There is a lot of talk these days about cabin air quality. AFA is actively working on this very issue.

To clear the air (and give you some of the facts) we prepared this bulletin.

What is the problem? Our members report health problems associated with poor quality air in the aircraft cabin. Maybe the air doesn't have enough oxygen, or maybe it is contaminated with cleaning products, de-icing fluid, oil, or pesticides. Exposure to viruses (like the common cold) and bacteria (like tuberculosis) are also a concern.

This bulletin describes three problems with the air quality in the aircraft cabin: (1) Not enough oxygen; (2) Not enough outside air to dilute whatever is in the cabin air; and (3) A contaminated air supply. Exposure to pesticides, ozone gas, and infectious agents (including SARS) are also serious problems. More information is available on the AFA Air Safety, Health, & Security website.

Problem 1: Not enough oxygen?

The aircraft cabin must be pressurized because there is not enough oxygen in the air above 25,000 feet for you to survive for more than a minute or two. It is important to remember that the amount of oxygen in the air is pretty much independent of how many air packs are operating or on what setting. (Inadequate ventilation causes other problems – see Problem #2.) The amount of oxygen available to your body during a flight will depend on the altitude to which the cabin is pressurized. For example, the aircraft might be flying at 40,000 feet but the effective altitude (air pressure) in the cabin may be 8000 feet. The Federal Aviation Administration (FAA) says that aircraft have to be designed so that the effective altitude in the cabin does not exceed 8000 feet, but there is no oversight of this rule in operation. The effective altitude in the cabin can be less than 8000 feet: if a pilot is flying below the maximum allowable flight altitude, then the cabin will likely be pressurized to a lower altitude too. Flying at a lower altitude generally means that you get more oxygen and that the aircraft uses more fuel. In some cases, the aircraft cabin may be pressurized higher than 8000 feet.

When it comes to oxygen, you might be told all about partial pressures and percentages, but the bottom line is this: all other things being equal, there is less oxygen in the pressurized cabin than on the ground. For example, at 8000 feet, you get about three-quarters as much. If your body is in good working order, you should use that smaller supply of oxygen more efficiently than you would on the ground.

However, if you smoke, are overweight or unfit, old(er), pregnant, anemic, taking certain
medications, or have heart/lung disease, your body will use that smaller amount of oxygen less efficiently.

There are mixed reviews as to whether or not the amount of oxygen you get when the cabin is pressurized to 8000 feet, for example, is enough. The 8000 feet design standard was passed in 1957, and the issue has not been revisited since.

Some articles suggest that it was developed for the needs of super-fit military types\(^2\) as an upper operating limit, and that a 5000-6000 feet limit was intended for normal operating conditions\(^3\,4\). Still, other people say that aircraft could be safely pressurized to an even higher altitude, meaning less oxygen for you.

It is true that people who live at 8000 feet (like in Buena Vista, Colorado) breathe air with this smaller amount of oxygen all the time, but their bodies have had time to adjust (or "acclimate"). Apparently, it takes the average person about six weeks of living at that altitude to properly adjust. Certainly, all other things being equal, you need more oxygen than the passengers do because you are moving and lifting and pushing and carrying, while they are watching a movie or sipping a drink.

*In summary, there is less oxygen in the cabin air at altitude than on the ground. It has been suggested that this reduced amount of oxygen is not enough for people who are active and/or have certain physical conditions.*

**Problem #2: Not enough outside air.**

There are many sources of airborne contaminants in the cabin. Maybe people track deicing fluid in on their shoes, or the door seals get sprayed, such that a puddle of deicing fluid forms on the cabin floor. Maybe the cabin isn't ventilated for long enough after pesticides are applied, or the lav is not working properly. Upholstery and carpet can emit low-level gases, and can be contaminated with allergens from pet hair that people bring in on their clothes, and damp insulation behind the walls can be a breeding ground for mold.

The main and constant source of airborne contaminants in the cabin is the people. You (and everybody else) are a source of "bioeffluents"; when you breathe out, your breath contains all kinds of gases and vapors (such as carbon dioxide, ethanol, and aldehydes). Water droplets in your breath (or in a sneeze or cough) can transport bacteria or viruses into the air. Meanwhile, you are busy shedding skin particles (that also serve to transport bacteria and viruses) and your digestive system is busy generating gases.

A steady flow of outside air into the cabin serves to dilute or remove these contaminants. For decades, an inadequate supply of outside air (or a supply of dirty air) has been associated with "sick building syndrome" – symptoms such as nausea, fatigue, and headaches on the ground\(^5\).

Building owners must meet minimum outside air supply requirements. They do not have the option to reduce outside airflow to save money. On aircraft, there is no minimum required outside air supply to ventilate the passenger cabin. The Federal Aviation
Administration just says that the passenger cabin must be "suitably ventilated" (14 CFR 121.219).

How much air is supplied in the economy section? Data suggests somewhere between 6 and 10 cubic feet per minute of outside air to each person. Is this enough? It is about half of what is recommended to control symptoms in a variety of environments, including transportation vehicles.

On most aircraft, about half of the air you get is recirculated. Many of the majors pass the air they return to the cabin through a high efficiency (HEPA) filter first. You might be told that, by replacing outside air with recirculated air, your airline is doing you a favor. After all, you are getting "clean" air that isn't as dry as usual. This is not quite right.

First, under normal conditions in flight, recirculated air is not as clean as outside air. HEPA filters can only trap solid particles; they don't remove gases (like carbon monoxide and ozone, for example) before the air gets recirculated.

Second, not all aircraft are equipped with these HEPA filters because they are not required. Also, filters are only effective if they are regularly inspected and changed. There are no such regulations in place.

It is true that the outside air at altitude is very dry and that this can be a nuisance. The airlines generally do not humidify it because moisture can cause problems of its own, such as mold growth and ice build-up behind the fuselage, depending on the temperature. However, keep in mind that the source of the moisture in the recirculated air that you are breathing is other peoples' breath.

The cockpit gets up to 20 times more outside air than the passenger cabin, and typically, none of it is recirculated. How does the air quality in the cockpit compare with the cabin?

The bottom line is that the outside air needs to be clean, and you need enough of it to dilute or remove contaminants in the cabin air. Some of these contaminants can be a nuisance, but others can be toxic.

The amount of available outside air will vary by aircraft type, but assuming that the air supply is not contaminated, getting the pilots to use all the air packs, and on their highest settings, will improve the cabin environment.

Certainly, the experts on job-related safety and health hazards at the Occupational Safety & Health Administration tell their officers that investigate "sick building syndrome" reports on the ground that "extensive air monitoring may not be warranted because inadequate introduction and/or distributions of fresh air may be the main problem".6

Some people say that an aircraft is a "unique environment", so you don't need as much outside air as in other vehicles or office buildings. We agree that the aircraft is "unique" but if anything, you need more air.

- First, if you don't feel well on a bus, you can open the window or get off at the next stop.
Second, people are more likely to travel on an aircraft when sick than on a bus because it can be expensive or impossible to change a flight.

Third, the concentrations of bioeffluents (those gases, vapors, and skin particles that everybody produces) build up more quickly in an aircraft than in a bigger, less-densely populated space like a building. You need more ventilation in an aircraft than in an office building or a school to protect against this.

In summary, there is no minimum ventilation standard that applies to the passenger cabin, even though contaminant levels can rise more quickly in an aircraft than in a building because an aircraft is a relatively small space. Inadequate ventilation can cause occupants to feel sick.

Problem 3: Contaminated air supply.

In some cases, the quality of the outside air brought into the cabin is the problem. During ground operations, exhaust fumes and heated deicing fluid can get sucked into the air supply systems.

Also, at altitude, the outside air may contain ozone gas which is a strong irritant and may lower your immunity to infection.

Sometimes, the air supply can be contaminated internally. This problem is not new - it has been recognized by the airline industry for at least 20 years. To understand how this can happen, it helps to understand the basics on how the systems work.

How do the ventilation systems work? Outside air is usually heated and compressed in one of two places before it is conditioned, mixed with recirculated air, and then sent to the cabin.

One of those places is the auxiliary power unit (APU) which is an engine that is independent of the aircraft engines and typically sits 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 take off and ascent when the aircraft engines need all of their compressed air for engine thrust. In some cases, the APU can be used during other phases of flight.

Moving parts in the APU are lubricated with oil. If the oil reservoir is overfilled, or if there is a leaky seal or a cracked joint, for example, then the heated oil can contaminate the air as it is being compressed and conditioned before it goes to the cabin and cockpit. In addition, the APU inlet (located near the tail on the underside of the aircraft) can act just like a vacuum cleaner hose, sucking in whatever it finds nearby, and mixing it with the air that goes to the cabin and cockpit. This includes hydraulic fluids, lavatory water, and deicing fluid that can spill or spray into the belly from various locations throughout the aircraft, migrate to the back of the aircraft, and drip through rivet holes in front of the APU inlet.

In flight, the most likely place for the outside air to be compressed is the aircraft engines. Most of the air compressed in the aircraft engines is used for engine thrust, but a portion of that compressed air is routed to the ventilation systems.
Like the APU, the aircraft engines are full of moving parts that are lubricated with oils – oils that can leak into the air supply. In addition, the air compressors in wing-mounted engines can ingest hydraulic fluids from local hydraulic systems if there is a line break, for example. And finally, just like the APU, the air compressors in tail-mounted engines are like a vacuum cleaner hose and can suck in fluids that spill or spray into the belly and migrate to the back.

**Can we prove that this happens?** Leaks and spills of oils and other fluids are reported relatively infrequently but persistently. The FAA does not keep track of these incidents. In some cases, it has been possible for AFA to correlate symptom reports with airline mechanical records that indicated a leakage or a problem in the APU or engines. Airline mechanical records should be freely available to affected flight attendants, but in reality, they are very difficult to access. The best way to prove that a mechanical problem resulted in a contaminated air supply would be to monitor the air supply during an incident, but the FAA does not require this, despite the recommendations of the 2002 National Research Council committee on aircraft air quality.

Recently, the FAA did formally acknowledge one type of air supply contamination on one series of aircraft types. On 8 August 2000, they published an Airworthiness Directive that requires certain modifications to the hydraulic lines and related parts in the APUs of certain McDonnell Douglas aircraft types. The directive was "prompted by reports of smoke and odor in the passenger cabin and cockpit due to hydraulic fluid leaking into the APU inlet, and subsequently, into the air conditioning system" (65 FR 48368, August 8, 2000). This is a step in the right direction but will only address a tiny piece of the problem.

**What is in the air?** There are two airborne contaminants that raise particular concern: (1) tricresylphosphates (TCPs), used as an additive in some popular engine oils; and (2) carbon monoxide, a colorless gas that can be formed when you burn oils and hydraulic fluids to high temperatures. TCPs are neurotoxic, which means that they can damage your brain and nerves. Carbon monoxide is an asphyxiant - it reduces your body's oxygen supply. Remember that you are already getting less oxygen when you are in a pressurized cabin than you would on the ground.

Symptoms of exposure include dizziness, fainting, memory loss, seizures, tremors, vision problems, tingling, weakness, and chills.

You might be told that it isn't possible to be exposed to TCPs or carbon monoxide. This is not true. Scientists have heated two popular engine oils to the temperatures found in an operating aircraft engine and found both TCPs and carbon monoxide in the aerosol/fume that was given off.

So – we know that oils and hydraulic fluids can get into the air supply (because the airlines and the FAA say so) and we know what at least some of the airborne contaminants are. We also have reports from hundreds of flight attendants around the world who report symptoms that are consistent with exposure to neurotoxins (such as muscle tremors, memory loss) and/or asphyxiants (such as...
headaches, dizziness, nausea). This is a very serious problem.

To sum up… Problems with aircraft quality include: (1) not enough oxygen; (2) not enough outside air to dilute or flush out contaminants generated inside the cabin; and (3) a contaminated air supply. For information on pesticides and other problems, contact the AFA international office. Also keep in mind that the health impact of any combination of these problems has not been properly investigated.

You might be told that you have a headache and feel dizzy because you are stressed out, tired, and dehydrated. Even if you are all of the above, don't forget about the potential problems and health effects associated with cabin air quality. Some symptoms are a nuisance, others are serious.

There are solutions…

- First, we recommend that the FAA revisit its cabin altitude limit and collect blood oxygen saturation measurements from members of the flying public and from active flight attendants to examine whether a representative range of people are getting enough oxygen at altitude.

- Second, we recommend that the airlines be required to continuously monitor levels of some airborne contaminants during flights, including ozone and carbon monoxide. Among other things, this would increase the accountability of the airlines.

- Finally, the air supply needs to be clean. We have collected extensive information from two airlines outside the US that have implemented more frequent inspections and parts replacement and achieved a significant reduction in reported air supply contamination incidents. Unfortunately, our efforts to have these implemented in the US have not yet been successful. If airlines routed their aircraft to maximize ground time at maintenance bases, more frequent checks would be easier to achieve.

Whatever the problem, the passenger cabin is your workplace. If you have a problem:

- REPORT IT TO YOUR AFA SAFETY & HEALTH REPRESENTATIVE;
- FILL OUT THE AFA AIR QUALITY INCIDENT REPORTING FORM;
- FILE A REPORT WITH YOUR AIRLINE; AND
- BRING THIS BROCHURE TO YOUR DOCTOR IF YOU ARE BEING TREATED FOR SYMPTOMS RELATED TO AIRCRAFT AIR QUALITY.

Don't just accept a headache after every shift.
If you need to, make a stink.

LET’S CLEAR THE AIR.
**End notes**


2. McFarland, RA; Edwards, HT. “The effects of prolonged exposures at altitudes of 8,000 to 12,000 feet during trans-Pacific flights.” Journal of Aviation Medicine, 8: 156-177 (1937).


**Some extra reading**


Hocking, MB and Foster, HD. Re: Jet Aircraft Travel and Colds. Letter to the Editor submitted to JAMA, 16 October 2002.


