APPLICATION NOTES

MITSUBISHI ELECTRIC

COOLING & HEATING

Live Better

Application Note 2016:

Putting Air-source Outdoor Units Inside

Installing outdoor units inside offers several benefits: when roof space or building height is a concern, installing the outdoor unit inside will reduce roof space requirements and reduce distance between the outdoor and indoor units. If auxiliary heat is required to satisfy the building load, putting the outdoor unit inside is a great way to add heat to your building without installing duct heaters or baseboard throughout the building. These 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. 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

Installation Location

The installation location for the unit has to be large enough to ensure that proper service clearance is maintained around the unit. The space also has to be high enough to ensure that ducting off the top of the unit is possible. A minimum height of 9 feet is will allow proper ducting off of the top of an outdoor unit. There will also need to be access to the exterior 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 space. 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.

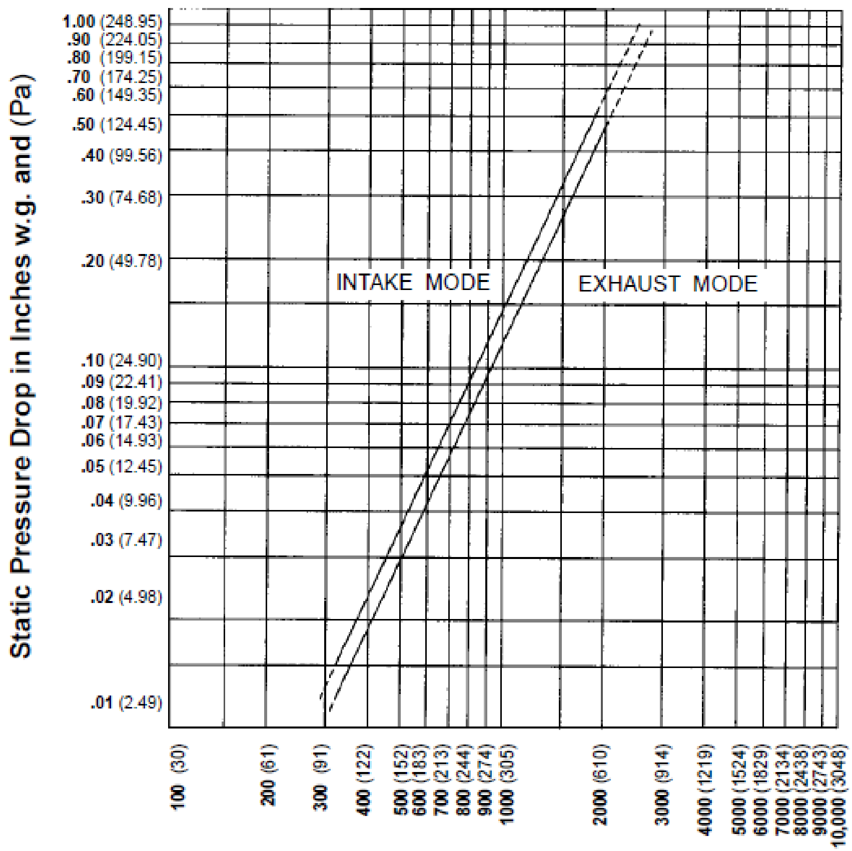
Louver Selection

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. As the outdoor units only have an available external static pressure of 0.24 in. w.g., selecting a louver that is too small and incurs too high a pressure drop will cause a lessened air flow that 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. So the louver size to exhaust an 8 ton unit at 6,180 CFM would be:

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

Free Area Velocity in feet and (meters) **per minute**
Standard air .075 lb/ft³

PRESSURE DROP



Air Velocity in feet and (meters) **per minute through Free Area**

Figure 1: 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 in. w.g. leaving almost nothing for fittings and ducting from the unit. 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, a booster fan equal to the exhaust CFM of the unit may be incorporated to overcome the pressure drop. If a fan is used, the outdoor units should be allowed to exhaust into the space and a relief damper should be incorporated. The fan will take air in to ensure heat can be exchanged with outside air or to reject heat from building.

Local code may require the use of an automatic control damper regardless of whether the system is being designed to recirculate air. Several manufacturers offer a louver sizing tool that calculate the pressure drop for a louver based on specific size and type.

Duct Design

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 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 .08 -.10 in. of ESP loss/100 ft of duct. Using a duct sizing calculator is the best way to size the duct. The elbow that is being used should either be a smooth radius elbow or include turning vanes to reduce the pressure drop through the fitting as shown in the Figure 2 below:

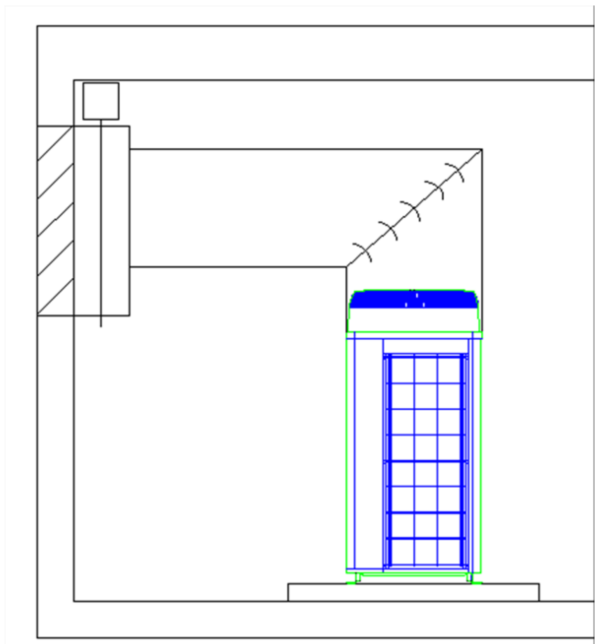


Figure 2: Ductwork from exhaust fan to louver; elbow shown with turning vanes.

If multiple units are being installed in the same room, a common exhaust plenum should never be used. This could cause one system to exhaust air through another unit.

Condensing Unit Ambient Conditions for Heating

For the purpose of discussion, the room will be defined as the inside space where the outdoor unit(s) will be installed. The temperature at which the room is being kept depends on whether there is auxiliary heat being added to the system 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. 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

The advantages to maintaining the room at 40 °F are that the system will have no temperature heating de-rate. The other advantage is that because the space is above freezing, there is no need to utilize heat tracing to prevent condensate from freezing. These benefits may be over shadowed; maintaining the room at 40 °F will limit the use of the heat pump cycle for 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 is coming 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.

Maintaining the room at 20° F

For regions of the country where the design temperature is above 10 °F, it may be more beneficial, from a first cost and ease of installation standpoint, to upsize the outdoor unit and indoor units to meet the load at the design temperature. For regions of the country where the design temperature is below 10 °F, the room should be maintained at 20 °F to maximize the use of the heat pump cycle.

Take the weather conditions in Boston Massachusetts as an example. Approximately 65% of the heating hours in Boston occur below 40 °F, while only 5% of the heating hours occur below 20 °F. This means that if the room is maintained at 20 °F, in Boston, for 95% of the year the heat pump will be used to heat and for only 5% of the year auxiliary will be used to heat. If the room is going to be maintained at 20 °F, the outdoor unit and indoor units will need to be upsized to meet the load at 20 °F. Typically this would result in upsizing the indoor and outdoor units by 20%.

This method maximizes the benefit of the heat pump cycle. The downside to this method is that because the space is below freezing the condensate drain will need to be heat traced in order to prevent freeze up.

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 change over point can be a function of the local utility cost. If the natural gas utility rates are low and the electric 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 the 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 in order to provide enough capacity to backup the system. Take the example of a PURY-P120TJMU being put inside with a change over temperature of 20 °F. The first step is to figure out how much heat the unit will be generating from heat of compression. In heating the power input for the PURY-P120TJMU is 11.02 kW, so the heat being generated by this unit would be:

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

The total heating capacity for the unit is 135,000 BTU/H at 40 degrees. This means that 97,388 BTU/H needs to be generated by the unit heater in order 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 ^{o}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 being 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 being mounted 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. As long as 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 by 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.

Damper and heater control

The damper and unit heater controls are integral to how well and efficient the system will operate. Figure 3 illustrates a room layout for a system that is not using any unit heater to provide supplemental heat:

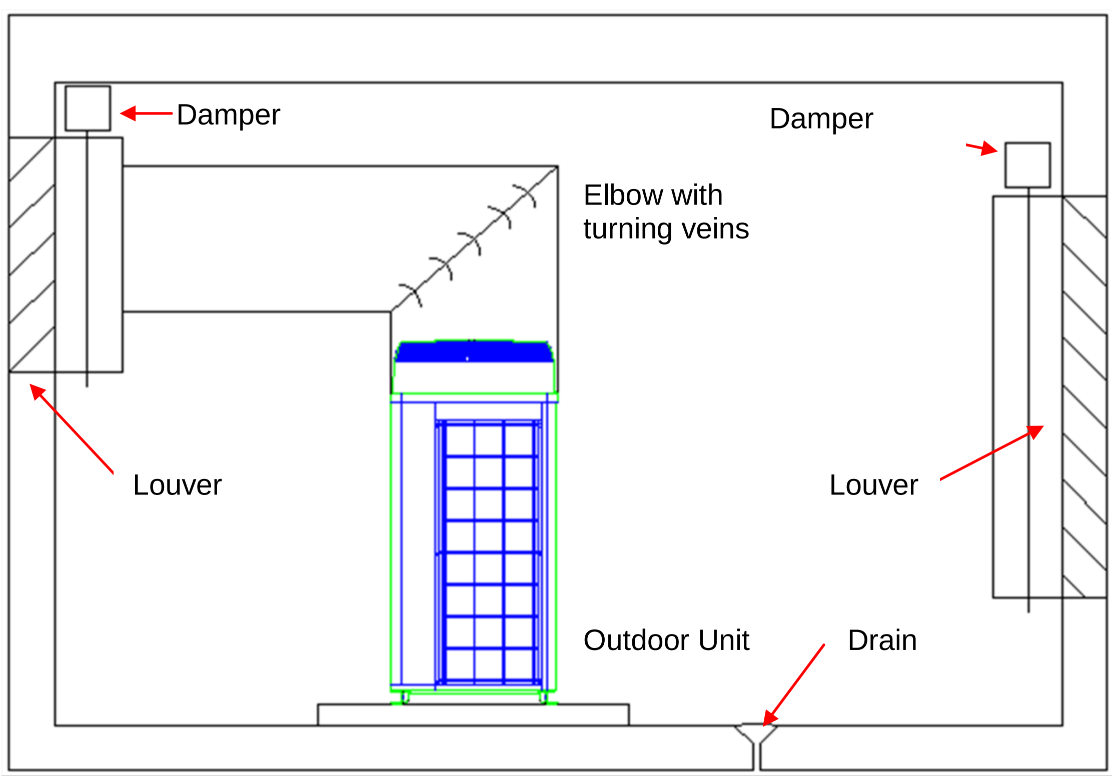


Figure 3: Outdoor Unit installed indoors with damper

In the above example there is really not much need for damper control. They are simply there to meet code requirements. An example can be found in IECC 2006 paragraph 502.4.4 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 4 illustrates a layout of a room using a unit heater to provide auxiliary heat to the system:

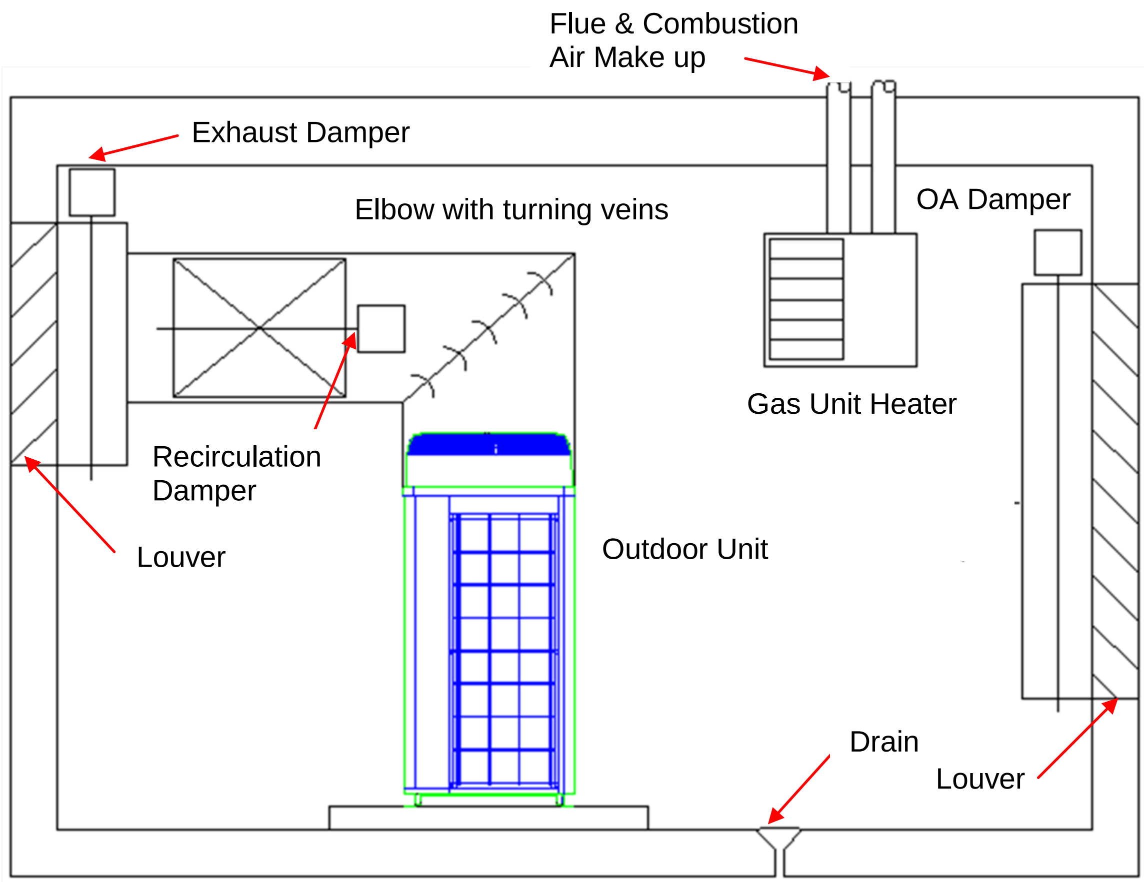


Figure 4: Outdoor Unit installed indoors with damper and heater control

The example shown above requires a 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^o F or higher

To maintain the space at 40^o F the outside air (OA) temperature will need to be monitored and internal space temperature will need to be monitored. When the outside air temperature falls below 40^o F and the internal space temperature falls below 40^o 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 40^o F. Upon the outside air temperature reaching 45^o F (a 5° F dead band) or an internal room temperature of 60^o F, the outside air and exhaust air dampers shall open and the unit heater shall de-energize.

Maintaining the room at ambient 20° F

The outside air temperature and internal space temperature will need to be monitored. When the outside air temperature falls below 20^o F and the internal space temperature falls below 40^o 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 20^o F. Upon the outside air temperature reaching 25^o F (a 5° F dead band) or an internal room temperature of 60^o 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^o 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 20^{o}F to whatever the utility rates dictate.

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 of 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 5-10 illustrate a sample mechanical room layout for 96 and 48 ton.

96 TON EXAMPLE USING ALL PURY-288'S (Roof Discharge)

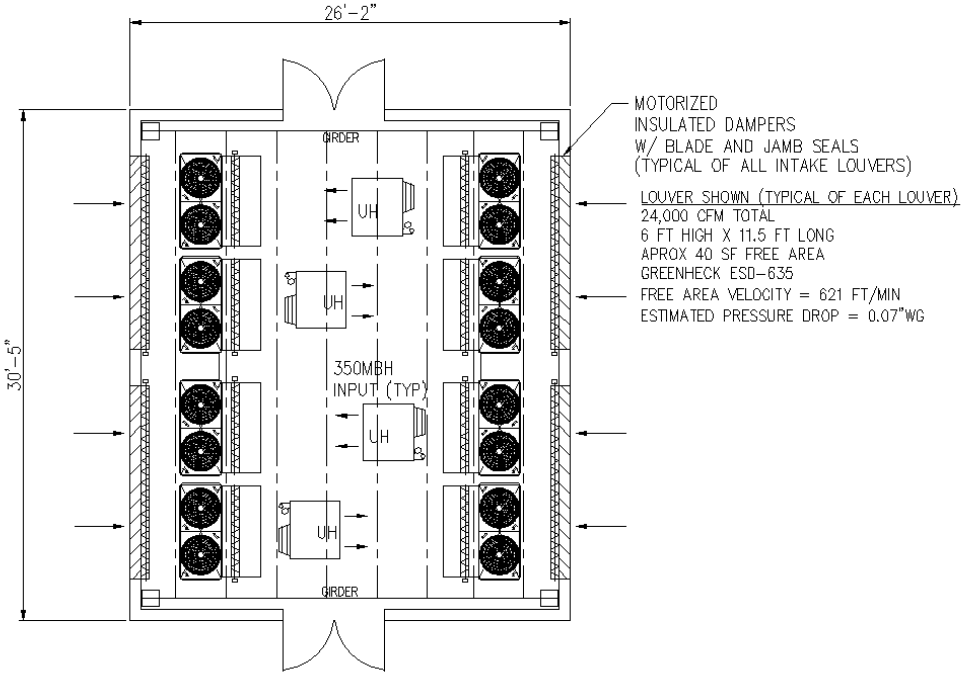


Figure 5: Top View

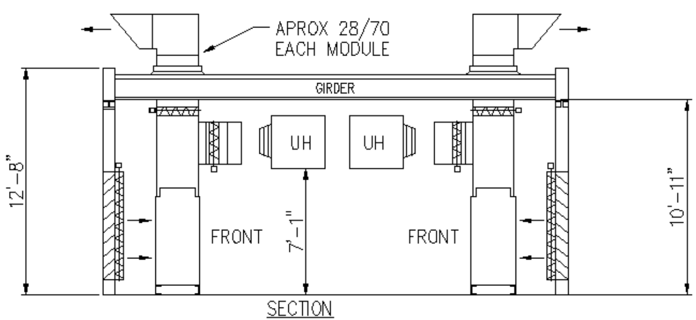


Figure 6: Elevation View

96 TON EXAMPLE USING ALL PURY-288'S (Side Wall Discharge)

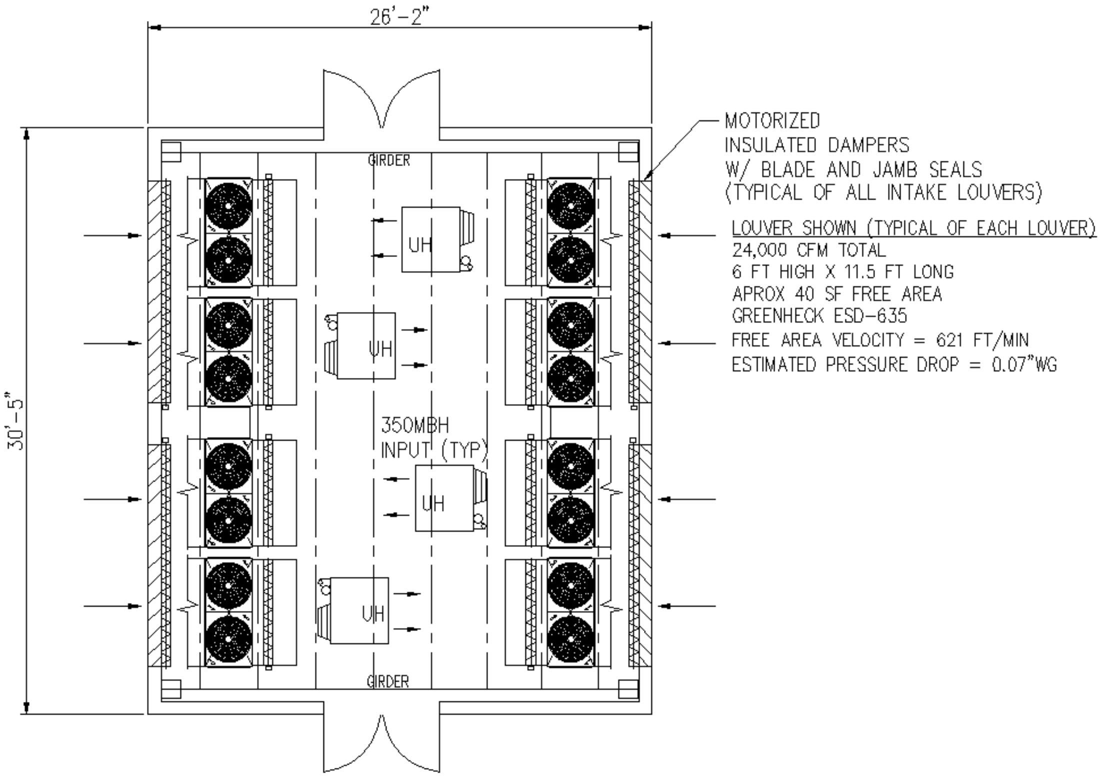


Figure 7: Top View

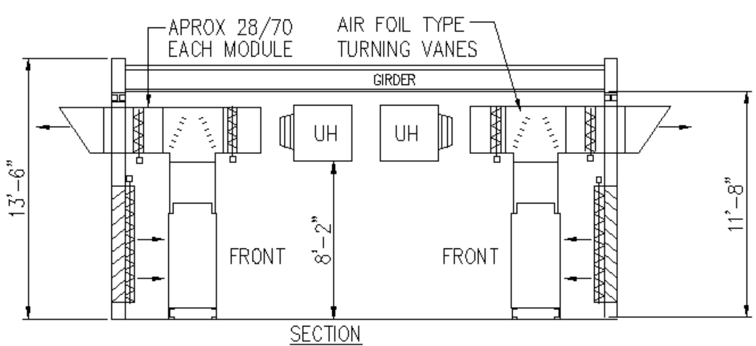


Figure 8: Elevation view

48 TON EXAMPLE USING ALL PURY-288'S (Side Wall Discharge)

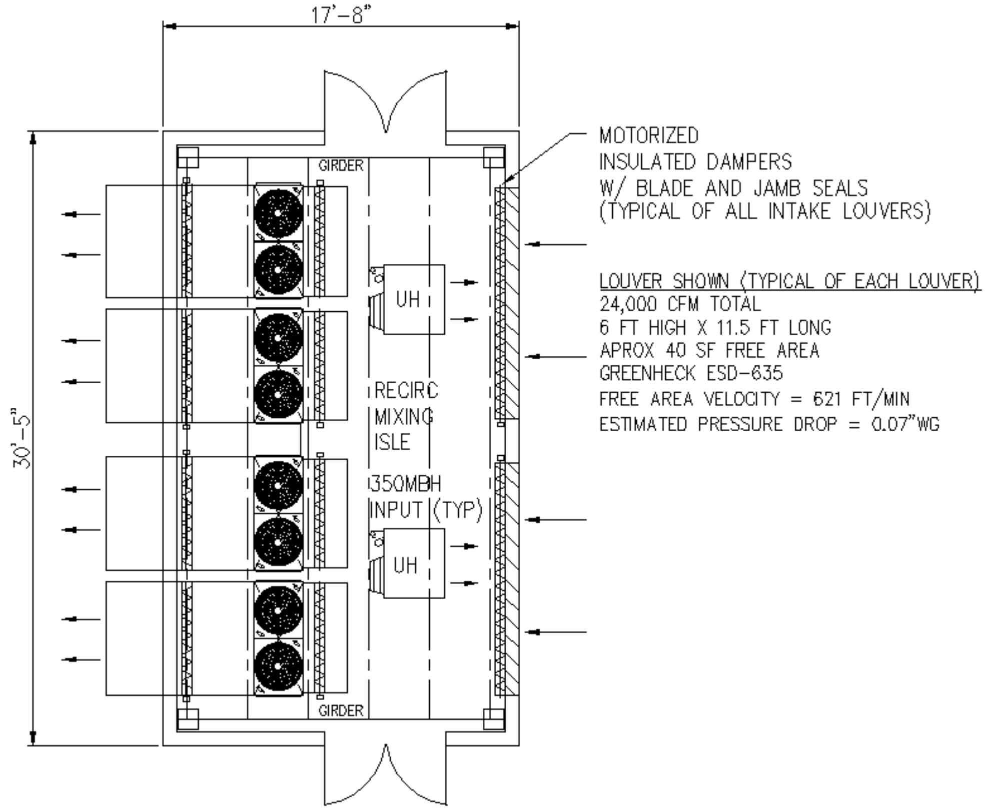


Figure 9: Top View

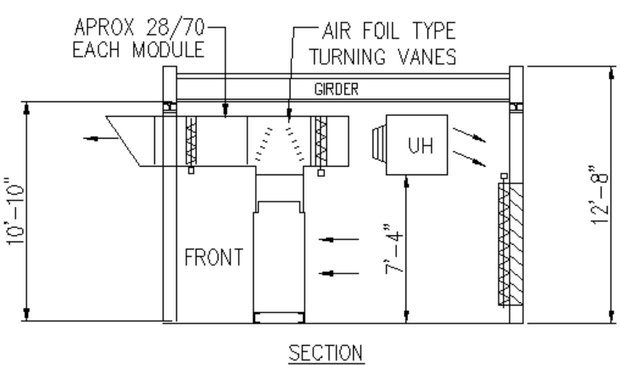


Figure 10: Elevation view

48 TON EXAMPLE USING ALL PURY-288'S (Side or Roof Discharge)

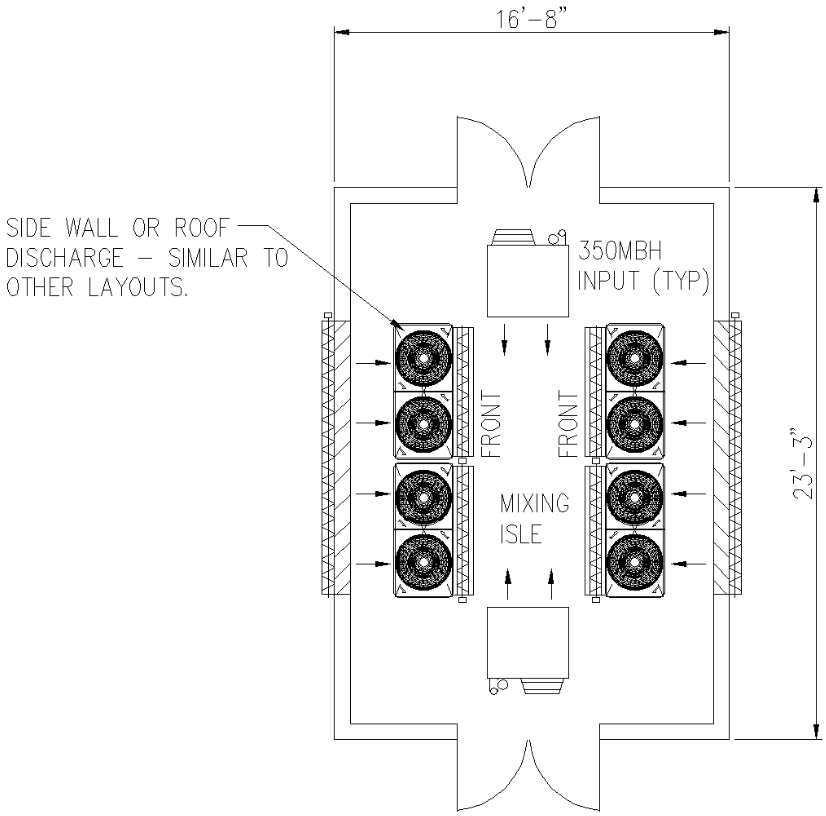


Figure 11: Top View