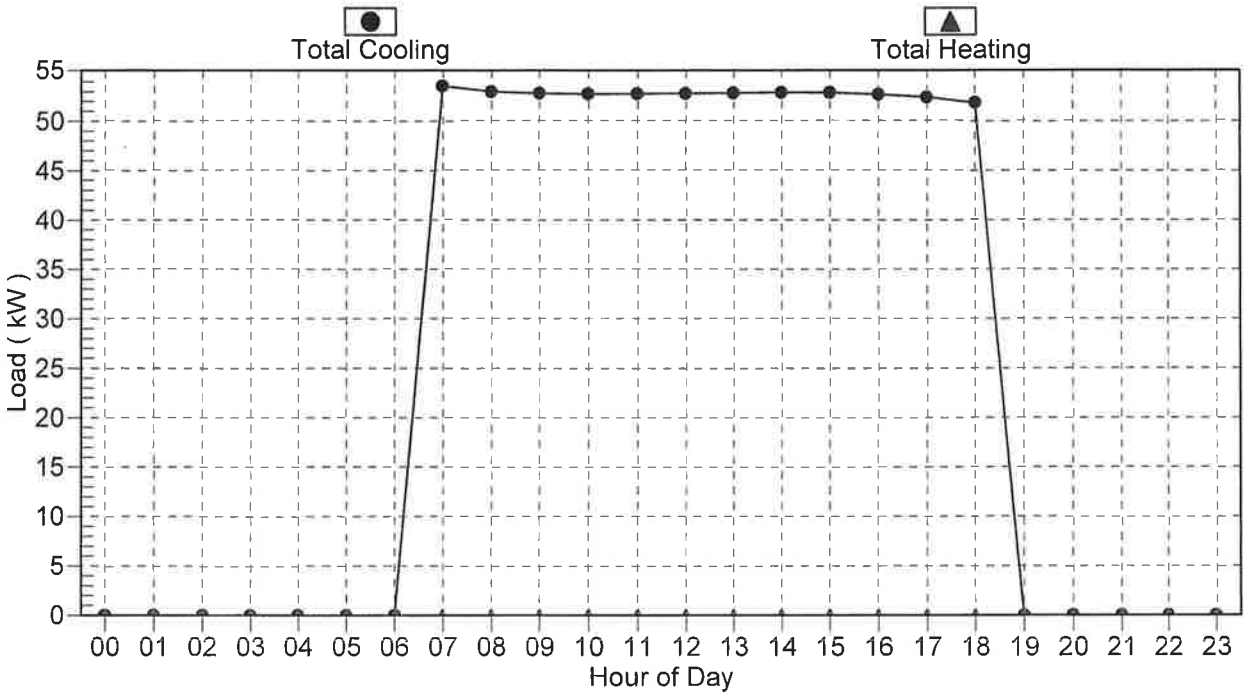
Air Density x Heat Capacity x Conversion Factor: At sea level = 1.207; At site altitude = 1.205 W/(L/s-K)
Air Density x Heat of Vaporization x Conversion Factor: At sea level = 2947.6; At site altitude = 2942.0 W/(L/s)
Site Altitude = 15.8 m

TABLE 2: ZONE DATA

Component	Location	Dry-Bulb Temp (°C)	Specific Humidity (kg/kg)	Airflow (L/s)	CO2 Level (ppm)	Sensible Heat (W)	Latent Heat (W)
1 Conference Room (Deadband)							
Ventilation Air	-	-	-	40	-	-	-
Cooling Coil Inlet	-	19.1	0.00865	250	0	-	-
Cooling Coil Outlet	-	18.3	0.00864	250	0	237	0
Heating Coil Inlet	-	18.3	0.00864	250	0	-	-
Heating Coil Outlet	-	18.3	0.00864	250	0	0	-
Zone Air	-	18.3	0.00864	250	0	0	-
2 Asst Manager (Deadband)							
Ventilation Air	-	-	-	11	-	-	-
Cooling Coil Inlet	-	18.9	0.00864	120	0	-	-
Cooling Coil Outlet	-	18.3	0.00864	120	0	80	0
Heating Coil Inlet	-	18.3	0.00864	120	0	-	-
Heating Coil Outlet	-	18.3	0.00864	120	0	0	-
Zone Air	-	18.3	0.00864	120	0	0	-
3 Manager (Deadband)							
Ventilation Air	-	-	-	13	-	-	-
Cooling Coil Inlet	-	18.8	0.00864	180	0	-	-
Cooling Coil Outlet	-	18.3	0.00864	180	0	92	0
Heating Coil Inlet	-	18.3	0.00864	180	0	-	-
Heating Coil Outlet	-	18.3	0.00864	180	0	0	-
Zone Air	-	18.3	0.00864	180	0	0	-
4 General Perimeter (Deadband)							
Ventilation Air	-	-	-	54	-	-	-
Cooling Coil Inlet	-	18.8	0.00864	520	0	-	-
Cooling Coil Outlet	-	18.3	0.00864	520	0	311	0
Heating Coil Inlet	-	18.3	0.00864	520	0	-	-
Heating Coil Outlet	-	18.3	0.00864	520	0	0	-
Zone Air	-	18.3	0.00864	520	0	0	-
5 Chief Engineer (Deadband)							
Ventilation Air	-	-	-	11	-	-	-
Cooling Coil Inlet	-	18.8	0.00864	160	0	-	-
Cooling Coil Outlet	-	18.3	0.00864	160	0	80	0
Heating Coil Inlet	-	18.3	0.00864	160	0	-	-
Heating Coil Outlet	-	18.3	0.00864	160	0	0	-
Zone Air	-	18.3	0.00864	160	0	0	-
6 Engineering (Deadband)							
Ventilation Air	-	-	-	34	-	-	-
Cooling Coil Inlet	-	18.8	0.00864	400	0	-	-
Cooling Coil Outlet	-	18.3	0.00864	400	0	201	0
Heating Coil Inlet	-	18.3	0.00864	400	0	-	-

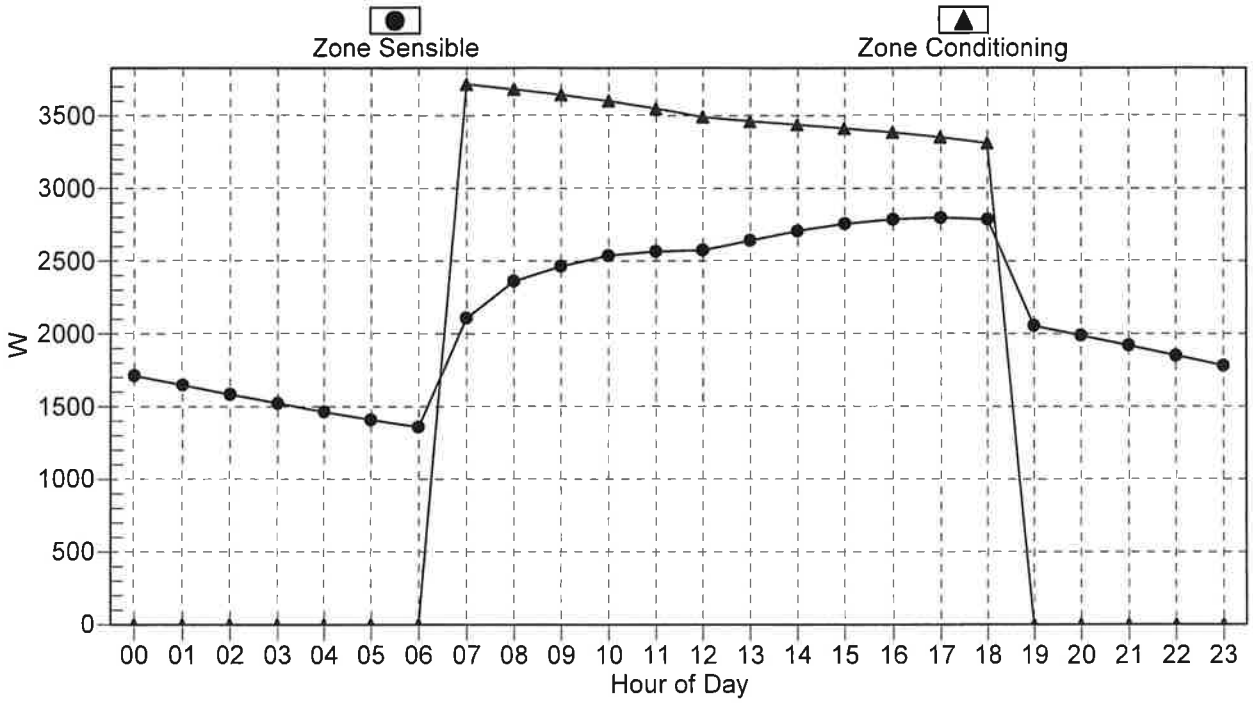
Component	Location	Dry-Bulb Temp (°C)	Specific Humidity (kg/kg)	Airflow (L/s)	CO2 Level (ppm)	Sensible Heat (W)	Latent Heat (W)
Heating Coil Outlet	-	18.3	0.00864	400	0	0	-
Zone Air	-	18.3	0.00864	400	0	0	-
7 General Core Office (Deadband)							
Ventilation Air	-	-	-	163	-	-	-
Cooling Coil Inlet	-	19.0	0.00865	1050	0	-	-
Cooling Coil Outlet	-	18.3	0.00864	1050	0	892	0
Heating Coil Inlet	-	18.3	0.00864	1050	0	-	-
Heating Coil Outlet	-	18.3	0.00864	1050	0	0	-
Zone Air	-	18.3	0.00864	1050	0	0	-

Data for July



Zone: 1 Conference Room

Data for August



Zone: 2 Asst Manager

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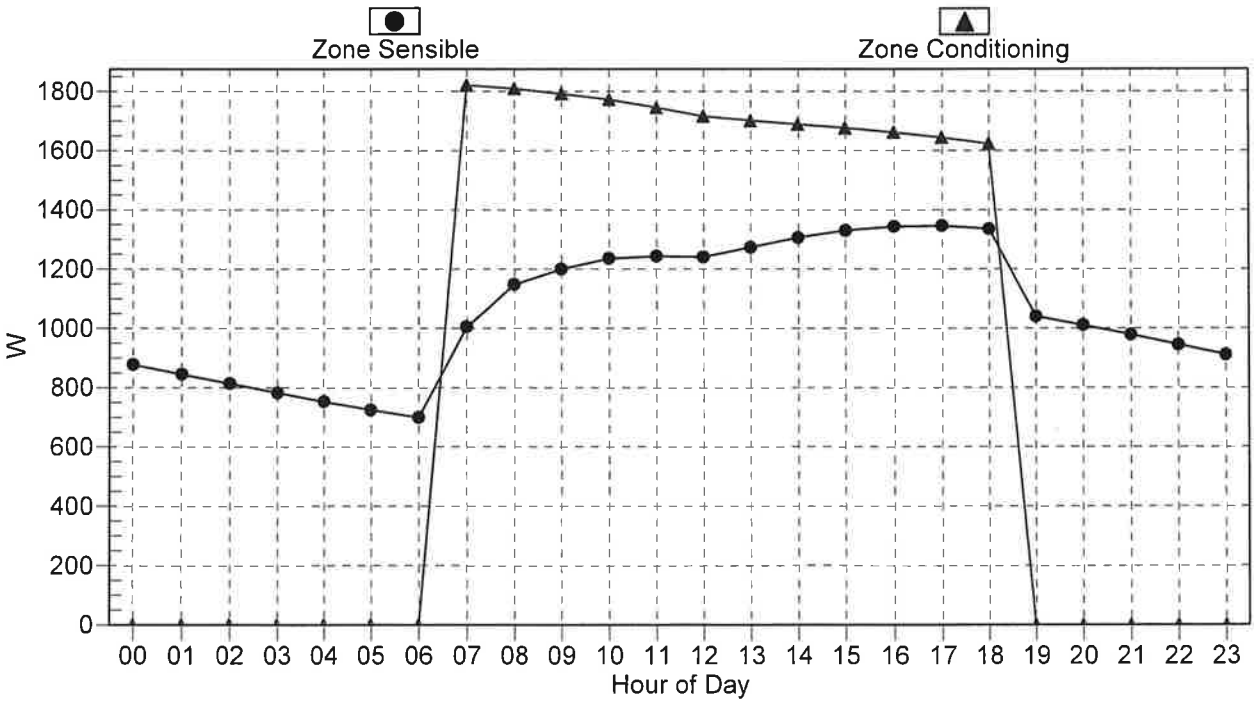

Zone: 3 Manager

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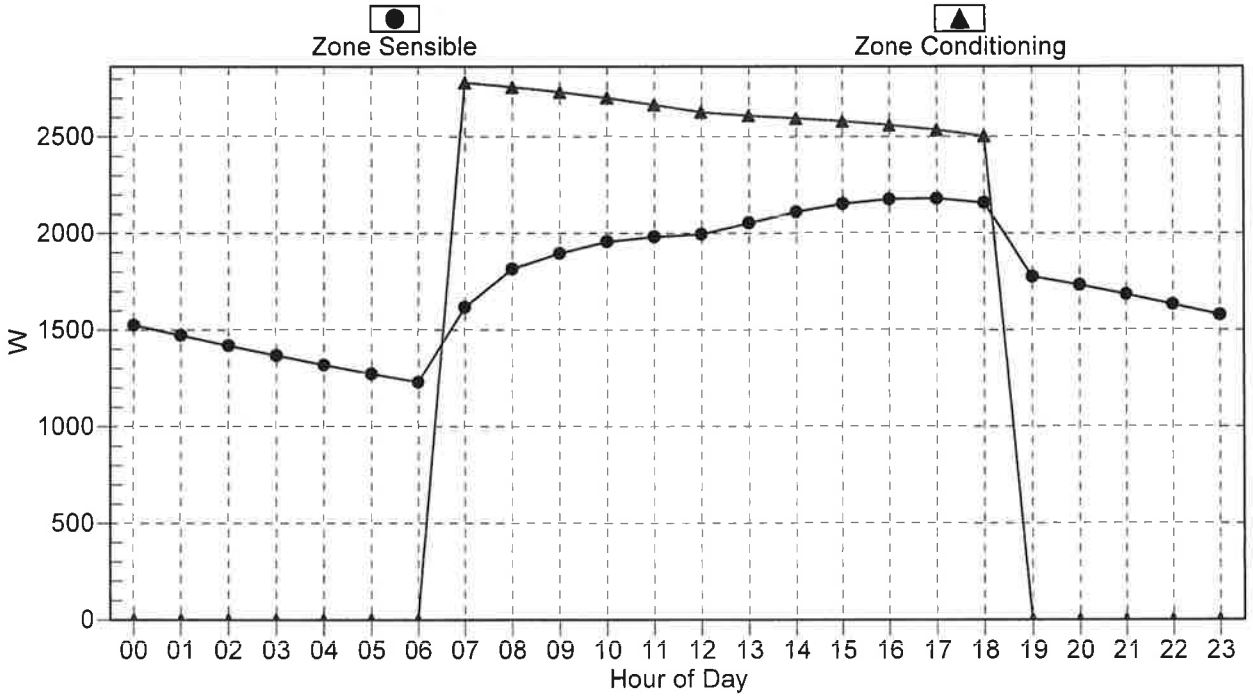

Zone: 4 General Perimeter

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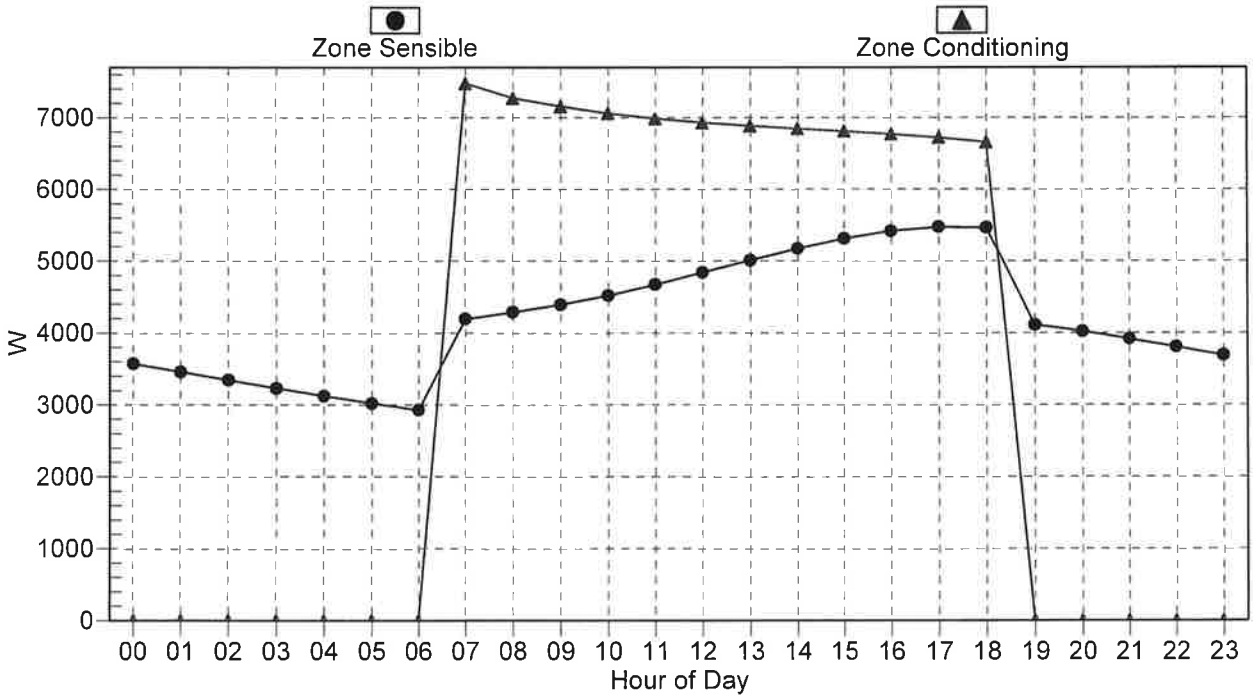

Zone: 5 Chief Engineer

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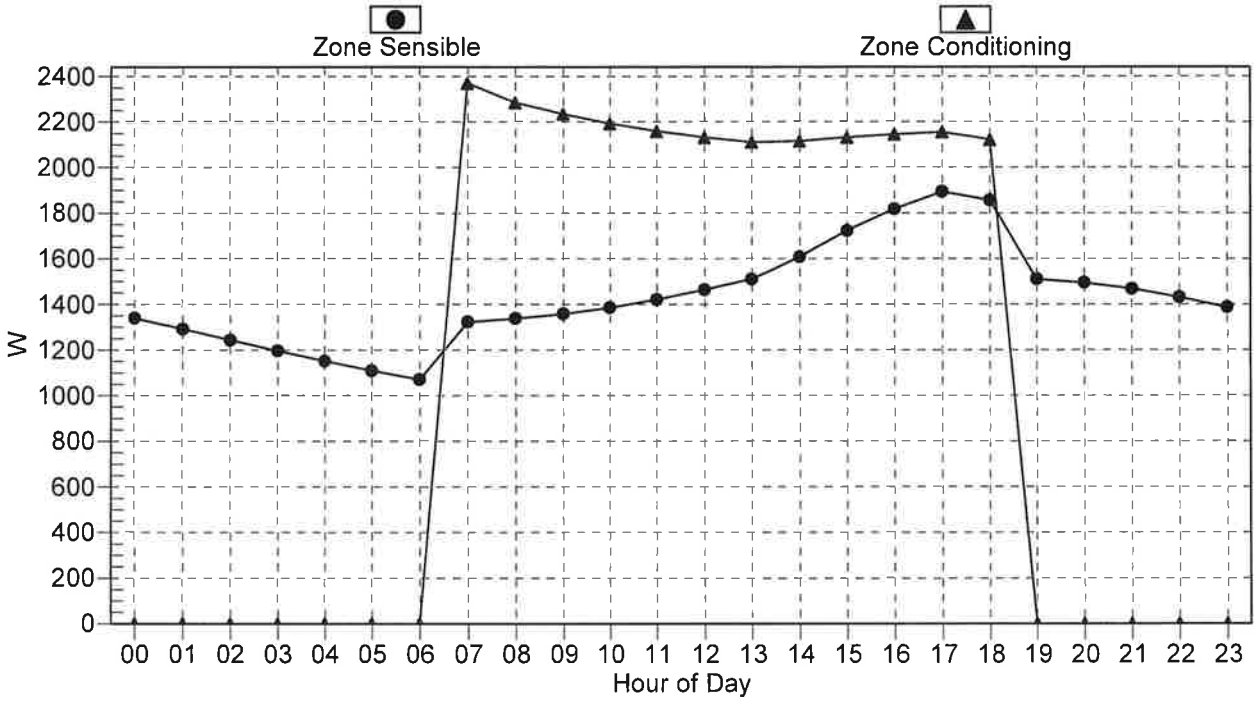
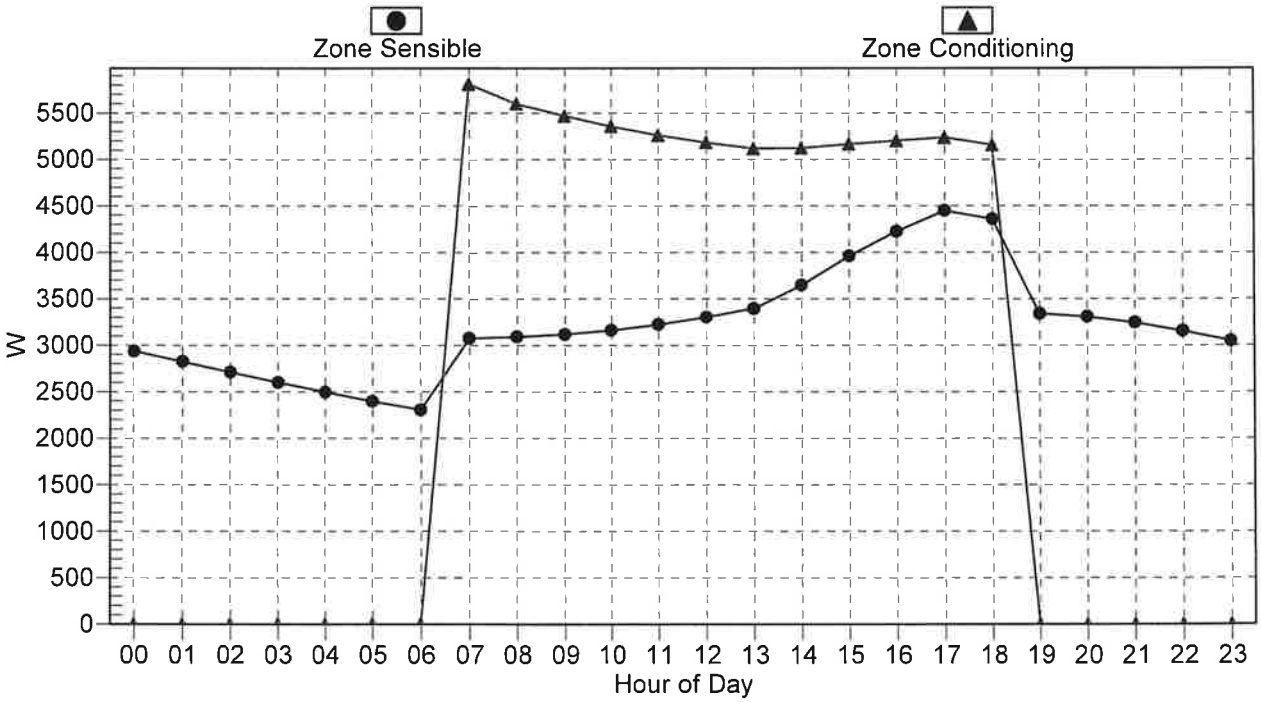


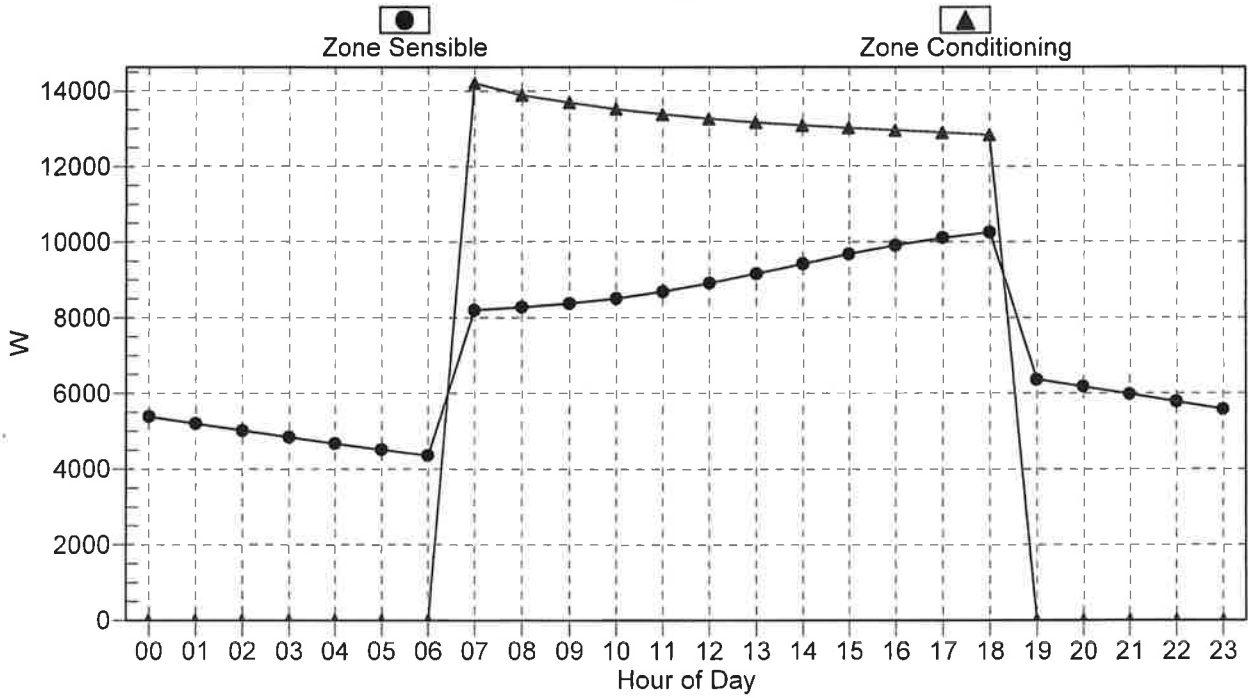
Zone: 6 Engineering

Data for August



Zone: 7 General Core Office

Data for August



HVAC systems Classification

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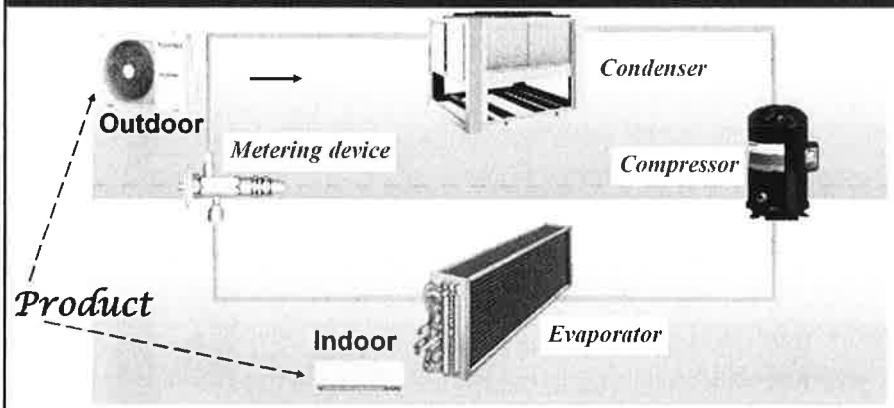
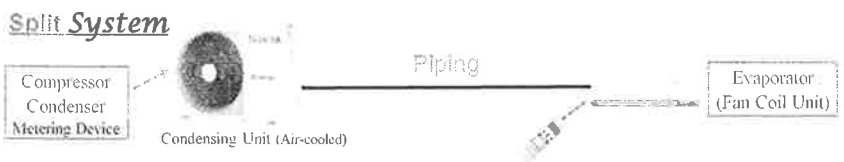
Basic Air-conditioning Components





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HVAC products

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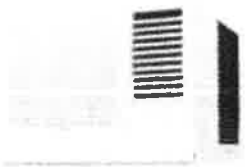
Residential Product

WRAC

Window Room (or Rack) Air Conditioner

1 watt = 3.412 BTU/h



Cooling only (7, 9 & 12k BTU/h)



Cooling only (18 & 24k)

packaged unit comp, condens Expansion, Evaporator all inside.

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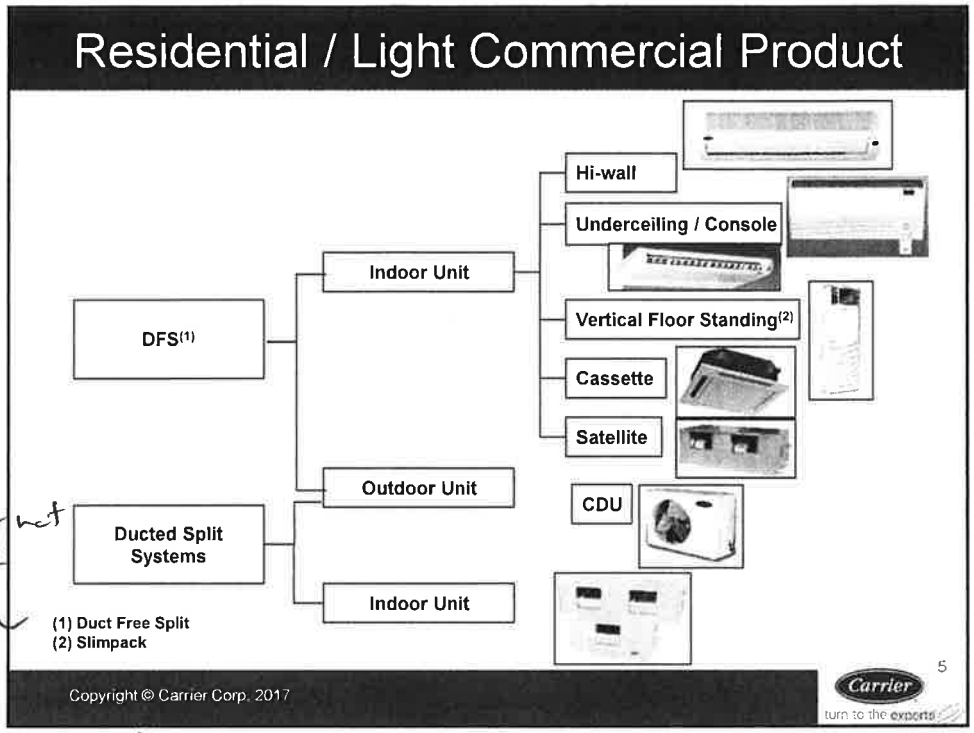
Residential / Light Commercial Product



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5

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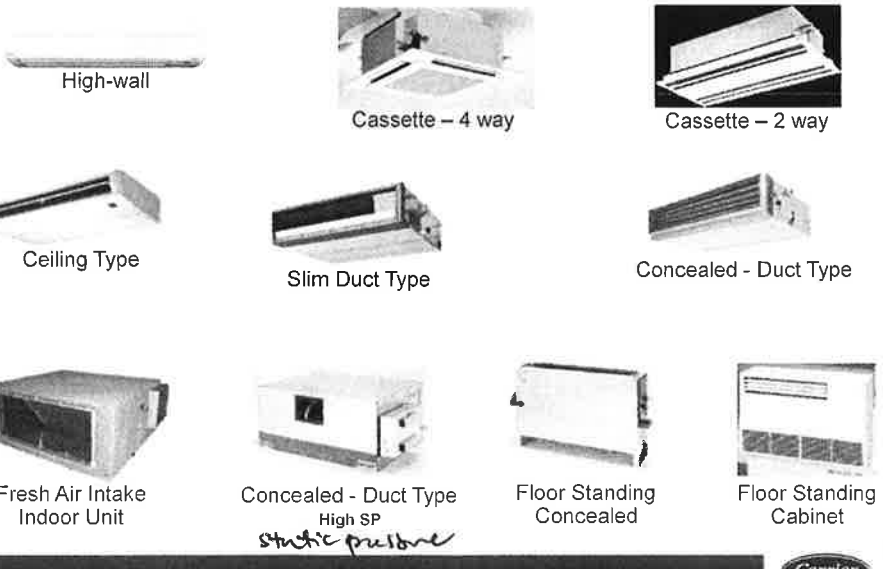
motor is usually not a problem. But fan is the factor for efficiency.

Air passing coil should not be more than 2.5m/s face velocity

Indoor Units - FCUs



static pressure

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6

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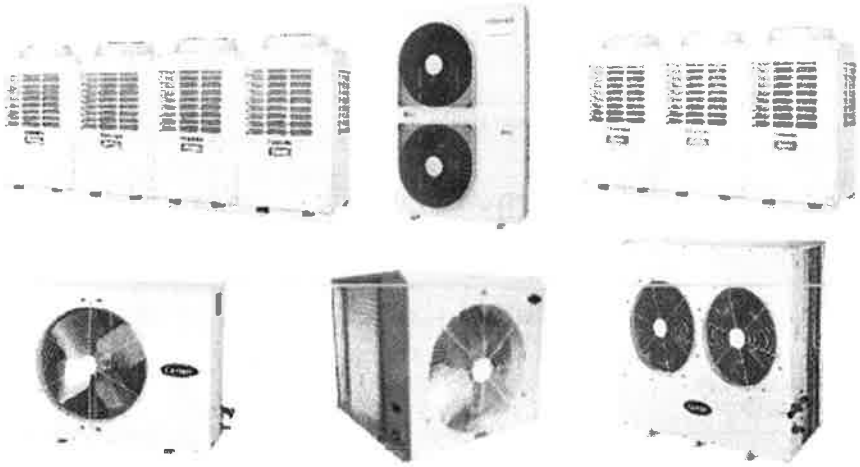
Outdoor Units - CDUs



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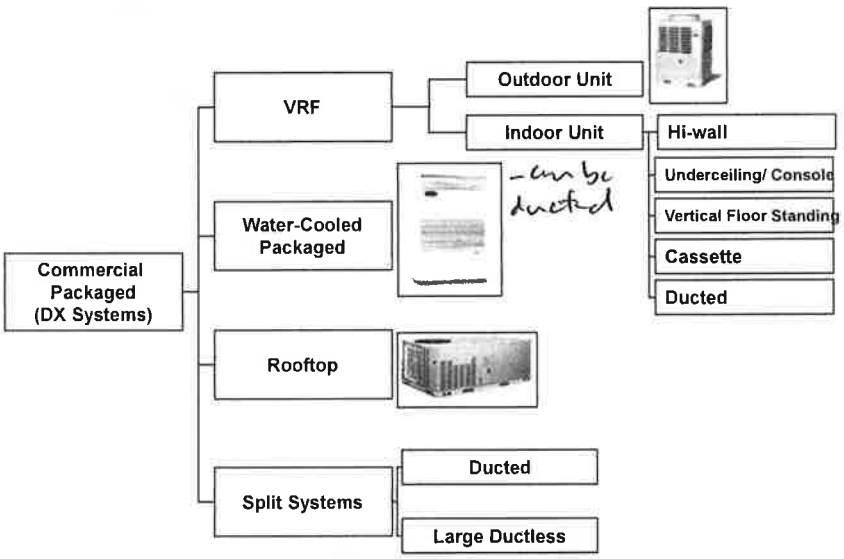
Commercial Packaged Product



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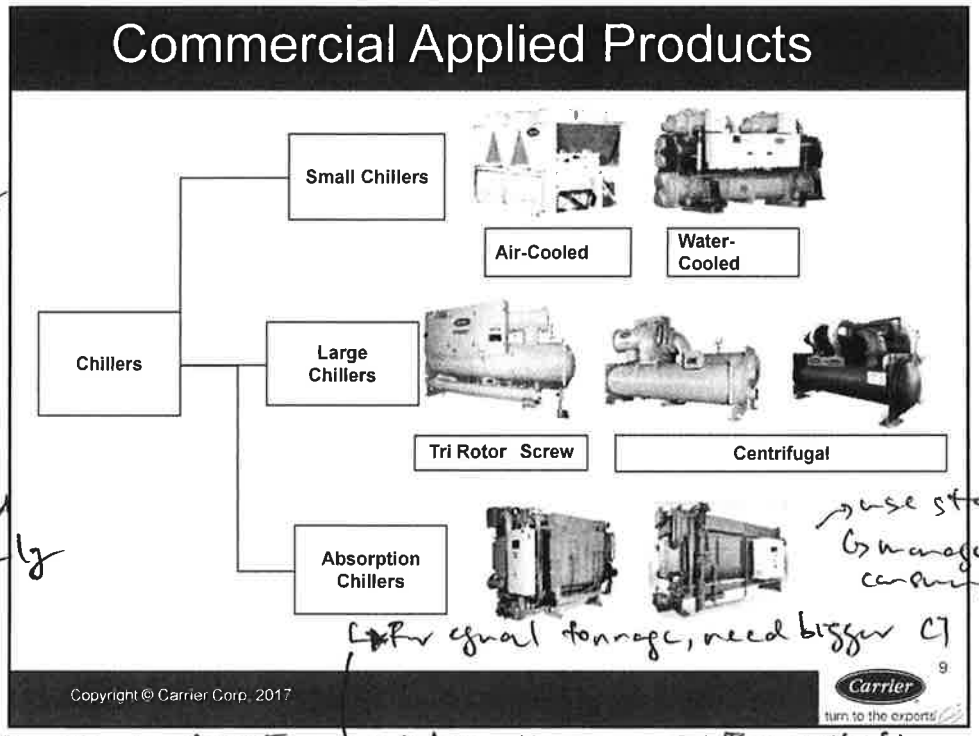
air-cooled chiller
↳ poor efficiency
↳ not good for environment.
↳ but because availability of water is not an issue, Singapore uses water-cooled chiller extensively

Commercial Applied Products



↳ use steam/gas ↳ manage power consumption.

↳ For equal tonnage, need bigger CT

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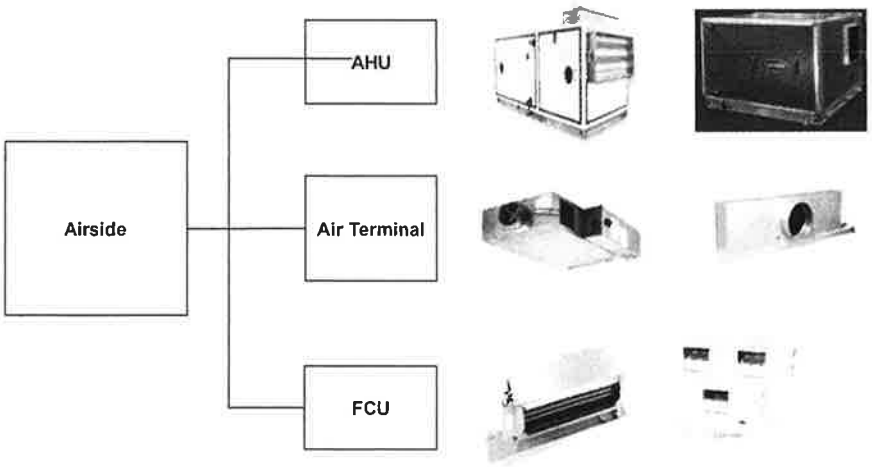
For AHU configuration of seasons, chiller can serve for both cold and warm.

↳ when excess energy is available.
↳ use steam to run absorption chiller.
↳ recover excess energy

Commercial Applied Products



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Ancillary Equipment

Pumps



Cooling Tower



Ventilation Fans



Water Tanks



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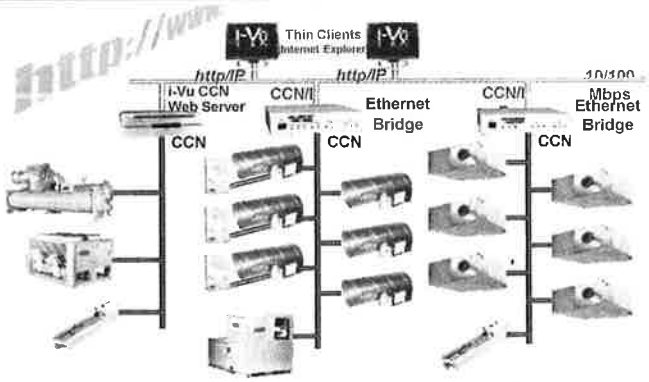
Commercial Applied Products

Controls



Auxiliary



Cooling Tower



Pump

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HVAC systems

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Single Split System

(Residential)

Evaporator



Fan Coil Unit
(Hi Wall)



Compressor
Condenser
Metering Device



Condensing Unit
(Air-cooled)

- 10K
- 13K
- 16K

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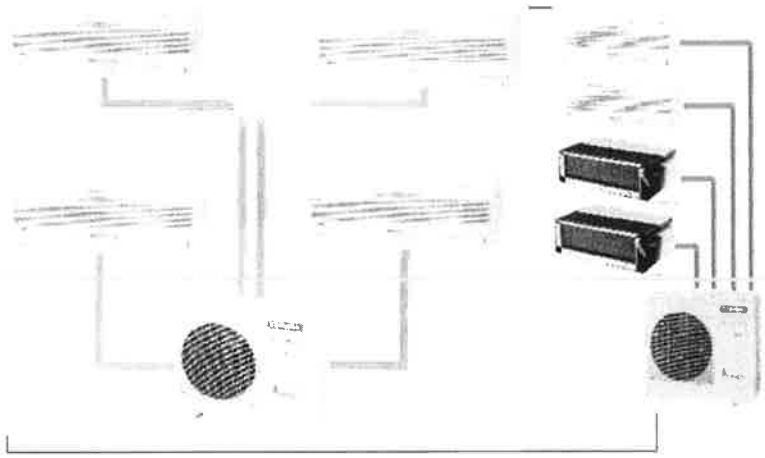
Multi Split System

2:1

3:1

4:1



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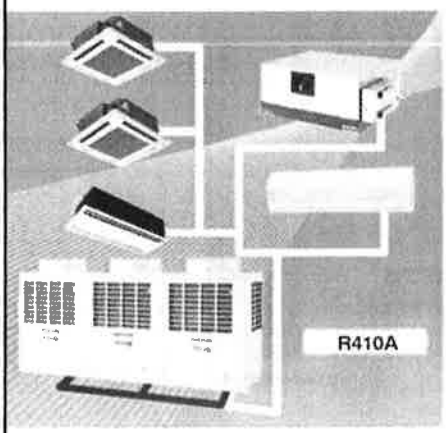
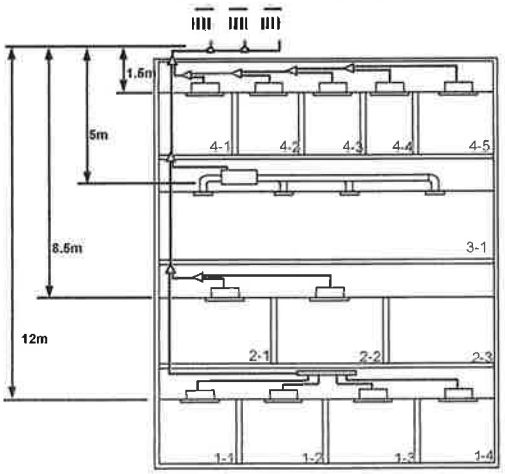
Variable Refrigerant Flow (VRF) System



Typical VRF Piping Layout



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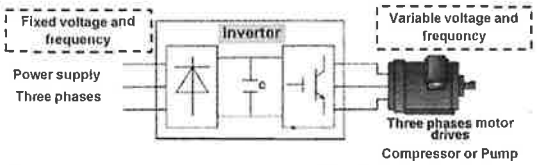
System Efficiency Improvement

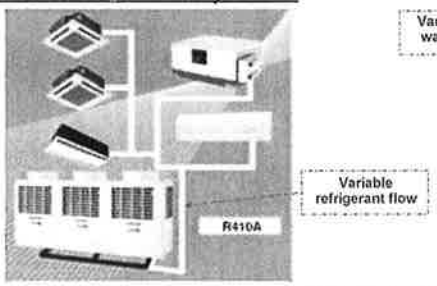
Inverter



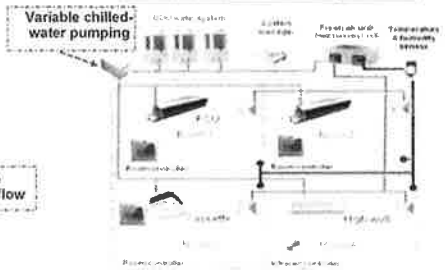
Inverter controls speed of compressor or pump to deliver required cooling medium

- refrigerant in DX (Direct Expansion) VRF (Variable Refrigerant Flow) System
- Chiller, chilled/condensing water pump, cooling tower fan in chilled-water system

Toshiba VRF System



Carrier VWV System



VWV – Variable Water Volume

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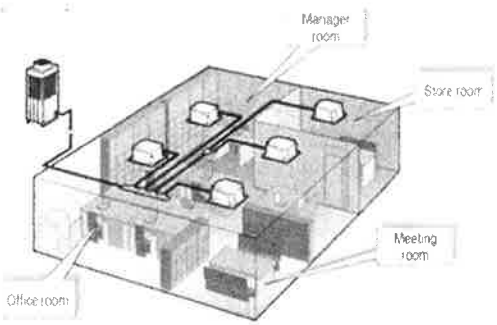
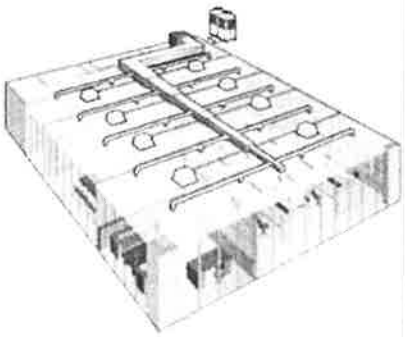
Typical VRF systems

Light commercial application



Direct Ventilation System

Common Ventilation System



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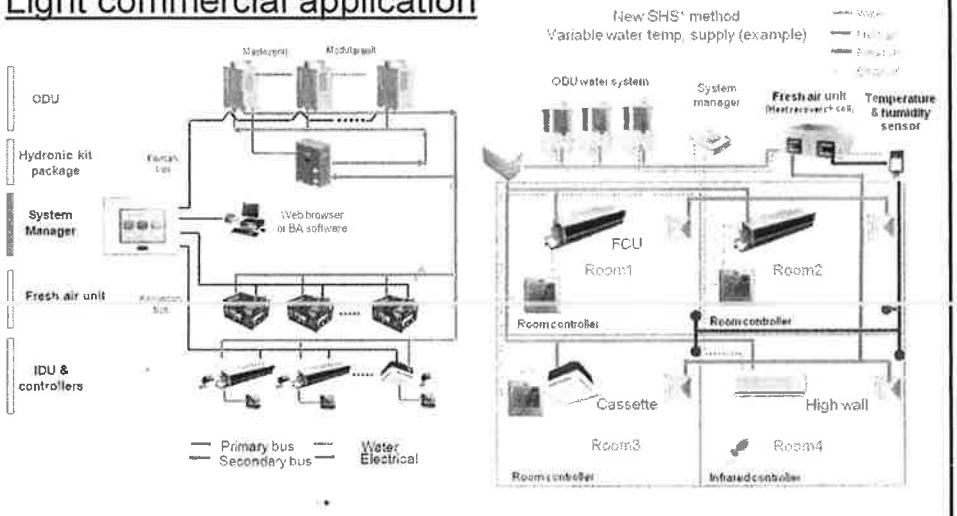
Typical chilled water system

Light commercial application



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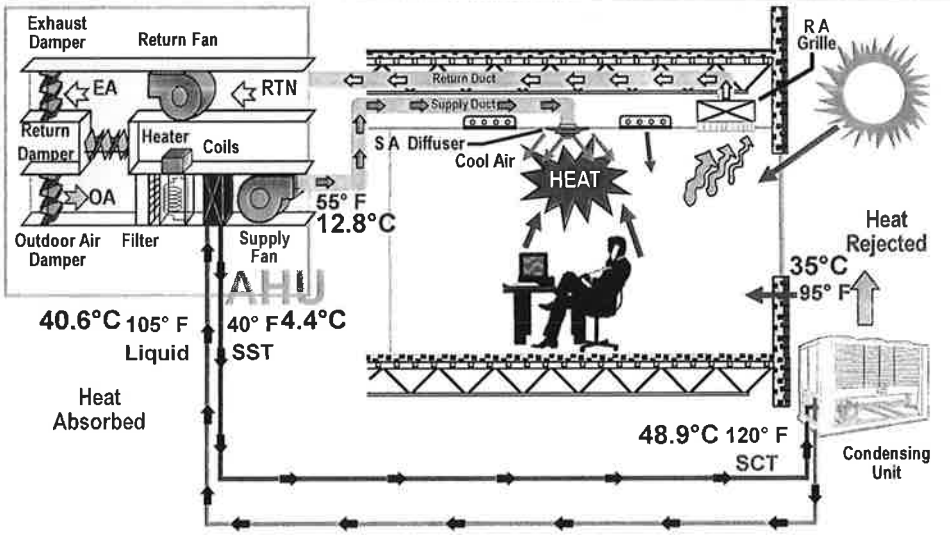
turn to the experts

Air-cooled DX System



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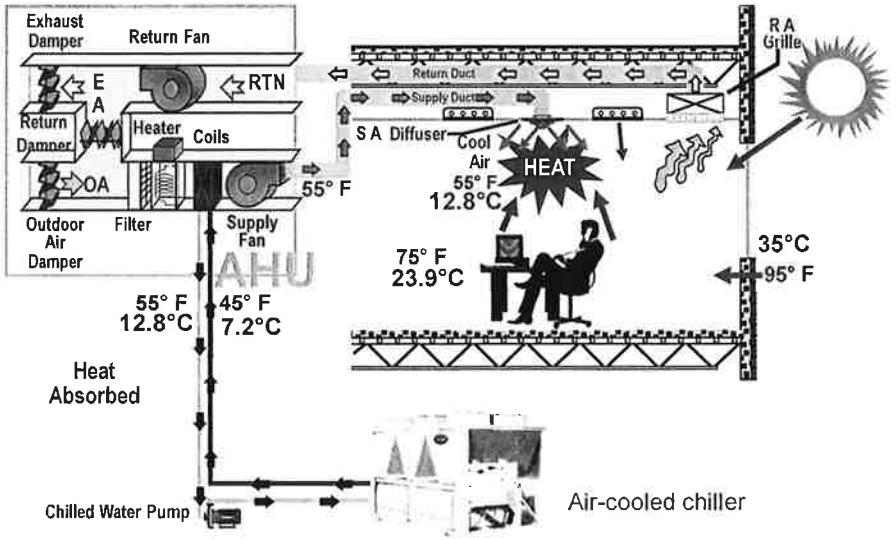
Air-cooled Chilled-water System



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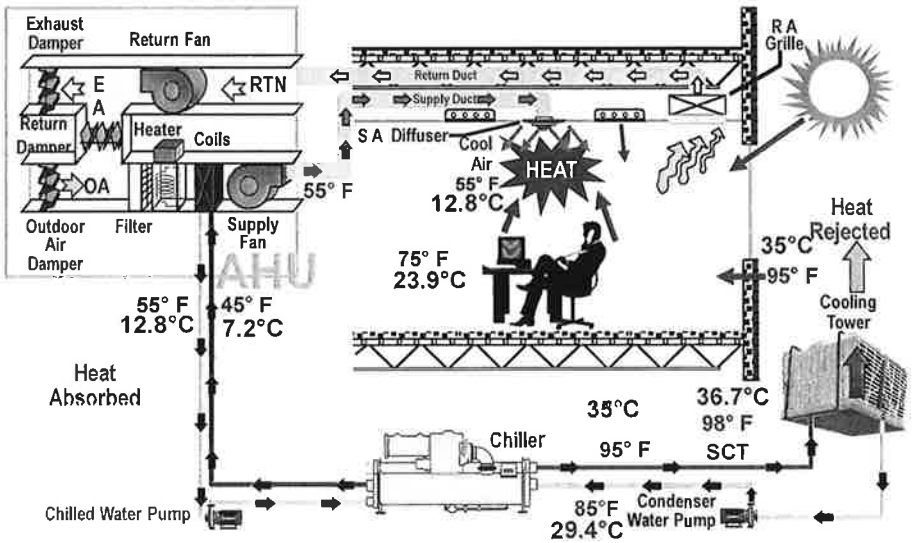
Water-cooled Chilled-water System



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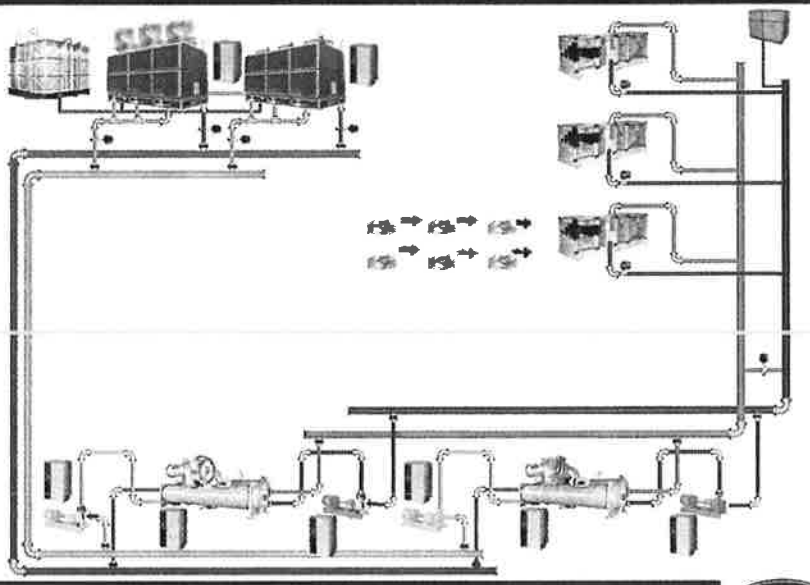
Typical large chilled water system



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Variable Refrigerant Flow (VRF) system

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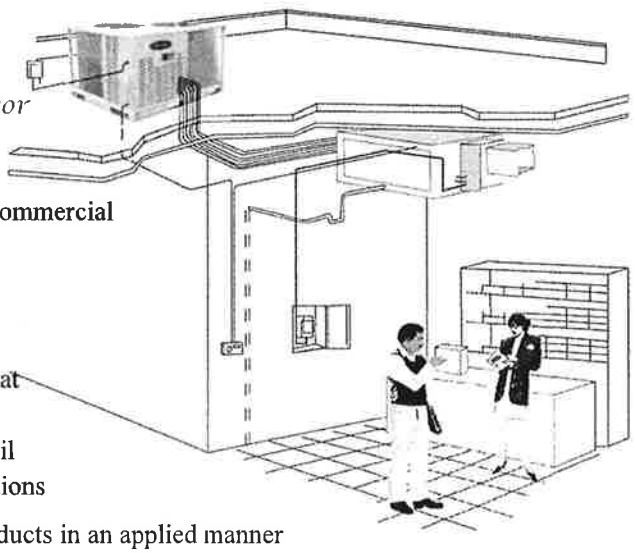
Fix Speed System

Capacity control -
Cycling of compressor



- Residential to large commercial
- ¾ to 120+ tons
- Applications
  - Cooling only
  - Cooling with heat
  - Heat pump
  - Furnace with coil
  - Process applications
- Utilize packaged products in an applied manner

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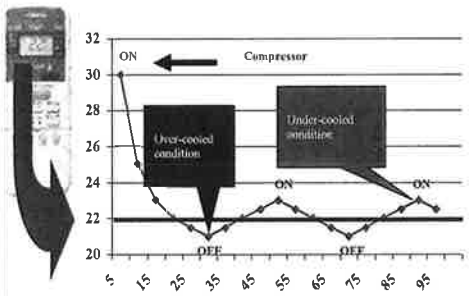
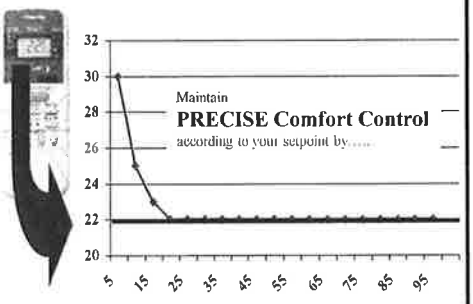
Fix versus Variable Speed System

Comfort Control – FS vs VRF



Conventional Split Air Conditioner
- Fix Speed



VRF
- Inverter

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Why Part load is important?

A building is rarely at full load.

For a building to be at "full-load"

- ✔ Design day weather
- ✔ Fully occupied
- ✔ Full solar load
- ✔ Full equipment and lighting load
- ✔ Full ventilation rates

Must occur simultaneously!



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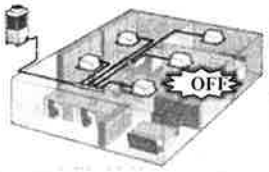
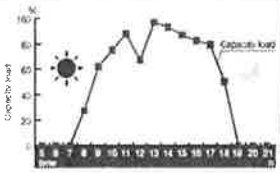
What is Part load?

In case of:
Operate some of indoor units.
Example: office area is on, meeti room is off.



In case of:
Outdoor unit temperature is lower than standard condition.
Example: night



In case of:
Indoor load is decreasing after running certain time.
Example: office closed



Application:



Apartment, villa



Office building

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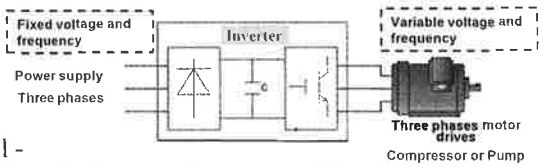
turn to the experts

System Efficiency Improvement

Inverter



Capacity control -

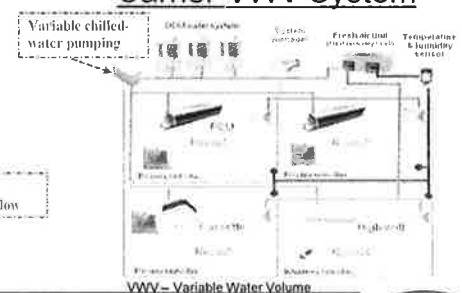
Inverter controls speed of compressor or pump to deliver required cooling medium continuously

- refrigerant in VRF (Variable Refrigerant Flow) System
- Chiller, chilled/condensing water pump, cooling tower fan in chilled-water system

Toshiba VRF System



Carrier VWV System



VWV – Variable Water Volume

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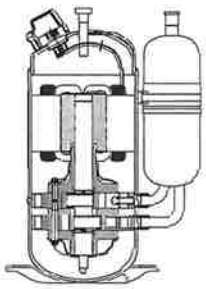
turn to the experts

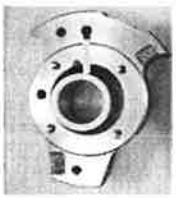
Compressor Comparison (VRF)

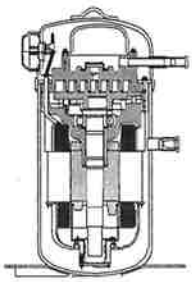
Twin Rotary compressor	Scroll compressor

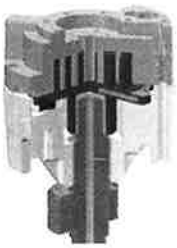




DC Twin Rotary Compressor
- High Reliability
- High Efficiency
- Low Noise







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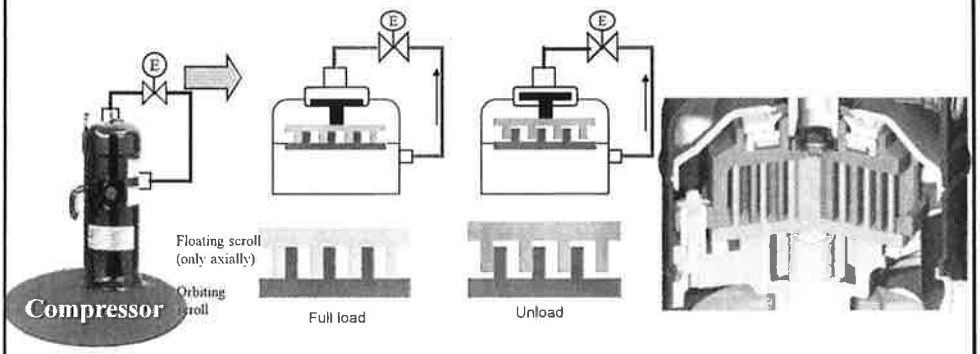
Digital Scroll Compressor Principle

It has 2 modes of operation, loaded (normal operation) and unloaded (the floating scroll is separated from the orbiting scroll, and no compression)



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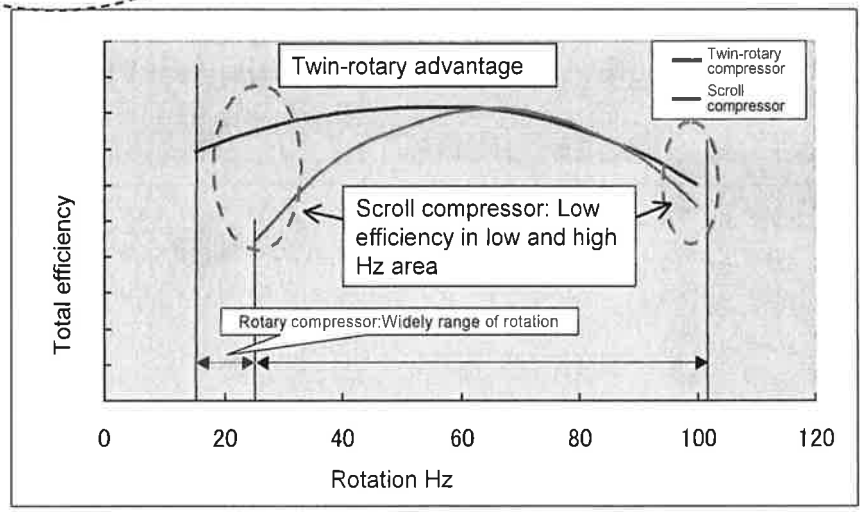
Compressor Performance Comparison

Twin Rotary vs Scroll compressor performance comparison



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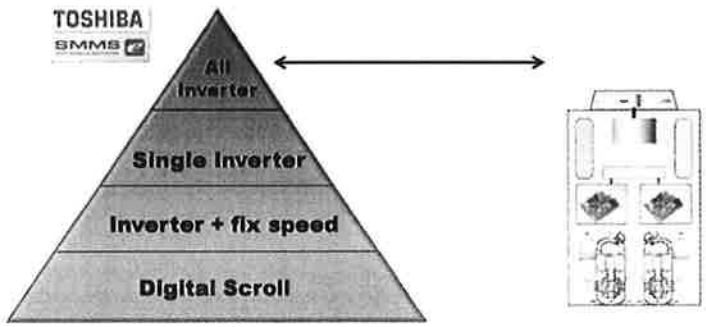
VRF system classification

INV compressor	**INV compressor**
INV compressor	--
INV compressor	Fix speed COMP.
FIX speed digital scroll compressor	Scroll compressor



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inverter
VFD is
same
- smaller module
- ability to run at part load to higher efficiency.

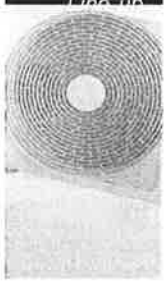
Single inverter hi-wall

TOSHIBA
Leading Innovation

INVERTER

Single Inverter Hi-wall Line-up (Heat Pump)

Product Line-up





RAS-10SKV-E2



RAS-10SAV-E2



RAS-13SKV-E2
RAS-16SKV2-E



RAS-13SAV-E2
RAS-16SAV2-E
RAS-18SAV-E2
RAS-22SAV-E2



RAS-18SKV-E
RAS-22SKV-E

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signage
↳ 3-phase supply
↳ φ15/200V

HDB
↳ castform
30 amp
↳ new 60 amp

heat pump
↳ opp. of cooling.

EER
↳ cooling
COP → correct
↳ heating.

MULTI-SPLIT SYSTEM - RESIDENTIAL

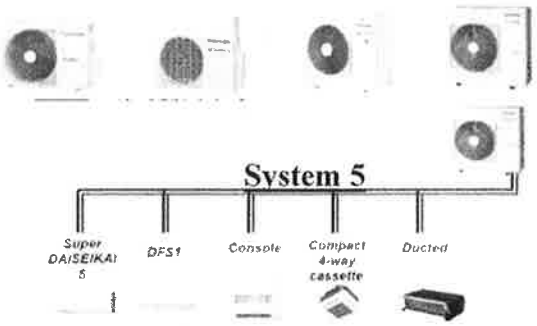
System 5
RAS-5M34UAV-E



Weight: 75kg

Class	Cooling (kW)	Heating (kW)	2-room multi-split	3-room multi-split	4-room multi-split	5-room multi-split
14	4.0	4.4	RAS-M14GAV-E	–	–	–
18	5.2	6.7	RAS-M18GAV-E	RAS-3M18SAV-E	–	–
23	6.8	7.2	–	–	RAS-4M23SAV-E	–
26	7.5	9.0	–	RAS-3M26GAV-E1	–	–
27	8.0	9.0	–	–	RAS-4M27GAV-E1	–
34	11.0	14.0	–	–	–	RAS-5M34UAV-E

Capacity (kW)	Cooling	10.0 (3.7 to 11.0)
	Heating	12.0 (3.4 to 14.0)
Power consumption (kW)	Cooling	2.923
	Heating	2.833
Dimension (mm)	Height	880
	Width	900
	Depth	320
EER		3.42
COP		4.24
Sound pressure (dB)	Cooling	51
	Heating	54
Total piping length (m)		80
Height difference (m)		15
Outdoor temperature range (°C)	Cooling	10 to 43
	Heating	-10 to 22



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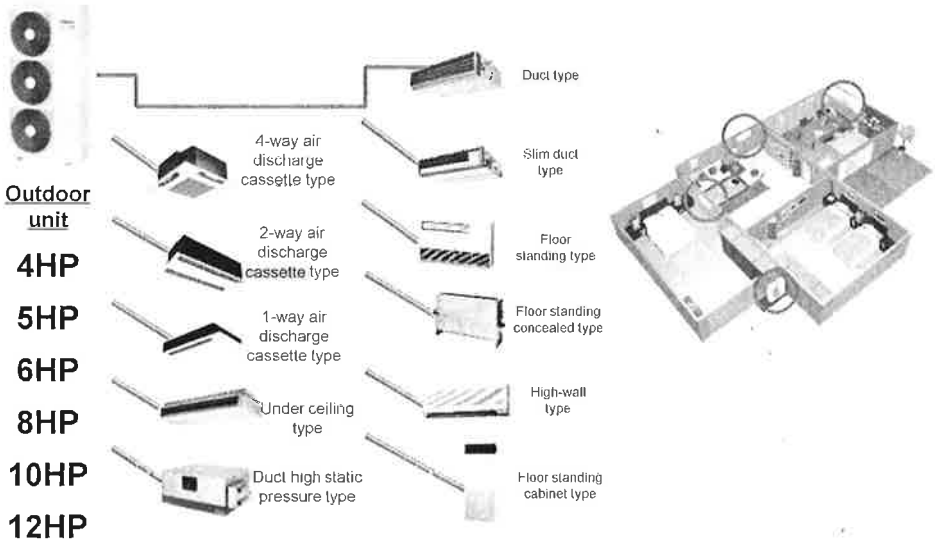
MINI-SMMS PRODUCT PORTFOLIO



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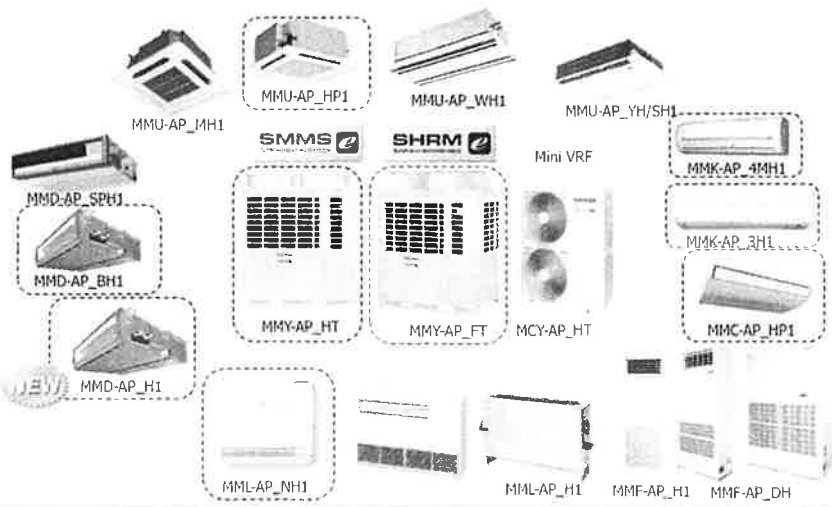
VRF Indoor units

Common to all VRF Toshiba ranges



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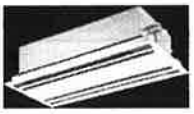
Indoor Units - FCUs

High-wall



Cassette – 4 way



Cassette – 2 way



Ceiling Type



Slim Duct Type



Concealed - Duct Type



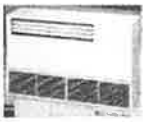
Fresh Air Intake
Indoor Unit



Concealed - Duct Type
High SP



Floor Standing
Concealed



Floor Standing
Cabinet

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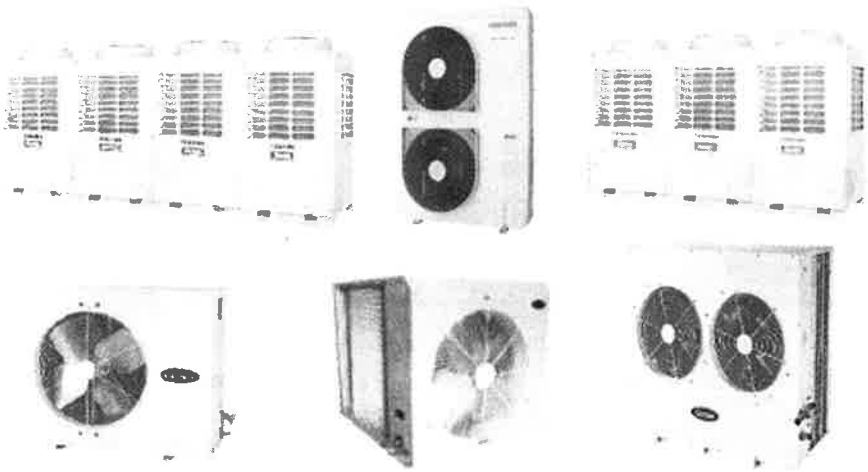
Outdoor Units - CDUs



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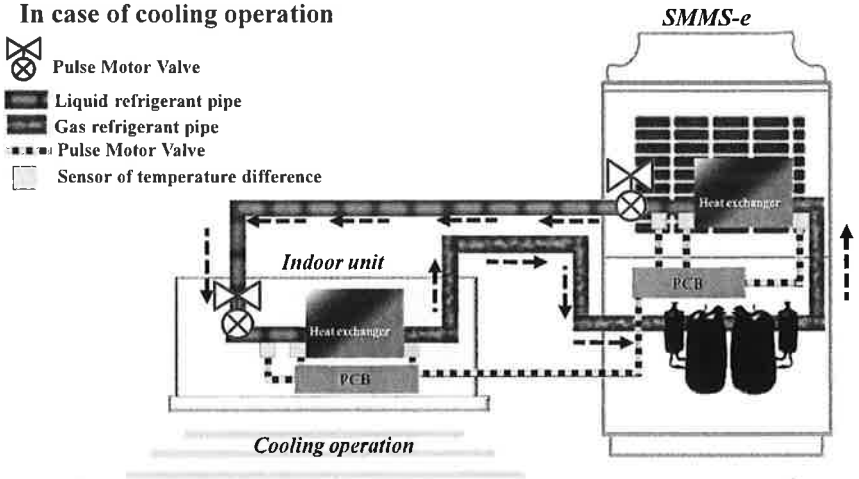
Intelligent VRF control

In case of cooling operation



Control the flow of refrigerant to each indoor unit via independent PMV control

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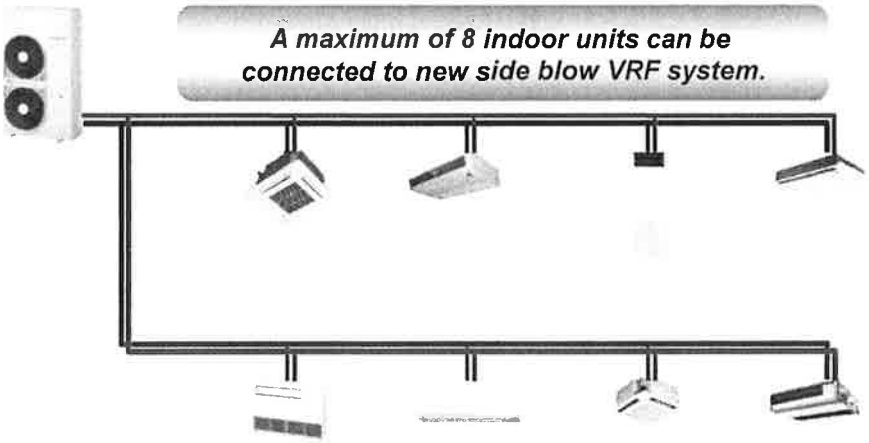
Typical specification

VRF

Specifications
-Max connectable indoor unit-

A maximum of 8 indoor units can be connected to new side blow VRF system.



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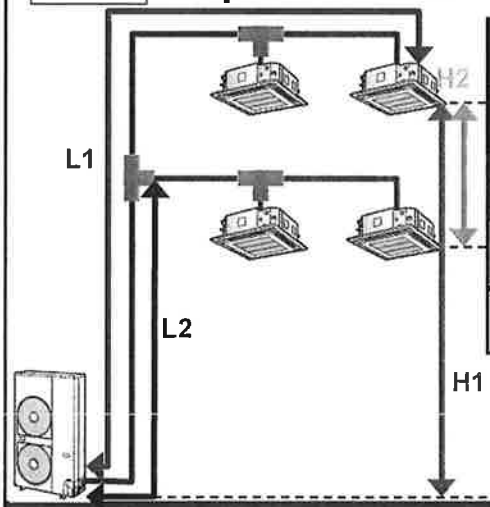
Typical specification

VRF **Specifications -Piping length**



L1	Max length from CDU to FCU	60
L2	Max. length 1 branch to FCU	30
H1	Max. height CDU to FCU	15
H2	Max. height FCU to FCU	10
	Max. total pipe length	100

(m)

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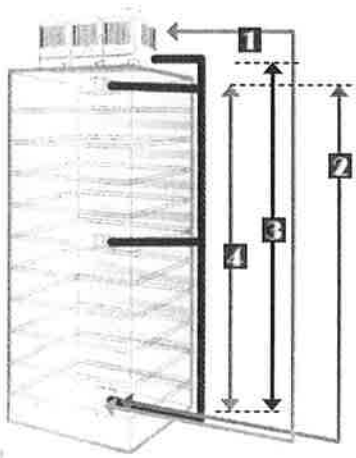
Piping summary



Total length	1000m*
1 Farthest equivalent length	235m
2 Farthest pipe from 1st branch	90m**
3 Height between CDU-FCU (outdoor unit above / below)	70m***/ 40m
4 Height between FCU-FCU	40m

* : Above 34HP combination
** : 65m if the height piping length between CDU and FCU is more than 3m
*** : 70m is tentative, which may change.
50m if piping length between FCU's is more than 3m

Piping capability can provide more benefits for the system design, the installation flexibility, and the installation cost.

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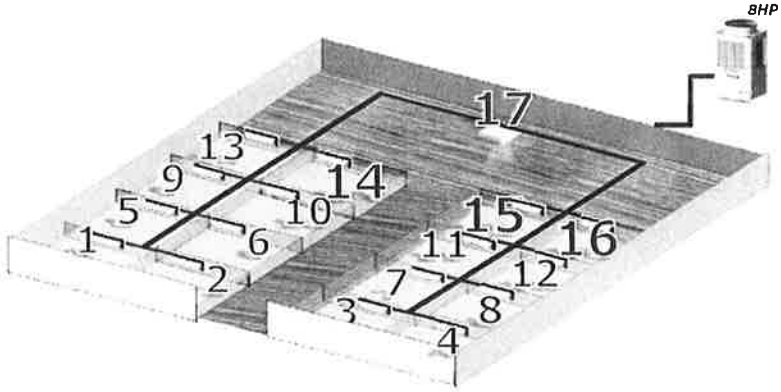
Connectable no. of indoor units

Connectable indoor units are 17 with SMMS-e

8HP Model



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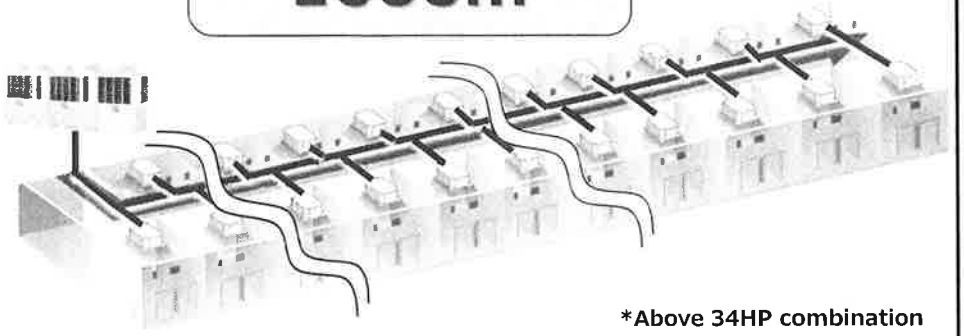
Total pipe length

SMMS-e Max. total length

1000m



***Above 34HP combination**

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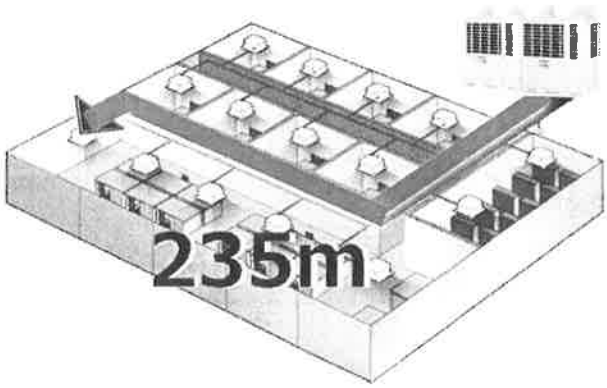
Equivalent length



Maximum equivalent distance between outdoor unit and farthest indoor unit is 235 meters.

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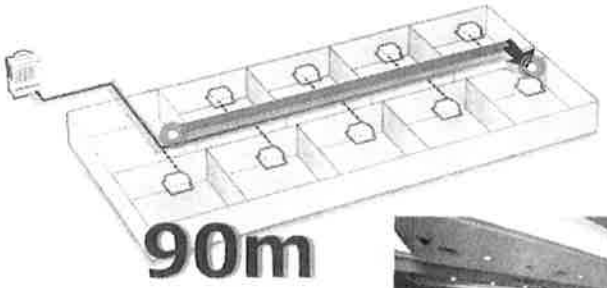
Farthest pipe from 1st branch







The piping distance from the 1st branch to the furthest indoor unit is 90m, increasing the flexibility of the installation within the hotel or office building.

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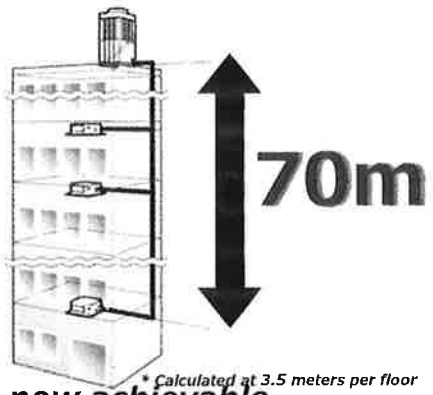
Height between cdu to idu

An 14-story building is covered by single system with greater support for height difference between indoor unit to outdoor unit.





** Calculated at 3.5 meters per floor*

A maximum of 70 meters is now achievable between outdoor and indoor units. Allowing for easy installation even when installing in the tallest of buildings.

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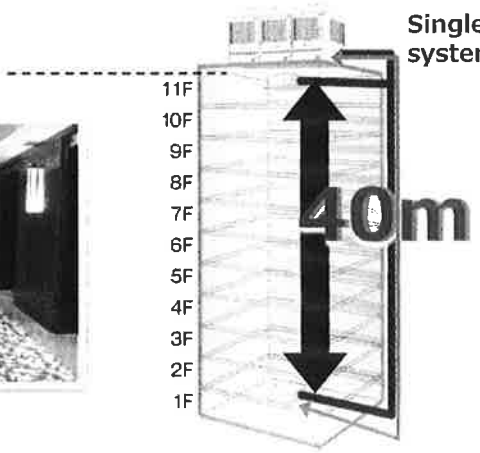
Height between indoor units





A maximum of 40 meters between indoor units is enough to cover an entire 11-story building

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Maximum Length of Refrigerant Piping

- Piping length depends on the application
- Consult manufacturer's recommendations

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Refrigerant Safety consideration

- Safety for leakage

When selecting an indoor unit in a small room, assure that the possible concentration of leaked refrigerant gas is below the Concentration limit in the event if the refrigerant leaks in the room from the indoor unit .

Criteria

$$\frac{\text{Total amount of refrigerant (kg)}}{\text{Minimum volume of the indoor unit installed room } (m^3)} <= \text{Concentration limit} = \underline{\mathbf{0.3\ kg/m^3}}$$

For R410A

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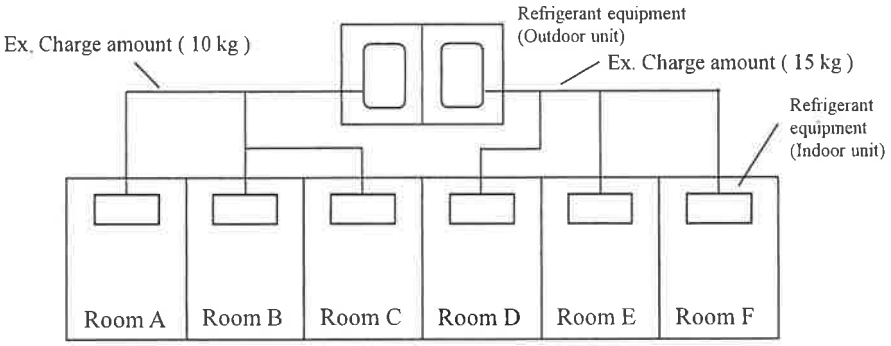
Refrigerant charge and Safety consideration

- In case that there are 2 or more refrigerant circuits in a single system



Select the smallest volume room on each circuit

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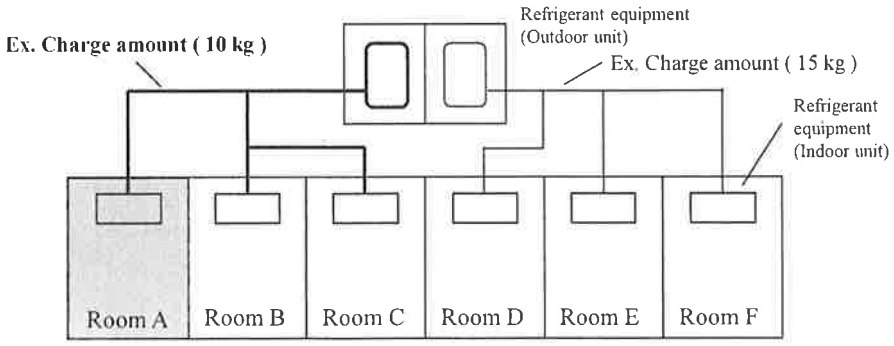
Refrigerant charge and Safety consideration

- In case that there are 2 or more refrigerant circuits in a single system



The possible amount of leaked refrigerant gas is 10 kg

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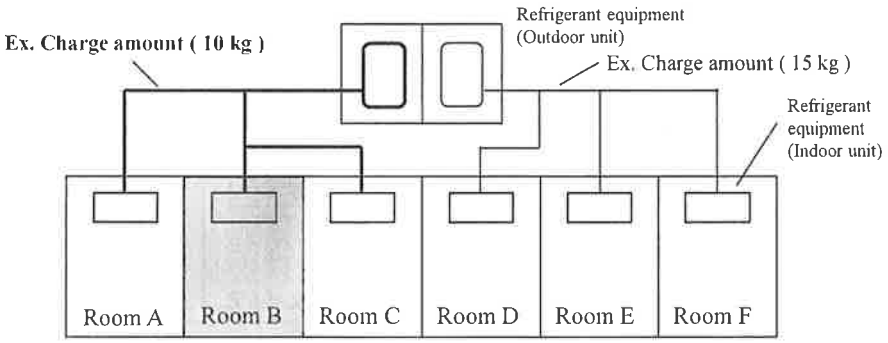
Refrigerant charge and Safety consideration

- In case that there are 2 or more refrigerant circuits in a single system



The possible amount of leaked refrigerant gas is 10 kg

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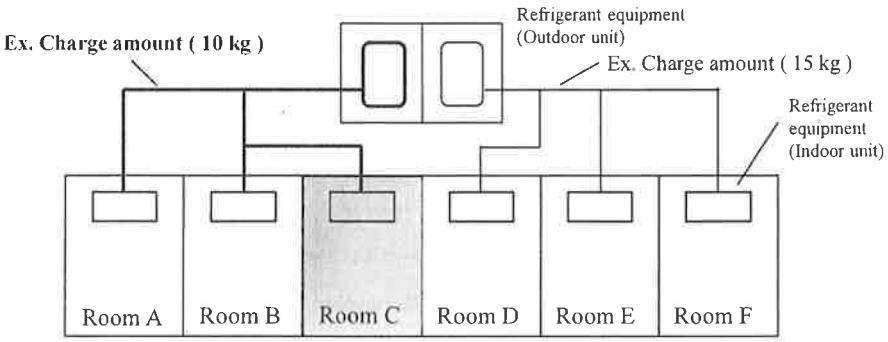
Refrigerant charge and Safety consideration

- In case that there are 2 or more refrigerant circuits in a single system



The possible amount of leaked refrigerant gas is 10 kg

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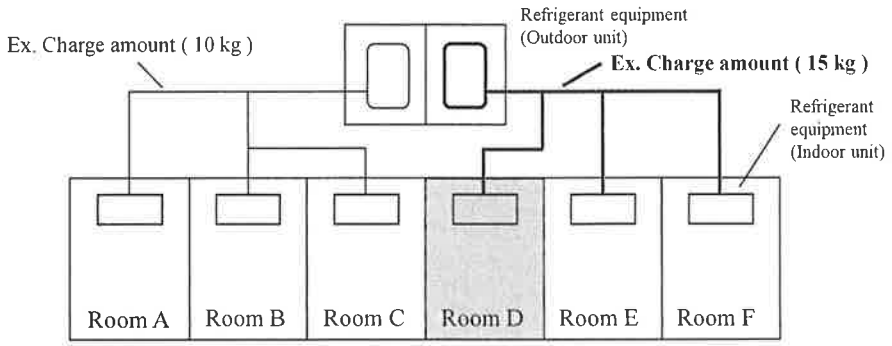
Refrigerant charge and Safety consideration

- In case that there are 2 or more refrigerant circuits in a single system



The possible amount of leaked refrigerant gas is 15 kg

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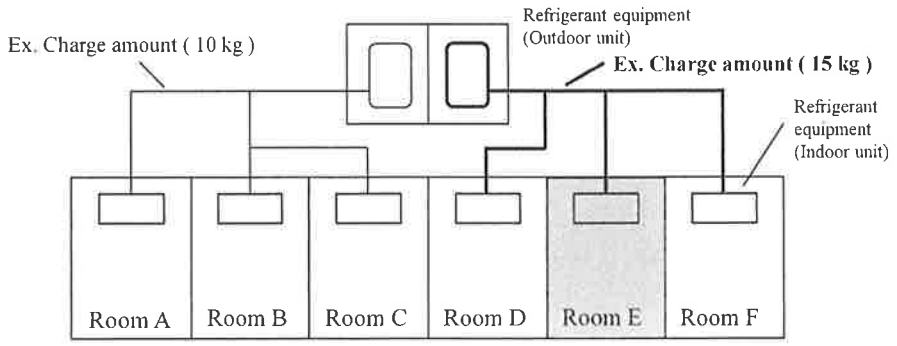
Refrigerant charge and Safety consideration

In case that there are 2 or more refrigerant circuits in a single system



The possible amount of leaked refrigerant gas is 15 kg

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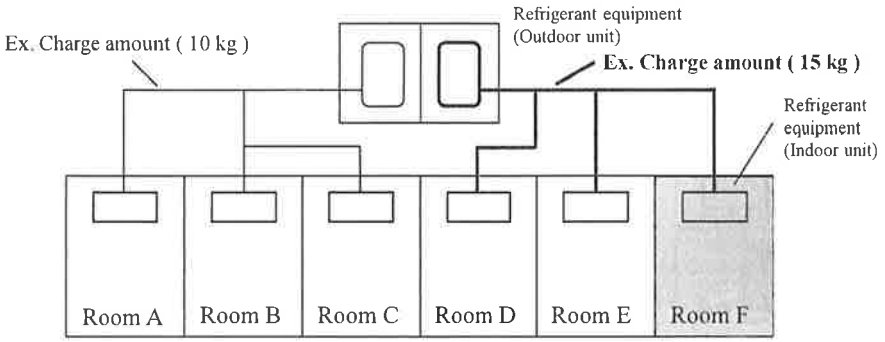
Refrigerant charge and Safety consideration

In case that there are 2 or more refrigerant circuits in a single system



The possible amount of leaked refrigerant gas is 15 kg

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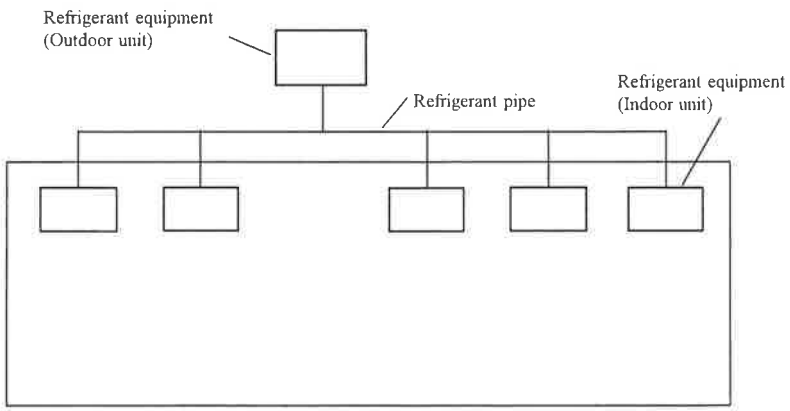
Refrigerant charge and Safety consideration

In case of no partition



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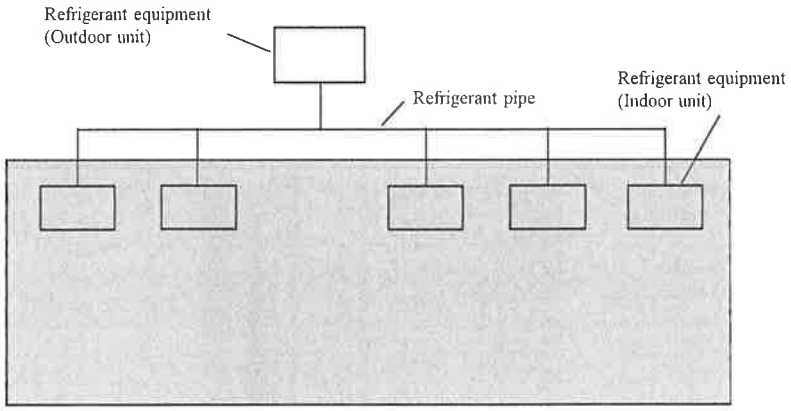
Refrigerant charge and Safety consideration

In case of no partition



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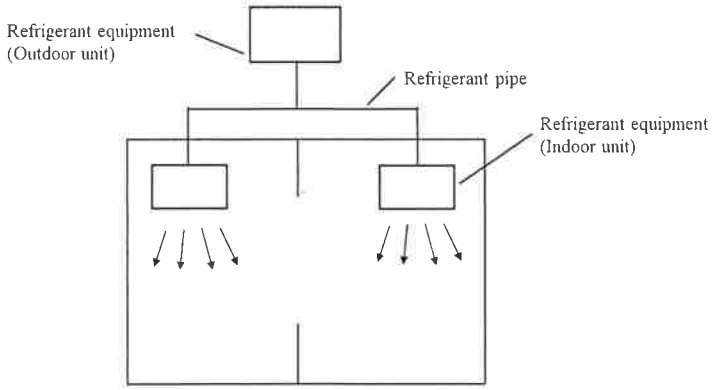
Refrigerant charge and Safety consideration

In case that there is an effective opening with the adjacent room for leaking refrigerant gas



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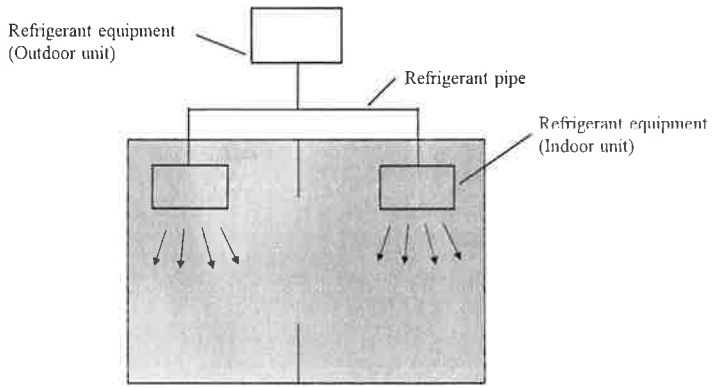
Refrigerant charge and Safety consideration

In case that there is an effective opening with the adjacent room for leaking refrigerant gas



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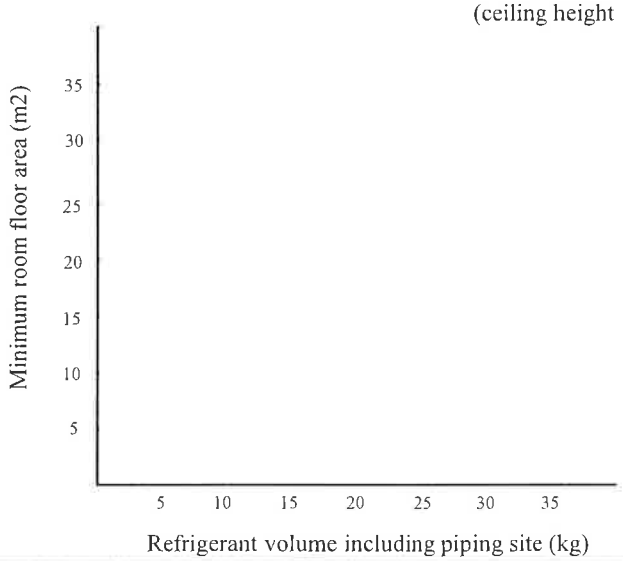
Refrigerant charge and Safety consideration

(ceiling height : as 2.7m)



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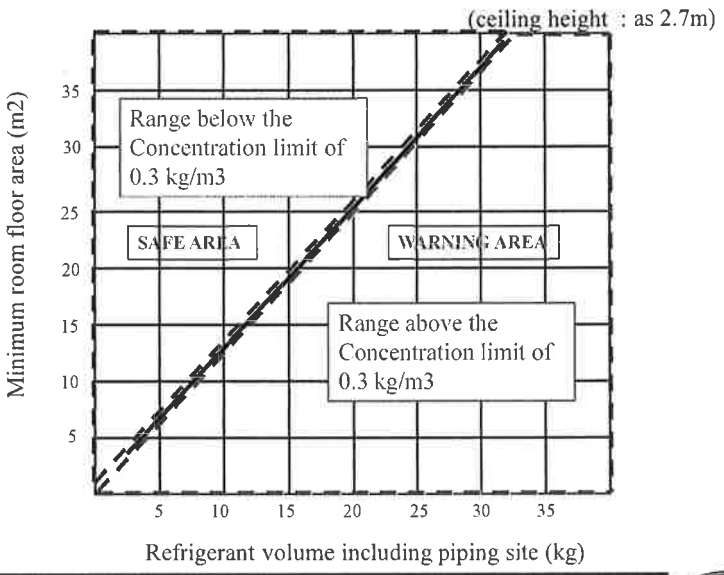
Refrigerant charge and Safety consideration



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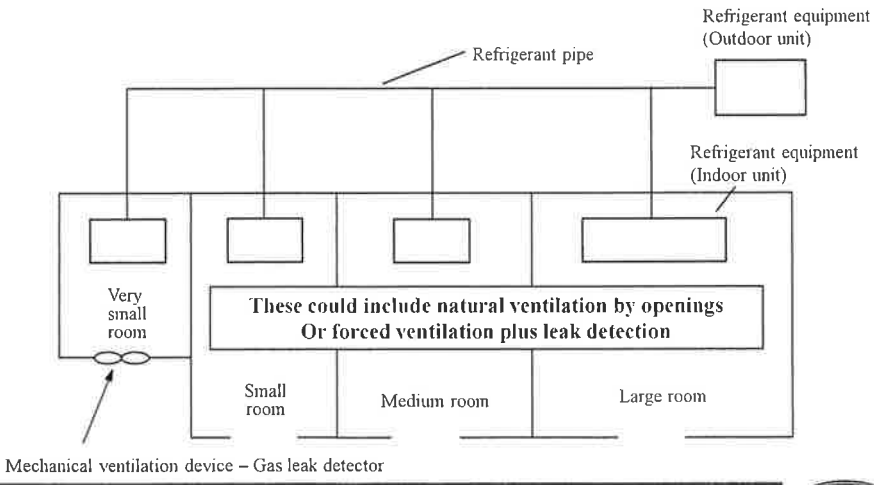
Refrigerant charge and Safety consideration

In the event of a small room within the warning area, please take some effective counter measures



refrigerant sensor to activate ~~refrigerant~~ mech vent to exhaust refrigerant out.

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Standard Rating Conditions

Extract from:
ANSI/AHRI STANDARD 1230-2010

Table 8. Operating Conditions for Standard Rating and Performance Operating Tests for Systems ≥ *65,000 Btu/h* [19,000 W]

TEST	INDOOR SECTION		OUTDOOR SECTION					
	Air Entering		Air Entering				Water[5]	
			Air Cooled		Evaporative			
	Dry-Bulb °F [°C]	Wet-Bulb °F [°C]	Dry-Bulb °F [°C]	Wet-Bulb °F [°C]	Dry-Bulb °F [°C]	Wet-Bulb °F [°C]	IN °F [°C]	OUT °F [°C]
Standard Rating Conditions Cooling[3]	80.0 [26.7]	67.0 [19.4]	95.0 [35.0]	75.0[1] [23.9]	95.0 [35.0]	75.0 [23.9]	85.0 [29.4]	95.0 [35.0]
Low Temperature Operating Cooling[3]	67.0 [19.4]	57.0 [13.9]	67.0 [19.4]	57.0[1] [13.9]	67.0 [19.4]	57.0 [13.9]	NA	70.0[2] [21.1]
Maximum Operating Conditions[5]	80.0 [26.7]	67.0 [19.4]	115 [46.1]	75.0[1] [23.9]	100 [37.8]	80.0[4] [26.7]	90.0[2] [32.2]	NA

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Standard Rating Conditions

Toshiba Rated Conditions

Cooling :
Indoor air temperature 27°C DB/19°C WB,
Outdoor air temperature 35°C DB

Heating :
Indoor air temperature 20°C DB,
Outdoor air temperature 7°C DB/6°C WB

The reference piping consists of 5 m of main piping and 2.5 m of branch piping connected with 0 meter height

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Other Conditions – Cap Correction

11-1. Outdoor unit

11-1-1 Specifications

Standard model (Single unit)

Equivalent HP				5HP (*)	6HP (*)	8HP	10HP
Model name		Heat Pump	MMY-	MAP0501HT8	MAP0601HT8	MAP0804HT8	MAP1004HT8
		Cooling Only	MMY-	MAP0501T8	MAP0601T8	MAP0804T8	MAP1004T8
Outdoor unit type				Inverter unit			
Cooling capacity (*1)			(kW)	14.0	16.0	22.4	28.0
Heating capacity (*1)			(kW)	16.0	18.0	25.0	31.5
Power supply (*2)				3phase 4wires 50Hz 400V (380-415V)			
Electrical characteristics (*1)	Cooling	Running current	(A)	5.85	7.28	8.50	11.4
		Power consumption	(kW)	3.65	4.64	5.40	7.41
		Power factor	(%)	90	92	92	94
		EER (Energy Efficiency Ratio)	(kW/kW))	3.84	3.45	4.15	3.78
	Heating	Running current	(A)	6.09	7.08	8.8	11.80
		Power consumption	(kW)	3.84	4.56	5.53	7.50
		Power factor	(%)	91	93	91	92
		EER (Energy Efficiency Ratio)	(kW/kW))	4.17	3.95	4.52	4.20
	Starting Current		(A)	Soft Start			

Actual capacity = nominal cap x T_{indoor} correction x $T_{outdoor}$ correction x pipe length correction

Refer to Product catalog for more information

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Other Conditions – Cap Correction

1. Specifications



Concealed Duct Type

Model name		MMD-	AP0074 BH-E	AP0094 BH-E	AP0124 BH-E	AP0154 BH-E	AP0184 BH-E	AP0244 BH-E	AP0274 BH-E	AP0304 BH-E	AP0364 BH-E	AP0484 BH-E	AP0564 BH-E
Cooling?Heating capacity (Note 1)		(kW)	2.2/2.5	2.8/3.2	3.6/4.0	4.5/5.0	5.6/6.3	7.1/8.0	8.0/9.0	9.0/10.0	11.2/12.5	14.0/16.0	16.0/18.0
Electrical characteristics	Power supply		1 phase 50Hz 230V (220 – 240V) (Separate power supply for indoor units is required.)										
	Running current	(A)	0.29		0.34		0.43	0.52		0.61	0.83	0.98	
	Power consumption	(kW)	0.033		0.039		0.050	0.060		0.071	0.107	0.128	
	Starting current	(A)	0.5		0.59		0.75	0.90		1.05	1.44	1.70	

Actual capacity = nominal cap x T_{indoor} correction x pipe length correction

Refer to Product catalog for more information

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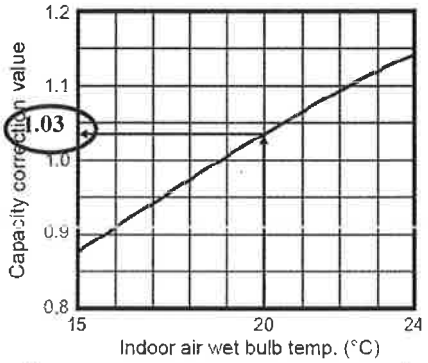
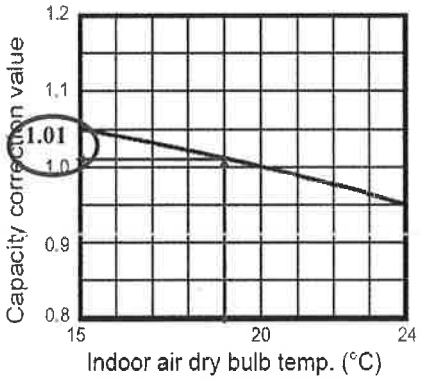
Capacity Correction – Design Indoor Temp

Correction for Design indoor temperature (e.g. Toshiba)

Cooling



Heating



Design condition

Indoor temperature

When cooling : 27.0 C DB / 20.0 C WB

When heating : 19.0 C DB

Why WB for cooling and DB for heating?
What are the rated values?

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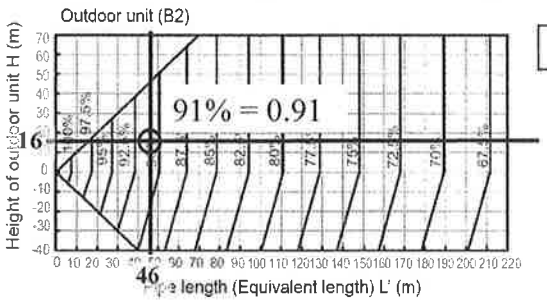
Capacity Correction – Piping Design

Correction for Design longest length and the largest height (e.g. Toshiba)

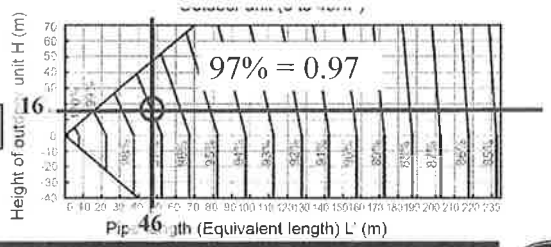


Cooling

Assume

Equivalent piping length (m)	Height difference (m)
46	16

Heating



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Overview:

Electrical power supply determination

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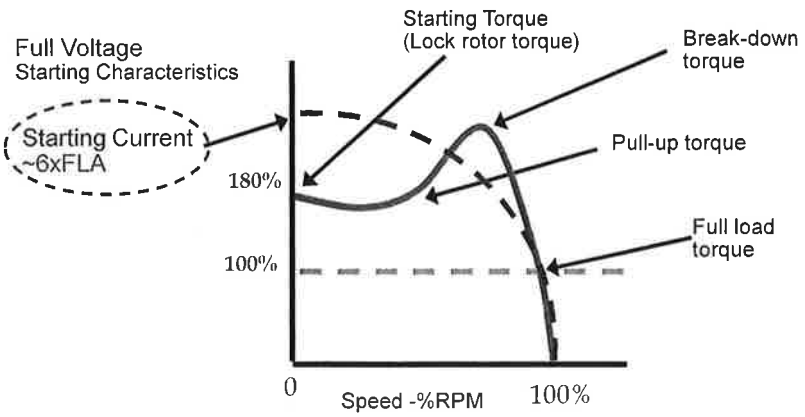
turn to the experts

Motor Starting Characteristic

Typical Motor Starting Curve



High starting current can cause problems in the electrical system

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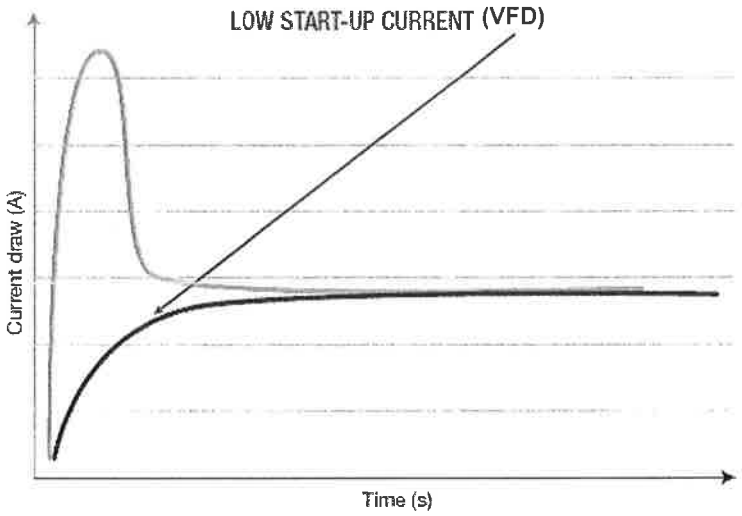
VFD Starting Characteristic



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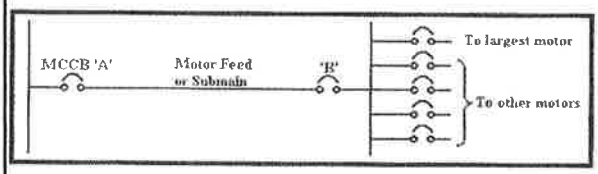
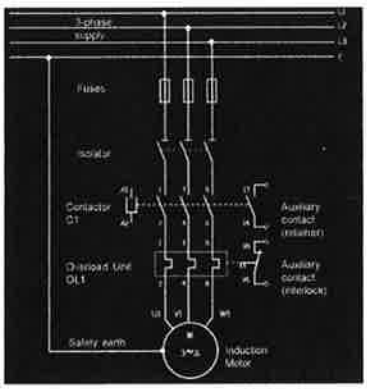
Electrical Protection for AC Motors



Overcurrent

Short-circuit

New Cable Colour Code		
	Single Phase	Three Phase
Phase Conductor (Line)	Brown	Line 1 Brown Line 2 Black Line 3 Grey
Neutral Conductor	Blue	
Protective Conductor (Earth)	Green-and-Yellow	



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Circuit Protection Devices

Circuits must be protected from excessive current

- Fuses
  - Plug, element, cartridge
  - One-time devices
- Circuit breakers
  - Can be reset
- Ground Fault Circuit Interrupters (GFCI)
  - Senses small current leaks to ground

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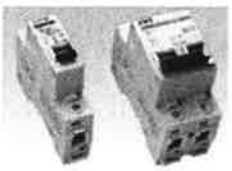
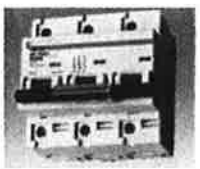
Circuit Breaker



SP & DP MCB



3P MCB



ACB



HRC Fuse



3P MCCB

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Power Supply

Minimum Circuit Ampacity (MCA) determines required wire size

MCA = (1.25 * Current of largest motor)
+ Sum of all other loads

MCA of a condensing unit = (1.25 * RLA of compressor)
+ (FLA of OEM motors
+ Control amps)

MCA of indoor unit with electric heat = (1.25 * FLA of largest motor)
+ (1.25 * FLA of electric heater)
+ Sum of all other loads

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MOCP

Defines MAXIMUM size of overcurrent protective device

A smaller device may be used, if nuisance trips are not a problem

MOCP = (2.25 * Current of largest motor) + Sum of all other loads

Round down to the next lower standard rating, but not lower than the MCA value

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ROCP

Defines RECOMMENDED size of overcurrent protective device

ROCP = (1.5 * Current of largest motor) + Sum of all other loads

May be used if the unit has been tested at the ROCP value AND does not trip the overcurrent protection device

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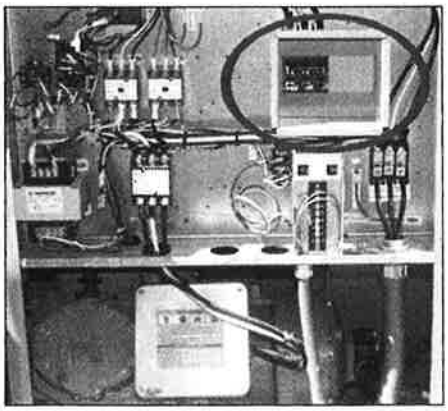
Protective Device

- Fuse or Circuit Breaker
- HACR Breaker



Usage defined by code and availability

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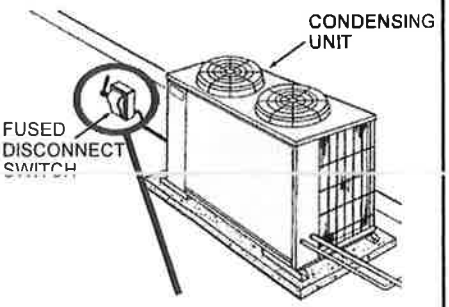
Disconnect

- Located within "line of sight"
- Field-installed or factory-supplied
- Fused or non-fused



Factory-installed disconnect



Field-installed disconnect

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Input power measurement

Input power calculation

$$Pi = \frac{V \; x \; I \; x \; PF \; x \; \sqrt{3}}{1000}$$

Pi	= Three Phase power in kW
V	= RMS Voltage, mean line to line of 3 Phases
I	= RMS Current, mean of 3 phases
PF	= Power factor as Decimal

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Review of System Design Steps & Parameters

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System Design Steps

All-Air System

1. Load Estimate
2. Psychrometric Estimate of Coil Entering and Leaving Conditions
3. Coil Selection and Air Handler Sizing
4. Refrigeration Plant Sizing
5. Room Air Distribution Design
6. Air Duct Design
7. Fan Selection
8. Control System Selection

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Comfort Chart (ASHRAE 2001)

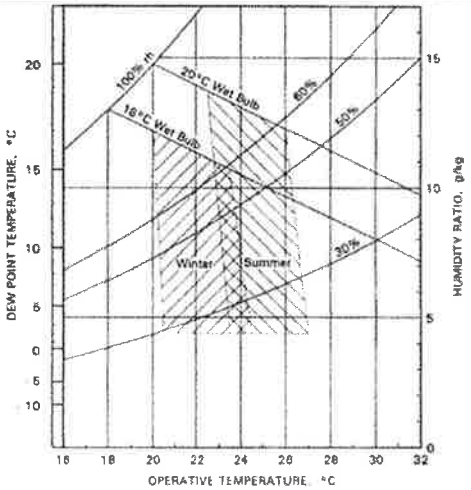

Fig. 5 ASHRAE Summer and Winter Comfort Zones
(Acceptable ranges of operative temperature and humidity for people in typical summer and winter clothing during primarily sedentary activity.)

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Definition of Comfort



Good Indoor Air Quality			
Ventilation	***Filtration***	***Source Control***	***Humidity Control***
Dilute indoor air with sufficient outdoor air	Remove particulates and bioaerosols	Minimise the generation of pollutants within the indoor space	Reduce the risk of fungi & bacteria growth

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Space Requirements

Temperature, Humidity per application according to ASHRAE.

General Category*	Inside Design Conditions*
Office Buildings	70-74F / 50% *21.2 – 23.3C*
Dining & Entertainment	70-74F / 50-60% *21.2 – 23.3C*
Radio / TV Studio	74 – 78F / 40-55% *23.3 – 25.6C*
Transportation Centers	70-74F / 50-60% *21.2 – 23.3C*
Museum / Library	68-72F / 40-55% *20.0 – 22.2C*

* Columns per 1999 ASHRAE Handbook, Table 1

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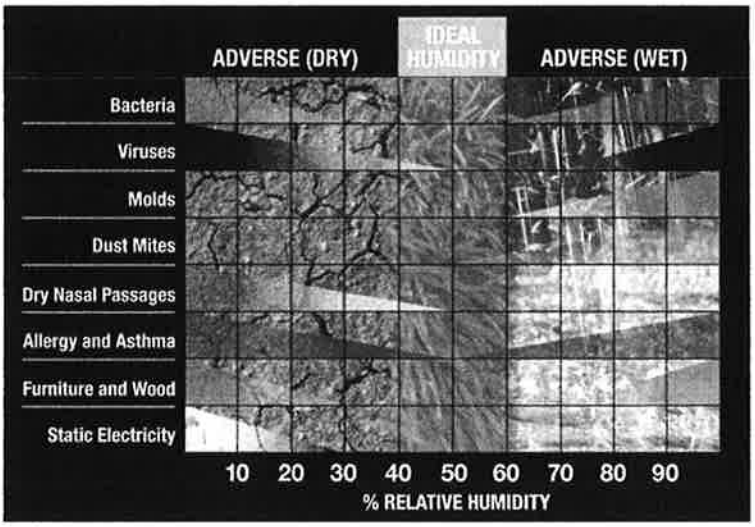
Turn to the experts

Why Correct Humidity Is Important



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Good IAQ example (Singapore)

Parameter	Acceptable limit
Air Temperature	**23 – 25 °C**
Relative Humidity	**≤ 65% for new** **≤ 70% for old**
Air Movement	**< 0.3 m/s**
Carbon Dioxide	**700 + outdoor ppm**
Carbon Monoxide	9 ppm
Formaldehyde	0.08 ppm
TVOC	1 ppm
Respirable Suspended Particle (PM4)	50 µg/m3
Particulate Matter 2.5 (PM2.5)	**37.5 µg/m3**
Total Bacteria Count	1,000 cfu/m^3 (colonial forming unit)

SS554: 2016 table 1

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Humidity

High and low humidity can present problems.

Want to target middle of acceptable range (50%)



10% 40% 60% 100%

Respiratory, dryness, static electricity,

Special Building Construction

50%

Microbial, Mold, Dust Mite growth

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Humidity

Ratio of Sensible load to total load is the "sensible heat ratio"

Sensible loads	Consist of ***Latent Loads***
Solar	*People*
Computers	*Kitchens*
Lights	*Pools*
Transformers	*Outdoor Air*
Motors	

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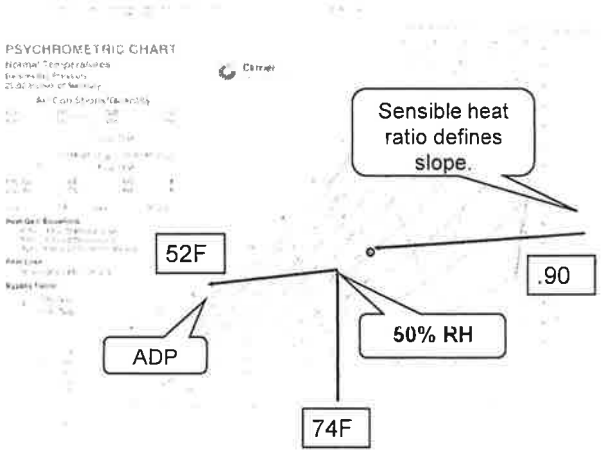
Coil Requirements

Using proven psychometric chart, parallelogram identifies air temperature leaving coil per **SHR**.



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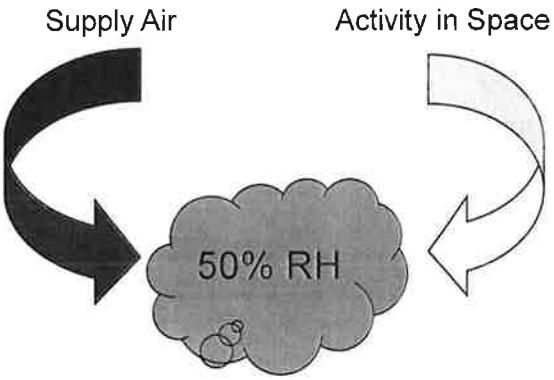
Humidity

To maintain 50% humidity in the space, supply air must compensate for humidity produced in the space.



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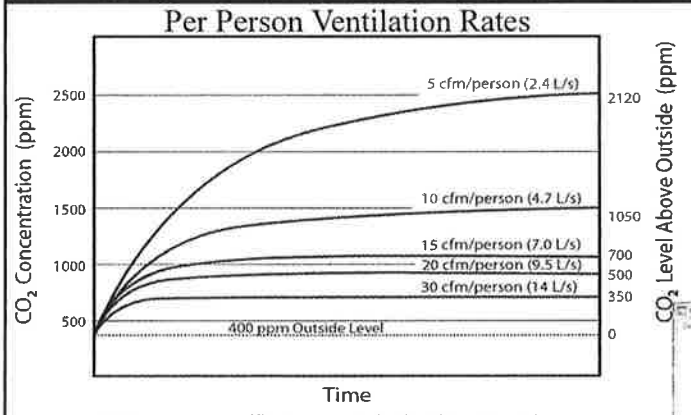
CO2 Equilibrium Levels



Note: Assumes office type activity level (1.2 MET)

420 Btuh

= 123 w



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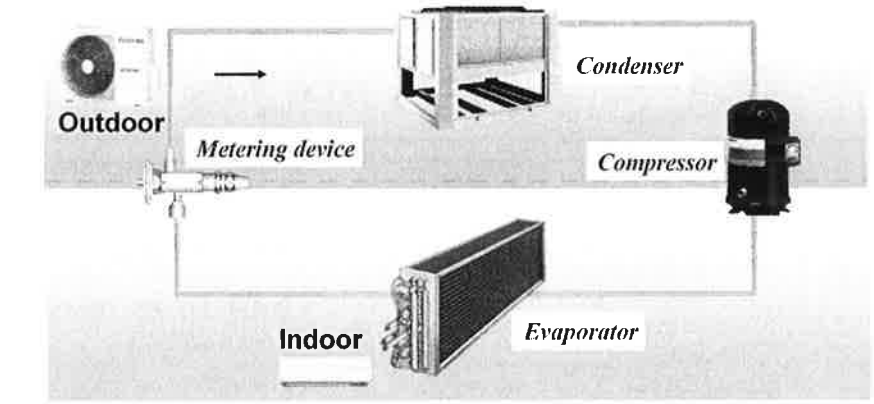
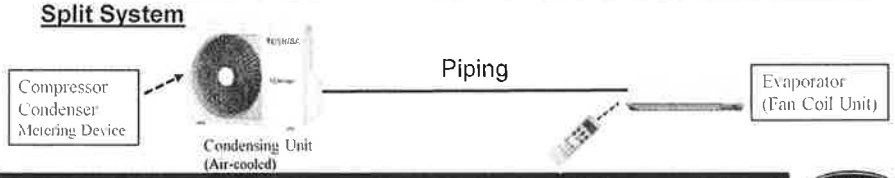
Basic Air-conditioning Components



Split System



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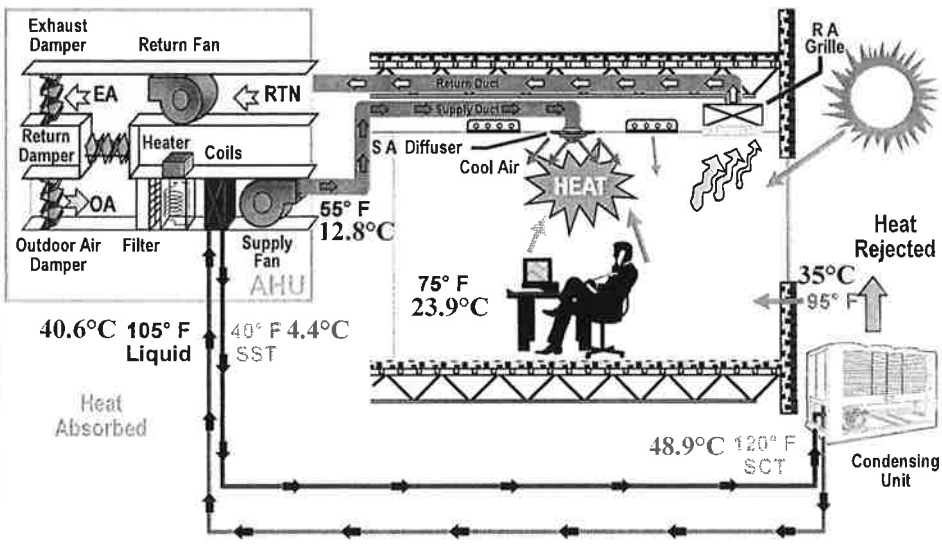
Air-cooled DX System



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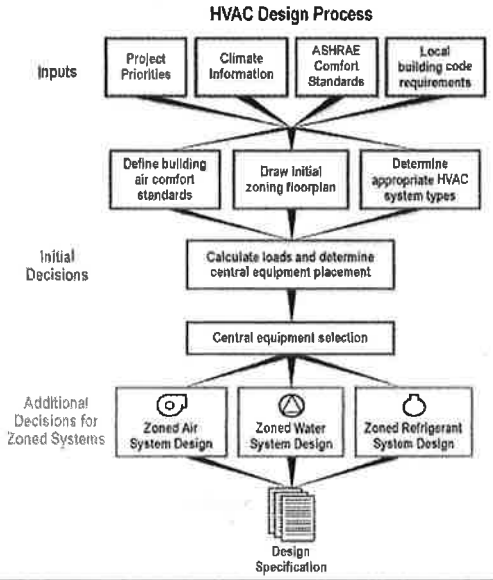
HVAC design process



Steps involved in effective HVAC design

1. **Project priorities and *inputs***
2. ***Initial decisions***
3. **Additional decisions** (for zoned systems)

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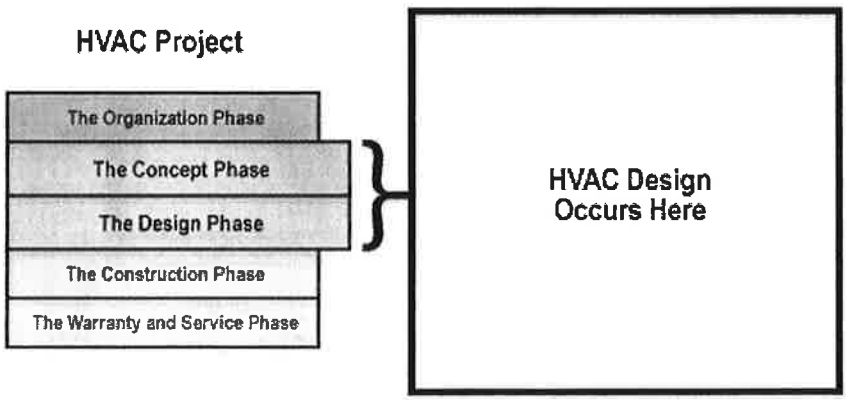
Role of design in an HVAC project

HVAC system design occurs as part of the conceptual and design phases in a HVAC project. Once the design is finalized, construction of the HVAC system begins.



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Typical HVAC project timeline

ORGANIZATION PHASE

Organization Type:
- Design/Build
- Plan & Spec

Purchase Method:
- Competitive Bid
- Negotiation

Create Project Team

CONCEPT PHASE

Project Criteria
- Comfort Level
- Costs
- Appearance

System Choice

Coordination:
- Space
- Budgets

DESIGN PHASE

Load Calculations

Equipment Selection

Air Distribution

Water Distribution

Automatic Controls

Construction Documents

Coordinate Details

CONSTRUCTION PHASE

Pricing

Award of Contracts

Equipment Purchase

Submittal & Approval

Installation

Commissioning

WARRANTY & SERVICE PHASE

Resolve Equipment Failure & System Operational Problems

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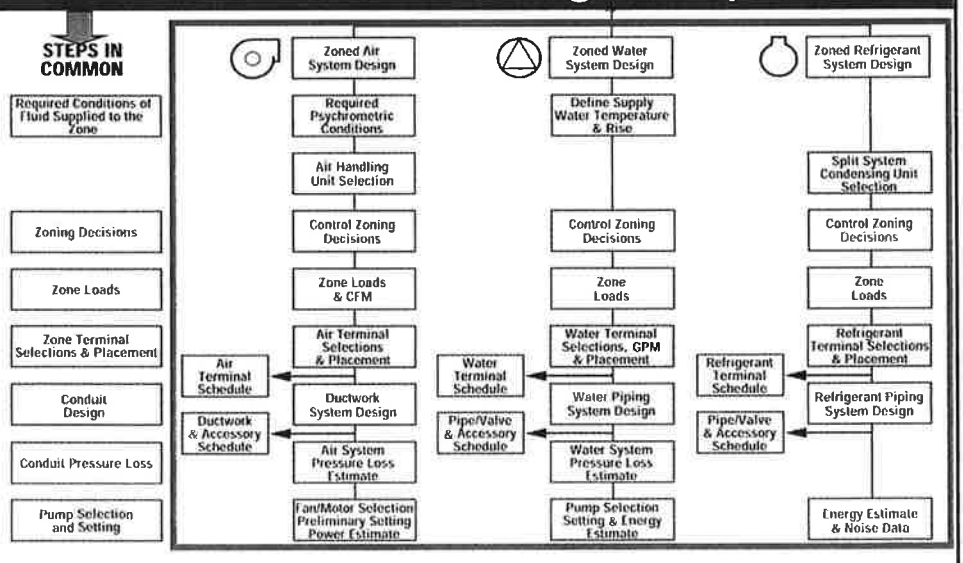
Carrier turn to the experts

Common design steps



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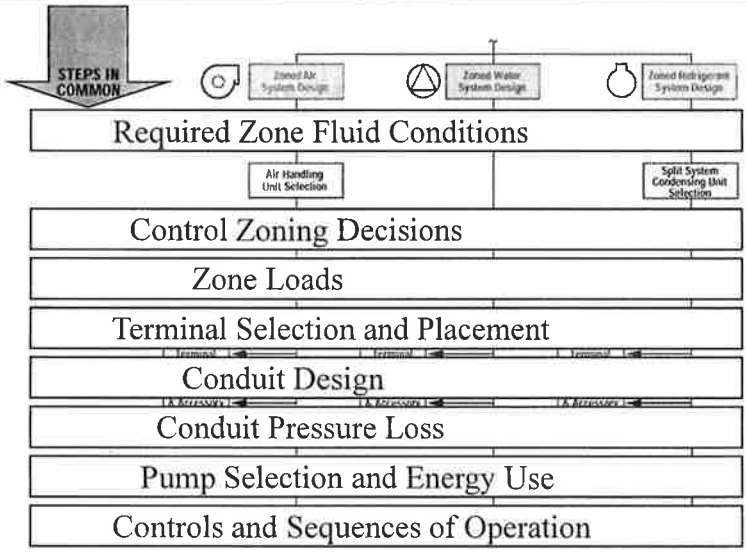
Carrier turn to the experts

Common HVAC System Design Steps



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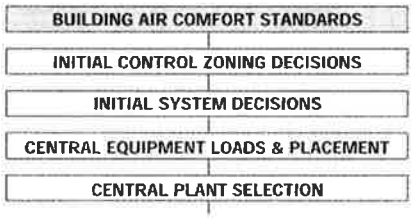
Initial decision



- ***Initial decisions*** drive system choice ("big picture").
- One step may have priority over another:
  - I.E. - Single story mall - must use roof-mounted equipment due to lack of interior mechanical room.
  - Building IAQ needs - must have system with good ventilation. This favors zoned air systems.
- Results in ***central equipment selection & placement***

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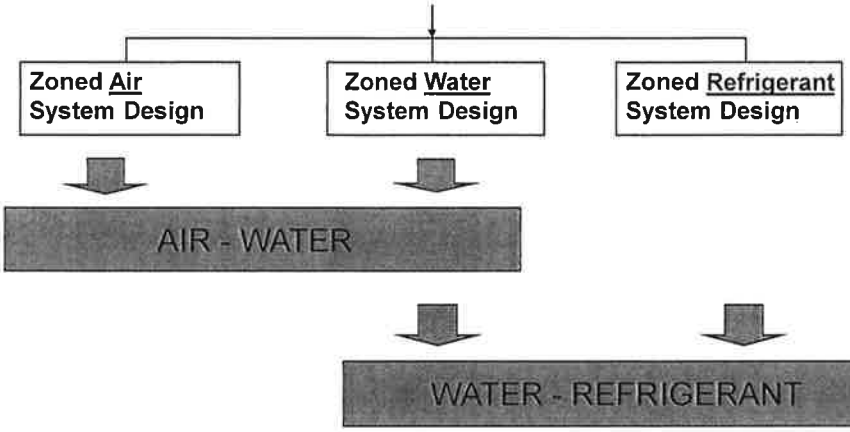
Combination types

A Function of the Delivery Fluid



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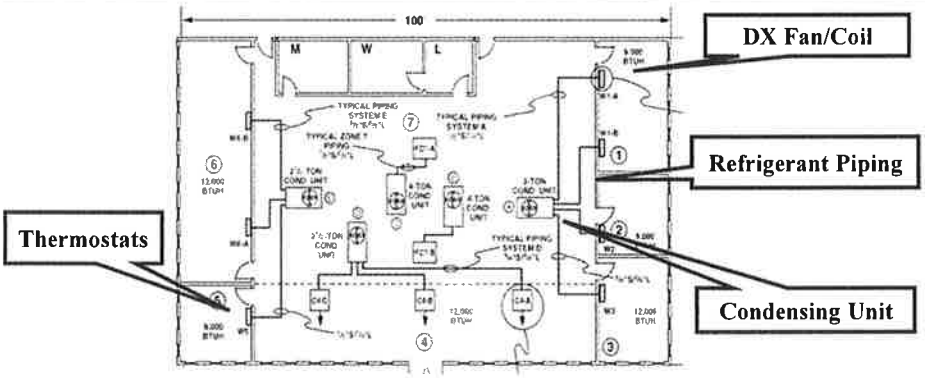
Typical refrigerant system



1- Control Zone Fan/Coil Terminal (DX Coil) - Delivers Cool/Hot Air to Control Zone

2- Condensing Unit - Source of Cooling

3- Refrigerant Piping Delivers Cooling to Terminals

4- Controls in Each Zone (Thermostat in Terminal)

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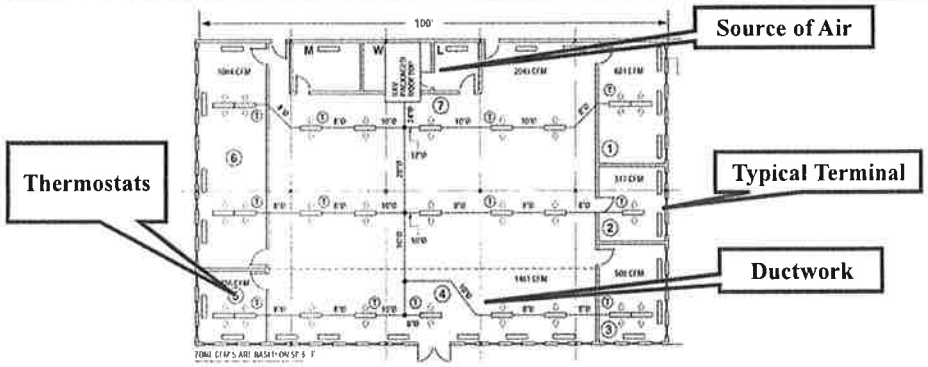
Typical all air system



1. Central Source of Air (Rooftop Unit or Air Handling Unit) - Fan and Coil (Cooling/Heating)
2. Ductwork System to Deliver Air to Building
3. Air Terminals to Deliver Air to Building Control Zones
4. Controls in Each Zone (Thermostat in This Case)

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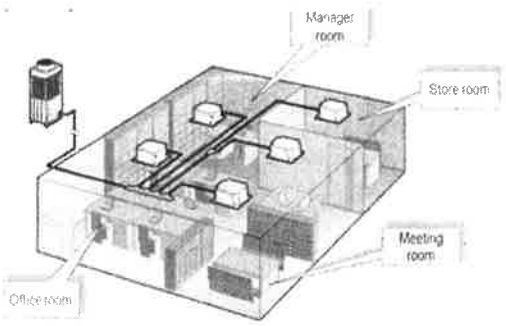
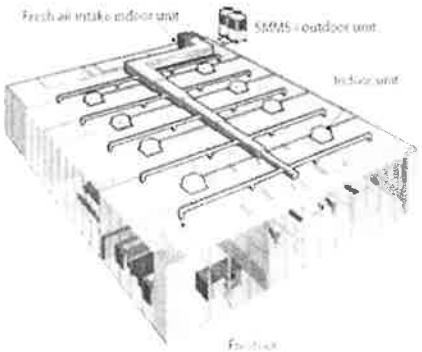
Typical VRF systems



Direct Ventilation System

Common Ventilation System



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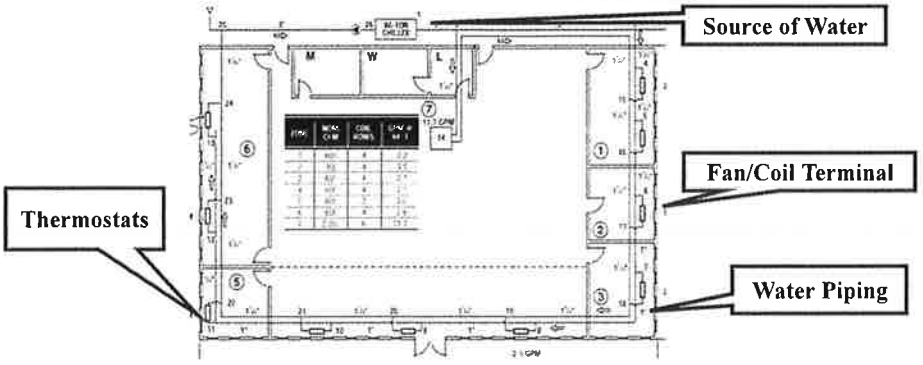
Typical all water system



1- Central Source of Water (Chiller and Pump)

2- Water Piping Delivers Water to Control Zone Terminals

3- Fan/Coil Terminals or Air Handling Units - Delivering Cool/Hot Air to Control Zone

4- Controls in Each Zone (Thermostat Located on Terminal)

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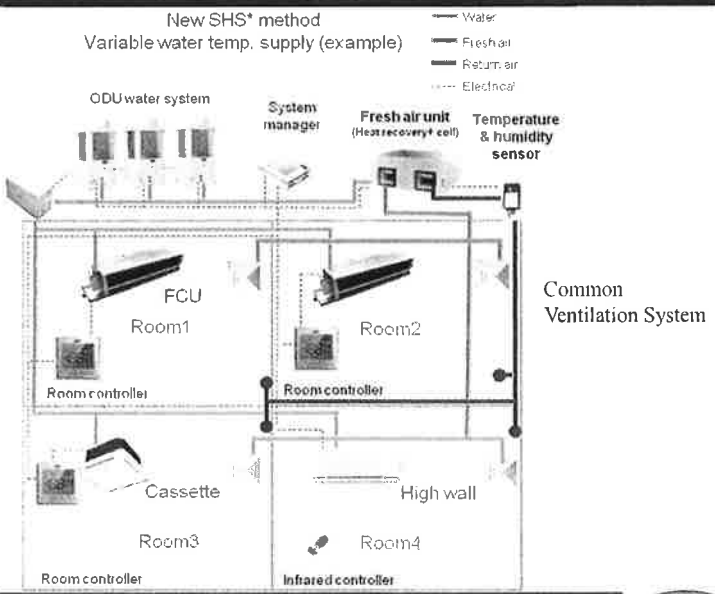
Typical chilled water system



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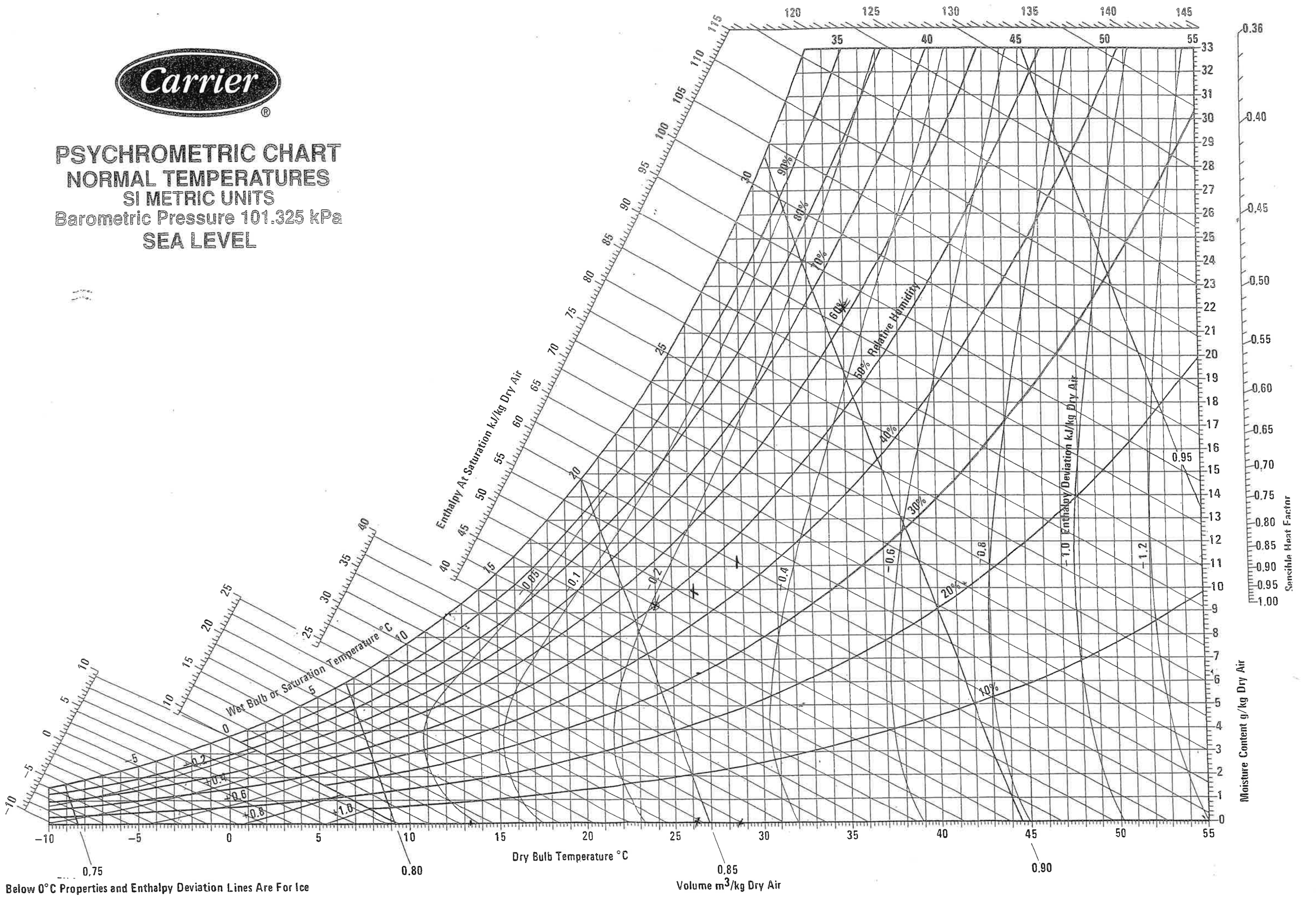
SI METRIC UNITS
Barometric Pressure 101.325 kPa
SEA LEVEL



Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

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PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 101.325 kPa
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