Pall Corporation





CABIN AIR FILTRATION
CURRENT TECHNOLOGIES AND FUTURE SOLUTIONS

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Filtration. Separation. Solution.™

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Presentation Content

Current Technologies for Commercial Aircraft:

- Cabin Air Recirculation System
- True HEPA Filter Elements for Bacteria & Virus Removal
- Filter Elements for Odour/VOC Removal

Future Technologies for Outside Air Treatment:

- Carbon Adsorbent
- Catalytic Converters
- PhotoCatalytic Oxidation
- Plasma Oxidation
- Particulate Filtration

Conclusions

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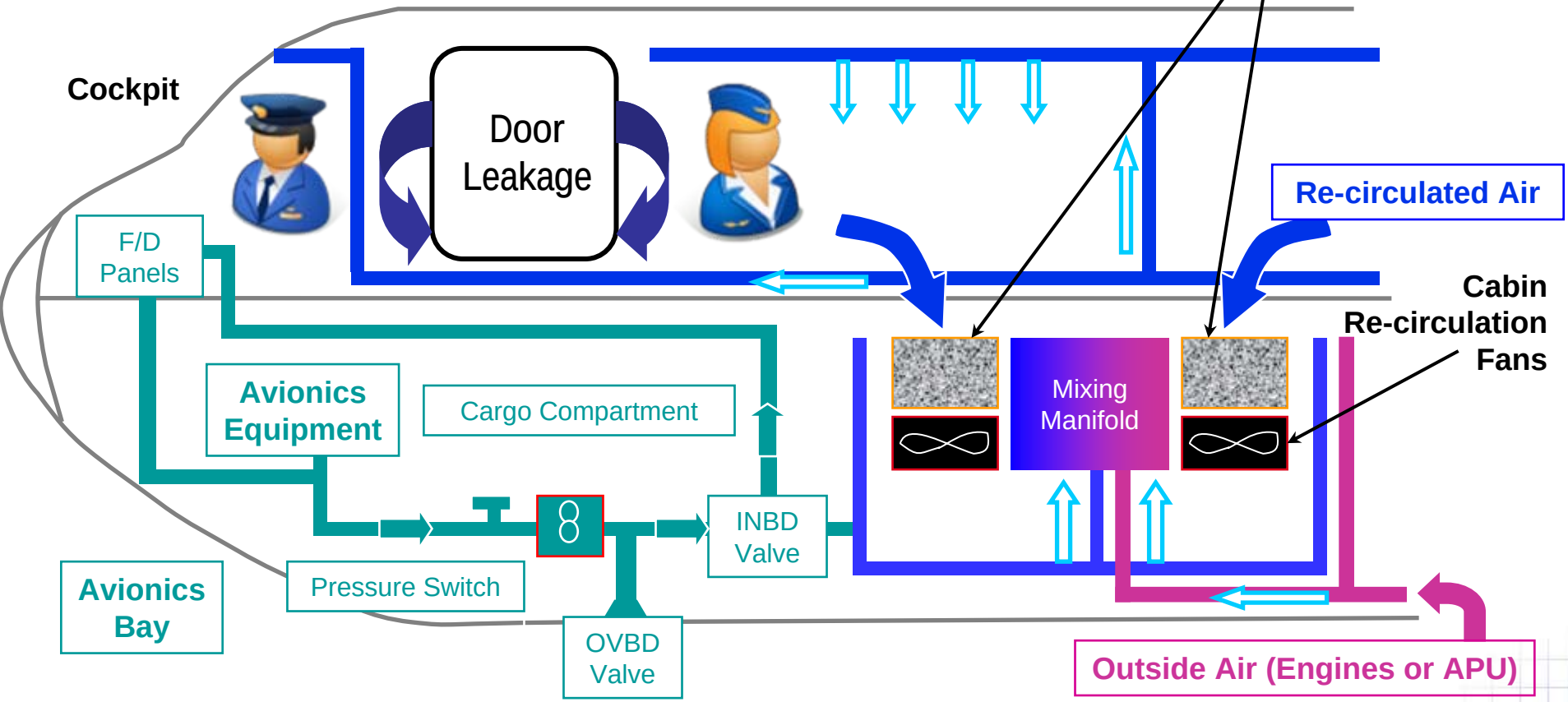
Typical Cabin Air System

Air passes from the bottom of the cabin, through the recirculation filters, into the mixing chamber where it is mixed with outside air (50/50) and then passed back into the cabin.



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Current Technologies
HEPA Filters for Recirculated Air

- HEPA = High Efficiency **Particulate** Air Filter
  European Standard EN 1822-1:
  HEPA filter = 85% to 99.995% efficiency (classes H10 to H14)

- HEPA filters on latest commercial aircraft: 99.99% sodium flame / 99.97% D.O.P. efficiency

Improve Cabin Air Quality
by Removing Particulate Contamination
(e.g., dust, fibers, skin flakes, smoke droplets, microbes)

HEPA filters introduced in 1994

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Current Technologies
Bacteria/Virus Removal Filters

Improve Cabin Air Quality by Removing Bacteria and Viruses

Photo reproduced courtesy of United Airlines

– **Bacteria** (typically 0.5 to 1.5 µm in size)
  - Tested with Brevundimonas diminuta
    – 0.3µm by 0.6µm length
  - Bacillus subtilis - 0.7 µm diameter

– **Virus** (typically 0.01 to 0.1µm in size)
  - Tested with MS2 Coliphage - 0.023 µm diameter
    (For info: Corona virus 0.08 to 0.16 µm dia.
    Bird/Avian Flu virus, H5N1 current strain, approx 0.1 µm dia)

'True HEPA' Cabin Air Filters Have a Microbial Removal Efficiency of > 99.999%

Microbially tested filters introduced in 1998

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Current Technologies
Odour/VOC Removal

Volatile Organic Compounds (VOCs) – why is it a problem?

- Hydraulic fluids
- Engine and APU lubricants
- Jet fuels
- De-icing fluids
- In-flight catering
- Human bio effluent

These trace chemicals may be present in both the recirculated air and outside air entering the ECS.

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Current Technologies
Odour/VOC Removal

Improve Air Quality by offering BOTH particulate and VOC/Odour removal capability

- Combined filter elements are available for selected aircraft types
- Current technology is a disposable filter element using an adsorbent solid.
- Removes odours & Volatile Organic Compounds
- Proven in-service experience

Odour filters introduced in commercial A/C 1990's

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Future Technologies for Outside Air Treatment

- Carbon Adsorbent
- Catalytic Converters
- PhotoCatalytic Oxidation
- Plasma Oxidation
- Particulate Filtration

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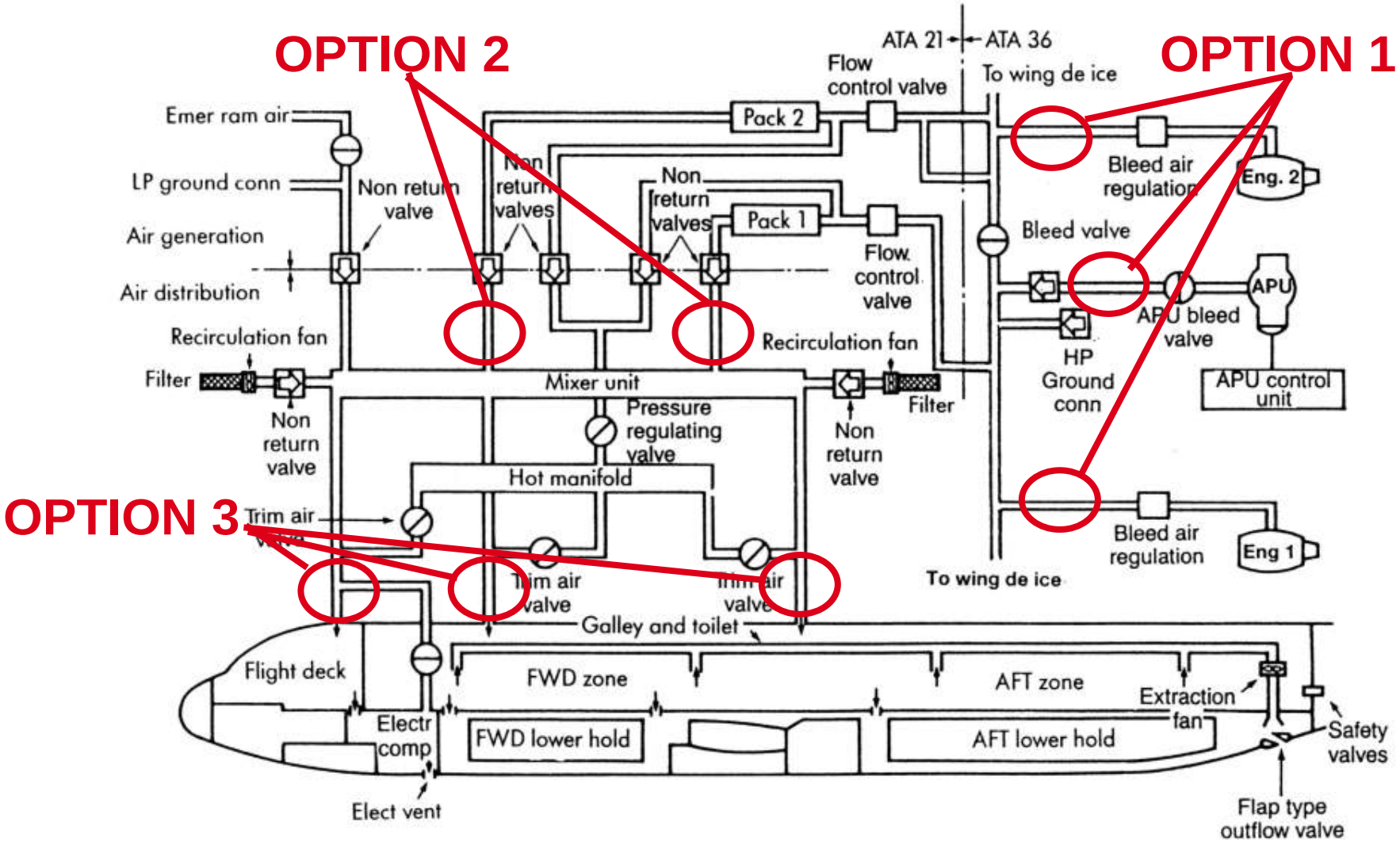
Outside Air Treatment
Possible Locations



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Captures and retains the VOCs/Odours

Adsorption is the adhesion of a substance to the surface of a solid or liquid

- Suitable for low temperature applications (e.g. carbon adsorption filters can work effectively up to 70°C, 158°F)

Advantages	Disadvantages
• High adsorption efficiency for a variety of gaseous contaminants • No electrical power is needed.	• Require removal and replacement at regular maintenance intervals. • Carbon cloth needs sufficient residence time

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Applications

- BAE146/RJ Aircraft (Carbon cloth filter). Combined recirc air and outside air
- Currently, no other qualified aircraft applications (treating outside air supply)

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VOCs/Odours are oxidised to CO_2 and H_2O

Catalytic Oxidation is a process in which the catalyst promotes the oxidation of gaseous contaminants

- Located in high temperature positions. Need an operating air temperature of at least 150 °C (302°F) to work effectively.

Advantages	Disadvantages
• No electrical power, no moving parts	• Residence time must be long enough for complete oxidation. • Must be either completely replaced periodically, or the catalyst has to be regenerated.

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Applications

- Ozone converters common on aircraft for many years
- Combined ozone/VOC converter an option on Airbus aircraft

Photo: Engelhard

Photo: BASF

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Future Technologies
PhotoCatalytic Oxidation

VOCs/Odours are oxidised to CO_2 and H_2O

Photocatalytic oxidation is a process in which the catalyst for promoting oxidation is activated by UV radiation.

- Most common catalyst is titanium dioxide (TiO_2)
- Low temperature applications (e.g. up to 50°C, 122°F)

Advantages	Disadvantages
• no moving parts.	• Residence time must be long enough for complete oxidation [*Note: UV radiation source does require electrical power*]

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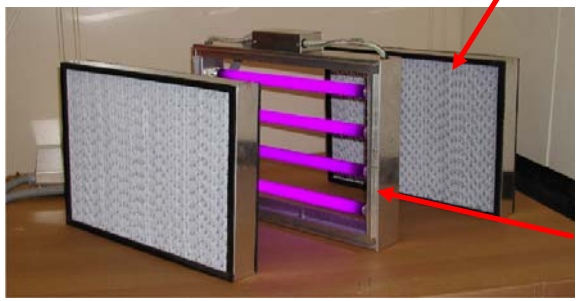
Future Technologies
PhotoCatalytic Oxidation

Applications

- Currently, no qualified aircraft applications
- Many units sold for industrial & domestic use (indoor air cleaning)

Lab prototype (Aircraft use)

photocatalytic grid (e.g. filter coated with TiO2 catalyst)



UV light source

Domestic use

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Future Technologies
Non-thermal plasma oxidation

VOCs/Odours are oxidised to CO_2 and H_2O

Plasma is a state of matter containing a mixture of ions and free moving electrons. The highly reactive species present in the plasma reactor, oxidise the airborne contaminants.

Advantages	Disadvantages
• Effectively a self-cleaning device	• Residence time must be long enough for complete oxidation • Requires electrical power to generate plasma • Generates ozone

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Future Technologies
Non-thermal plasma oxidation

Applications

- One business jet aircraft application
- Technology used for industrial & domestic use (indoor air cleaning)

Domestic use

Photo: Plasma-Clean

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Capture and retain fine carbon, dust, sand and oil mist or droplets

Filtration is the removal of particles from a fluid by passing through a filter or a filtering medium

- Contamination by airborne particles causes premature malfunction of the bleed air system and components.
- Small sticky soot particles cause stiction and buildup

Filter Design & Maintenance Considerations

- Location of filter and type of contamination will decide type of filter media
- Filters are designed for minimum weight & pressure drop increase
- Filters require removal and replacement at regular maintenance intervals.

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Applications

- High temp APU air - F100 product certified
- Low temp air – variety of filters used on other aircraft and transportation systems

Used and clean filter medium samples

Photo: Pall F100 bleed air filter

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Conclusions

Current Technologies:

- Recommend HEPA recirculation filters (>EU13)
- True HEPA filters remove bacteria and viruses - provide microbial equivalent (or better) of outside air
- Odour/VOC removal is an option

Future Solutions/New Technologies:

- VOC oxidation or VOC adsorption to improve quality of outside air
- Particulate filters to improve quality of outside air

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Thank you for your Attention

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