Hazardous Chemicals on Jet Aircraft: Jet Oils and Aerotoxic Sydrome

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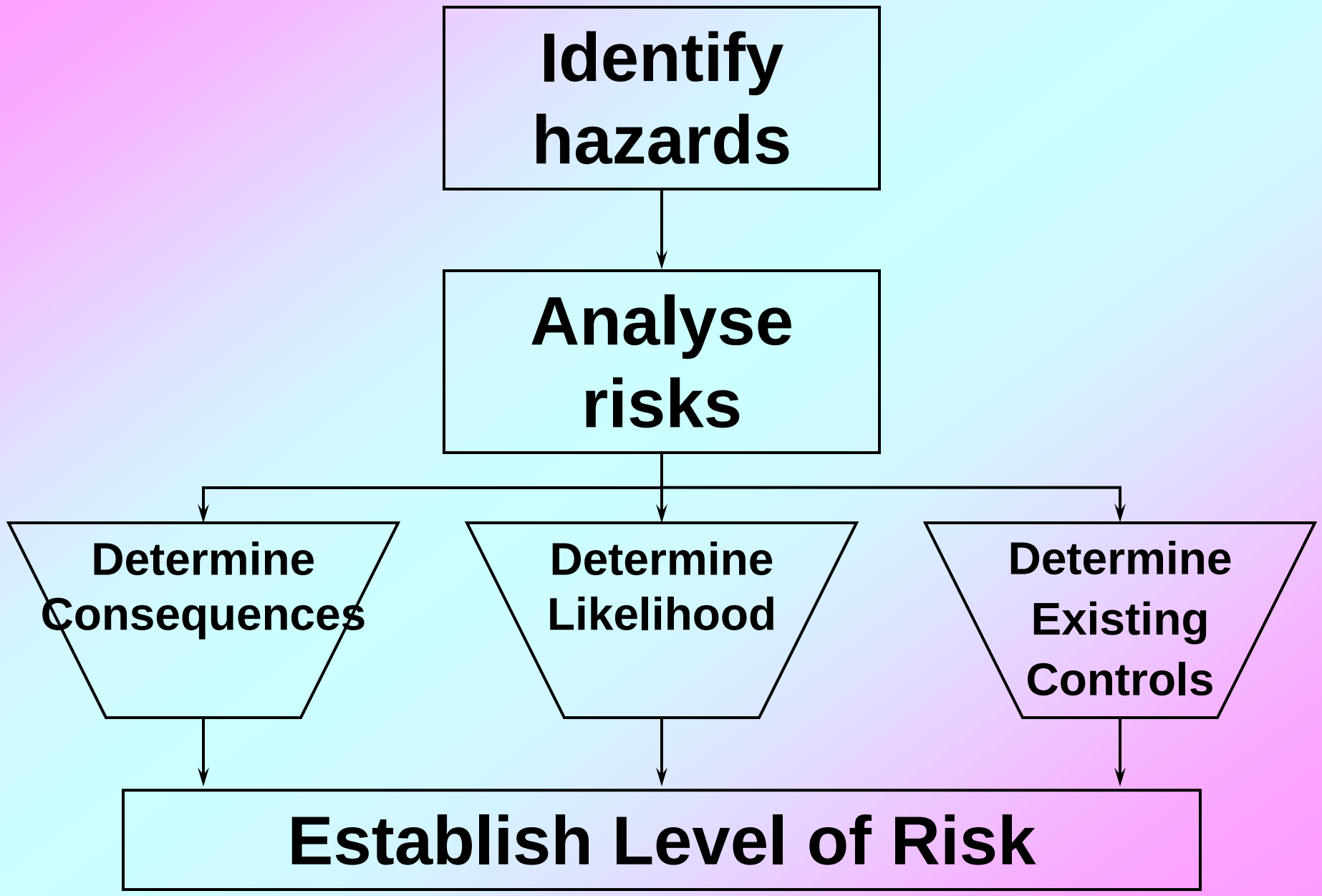
The Working Environment

- The cabin of an airplane is a specialised working environment and should be considered as such
- Opportunities for fresh air and escape are limited where contamination occurs
- Recommendations for pressurisation of airplane cabins (to an equivalent of 8000 feet) were established in the 1960s using healthy male volunteers
- Interactions between chemical exposures and the hypoxia of flying is poorly considered
- “Others” are found in workplaces and workplace risks assessments and exposure standards do not apply to them
- An impact on physiological function is more likely where individuals are undertaking effort

Process of Risk Assessment

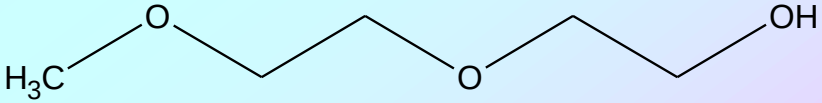


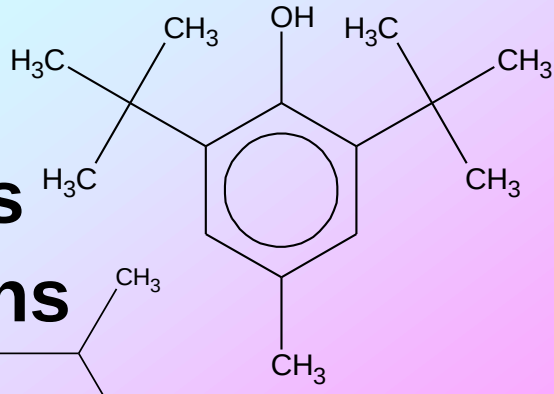
Identify Hazards

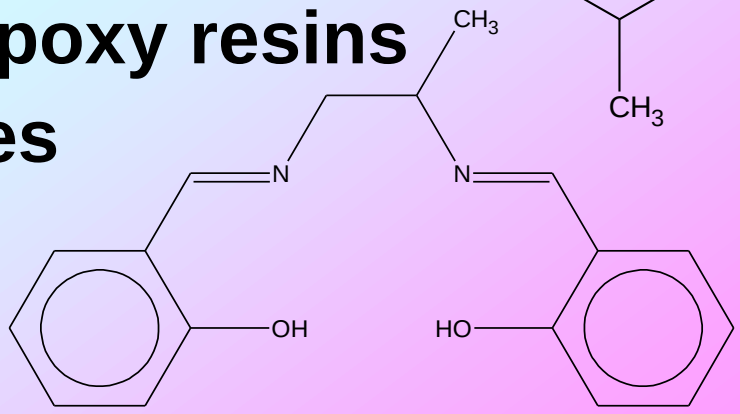
Aviation Chemicals

Chemicals used in aviation include

- **Fuels (including its combustion products)**
- **Fuel additives**
- **Lubricants (mineral and synthetic based)**
- **Hydraulic fluids (mineral and synthetic based)**
- **Greases**
- **Coolants and de-icing chemicals**
- **Sealants, adhesives, epoxy resins**
- **Corrosion preventatives**
- **Speciality chemicals**







Case Study: Mobil Jet Oil II

Warning (pre-1998)

Warning (post-1998)

The Oil

- The oils and hydraulics used in airplane engines are toxic, and specific ingredients of such materials are irritating, sensitising and neurotoxic
- Information provided by oil manufacturers to airplane manufacturers understates the toxicity of their oil products
- This has been accepted uncritically by airplane manufacturers and airline operators and is used by them in a manner that misleadingly understates risk

The MSDS

ExxonMobil

Product Name: MOBIL JET OIL II
Revision Date: 17Aug2004
Page 1 of 7

MATERIAL

SECTION 1 PRO

Name	CAS#	Concentration*
1-NAPHTHYLAMINE, N-PHENYL-	90-30-2	1%
DIPHENYL AMINES ALKYLEES	68411-46-1	0.1 - 1%
TRICRESYL PHOSPHATE	1330-78-5	1 - 5%

This product is not expected to produce adverse health effects under normal conditions of use and with appropriate personal hygiene practices. Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/ fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation.

POISON SCHEDULE NUMBER: **AU_NC_POIS_SCHED - None Allocated.**

HEALTH HAZARDS

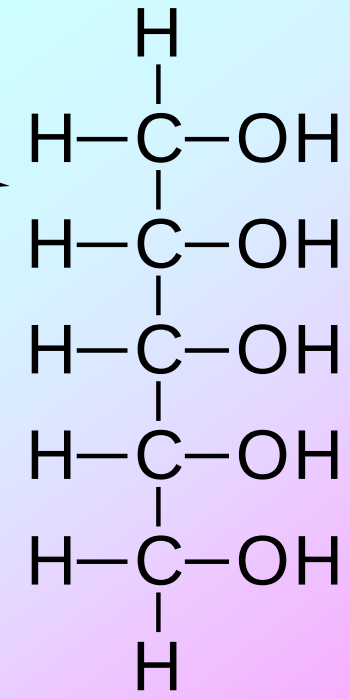
This product is not expected to produce adverse health effects under normal conditions of use and with appropriate personal hygiene practices. Product may decompose at elevated temperatures or under fire conditions and give off irritating and/or harmful (carbon monoxide) gases/vapours/fumes. Symptoms from acute exposure to these decomposition products in confined spaces may include headache, nausea, eye, nose, and throat irritation. High-pressure injection under skin may cause serious damage.

The Oil

- If oil or hydraulic fluids leaks into the cabin, this contamination may be in the form of:
  - unchanged oil/fluid, degraded oil/fluid from long use in the engine, combusted oil/fluid or pyrolised oil/fluid
  - gases, vapours, mists and particulate matter
  - irritant or toxic vapours or gases may be adsorbed onto the surface of mists or particulates

The Engine Oil

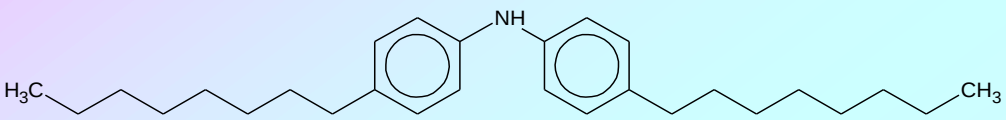
- All Jet oils are fairly similar in content
- Based on a synthetic polyol oil base, such as derivatives of erythritol



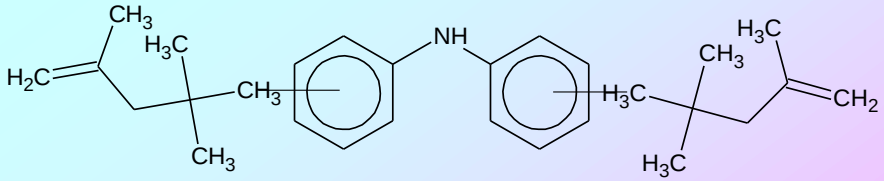
- Contain various additives to enhance performance, including
- A substituted diphenylamine, added as an antioxidant
- Tricresyl phosphate added to prevent metal wear and as a fire retardant
- N-Phenyl-1-naphthylamine (PAN) is an antioxidant

The Substituted Diphenylamine

- The substituted diphenylamine is added as an oxidant
- Added at a concentration of about 1%



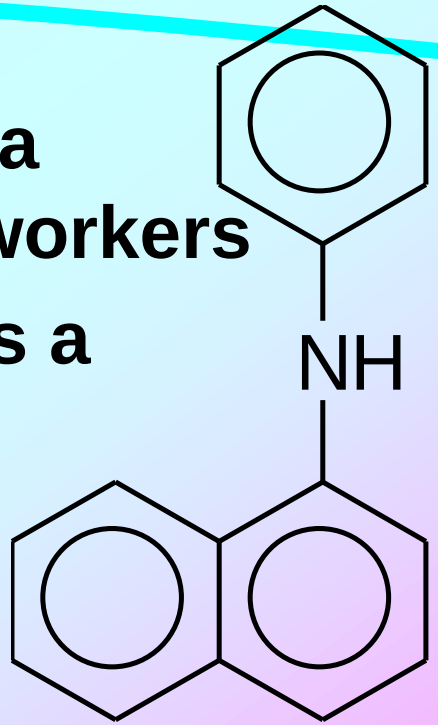
Benzamine, 4-Octyl-*N*-(4-Octylphenyl)



N-Phenyl-benzeneamine, reaction product with 2,4,4-Trimethylpentene

- Considered hazardous to the environment (has properties of poor biodegradability and toxicity to aquatic invertebrates)

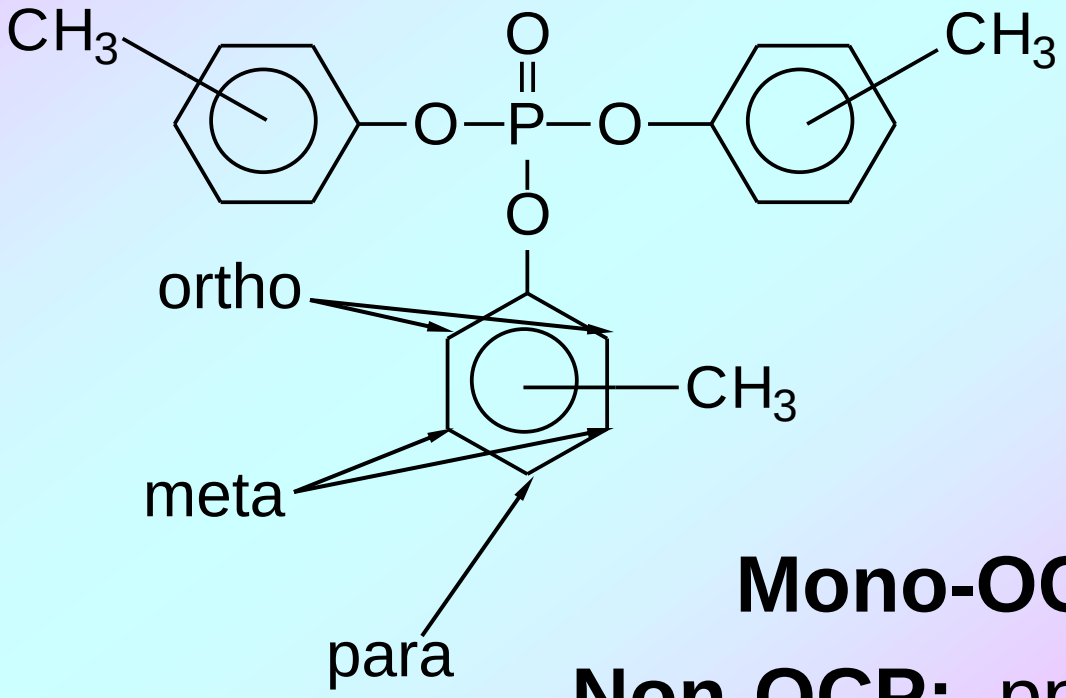
N-Phenyl-1-naphthylamine



- N-phenyl-1-naphthylamine (PAN) is a sensitiser in animals and exposed workers
- The contaminant 2-naphthylamine is a carcinogen
- Lung and kidney cancer reported in animals and workers exposed to an oil containing 0.5-1% PAN
- Not known if concentration of PAN in jet oil (1%) is a carcinogenic risk
- PAN is considered a skin sensitisation risk

Tricresyl Phosphate

- Tricresyl phosphate (TCP) has an organo-phosphate structure, with three cresyl groups attached to a phosphate group



Tri-OCP: ooo

Di-OCP: oop oom

Mono-OCP: opp opm omm

Non-OCP: ppp ppm pmm mmm

Tricresyl Phosphate

- Manufacturer admits in documentation to TOCP levels in oil of 5 ppb (0.005 ppm)
- Evidence to Senate Inquiry also admitted to 6 ppm DOCPs and 3070 ppm MOCPs

Isomer	Conc	Rel Tox	Equiv
TOCP	0.005 ppm	1	**Tox** 1 ×
DOCPs	6 ppm	5 ×	30 ×
MOCPs	3070 ppm	10 ×	30700 ×
		Total	**30731 ×**
Other O-OPs	? ppm	? ×	? ×

Assess Exposures

Studies of Air Contamination

- A number of studies have been conducted looking at the range of toxicants in air at altitude
- Until recently, all have methodological problems:
  - inability to collect poorly volatile contaminants
  - inadequate sample collection time
  - inadequate sample volume
  - storage of samples
  - no chain of custody
  - not taking account of altitude
  - studies conducted on the ground
- No monitoring has been conducted during a leak incident

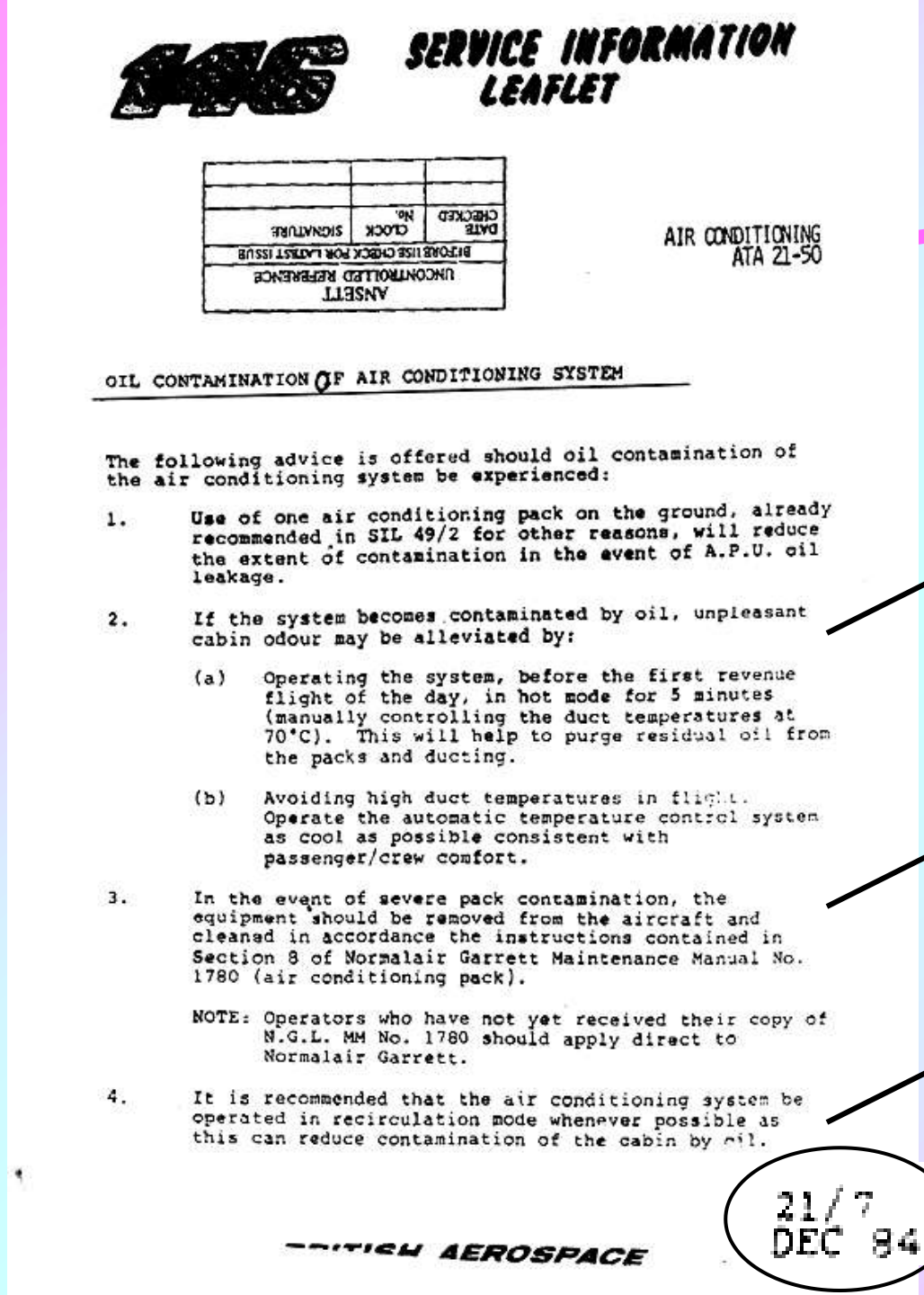
Exposure Standards

- A common assertion is that all chemical exposures are within acceptable TWA exposure standards. These:
  - Apply only to the specified chemical
  - Do not protect "nearly all workers"
  - Cannot protect sensitive workers – they are NOT no effect levels
  - Poorly consider periods of peak exposure
  - Ignore skin exposure
  - Ignore exposures to other contaminants
  - Must not be applied to people other than workers (ambient standards are often 100-1000 times lower)
  - Must not be applied to unusual environments (for example, at 2400 m altitude)

Leak Incidents

- The aviation industry itself acknowledges that air quality exposure events are primarily due to oil leaking into the air supply
- All parties acknowledge that a problem exists, but then deny that it is a serious matter, suggesting that it is not it is an air safety issue, rather an OHS, general health or comfort issue
- Regulatory agencies indicate that “serious impairment“ includes the loss of crew’s ability to see flight deck instrumentation or perform expected flight duties
- This excludes purely psychological aspects of the concern of odours, and concerns about long-term exposure

Oil Leaks



146 SERVICE INFORMATION LEAFLET

DATE CHECKED	CLOCK No.	SIGNATURE

BEFORE USE CHECK FOR LATEST ISSUE

UNCONTROLLED REFERENCE ANSETT

AIR CONDITIONING
ATA 21-50

OIL CONTAMINATION OF AIR CONDITIONING SYSTEM

The following advice is offered should oil contamination of the air conditioning system be experienced:

1. Use of one air conditioning pack on the ground, already recommended in SIL 49/2 for other reasons, will reduce the extent of contamination in the event of A.P.U. oil leakage.

2. If the system becomes contaminated by oil, unpleasant cabin odour may be alleviated by:

   (a) Operating the system, before the first revenue flight of the day, in hot mode for 5 minutes (manually controlling the duct temperatures at 70°C). This will help to purge residual oil from the packs and ducting.

   (b) Avoiding high duct temperatures in flight. Operate the automatic temperature control system as cool as possible consistent with passenger/crew comfort.

3. In the event of severe pack contamination, the equipment should be removed from the aircraft and cleaned in accordance the instructions contained in Section 8 of Normalair Garrett Maintenance Manual No. 1780 (air conditioning pack).

   NOTE: Operators who have not yet received their copy of N.G.L. MM No. 1780 should apply direct to Normalair Garrett.

4. It is recommended that the air conditioning system be operated in recirculation mode whenever possible as this can reduce contamination of the cabin by oil.

BRITISH AEROSPACE

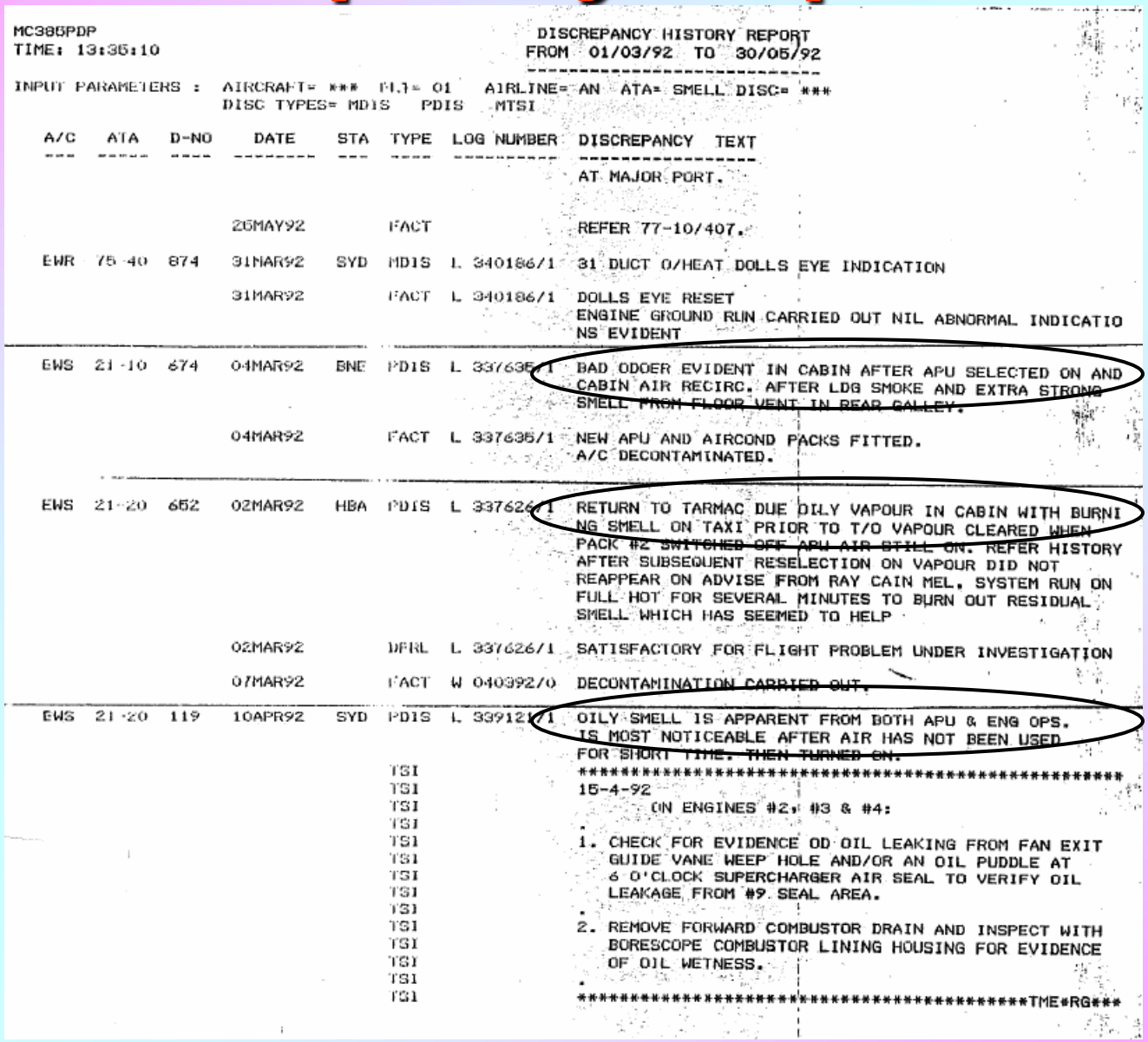
21/7 DEC 84

If the system becomes contaminated by oil ...

In the event of severe pack contamination

Operate in recirc mode wherever possible to reduce contamination

Discrepancy Reports



MC386PDP
TIME: 13:35:10

DISCREPANCY HISTORY REPORT
FROM 01/03/92 TO 30/05/92

INPUT PARAMETERS : AIRCRAFT= *** FLT= 01 AIRLINE= AN ATA= SMELL DISC= ***
DISC TYPES= MDIS PDIS MTSI

A/C	ATA	D-NO	DATE	STA	TYPE	LOG NUMBER	DISCREPANCY TEXT
							AT MAJOR PORT.
			26MAY92		FACT		REFER 77-10/407.
EWR	75-40	874	31MAR92	SYD	MDIS	L 340186/1	31 DUCT O/HEAT DOLLS EYE INDICATION
			31MAR92		FACT	L 340186/1	DOLLS EYE RESET ENGINE GROUND RUN CARRIED OUT NIL ABNORMAL INDICATIONS EVIDENT
EWS	21-10	674	04MAR92	BNE	PDIS	L 337635/1	BAD ODOER EVIDENT IN CABIN AFTER APU SELECTED ON AND CABIN AIR RECIRC. AFTER LDG SMOKE AND EXTRA STRONG SMELL FROM FLOOR VENT IN REAR GALLEY.
			04MAR92		FACT	L 337635/1	NEW APU AND AIRCOND PACKS FITTED. A/C DECONTAMINATED.
EWS	21-20	652	02MAR92	HBA	PDIS	L 337626/1	RETURN TO TARMAC DUE OILY VAPOUR IN CABIN WITH BURNING SMELL ON TAXI PRIOR TO T/O VAPOUR CLEARED WHEN PACK #2 SWITCHED OFF APU AIR STILL ON. REFER HISTORY AFTER SUBSEQUENT RESELECTION ON VAPOUR DID NOT REAPPEAR ON ADVISE FROM RAY CAIN MEL. SYSTEM RUN ON FULL HOT FOR SEVERAL MINUTES TO BURN OUT RESIDUAL SMELL WHICH HAS SEEMED TO HELP
			02MAR92		DFRL	L 337626/1	SATISFACTORY FOR FLIGHT PROBLEM UNDER INVESTIGATION
			07MAR92		FACT	W 040992/0	DECONTAMINATION CARRIED OUT.
EWS	21-20	119	10APR92	SYD	PDIS	L 339121/1	OILY SMELL IS APPARENT FROM BOTH APU & ENG OPS. IS MOST NOTICEABLE AFTER AIR HAS NOT BEEN USED FOR SHORT TIME. THEN TURNED ON.
					TSI		**********
					TSI		15-4-92
					TSI		ON ENGINES #2, #3 & #4:
					TSI		.
					TSI		1. CHECK FOR EVIDENCE OD OIL LEAKING FROM FAN EXIT GUIDE VANE WEEP HOLE AND/OR AN OIL PUDDLE AT 6 O'CLOCK SUPERCHARGER AIR SEAL TO VERIFY OIL LEAKAGE FROM #9 SEAL AREA.
					TSI		.
					TSI		2. REMOVE FORWARD COMBUSTOR DRAIN AND INSPECT WITH BORESCOPE COMBUSTOR LINING HOUSING FOR EVIDENCE OF OIL WETNESS.
					TSI		.
					TSI		**********TME*RG***

- Over 3,000 Reports during 1992-94 at Ansett Airlines

Numbers of Leak Incidents

Type of report and country	Year(s)	Aircraft type	Number of reports	Comment
BALPA - UK	2001	B757	**1667+**	1667+ reports of smoke or fumes mostly thought to be from oil in air conditioning system
UK CAA MOR*	1988-Jan 2004	B757	**104+**	"Smoke and or fumes" – oil/smoke/fumes/de-icing/hydraulic fluid •16 reports 1988 - 1998 •88 reports 1999 – January 2004
UK CAA MOR*	1985-2003	Bae 146	**85+**	"Smoke and or fumes" – oil/smoke/fumes/de-icing/hydraulic fluid •11 reports 1985 - 1995 •68 reports 1996 – 2003
Other UK data	1998-2004	B757	**47**	Reports sent via email or airline reports (but not on CAA data base)
Other UK data	2002-2004	Bae 146	**23**	Airline reports not on CAA data base
CAA - UK	1989-1999	5 Jet types	**128**	Smoke/gas fumes (non-mandatory) •1 event every 22,265 flights •B757 (21) , BAe 146 (17)
AAIB - UK	2000-2002	Bae 146/ B757	**19**	Smoke/fumes incidents •B757 -10 •BAe 146 - 9+
BAE - UK	1985-2000	Bae 146	**439**	•36 operators report 227 cases of contaminated air -1985 - 2000 •1 operator reports 212 cases of tainted cabin air 1996 -1999
Aircraft Defect Reports - Australia	1991-1999	Bae 146	**775**	Mandatory reports in aircraft technical log. Number of reports •1992 – 418 reports = 1 every 66 flights •1997 - 189 •1999 (6 months)- 168 reports = 1 every 131 flights
Odour Occurrence	1991-2000	Bae 146	**791**	Optional (voluntary) BAe 146 odour occurrence reports

Leak Incidents

- Evidence is available that suggests that there are a substantial number of leak incidents on airplanes, especially on certain models of aircraft. Many of these leaks go unreported to aircraft operators
- Of those leak incidents that are reported to aircraft operators, many are not reported to regulatory authorities
- Of those leak incidents that are reported to regulatory authorities, not all are added to relevant databases
- Only a very small number of leak incidents are investigated fully

Assessing Risks

Assessing Risks

- Where contamination of air in flight deck and passenger cabin occurs
- Where this is sufficient to cause symptoms of discomfort, fatigue, irritation or toxicity
- This contravenes air quality provisions of Federal Aviation Regulations, most notably FAR/JAR 25.831

Aerotoxic Syndrome

Sign or Symptom — Number of cases/reports	89	248	53	112	7	50	21	106
Fainting/loss of consciousness/grey out	4%	4%			3/7	14%		
Respiratory distress, shortness of breath, respiration requiring oxygen		73%		2%	4/7	62%	26%	4%
Irritation of eyes, nose and throat					7/7		32%	37%
Eye irritation, eye pain	35%	74%	57%	24%	4/7	76%		
Sinus congestion	35%	54%		5%	2/7			
Nose bleed		17%			1/7	4%		
Throat irritation, burning throat, gagging and coughing	2%	64%	57%	43%	2/7	76%		
Cough		69%			2/7	12%		
Difficulty in breathing, chest tightness		68%			3/7	62%		
Loss of voice		35%			1/7			
Rashes, blisters (on uncovered body parts)			36%		4/7	48%	16%	8%
Nausea, vomiting, gastrointestinal symptoms	26%	23%	15%	8%	6/7	58%	5%	15%
Abdominal spasms/cramps/diarrhoea	26%				3/7	20%	5%	16%
Blurred vision, loss of visual acuity	11%	13%		1%	4/7	50%	5%	4%
Shaking/tremors/tingling	9%			3%	3/7	40%		
Numbness (fingers, lips, limbs), loss of sensation			8%	2%	4/7		10%	12%
Trouble thinking or counting, word blindness, confusion, coordination problems	26%	39%	42%		6/7	58%	21%	22%
Memory loss, memory impairment, forgetfulness			42%		7/7	66%	26%	
Disorientation	26%			15%	4/7		16%	8%
Dizziness/loss of balance	47%			6%	4/7	72%	16%	3%
Light-headed, feeling faint or intoxicated	35%	54%		32%	7/7		21%	33%
Chest pains	7%	81%		6%	2/7	22%		
Severe headache, head pressure	25%	52%		26%	7/7	86%	21%	33%
Fatigue, exhaustion					7/7	62%	21%	30%
Chemical sensitivity			32%		4/7	72%	26%	10%
Immune system effects							21%	3%
Behaviour modified, depression, irritability	26%	20%	60%		4/7	40%		27%
Change in urine		3%	6%			4%		
Joint pain, muscle weakness, muscle cramps		29%			2/7	38%	5%	30%

Aerotoxic Syndrome

Features:

1. **Associated with air crew exposure at altitude to atmospheric contaminants from engine oil or hydraulic fluids**
2. **Chronologically juxtaposed by the development of a consistent symptomology of irritancy, toxicity, neurotoxicity and chemical sensitivity**
3. **Obvious short term effects, but a long term syndrome apparent**

Aerotoxic Syndrome

Clusters of Symptoms

- **Loss of consciousness/Inability to function**
- **Symptoms of direct irritation to eye, airways or skin**
- **Respiratory symptoms secondary to irritation**
- **Skin symptoms secondary to irritation**
- **Gastrointestinal symptoms**
- **Neurotoxic symptoms**
- **Neurological/neuropsychological symptoms**
- **Nonspecific general symptoms such as chronic fatigue, chemical sensitivity**

Characterising Risks

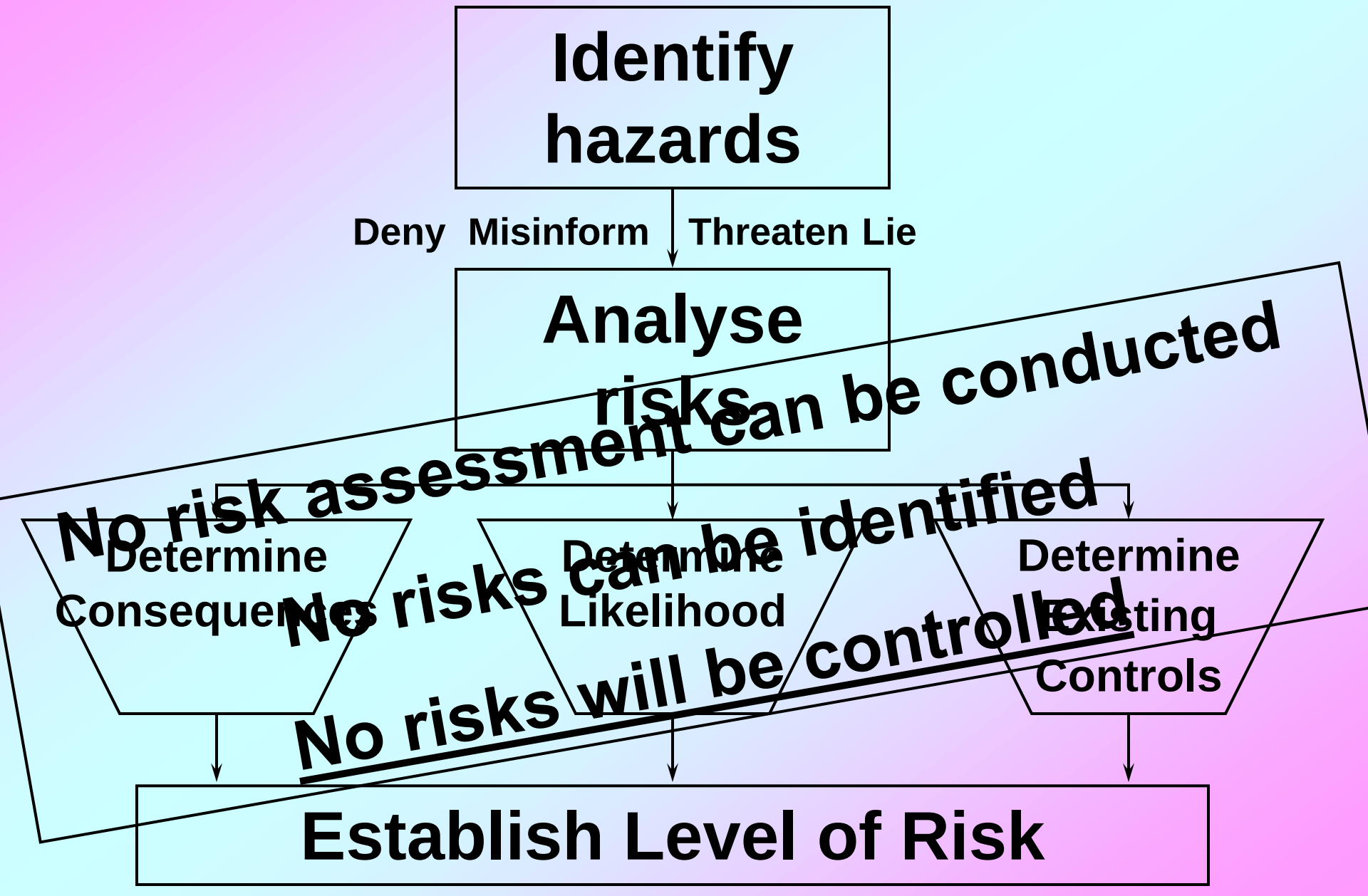
Risks to Safety

- There is a significant aviation safety matter to flight crew where leak incidents affect the ability of pilots and flying officers to fly planes safely
- There is a significant health and safety matter to airline staff and passengers where leak incidents affect their health

Risks to Health

- Symptoms of immediate nature and reported by exposed staff in single or few leak incidents are consistent with the development of irritation and discomfort
- Symptoms of a short term nature (that is, continuing symptoms for up to six months) reported by some exposed staff following small numbers of leak incidents are consistent with the development of initially temporary but eventually irreversible health problems in a number of body systems
- Symptoms of a long term nature (that is, sustained symptoms for at least six months) reported by some exposed staff following small to moderate numbers of leak incidents are consistent with the development of an irreversible discrete occupational health condition, termed aerotoxic syndrome

Real Process of Risk Assessment



Deny Misinform Threaten Lie

- There are no engine oil leaks
- Well, there may be some engine oil leaks, but they are very uncommon
- Well, there more a few engine oil leaks than we would like, but the oil is safe under normal conditions of use
- Well, the oil may contain hazardous ingredients, but not at levels that it affects the health of crew
- The health problems being reported by our workers are not related to the leaks
- This is an occupational health, not safety, problem
- Well, if there are health problems, they are related to some other health condition
- Well, there may be a few health problems from exposure to oil leaks, but they are transient or mild, and are reversible (this breaches FAR 25.831)

Genesis of Aerotoxic Syndrome