PALL Aerospace

Filtration. Separation. Solution.SM

Cabin Air Quality

By Eric Christopher Bula Pall Aerospace Chief Engineer.

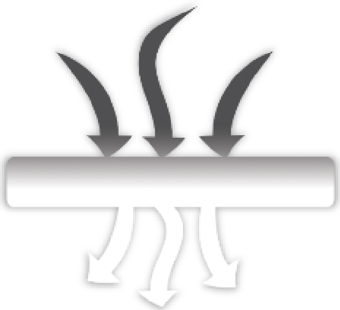
May, 2017

Disclaimer ///

This presentation is the confidential work product of Pall Aerospace. No portion of this presentation may be copied, published, performed, or redistributed without the express written authority of a Pall Corporation Officer.

The technical data incorporated in this presentation is subject to the export control laws of the United States, in particular, the Export Administration Regulations, ECCN 9E991. Technical data may not be transferred or otherwise disposed of, either in its original form or after being incorporated into other data, in any way inconsistent with U.S. export control laws.

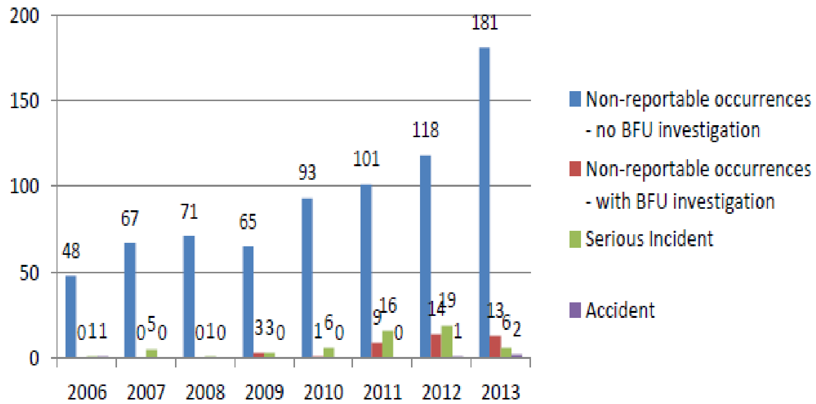
Cabin Air Quality
- Concerns -



PALL Aerospace

The Need For Improved Cabin Air Quality

BFU Study of occurrences in conjunction with cabin air



A total of 845 reports are included in this study:

- 663 of them were connected to Cabin Air Quality
- in 180 reports, health impairments were described although there could not be a conjunction with Cabin Air Quality
- in one case a fire occurred in an airplane
- in another there were flying sparks and smell development due to a defective fan.

400+ reports

75 events

(only in 2014)

- American A321 near Las Vegas on Feb 10th 2017, smoke and haze in cabin
- British Airways A320 near Lisbon on Feb 11th 2017, smoke indication
- GoJet CRJ9 at Boston on Feb 10th 2017, smell of smoke
- Volaris A320 at Mexicali on Jan 21st 2017, burning odour and smoke in cabin
- VivaAeroBus A320 near Tijuana on Jan 23rd 2017, smoke in cabin
- Jin B772 at Seoul on Feb 8th 2017, engine fire indication
- Jin B772 at Bangkok on Feb 7th 2017, smoke in cabin before departure
- Easyjet A319 at London on Oct 1st 2016, fumes and vibrations
- Westjet B738 at Calgary on Feb 3rd 2017, fumes and smoke in cockpit and cabin
- Westjet B738 at Calgary on Feb 2nd 2017, fumes and smoke in cockpit and cabin
- Germanwings A319 enroute on Feb 1st 2017, captain dizzy, both flight crew on oxygen
- Tiger A320 near Coffs Harbour on Jan 20th 2017, smoke in cockpit and cabin
- Easyjet A319 near London on Dec 31st 2016, smell of smoke in aft galley
- KLM B744 near Amsterdam on Jan 15th 2017, cargo smoke indication
- Fedex B752 near Rochester on Jan 10th 2017, cargo smoke indication
- Swift B734 at Saint Louis on Jan 8th 2017, smoke in cockpit
- Asiana A321 near Jeju Island on Jan 5th 2017, cargo smoke indication
- Georgian CRJ2 at Toronto on Dec 26th 2016, white smoke on board on departure
- Brussels A333 near Basel on Jan 2nd 2017, smoke and odour on board
- LATAM A321 near Porto Alegre on Dec 27th 2016, cargo smoke indication
- Santa SSLH at North Pole on Dec 24th 2016, smoke in cockpit
- Delta B752 over Pacific on Dec 20th 2016, smoke in cabin
- Norwegian B738 near Stavanger on Dec 16th 2016, smoke in cockpit

Source: Aviation Herald (avherald.com)

Reports and incidents related to cabin air have increased year on year for the past decade.

Impact of Fume Events

- Every day an average of 5.6 bleed air contamination events take place in the US

- 60% are reported in flight and 3% result in an emergency action

Sources of Cabin Air Odours

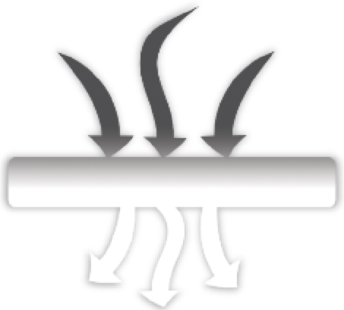
System	Number	Examples
APU	24	Oil, de-icing fluid
Avionics	13	Fan
Fire	9	
ECS	23	Fan
Electrical systems	33	Fan, other components
Electrical system of the cabin	21	Lights
external contamination	11	Dry ice, cigarettes, luggage
Coffee machine	11	Contamination / defect
ovens	24	Contaminations of foreign objects
System error	9	Leakages of hydraulic and fuel lines
Import of technical compounds	8	Glue, de-icing fluid
Engine	13	
Engine - washing	11	
Engine - oil overfill	3	
Engine - bird strike	10	
Other	5	Cannot be correlated to one of the above-mentioned groups
Not determined	42	
Unknown	386	
None	3	

Transmitted technical causes

Source: BFU

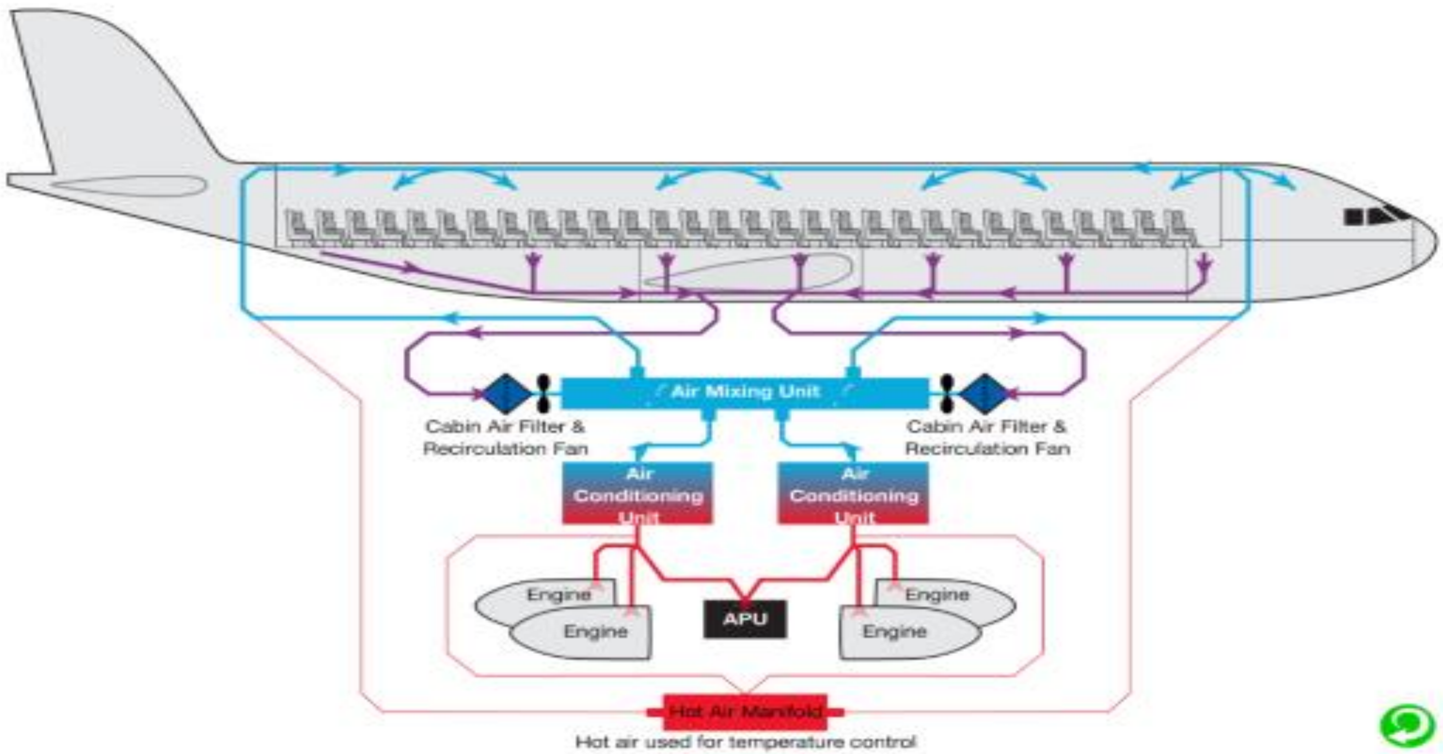
PALL Aerospace

- Current System Architecture -



PALL® Aerospace

Typical Cabin Air System

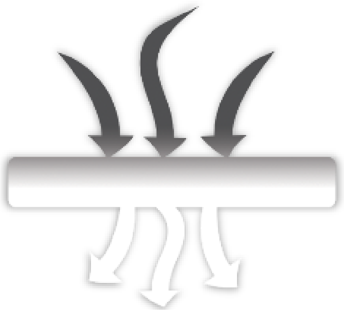


In a typical commercial cabin air recirculation system, air supplied into the cabin consists of approximately:

- 50% outside air from either engine's compressor stage (engine 'bleed air') or the Auxiliary Power Unit (APU) mixed with approximately
- 50% of filtered, recirculated air.

PALL Aerospace

- VOC's What/Where-



Sources of Air System Contamination

Today's minimum performance:

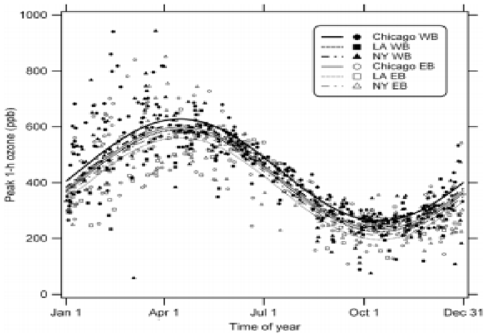
Particulate

- Bacteria
- Viruses

New Technology to protect passengers & crew:

VOCs

- Bleed air
- Airport pollution
- Galley/cabin
- Electrical
- Microbial



Ozone

How do we categorise VOC's?

What is a VOC?

"any organic compound having an initial boiling point less than or equal to 250°C (482°F) measured at a standard atmospheric pressure."

There are three distinct groups of Volatile Organic Compounds (VOCs). These differ based on the boiling point of each chemical; they include:-

VVOCs (Very Volatile Organic Compounds) <50°C
VOCs (Volatile Organic Compounds) 50-150°C
SVOCs (Semi Volatile Organic Compounds) 150-250°C.

Some chemicals, e.g. Formaldehyde & Acetaldehyde more accurately fit within the VVOC grouping, whilst chemicals including Benzene, Toluene and Xylenes fit more accurately within the VOC grouping, Tricreysl Phosphates TCP, Tributyl Phosphates TBP & Triphenol Phosphates TPP fall into the SVOC category.
VVOC's & VOC's are in vapour form whilst SVOC's are a combination of vapour & ultra fine condensates, latter due to cooling via Air Cycle Machine.

Sources of VOC's

- With regard to chemical exposures, air quality could be affected by following:
  - Outdoor air in general
  - Airport environment (e.g., fuel, exhaust gases, particles etc.)
  - De-Icing procedures (e.g., propylene glycol)
  - Ozone at high altitude
  - Bio-influenced emissions by occupants in aircraft, predominantly carbon dioxide (CO2), certain volatile and semi volatile organic compounds (VOC/SVOC) and, occasionally offensive smell
  - VOC/SVOC emissions by entertainment devices
  - Technical dysfunctions of aircraft systems, e.g. sealing failures (engine oil, hydraulic liquids, combustion products of overheated oils)
  - VOC/SVOC emissions by maintenance and cleaning (cabin equipment, galley, engines, environmental control system, furnishings etc.)
  - Cabin generated VOC's (Galley, Lavatory, cleaning products, alcohol, passengers)

Bleed Air VOC's

https://www.youtube.com/watch?v=ETRZDsgjEvE

- Bleed air contains VOC's – particularly as engines age
  - Seal leakage- particularly at engine start up, take off and descent
  - Hydraulic fluid leakage in APU
  - Taxiing behind other aircraft
  - Ground vehicles
  - De-icing fluid in APU and engine inlets
  - Engine wash

Fume events are seldom dangerous but they can be disruptive because identifying a smell is time consuming and crew members are not always able to detect its source. Despite the rarity of such incidents, they do occur frequently enough to concern airlines.

PALL Aerospace

Cabin Air Contaminant
- ultra fine particles (<0.1 microns)-

Cabin air particulate tests measured using particle counter in range 1µm to 20nm:

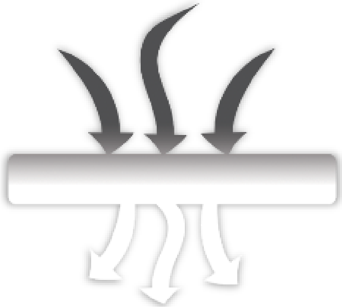
In air delivered to **cabin** with recirculation air only (fan only)	**10** particles per cc air
In air delivered to **cabin** with APU and fan running	**50,0000** ultra fine particles per cc air
• reduced to (after 2 hours and located away from the nozzle)	**35,000** per cc air

Office and **home** environment	**8,000** particles per cc air
Carpark next to motorway	**50,000** particles per cc air

Hydro carbons are the probable source of Ultra Fine Particles (UFPs)

PALL® Aerospace

- VOC Returns Analysis –



Adsorbed Compounds
- A320 A-CAF -

- analysis of HEPA and Carbon Filters from March 2016 returns

HEPA Filter Analysis

Method	**Compound**	**RB2-1726**	**% Tot**	**RB2-1728**	**% Tot**	**Comments**
		µg/g	**%**	**µg/g**	**%**	
280 TD	hexadecanoic acid	374.56	19.2	172.94	15.5	Carboxylic acid
280 TD	octadecanoic acid	199.7	10.2	101.58	9.1	Carboxylic acid
280 TD	(S)-2-hydroxypropanoic acid	184.09	9.4	64.21	5.7	Carboxylic acid
280 TD	bis(2-ethylhexyl) phthalate	118.21	6.1	67.27	6.0	Plasticiser
280 TD	fluoric compound	104.84	5.4	78.2	7.0	
280 TD	1-chloro-octadecane	93.49	4.8	72.46	6.5	
280 TD	di-n-octyl phthalate	75.68	3.9	39.83	3.6	Plasticiser
280 TD	tetradecene	54.89	2.8	40.77	3.7	Linear Alpha Olefin
120 TD	tetradecanoic acid	43.61	2.2	19.53	1.7	Carboxylic acid
280 TD	hexadecene	42.19	2.2	22.5	2.0	Linear Alpha Olefin
280 TD	acetic acid	41.81	2.1	21	1.9	Carboxylic acid
280 TD	alkylated aromatic hydrocarbon	41.04	2.1	11.34	1.0	
280 TD	amide	40.97	2.1	110.02	9.9	
280 TD	pentadecanoic acid	35.69	1.8	12.8	1.1	Carboxylic acid
280 TD	acetophenone	34.1	1.7	10.77	1.0	
280 TD	1-(chloromethyl)-3-phenoxy-benzene	31.72	1.6	6.9	0.6	
280 TD	phthalate	29.01	1.5	17.33	1.6	
280 TD	hexadecenoic acid	23.8	1.2	7.1	0.6	Carboxylic acid
280 TD	9-octadecenoic acid	23.24	1.2	14.43	1.3	Carboxylic acid
280 TD	benzaldehyde	22.89	1.2	9.39	0.8	
280 TD	benzene	22.03	1.1	11.64	1.0	

Carbon Filter Analysis

Method	Compound	Mean RB2-1726	% Tot	Mean RB2-1728	% Tot	Comments
		µg/g	%	µg/g	%	
CS2 Extr	decamethylcyclopentasiloxane	12918	12.7	13844	11.8	Cosmetics, hair spray, skin care products
CS2 Extr	tributhylphosphate	5769	5.7	4935	4.2	Component of aircraft hydraulic fluid
CS2 Extr	octamethyl cyclotetrasiloxane	5362	5.3	4532	3.9	Cosmetics, personal care products, cleaning agents
CS2 Extr	alkylated aromatic hydrocarbon	4414	4.3	5604	4.8	Related to kerosene
CS2 Extr	isopropyl myristate	3442	3.4	5269	4.5	Solvent for perfumes, skin care products
CS2 Extr	menthol	3151	3.1	3316	2.8	Topical medicines, perfumes
CS2 Extr	limonene	3214	3.1	2383	2.0	Cosmetics, fragrances, cleaning agents
CS2 Extr	hexadecane	2609	2.6	3293	2.8	Fuel additive, diesel/petrol vehicles
CS2 Extr	1-tetradecene	2662	2.6	3064	2.6	Solvent for perfume, lubricants and grease
CS2 Extr	pentadecane	2606	2.6	3371	2.9	Jet fuel component
CS2 Extr	n-octyl ether	2358	2.3	3394	2.9	
CS2 Extr	ester	2283	2.2	3195	2.7	
CS2 Extr	diisobutylphthalate	2324	2.3	3289	2.8	Common plasticiser
CS2 Extr	salicylic acid	2368	2.3	3516	3.0	In plant based products, tea, coffee, fruit & veg
CS2 Extr	tetradecane	2322	2.3	2474	2.1	Solvent for perfume, lubricants and grease
CS2 Extr	n-hexyl salicylate	2094	2.1	3376	2.9	
CS2 Extr	dodecamethylcyclohexasiloxane	1796	1.8	2417	2.1	
CS2 Extr	siloxane	1614	1.6	2154	1.8	
CS2 Extr	heptadecane	1774	1.7	2664	2.3	
CS2 Extr	undecane	1619	1.6	1172	1.0	
CS2 Extr	tridecane	1604	1.6	1522	1.3	

PALL Aerospace

Adsorbed Compounds
- cargo hold air VOC filter -

Filter 1

Compound	Qty L1 µg/g	Qty L2 µg/g	Qty (L1+L2) µg/g	% Total	
methyl-cyclohexane	148.7	666.6	815.3	11.4	CS2 Extr
1,1,3-trimethyl-3-phenylindan	509.1	286.7	795.8	11.1	CS2 Extr
heptane	212.8	324.3	537.1	7.5	CS2 Extr
toluene	181.8	349.3	531.1	7.4	CS2 Extr
propylene glycol			402.62	5.6	120TD
methyl-hexane	84.2	207.5	291.7	4.1	CS2 Extr
m-xylene	129.4	118.7	248.1	3.5	CS2 Extr
undecane	126.3	83.7	210	2.9	CS2 Extr
decane	114.3	75.5	189.8	2.7	CS2 Extr
p-xylene	53.8	111.2	165	2.3	CS2 Extr
dodecane	92.3	58.1	150.4	2.1	CS2 Extr
nonane	84.6	61.6	146.2	2.0	CS2 Extr
siloxane	73.4	63	136.4	1.9	CS2 Extr
tridecane	74	46.8	120.8	1.7	CS2 Extr
octamethylcyclotetrasiloxan	70.7	46.3	117	1.6	CS2 Extr
alkane	68.4	44.5	112.9	1.6	CS2 Extr
alkylated aromatic hydrocarbon	58.7	54.1	112.8	1.6	CS2 Extr

Filter 2

Compound	Qty L1 µg/g	Qty L2 µg/g	Qty (L1+L2) µg/g	% Total	
toluene	518.2	335.7	853.9	19.0	CS2 Extr
methyl-cyclohexane	147.9	218.9	366.8	8.1	CS2 Extr
heptane	127.5	90.2	217.7	4.8	CS2 Extr
propylene glycol			196.65	4.4	280TD
m-xylene	101	44	145	3.2	CS2 Extr
methyl-hexane	71.6	71.2	142.8	3.2	CS2 Extr
siloxane	66.3	72.6	138.9	3.1	CS2 Extr
undecane	82	42.9	124.9	2.8	CS2 Extr
dodecane	60.8	42.1	102.9	2.3	CS2 Extr
alkane	73.8	27.2	101	2.2	CS2 Extr
benzene			99.52	2.2	280TD
p-xylene	56	40.9	96.9	2.2	CS2 Extr
decane	58.4	35.8	94.2	2.1	CS2 Extr
tridecane	49.1	43.6	92.7	2.1	CS2 Extr
alkane	58	22.7	80.7	1.8	CS2 Extr
octamethylcyclotetrasiloxan	55.4	23	78.4	1.7	CS2 Extr
tetradecamethylheptasiloxane	38.5	37.7	76.2	1.7	CS2 Extr

Filter 3

Compound	Qty mg/g	Qty µg/g	% Total	
1,1,3-trimethyl-3-phenylindane	9.88	9880	7.71	CS2 Extr
tributylphosphate	8.64	8640	6.74	CS2 Extr
toluene	8.24	8240	6.43	CS2 Extr
heptane	8.11	8110	6.33	CS2 Extr
methyl-cyclohexane	6.85	6850	5.35	CS2 Extr
m- +p-xylene	6.63	6630	5.17	CS2 Extr
benzene	5.14	5140	4.01	CS2 Extr
octamethyl cyclotetrasiloxane	4.13	4130	3.22	CS2 Extr
3-methyl-hexane	3.65	3650	2.85	CS2 Extr
undecane	3.52	3520	2.75	CS2 Extr
decamethyl cyclopentasiloxane	3.36	3360	2.62	CS2 Extr
decane	3.16	3160	2.47	CS2 Extr
alkane	2.56	2560	2.00	CS2 Extr
o-xylene	2.41	2410	1.88	CS2 Extr
alkylated aromatic hydrocarbone	2.25	2250	1.76	CS2 Extr
methyldecane	2.13	2130	1.66	CS2 Extr
2-ethyl-1-hexanol	2.11	2110	1.65	CS2 Extr

Filter 4

Compound	Qty mg/g	Qty µg/g	% Total	
toluene	6.06	6060	10.96	CS2 Extr
tributylphosphate	4.88	4880	8.83	CS2 Extr
benzene	3.41	3410	6.17	CS2 Extr
m- +p-xylene	3.19	3190	5.77	CS2 Extr
decamethyl cyclopentasiloxane	2.58	2580	4.67	CS2 Extr
octamethyl cyclotetrasiloxane	2.41	2410	4.36	CS2 Extr
heptane	2.33	2330	4.21	CS2 Extr
methyl-cyclohexane	2.15	2150	3.89	CS2 Extr
decane	1.62	1620	2.93	CS2 Extr
undecane	1.3	1300	2.35	CS2 Extr
o-xylene	1.18	1180	2.13	CS2 Extr
3-methyl-hexane	1.15	1150	2.08	CS2 Extr
1,2,4-trimethylbenzene	1.1	1100	1.99	CS2 Extr
dodecane	0.99	990	1.79	CS2 Extr
nonane	0.94	940	1.70	CS2 Extr
2-ethyl-1-hexanol	0.93	930	1.68	CS2 Extr
dibutylphthalate	0.87	870	1.57	CS2 Extr

Filter 5

Compound	Qty µg/g	% Total	
m- + p-xylene	1835.3	6.88	CS2 Extr
propylene glycol	1463.75	5.49	280TD
1-phenyl-1,3,3-trimethylindane	1460.5	5.47	CS2 Extr
benzene	1442.4	5.41	CS2 Extr
heptane	851.7	3.19	CS2 Extr
tributyl phosphate	837.6	3.14	CS2 Extr
octamethylcyclotetrasiloxane	790.3	2.96	CS2 Extr
o-xylene	757.22	2.84	280TD
undecane	732.2	2.74	CS2 Extr
toluene	664.09	2.49	280TD
trimethylbenzene	638.21	2.39	280TD
decane	609.2	2.28	CS2 Extr
decamethyl cyclopentasiloxane	550.5	2.06	CS2 Extr
trans-decahydronaphthalene	528.75	1.98	280TD
ethylbenzene	477.54	1.79	280TD
alkane	472.3	1.77	CS2 Extr
methyldecane	467.5	1.75	CS2 Extr

Filter 6

Compound	Qty µg/g	% Total	
benzene	1286	8.27	CS2 Extr
propylene glycol	1285.16	8.27	280TD
toluene	1134.9	7.30	CS2 Extr
heptane	886.1	5.70	CS2 Extr
tributyl phosphate	776.4	4.99	CS2 Extr
m- + p-xylene	588.2	3.78	CS2 Extr
methyl-cyclohexane	529.9	3.41	CS2 Extr
3-methyl-hexane	422.7	2.72	CS2 Extr
octamethylcyclotetrasiloxane	367.2	2.36	CS2 Extr
decamethyl cyclopentasiloxane	360.6	2.32	CS2 Extr
o-xylene	293.89	1.89	280TD
decane	273	1.76	CS2 Extr
ethylbenzene	256.74	1.65	280TD
undecane	243.8	1.57	CS2 Extr
trimethylbenzene	220.1	1.42	280TD
nonane	216.71	1.39	280TD
2-ethyl-1-hexanol	206.5	1.33	CS2 Extr

Bleed Air contaminants identified from 6 cabin air VOC filters
– non passenger a/c (recirculation line)

Press Release

EASA
European Aviation Safety Agency

Press Release

Cologne, March 23, 2017

EASA publishes two studies on cabin air quality

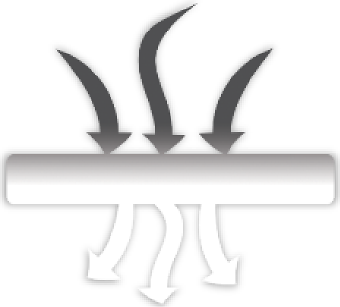
EASA publishes two studies it commissioned with the aim to gain solid scientific knowledge about cabin air quality on board large aeroplanes operated for commercial air transport.

Study 1: Cabin air quality (CAQ) measurement campaign - study conducted by a consortium of the Fraunhofer Institute for Toxicology and Experimental Medicine and the Hannover Medical School.

Study 2: Characterisation of the toxicity of aviation turbine engine oils after pyrolysis - study conducted by a consortium of the Netherlands Organisation for Applied Scientific Research and the Dutch National Institute for Public Health and the Environment.

Both reports can be found on EASA website here:
https://www.easa.europa.eu/document-library/research-projects

- FILTER TECHNOLOGY -

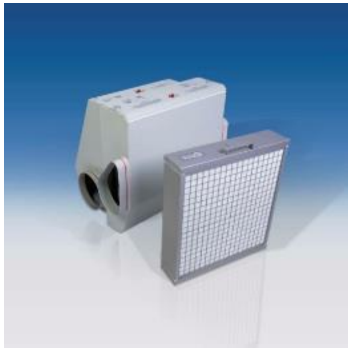


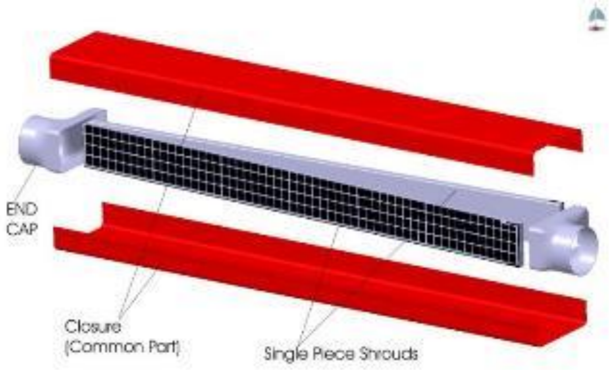
PALL Aerospace

Pall Aerospace Cabin Air Products

Pall Aerospace currently supply:

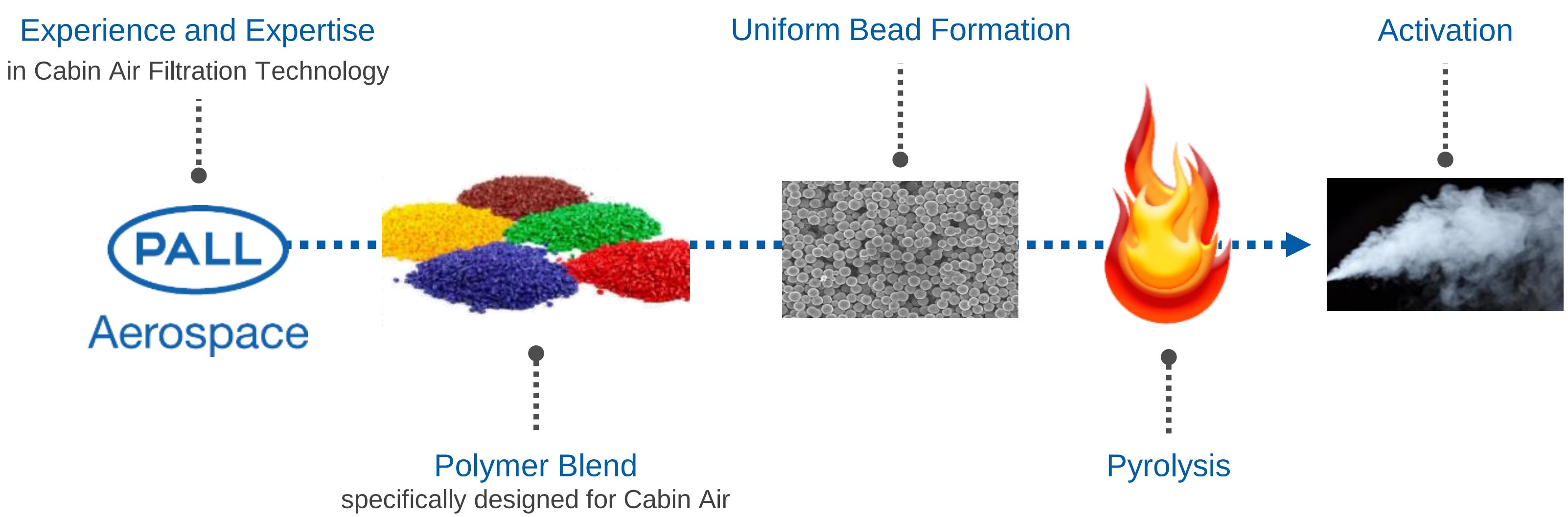
- HEPA filters for most aircraft types.
- ACAF for Airbus and Boeing aircraft
    - *A330/340, A320, B757 cockpit*
    - *Pall have been supplying ACAF for over 10 years – A330/A340*
    - *Pall manufacture CBRN filters using carbon technology*
    - *We have extensive experience in adsorption technologies*
    - *Products in development for A380, B777, B737, B767, B757 cabin*





PALL Aerospace

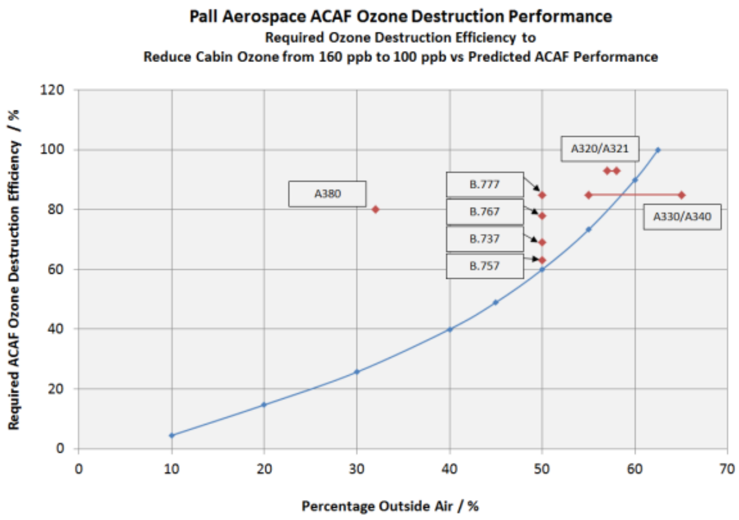
Active Carbon Technology



- Immobilized activated carbon matrix is comprised of specially formulated activated carbon beads derived from polymer spheres

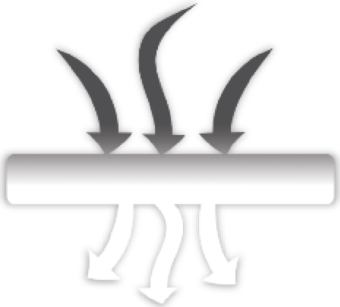
Ozone Removal

- Germany introducing maximum ozone levels across all sectors
  - 100ppB maximum
- Pall A-CAF removes ozone



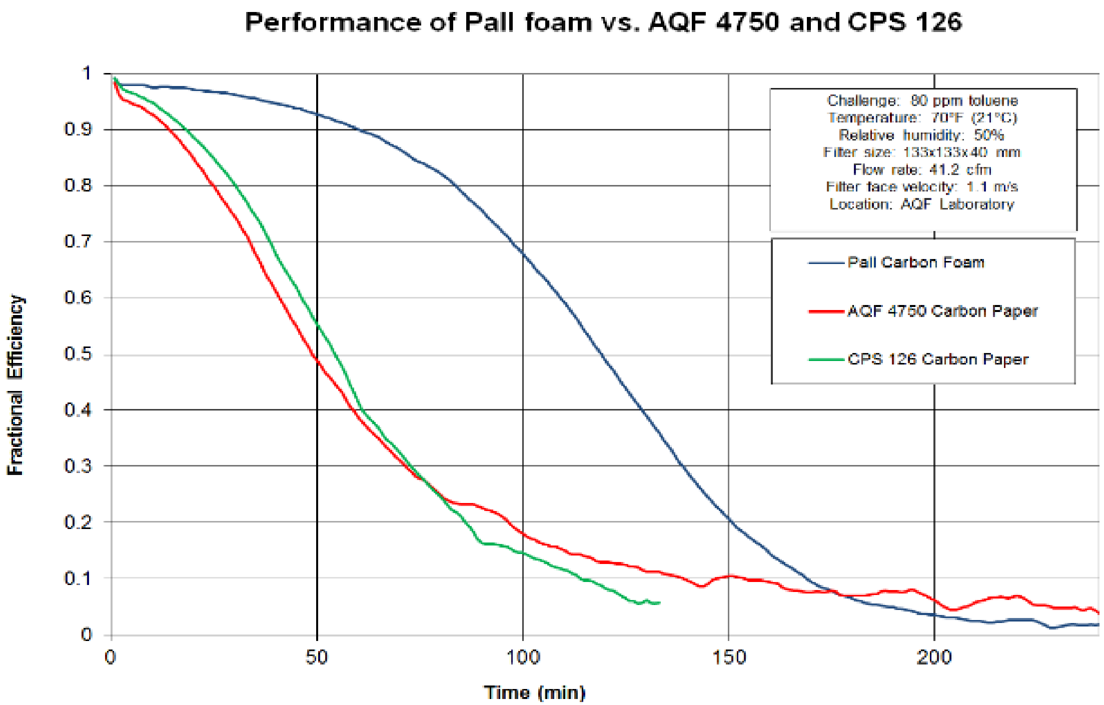
PALL Aerospace

- Empirical data -



Carbon Materials
- comparison -

Comprehensive test program comparing all available carbons



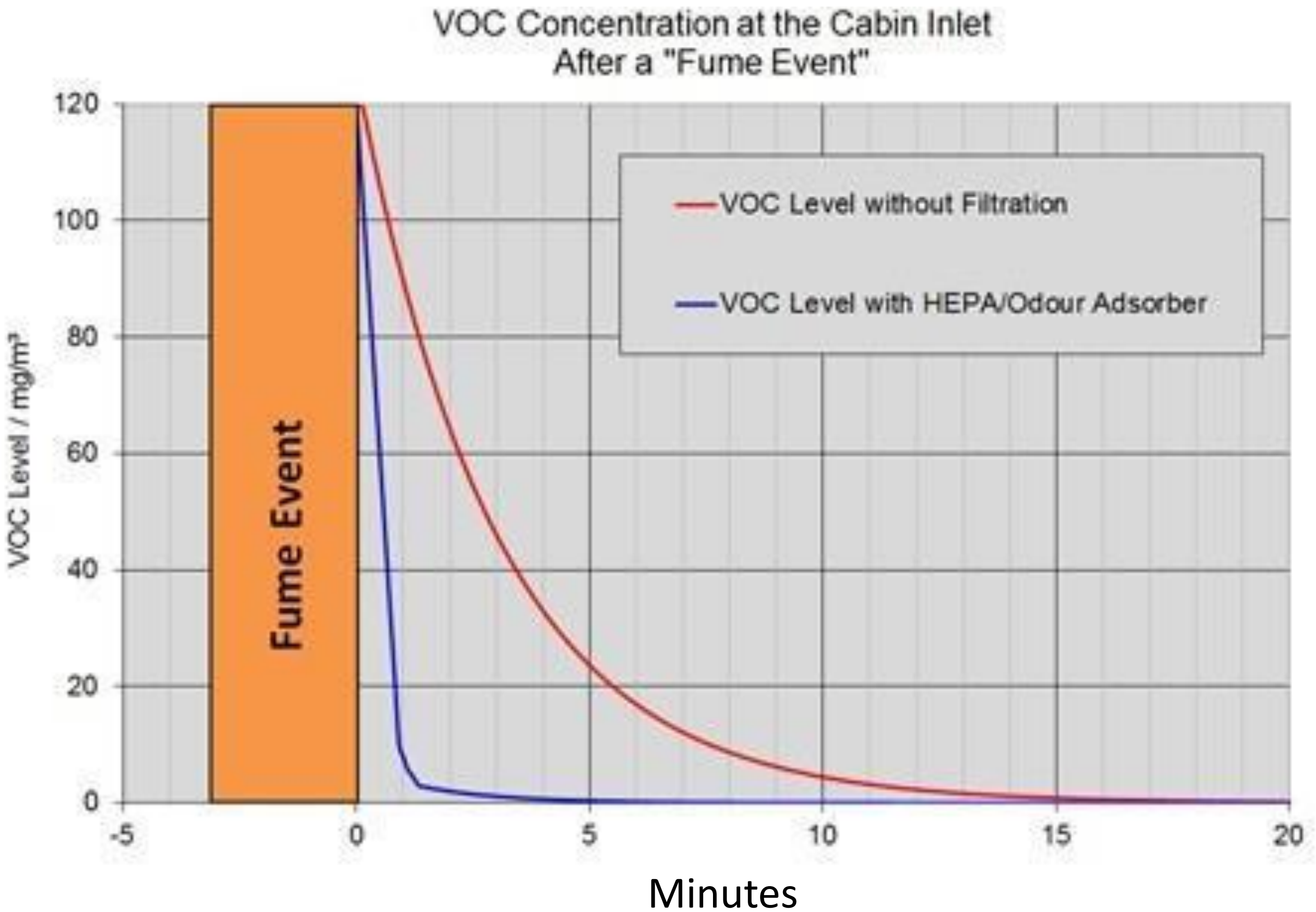
Identical volumes of carbon used.

Graph shows the performance of the Pall polymeric bead carbon was significantly better than a coconut shell carbon.

The specially formulated polymeric bead matrix was around twice as efficient.

PALL Aerospace

Relative Cabin Air VOC Removal
- after Fume Events-



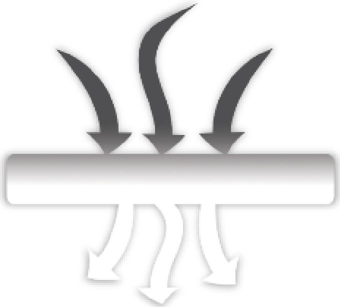
PALL Aerospace

How The A-CAF Recirculation Help

- It **WILL**
  - Remove non persistent odours and fume from the cabin 3 to 4 times faster than a cabin without A-CAF
    - By calculation and trials on an aircraft.
  - Reduce the number of reported incidents
      - Reduce lingering smells
      - Improve crew confidence in air quality
  - Demonstrate the airline is taking all available measures to improve air quality
  - Reduce ozone levels to impending limits (100ppB)

- It **WILL NOT** stop fume events
  - Recirculation line only
  - Will not prevent the initial entry of bleed air odours to the cabin

CABIN AIR FILTRATION
- ***PURE**cabin* –



PALL Aerospace

The Remaining Problem

- Current filtration systems only filter the recirculating air

- Full cabin air filtration will eliminate virtually all fume events
  - Improve cabin air quality
  - Prepare for potential future regulations
  - Further reduce Diversions and Turnbacks
  - Mitigate conditions for microbial VOC
    - Damp, humid conditions can introduce microbial VOC
    - Fume events can introduce microbial VOC
    - Discernible odour can be detected at parts per Trillion (ppT)

  – Viability of including microbial reduction brought into scope

PALL Aerospace

The Solution

The ***PURE****cabin* system will comprise of:

- Mist and Vapour Eliminator (MAVE)
  - May include active, in-line anti-microbial
- Specialized sensor to identify fume event
- Existing HEPA-VOC (HVOC) Filter recirculation filters

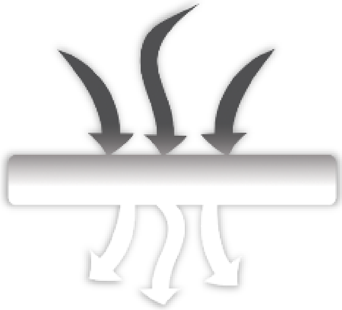
The ***PURE****cabin* requirements are:

- MAVE Filter change-out to be in line with routine maintenance activity
- Cabin Odour Filter to remove cabin-introduced VOC's
- VOC sensor to identify fume event signatures for maintenance activities

A real step up in Cabin Air Management!

***PURE**cabin*

- VOC SENSOR -



PALL Aerospace

VOC Sensing
(Cabin & Bleed Air)

- Three prototypes assembled & tested in A320 in hanger
- Fume events simulated by spraying / burning fluids in cargo hold
- Vapours & fumes drawn through HEPA filter and circulated through cabin

Identifies Presence and Disappearance of Fume event

Categorizes the fume event based on prescribed conditions, e.g.:

- Event #1 – Skydrol leak
- Event #2 – Lube oil leak
- Event #3 – Deicing Fluid
- Event #4 – Other

Improves efficiency of maintenance activities
Enables predictive maintenance (identifying trend of VOC levels in line with impending failures)

Enables pilot decision to fly post fume event
(without the need for aircraft engineers to fly to the a/c)

Ensures a pro-active approach by improving overall cabin air quality for crew and passengers

THANK YOU

Aerospace

Pall Aerospace

10540 Ridge Road
New Port Richey, FL 34654
+1 727 849 9999 telephone
+1 800 933 3111 toll free US

Portsmouth - UK
+44 (0)23 9233 8000 telephone
aerospace@pall.com

Filtration. Separation. Solution.SM

Visit us on the Web at www.pall.com/aerospace

Pall Corporation has offices and plants throughout the world. For Pall representatives in your area, please go to www.pall.com/contact

Because of technological developments related to the products, systems, and/or services described herein, the data and procedures are subject to change without notice. Please consult your Pall representative or visit www.pall.com to verify that this information remains valid.