GROUND COOLING

PRE-CONDITIONED AIR SYSTEMS (PCA)

CAVOTEC

WE CONNECT THE FUTURE

Cavotec wants to contribute to a future world that is cleaner, safer and more efficient by providing innovative connection solutions for ships, aircraft and mobile equipment today.

Airports are an integral part of national and global transport infrastructure. The aviation industry continually develops and improves its infrastructure to keep up with the growing demand. Key issues facing the sector include improving turnaround times, cutting emissions, enhancing safety and cooling aircraft.

For nearly half a century, Cavotec is at the forefront of the industry when it comes to powering, cooling and refuelling aircraft, whilst being serviced on the ground. We are devoted to the advancement and application of the latest technologies for the Ground Support Equipment (GSE).

When it comes to Pre-Conditioned Air (PCA), Cavotec has developed and manufactured the widest PCA product offering, with Point of Use or central PCA systems, fixed or mobile units, diesel or electrically powered including unique air distribution systems such as the PCA Pop-up pit.

Cavotec has a total installed base of 2400+ PCA worldwide installations engineered in compliance with AHM974 (Conventional PCA) and AHM997 (Sub-freezing PCA).

PCA Systems

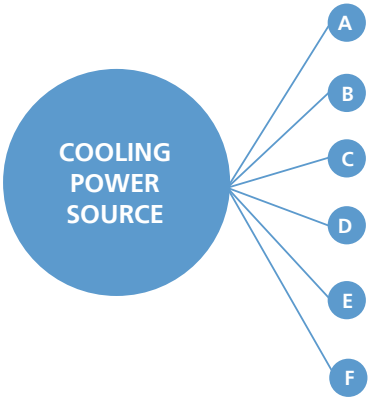
Cavotec PCA systems are engineered and manufactured in our Centres of Excellence located in the USA and Germany. Our engineering is based on our long experience in cooling aircraft, taking into considerations the ASHRAE and aircraft cooling requirements such as the IATA AHM and ground operation processes.

Benefits of the Cavotec PCA Systems

- APU can be switched off while on stand/ gate.
- Full design and performance responsibility from the PCA up to the aircraft inlet.
- PCA technology range suitable for all aircraft categories (up to Code F, down to -25°C (-13°F) discharge temperature) and suitable for all ground handling operations in all climates.
- Faster pull down and cabin cooling time for a reduced aircraft Turn Around Time (TAT).
- Improved cabin comfort (with reduced humidity) for an enhanced passenger experience.
- Best-in class Sub-freezing PCA with a tested and approved safety system (AHM997) interfacing with the Visual Docking Guiding System (VDGS) minimise possible human error.
- Cavotec Gate Operator Terminal pre-defined with individual settings and limitations for all aircraft types according to AHM997 and AHM974.
- Reduced APU maintenance costs.
- PCA system designed for collision avoidance with Cavotec pit systems.
- PCA pits including hoses and connectors engineered for a minimum cooling loss.
- Design versatility adaptable to any site location (contact gates, remote apron & MRO facility).

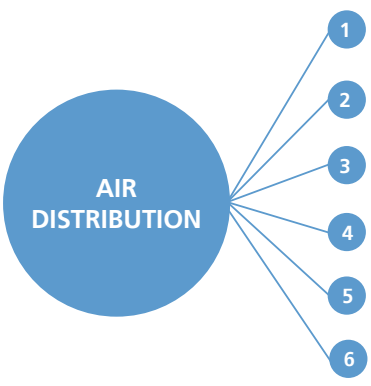
Cavotec PCA system is made of:
- Cooling Power Source
- Air Distribution

Two of Cavotec's Cooling Sources are Sub-freezing PCA in compliance with AHM997: Cavotec "Sub-Z" & "PCAir" models with a minimum discharge temperature of -25°C (-13°F).

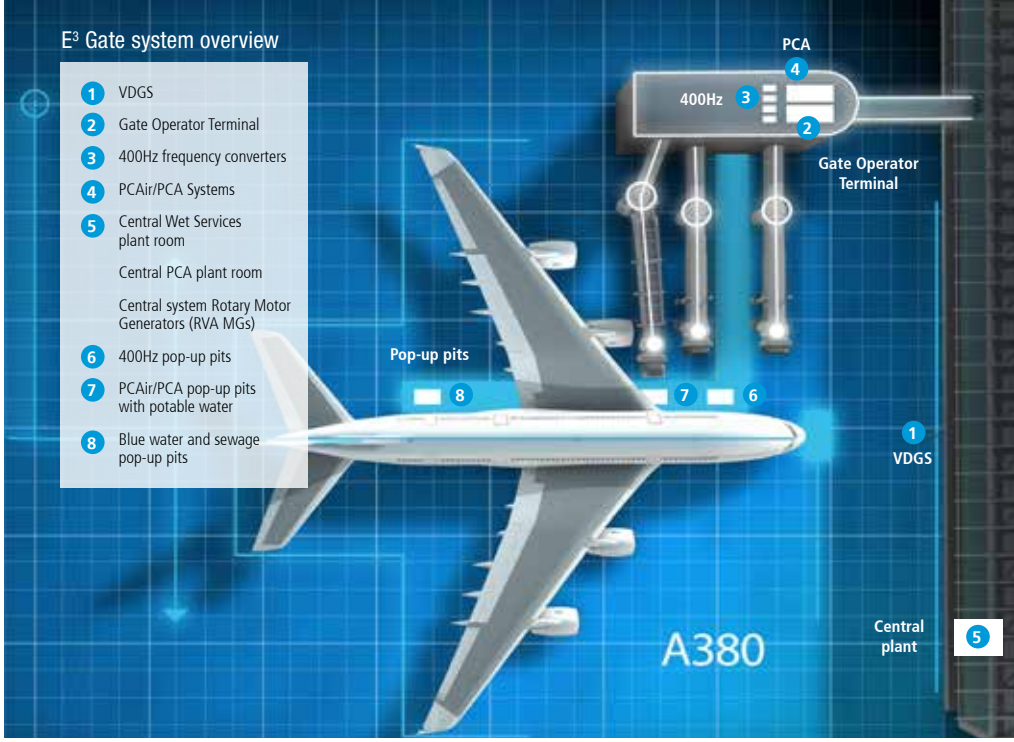


PCA System	PCA Technology
Mobile electric DX PCA *DX Series*	Electrical powered with Vapour cycle Direct Expansion
Point of Use DX PCA *DX Series*	Electrical powered with Vapour Cycle Direct Expansion
Central PAC (AHU) *PAC Series*	Air Handling Unit with 1 or 2 water circuits (EGW or CW+EGW)
Central DX-Hybrid PCA *Arctic Series*	2 cooling stages - Chilled Water + Vapour cycle Direct Expansion
Central DX-Hybrid PCA Sub-Z (CW+DX) *Arctic Series*	3 to 4 cooling stages – CW + Vapour cycle Direct Expansion
Central PCAir *PCAir Series*	Brayton cycle – Expanded Pre-compressed Air

Sub-Freezing



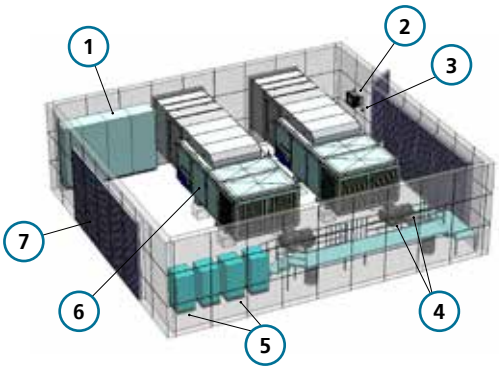
Air Distribution	System
PCA Hose basket	Flat hose stored in a basket (Bridge Mounted)
PCA Manual Hose Reel	Flat hose reeled on a small carriage (Apron Mounted)
PCA Hose retriever	Motorised hose reel (Bridge Mounted)
PCA Hose scissor	PCA Hose scissor (Ground Mounted)
PCA Hatch pit	Hatch pit with 1 or 2 reinforced hard-drawn PCA hose(s)
PCA Pop-up pit	Pop-up pit with 1 or 2 steel spiral reinforced PCA hose(s)



E³ Gate System: Economy, Ergonomics, Environment

The Cavotec E³ Gate System is a new way of designing APU-free airport gates and hangars that makes unprecedented improvements in terms of Economics, Ergonomics and the Environment: E³.

The Cavotec E³ Gate System integrates the latest technologies to provide the capacity to service modern aircraft in the most demanding ambient conditions. Presented during the IATA "Ramp of the Future" summit in Kuala Lumpur in 2014 demonstrating the improments it can provide to the industry.



1. Main power distribution board
2. Gate Operator Terminal (GOT)
3. Emergency stop button
4. PCAir distribution valves
5. 400Hz converters
6. PCAir unit
7. Air inlet louvers (sand trap)

Benefits of the Cavotec E³ Gate System

Economy:

- Fuel savings (aircraft APU & GSE).
- Reduced GSE CAPEX and OPEX (maintenance costs).
- Reduced insurance cost due to zero risk of collision and damages between GSE equipments and aircraft.
- Faster turnaround time.
- Extra revenues with carbon credits.
- Improved utilisation ground handling manpower & efficiency.
- No requirement of GSE fleet management (5 ground handling services*).

Ergonomics:

- Improved working environment & conditions.
- Higher level of safety.
- Less manpower intensive.
- Seamless integration of services at the gate.
- Pleasant passenger boarding and disembarking experience.
- No risk of collision between GSE & aircraft (5 ground handling services*).

Environment:

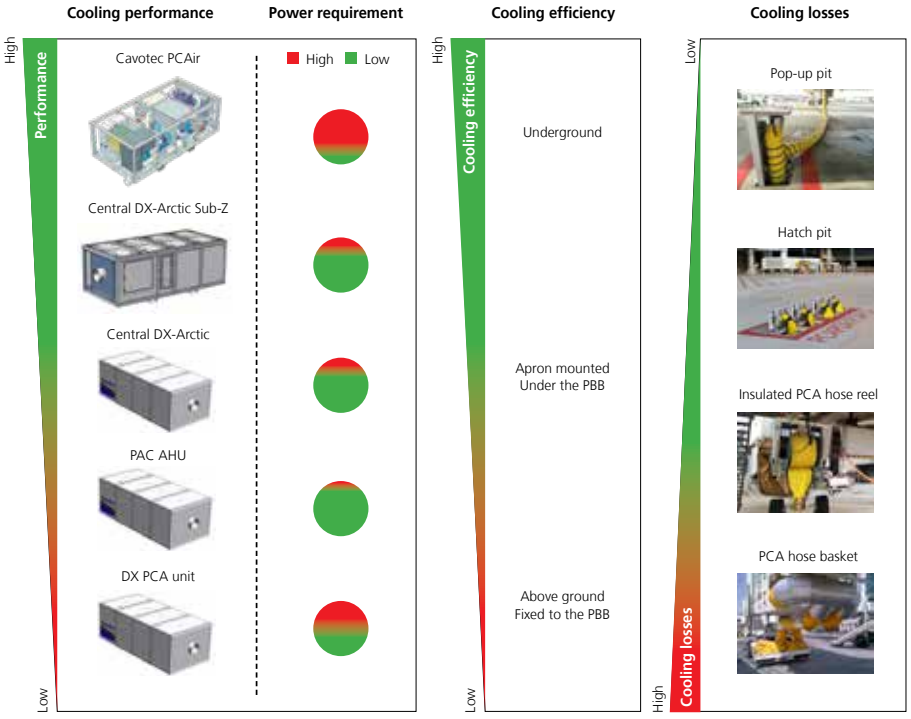
- 60% emissions reduction at the ramp (compare to the usage of mobile diesel GSE).
- No APU time during ground operations and switched off <60s after contact.
- Reduced noise emissions.
- Cleaner air (crew, passengers, airport operators and neighbourhood).
- Reduced Airport CO_2 footprints.

** 400Hz - PCA - Potable Water - Blue Water - Sewage*

Fixed Electrical PCA System performance evaluation

Based on Cavotec PCA expertise and wide product range, we are able to propose to our clients the best suitable PCA design combining the required efficient cooling performance within the budgetary constraints.

The following illustration translates some of the options and combinations that will provide the best-in-class PCA system for the airport and airlines.



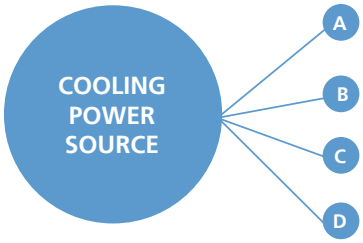
- As demonstrated in this illustration, the highest performing PCA system will be based on the Cavotec PCAir or DX-Arctic Sub-Z (Sub-freezing PCA range) with the underground air distribution (Pop-up or hatch pits).
- The top 2 PCA units are designed in compliance with the subfreezing standard AHM997 and the specific requirements from the aircraft manufacturer (Airbus).
- This optimum design will ensure efficient cooling of any aircraft in the most severe ambient conditions (such as the Middle East or South East Asia), it will reduce the Pull-Down time improving the TAT (Turn Around Time) and over all airport capacity.

Conventional PCA System

Cavotec Series PDX is a complete and self-contained unit designed for Point of Use installations. The PDX series are designed to meet the requirement of mass-flow, static inlet pressure, and low-temperature air for effective cooling of all commercial aircraft in compliance with AHM974.

Standard design based on the following ambient conditions: 35°C (95°F) db / 26°C (79°F) wb. Special version available for 46°C (115°F) db / 29°C (84°F) wb.

Cooling capacity from 30T to 150T with one or two PCA outlets.



PCA System	PCA Technology
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Point of Use DX PCA *DX Series*	Electrical powered with Vapour Cycle Direct Expansion
Central PAC (AHU) *PAC Series*	Air Handling Unit with 1 or 2 water circuits (EGW or CW+EGW)
Central DX-Hybrid PCA *Arctic Series*	2 cooling stages - Chilled Water + Vapour cycle Direct Expansion

Electrical DX PCA series

ME-PDX: Mobile Electrical DX PCA
PDX: Fixed Electrical DX PCA

Standard features:

- Discharge temperature: -4°C to +55°C (24.8°F to +130°F) variable
- Direct-digital controller
- Locally-mounted controls
- Remote control provisions
- Available RS485/232 interface
- Remote cabin sensing
- Anti freeze-up function
- High-efficiency centrifugal blower
- 50 or 60Hz input power
- Condensate water pump
- Disposable air filters
- Network ready
- Full motor / compressor protection
- Dual output manifold
- Variable-speed blower drive
- Hermetic Scroll, R407C

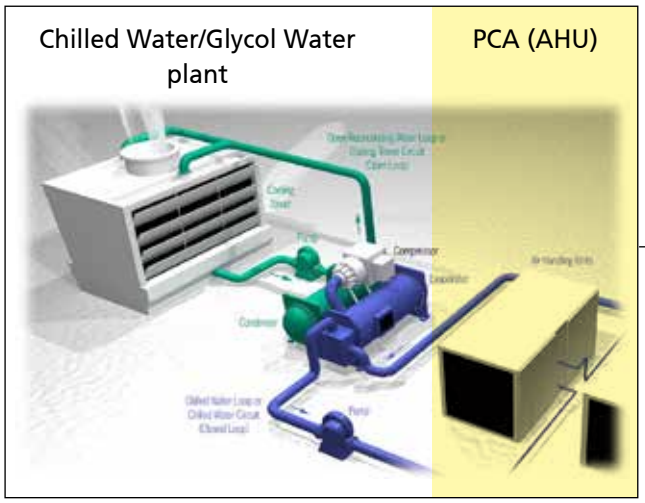
The various models can be adapted to any types of ground operations: mobile, bridge mounted and apron mounted.

Central PAC (AHU)

- Air Handling Unit
- 1 or 2 water circuits (EGW or CW+EGW)
- Complies with AHM974

Technical characteristics:

- Air flow variable 32-250kg/min (70-550lb/min)
- PCA outlet temperature range: -5°C (23°F) for cooling, up to 55°C (131°F) for heating
- Air pressure up to: 12500Pa (50inch W.C.)
- Noise level: <85dB at 4.6m distance in all directions
- Design condition up to dry- wet bulb 50°C/30°C (122°F/86°F) ambient
- CW temperature 7°C/12°C (45°F/54°F)
- EGW temperature -8°C/0°C (18°F/32°F)



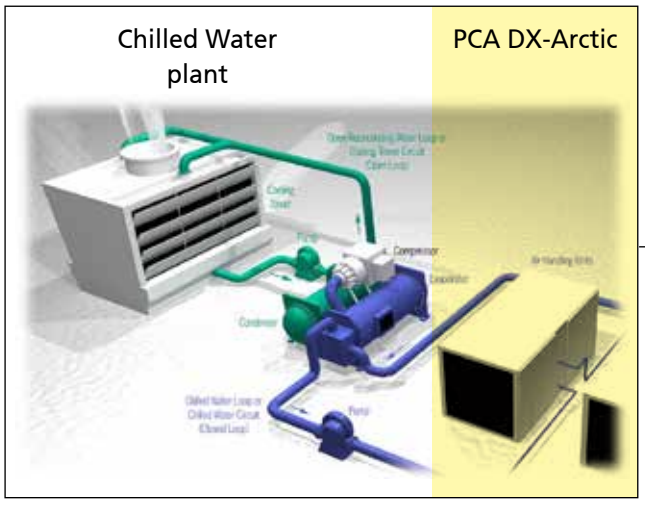
PCA Pop-Up pits

Central DX-Arctic PCA

- 2 stage cooling
- Chilled Water + Vapour cycle Direct Expansion
- Complies with AHM974

Technical characteristics:

- Air flow variable 41-250kg/min (90-550lb/min)
- PCA outlet temperature range: -4°C (24.8°F) for cooling, up to 55°C (130°F) for heating
- Air pressure up to: 11707Pa (47inch W.C.)
- Noise level: <85dB at 4.6m distance in all directions
- Design condition up to dry- wet bulb 50°C/30°C (122°F/86°F) ambient
- Compressors: fully hermetic scroll



PCA Hatch pits

Sub-freezing PCA System

The introduction of the new AHM997 standard for Sub-freezing ground cooling is a result of several years' development and testing, carried out primarily by Cavotec and Airbus. It covers the development of necessary safety devices, as well as required operating procedures.

The new functional standard is a starting point for a new generation ground cooling system able to deliver 25-50% more cooling power into aircraft than has been previously possible.

The performance of the Sub-freezing ground cooling system is comparable to the APU/air pack, which makes it an attractive alternative in hot and humid climates such as the Middle East and Asia. Today, 140 airports restrict the use of APU.

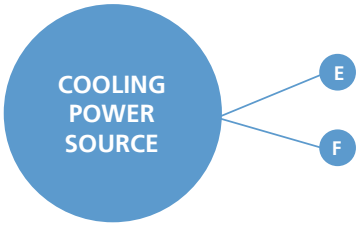
Cavotec's innovative technologies include 3 Sub-freezing PCA System (compliant to AHM997) that can cool all types of aircraft – including A380 super-jumbos – quickly and effectively under the most severe ambient conditions. Cavotec developed and installed the first system of its kind to comply with IATA's AHM997 (Installed in 2012).

Cavotec pioneered the Sub-freezing PCA and developed 3 major systems in order to ensure the compliance to the AHM997:

- Cavotec Sub-freezing PCA technology capable of providing discharge temperatures down to -25°C (-13°F).
- Cavotec Sub-freezing PCA connector and an automated control system continuously measuring the temperature and static pressure at the aircraft inlet.
- Cavotec Gate Operator Terminal: safe operation with pre-defined parameters and limitations for all aircraft and a semi-automated operation of the ground cooling.

The result is a ground cooling system that delivers, under safe conditions with aircraft ventilation systems, more cooling power than any other PCA system.

Cavotec Sub-freezing has been referenced into Airbus Fast magazine #52 (p32-36) issued in August 2013[1].



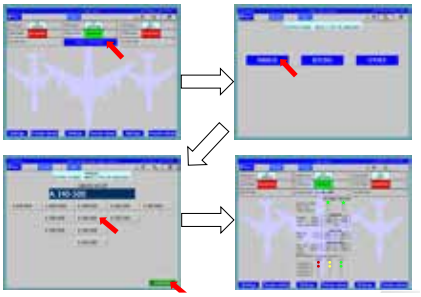
PCA System	PCA Technology
Central DX-Hybrid PCA Sub-Z (CW+DX) *Arctic Series*	3 to 4 cooling stages – CW + Vapour cycle Direct Expansion
Central PCAir *PCAir Series*	Brayton cycle – Expanded Pre-compressed Air

[1] *http://www.aircraft.airbus.com/support-services/publications/*

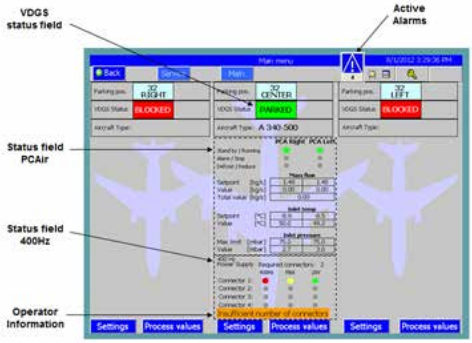
Gate Operator Terminal

Cavotec E³ gates incorporates a Gate Operator Terminal (GOT) which is one of the key Sub-freezing PCA safety features able to communicate with the VDGS and Flight Management System which ensures accurate information of the aircraft type to be serviced at the gate or apron.

The system includes a complete database of Airbus, Boeing and other representative aircraft with individual settings and limitations for safe ground operations in compliance with AHM997 and AHM974.



GOT interface



GSE visualisation

Cavotec PCAir Gate Operator Terminal

Cavotec Sub-freezing PCA connector

The patented Cavotec PCA connector/adapter continuously measures temperature and static pressure at the aircraft inlet. This is a mandatory safety device requirement for complying with the AHM997 to protect the aircraft integrity while using Sub-freezing temperatures.

Cavotec has pioneered the Sub-freezing PCA connector in compliance with the AHM997. Until now, Cavotec patented PCA Sub-freezing connector is the only one in operation worldwide.

The PCA connector has been engineered with integrated sensors which will continuously measure temperature and static pressure at the aircraft inlet.

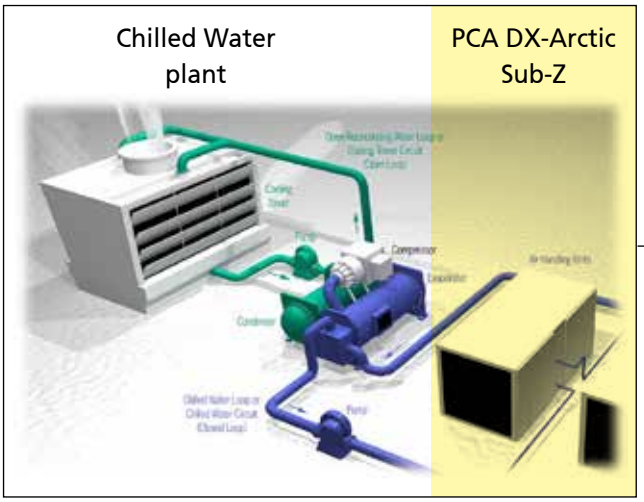
Sub-freezing PCA Connector
Patented design by Cavotec

Central DX-Arctic Sub-Z PCA (CW+DX)

- 3 to 4 cooling stages
- CW + Vapour cycle Direct Expansion
- Complies with AHM997 & AHM974

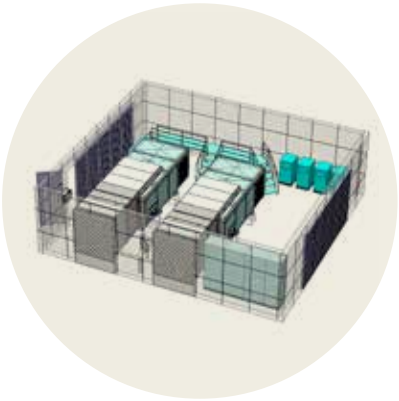
Technical characteristics:

- Air flow variable 60-300kg/min (132-661lb/min)
- PCA outlet temperature range: -25°C (-13°F) for cooling, up to 55°C (131°F) for heating
- Air pressure up to: 12500Pa (50inch W.C.)
- Noise level: <85dB at 4.6m distance in all directions
- Design condition up to dry- wet bulb 50°C/30°C (122°F/36°F) ambient
- Compressors: fully hermetic scroll
- CW temperature 7°C/14°C (45°F/57°F)



PCA Pop-Up pits


ROLLS
ROYCE
CRYOTEC
CRYOTEC
AS



GSE technical room
with PCAir and 2500+ GPU

Cavotec Central PCAir

- Air Cycle unit which is powered by compressed air
- A centralised compressor system generates dry compressed air, distributed to each gates where the PCAir units are installed
- Complies with AHM997 & AHM974

Technical characteristics:

- Mass flow: 1.0-2.0kg/s (2.2-4.4lb/s)
- PCA temperature range: -25°C (-13°F) for cooling, up to +50°C (132°F) for heating
- Specific Humidity: <1.7g water/kg dry air
- Total cooling power: 300kW (defined at -20°C/+40°C (-4°F/104°F) and RH65%, including the reduction of latent heat)
- Sensible cooling power: 140kW (defined at -20°C/+40°C (-4°F/104°F) and RH65%)
- Noise level: <80dB at 4.6m distance in all directions
- Required compressed air flow: 6 – 10 bar; 63 Nm³/min; +40°C (104°F); PDP: -30°C (-22°F), oil free air
- Required electrical power: 400V 50Hz, max. 35Amp
- Weight: Fixed unit: 4,000kg (8,819lbs)

Compressor room

PCAir - Gate

PCA Pop-Up pits

Cavotec PCA Distribution

Cavotec has engineered a set of efficient air distribution products including PCA hoses and connectors with the aim of reducing the cooling losses, hence improving the PCA system efficiency.

Cavotec PCA Pop-up and Hatch pits

Cavotec is the worldwide leader of in-ground pop-up & hatch pit systems and was the first to develop this revolutionary technology in the 70's. The Cavotec PCA Pit serves as user friendly storage device for pre conditioned air hose and other facilities, such as potable water supply. This system is used to service aircraft whilst parked on the ground, at the gate or in a hangar. It is located very close to the aircraft inlets and therefore reduces the loss of temperature and optimises the set up time.

Client benefits:

- Minimum cooling losses due to a reduced length of the PCA hose that guarantees a higher PCA system cooling performance and reduced AHU dimensioning.
- Faster connection to the aircraft ensuring a reduced use of the APU (fuel burn savings and lower air & noise pollution).
- No requirement of mobile GSE for servicing the aircraft (no more air and noise pollution due to mobile PCA services).
- Faster turnaround time and increased utility of the gate.
- Highly ergonomic with a counter weight opening/closing mechanism, an easy grip of the PCA connector and hoses due to a higher position, limiting the physical effort for ground operators and likeliness of on-the-job accidents.
- High position when open ensuring good visibility for ground operators working around the aircraft.
- Low maintenance cost, longer life cycle of the PCA hose and faster maintenance operation thanks to the maintenance access cover.
- No dependence on the Passenger Boarding Bridge availability and operations.
- Load class EN124 Class F900 standard.
- Improved cabin air and healthier conditions for passengers because of a vertical PCA hose storage reducing the potential build up of bacteria and fungus.
- Design adaptable to any gates types (from Code C up to Code F).
- Customised design (e.g. heaters, sand proof design in order to fit into the specific airport ambient conditions).
- Concentration of services into 1 pit connection point (in addition, potable water for avoiding trucks, electrical sockets for connecting E-GSE and compressed air for tooling).

Cavotec has developed a wide range of PCA hose reel, either manual or motorised. Less efficient than Cavotec pits in terms of cooling efficiency, they propose a satisfying PCA air distribution system under 30°C (86°F) ambient conditions.

Cavotec PCA Motorised Hose reel

- Self-contained motorised reels, controlled via a remote control fixed onto the Passenger Boarding Bridge.
- Easy reeling and unreeling limiting the abrasion level on the PCA hose for an improved PCA hose life cycle.
- Enhanced design for improving integration with the PBB design.
- Excellent PCA hose management, with a hose properly reeled and stored when retracted.

Cavotec PCA Manual Hose reel

Cavotec PCA Hose Reels are designed for the demanding applications of fixed and mobile preconditioned air systems for aircraft ground support at airport ramps and bridge mounted units. Cavotec PCA reels handle 80' of 14" I.D. preconditioned air ducting and are designed for ergonomic handling of air ducting in airport ground support applications.

The large casters make it easy to move around the ramp with minimum effort. When properly connected, the PCA reels supply continuous clean preconditioned air to stationed aircraft.

The reels are powder coated with paint that provides superior corrosion resistance.

The PCA reels also offer numerous ergonomic options such as a standard clutch, dual sealed bearing rollers. The Cavotec PCA reels are offered in multiple sizes and colours.

Cavotec PCA Hose basket

Cavotec has pioneered the PCA hose basket mainly used for PBB gate design.

The system is made of a steel basket mounted on 4 wheels and can be moved along with the PBB. It offers a long PCA hose storage capacity.

Cavotec PCA Hose scissor

Cavotec is the world leading company for supplying 400Hz crocodiles. We have extended this competence to the PCA system with the engineering of PCA hose scissors.

They are stored on the apron and can be deployed along the aircraft in order to reach the aircraft inlets. The PCA scissor also provides the capacity of integrating the PCA hose into an insulated duct for limiting the cooling losses.

Cavotec Telescopic Air Duct (TAD)

As part of Cavotec PCA System, Cavotec Series TAD Telescoping Air Duct assembly is designed to transport cold or hot preconditioned air (pc air) across the telescoping sections of an apron-drive passenger boarding bridge.

With thousands of gates in service world-wide since 1984, these units have demonstrated an extremely high level of reliability and maintenance-free long life.

The duct is:
- Fully insulated
- Flame-proof and smoke retardant
- Significantly reduced air losses and pressure drop
- Available in either 2-tunnel or 3-tunnel versions

We are present in:

Australia
China
Denmark
Finland
France
Germany
Hong Kong
India
Italy
The Netherlands
New Zealand
Norway
Singapore
Spain
Sweden
Switzerland
Turkey
UAE
UK
USA

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