APC

APPLICATION NOTE #123

ACRP Remote Air-Cooled Condenser Application and Placement

By Ozan Tutunoglu

Abstract

The InfraStruXure InRow RP (ACRP100, ACRP101, and ACRP102) is an air-cooled DX air conditioner for data centers. All air-cooled air conditioners require the use of remote air-cooled condensers. This application note outlines the placement, refrigerant line pipe sizing, and maintenance of air-cooled condensers for the ACRP100 series units.

Introduction

The InfraStruXure InRow RP is an air-cooled DX air conditioner designed to be placed in-row, between IT equipment racks. The in-row design allows the RP to draw in air from the rear, capturing heat from the IT equipment in the hot aisle, and neutralizing it before it mixes with the room air. Conditioned air is then discharged into the cold aisle, ready for immediate use by the equipment in the adjacent racks. An air-cooled condenser is required to reject the heat load as well as the power drawn by the compressor. The air-cooled condenser, installed outside, rejects the heat to the outdoor ambient air.

The maximum heat rejection of the ACRP unit is approximately 60 kW (205,000 Btu/hr). The selected air-cooled condenser must meet the capacity requirements at the maximum outdoor ambient air temperature of the region where the air-cooled condenser is installed. American Power Conversion offers remote air-cooled condensers for three outdoor ambient air temperatures in order to keep the refrigerant condensing pressures at a desired level: 35 ^oC (95 ^oF), 40 ^oC (105 ^oF) and 46 ^oC (115 ^oF).

Elevation from sea level is a factor that negatively affects air-cooled condenser performance. The density of the air is reduced with higher elevation from sea level, the lower air density means lower air mass flow rate drawn by condenser fans. The negative effect of elevation from sea level was taken into consideration during the condenser selections for the ACRP units. See ACRP technical data manual for physical data and performances.

Piping Application of Remote Air-Cooled Condensers

Refrigerant grade copper tubes must be used and common standard refrigeration practices must be applied. The liquid line piping exposed to the sun or any other type of heat source must be insulated to prevent gas flashes in the liquid refrigerant pipe. Hot gas lines that are exposed to personnel should also be insulated. Anchor all refrigerant piping using appropriate vibration pads to eliminate vibration, created by the ACRP unit, from spreading into the building. Do not attach piping directly to large wall or ceiling panels.

Legendary Reliability®

Refrigerant hot gas piping

The designer must accomplish two objectives with the hot gas piping design between the air conditioner and the air-cooled condenser: good oil return and reasonable refrigerant pressure drops. Minimum or maximum refrigerant gas velocities and maximum refrigerant pressure drop in hot gas lines can be found in text books and leaflets published by the manufacturers. Note that the information in each text might be a little different. Poor oil return due to improper piping design will reduce the oil level in the compressor. It is critical that oil returns to the compressor crankcase to prevent compressor damage. High refrigerant pressure drops (between the compressor outlet and condenser inlet) will increase the discharge pressure and compressor compression ratio which will result in an increase of the compressor's power consumption and a reduction in unit capacity.

Certain levels of minimum refrigerant gas velocities are needed in the hot gas lines to carry the oil back to the compressor. The minimum velocity in the horizontal hot gas pipes should be above 500 fpm (2.54 m/s) and minimum velocity in the vertical hot gas pipes should be above1000 fpm (5.08 m/s) at all times. The pipe size of hot gas vertical rise is usually selected one size smaller than horizontal hot gas pipe size. If the hot gas refrigerant velocity in the vertical risers gets below 1000 fpm (5.08 m/s) when the cooling capacity of the ACRP is at its minimum, double risers should be used to keep gas velocity above 1000 fpm (5.08 m/s). The detailed information about design of double risers can be found in ASHRAE Fundamentals, condenser manufacturer installation manual, or other publications. To provide proper oil return, the frequency of the variable speed compressor in the ACRP unit is increased for short time to increase the gas velocities in the pipes to push back any oil trapped in pipes. Refer to Application Note #119 for ACRP controls.

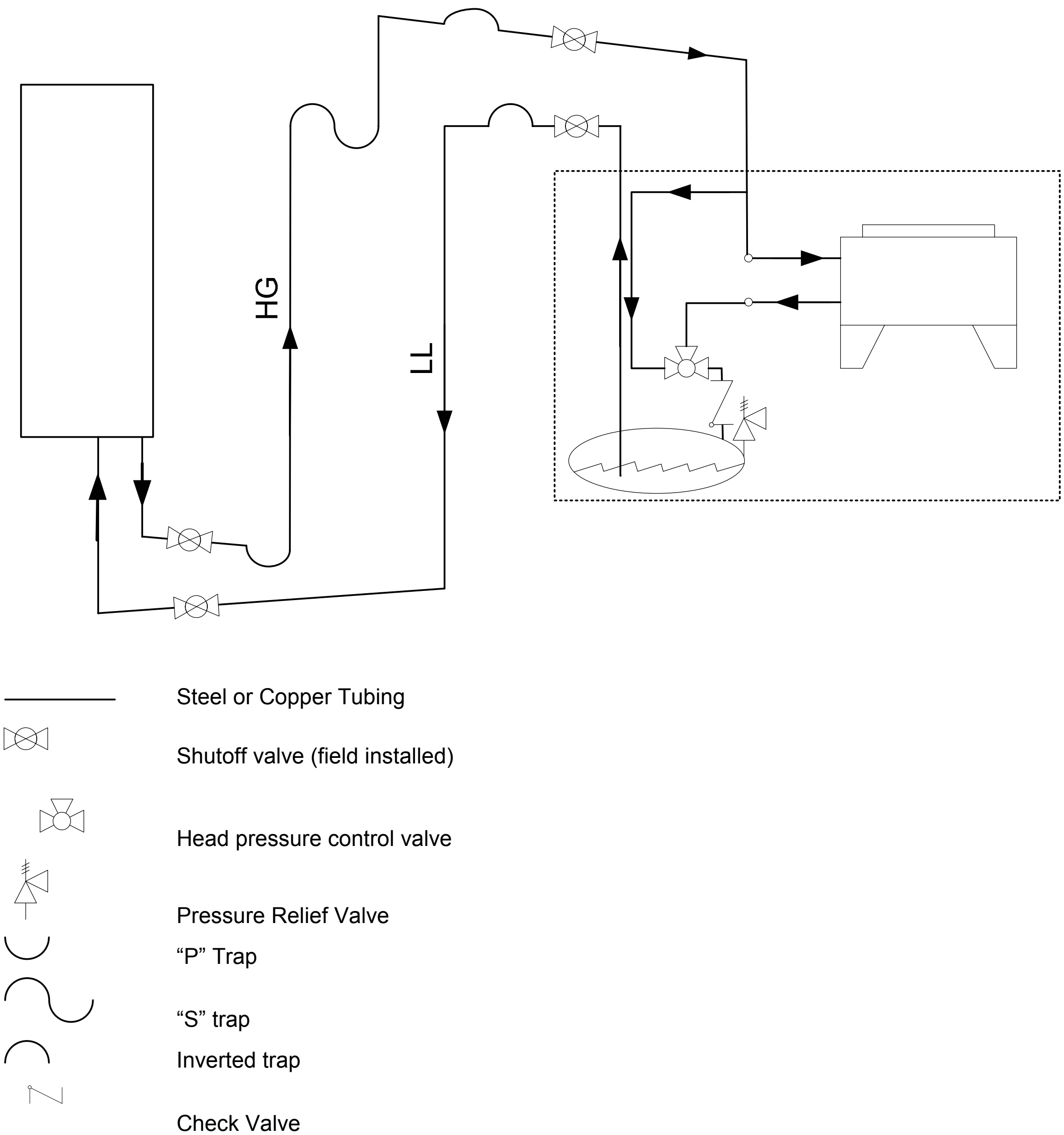
Having the refrigerant gas velocities above minimum requirements is not enough to have proper oil return. Every horizontal pipe needs to be pitched down in the direction of refrigerant flow to obtain good oil circulation. The pitch in the horizontal section of the line, P traps at the foot of risers, and inverted P traps at the top of risers are needed to trap the oil during compressor off cycles. This prevents oil from migrating to the compressor through the discharge connection. Risers longer than 25 ft (7.6 m) should have S traps every 20 ft (6.1 m). Different sources use different maximum gas velocities in hot gas pipes; some use maximum 3000 fpm (15.24 m/s) some use 4000 fpm (20.32 m/s). Higher gas velocities will create higher pressure drops.

As mentioned above, higher discharge pressures will increase the compressor power consumption and decrease compressor capacity. APC recommends that the total maximum hot gas pipe pressure drop be 10 psi (68.9 kPa) for maximum cooling capacity of the ACRP units, which contains a variable speed compressor. Minimum velocity and hot gas pressure drops, as explained in detail above, should be considered when selecting hot gas line size.

Refrigerant liquid piping

Due to oil mixing and moving with liquid refrigerant, there is no minimum velocity requirement for the liquid lines. The maximum velocity should be less than 360 fpm (1.83 m/s) to prevent liquid hammering. The total maximum friction pressure drop of liquid refrigerant lines should be less than 6 psi (41.4 kPa). Selecting larger line sizes than needed will increase the total refrigerant charge of the system.

Figure1 *– ACRP DX bottom piping schematic*



Remote Air-Cooled Condenser Location Compared to RP Unit's Location

Remote air-cooled condensers must be installed at a higher elevation than the air conditioning unit. The reason behind this is to have sub-cooled liquid refrigerant in the liquid piping, especially at the expansion valve inlet, at all times. Gas bubbles in the liquid line at the thermostatic expansion valve inlet will adversely affect the thermostatic expansion valve's operation in the unit. Bubbles of flash gas within the liquid line of the air conditioning unit displace liquid in the port of the expansion valve, reducing the liquid flow. In addition, flash gas flowing through the port may erode the valve seat.

The leaving refrigerant from the condenser is in liquid form and its temperature is lower than the refrigerant condensing temperature, which is the saturation temperature of the condensing pressure. The difference between the refrigerant condensing temperature and the refrigerant liquid temperature is called sub-cooling temperature. To prevent bubbling in the refrigerant liquid piping, the sub-cooling temperature must be positive in the liquid line.

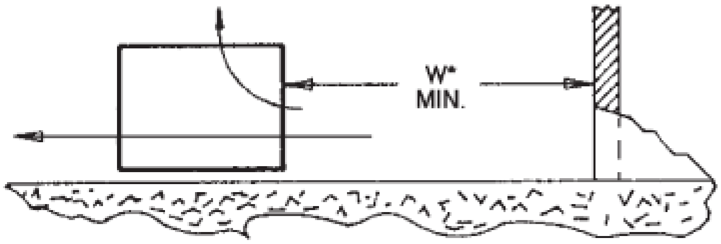
Raising the height of refrigerant liquid piping will result in a hydrostatic pressure drop. Every 2 ft (0.6 m) rise in the liquid R407C or R22 refrigerant piping will create approximately 1 psi (6.9 kPa) pressure drop in liquid lines. For example, assume that the elevation of the RP is at 0 ft and the condenser is located 30 ft (9.1 m) below it. Since the air-cooled condenser is 30 ft (9.1 m) below the RP level, the refrigerant liquid pressure at the thermostatic expansion valve inlet is approximately 15 psi lower than the refrigerant liquid pressure at the air-cooled condenser outlet. This lower pressure will probably prevent sub-cooling at the thermostatic expansion valve inlet which will create bubbling due to the flashing of some of the liquid. This example shows that the remote air-cooled condenser must be installed at a higher elevation than the air-cooled RP units.

Caution!!!
The air-cooled condenser must be located above the ACRP units to prevent the occurrence of refrigerant flash gas at the thermostatic expansion valve inlet.

Space and Location Requirements

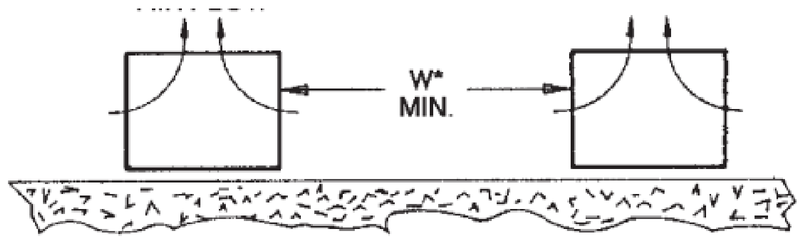
In addition to the location requirement relative to the ACRP unit, other location factors should be considered. The location selection of the air-cooled condenser affects the supply of ambient air to the condenser and the removal of hot air from the condenser area. Failure to follow the guidelines below from the Heatcraft Larkin “Air Cooled Condenser Installation & Operation Manual” will result in higher condensing pressures, thus causing poor operation and possible eventual failure of the equipment. Remote air-cooled condensers must not be located in the vicinity of steam, hot air, or fume exhaust.

Figure 1 – Walls or obstructions



The air-cooled condenser should be located so that air may circulate freely and not be recirculated. For proper airflow and access, all sides of the condenser should be a minimum of "W" away from any wall or obstruction where "W" is the total width of the condenser. It is preferred that this distance be increased whenever possible. Care should be taken to ensure that ample room is left for service clearance in front of access doors and panels. Overhead obstructions are not permitted. When the unit is in an area where it is enclosed by three walls the unit must be installed as indicated in **Figure 3**.

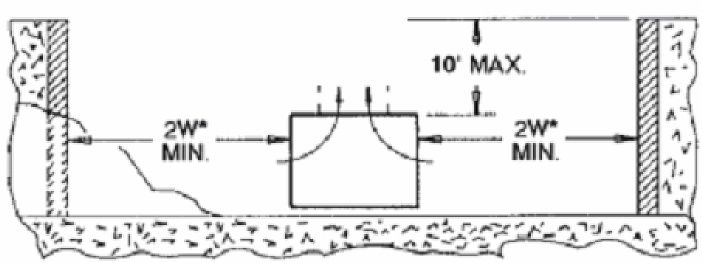
Figure 2 – Multiple units



"W" = Total width of the condenser.

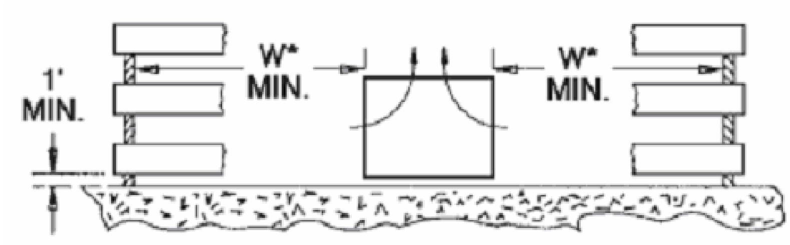
For condensers placed side by side, the minimum distance between condensers is the width of the largest condenser. If condensers are placed end to end, the minimum distance between condensers is 4 feet (1.22 meters).

Figure 3 – Units in pits



The top of the condenser should be level with the top of the pit, and side distance increased to “2W”. If the top of the condenser is not level with the top of the pit, discharge cones or stacks must be used to raise the discharge air to the top of the pit. This is a minimum requirement.

Figure 4 – Decorative fences



Fences must have a minimum of 50% free area, with a 1 foot (0.3 meter) undercut, a “W” minimum clearance, and must not exceed the height of the condenser. If these requirements are not met, the condenser must be installed as indicated in **Figure 3**.

Maintenance

Remote air-cooled condensers require little maintenance. The condenser coil requires periodic cleaning. Most manufacturers suggest cleaning the coil every six months and more frequently depending on the location of the condenser. No acid base cleaners should be used under any circumstances. A brush, vacuum cleaner, pressurized steam or a commercially available coil cleaning foam can be used. Manufacturer installation and operation manuals should be checked for more detailed information.

Note that failure to clean the coil will drop the condenser volumetric air flow rate and result in higher condensing pressures or possible loss of cooling. Motors, wiring connections, and other components of the condenser should be visually checked periodically.

About the Author:

Ozan Tutunoglu is a Senior Mechanical Engineer in the Cooling Solutions division at American Power Conversion (APC). He received a Bachelors degree in mechanical engineering from Istanbul Technical University in Istanbul, Turkey and a Masters in mechanical engineering from Johns Hopkins University in Baltimore, MD and is a member of ASHRAE and ASME.