

Application Note 2016

Installing Air-Source Outdoor Units Indoors

Table of Contents

Introduction.....	3
Installation Location	3
Louver Selection.....	4
Duct Design	6
Ducting Off the Top of the Units	6
Avoid Combined Ductwork.....	6
Avoid Inline Fans if Possible	7
Condensing Unit Ambient Conditions for Heating.....	7
Maintaining the room at 40 °F.....	7
Allowing the room to drop below 40°F	8
Changeover based on utility cost	9
Unit Heater Sizing and Selection	9
Condensate Removal and Ice Build-up.....	10
Gas Fired Equipment in Mechanical Space	10
Damper and heater control	11
Maintaining the room at 40 °F or higher	13
Maintaining the room at T_{min}	13
A2L Considerations.....	13
Leak detection equipment	13
Leak detection sequence of operations	14
Detailed Mechanical Room Ventilation Requirements	14
Sample Mechanical Room Layout w/ Multiple Unit Heaters.....	16
96 Ton Example (Roof Discharge).....	17
96 Ton Example (Side Wall Discharge)	18
48 Ton Example (Side Wall Discharge)	19
48 Ton Example (Side or Roof Discharge)	20

Introduction

On most VRF projects the City Multi system's Outdoor Units (ODUs) are located either on the roof of the building, on the ground around the perimeter, or both. However, there are a few applications where the units must be located inside the building instead.

In some projects there is no available space outside the building to locate the ODUs. The ground around the building is taken up with occupied spaces such as a patio, walkways, parking spaces, etc. If the roof is also being utilized for other equipment or for some other purpose, it might be necessary to move the ODUs inside.

In very tall buildings the refrigerant cannot reach the middle section from the ground or from the roof because of line length and height restrictions. Installing the ODUs in mechanical spaces on the middle floors allows air cooled units to still be utilized.

If auxiliary heat is required to satisfy the building load, locating the ODUs inside is a great way to distribute heat without installing duct heaters or baseboard throughout the building. Heaters can be added to the mechanical space where the ODUs are located, allowing the VRF system to do the work of distributing the heat.

The above advantages cannot be realized without some design considerations in addition to those typically seen on VRF projects to ensure the system will operate properly inside the building. Some of the basic design considerations are:

- Installation location (room dimension, required clearance, exterior wall area)
- Louver Selection
- Duct Design
- Selecting Room Temperature Conditions
- Unit Heater Selection and Sizing
- Condensate/Ice
- Damper and heater control
- A2L Refrigerant Leak Detection and Leak Shutdown Sequence

Individual VRF circuit charge should not exceed 175lb to avoid triggering UL machinery room requirements (Largest possible charge on 32-ton heat recovery system is 167lb).

Installation Location

Ducting the discharge air from the top of the ODU to an outside wall louver is the best and most efficient way to install a unit inside. The installation location for the unit must be large enough to ensure that proper service clearance is maintained around the unit. The ceiling also must be high enough to ensure that ducting off the top of the unit is possible. A height of 9 feet should allow proper ducting off the top of an outdoor unit but housekeeping pads and drain pans may require more. There will also need to be a close point to access the exterior of the building for exhaust and fresh air intake.

The amount of wall area needed for intake will depend on the number of units being put into a location. The exhaust and supply louvers will need to be installed a minimum of 3 feet apart to prevent short cycling the outdoor unit. A good rule of thumb for wall area requirement is: 4 square feet of wall area per 1000 CFM of supply air and 2.2 square feet of wall area per 1000 CFM of exhaust air.

Louver Selection

The main factor in selecting the louver to be used when installing outdoor units inside is the pressure drop that will be seen to exhaust air or supply air through the louver. Depending on the selected model as well as the required modes of operation (heating, cooling), the available external static pressure will vary. Some high-efficiency models (EM) do not have any external static pressure available in heating mode; therefore, if heating performance is required for the project these models cannot be utilized inside of a mechanical room. Please refer to Table 1 for the available external static pressures and modes:

ODU Model	Modes with ESP > 0 in. w.g. Available	Available ESP settings: 0.00, 0.12, 0.24, 0.32 in. w.g.
High Efficiency		
EM72	cool/heat	all
EM96	cool/heat	all
EM120	cool/heat	all
EM144	cool/heat	all
EM168	cool only	all
EM192	N/A	N/A
EM264	cool/heat	all
EM288	cool/heat	all
EM312	cool only	all
EM336	cool only	all
EM360	N/A	N/A
EM384	N/A	N/A
Hyper Heating		
HM72	cool/heat	all
HM96	cool/heat	0.00 - 0.24 in. w.g.
HM120	cool/heat	0.00 - 0.24 in. w.g.
HM144	cool/heat	all
HM192	cool/heat	0.00 - 0.24 in. w.g.
HM240	cool/heat	0.00 - 0.24 in. w.g.

Table 1: External static pressures available for X-Gen models. Note that EM168, EM312, and EM336 have 0 in. w.g. available in heating, and EM192, EM360, and EM384 do not have any external static pressure option available.

Because the external static pressure varies depending on the model(s) being utilized, selecting a louver that is too small and incurs too high a pressure drop will allow for less air flow and could affect the performance of the system. A rule of thumb for louver sizing is 500 feet per minute (fpm) through the supply louver and 900 fpm through the exhaust louver. Louvers are typically sized as having 50% free area, but this will vary based on louver type. For example, the louver size to exhaust an 8-ton unit at 6,180 CFM would be as follows:

$$\frac{6180 \text{ CFM}}{900 \text{ FPM}} \div 50\% \text{ Free Area} = 13.7 \text{ ft}^2$$

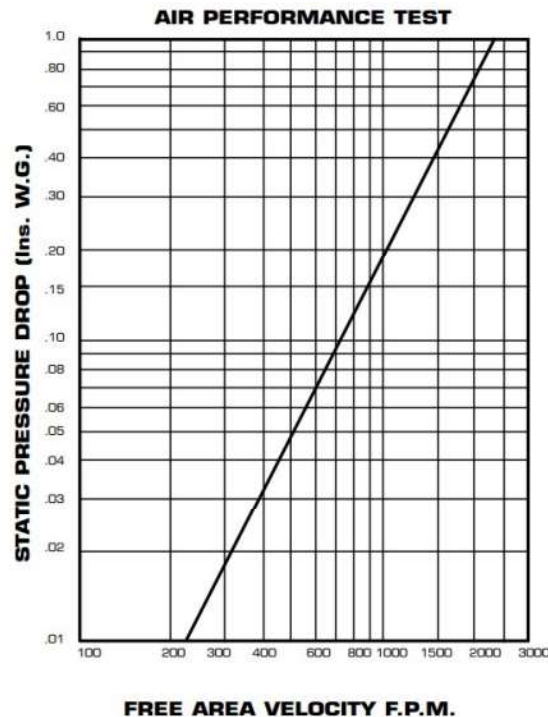


Figure 1: Sample Pressure Drop Chart for combination louver/damper assembly

If both louvers were sized at 900 fpm, the pressure drop through both louvers would be 0.23” w.g. leaving almost nothing for fittings and ducting from the unit.

Several manufacturers offer a louver sizing tool that calculates the pressure drop for a louver based on specific size and type.

While the louver sizing should be based on the allowable pressure drop as shown in Figure 1, the available wall area must be considered. If the design exceeds the available external static pressure of the unit, an inline fan may be considered but it is not recommended. See section “Avoid Inline Fans if Possible” for more information.

Local code may require the use of an automatic control damper regardless of whether the system is being designed to recirculate air.

Duct Design

Ducting Off the Top of the Units

Because most of the static pressure available will be taken up by the louvers, the duct design of the system becomes critical in maintaining proper airflow without exceeding the available external static pressure from the unit. In most cases the duct design will consist of an elbow off the top of the unit with a short duct run into the back of an exhaust plenum/louver.

The duct coming off the top of the unit should be sized for a pressure drop of 0.08" - 0.10" of ESP loss/100' of duct. Using a duct sizing calculator is the best way to size the duct. A complete pressure drop calculation should be done to determine the total external pressure loss, including the ductwork, elbow(s), transitions, louvers, bird screens, etc. Depending on the model, the maximum ESP available on the module is as little as 0.24", so only a limited amount of ductwork will be allowed.

The elbow(s) being used should either be a smooth radius elbow or include turning vanes to reduce the pressure drop through the fitting as shown in Figure 2 below:

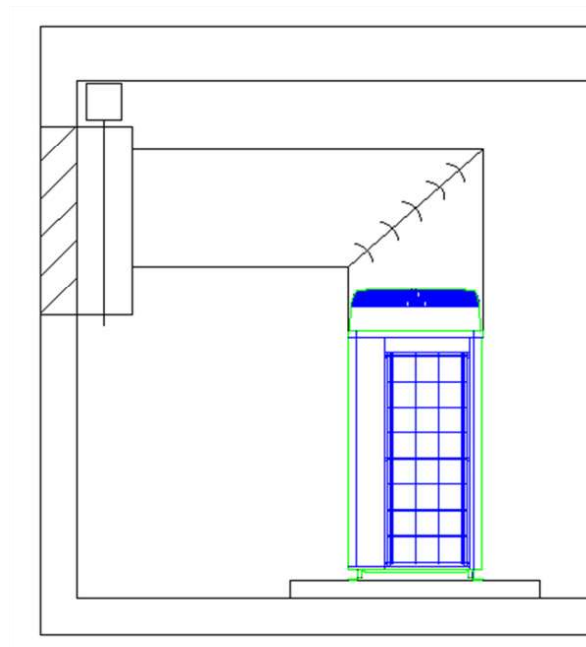


Figure 2: Ductwork from exhaust fan to louver; elbow shown with turning vanes.

Avoid Combined Ductwork

It is very important that each ODU module get ducted separately to the outside wall, and that the ducts are not joined in a "pants leg" or other such fitting, even for modules that are twinned together. The air flow rates through each module will be different, and at times one of the fans

may need to be completely off even though the compressor is operating. A combined system would allow one of the modules to blow against the other, preventing normal operation of the fan.

Avoid Inline Fans if Possible

If the only available mechanical space is not located at an exterior wall, the pressure drop through the exhaust ductwork and make up air ductwork could easily exceed the available ESP from the modules. It may be tempting to install inline fans to assist the air in and out of the room, but this presents several problems. The fans on the ODUs are variable speed to be able to move different amounts of air over the refrigerant coil, and unless the inline fan accurately tracks the desired flow rate then the system controls will be constantly fighting to maintain desired pressures and temperatures in the refrigerant line. If the inline fan is not modulated at all then the airflow over the coil will never change and capacities could be reduced.

Fans installed inline will also result in one of the fan motors having a reduced life as one of them will always be placing an additional load on the other.

Condensing Unit Ambient Conditions for Heating

The temperature at which the mechanical room is being kept depends on whether there is auxiliary heat being added to the system via heaters located in this room or if the room is just being used to house the outdoor units.

If the room is just being used to house the outdoor units, then the room temperature can be allowed to vary with the outdoor ambient temperature. This assumes no other items such as pumps, boilers, water piping, etc., are in the mechanical space with the ODUs.

When using a unit heater to provide auxiliary heat to the system, looking at the room temperature becomes an important part of the heating design of the system. There are several different methods for selecting the temperature at which the room will be maintained.

Maintaining the room at 40 °F

One advantage of maintaining the room at 40° F is that because the space is above freezing, there is no need to utilize heat tracing to prevent condensate from freezing. Another advantage is that maintaining the room at 40°F will make it so the system (regardless of model) will have no temperature heating de-rate.

These benefits may be overshadowed, as maintaining the room at 40° F will limit the use of the heat pump drawing heat from outside for building heating. When a unit heater is used to maintain the room temperature, the heat energy being used to heat the building is either coming from heat of compression, or the unit heater. When the space is allowed to use ambient air, the heat comes from the outside and heat of compression rather than being generated by the unit heater. Effectively, the heating hours seen by the system are limited to an ambient temperature above 40° F.

Allowing the room to drop below 40°F

Another path is to allow the mechanical room temperature to drop below 40°F as outdoor ambient drops by refraining from installing any auxiliary unit heaters in the space. One disadvantage to this method is that because the room can be below freezing, the condensate drain will need to be heat traced to prevent freezing.

If this path is taken, special consideration must be given to what models are selected as different X-Gen models will have varying temperatures where heating capacity will begin to derate. Choosing a Hyper Heating model selection may be more economical than upsizing a High Efficiency model selection. Please refer to Table 2 for compiled ambient air heating mode derate threshold temperatures, the temperatures at which the units will begin to derate capacity in heating mode:

ODU Model	Ambient Air Heating Starting Derate Temperature (°F W.B.)
High Efficiency	
EM72	10
EM96	15
EM120	15
EM144	19
EM168	33
EM192	33
EM264	28
EM288	28
EM312	28
EM336	28
EM360	40
EM384	40
Hyper Heating	
HM72	-13
HM96	-13
HM120	-14
HM144	-12
HM192	-12
HM240	14

Table 2: Ambient Air Heating Derate Temperatures for High Efficiency and Hyper Heating models

Complete unit derate (temperature correction) charts can be found in the capacity tables section of the City Multi R32 data book. An example chart for model EM120 is shown below:

Outdoor unit temperature correction

To be used to correct outdoor unit only

Outdoor unit capacity is NOT affected by the indoor temperature.

Outdoor unit power input is affected by the indoor and outdoor temperatures. Please consult the sales office for details.

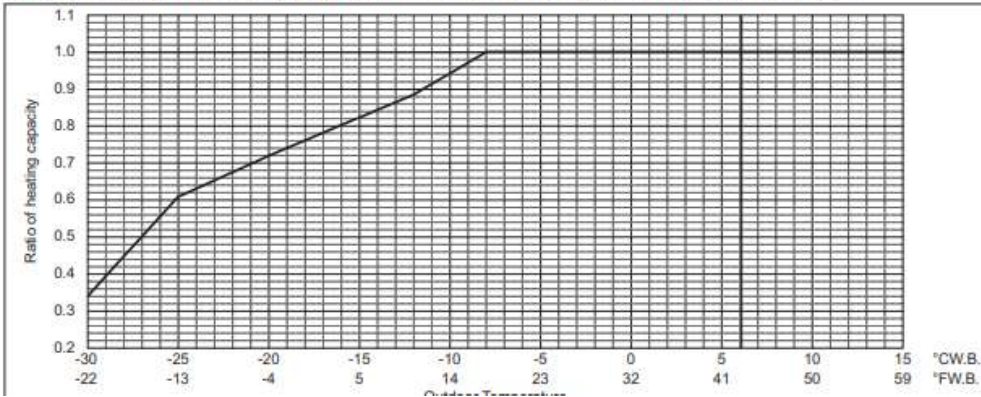


Figure 3: EM120 Capacity Derate chart

If the units are to be installed in an existing mechanical room with previously installed auxiliary unit heaters, it may be more economical to utilize the existing heaters to maintain the space at some temperature below 40°F (while still heat tracing condensate drains) instead of selecting a Hyper Heating model or upsizing a High Efficiency model to match derate temperatures to ambient design temperature. A minimum temperature (T_{min}) will need to be established based on the worst-case derate temperature of the units in the room.

Changeover based on utility cost

As stated in the application note: *Proper Design of CITY MULTI VRF Air Source Heat Pump Systems for Heating in Low Ambient Conditions*, the changeover point can be a function of the local utility cost. If the natural gas utility rates are low and the electricity rates are high in a particular area it may make more sense to select the changeover temperature based on a BTU/dollar calculation. See the *Design of CITY MULTI VRF Air Source Heat Pump Systems for Heating in Low Ambient Conditions* applications note for more details on this calculation.

Unit Heater Sizing and Selection

When providing backup heat for the system with a unit heater in the space, the sizing and selection of the unit heater becomes critical to the operation of the system. The first step is to decide how big the unit heater will need to be to provide enough capacity to back up the system. Take the example of a 10-ton ODU installed inside with a changeover temperature of 20 °F. The first step is to figure out how much heat the unit will be generating from heat of compression. If in heating mode the power input for the 10-ton ODU is 11.02 kW, the heat being generated by this unit would be:

$$11.02 \text{ kW} * 3413 \frac{\text{BTU/H}}{\text{kW}} = 37,611 \text{ BTU/H}$$

The total heating capacity for the unit is 135,000 BTU/H at 40 °F. This means that 97,388 BTU/H needs to be generated by the unit heater to give the outdoor unit full capacity. Unit heaters are not available in such an exact size, so select a unit heater that is sized larger than the capacity required to meet the system heating load. It is also recommended that multiple unit heaters are used rather than just one. This will provide some back-up to the system if one of the unit heaters fails.

The type of unit heater that is being used (typically gas, electric, or hot water) is usually a function of what the building has available. Any of the unit heater types should work to provide heat to the system, but each has different design considerations. The gas unit heater will need to be sealed combustion with vents for both combustion exhaust and fresh air make up, provided with a stainless-steel heat exchanger, and a two stage or fully modulating gas valve. The multi position/modulating gas valve will allow for better temperature control in the space. When using an electric unit heater, it is recommended that the unit be corrosion resistant and equipped with multi-stage heating capability.

There is also the option of using multiple heaters to get better room control. Utilizing hot water unit heaters will generally not prove economical, as it will require the use of glycol in the hot water loop to operate at temperature below 40° F. This will also require the installation of a boiler, pumps, valves and controls if the hot water loop is not already in place.

Condensate Removal and Ice Build-up

As part of a function of the heat pump cycle, when the outdoor unit is in heating mode, condensate will develop on the outdoor coil. When the coil temperature is below freezing, this condensate will turn into frost/ice on the coil. This will cause the outdoor unit to go into defrost mode, removing the ice build-up from the coil. When the unit is installed outside, this is typically not an issue. The condensate will flow away from the unit and usually to the nearest drain.

When the outdoor units are installed inside, the condensate development must be taken into consideration. The units must be provided with a condensate pan, and the pan should be piped to a provided floor drain – there is no piping connection on the ODUs for condensate, the condensate leaves the units in multiple locations so a field provided drain pan is required in order to route the condensate to a drain location. If the space is being maintained above 40°F, freezing of the removed condensate in the pan or pipe is not an issue. If the space where the outdoor units are being installed is allowed to drop below 40 °F; further provisions must be made to prevent ice build-up in the condensate pan or freezing of the condensate pipe. This can be accomplished simply by heat tracing the condensate pan and pipe. The heat trace should be controlled so that it will energize when the space temperature falls below 40 °F.

Gas Fired Equipment in Mechanical Space

Some mechanical spaces for installing ODU indoors are dedicated to the HVAC system, but if the units are installed in a general mechanical room and there is other equipment in the mechanical space considerations must be made. For example, if there is any gas fired equipment such as a boiler or water heater, these will have flues to allow combustion gases to exit the building. However, if an ODU is operating and pulling several thousand CFM through an open louver on the wall, the water heater flue will act as an intake and not allow the exhaust to exit the building properly. In this case a closed combustion water heater should be selected so that the combustion air is ducted in and exhaust is ducted out, without being affected by the room airflow.

This is also true for any unit heaters located in the mechanical space as described below.

Damper and heater control

The damper and unit heater controls are integral to how well and efficient the system will operate. Figure 4 illustrates a room layout for a system that is not using any unit heater to provide supplemental heat:

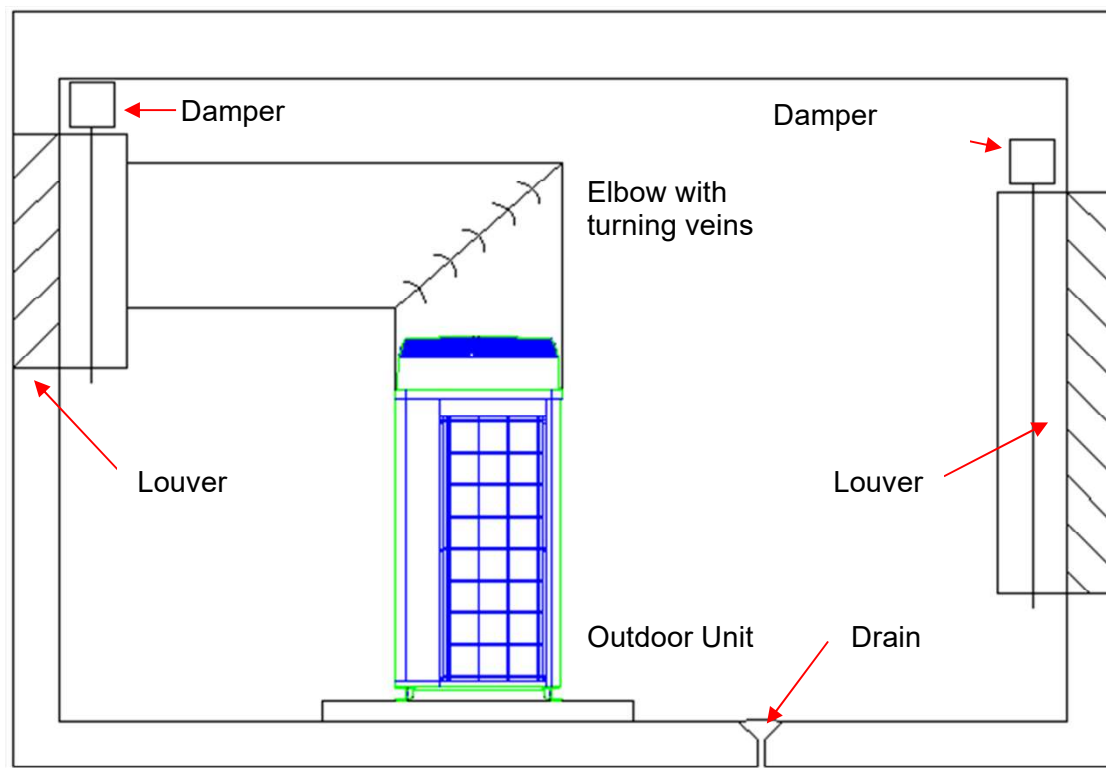


Figure 4: Outdoor Unit installed indoors with damper

In the above example there is not much need for damper control. They are simply there to meet code requirements. An example can be found in IECC 2024 paragraph C403.7.7 states:

Stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage rated damper and a maximum leakage rate of 4 cfm per square foot at 1.0-inch water gauge (w.g) when tested in accordance with AMCA 500D

Exception: Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height.

This doesn't mean that every installation will require motorized dampers, but it is important to check with local codes to ensure they are not required.

The control of the dampers in this installation is that the dampers will energize open based upon a call from the outdoor unit. The dampers used should be fail-open motorized dampers. Also, there should be heat tracing around the drain that will energize when the space temperature falls below 40°F.

Figure 5 illustrates a layout of a room using a unit heater to provide auxiliary heat to the system:

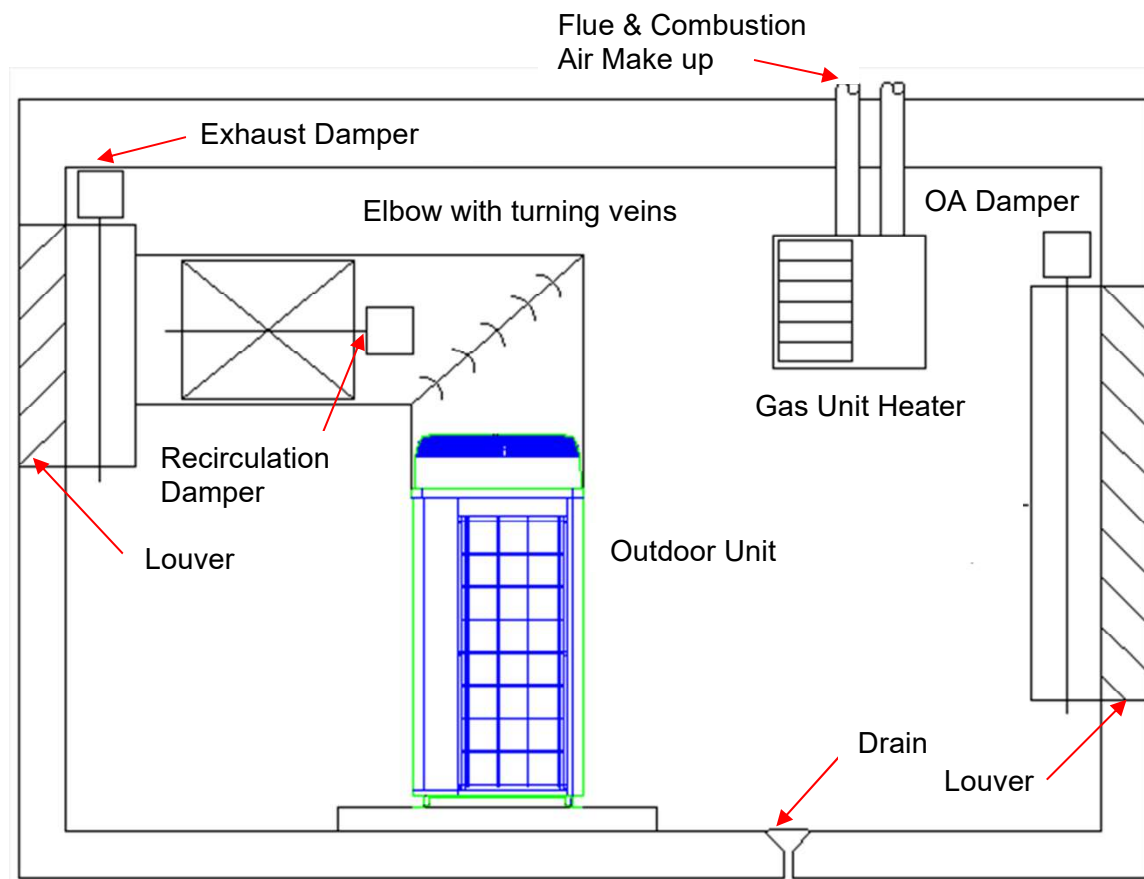


Figure 5: Outdoor Unit installed indoors with damper and heater control

The example shown above requires more complex control than the previous example. How the dampers and unit heaters are controlled will depend upon the temperature at which the space is being maintained. In this example the intake dampers at the intake louver should be high quality insulated blade dampers with blade and jamb seals in order to minimize leakage and heat loss while the system is in recirculation.

Maintaining the room at 40 °F or higher

To maintain the space at 40° F both the outside air (OA) temperature and internal space temperature will need to be monitored. When the OA temperature falls below 40° F and the internal space temperature falls below 40° F, the outside air damper and the exhaust air damper will close. The recirculation damper will open, and the unit heater will energize. The unit heater should be equipped with a thermostat to monitor space temperature and energize to maintain space temperature at 40° F. Upon the outside air temperature reaching 45° F (a 5 °F dead band) or an internal room temperature of 60° F, the outside air and exhaust air dampers shall open, and the unit heater shall de-energize.

Maintaining the room at T_{min}

The outside air temperature and internal space temperature will need to be monitored. When the outside air temperature falls below the predetermined temperature (T_{min}) and the internal space temperature falls below 40° F, the outside air damper and the exhaust air damper will close. The recirculation damper will open, and the unit heater will energize. The unit heater shall be equipped with a thermostat to monitor space temperature and energize to maintain space temperature at T_{min} . Upon the outside air temperature reaching $T_{min} + 5^{\circ}\text{F}$ (a 5 °F dead band) or an internal room temperature of 60° F, the outside air and exhaust air dampers shall open, and the unit heater shall de-energize. Also, the condensate pan and drain should be heat traced and will energize when the space temperature falls below 40° F.

The same control method can be used when utilizing a changeover temperature based on utility cost, the temperature will need to be adjusted from T_{min} to whatever the utility rates dictate.

A2L Considerations

Leak detection equipment

The latest generation of City Multi (X-Gen) utilizes R32 refrigerant which is classified as mildly flammable (class A2L), meaning that additional safety equipment is required in the mechanical room. A refrigerant leak detector (or detectors, depending on size of the indoor space), visual and audible alarms outside the room entrance and within the room (required only if system is not tied to BMS) and exhaust fan (or fans) with fail-open motorized damper and louvered opening will be required.

Leak detection sequence of operations

The refrigerant leak detector should include outputs necessary such that upon detection of a leak, the following sequence shall occur:

- Activate alarms (if system is not tied to BMS)
- Break L1, L2, and L3 power connection to all ODUs
- Open exhaust fan damper and room intake dampers
- Engage exhaust fan
- Send a signal to the BMS (if applicable)

After a leak is detected, all refrigerant piping and coils in the mechanical room shall be inspected for leaks using an approved A2L leak detection method.

Detailed Mechanical Room Ventilation Requirements

The exhaust fan and ductwork shall be installed in accordance with ASHRAE 15 section 7.6.4:

7.6.4* Mechanical Ventilation. Mechanical ventilation for *refrigerant* safety mitigation *shall* comply with this section. Where a *ventilated enclosure* is provided to control a *refrigerant* leak, the *refrigeration system* and *ventilated enclosure shall* be *listed* and installed in accordance with UL 60335-2-40 5/CSA C22.2 No. 60335-2-40 6 and *shall not* be required to comply with this section.

- a. Mechanical ventilation *shall* be provided that will remove leaked *refrigerant* from the space where *refrigerant* leaking from the *refrigeration system* is expected to accumulate. The space *shall* be provided with an exhaust or transfer fan. Fans used to *exhaust air* from the space or transfer air to a separate indoor space *shall* comply with Equation 7-10:

$$Q_{min} = \frac{Q_{req}}{C_{LFL}} \quad (7-10)$$

where

Q_{min} = minimum mechanical ventilation airflow rate, ft³/min (m³/h)

Q_{req} = required ventilation as determined from Table 7-4

C_{LFL} = *lower flammability limit* conversion factor as determined from Table 7-5

- b. *Mechanical ventilation *shall* be permitted to be continuous or activated by a *refrigerant detector*. Building fire and smoke systems *shall* be permitted to override this function.
1. Continuous Ventilation: Where continuous ventilation is provided, ventilation function *shall* be continuously verified per Section 7.6.4(b)(3).
 2. Refrigerant Detector Activated Ventilation: Where ventilation is activated by a *refrigerant detector*, the *refrigerant detector shall* be in accordance with Section 7.6.2.4. Upon *refrigerant detector* activation, the mechanical ventilation *shall* be activated and *shall* continue to operate for at least 5 minutes after the *refrigerant detector* has sensed a drop in the *refrigerant* concentration below the set point value. For mechanical ventilation systems used solely for refrigerant safety mitigation, ventilation function of refrigerant detector activated ventilation shall be verified in accordance with Section 7.6.4(b)(3) by a monthly self test.
 3. Verification of Ventilation Function: Ventilation function shall be verified by a method that confirms operation of the required fans. On detection of a ventilation system failure, compressor operation shall be stopped and a notification shall be provided. The

notification shall be to an operator workstation through a building automation system or by a local audible alarm.

- c. While the ventilation system is operating, *makeup air shall* be provided, and the volume of *makeup air shall not* exceed the volume of air being exhausted or transferred out of the space. Openings for *makeup air shall* be positioned to facilitate mixing of *makeup air* with leaked *refrigerant*. Inlets for *exhaust air*, and inlets used to mechanically transfer air to a separate indoor space, *shall* be located such that the bottom of the inlet is within 12 in. (30 cm) of the lowest elevation in the space where leaked *refrigerant* would be expected to accumulate.
- d. The *refrigerant* concentration of an indoor *effective dispersal volume shall not* exceed the limit *specified* in Sections 7.6.1.
- e. In addition to the requirements of Sections 7.6.3, there *shall* be no open-flame-producing devices that do not contain a flame arrestor, or hot surfaces exceeding 1290°F (700°C), installed within the space where the equipment is located.
- f. Electric motors larger than 1 hp (0.7 kW) driving fans located in the airstream of the discharge side of the ventilation system *shall* be of the totally enclosed or hermetically sealed type.
- g. Fan rotating elements *shall* be nonferrous or nonsparking, or the casing *shall* consist of or be lined with such material.
- h. Ventilation fans *shall* be *listed* in accordance with UL 507 or UL 705
- i. The discharge air openings of the ventilation system *shall* be located so as to prevent recirculation of *exhaust air* back into the space.

ASHRAE 15 Table 7-4 Required Ventilation for A2L Refrigeration Systems ^a

Excluded Charge (ms – EDVC) ^b	Q_{req}	Excluded Charge (ms – EDVC) ^b	Q_{req}
lb	ft ³ /min	lb	ft ³ /min
3.8	100	91.8	2400
7.6	200	95.6	2500
11.5	300	99.4	2600
15.3	400	103.2	2700
19.1	500	107.1	2800
22.9	600	110.9	2900
26.8	700	114.7	3000
30.6	800	118.5	3100
34.4	900	122.4	3200
38.2	1000	126.2	3300
42.1	1100	130.0	3400
45.9	1200	133.8	3500
49.7	1300	137.6	3600
53.5	1400	141.5	3700
57.4	1500	145.3	3800
61.2	1600	149.1	3900
65.0	1700	152.9	4000
68.8	1800	156.8	4100
72.6	1900	160.6	4200
76.5	2000	164.4	4300
80.3	2100	168.2	4400
84.1	2200	172.1	4500
87.9	2300	175.5	4590

- | |
|---|
| a. Charge sizes and ventilation rates shown in this table are based on R-32. |
| b. ($m_s - EDVC$) is the amount of <i>refrigerant</i> charge that is removed by mechanical ventilation and is therefore not included in calculations to determine compliance with Section 7.3. m_s and $EDVC$ are as defined in Section 7.6.4(a). |

Sample Mechanical Room Layout w/ Multiple Unit Heaters

When using multiple gas-fired unit heaters, consider placement to provide uniform temperature distribution in space. Consider placing intake of unit heaters near the recirculation duct discharge locations in the room to capture the colder air off the compressor units before it is introduced into the space. Also consider exhaust discharge in relation to intake to minimize short circuiting during summer operation. Figures 6-12 illustrate a sample mechanical room layout for 96 and 48 ton.

96 Ton Example (Roof Discharge)

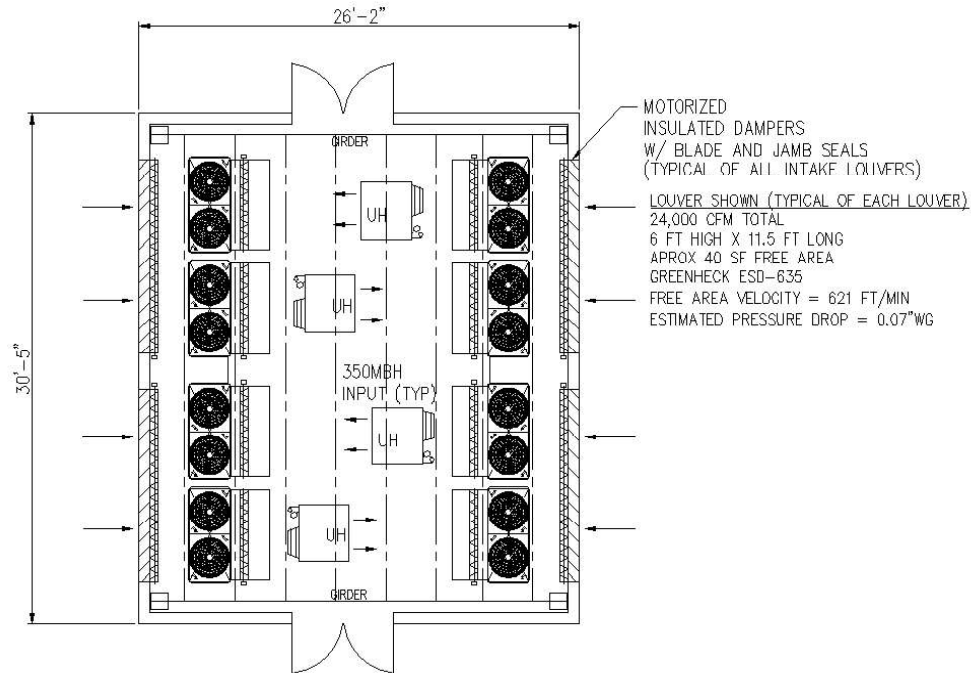


Figure 6: Top View

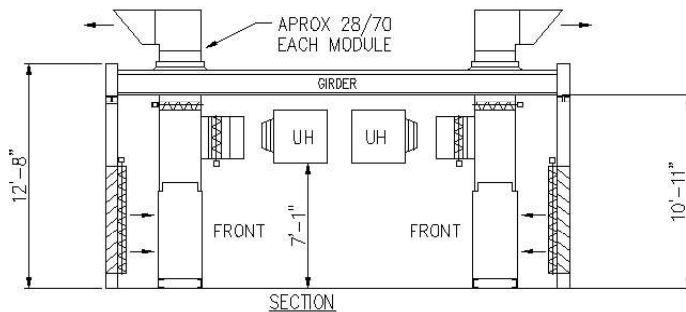


Figure 7: Elevation View

96 Ton Example (Side Wall Discharge)

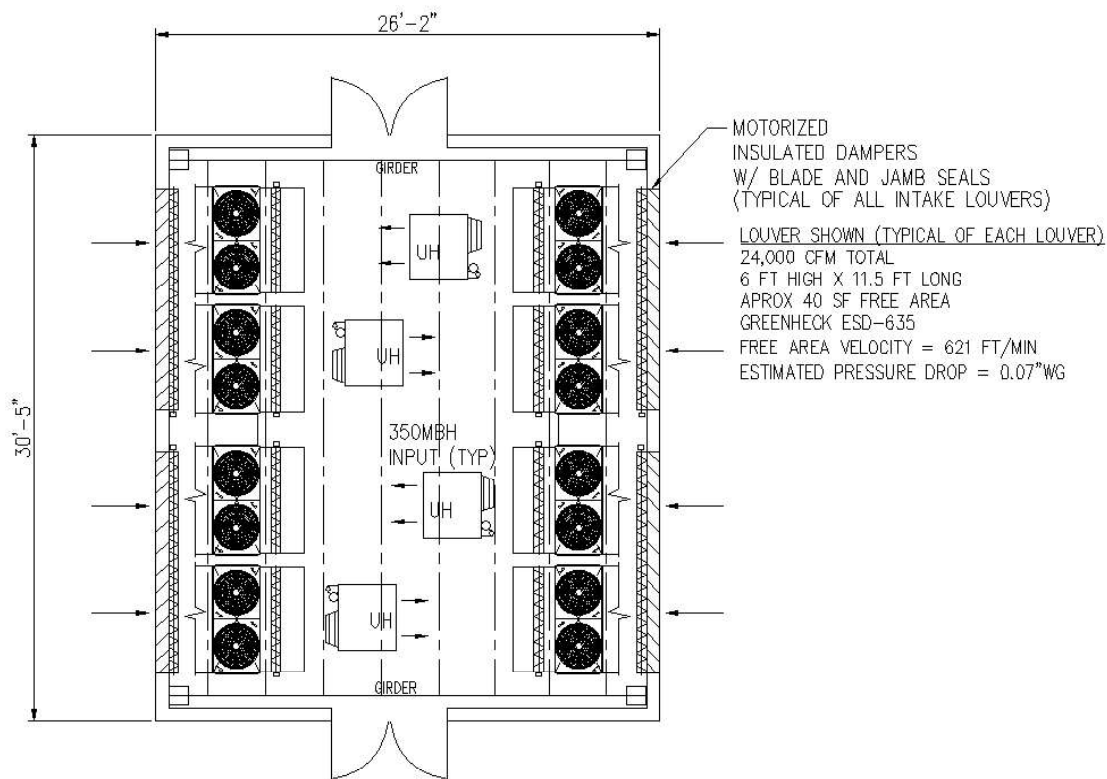


Figure 8: Top View

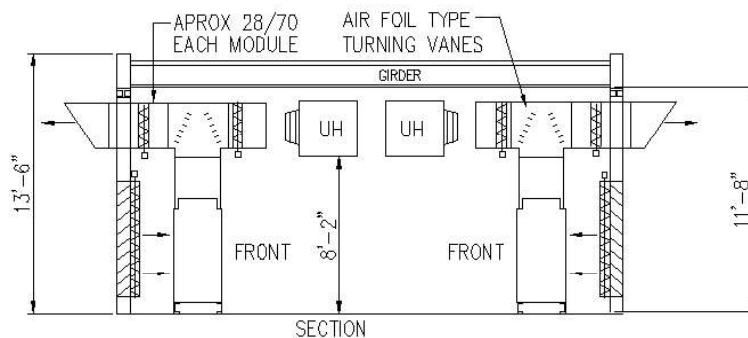


Figure 9: Elevation view

48 Ton Example (Side Wall Discharge)

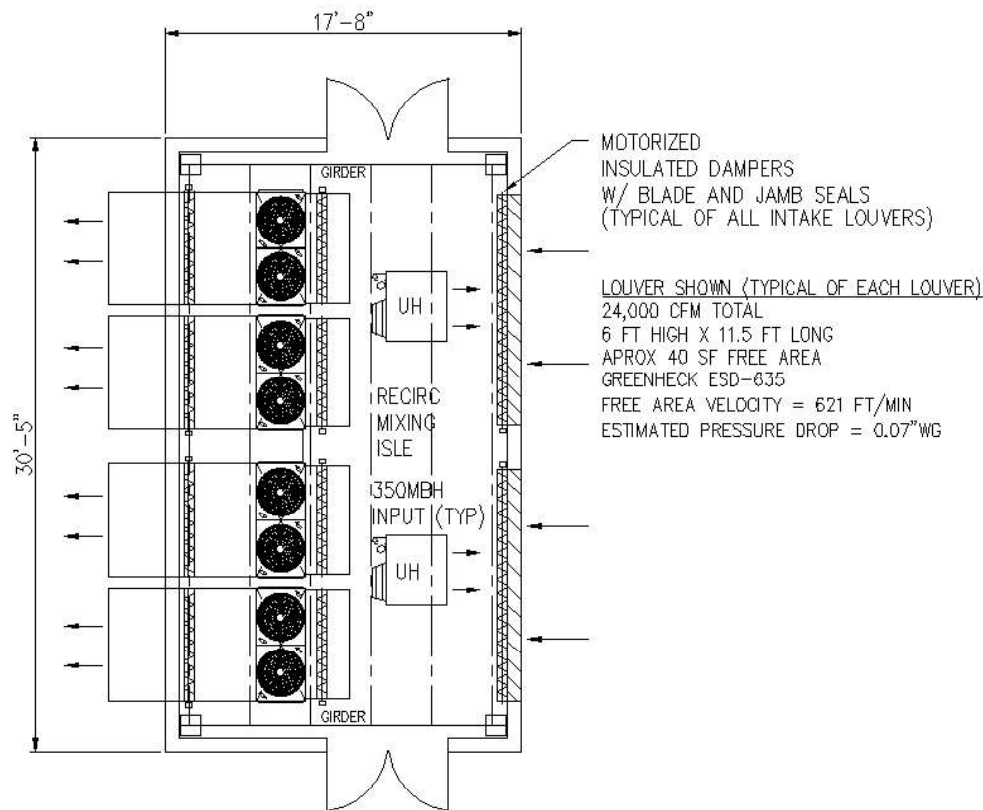


Figure 10: Top View

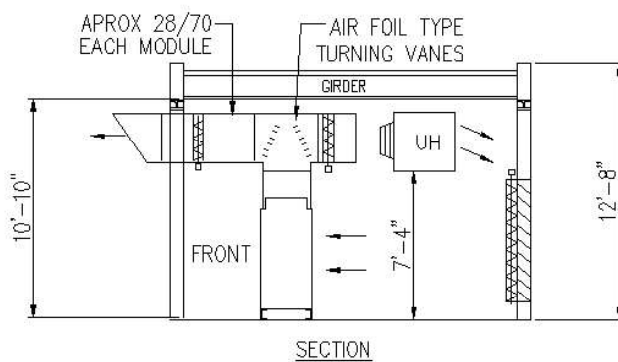


Figure 11: Elevation view

48 Ton Example (Side or Roof Discharge)

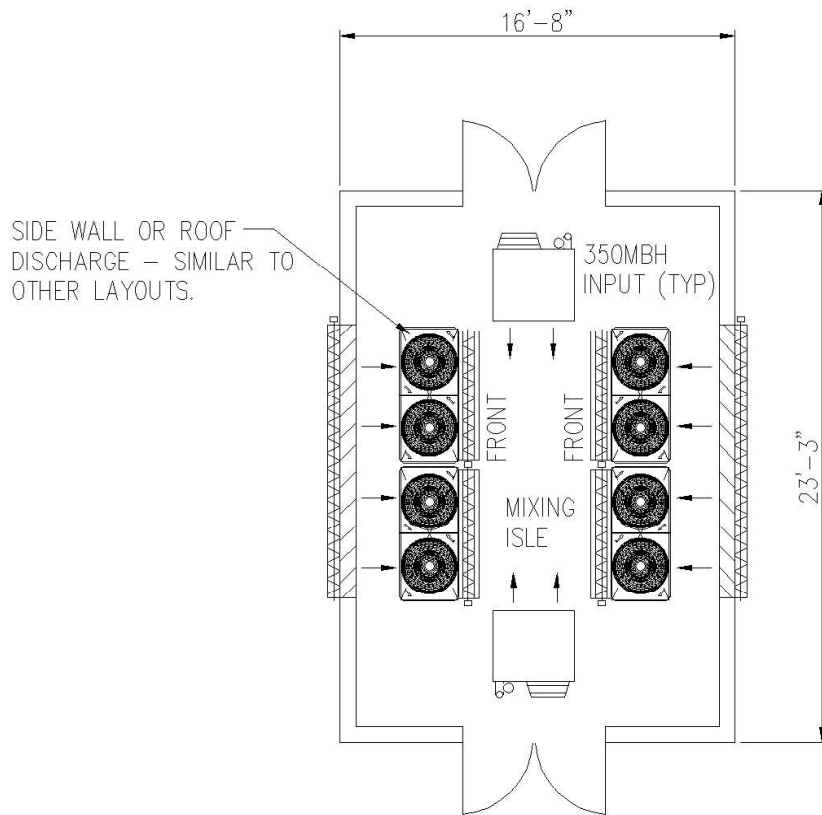


Figure 4: Top View