AIRCRAFT AIR QUALITY:

WHAT'S WRONG WITH IT AND WHAT NEEDS TO BE DONE

Submitted to
The Aviation Subcommittee of
The Transportation & Infrastructure Committee
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EXECUTIVE SUMMARY

This systematic overview of problems with aircraft air quality is submitted on behalf of the Association of Flight Attendants (AFA), a labor union that represents more than 50,000 flight attendants at 27 different airlines. At the heart of the failure of the US Federal Aviation Administration (FAA), the manufacturers, and the airlines to *resolve* problems with aircraft air quality is their failure to *acknowledge* problems with aircraft air quality. There are no standards for protective measures or access to information necessary to prove individuals' cases; there is effectively no government oversight, allowing the steady flow of "anecdotal" reports to be dismissed as unreliable, and therefore irrelevant.

It is no small task to describe and document problems with air quality on aircraft; hence, the length of this submission. The problems are varied, but the lack of oversight and protective measures is common to all and is in desperate need of remedy. Here, seven problems with aircraft air quality are described in detail, each accompanied by a series of proposed actions.

Inadequate ventilation. In buildings, owners must meet minimum ventilation standards intended to protect occupant health and comfort. On aircraft, there is no ventilation standard, despite the fact that aircraft are the most densely occupied of any environment. In buildings, workers can request an OSHA investigation of indoor air quality. On aircraft, there is no government body assigned to investigate related illness reports. Further, there are no protections in place for flight attendants assigned to fly to areas affected by Severe Acute Respiratory Syndrome (SARS), even though crewmembers do not have the option of "postponing non-essential travel." The World Health Organization recognizes flight attendants as potential "close contacts"; the Centers for Disease Control and Prevention does not. **(Pages 6-14)**

Polluted air supply on the ground. Exhaust fumes and heated deicing fluids can be ingested into the air supply systems, especially during ground operations. **(Page 14-15)**

Exposure to heated oils and hydraulic fluids. Heated oils and hydraulic fluids can leak or spill into the air supply systems during any phase of flight, potentially exposing passengers and crew to carbon monoxide and neurotoxins, such as tricresylphosphates. There are almost no protective measures in place to prevent air supply contamination, and contaminated aircraft can be – and are - dispatched as "airworthy." Chronic or even permanent neurological damage can result, although affected passengers and crew have little recourse without any record of air monitoring or access to maintenance records. Pilot incapacitation is an additional risk. The FAA has shown no signs that it plans to follow the recent National Research Council committee recommendation for requisite carbon monoxide monitoring on all flights. **(Pages 15-21)**

Reduced oxygen in the ambient air during flight. During flight, the aircraft cabin is maintained at a reduced pressure, generally equivalent to an altitude of 6,000 – 8,000 feet, although sometimes higher. At an effective altitude of 8,000 feet, the supply of oxygen is reduced by 25% relative to sea level. There is evidence that the current "8000 feet standard", first issued in 1957, is based not on health, but on operating costs, and that the reduced oxygen supply may be inappropriately low for a substantial portion of the flying public. **(Pages 22-25)**

Inadequate attention to the thermal environment. Providing air nozzles ("gaspers") at each occupant seat and work area allows flight attendants and passengers to adjust the temperature of their environment. This is especially important in areas where flight attendants are physically active. In addition, flight attendants regularly report that the galleys and jumpseats located near the aircraft doors are uncomfortably cold at ankle level, presumably because the doors are poorly insulated. A standard that defines a target temperature range and maximum vertical and horizontal temperature differentials would address this problem. Door heaters have already proven an effective and practical remedy. **(Pages 25)**

Exposure to ozone gas. Symptoms associated with ozone exposure are well documented and include respiratory distress and increased susceptibility to infection. Ozone levels increase with altitude and latitude, and are highest in the late winter and early spring. The exposure limit for ozone cited in the Federal Aviation Regulations is 2.5 times higher than the workplace limit set by the National Institute for Occupational Safety & Health. Airlines are under no obligation to monitor or record ozone levels in the cabin. **(Pages 26-29)**

Exposure to potentially high concentrations of pesticides. Some countries require that incoming aircraft are sprayed with pesticides to kill any insects that may be on board and may carry disease. The pesticides are applied in occupied or soon-to-be-occupied aircraft cabin without any measures to inform or protect the health of passengers or crew. Reported symptoms range from sinus problems and rash to anaphylactic shock and nerve damage. Differences in exposure levels and individual susceptibilities are described. The US Department of Transportation's investigation into the feasibility and efficacy of non-chemical methods to keep aircraft cabins insect free must be actively supported. **(Pages 29-34)**

On behalf of our 50,000 members, AFA thanks the members of the Aviation Subcommittee for considering these comments.

LIST OF ACRONYMS

AFA	Association of Flight Attendants, AFL-CIO
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
APU	Auxiliary Power Unit (a key component of aircraft air supply system)
BLS	US Bureau of Labor Statistics
CDC	US Centers for Disease Control & Prevention
CFM/p	Cubic feet of outside air per minute, supplied to each person (a measure of ventilation rate)
DOT	US Department of Transportation
FAA	US Federal Aviation Administration
OSHA	US Occupational Safety & Health Administration
NIOSH	US National Institute for Occupational Safety & Health
ppm	parts of contaminant per million parts of air (used as a measure of airborne concentration)
SARS	Severe Acute Respiratory Syndrome
SLE	sea level equivalent pressure (a measure used to standardize ventilation rates and contaminant concentrations)
TCPs	Tricresylphosphates
WHO	World Health Organization

Summary of aircraft quality problems, impact on the health of passengers and crew, and proposed actions.

Problem	Health Impact	Proposed Actions
1. Inadequate ventilation	· Reports of stuffy, smelly air and symptoms of "sick building syndrome" · Increased risk of disease transmission	· Establish a minimum ventilation standard for aircraft in operation, including the current fleet. · Require gaspers on all aircraft types. · Recognize flight attendants as at-risk for SARS transmission on aircraft.
2. Exposure to exhaust fumes and deicing fluid, especially during ground operations	· Reports of respiratory irritation, headache, nausea, etc. attributed to exposure to heated deicing fluids and exhaust fumes.	· Implement specific preventive measures to reduce the ingestion of exhaust fumes and deicing fluids into the air supply system.
3. Exposure to air contaminated with heated hydraulic fluids and oils.	· Reports of serious symptoms, including tremors, tunnel vision, and memory loss associated with "smoke in the cabin incidents." Symptoms are consistent with exposure to carbon monoxide and neurotoxic components of oils and hydraulic fluids.	· Require in-duct carbon monoxide monitoring on all flights and train pilots to respond to elevated levels. · Implement specific preventive measures to prevent the contamination of air supply systems, already proven effective at airlines in other countries. · Ensure that crew and passengers with particular medical documentation have timely access to specific airline records necessary to prove their case.
4. Inadequate oxygen during flight	· Reports of hypoxia (dizziness, fainting, tunnel vision) and in-flight cardiovascular or respiratory emergencies.	· Issue an operating standard consistent with the original operating intent of the existing design standard (i.e., 5,000-6,000 feet cabin altitude). At the very least, collect blood oxygen saturation data from active cabin crew and a cross-section of passengers to determine necessary cabin altitude requirements.

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Problem	Health impact	Proposed Actions
5. Inadequate attention to the thermal environment	· Regular reports of discomfort caused by cold air radiating from poorly-insulated doors into crew work areas. Also, gaspers that allow passengers and crew to adjust their local temperature are only optional.	· Establish a target temperature range and maximum allowable temperature differentials (horizontal and vertical). Door heaters have proven an effective remedy to maintain reasonable temperature differentials in areas adjacent to poorly insulated doors. · Require gaspers at individual seats and crew work areas.
6. Exposure to ozone gas	· Reports of respiratory distress consistent with ozone exposure. FAA exposure limit is not health based (e.g., 2.5 times higher than the NIOSH limit set for workers). No air monitoring provisions for ozone.	· Establish a health-based ozone standard. · Require monitoring on high-latitude flights and other elevated ozone areas during "ozone seasons." · Require that catalytic converters installed on aircraft that fly polar routes during ozone seasons be replaced more often.
7. Exposure to pesticides	· Reports of symptoms associated with exposure to pesticides and solvents, including anaphylactic shock. Exposures can be significant and are unregulated.	· Actively support the DOT-chaired task group that is investigating the feasibility and efficacy of mechanical methods of disinsection to replace current chemical spraying methods that jeopardize crew and passenger health.

INTRODUCTION

This systematic overview of problems with aircraft air quality is submitted on behalf of the Association of Flight Attendants (AFA), a labor union that represents more than 50,000 flight attendants at 27 different airlines. It is based on air quality incident reports submitted by flight attendants, passengers, and pilots; our participation in various investigative efforts and on various committees and working groups; our review of available reports and data; conversations with mechanics and engineers; and in a few cases, information and reports that the airlines and the US Federal Aviation Administration (FAA) have provided.

The following problems with aircraft air quality will be addressed: (1) Inadequate ventilation, and the attendant build up of contaminants and risk of transmitting Severe Acute Respiratory Syndrome (SARS) and other diseases, especially during ground operations (i.e., boarding and deplaning); (2) Exposure to exhaust fumes and heated deicing fluids that are ingested into the air supply systems, especially during ground operations; (3) Exposure to partly-combusted oils and hydraulic fluids that can contaminate the air supply systems during any phase of operation; (4) Reduced oxygen in the ambient air during flight; (5) Inadequate attention to the thermal environment; (6) Exposure to ozone gas; and (7) Exposure to potentially high concentrations of pesticides. Although these problems are described individually, crew and passengers are subject to various combinations during any given flight.

At the heart of the failure of the FAA, the airlines, and the manufacturers to *resolve* these problems is their failure to *acknowledge* these problems. Notwithstanding the cost to the health of passengers and crew, the existing state of aircraft air quality is cheaper to maintain. It relies on: (1) The FAA's 1975 preemption of Occupational Safety and Health Administration (OSHA) protections for crewmembers (40 FR 29114, 1975) (2) The absence of effective standards to regulate the design, maintenance, and operation of aircraft air supply systems; (3) The fact that the airlines are under no obligation to provide crew and passengers with particular information that would help prove the relationship between aircraft air quality and illness; and, most importantly, (4) The shortage of published objective data that indicate problems with aircraft system design or operation.

This last point – the shortage of objective data – is key. It is maintained by the near-refusal of airlines and manufacturers to allow researchers financially independent of the airline industry access to aircraft, and the FAA's apparent refusal to institute and manage a centralized air quality incident reporting system that could be used to target problem aircraft or problem routes. Instead, the literature is peppered with industry-funded "studies" that find fault not with aircraft systems, but with occupants' physical and psychological states. Meanwhile, the steady flow of "anecdotal" reports collected by unions is dismissed as unreliable, and therefore irrelevant.

EXISTING SOURCES OF DATA

AFA accepts air quality incident reports from its members on a standardized reporting form. This source of reporting is not as useful as we would like, largely because there is no guarantee that our members will report problems to AFA. Generally, there is a culture of resignation that aircraft air quality will not improve.

If the impact of an air quality incident is serious enough to require lost work time or medical attention, then a flight attendant's first priority is generally to file a report with the airline and initiate a workers' compensation claim. Even then, AFA receives regular anecdotal reports from members that are discouraged *by their airline supervisors* from filing a claim for compensation because "it will be denied anyway." Also, as noted above, there is a series of hurdles in place that makes it very difficult to definitively link illness to aircraft air quality. Further, the self-insured status of the airlines means that their workers' compensation systems are self-regulated, with little or no oversight and plenty of abuse, including near-blanket denials of illness claims relating to air quality. It is not unusual for an affected flight attendant to have to pay to hire an attorney to appeal a simple claim, in addition to paying their medical bills out-of-pocket. The expense, hassle, and potential for discipline discourage workers from filing both incident reports and claims for compensation. So, union and company reporting systems suffer from underreporting, but for different reasons.

Neither the FAA nor the US National Transportation Safety Board collect work-related illness reports from either the airlines or crewmembers. A search of the FAA's Service Difficulty Reporting System - a reporting system for maintenance problems - identified almost 8,268 reports that mentioned "smell", "fume", "odor", "gas", "toxic fume", or "toxic gas" between January 1, 1986 and March 7, 2000. However, these are not illness reports and the validity of this sample is unknown.

Despite the fact that OSHA does not have jurisdiction over crewmembers, the airlines are required to log crewmember-reported occupational illnesses and "recordable" injuries, as per 29 CFR 1904, because the US Bureau of Labor Statistics (BLS) may enlist any airline to participate in its annual survey of occupational injuries and illnesses. As a result, the BLS has extensive documentation of flight attendants' work-related injuries and illnesses, and its analysts have provided extensive information to AFA, as per our many requests. For reasons that are unclear, however, the FAA has elected not to work with the BLS or AFA to analyze this information, and instead maintains that it is necessary to start data collection "from scratch" before it can rule on whether any new crewmember safety and health regulations are justified. Instead of issuing OSHA-type incident reporting regulations, the FAA plans to develop a voluntary crewmember safety and health "partnership program" with the airlines, including incident reporting *recommendations*. The airlines' history of ignoring FAA-issued recommendations speaks for itself.

Although the data that the BLS has collected is useful, there is evidence that the logs of air quality-related illnesses currently maintained by the airlines (and sometimes submitted to the BLS) underestimate the true rate, even of *reported* incidents. For example, in mid-1998, a representative at one airline gave AFA a copy of their OSHA 200 log that reported incidents for the first six months of 1998. Seven months later, somebody else at the same airline gave AFA another copy of the 1998 OSHA 200 log, this one printed in December 1998. Nineteen of the 27 occupational illnesses logged in the first six months of 1998 on the June log as "inhalation – unknown cause" or "inhalation-chemical" had been removed on the December log, without justification. This type of discrepancy highlights the need for independent oversight of any data collection effort.

In conclusion, AFA maintains a voluntary air quality incident reporting system but can not estimate a system-wide rate of reported incidents; there is evidence of institutional underreporting to the airlines and discrimination within the compensation system; no government agency is required to systematically collect aircraft air quality incident reports from either crew or passengers; the FAA has not shown any interest in available BLS data and does not intend to issue incident reporting requirements; and airlines oversee their own incident reporting systems.

EXAMPLES OF AIR QUALITY INCIDENT REPORTS RECEIVED BY AFA

The symptoms that flight attendants report, whether to the airlines or unions, range from headaches, nausea, and fatigue, to fainting, neuromuscular damage, and memory loss. Here is an example of an excerpt from a more serious report:

> *"After the aircraft door closed for departure, a strong odor came into back of cabin; at 10,000 feet, flight attendant in aft jumpseat felt 'weird', had difficulty focusing, metallic taste in mouth, body heavy, skin felt hot, nauseous; she went to cockpit to use their oxygen; when there, warning light went off; pilot said there was a hydraulic leak in the main system."*

Time and again, the aircraft occupants are the only "sensors" on board.

Some interested parties assert that these symptoms are explained, not by problems with aircraft air quality, but with "multiple factors" such as jet lag, dehydration, fatigue, or simply "hysteria". Nobody could argue that being on duty for long flights, crossing time zones, and attending to the public are not stressors in and of themselves. However, the data that AFA has reviewed – including medical reports - highlight the persistence and the patterns of symptoms that are often correlated with documented air quality problems.

Often, there is a correlation between incident type or symptoms and certain aircraft models, aircraft, or routes, making the problems easier to define. For example, at one airline, almost half of the 68 air quality incidents logged by the company over seven months were reported on a single aircraft type, although that aircraft type only made up 5% of the fleet. Also, there was a definite pattern to the symptoms – most reports mentioned dizziness and fainting. Another airline logged 760 incidents over a nine-year period that involved either a visible aerosol in the cabin and reported symptoms, or mechanical records that indicated contamination, or both. A single aircraft type was involved in three-quarters of these incidents, even though that aircraft type only made up about half of the fleet.

AIR QUALTY PROBLEMS AND PROPOSED ACTIONS

What follows is an overview of the seven problems listed above, each accompanied by a series of proposed actions.

I. Inadequate ventilation, and the attendant build up of airborne contaminants and increased risk of disease transmission, especially during ground operations

a. Ventilation and "sick building syndrome"

To ensure occupant satisfaction and control ventilation-related reports of ill health and discomfort, the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) recommends a minimum of 15 cubic feet of outside air per minute per person (15 CFM/p) for most indoor environments, including transportation vehicles (Standard 62). Outside air is intended to dilute or remove pollutants generated by occupants, including various gases ("bioeffluents") and infectious agents (bacteria and viruses). Outside air also controls the levels of airborne contaminants released from surfaces (e.g., new carpet, cleaning agents) and processes (e.g., cooking), although in densely occupied spaces like aircraft, people are the main polluters. ASHRAE's Standard 62 is largely based on ventilation engineers' experience with reports of "sick building syndrome", air monitoring, and ventilation rates; specifically, health-based studies of occupants in building environments generally report a marked reduction in symptoms reported by occupants when 15 CFM/p or more of outside air is provided. If occupants are active, then ASHRAE recommends an increased supply of cooler air (Standard 62, Standard 55). On aircraft, this would apply during boarding and "deplaning" to counteract the increased airborne contaminant load generated by sweating passengers and crew that breathe more rapidly and deeply.

In buildings, owners have to comply with minimum ventilation requirements cited in building codes; typically these reflect ASHRAE's Standard 62 (including 20 CFM/p for offices). *Building owners do not have the option to provide less outside air to save on heating and air conditioning costs.* On aircraft, there is no minimum ventilation standard for outside air supply. Airlines are given the option to provide less outside air to save on fuel costs. They need only maintain cabin pressure, which requires approximately 3 CFM/p of outside air.

In buildings, workers that experience symptoms associated with poor indoor air quality (e.g., nausea, headache, dizziness, unusual fatigue) have the right to request an OSHA air quality investigation. OSHA compliance officers are referred to ASHRAE Standard 62 for non-industrial settings. *On aircraft, crewmembers that experience such symptoms have no recourse because they are not covered by OSHA* and Federal Aviation Regulations (FARs) do not allow for air quality investigations.

To best compare ventilation in aircraft and buildings, it is necessary to consider the significantly different volume of "dilution air" that is effectively allocated to each occupant. Airborne contaminants that are generated by people, interior surfaces, and processes are effectively diluted (or concentrated) in this volume of air. The amount of "dilution space" allocated to each person will determine the time it takes for people-generated contaminants to reach their maximum concentration, and the ventilation rate will determine what that maximum concentration will be. In offices, approximately 350-1,100ft3 of dilution air is effectively provided to each person, and **15-20 CFM/p** of outside air is usually provided. This corresponds with a maximum concentration of carbon dioxide (a gas that people generate, and a convenient, oft-used indicator of ventilation) of approximately 1,000 ppm (parts per million parts of air) that will probably never be reached during a typical eight-hour work day because of the large volume of "dilution space" effectively allocated to each person, and the decent supply of outside air. Carbon dioxide levels that exceed 1,000 ppm are not dangerous, but are associated with increased "sick building syndrome" reporting by occupants (see Seppanen, 1999). On aircraft, 35-70ft3 of dilution air per person is typical, and economy-section ventilation rates are typically on the order of **6-8 CFM/p**. This corresponds with a maximum carbon dioxide concentration of approximately 1,800 ppm that is reached within an hour, and maintained from that point on.

On aircraft then, crew and passengers get a higher dose of people-generated contaminants – whether odorous, irritant, or infectious - which likely helps to explain the high volume of complaints received by cabin crew union safety and health representatives worldwide–. It must be noted that the cost of increasing the outside air supply from 5 CFM/p to 15 CFM/p has been estimated at $0.12 (US) per passenger per hour of flight5.

A comparison of air monitoring data collected in buildings and aircraft supports these statements. A review of almost 800 air quality surveys in "problem-free" buildings indicated that only 2.5% of the carbon dioxide measurements were higher than that recommended by ASHRAE Standard 62. In the aircraft cabin, measurements collected on 23 flights averaged 1,756 ppm, and 87% of the samples exceeded the 1,000 ppm upper limit recommended by ASHRAE. Another published study reported average carbon dioxide levels of 1,500 ppm. More recent air monitoring on eight B-777s measured mean carbon dioxide levels that ranged from 1,252 ppm to 1,758 ppm.

Although there is no minimum operating standard for aircraft ventilation, the FAA does now require that ventilation systems on *new aircraft types* must be *designed* to provide at least 0.55 pounds of outside air (lb/min) to each occupant (equivalent to **7.5 CFM/p,** sea level equivalent pressure), as per 14 CFR 25.831(a). However, this 1997 design standard still does not apply to any aircraft being operated today.

Since then, one major US aircraft manufacturer has proposed a minimum operating standard of **5 CFM/p** for aircraft, apparently on the basis of two studies published in the 1980s that assessed *visitors' perception of odor intensity* in a test chamber and auditoria, respectively. It is impossible to follow the logic of applying the results of these odor studies to the health and comfort of occupants on commercial aircraft.

b. Ventilation and risk of infectious disease transmission

Anecdotally, passengers and crew report an association between infectious disease transmission and air travel. These reports are consistent with the close proximity of cabin occupants and the low ventilation rates on aircraft; however, it is difficult to substantiate these claims because of the latency period between infection and symptoms, and the challenge of contacting passengers and crew after any given flight.

Recently, one study did track 1,100 passengers that traveled between the same two US cities, half on aircraft with a 50-50 mix of recirculated and outside air, and half on similarly configured aircraft with 100% outside air. There was no meaningful difference in the frequency of self-reported colds and flu between groups, leading the researchers to report "no evidence that aircraft cabin air recirculation increases the risk for [upper respiratory tract] symptoms in passengers traveling aboard commercial jets." However, neither the ventilation rates during cruise, nor ventilation shut-downs or slow-downs on the ground, nor the presence of gaspers were reported; as such, there is no assurance that the only air quality-related difference between the two sets of flights was the use of 50% recirculated air. (The airlines were informed of the study in advance.)

Further, a subsequent letter to the editor noted that the rate of upper respiratory infection reported by the cohort of airline passengers was four times the national average, suggesting an *increased* risk of disease transmission on commercial flights. This increased risk is likely facilitated by the close proximity of passengers and crew, and low ventilation rates, compared to other environments, as described above. Contact with infected surfaces likely contributes to this increased risk of infection.

In the media, high efficiency particulate (HEPA) filters have been billed as the cure-all for airborne transmission of SARS and other infectious diseases. There is no minimum requirement to install or properly maintain HEPA filters on aircraft; however, some of the major US airlines report that they have done so. Assuming that HEPA filters are installed and maintained properly, they *should* be effective at removing the bulk of small particulate from the portion of air that is recirculated, including bacteria. Viruses are smaller than the pores of a HEPA filter, but if they travel in clusters or on big water droplets (e.g., generated by a sneeze or cough), then they should be trapped by a properly fitted HEPA filter.

However, even the best HEPA-filtered recirculated air does not replace outside air. It does not have the same capacity to dilute or remove infectious agents, and it will not remove gaseous contaminants. Despite this, HEPA filtered air is touted by some parties as being *superior* to outside air because it is more humid. The upside of recirculated air is that it *is* more humid than the outside air supplied by the engines; one downside is that the source of humidification is your neighbors' breath.

As to the risk of exposure to airborne infectious agents, the recirculated air is only part of the problem. If your neighbor sneezes on you, then the aircraft air supply system will be of little assistance at reducing the risk of infection, although vigilant hand-washing and resisting the temptation to touch your face are warranted. If the person sitting two rows down from you sneezes or coughs, then it is important that the airline is providing a maximum amount of outside air to flush through the cabin to remove the infectious particles before they reach you.

Recently, the World Health Organization (WHO) defined "close contacts" as passengers within two seats rows of a person infected with SARS, in addition to the on-board flight attendants. Presumably, the WHO recognizes the potential for ambient air to "drift" between seat rows before returning to the air supply system or being dumped overboard. On one flight, passengers sitting seven rows in front and five rows behind a person with symptomatic SARS developed the disease; however, in this case, the *route* of transmission was not confirmed (i.e., airborne versus touch).

But whether two rows or seven rows, with an overall SARS case fatality rate approaching 15%-; 27 cases of SARS transmission on aircraft, including four flight attendants (see WHO Update 62); evidence that a surface can stay infected for four days; and infectious disease specialists anticipating a surge of cases when winter hits, it is clear that the response of the airlines, the US Centers for Disease Control and Prevention (CDC), and FAA has been totally inadequate to date. *Flight attendants do not have the luxury of postponing travel to affected parts of the world; they must be recognized as at-risk and protected as such.* Airlines' concerns about the aesthetics of wearing gloves and masks should not be more important than flight attendants' health. Trips to SARS-affected areas should not be "business as usual."

In infectious disease jargon, the length of time that an infectious agent stays airborne is called the "residence time." It is considered good practice to decrease the residence time of infectious agents, by increasing the flow of air into the space. This reduces risk of transmission because the viruses or bacteria spend less time in the air, where they can be inhaled.

Another element of aircraft ventilation that may reduce the risk of airborne transmission of disease is the air nozzles ("gaspers") located above passenger seats on some aircraft. Typically, gaspers provide a mix of outside and recirculated air, although this will vary with aircraft type. There is inadequate information to determine how effective a gasper is at protecting passengers and crew from *direct* exposure to infectious agents generated by their neighbors; the protection will depend on the speed of the supply air, and the shape and placement of the nozzle. However, at the very least, a gasper introduces additional air, reducing the residence time of infectious particles. Also, gaspers give passengers and crewmembers some control over the local temperature, which is also important. (See pages 17-18.)

In summary, regarding aircraft ventilation:

- There is no minimum, standardized amount of outside air supplied to the cabin to ensure that airborne contaminants are diluted and removed, despite the fact that the aircraft is the most densely occupied of any environment;

- There is no agency to conduct air quality inspections, as necessary;

- The increased activity level of passengers and crew during ground operations necessitates an increased flow of cooler outside air;

- On a per-passenger basis, the cost of doubling the outside air supply is negligible and should reduce the frequency of "sick building" type symptoms and airborne disease transmission;

- The CDC and FAA do not recognize flight attendants' potential for close contact with SARS, and provide no protection;

- HEPA-filtered air is no replacement for outside air; and

- Gaspers introduce additional air to the cabin and provide occupants some control over cooling.

Proposed actions to reduce illness associated with low ventilation

1. For aircraft types in the current fleet that can not achieve the necessary 15 CFM/p of outside air flow provided in so many other indoor environments, require that all air packs be operated at their highest flow, when the aircraft is fully occupied. For current aircraft types that can achieve 15 CFM/p, and for new

aircraft types, issue an operating standard of 1.1 lb/min (equivalent to 15 CFM/p at sea level).

2. For ground operations, ensure a minimum 15 CFM/p supply of outside air and provide adequate cooling. Do not allow the airlines to leave passengers and crew on board for more than 30 minutes without ventilation.

3. At least on trips to, from, and within destinations affected by SARS, airlines should be required to provide maximum ventilation in the cabin, and crewmember access to appropriate respiratory protection and gloves with appropriate education and training on safe work practices. Flight attendants who are immunocompromised (and documented as such) must have the choice to opt out of trips to SARS-affected countries without fear of discipline.

4. To achieve the benefits of additional air and cooling capacity, require that operational gaspers be provided at each passenger and crewmember seat, as well as in the aisles and galleys.

II. Exposure to exhaust fumes and heated deicing fluids that are ingested into the air supply systems, especially during ground operations.

The quality and quantity of air supplied to the cabin while the aircraft is occupied and sitting at or near the gate is a major source of complaints. Exhaust fumes from diesel-powered ground service vehicles and other aircraft can be ingested into the supply air, especially if the air intake is located near to the vehicles. Other air supply sources on the ground include the airport itself, the Auxiliary Power Unit (APU) located in the aircraft tail, the pneumatic ground power unit, and the pneumatic start cart. All but the airport air introduce the oft-polluted air outside the aircraft to the cabin and cockpit. Deicing fluid can also enter the air supply when the aircraft is being deiced, contaminating the air supply system and also creating a safety hazard on certain aircraft types.

Proposed actions to improve the quality of the supply air during ground operations: Air from inside the airport is the prefered source of supply air on the ground. Require that any portable air intakes be moved, to the extent possible, away from pollution sources (e.g., move air intakes located underneath the jet bridges to the top) so that the air drawn into the cabin is less likely to contain exhaust fumes. Also, require that ground air supply systems, including the APU, be turned off when an aircraft is being deiced.

III. Exposure to partly-combusted oils and hydraulic fluids that can contaminate the air supply systems during any phase of operation.

Heated oils and hydraulic fluids can enter the air supply systems during any phase of flight. Although this happens infrequently, the health impact can be very serious, and the safety of flight can be compromised. What follows is a discussion of some of the contaminants that enter the supply air and the means by which they can do so during the various phases of flight. By now, it is now generally accepted in the aviation industry that this *can* happen - at least on particular aircraft types; after all, the airlines' own maintenance manuals describe clean up procedures. The frequency and the potential impact on the health of the aircraft occupants, however, are still under debate.

a. Overview of mechanical systems

With the exception of ground operations, the two major sources of supply air to the cabin are the aircraft engine compressors and the APU. The selection of the source (aircraft engines, APU, or some ground source) will largely depend on the phase of flight, the aircraft type, and the airport facilities. The supply air, whether from the aircraft engines or the APU, is then cooled, conditioned, mixed with about 50% recirculated air, and supplied to the cabin.

The aircraft engine compressors are the primary source of air to the cabin. Most of the air compressed in the aircraft engines is used for engine thrust, but a portion of that compressed air is "bled off" and routed to the air conditioning system. The APU is the auxiliary source of power and air. It too is essentially an engine, but it is independent of the aircraft engines, and it sits, in most cases, in the tail of the aircraft. The APU is often used for air supply on the ground, and on many aircraft types, it supplies the cabin with air during takeoff and ascent when the aircraft engines need all of their compressed air for engine thrust.

In the APU, the moving parts are lubricated with oils that can be heated to high temperatures during operation. Usually these hot oils are kept separate from the compressor, but sometimes (whether it is because of a leaky seal, a cracked joint, or overfilling by maintenance workers), the heated oils (or the gases that are generated) can leak into the air supply. The APU can also ingest any fluids that leak or spill into the belly of the aircraft and make their way to the aircraft tail (where the APU is typically located) according to the line of flight. This includes hydraulic fluids, deicing fluid, and fuel.

Lavatory fluids can also leak into the belly of the aircraft and enter the APU; heavy lavatory use can cause the lavatory tank to overflow such that the blue fluid and sewage leak into the aircraft belly. Also, if the lavatory pipes are not drained before an aircraft is scheduled to sit overnight in cold weather, the lavatory fluids can freeze overnight, causing the pipes to crack and the fluids to spray into the belly when the system thaws.

Like the APU, the engines – whether mounted on the wing or the tail – are full of moving parts that are lubricated with oils, and those hot oils, like in the APU, can leak into the compressors and enter the air supply. In addition, wing-mounted engines can ingest deicing fluids and hydraulic fluids that leaked from *local* hydraulic systems in the event of a line break, for example. Tail-mounted engines may ingest hydraulic fluids that leaked from hydraulic systems *throughout* the aircraft, for example, those used to control the wing flaps, the landing gear, and the flight controls. Like the rear-mounted APUs, tail-mounted engines may also ingest any other fluids that accumulate in the belly of the aircraft.

In summary, air supplied by the aircraft engine compressors and the APU can be contaminated with partly-combusted oils and hydraulic fluids. Depending on the temperature, some of these contaminants can accumulate on the lining of the air supply ducts, and the ducts are rarely cleaned, providing an additional source of contaminants.

b. Potential contaminants

Incomplete combustion of these oils, fluids, and other organics is one potential source of carbon monoxide (CO). Tricresylphosphates (TCPs) that contain at least one ortho-isomer are another potential airborne contaminant. TCPs are known for their anti-wear properties and are popular additives in engine oils and hydraulic fluids; they are also highly neurotoxic. Laboratory testing has confirmed these chemicals can be generated (in the case of carbon monoxide) and made airborne (in the case of TCPs) at temperatures typical of an operating aircraft engine.

On the maintenance front, the airlines draft their own maintenance manuals - including clean-up procedures. The FAA must approve these manuals, but we are unaware of any requisite measures for preventive maintenance. As an example of how "stringent" the cleanup procedures are, at one airline, a checklist of maintenance tasks for cleaning up oil in the air supply system, instructs the mechanics to clean the system and then find a flight attendant to board the aircraft to do a "fresh nose" test to make sure that there was no residual contamination. Once again, the occupants are the on-board sensors.

Requisite maintenance is unusual but not unheard of; for example, British Aerospace distributed an Inspection Service Bulletin in March 2001 in response to incidents involving impaired performance of flight crew and "circumstantial evidence" that this was caused by oil leaking into the air supply. British Aerospace told airlines that operate BAe146 aircraft to inspect the APU, engines, and air conditioning packs for oil contamination. Since then, several aviation authorities have incorporated this service bulletin into their regulations.

Another serious problem on the maintenance front is that the FARs allow the airlines to fly aircraft with an inoperative air conditioning pack or an inoperative APU, typically for at least 3 days. That APU or air pack could be inoperative because of contamination, but the aircraft is still considered airworthy.

c. Illness reports from crewmembers and passengers

More evidence of a problem with contamination of the air supply is the pattern and persistence of the reports provided by flight attendants, as well as passengers and pilots. The Civil Aviation Section of the International Transport Workers' Federation that represents aviation workers worldwide has been informed of "smoke in the cabin" incidents by flight attendants' safety representatives based in the US, Canada, Australia, Sweden, Denmark, France, and the United Kingdom. The reported symptoms are sometimes consistent with exposure to carbon monoxide and neurotoxic agents.

However, without any protective design, maintenance, or operating standards to prevent air supply contamination; without any air monitoring requirements; without the right to access to maintenance and mechanical records that can – and do - confirm contamination of the aircraft air supply; without the right to access to information on chemical products that enter the air supply; without a centralized system for reporting incidents; without much awareness among physicians, such that proper diagnosis and treatment for crewmembers exposed to toxic substances in their workplace is rare; and without case studies submitted to the peer-reviewed medical literature, the situation is unlikely to improve.

In 2000, a bipartisan senate committee in Australia did release a report summarizing its two-year inquiry into cabin air quality for the BAe146 aircraft http://www.aph.gov.au/senate/whatsnew.htm. It concluded that:

> "*Exposure of air crew and, potentially, passengers to cabin air which may be…even minutely affected, by fumes originating in an aircraft's engines raises the potential of occupational illness and, for certain individuals, an incapacity to continue work." (Section 6.22)*

Although the committee had been charged with investigating complaints on the BAe146, the report also identified similar problems on other aircraft, including the A320 and MD90 (Ibid., Section 6.2). The report recommended that the Australian Civil Aviation Safety Administration (CASA) introduce regulations that dictate specific preventive maintenance procedures and a national standard for checking and monitoring the engine seals and air quality in all passenger commercial jet aircraft. Finally, the committee recommended that CASA implement a national incident reporting system (Ibid., Section 1(b)).

Australia is ahead of the US in this regard: the Australian Transportation Safety Board reported that, last year, when an acrid smoke entered an aircraft cabin during taxi, the pilot stopped the aircraft and instructed the cabin crew to evacuate passengers through the left doors. Subsequent investigation found that a leak in a hydraulic coupling and inadequate sealing of the hydraulic bay had allowed the hydraulic mist to enter the passenger cabin. In contrast, we are aware of flights in the US where contaminated aircraft continue to fly passengers and crew until reaching a maintenance base, saving the airline the cost of taxiing an empty aircraft.

A few years ago, there was actually some regulatory action in the US, in response to

> *"…reports of smoke and odor in the passenger cabin and cockpit due to hydraulic fluid leaking into the auxiliary power unit inlet, and subsequently, into the air conditioning system"* (65 FR 48368, August 8, 2000),

The FAA now requires specific maintenance procedures to increase the robustness of specific hydraulic fluid lines shown to be prone to failure in the APU of certain aircraft types. This will, however, only address a very small piece of the problem on a single series of aircraft.

In conclusion, we know that these oils and hydraulic fluids can leak into the air supply systems; we know that certain contaminants can be generated under the conditions on commercial aircraft; and we know that flight attendants and passengers in a number of different countries have reported symptoms that are consistent with exposure to some of these contaminants, and may have reported nasty odors, mists, and fumes. We also know that in some cases, foreign governments have started to acknowledge the problem. However, cabin air quality problems persist in the US.

Proposed actions to reduce the impact of air supply contamination:

1. Require in-duct carbon monoxide monitoring on all flights and standard operating procedures that pilots must follow if levels of carbon monoxide are elevated, as per Recommendation #4 cited in the 2002 National Research Council (NRC) Committee report. Contaminated aircraft are not airworthy and should not be

treated as such.

2. Equip all aircraft with portable air samplers that could be exposed during an incident to better characterize cabin conditions and provide information to physicians.

3. Require the airlines to provide relevant maintenance and mechanical records to any crewmember or passenger with medical documentation of at least one symptom consistent with exposure to an asphyxiant or neurotoxin, as per the draft Clean Air Act of 2001.

4. Develop a proactive inspection and maintenance program to reduce the likelihood of air supply system contamination, and to identify leaks and spills promptly if they occur. The ASHRAE Aircraft Air Quality Committee has developed a series of draft recommendations to this effect. AFA is aware of airlines that have successfully reduced the incidence of contamination events and should provide specific recommendations. To facilitate such a program, the airlines should be required to route aircraft such that ground time at maintenance bases is maximized.

IV. Reduced oxygen supply during flight

The aircraft cabin is pressurized because the oxygen content in unpressurized air during flight is not adequate to sustain life. The introduction of compressed air into the aircraft cabin ensures that the internal cabin pressure (and the corresponding partial pressure of oxygen) is higher than the outside air pressure at the flight altitude. The cabin pressure is usually referred to in terms of its corresponding altitude ("cabin altitude"). During the certification process, the FAA requires the manufacturer to must demonstrate that the aircraft is "equipped to provide" a cabin altitude of not more than 8,000 feet at the maximum operating altitude (14 CFR 25.841(a)). This design standard corresponds with a supply of approximately 75% of the oxygen available at sea level.

On a new aircraft that is flown at or below its maximum certified operating altitude, the cabin altitude *in operation* should be equal to or less than 8,000 feet. If an aircraft is operated above its maximum certified altitude, then the effective altitude in the cabin can exceed 8,000 feet. Manufacturers anticipate some air leakage through door seals and cockpit windows as an aircraft ages, and report that these pressure losses are incorporated into the design of the air supply systems. However, without measurements or oversight, there are no assurances that aircraft are *operated* at or below a cabin altitude of 8,000 feet.

(14 CFR 25.841(a)). Thee 8,000 feet *design standardlimit* for cabin altitude was first issued in 1957 by the US Civil Aeronautical Board (CAB) and adopted by the FAA in 1964. No regulatory authority has issued an explicit *operating standard* for cabin altitude, except that when the cabin altitude reaches 10,000 feet (essentially an emergency condition), the pilots must don oxygen masks, and at 14,000 feet, oxygen masks are automatically provided to the cabin occupants.

There is no apparent health-based rationale for the 8,000 feet design standard, probably because the FAA was not required to provide substantiating material when it recodified the CAB regulations as Federal Aviation Regulations in 1964. The FAA must now thoroughly justify any new standards but the pressurization standard has not been revisited, and an operating standard has never been proposed. The 2002 National Research Council (NRC) Committee report on aircraft air quality does provide some insight however:

> *"Studies conducted in the 1940s suggested that the maximal acceptable degree of hypoxia in passenger aircraft corresponded to a cabin altitude of 8,000 ft, but it was recommended that under routine operating conditions, cabin pressure altitude should not exceed 5,000 – 6,000 ft. The altitude of 8,000 ft was a compromise between the aircraft design and operation requirements and the human performance impairments."*

Because occupants' oxygen needs vary according to activity level, health status, and age, there is controversy over whether even the 8,000 feet *design standard* is appropriate for the oxygen needs of the flying public. For example, a study of blood oxygen saturation among a group of 42 airline pilots measured an average blood oxygen saturation on the ground of 97% (95-99%) compared to 89% (80-91%) at altitude. The problem is that heart and lung disease, being overweight, old(er), unfit, and taking certain medications will mean that one's body uses that aforementioned reduced amount of oxygen at altitude less efficiently than might be expected among fit pilots. The second part of the problem is that more than half of Americans are overweight and obesity is on the increase in Europe. One in four Americans aged 18 and older smoke, approximately 17 million have asthma, and heart disease accounts for 40% of deaths of all Americans, making it the leading cause. Finally, the flight attendant population has changed after the removal of age restrictions in 1968. Given all of this, it seems more appropriate to base a standard on the blood oxygen saturation of a representative sample of the general public and the active flight attendants, at altitude, not young, sedentary pilots.

Probably the most-quoted position on the subject of cabin pressure is in the report issued by the National

Academy of Sciences (NAS) Committee on Airline Cabin Air Quality in 1986 that said for normal, healthy individuals

"…*pressurization of the cabin to an equivalent altitude of 5,000 to 8,000 feet is physiologically safe*."

However, the committee also reported

"… a 7-10% decrement in maximal performance at altitudes between 7,000 and 10,000 ft"

and *"various degrees of risk"* for people with cardiopulmonary disease and some other ailments at 8,000 feet.

It is not clear whether the committee's conclusions were based on blood oxygen saturation measurements of pilots, but the justification warrants a review because some researchers have suggested that the 8,000 feet limit was developed for the needs of fit military men and that a 6,000 feet limit may be more appropriate for the general public. It is also relevant to note, given the controversy over the definition of an appropriate altitude limit, that there are two cost incentives to pressurize the aircraft to the highest altitude (and therefore lowest absolute oxygen content) possible: first, flying at a lower altitude, all other things being equal, requires more fuel, and second, it is preferable to minimize the pressure differential between the inside and the outside of the aircraft to reduce the strain on the aircraft structure.

Proposed actions to reduce reports of hypoxia: If an operating standard for a maximum cabin altitude of 5,000-6,000 feet is not issued, as per the original intention of the 8,000 feet design standard, then the FAA must establish a research project to collect blood oxygen saturation measurements from a representative sample of passengers and active crew, in conjunction with cabin altitude data, at cabin altitudes ranging from 5000-8500 feet.

V. Inadequate attention to the thermal environment

In addition to providing additional air, gaspers improve the comfort of passengers and crew by providing some control over the thermal environment. To this end, gaspers should be required, not optional, especially in the crew work areas (galleys, aisles) to help compensate for flight attendants' increased activity level (e.g., from bending, lifting, pushing, carrying), and their proximity to the galley ovens.

Also, on the subject of temperature, flight attendants regularly report that the galleys and jumpseats located near the aircraft doors are often uncomfortably cold at ankle level. The doors are poorly insulated (for structural reasons) and, as such, are a strong source of radiant cooling. On the B747, cabin crews report that floor level door heaters improve the galley conditions immeasurably, although installation is only optional.

Proposed action to address temperature irregularities: Require gaspers, especially in crew work areas. Also, issue a thermal comfort standard with a defined target temperature range and maximum vertical and horizontal temperature differentials. Door heaters would be one means to comply with such a standard in the galleys, for example, and have already proven an effective and practical remedy.

VI. Exposure to ozone gas

Ozone is a highly reactive gas and its adverse effects on the respiratory system – even at very low concentrations - are well documented. One comprehensive literature review reported that "a single ozone exposure to healthy, non-smoking young adults in the range of 0.08 – 0.12 ppm produces a complex array of pulmonary responses". Ozone exposure is associated with reduced lung function, exacerbated asthma, and premature mortality. Also, the observed association between long term ozone exposure at £ 0.25 ppm and progressive and persistent lung function and structural abnormalities in test animals raises serious concerns about the effects of chronic exposure on people (Ibid.). Cited animal studies also support the hypothesis that chronic ozone exposure accelerates the aging of the human lung (Ibid.).

Respiratory symptoms associated with exposure include: painful, labored, or rapid and shallow breathing; pulmonary edema; chest tightness; cough; aggravated asthma; temporary decrease in lung capacity; and inflammation of the lung tissue. There is also evidence that ozone gas can induce immune system changes and increase susceptibility to infection. Children, asthmatics, and people with existing respiratory disease are most at risk. Both physical exertion and heat stress have been shown to exacerbate the effects of exposure to ozone. The reduced supply of oxygen at altitude magnifies the effects of exertion because of the attendant increase in the breathing rate.

At ground level, ozone is unnatural – a component of smog, and a public health menace. Exhaust fumes are a source of ozone that can be entrained into the aircraft supply during ground operations, as stated earlier. Generally though, ozone exposure is problematic during flight.

At altitude, ozone occurs naturally and is generally classified as protective of public health because it filters some of the ultraviolet light that can otherwise burn skin and initiate cancer. Commercial aircraft prove the exception to this rule because they operate within the ozone layer, such that the naturally occurring ozone gas not intended for human consumption can be captured and concentrated in the air supply systems. Ozone levels start to increase in the troposphere (located at approximately 26,000 feet altitude at the poles and 50,000 feet at the equator) and generally continue to increase with altitude up to 90,000 feet. The troposphere drops to lower altitudes in the late winter and early spring, such that ozone concentrations increase at flight altitudes, accordingly.

Some ozone will be removed from the air supply when it reacts with the inside surface of the air supply ducts; some ozone will be converted into oxygen if a catalytic converter is installed and operating; some ozone is delivered to the cabin and cockpit.

Ozone exposure limits are many and varied. According to the OSHA, the average concentration of ozone during an eight-hour shift must not exceed 0.1 ppm. The US National Institute for Occupational Safety & Health (NIOSH) is slightly more protective, recommending 0.1 ppm as a "ceiling limit" – never to be exceeded. The US Environmental

Protection Agency (EPA) limit of 0.12 ppm (one hour average) has long been criticized as having "no margin of safety against short-term [health effects]" (see Lippmann, 1993). The 1992 European Union Directive for ozone is more protective, citing a maximum eight-hour average of 0.056 ppm to protect health and a maximum one-hour average of 0.092 ppm for "population information".

The standards supposed to protect passenger and crew health are decidedly more liberal than any other public or occupational health standards. The FARs stipulate that, for flights scheduled to operate above 32,000 feet, the airline must demonstrate ozone levels will likely not exceed 0.25 ppm SLE (sea level equivalent pressure); this is two and a half times higher than even the NIOSH limit intended for worker populations. For flights scheduled to fly for four hours or more between 27,000 and 32,000 feet, an airline must demonstrate that the average ozone concentration will likely not exceed 0.1 ppm. *The different acceptable exposure limits for different altitudes are not health-based.* Further, airlines need not monitor the air to demonstrate compliance; they need only show "by analysis" that ambient ozone levels are unlikely to exceed the said limits. The accompanying degree of statistical uncertainty that must be demonstrated for these analyses is much higher ($p>0.14$) than what is generally considered sound scientific practice ($p>0.05$).

One wonders about the rationale for the 0.25 ppm SLE FAR when studies demonstrate adverse health effects at much lower concentrations. One key element cited by the FAA were the data published by their Civil Aeromedical Institute in which three sets of 28 subjects in their 20s were exposed to ozone in a test chamber intended to simulate flight conditions. When subjects occupied the chamber for three hours and exercised on a treadmill during the last 10 minutes of each hour, there was no significant difference in ozone-related symptoms, whether subjects were exposed to 0.20 ppm ozone or to no ozone at all. However, when the ozone level was increased to 0.30 ppm, all subjects reported ozone-related symptoms. The FAA appears to have picked the intermediate value – 0.25 ppm as an upper limit. Not only is this an imprecise basis for a regulation, the subjects and the physical demands are not representative of today's cabin crew.

Finally, the location of monitoring equipment is especially important when measuring the airborne concentration of ozone gas because it is so reactive. One sampling study reported that about 40% of the ozone present at ceiling height in the economy class section had "disappeared" when measured at a height of four feet above the floor. The ozone levels recorded at four feet above the cabin floor were underestimated, presumably because the "disappeared" ozone had already contacted and reacted with surfaces, including the respiratory tracts and lungs of the passengers and cabin crew. This phenomenon of occupants acting as "sinks" for reactive airborne contaminants has been described elsewhere.

Proposed actions to reduce the impact of exposure to ozone gas: Congress needs to set an ozone exposure limit for application on aircraft that is consistent with ground-based limits intended to protect public health. In-duct ozone monitoring should be required on all high-latitude flights above 32,000 feet, especially during seasons characterized by elevated ozone levels (e.g., late winter and early spring in the Northern hemisphere), in addition to other regions characterized by "fingers" of elevated ozone. At the very least, the airlines should demonstrate compliance with an appropriate (i.e., protective) ozone standard by (1) conducting spot check air monitoring, especially on polar flights during the seasons characterized by elevated ozone, and (2) more frequent replacement of catalytic converters installed on aircraft that fly those routes.

VII. <u>Exposure to potentially high concentrations of pesticides</u>

"Disinsection" is the industry term for the practice of treating aircraft with pesticides to kill any insects that might be on board and might pose a threat to plants, animals, or human health. There is a very serious need to rethink this practice. First, spraying chemical pesticides in an occupied or soon-to-be occupied cabin poses a documented risk to the health of passengers and crew. Second, there is no meaningful enforcement mechanism to ensure that states comply with international requirements intended to protect the health of aircraft occupants. Third, there are reports that some insects are developing chemical resistance to these pesticide products. Finally, chemical spraying is unnecessary because mechanical methods could be applied instead.

Since August 2000, AFA has received reports of illness attributed to pesticide exposure on more than 300 flights, including reports from pilots and passengers. We continue to receive reports and petition for changes. Other crewmember unions in Canada, Europe, and the US have also received complaints. Canadian and British cabin crews have unsuccessfully petitioned for protective gloves and masks.

The symptoms that crew and passengers have reported include sinus problems, swollen and itchy eyes, cough, difficulty breathing, hoarseness, skin rashes/hives that vary in intensity, severe headaches, and fatigue. In more serious cases, crewmembers cite memory loss, nerve damage, severe fatigue, and heightened sensitivity to other chemicals. Some cabin crew have provided medical reports that cite physical abnormalities in the blood, optic nerve, and nervous system that their doctors attribute to "pesticides" or, more generically, "some nerve gas" or "some chemical exposure." In addition to health concerns, there are severe implications for aviation safety, particularly if a pilot is unable to perform their duties, as has been described.

For an arriving aircraft to be received in some countries, flight attendants or agriculture agents must spray the passengers with a pesticide solution (e.g., 2% phenothrin) either during the flight or immediately upon arrival. Alternatively, licensed applicators heavily spray the aircraft cabin before flight attendants and passengers board ("residual treatment") with a solution that is considered chemically effective at killing bugs for eight weeks following treatment (e.g., 2% permethrin). If more than eight weeks elapses before an aircraft returns to a country with residual spraying requirements, then the flight attendants or agriculture agents must spray the passengers anyway. The flight attendants are not provided with any protective equipment and the passengers are not warned in advance.

Even if a passenger knew that Australia requires incoming aircraft to be sprayed, they may not know that a given airline sprays its aircraft that are eventually bound for Australia in Hong Kong on aircraft bound for San Francisco and Chicago, for example. That is, one need not fly to a country with spraying rules to be exposed to be these pesticides; sprayed aircraft are even routed on domestic flights.

The WHO approves these pesticides for application on aircraft because they are apparently effective at killing bugs that carry tropical disease. However, the US Environmental Protection Agency (EPA) will not approve either pesticide for application in the passenger cabin, and doubts that the benefits of spraying exceed the risks. Also, the EPA is reviewing the toxicity of permethrin because of evidence that it can damage the brain development of infants and fetuses. The EPA does approve permethrin for some other uses, such as cargo hold disinsection. However, the attendant exposure potential is quite different from that associated with working 15-hour shifts on aircraft that have been sprayed, but not vented properly.

The neurotoxic effects of permethrin have been documented both in animals and humans. Some of the typical effects observed following exposure to permethrin or phenothrin (tingling, burning, numbness) are caused by the action on nerve endings in the skin. Documented cases of acute, severe, neurologic effects (seizures, loss of consciousness) typically follow heavy exposures. It is unclear how these documented exposures compare to conditions in an aircraft. However, flight attendants' reports of damp surfaces - including the food preparation surfaces in the galley, and regular 15-hour flights indicate the potential for significant exposures, particularly in the crew rest area where the mattresses can still be wet with spray.

In addition to its neurotoxic properties, permethrin has been recognized as an irritant (both to eyes and skin) by the WHO (WHO, 1993), and has been shown to act as an endocrine disrupter, suggesting an adverse effect on the reproductive system. Of 64 cases of chronic pyrethroid intoxication reported to the Federal Health Office in Germany in 1993, eight presented symptoms classified as "multiple chemical sensitivity syndrome" (MCS). The symptoms of MCS suggest immune system involvement, whether related to the pyrethroids or other elements of the pesticide products. There is some concern that pyrethroids may be sensitizing agents; that is, they may produce skin and respiratory allergies. Pesticide exposure in general during the year prior to conception through to the second year after birth is associated with a statistically significant increase in childhood leukemia. Finally, an association between even low-level permethrin exposure and Parkinson's-like damage in the brains of test animals was recently reported.

Exposure differences and "people differences" likely account for the bulk of the difference in opinion of these sprays as "safe" and "unsafe"

As to exposure differences, there is evidence that spraying procedures differ by airline, both in terms of the quantity of in-flight product applied and the standard ventilation procedure following residual treatment. For in-flight spraying, agriculture agents and flight attendants from one airline spray the passengers with 60% more than the maximum recommended by the WHO. At other airlines, flight attendants report that they empty the cans of spray down the toilets. For residual spraying, reports from cabin crew at different airlines indicate that the ventilation period between spraying and boarding can vary from one hour to 24 hours. A related risk factor, for crewmembers especially, is the impact of being exposed repeatedly; this has been shown to facilitate a magnified physiological response. Also, the enzyme that acts as the "front line defense" against the pesticides applied on aircraft (butylcholinesterase) can be inhibited by exposure to byproducts of heated oils or hydraulic fluids, known to sometimes contaminate the air supply on commercial aircraft, as described above.

As to "people differences", those with pre-existing immune system disease, as well as infants and children, are considered to be more sensitive to the active ingredient in the residual sprays—. There are also reports that 3-4% of the population has a genetic defect that results in one of a number of faulty forms of the butylcholinesterase that are less effective at detoxifying the pesticides applied on aircraft, putting such people at increased risk. Research conducted in the 1940s reported reduced levels of that enzyme in women who were pregnant, and even in women who were menstruating, putting them and their babies at increased risk-.

Yet, despite these risks, exposure to pesticides and solvents are totally unregulated.

There is no doubt that it would be inconceivable for an attendant to spray passengers on a subway train, or for offices to be soaked with pesticides shortly before the start of the workday. Aircraft disinsection methods would not be acceptable in any other indoor environment. They should not be acceptable in the aircraft either.

In closing, it is encouraging to note that in recent months, the US Department of Transportation (DOT) has initiated an inter-agency task group that is investigating the potential for non-chemical methods of disinsection such as curtains or walls of moving air across open doors. Principles of mechanical disinsection have been successfully applied on domestic aircraft since the mid-1980s to control the spread of Japanese Beetles, replacing the application of a mixture of DDT and Sevin. This effort must be strongly encouraged.

Proposed actions to reduce the health impact of pesticide spraying rules: As per the 2002 NRC Committee classification of pesticide exposure in the passenger cabin as a "moderate hazard", Congress should ensure that the DOT-led inter-agency task group has adequate funding to develop, test, and promote non-chemical means of disinsection. In the meantime, airlines must be required to ensure that enough time lapses between residual spraying and boarding, such that the cabin interiors are dry and odor free. Also, flight attendants must be notified of the possible health effects associated with exposure to these sprays and (as per the 1995 DOT Notice of Proposed Rulemaking) passengers must be informed of countries' disinsection requirements before they purchase their airline tickets.

CONCLUSION

It is no small task to describe and document problems with air quality on aircraft; hence, the length of this submission. The problems are varied, but there is one constant: the lack of oversight and protective measures. From ventilation to pesticides, there are two sets of standards: one for the aircraft occupants and one for everybody else. This needs to change.

Airline industry representatives assert that there are no problems with aircraft air quality, only the occupants. Certainly, it is in their financial interest to say so. Free of any obligation to provide access to information, and buoyed by financial resources out of reach to crews and passengers, they seem to have convinced the FAA, thus far, that regulation is unnecessary. Flight attendants and passengers, on the other hand, say that there are many problems with aircraft air quality. Certainly, it is in the interest of their health and safety to say so, and to advocate for improvements.

AFA will continue to work on behalf of flight attendants to help prove the connection between air quality and illness, and to work towards change. It is in that spirit that we submit these comments. On behalf of our 50,000 members, AFA thanks the Committee for their consideration.