GCAQE
Global Cabin Air Quality Executive

Post-Smoke/Fume Event Procedure

Version 11-MAR-2024

Table of contents

Note

This document reproduces the contents of the 'Environmental Health' article "Health consequences of exposure to aircraft contaminated air and fume events: a narrative review and medical protocol for the investigation of exposed aircrew and passengers" by Burdon (2023) and Burdon (2023) supplement in a pragmatic and user-friendly format. Additional sources are referenced at the end of the document. The aim of this document is to provide practical and easily accessible guidance to crews and their treating physicians around the world. The original copyright & publication credits belong to the journal and respective authors.

1. General

1.1 What is a fume event?

Most commercial aircraft (except for the Boeing 787) use bleed air, i.e., air drawn from the engine or Auxiliary Power Unit (APU), to feed the air conditioning system. Engines are lubricated with oils, and many aircraft systems rely on hydraulic power. By design, these fluids, and their thermal decomposition products (including ultrafine particles) can contaminate the compressed air which is destined for the cabin and flight deck, known as a "fume event." This can occur over a **short period with higher concentrations** (i.e., an acute fume event, ranging from transient in normal operations to sustained failure conditions) or a **chronic long-term exposure to low-level concentrations**. Industry has recognised the potential for bleed systems to create fume events since the 1950s. Still, the system design is effectively unchanged and remains unfiltered.

Fume events (also known as contaminated air events) sourced to the aircraft air supply have, increasingly, become recognised as **a potential threat to flight safety and associated with impairment and adverse health effects in aircrew and passengers**. The term "Aerotoxic Syndrome", although not officially recognised as a diagnosis in the ICD, is used to describe both short- and long-term ill-health effects caused by exposure to contaminated cabin air. ICAO has recognised that there are **many sources of airborne contaminants in the passenger cabin** (e.g., engine oil, hydraulic fluid, de-icing fluid, exhaust fumes, electrical fumes, flame-retardants, and bioeffluents). However, ICAO has squarely focused on the need to train airline workers to recognise and respond to oil and hydraulic fluid fumes because of the recognised impacts on flight safety (ICAO, 2015).

1.2 The need for a standardised and accessible response protocol

Currently, there is little education and training on how to recognise a fume event and respond to it. Most doctors (even AME's) and hospitals are unfamiliar with aviation fume events and have no idea how to respond. There have been calls for medical guidance (Harper, 2005; Harrison, 2009; BG Verkher, 2014; IATA, 2015; Michaelis, 2017; CAA, 2017; Heutelbeck, 2018; Hageman, 2019; CEN, 2022; Burdon, 2023) on how to assess and treat aircrew after fume events. Without a standardised and detailed medical protocol that is readily accessible to occupational, aviation, and urgent medicine physicians, though, there is a "lack of data to evaluate the exposure to certain air contaminants that result from fume events" as quoted in a recent EASA study. (Schuchart, 2017) That study and others call for additional data related to contaminated cabin air events (Schuchart, 2017). An agreed procedure to assess and document the medical impacts of these occurrences would provide a standardised body of evidence. This would more systematically define the health impacts and could also support the development of more targeted medical tests and treatment options. Ideally, it would also motivate technological improvements to prevent exposure to fumes.

1.3 Objectives of a standardised post-smoke/fume event procedure

This document is a practical reference based on the article by Burdon (2023) "Health consequences of exposure to aircraft contaminated air and fume events: a narrative review and medical protocol for the investigation of exposed aircrew and passengers" and supplement. It provides practical guidance on actions to be taken in the form of checklists, and it outlines the different medical tests and tools available today in response to a fume event. The following pages outline a proposed standard procedure to follow a smoke and/or fume event. They cover different areas including onboard recognition, suitable operational

procedures during and after the flight, event reporting procedures, and medical follow-up. The medical component intends to guide physicians in recognizing, assessing, and managing persons suffering from the toxic effects of inhaling fumes sourced to heated engine oil and hydraulic fluids on aircraft. Next to the scientific background of the protocol, other sources include ICAO, IATA, EASA guidance documents, as well as existing manufacturer and airline procedures.

The aim of this document is trifold:

(1) provide **practical guidance to crews** in case of a fume event incident,
(2) ensure that crew members receive **proper medical follow-up,**
(3) **standardise medical data gathering** for future research.

1.4 Recognition

What?

Most fume events will be a fume/odour only, with no visible component. Although, in limited cases, olfactory cues (i.e. smell) may not be noticeable, especially if the fumes are introduced gradually, if the concentration remains constant, or if the crew workload is heavy and demands full attention. Less frequently, a haze, mist, or smoke may occur.

dirty socks/smelly feet, wet dog, musty, old cheese, acrid, foul, vomit, chemically, oily, electrical, burning	**Oils**
acrid, pungent, sweet, 'hydraulic'	**Hydraulic fluid**
sweet	**De-icing fluid**
acrid, 'electrical', burning	**Electrical**
kerosene	**Fuel**

Table 1 - Common descriptions for selected sources of contamination

The most common descriptors for the smell of oil and hydraulic fluid fumes are dirty socks and acrid, respectively. However, odour characteristics may vary with the upstream bleed air temperature. Also, there are inter-individual differences in sensitivity to and the sense of smell. Finally, the ability to detect fumes may be influenced by the rate of onset and the capability to detect fumes is reduced by 75% within a few minutes i.e. olfactory fatigue (AAIHA,1989 ;ICAO, 2015).

When?

Transient low level oil fumes can be detected when power changes occur or when there is a change in air supply configuration or a low power setting. This includes engine/APU start, taxi, take off, top of climb, top of descent, descent, approach. Oil leakage from the APU can occur even when the APU is not operating due to contamination of the Environment Control System (ECS). Excess moisture conditions can create the dirty sock odours. Other less frequent abnormal or failure conditions can create odours/smoke at any time.

Note: Many people advise that they consider the transient dirty sock odour as normal and therefore not a fume event. This is incorrect. Fume events may be transient, regular with no visual cue or far less often sustained, visible and more noticeable to many. Therefore, both types of events should be considered important and need to be reported. (EASA, 2011; CEN, 2022)

2. CAQ Occurrence - Crew Checklist

UPON RECOGNITION (ON GROUND/IN FLIGHT) – FLIGHT CREW	
☐	Apply QRH – Smoke/fumes checklist (even without visible smoke)
☐	Crew oxygen / 100% (recommended in all fume events when time/conditions permits)
☐	Try to identify source and effects Consider cabin crew information: ● Source (vents, cabin) ● Smell (type, intensity, when, duration) ● Location (specific details if known) ● Symptoms (Cabin crew/passengers) ● Action (oxygen, medical care required?) *Note: if able, consider using the Cabin Air Contamination Reporting Form*
☐	Return to gate if on ground / Consider diversion if in flight
☐	Inform dispatch / maintenance
☐	Check for possible crew or passenger impairment/incapacitation

IMMEDIATELY AFTER ARRIVAL – FLIGHT CREW	
☐	Complete your SOPs
☐	Inform Ground Supervisor ‘red cap’ to delay boarding, loading, and fuelling until advised
☐	Obtain the ‘CAQ Occurrence – Event Reporting’ from the form folder

AFTER DISEMBARKATION – FLIGHT CREW	
☐	Gather the crew and obtain their findings ● What did you observe/smell/feel? When? Where? Duration? Effects? ● What did the passengers observe/smell/feel? When? Where? Duration? Effects? ● How do you feel now? What physiological/cognitive symptoms do you have? ● Did you experience any fume events before this occurrence? *Note: If visible symptoms, take video/pictures for future reference*
☐	Contact Operations Control Centre (OCC) / Manager On Duty (MOD)
☐	Advise Ground Supervisor ‘red cap’ on actions to be taken
☐	Ask for a doctor/medical assistance based on “a possible poisoning by inhalation of thermally degraded substances of engine oil or hydraulic fluid fumes”

IMMEDIATE REPORTING – FLIGHT CREW *Note: take a picture of all relevant documents for future reference*	
☐	Complete the 'CAQ Occurrence – Event Reporting Form' *Note 1: only one form is needed for an entire crew (FCM + CCM)* *Note 2: consider delegating this task to CM2, but review before accepting*
☐	Complete aircraft technical log (ATL)

ARRIVING AT A MEDICAL FACILITY/DOCTOR	
☐	Hand over 'CAQ Occurrence - Doctor Information' letter to the doctor in charge and give a detailed history of the fume event (incl. time, severity/intensity, duration, previous exposures)
☐	Flight Crew: Hand over the previously filled out 'CAQ Occurrence – Event Reporting Form'
☐	Request a clinical examination and ask the doctor to fill out the 'CAQ Occurrence - Patient Record' form.
☐	Ensure general investigations/ samples (ref Patient Record form 5C) are taken
☐	**Make sure you have copies of all medical documentation (incl. patient record form)** ● *Ask for a physical copy, or consider taking pictures* ● *Medical confidentiality entitles every crew member to keep his/her own assessment.* ● *Consider using a sealed envelope*

NOTE
Not all examinations or investigations may be necessary or available, with specialist laboratories required in some cases, with storage, transfer, and cost to be taken into account. It is recommended to gather as much data as practical (table 5B/C) given potential exposure to fumes in aircraft.

Air crew should not be cleared to fly without an assessment. However, when cleared before, but symptoms or concerns occur afterwards or continue, you should not hesitate to see a doctor as soon as possible.

POST-SAMPLING FOLLOW-UP	
☐	Make sure that the tubes are **correctly labelled** with name and birthdate
☐	**Transfer all documentation/samples** to the appropriate CAQ centre of expertise ***Note*** *Shipping blood and urine samples necessitates adherence to dangerous goods regulations due to the potential biohazardous nature of these specimens. In compliance with safety protocols, special attention must be paid to temperature control and packaging specifications. Failure to adhere to these guidelines could compromise the integrity of the samples and pose risks to both handlers and the public.*

INDIVIDUAL FOLLOW-UP	
☐	Monitor symptoms and **keep a journal**
☐	If symptoms persist (5+ days), contact your company doctor or designated centre of expertise
☐	In case of continued symptoms or complaints, consult a specialist in the following areas as required: • Lung/heart (e.g. Palpitations/breathing issues/airway irritations/abnormal fatigue) • Neurological/-behavioural (e.g. tremors/nerve pains/headaches/numb feeling fingers/toes) • Neurocognitive (cognitive problems) • Irritants • Sensitisation • Skin • Gastrointestinal • …

POST-FLIGHT REPORTING *Note: take a picture of all relevant documents for future reference*		
☐	Flight Crew: Complete the mandatory occurrence report (MOR/ASR) within 72h Attach the *'CAQ Occurrence – Event Reporting Form'* *Commission Implementing Reg (EU) 2015/1018* • *4(2) Any smoke/fumes* • *4(3) Contaminated air in the cockpit or in the passenger compartment which has or could have endangered the aircraft, its occupants or any other person* • *4(9) Any use of crew oxygen system by crew.*	
☐	Flight Crew: Consider contacting the national Accident Investigation Body (AIB) *e.g. oxygen required, flight crew incapacitation, serious injury (>48h hospital, damage to internal organ), smoke*	
☐	Inform your crew to file an occupational health and safety report (one per person)	
☐	Inform your crew of the option to file an individual voluntary occurrence report (VOR) EU crews can use airline VOR or other established reporting systems (e.g. https://e2.aviationreporting.eu/reporting) to capture any other safety-related information which is perceived by the reporter as an actual or potential hazard to aviation safety that was not captured by mandatory system. (EU) No 376/2014	
☐	Forward all forms to the Safety department (if no automatic transfer) and crew involved	
☐	Consider advising your union or GCAQE via https://gcars.app	

3. CAQ Occurrence – Event Reporting Form

SECTION 1: FLIGHT AND REPORTER DETAILS

AC Reg.:
A/C Type:
Tech log #:
DEP:
ARR:

Flight Date:
Reporter:
Employee id:

Crew type

- ☐ Fight crew
- ☐ Cabin crew
- ☐ Maintenance
- ☐ Other

SECTION 2: FLIGHT PHASE AND SMOKE/FUME LOCATION

Flight Phase

- ☐ Parked (pre-flight)
- ☐ Pushback
- ☐ Engine start
- ☐ Taxi-out
- ☐ Take-off
- ☐ Climb
- ☐ Cruise
- ☐ Descent
- ☐ Approach
- ☐ Landing
- ☐ Taxi-in
- ☐ Parked (post-flight)

Engine start using:

- ☐ APU bleed
- ☐ Engine X-bleed
- ☐ Ext. Air Starter

Event

☐ Single ☐ Multiple

Estimated duration: …… : ……

Engine power changes

- ☐ Yes
- ☐ No
- ☐ Unknown

Configuration at event start:

Pack 1:	☐ ON	☐ OFF
Pack 2:	☐ ON	☐ OFF
Bleed 1:	☐ ON	☐ OFF
Bleed 2:	☐ ON	☐ OFF
APU Bleed:	☐ ON	☐ OFF
X-bleed:	☐ CLSD	☐ OPEN
External Airco:	☐ YES	☐ NO
Ext. Air Starter:	☐ YES	☐ NO

Known history of similar events on this aircraft?

- ☐ Yes
- ☐ No
- ☐ Unknown

Recent aircraft history

- ☐ None
- ☐ De-/Anti-icing
- ☐ Engine/APU oil servicing
- ☐ Hydraulic fluid servicing
- ☐ Pesticide application
- ☐ Fuelling ongoing
- ☐ Other:

Evidence of smoke or fire:

- ☐ Smoke
- ☐ Fire
- ☐ Odours only (No smoke, no fire)
- ☐ None

Type of smoke or fire:

- ☐ Open flame
- ☐ Generalised smoke
- ☐ Local smoke
- ☐ None

Location of smoke or fire:

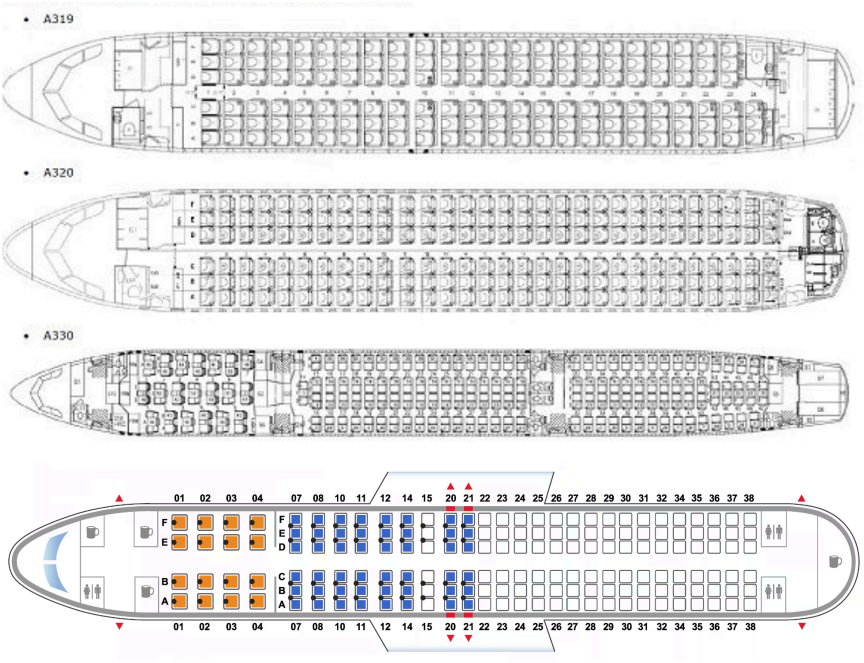
- ☐ Flight Deck
- ☐ Forward Cabin
- ☐ Mid Cabin
- ☐ Aft Cabin
- ☐ Upper Deck Cabin
- ☐ Flight crew rest area
- ☐ Cabin crew rest area
- ☐ Lavatory
- ☐ Galley
- ☐ Cargo
- ☐ Other

Smoke/Fume Source:

- ☐ Air supply system vents
- ☐ Cabin item
- ☐ Flight deck equipment
- ☐ Galley equipment
- ☐ Other
- ☐ Unknown

Odour:

- ☐ Acrid
- ☐ Chemical
- ☐ De-icing
- ☐ Dirty socks
- ☐ Exhaust
- ☐ Electrical
- ☐ Fuel
- ☐ Musty or mouldy
- ☐ Oily/burning oil
- ☐ Vomit
- ☐ Other



Event description:

SECTION 3: SYMPTOMS & EQUIPMENT USED

Symptoms reported by:	Equipment used	Flight Crew	Cabin Crew	Maintenance	Passengers
☐ Fight crew ☐ Cabin crew ☐ Maintenance ☐ Passenger(s) ☐ Other ☐ None	Oxygen mask	☐	☐	☐	☐
	Smoke goggles	☐	☐	☐	☐
	Smoke hood	☐	☐	☐	☐
	Portable O2 bottle	☐	☐	☐	☐
	Fire extinguisher	☐	☐	☐	☐

Medical assistance required?	Comments (e.g. duration of symptoms, intensity…)
⬜ Fight crew ⬜ Cabin crew ⬜ Maintenance ⬜ Passenger(s) ⬜ Other ⬜ None	

Complaints / Symptoms: none ☐ / minor ☐ / average ☑ / major ☐

	Flight Crew	Cabin Crew	Maintenance	Passengers
Abnormal taste	☐	☐	☐	☐
Dizziness	☐	☐	☐	☐
Fatigue/weakness	☐	☐	☐	☐
Headache	☐	☐	☐	☐
Irritated eyes, nose, throat	☐	☐	☐	☐
Slowed thinking	☐	☐	☐	☐
Tingling	☐	☐	☐	☐
Trouble breathing	☐	☐	☐	☐
Other	☐	☐	☐	☐

Keep a detailed record of the event – Severity, duration, phase of flight, effect on others, aircraft incident/defects identified & frequency and brief nature of previous events…

4. CAQ Occurrence – Doctor information

Dear colleague,

The patient you are seeing is an air crew member who has been exposed to smoke, gas or fumes (possibly also with an odour) in the course of their flight duties. To determine any impact of this exposure on their health, we ask you to subject them to a medical examination, both as a precautionary measure and to help us investigate the incident from a medical point of view.

As part of this examination, the crew member will provide you with our Cabin Air Quality Occurrence - Patient Record Form, duly completed by them, along with a description of any health problems or symptoms they may have experienced or still be experiencing following the event.

While paying due and full respect to your diagnostic and therapeutic freedom, we ask you to assess the patient's medical history, clinically examine them and determine several blood and urine values as specified on the form. Detailed scientific information on specific tests is available in the full medical protocol (hyperlink). We further ask you to compile a brief medical report including any material on your findings and to hand this to the patient.

Many thanks in advance for your examination and your assistance. Should you have any questions, please do not hesitate to contact us: (add full address and contact information)

Sincerely,
(company doctor)

Chère/cher collègue,

Le patient qui s'adresse à vous fait partie de l'équipage d'un avion ayant été exposé à la formation de gaz, de vapeur d'eau ou de fumée, associée à d'éventuelles émanations olfactives. Afin de vérifier une possible conséquence de cette exposition sur sa santé, nous vous prions de bien vouloir nous faire part de vos observations et conclusions dans la perspective de soins médicaux et afin d'évaluer l'incident en termes de médecine aéronautique.

Lors de la consultation, le membre d'équipage vous remettra un formulaire (Cabin Air Quality Occurrence - Medical Sheet) permettant d'apporter des précisions sur des troubles éventuels.

Dans le respect de votre liberté diagnostique et thérapeutique, nous vous prions, outre l'anamnèse, de procéder à un examen clinique du patient ainsi qu'une série d'analyses de sang et d'urine, comme le prévoit le formulaire. Nous vous remercions enfin de rédiger un bref rapport médical, assorti d'une annexe comportant les résultats.

Nous vous remercions de votre avis médical et de votre aide. Nous sommes bien évidemment à votre disposition pour tout complément d'information: (add full address and contact information)

Meilleures salutations,
(company doctor)

Sehr geehrte Frau Kollegin,
Sehr geehrter Herr Kollege

Der bei Ihnen vorstellige Patient gehört zu einer Flugzeugbesatzung, bei der es während des Flugbetriebes zu einer Gas-, Dampf- oder Rauchbildung mit allfälliger geruchlicher Wahrnehmung gekommen ist. Um eine mögliche gesundheitliche Auswirkung der Exposition abzuklären, bitten wir Sie im Rahmen der Fürsorge und zur flugmedizinischen Aufklärung des stattgehabten Vorfalls um Ihre Mithilfe.

Anlässlich der Untersuchung wird Ihnen das Besatzungsmitglied ein Formular (Medical Sheet Fume Event) mit Angaben allfälliger Beschwerden aushändigen. Unter Wahrung Ihrer diagnostischen und therapeutischen Freiheit bitten wir Sie, das Besatzungsmitglied nebst Erhebung der Anamnese klinisch zu untersuchen und eine Reihe von Blut- und Urinwerten, welche auf dem Formular ersichtlich sind, zu bestimmen.

Für die Abklärung und Ihre Mithilfe danken wir Ihnen bestens und stehen für Rückfragen gerne zur Verfügung: (add full address and contact information)

Freundliche Grüsse
(company doctor)

Beste collega,

De patiënt die u ziet, is een lid van het vliegend personeel dat tijdens de uitoefening van zijn/haar taken is blootgesteld aan rook, gassen of dampen (eventueel met een geur). Om de eventuele impact van deze blootstelling op zijn/haar gezondheid te bepalen, vragen we u om deze persoon aan een medisch onderzoek te onderwerpen, zowel uit voorzorg als om ons te helpen om het incident zelf vanuit medisch oogpunt verder te onderzoeken.

Als onderdeel van dit onderzoek zal het bemanningslid u een ingevuld formulier (Patient Record Form) bezorgen, samen met een beschrijving van eventuele gezondheidsproblemen of symptomen die hij/zij mogelijk heeft ervaren of nog steeds ervaart na het incident.

Met alle respect voor uw diagnostische en therapeutische vrijheid, vragen wij u om de medische geschiedenis van de patiënt te beoordelen, deze klinisch te onderzoeken en een aantal bloed- en urinewaarden vast te stellen zoals gespecificeerd op het formulier. Gedetailleerde wetenschappelijke informatie over specifieke tests is beschikbaar in het volledige medische protocol (hyperlink). Verder vragen wij u een kort medisch rapport op te stellen met eventueel materiaal over uw bevindingen en dit aan de patiënt te overhandigen.

Bij voorbaat hartelijk dank voor uw onderzoek en uw hulp. Mocht u nog vragen hebben, neem dan gerust contact met mij op: (vul adres en contactgegevens in)

Met professionele groet,
(bedrijfsdokter)

5. CAQ Occurrence - Patient Record Form

Patient identification		**Medical facility identification**	
Incident Date & Time		ID	(LEAVE BLANK)
Patient Name		Physician Name	
Birthdate		Institute/location	
Telephone		Telephone	
Email		Email	
Total hours/years flight experience			

A. Patient Event Description

For oxygen mention duration, flow rate, in-/post-flight
For type and extent of the event mention smell, mist, location, timing / for symptoms refer to table below

(TIME)	Blood pressure	/	Heart Rate		Oxygen saturation	%

B. Symptoms

Complaints / Symptoms (indicate whether symptoms are minor -☐ / average ✓☐ / major +☐)

Neurological

- ☐ Headache
- ☐ Vision problems (Blurred/tunnel vision)
- ☐ Nystagmus
- ☐ Disorientation
- ☐ Difficulty in speaking/writing
- ☐ Loss of balance
- ☐ Erratic movements
- ☐ Vertigo
- ☐ Shaking / tremors
- ☐ Incoordination*
- ☐ Seizures
- ☐ Fainting
- ☐ Paresthesias 'tingling' ('Pins & needles')
- ☐ Numbness
- ☐ Impaired or loss of consciousness
- ☐ Sweating
- ☐ Metallic/altered taste
- ☐ Flushing
- ☐ Pallor

Neurobehavioural

- ☐ Memory impairment
- ☐ Memory loss
- ☐ Lightheadedness
- ☐ Dizziness
- ☐ Drowsiness / Lethargy
- ☐ Concentration issues (brain fog)
- ☐ Slowed mental processing
- ☐ Word finding problems
- ☐ Confusion
- ☐ Disorientation
- ☐ Feeling intoxicated
- ☐ Feeling anxious
- ☐ Feeling depressed
- ☐ Feeling of unreality

Respiratory

- ☐ Coughing
- ☐ Breathing difficulties/ ⬜ Shortness of breath
- ☐ Tightness in chest
- ☐ Chest pain / discomfort
- ☐ Lung irritation
- ☐ Respiratory failure requiring oxygen
- ☐ Sinus problems

Cardiovascular

- ☐ Variable heart rate
- ☐ Palpitations
- ☐ Changes in blood pressure
- ☐ Chest tightness

Gastrointestinal

- ☐ Nausea
- ☐ Vomiting
- ☐ Cramps

Irritation

- ☐ Eye irritation
- ☐ Nose irritation

General

- ☐ Fatigue
- ☐ Muscle weakness
- ☐ Joint/Muscle pain

☐ Diarrhoea	☐ Upper airways (throat) ☐ Hoarse voice ☐ Burning ☐ Redness ☐ Rash / Blisters	☐ Twitching ☐ Feeling unwell ☐ Dry mouth ☐ Increased saliva ☐ Performance decrement ☐ Chemical sensitivity
Progression of symptoms/notes		

C. Clinical Examination[6,7]

- ☐ General appearance (e.g. breathlessness, pallor, agitation)
- ☐ Measure and record respiratory and heart rate, blood pressure.
- ☐ Auscultation of heart and lungs.
- ☐ General physical examination.
- ☐ Record if oxygen was used and when it was applied.
- ☐ Record oxygen saturation (SpO2 - if oximeter available, record if supplemental oxygen being used).
- ☐ Monitor SpO2, if initial SpO2 <95%.
- ☐ Assess neurological status (conscious state, balance, muscle weakness, numbness, pupils, muscle reflexes, check for tingling of limbs, muscle cramps, tremor).
- ☐ Assess Mini-Mental State Examination MMSE: (Orientation for time and plane; attention and calculation; memory and processing speed).

D. General Investigations[6,7]

Routinely available

- ☐ **Full blood examination**
  (Hb, WCC and differential count) EDTA-tube 4ml (purple cap)
- ☐ **Acute phase reactants**
  (e.g. C-reactive protein SST 8ml (white cap),
  ESR EDTA 4ml (purple cap), fibrinogen Sodium citrate 2.7ml (light blue cap);
- ☐ **Routine biochemistry**
  (U&E/Cr, LFTs, LDH) SST 8ml (white cap),
- ☐ **Muscle enzymes**
  (e.g. Troponin, CKMM and CKMB, aldolase) Lithium Heparin 8ml (green cap);
- ☐ **Cholinesterase**
  AChE (within 4-48 hours) EDTA 4ml (purple cap)
  BChE (within 4-24 hours) SST 8ml (white cap)
- ☐ **COHb (Carboxyhaemoglobin)** (within 2-4 hours) Record time since exposure and/or time of last cigarette. (Indication of CO intoxication) heparinised syringe 5ml
- ☐ **Methaemoglobin** (within 2- 4 hours) heparinised syringe 5ml
- ☐ Others as clinically needed

[6] Burdon (2023) - Table 7 Immediate post flight medical protocol
[7] Burdon supplement (2023) - Appendix 4, Section 1B

☐ **Neurobehavioral**

basic quick (5 min) testing of Processing Speed via the Symbol Digit Modalities test (SDMT) (oral & written) and/or digit span forwards and backwards is recommended initially, followed by early referral for more detailed neuropsychological testing later as required.

Non-Routinely available

☐ **Neuropathy Target Esterase (NTE)** (lymphocytic) - only fresh blood can be analysed.

☐ **VOCs**[8] – Human biomonitoring (HBM) for aliphatics, aromatics, ketone, alcohols, and organics such as n-heptane, n-hexane, benzene, toluene, n-pentane, n-octane, acrolein, formaldehyde etc (Fluoride Oxalate 2ml) + (Normal EDTA 5ml, 2ml blood samples have to be transferred to coated head-space tubes for GCMS analysis – contact specialist lab) - check

☐ **OPs**[8] – Human biomonitoring (HBM) for triaryl, trialkyl, triaryl-alkyl organophosphates (OPs). The analysis group may include: Tricresyl phosphate (TCP) - Meta, para, ortho isomers; Trixylyl phosphate (TXP); Tributyl phosphate (TBP); Triphenyl phosphate (TPP), dibutyl phenyl phosphate (DBPP); triisobutyl phosphate (TiBP); 2,6-di-tert-butyl-p-cresol (BHT) and, isopropylated phosphate (3:1) (PIP 3:1/TIPP) and mixed esters of TCP, metabolites of TCP (DoCP, DmCP, DpCP); TBP (DBP) TPP (DPP) (yellow container 20-50ml)

⬜ **Autoantibodies against neuronal and glial proteins in blood biomarker testing**
[currently not available]
Burdon (2023), Section: Emerging issues
Burdon supplement (2023) section 1b, 2, Appendix 8 for methodology

E. Further testing as clinically needed[9,10]

Lung & heart
Short-Term

☐ Auscultation of lung & heart, Blood pressure, oxygen saturation SpO2 (record inspired oxygen concentration, Monitor oxygen saturation if <95%)

☐ Spirometry, ECG and specialised blood tests - if clinically indicated

Respiratory function testing within two weeks:

- Detailed lung function tests (spirometry, DLCO and FeNO and/or DLNO, if available).
- Check oxygen saturation SpO2.

☐ Consider:

- Arterial blood gas analysis breathing room air at rest – undertake earlier if there is clinical need
- Expired nitric oxide (FeNO) if available.
- Exercise testing with oxygen saturation or blood gas analysis.

[8] not all necessarily will be undertaken
[9] Burdon (2023) - Section: Clinical effects (other findings) and Table 9, Table 10, Table 11, Table 12
[10] Burdon supplement (2023) - Sections 3 to 9

○ Exhaled gas analysis (ergo spirometry, if available). ○ Blood tests (troponin, if indicated e.g., presence of cardiac irregularity). ○ ECG – if clinically indicated. Long term (if symptoms persist) ☐ Repeat routine lung function tests (spirometry, diffusing capacity). ☐ Static lung volumes. ☐ Percutaneous oxygen saturation or arterial blood gas analysis, as indicated. ☐ Appropriate radiology, for example, chest X-ray, high resolution lung scan (HRCT chest). ☐ Respiratory orientated exercise test or screen with six-minute walk test. ☐ Respiratory muscle strength testing. ☐ Bronchial provocation (methacholine, mannitol or other agent) testing. ☐ Blood tests as clinically indicated. ☐ Specific cardiac function tests as appropriate. ☐ Exercise testing with oxygen saturation or blood gas analysis.	
Neurological/Neurobehavioural Immediate post-flight/event (Section 4A) ● Full general medical assessment. ● Detailed neurological assessment and examination. ● Objective assessment of vestibular function. ● MRI brain scan. ● Consider referral to a neurologist for severe neurological symptoms and signs. Late/subsequent (Section 4B) If symptoms persist over weeks or months: ● Full general medical assessment. ● Detailed neurological assessment and examination. ● Objective assessment of vestibular function. ● MRI – Refer to methodology in (Reneman, ref 37 or ref 132*). ● PET/SPECT – Refer to methodology in (Heuser, ref 38 or ref 117*). ● EMG/ENG: polyneuropathy. ● Skin biopsy/IENF (intraepidermal nerve fibers) – Small fiber neuropathy. There is an international guideline on how to perform this diagnostic (Lauria, ref 209). *Burdon (2023)	
Neurocognitive (Section 4C) Neurocognitive tests that are deemed applicable include the following areas: ● Processing speed, written and oral. ● Attention and concentration. ● Reaction time to stimuli. ● Sequential reaction time. ● Complex problem-solving.	

● Short and long term visual and verbal memory. ● Cognitive flexibility/capacity to change direction. Neurocognitive testing ● Coding test from WAIS. ● Symbol Digit Modalities Test (written and oral versions), see Section 1B. ● CALCAP – Simple and choice reaction time tests.	
Irritants Management – Immediate post-flight / Late/subsequent: ● Avoid ongoing exposure to irritants. ● Manage symptoms as appropriate to the organ system involved.	
Sensitisation Management – Immediate post-flight / Late/subsequent: ● Avoid ongoing exposure to irritants. ● Manage symptoms as appropriate to the organ system involved. ● Consider referral to organ system specialist.	
Skin Management – Immediate post-flight / Late/subsequent: ● Avoid ongoing exposure to irritants. ● Consider standard dermatological treatment. ● Manage symptoms as appropriate to the organ system involved. ● Consider referral to dermatologist if recurrent.	
Gastrointestinal Management – Immediate post-flight / Late/subsequent: ● Investigations as clinically indicated. ● Consider referral to gastroenterologist.	
Other: Chronic fatigue; chemical sensitivity; reproductive effects; malignancy; susceptibility to infections; sleep disturbances, visual effects and joint aches and pains. Refer to the medical protocol (published paper or full supplement) for further guidance.	

F. Lab Results

BLOOD	
Full blood examination	
☐	Complete blood count (CBC/FBC)
☐	Total white cell count (WCC)
☐	Differential white cell count (WCC)
☐	Haemoglobin (Hb)
Acute phase reactants	
☐	C-reactive protein
☐	ESR
☐	Fibrinogen
Routine biochemistry	
☐	U&E/Cr (Creatine kinase with isoenzymes)
☐	LFT (Liver transaminases)
☐	LDH
Muscle enzymes	
☐	Troponin
☐	CKMM
☐	CKMB
☐	Aldolase
Specific	
☐	Carboxyhaemoglobin (COHb) (within 2-4h post-flight) Note time since exposure and/or time of last cigarette.
☐	Methaemoglobin (within 2-4h post-flight) Note time since exposure
Cholinesterase	
☐	Acetylcholinesterase (AChE)
☐	Butyrylcholinesterase (BChE)
Non-routinely available	
☐	Neuropathy Target Esterase (NTE)

URINE	
☐	2,5-Hexandion (metabolite of n-hexane)
☐	Tricresyl-phosphate (TCP) and metabolites (DoCP, DmCP, DpCP)
☐	Triphenyl-phosphate (TPP) (or metabolite Diphenylphosphate DPP)
☐	Tributyl-phosphate (TBP) (or metabolite Dibutylphosphate DBP)
☐	Trixylyl phosphate (TXP)
☐	Dibutyl phenyl phosphate (DBPP);
☐	Triisobutyl phosphate (TiBP);
☐	2,6-di-tert-butyl-p-cresol (BHT)
☐	Isopropylated phosphate (3:1) (PIP 3:1/TIPP)
☐	Mixed esters of TCP

Please add a copy of the original lab analysis and only indicate those lab results which are outside of normal parameters.

References

AIHA. Odour Thresholds for Chemicals with Established Occupational Health Standards. Fairfax, VA, USA: American Industrial Hygiene Association; 1989. ISBN: 13: 9780932627346

BG Verkehr. Medizinisches Standardverfahren Nach Fume-Events (Standard medical procedure after fume events). Hamburg: BG Verkehr; 2014.
https://www.bg-verkehr.de/redaktion/medien-und-downloads/informationen/branchen/luftfahrt/standard-verfahren-eng.pdf

Burdon J, et al. Health consequences of exposure to aircraft contaminated air and fume events: a narrative review and medical protocol for the investigation of exposed aircrew and passengers. Environmental Health. 2023; 22(1): 43. DOI: 10.1186/s12940-023-00987-8. https://doi.org/10.1186/s12940-023-00987-8

Burdon J, et al. Supplement: Health consequences of exposure to aircraft contaminated air and fume events: a narrative review and medical protocol for the investigation of exposed aircrew and passengers. Environmental Health. 2023; 22(1): 1-29.
https://doi.org/10.1186/s12940-023-00987-8

CAA. Information for Health Professionals on Aircraft Fume Events. Civil Aviation Authority - UK Department for Transport/Division 2017. https://www.caa.co.uk/passengers/before-you-fly/am-i-fit-to-fly/guidance-for-health-professionals/aircraft-fume-events

CEN. Cabin Air Quality on Civil Aircraft - Chemical Compounds - Technical Report. Brussels: CEN CENELEC; 2022. PD CEN/TR 17904:2022. https://www.en-standard.eu/pd-cen-tr-17904-2022-cabin-air-quality-on-civil-aircraft-chemical-compounds

EASA. Comment Response Document (CRD) to Advance Notice of Proposed Amendment (A-NPA) 2009-10 - Cabin Air Quality Onboard Large Aeroplanes. Cologne, Germany: European Aviation Safety Agency; 2011.
https://www.easa.europa.eu/sites/default/files/dfu/CRD%20to%20A-NPA%202009-10.pdf

Hageman G, et al. Aerotoxic Syndrome: Discussion of Possible Diagnostic Criteria. Clin Toxicol. 2019; 58(5): 414-6.
https://doi.org/10.1080/15563650.2019.1649419

Harper A. A Survey of Health Effects in Aircrew Exposed to Airborne Contaminants. J Occup Health & Safety - Austr and New Zealand. 2005; 21(5): 433-9. https://perma.cc/R4RA-QQNT

Harrison R, et al. Exposure to Aircraft Bleed Air Contaminants Among Airline Workers - A Guide for Health Care Providors. San Francisco, CA, USA: Occupational Health Research Consortium in Aviation (OHRCA); 2009.
http://www.ohrca.org/medical-protocols-for-crews-exposed-to-engine-oil-fumes-on-aircraft

Heutelbeck A, et al., On the Need for a Standardized Human Biomonitoring Protocol for In-Flight Incidents (Called “Fume Events”). ‘editor’ 2nd International DiMoPEx Conference on “Pollution in Living and Working Environments and Health,” DiMoPEx Working Groups Meeting; 2018. 30-31 October 2017; Cesare Maltoni Cancer Research Center, Ramazzini Institute, Bologna, Italy: Journal of Health and Pollution. https://doi.org/10.5696/2156-9614.8.17.1

IATA. Guidance for Airline Health and Safety Staff on the Medical Response to Cabin Air Quality Events: Smoke, Fumes/Odours. Montreal, Canada: International Air Transport Association; 2015.
https://www.iata.org/contentassets/ccbdc54681c24574bebf2db2b18197a5/guidance-medical-response-cabin-air-events.pdf

ICAO. Guidelines on Education, Training and Reporting Practices Related to Fume Events (CIR 344). Montréal, Canada: International Civil Aviation Organization; 2015.

Schuchardt S, et al.. EASA Research Project: CAQ Preliminary Cabin Air Quality Measurement Campaign. Final Report EASA_REP_RESEA_2014_4. Cologne, Germany: European Aviation Safety Agency; 2017.https://www.easa.europa.eu/document-library/research-reports/easarepresea20144