APC

APPLICATION NOTE #120

ACRP Requirements for Selecting 3rd Party Remote Air-Cooled Condenser and Flooded Receiver

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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 requirements for selecting third party remote condenser and flooded receiver for InRow RP air-cooled product.

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 InRow 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 outdoor ambient air.

Performance Requirements for Air-Cooled Condenser

The thermal heat rejection (THR) of the InRow RP unit for different applications can be seen below. However it is suggested that maximum THR value should be used for condenser selection to provide extra condenser capacity for future head load additions. 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°C (95 °F), 40°C (105°F) and 46°C (115°F).

Table 1 – InRow RP unit's THR values, hot aisle / cold aisle application

Return air Condition	Net Total Cooling Btu/hr (kW)*	Thermal Heat Rejection (THR) Btu/hr (kW)
90°F DB, 66.2°F WB (32.2°C DB, 19.0°C)	104,100 (30.5)	167,300 (49.0)
85°F DB, 64.6°F WB (29.4°C DB, 18.1°C)	99,000 (29.0)	160,500 (47.0)
80°F DB, 62.8°F WB (26.7°C DB, 17.1°C)	91,900 (26.9)	146,800 (43.0)

*Total and sensible capacities are same; there is no latent capacity due to high return air temperatures.

Note: Unit is not recommended for use with total loads of 10 kW or less.

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Table 2 – InRow RP unit's THR values, RACS and HACS applications

Return air condition	Net total cooling Btu/hr (kW)*	Thermal heat rejection (THR) Btu/hr (kW)
105°F DB, 70.8°F WB (40.6°C DB, 21.6°C)**	125,000 (36.6)	202,500 (59.3)
100°F DB, 69.3°F WB (37.8°C DB, 20.7°C)	126,000 (36.9)	204,900 (60.0)
95°F DB, 67.8°F WB (35°C DB, 19.9°C)	115,100 (33.7)	186,500 (54.6)
90°F DB, 66.2°F WB (32.2°C DB, 19.0°C)	104,100 (30.5)	167,300 (49.0)
85°F DB, 64.6°F WB (29.4°C DB, 18.1°C)	99,000 (29.0)	160,500 (47.0)

*Total and sensible capacities are same; there is no latent capacity due to high return air temperatures.

**Airflow reduced to maintain adequate return gas temperature.

Note: Unit is not recommended for use with total loads of 10 kW or less.

Elevation above 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 must be taken into consideration during the condenser selections for the InRow RP units. Remote air-cooled condenser selection procedure may change from vendor to vendor, but size and capacity of the condenser increases with the higher elevation from sea level. If the altitude is 4,000 ft (1,200 m), the altitude correction factor is 1.10 and the corrected design THR is calculated by 60 kW (205,000 Btu/hr) multiplied by 1.10 or 66 kW (225,400 Btu/hr).

Table 3 – Altitude correction factor

Altitude ft (m)	Correction factor
0	1.00
1,000 (300)	1.02
2,000 (600)	1.05
3,000 (900)	1.07
4,000 (1,200)	1.10
5,000 (1,500)	1.12
6,000 (1,800)	1.15
7,000 (2,100)	1.17

The refrigerant R407C is a zeotropic blend of three refrigerants, and there is a significant glide which means the dew and bubble temperatures of the refrigerant at a given refrigerant condensing pressure differs. At dew temperature at given pressure, gas refrigerant starts condensing. Bubble temperature of a fluid at given pressure is where liquid refrigerant starts evaporating. The selected design condensing pressure for the InRow RP unit is 305 psig (20.7 bar) that yields reliable, continuous problem free operation. The R407C bubble and dew temperatures at 305 psig are 121.9°F (49.9°C) and 129.8°F (54.3°C) respectively. The use of dew temperature for condenser selection will overrate and use of bubble temperature will penalize the condenser capacity. So using mid-point temperature as the condensing temperature is the method which should be accepted. The mid-point condensing temperature at 305 psig (20.7 bar) R407C refrigerant pressure is calculated as sum of 121.9°F (49.9°C) and 129.8°F (54.3°C) divided by two or 125.9°F (52.2°C). The difference between outdoor ambient temperature and mid-point condensing temperature is called design condenser temperature difference.

Table 4 – Refrigerant (R407C) temperatures at 305psig (20.7 bar) design pressure

Bubble temperature	Dew temperature	Mid-point temperature
121.9°F (49.9°C)	129.8°F (54.3°C)	125.9°F (52.2°C)

For example; if the summer outdoor air design temperature of a region is 105°F (40.6°C), and the altitude is 4,000 ft (1,200 m), the design condenser temperature difference is calculated by subtracting 105°F (40.6°C) from 125.9°F (52.2°C) or 20.9°F (11.6 K). The selected condenser must have the minimum capacity of corrected design THR which is InRow RP THR multiplied by altitude correction factor or 66 kW (225,400 Btu/hr) at 20.9°F (11.6 K) design condenser temperature difference.

Flooded Receiver Requirement for Low Ambient Protection

Working principle

The remote air-cooled condensers selected for InRow units must be equipped with flooded receiver assembly for head pressure control at low outdoor ambient air temperatures, because the InRow RP unit has a variable speed compressor that changes unit capacity according to compressor speed. The condensing temperature in the InRow RP unit must be kept above 85°F (29.4°C) to prevent liquid refrigerant entering the compressor. The heat rejection from hot gas refrigerant to outdoor ambient air in the remote air-cooled condenser occurs via forced or natural convection. When the condenser fans are running, they will draw air through condenser coil and convection heat transfer occurs. Without any air flow, there still is natural convection heat transfer which may be enough to drive the condensing temperature below critical point at low outdoor ambient temperatures. An air conditioner which operates at 100% capacity may need a flooded receiver assembly for outdoor ambient air temperatures -10°F (-23.3°C) and below. However an air conditioner unit design that can regulate refrigerant mass flow rate and cooling capacities like InRow RP units do, need a flooded receiver assembly at higher outdoor ambient air temperature than expected. A flooded receiver assembly is required for InRow RP units at outdoor air temperatures of 45°F

(7.2°C) and below, because the condensers are selected for maximum capacity and capacity of an InRow unit can go as low as 10kW.

A viable method used to reduce and regulate condensing temperature at low outdoor ambient air temperature is flooding the condenser internal volume with liquid refrigerant. This method requires additional refrigerant R407C charge as shown below. A receiver assembly, which contains a relief valve, receiver, and head pressure control valve, is required to control the additional refrigerant during warmer ambient air temperatures. The idea of flooding the condenser internal tube volume with liquid refrigerant to reduce its capacity comes from a basic heat transfer fact: the heat transfer coefficient of a single phase (liquid) fluid is much lower than heat transfer coefficient of a two phase (gas and liquid) fluid.

Additional flooded charge and flooded receiver selection

The charge table in the InRow RP installation manual shows the refrigerant charges needed to fill the liquid line between the condenser and InRow RP unit, the unit's standard charge, and additional flooded charge for the condensers offered by APC.

Standard charges for the 3rd party condensers can be obtained from the specific vendor technical bulletins. To calculate the additional flooded charge, one should first obtain the condenser inner tube volume. The 100% flooded charge of the condenser then can be calculated by multiplying the condenser inner volume ft^3 (m^3) with 78 lb/ft^3 (1250 kg/m^3) density of liquid R407C at 0°F (-17.8°C) and 200 psig (13.8 bar). Finally, the additional flooded charge is calculated by multiplying the 100% flooded charge of the condenser with outdoor ambient coefficients that can be seen below.

Table 5 – Flooded refrigerant charge outdoor air temperature coefficient

	Design winter outdoor air temperature [°F (°C)]				
	40 (4.4)	20 (-6.7)	0 (-17.8)	-20 (-28.9)	-40 (-40.0)
Flooded charge outdoor air temperature coefficient	0.70	0.77	0.81	0.84	0.92

Caution!!!

The size of the flooded receiver must be capable of holding the entire flooded refrigerant charge or damage may occur to the refrigeration system or compressor.

The flooded receiver assembly must contain a receiver, rotolock valves, head pressure control valve, pressure relief valve, and flexible heater. A drawing of one of the flooded receiver assembly designed by APC can be seen below.
The receiver should have two sight glasses at one third and two third of receiver diameter for horizontally installed receivers to observe the refrigerant liquid level. External surfaces of the receiver should also be insulated.
200 W flexible rubber heater with thermostat built in should be wrapped around receiver before insulating the receiver. The 60°F (15.6°C) / 75°F (23.9°C) thermostat built in the heater will open when it senses temperature at 75°F (23.9°C) and closes

60°F (15.6°C). Flooded receiver assembly without a heater may cause compressor starting problems. Without a heated receiver, all refrigerant will migrate to receiver since it is the coldest portion of the system. Figure 1 and 2 below show two ways of designing flooded receiver assembly.

The pressure relief valve should have a pressure relief rating of 420 psig (30 bars).

The head pressure control valve with 180 psig (12.4 bars) set point or above will sense the drop in refrigerant discharge pressure and restrict condenser liquid outlet, this will result in flooding the condenser with liquid refrigerant. The Sporlan OROA valve is used in APC designed flooded receiver assemblies. However there are other options; combination of ORD (open on rise of differential pressure) and ORI (open on rise of inlet pressure) valves can also be used.

There should be a check valve at the liquid inlet. The flooded receiver assembly should be installed below the condenser coil level so that refrigerant can drain into the flooded receiver during compressor off cycle. A great attention should be given selection of the head pressure control valve. Table 6 below shows some head pressure control valve vendors and their parts.

Table 6 – Head pressure control valve vendors

Vendor	Vendor Part Number
Sporlan	OROA
Sporlan	ORI & ORD
Danfoss	KVR & NRD

Variable Fan Speed and Proportional Fan Speed Control

The condensers offered by APC are equipped with variable speed EC fans. An air-cooled condenser selected for an InRow RP unit must have variable speed fans, because cooling capacity and thermal heat rejection of an InRow RP unit changes with the load in a data center, a condenser without variable speed fans will result in unstable condensing pressure. EC fans have certain advantages over variable speed fans available in the market: they are very quite and consume much less energy.

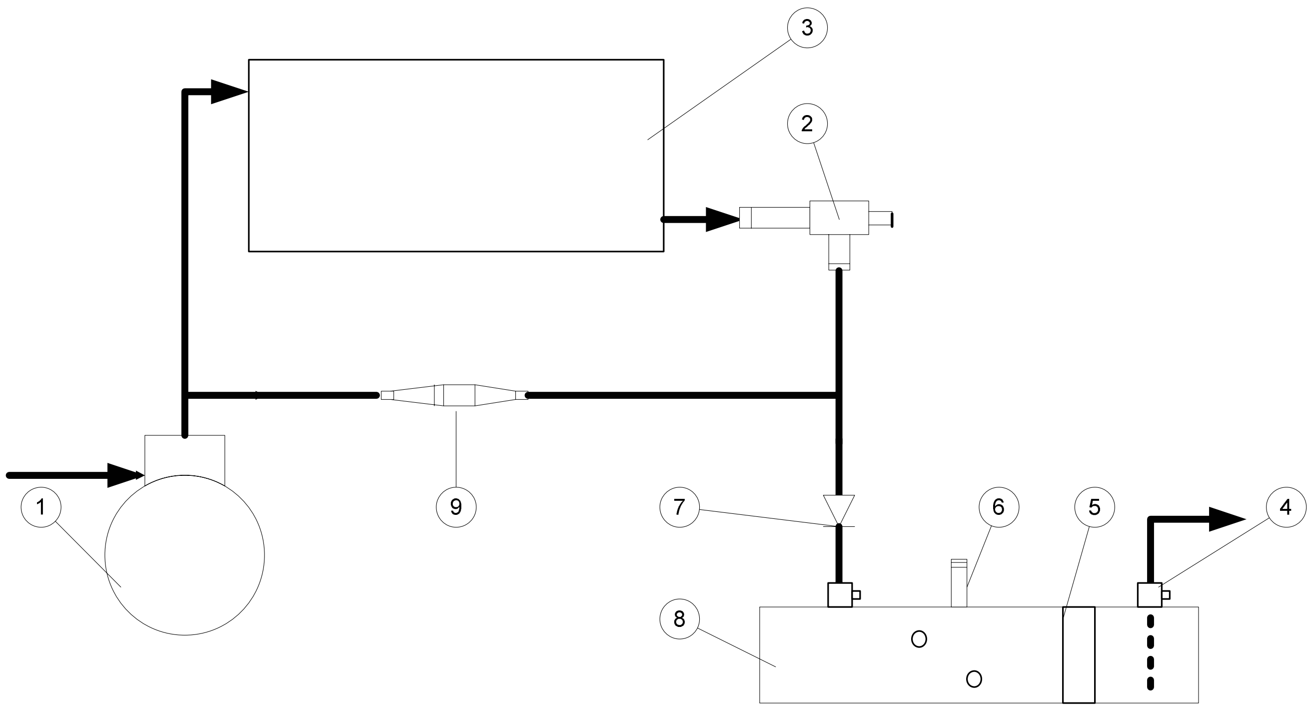
The EC fan controller is built in the EC motor; set pressure of 210psig (14.5 bar), throttling range of 100psi (6.9 bar), and other functions are programmed into the EC fan controller. A pressure transducer is installed to measure refrigerant discharge pressure. There is no low voltage signal wiring between the InRow RP unit and the remote air-cooled condenser. The EC fan controller will start each fan when the discharge pressure reaches 210psig (14.5 bar), the EC fans will run at 100% fan speed when discharge pressure reaches 310psig (21.4 bar). The 3rd party remote air- cooled condenser must have a pressure transducer and a fan speed controller, the 210psig (14.5 bar) pressure set point and 100psi (6.9 bar) must be programmed or entered manually into the controller. This will provide condenser fans to operate on refrigerant discharge pressure rise without signal wires between InRow RP and the remote air-cooled condenser.

Caution!!!

The 3rd party condenser and flooded receiver assembly must comply with local codes and standards.

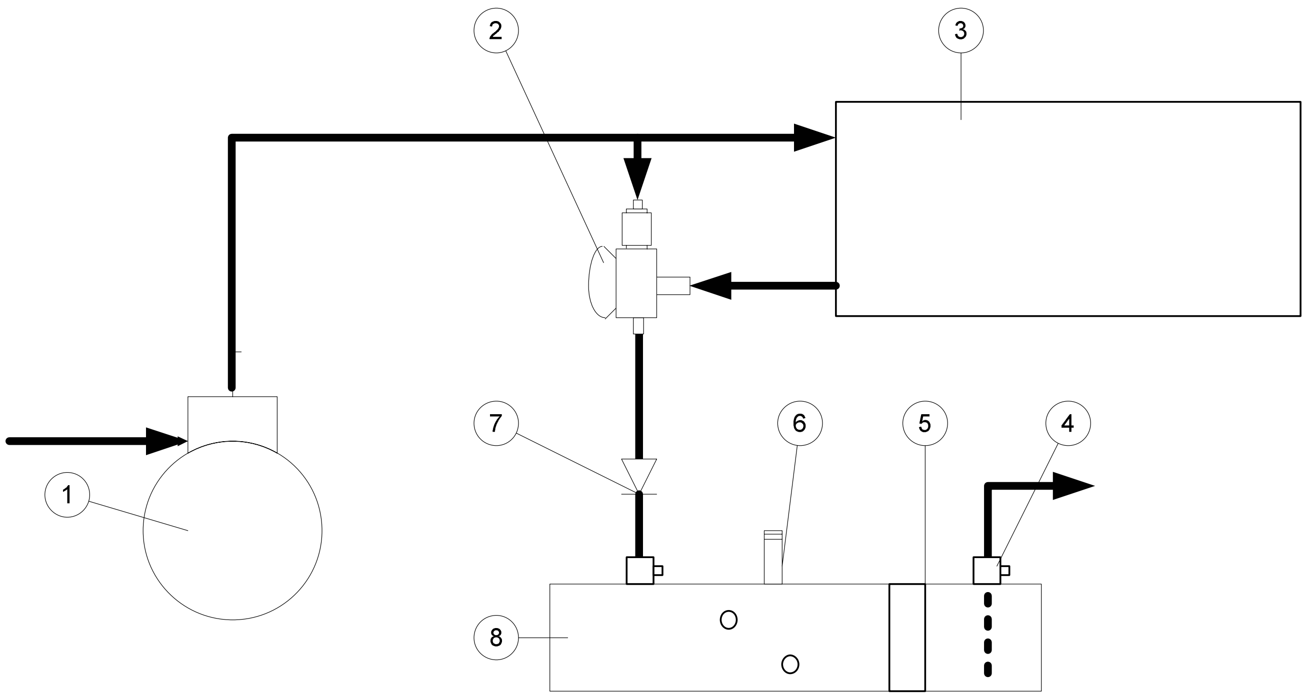
The 3rd party condenser must be capable of starting the condenser fans on discharge pressure rise, since InRow RP unit does not support interconnect wiring between the unit and the condenser.

Figure 1 – Piping schematic, head pressure control with two valves



1. Compressor
2. Valve, Opens on Rise of Inlet Pressure
3. Condenser
4. Rotolock Valve
5. Flexible Heater with Built in Thermostat
6. Pressure Relief Valve
7. Check Valve
8. Receiver with Sigh Glasses
9. Valve, Opens on Rise of Differential Pressure

Figure 2 – Piping schematic, head pressure control with single valve



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8. Receiver with Sigh Glasses

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