

Application Guidelines for the InfraStruXure InRow SC Condenser

By David Roden

Abstract

The InfraStruXure InRow SC (ACSC100 and ACSC101) is a self-contained air conditioner for server rooms and wiring closets. This application note outlines various considerations for the condenser section to ensure proper operation.

Introduction

The InfraStruXure InRow SC is an air cooled, self-contained, cooling-only air conditioner designed to be placed in-row. The in-row design allows waste heat from the IT equipment to be drawn into the return of the SC unit and neutralized before it mixes with the room air. Conditioned air is discharged into the cold aisle for immediate use by the equipment in the adjacent racks. The heat absorbed from the air stream must then be rejected from the room; this is accomplished by the condenser section in the upper half of the InRow SC enclosure. The condenser section is designed to be connected to a drop ceiling plenum. See **Figure 1** for a diagram of the airflow.

Figure 1 – InfraStruXure InRow SC airflow diagram



Hot discharge gas from the compressor enters the condenser coil, the condenser fans draw in air from the plenum and then blow it across the coil. Heat from the refrigeration system transfers to the air and that air is then discharged back into the plenum space. The condenser fan assembly contains 3 variable speed fans, controlled by the unit firmware. The condenser ducting kit consists of 3 flexible air ducts, each 6 foot long, 10 inch diameter (1.8m long, 254mm diameter) and a ceiling tile adapter plate. The ACSC100 comes with a 24" x 24" adapter; ACSC101 comes with a 600mm x 600mm adapter plate. The InRow SC unit overall has the same form-factor as a NetShelter SX rack, except is half the width (InRow SC is 300mm wide).

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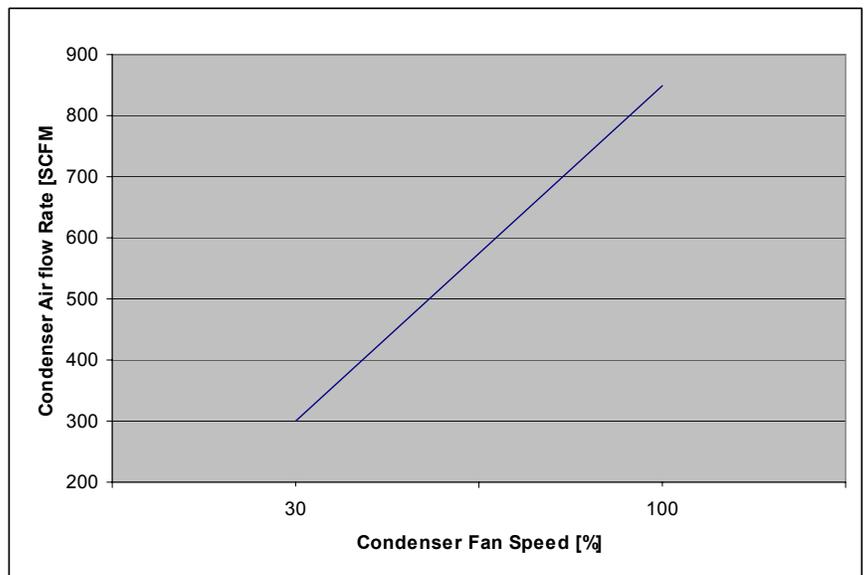
Standard Condenser Application

Installation of the unit using the flexible air ducts and ceiling tile plate, connected to a building cooling system return plenum is the preferred method for managing condenser air on the InRow SC. The plenum must provide an adequate volume of airflow, within a set temperature range, and be able to treat the heat rejected by the unit on a continuous basis in order to ensure proper operation and prevent downtime. Review the requirements below to ensure the plenum can meet the unit's needs. If not, you must consider alternate means of managing the condenser air or a different cooling product entirely.

The SC condenser fan speed is varied between a minimum of 30% to a maximum of 100%, see **Figure 2** for a chart of airflow versus fan speed. The maximum condenser airflow is 850 CFM (1440 m³/hr) which requires the plenum to provide at least this much airflow to the condenser inlet and remove that much from the condenser discharge.

Figure 2 – Airflow vs. Fan speed

The SC condenser must also receive air that is from 32 - 105 F (0 - 40 C), temperatures outside those limits will significantly impact the unit performance and can cause the unit to shut down. Finally, the InRow SC can reject up to 10 kW (34000 BTU/hr) of heat which must be treated by the building comfort cooling system or exhausted to the outside ambient air. **All 3 of these requirements must be met on a continuous (24 x7) basis to ensure reliable operation of the InRow SC unit.** If the building cooling system has night and weekend set backs, is shut down during the off-season and/or for maintenance, or has limited remaining capacity you may need to consider



alternatives to the standard installation. **Having a very large plenum is not substitute for proper ventilation and heat rejection.** Heat rejected into the plenum still must get out of the facility and into the ambient environment. Otherwise it will simply accumulate in the plenum and cause the unit to shut down. While the actual size of the plenum is not critical, it is recommended that the plenum be at least 12" (300mm) deep to prevent restriction of the duct tubes outlets.

Condenser Airflow and Temperature Requirements

The installation of the duct tubes can impact the airflow through the condenser. The maximum rated airflow through condenser is 850 CFM (1440 m³/hr), based on 6 feet (1.8m) of straight duct runs. Any bends in the tubes or extensions to the duct tubes create additional pressure drop that restricts the airflow through the condenser and reduces the performance of the unit. When installing the duct tubes, route them in the straightest possible manner and trim the excess if needed to minimize bending.

Figures 3 and 4 show the maximum condenser airflow against additional pressure drop. As you can see any additional losses beyond the design conditions will reduce the airflow.

Figure 3 – Airflow vs. Pressure Drop (English)

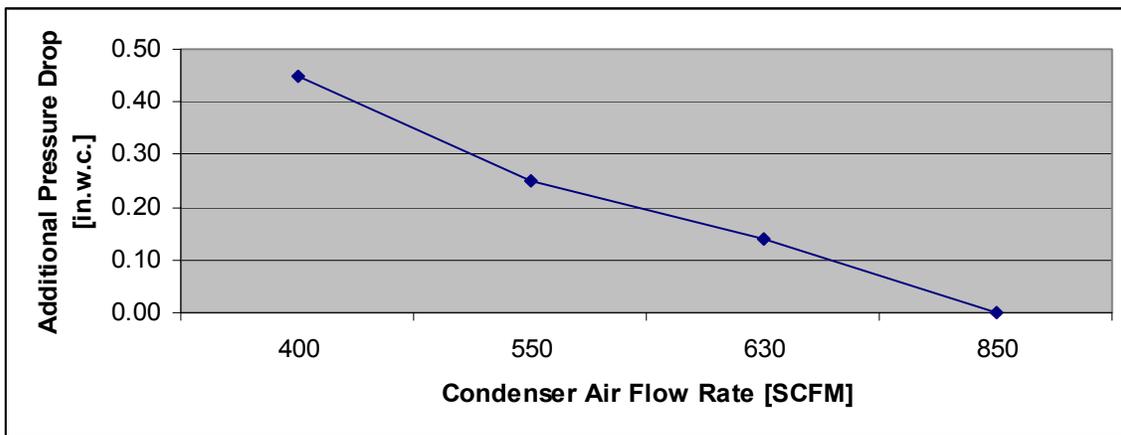
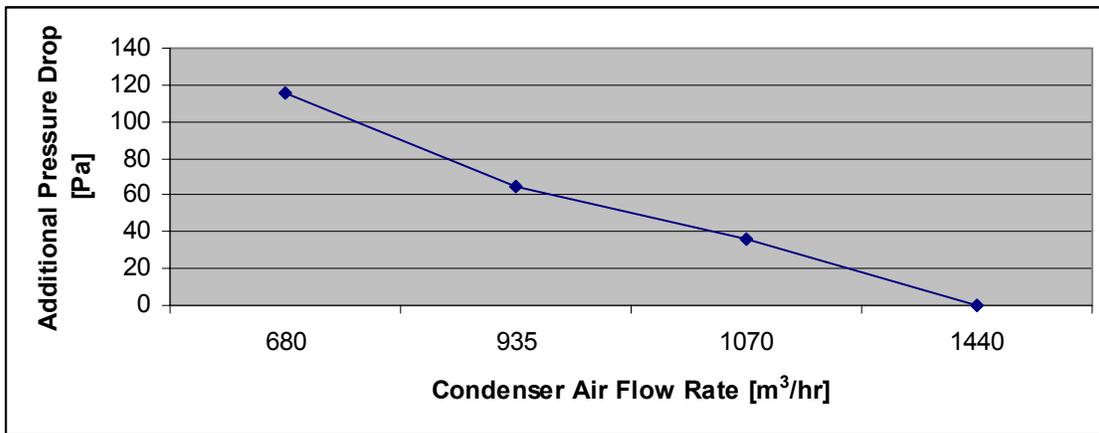


Figure 4 – Airflow vs. Pressure Drop (Metric)

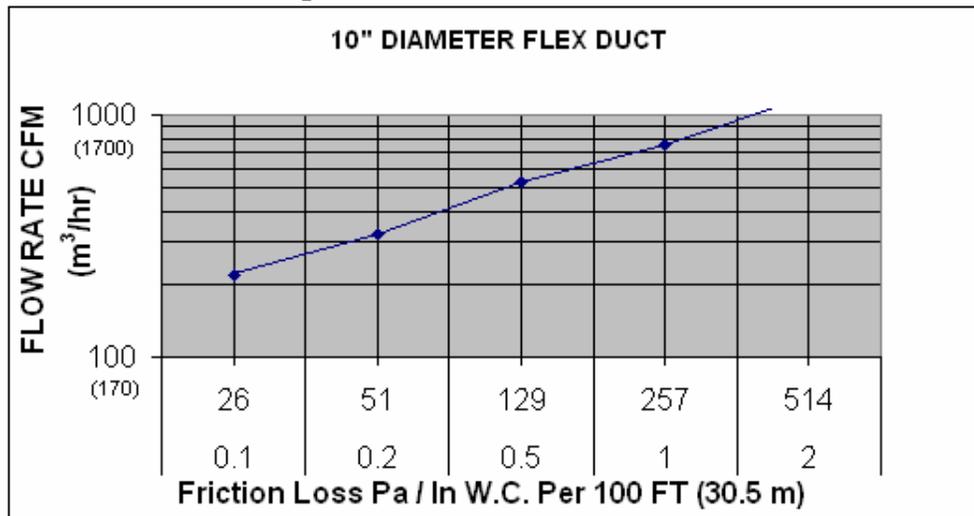


In **Table 1** you can see how different bends impact the pressure drop as well. Please note the differences between inlet and outlet when making any calculations of additional losses; the inlet and outlet are in series, so the figures are additive. The relationship between flow rate through the duct tubes and the friction loss is shown in **Figure 5**; use this chart when considering extending the duct tubes beyond the standard 6 foot (1.8m) length. **It is recommended that you have no more than 0.25" (65 Pa) of additional pressure drop on the condenser tubes to avoid excessive restriction on the airflow.** When the maximum condenser airflow is reduced the maximum allowable condenser inlet temperature is also reduced, this is discussed below.

Table 1 – Losses due to bends in duct tubes

Dynamic Pressure Drop at Sea Level				
Bend Type	Condenser Inlet Duct		Condenser Outlet Duct	
	in. w.c.	Pa	in. w.c.	Pa
45°	0.018	4.7	0.005	1.2
60°	0.024	6.2	0.006	1.6
90°	0.030	7.8	0.008	1.9

Figure 5 – Friction Loss vs. Flow Rate



The next consideration after airflow is the temperature of the condenser inlet air. The SC is rated using 95 F (35 C) air into the condenser. Higher air temperatures will result in the unit’s maximum cooling capacity being reduced. This may impact your application depending on the load within the room. Reducing the condenser inlet temperature will not increase the unit capacity beyond the published values, however the unit will require less condenser airflow to reject the same amount of heat and consume less power. See section on Condenser Ducted to Other Rooms for additional discussion. **Figure 6** shows a chart comparing the inlet temperature versus cooling performance, based on a constant 850 CFM (1440 m³/hr) of airflow. As illustrated, with inlet temperatures above 105 F (40 C) the capacity reduction becomes much more extreme. The unit has a

High Head Pressure Protection feature which will proactively decrease the unit’s cooling capacity in order to reduce the refrigerant discharge pressure and prevent the unit from shutting down on a high head pressure alarm, avoiding a total loss of cooling. If the airflow to the condenser is restricted for any reason, then that maximum allowable inlet temperature is reduced. See **Table 2** for temperatures compared to restricted condenser airflows. Even modest restrictions to airflow will have a significant impact on the upper temperature limit. Humidity of the condenser inlet air is not a factor that needs to be considered, however condensation inside the duct tubes and the SC condenser section must be avoided. See section on Condenser Ducted to Outdoors for additional discussion related to this.

Figure 6 – Capacity vs. Condenser Inlet Temperature

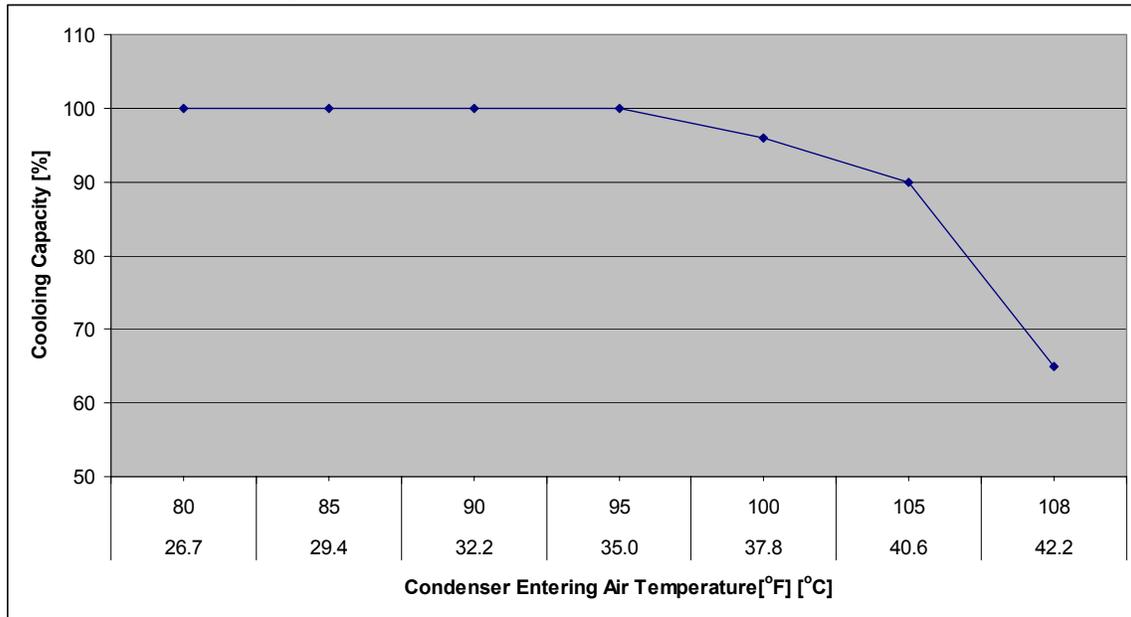


Table 2 – Restricted Airflow Temperature Limitations

Additional Pressure Drop [in w.c.] (Pa) (Without Compensation Fan)	0.0	0.1(25)	0.25(64)	0.45(116)
Condenser Air Flow Rate [SCFM] (m ³ /hr)	850 (1440)	700 (1990)	550 (935)	400 (680)
Maximum Condenser Entering Air Temperature [°F] (°C)	108 (42.2)	103 (39.4)	98 (36.7)	88 (31.1)

Alternative Condenser Installations

Many facilities do not have ceiling plenums that meet the heat rejection needs of the SC. In these situations you must plan for alternate methods of installing the unit or modify the plenum so it does meet the requirements. For example, if the building

cooling system has night and weekend set backs, this may cause operational issues with the InRow SC during those periods due to reduction of air movement within the plenum and accompanying rise in plenum temperature. It may be possible to modify the plenum to include additional equipment, such as roof ventilators or VAV boxes. These devices can provide the ventilation needed during off-hours to reject the heat from the SC unit to the outdoors. This allows for a standard installation of the InRow SC because the plenum can now be considered to be continuously available. A consulting engineer or design-build contractor should be involved in the process of determining the feasibility of this approach and selection of ventilation equipment.

Other possibilities include connecting both the condenser inlet and outlet directly to the ambient air for heat rejection, drawing and discharging condenser air from an adjacent room in the facility, or fabricating custom duct work to act as a substitute plenum, which then ties into the building return system. While none of these scenarios are specifically endorsed by APC, they can be very effective at rejecting heat from the SC.

Condenser Ducted Outdoors

Connecting the SC condenser ducts directly to the outdoors is possible and there are several factors that need to be considered when investigating this approach. **It is recommended that outdoor air be filtered and preconditioned for optimal operation of the SC unit.** As mentioned there is a recommended upper limit of 105 F (40 C) on the inlet air temperature for the condenser; this minimizes any reduction in the unit cooling capacity. There is also a recommended lower limit; entering condenser air temperatures below 32 F (0 C) may cause condensation on the outer casing of the SC units depending on indoor conditions. Additionally, the SC does not provide for alternate means of low ambient control, other than the fan speed control. At very low temperature, the condenser fans may not be able to modulate low enough to prevent erratic operation of the unit. Alterations to the piping system to install head pressure control valves or other methods of head pressure control will void all factory warranties and violate UL or other safety certifications, so inlet temperatures below 32 F (0 C) must be avoided.

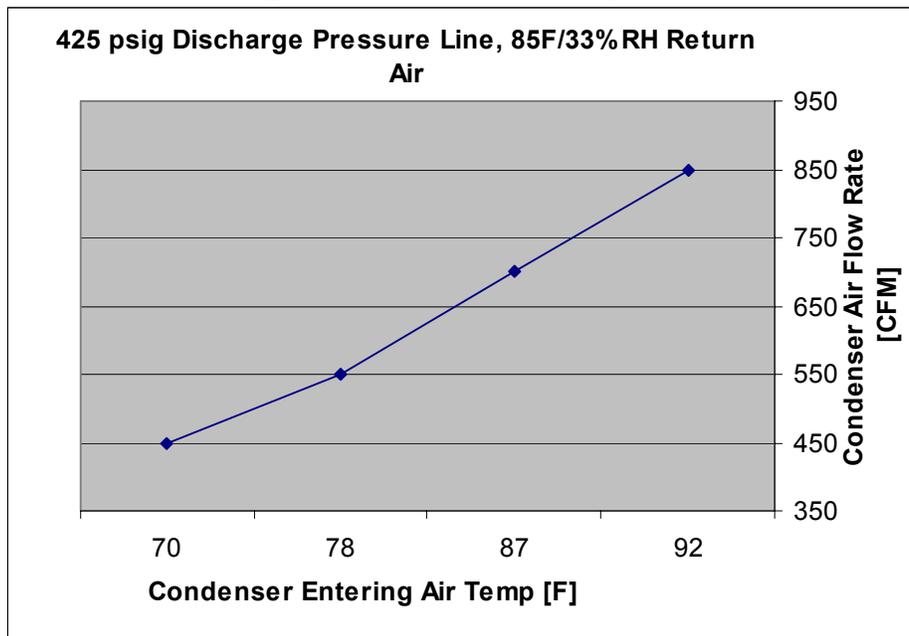
The duct tubes inlets/outlets also need to be protected from a variety of environmental concerns. Dust filters, debris screens, rain and snow shields, and appropriate wall louvers or roof caps need to be installed. All these additions will affect static pressure load to the condenser fans and must be taken this into account. Booster fans will most likely be required to overcome the additional pressure drop, see the section on Custom Duct Work for additional discussion on this.

Condenser air drawn from parking garages, industrial zones, coastal areas, or other areas with air containments or air entrained with corrosive chemicals is prohibited. The InRow SC does not have coil coatings or other corrosion resistant materials in the condenser section. Operation in these environments can damage the unit and reduce its operating life. Condenser air drawn from environments classified as hazardous or explosive is also prohibited. The SC is not an explosion proof product; operation in environments classified as hazardous will result in damage to facilities, equipment and possibly personal injury or death.

Condenser Ducted to Other Rooms

Another approach is to connect the condenser ducts to an adjacent room. This solution can overcome the lack of ceiling plenum or the complexity of preconditioning outdoor air. Similarly, the condenser inlet can be taken from the server room itself and only the condenser exhaust discharged into another part of the building, or outside. This causes the room to be negatively pressurized, drawing in unwanted contaminants and unconditioned air. That infiltration air can introduce additional heat and moisture into the space, reducing the effectiveness of the SC. This risk can be mitigated by adding a louver in the door or wall that connects to an adjacent space that has conditioned air, such as an office area. Using room air for the condenser inlet will reduce its airflow requirements and thus reducing the volume of infiltration air into the room, which in turn helps the SC unit maintain a more stable temperature in server room or wiring closet. This has an additional benefit of reducing the power consumed by the condenser fans. **Figure 7** shows how the airflow requirements are significantly reduced as the inlet temperature decreases. For example, with an evaporator return air condition of 85 F, 33 %RH, a condenser inlet temperature of 70 F (21 C) would require only 450 CFM (765 m³/hr). This translates approximately into a 250 Watt reduction in unit power consumption and drives down total cost of ownership.

Figure 7 – Airflow vs. Inlet Temperature



Custom Duct Work

Field designed and fabricated duct work can be provided to act as a substitute plenum space, connecting to a building return system, or in lieu of a direct connection to the outdoors. There are 3 duct connections on the unit; the rear-most duct is for

condenser inlet air, and the remaining 2 ducts are for condenser exhaust. The condenser exhaust ducts can be merged to one duct for simplicity. Inlet and outlet ducts should be sized to have minimum air pressure drop, see the discussion above regarding friction losses and airflow restrictions. Booster fans will usually be required to compensate for the pressure drop due to long duct runs. In all cases the duct work must meet the same requirements as the other installation methods in terms of adequate volume and temperature of airflow, protection from the environment and continuous availability. Duct installations also need to meet all applicable local and national codes.

About the Author:

David Roden is the Product Information Manager for Small Cooling Solutions at American Power Conversion (APC). Previously David was the Senior Applications Engineer for precision cooling solutions at APC, supporting data center projects worldwide. Prior to joining APC, David served as an officer in the United States Army. He received a Bachelors degree in mechanical engineering from Rensselaer Polytechnic Institute in Troy, NY and is a member of ASHRAE.