AC NO: 00-52

DATE: 7/21/77

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: OZONE IRRITATION DURING HIGH ALTITUDE FLIGHT

1. PURPOSE. This advisory circular defines ozone irritation, discusses its causes and symptoms, and describes a means of dealing with the problem should it occur in flight. The circular has been prepared because cases of ozone irritation have recently been identified on some flights operating at high altitudes.

2. BACKGROUND.

a. The normal oxygen molecule (O_2) is made up of two oxygen atoms. The ozone molecule (O_3) is made up of three oxygen atoms. While oxygen constitutes approximately one-fifth of the earth's atmosphere, ozone is generally much less than one part per million by volume (ppm) at sea level.

b. The total amount of ozone in the atmosphere and its distribution with altitude varies with latitude, season of the year, and weather conditions. The total concentration and magnitude of seasonal variation of ozone are greatest at high latitudes and least at the equator. Although ozone concentration in the atmosphere generally increases with altitude, the most significant increases occur at and above the tropopause. Flights below the tropopause seldom encounter high concentrations of ozone. Scientific studies have shown that the concentration of ozone at jet aircraft operating altitudes is highest during February through April in the northern hemisphere, and during August through October in the southern hemisphere. Basically this is because the tropopause is lower at this time of year, and ozone tends to descend with the tropopause. In addition, during the spring the upper atmospheric winds characteristically transport higher concentrations of ozone to lower altitudes. Abnormally high concentrations of ozone may occur and persist for short periods of time at certain geographic locations and altitudes near and above the tropopause. The reasons for these occurrences are not well understood at present.

c. Exposure to ozone concentrations below 0.3 ppm for about one hour is usually nonsymptomatic. Exposure to concentrations of about 0.3 ppm causes irritation to the eyes, nose, mouth, and throat. Decreases in night vision ability have been reported by one researcher for exposure to 0.2 ppm for three hours or more, although day vision is reportedly unchanged. Concentrations above about 0.3 ppm can bring about shortness of breath, coughing and, in rare cases, chest pains. The degree of irritation generally increases with increasing levels of ozone concentration, exposure time, and physical activity. People with preexisting respiratory ailments may experience more than average irritation from a given amount of ozone. While occasional exposures are not dangerous or incapacitating for aircrews or passengers during jet flights, the irritation may be quite annoying. The irritation is temporary at these exposure levels; however, until more is known about this subject, it is recommended that exposure to ozone be minimized.

d. Ozone at low concentrations is recognizable by its odor, which is described by some as an "electrical" smell, associated with electrical arcing or lightning. However, the human sense of smell adapts quickly and the odor fades. Therefore, odor is not a reliable indicator of the presence of ozone at concentrations which may cause irritation.

e. Some of the newer subsonic air carrier and general aviation jets are currently certificated to operate at altitudes up to 45,000 and 51,000 feet, respectively, where the concentration of ozone is usually higher.

f. Ozone irritation is generally not a problem on supersonic aircraft, since the ozone is broken down into oxygen by the higher pressurization bleed air temperatures associated with operation at supersonic speeds.

3. RECOMMENDED PROCEDURES. (This section does not apply to aircraft equipped with pressurization and air conditioning systems which break down or filter out ozone to an imperceptible level.)

a. Since high ozone concentrations usually occur at or above the tropopause, the pilot should, during preflight preparation for a high altitude flight, become familiar with the forecast height of the tropopause along the planned route of flight. If the planned flight is near or above the tropopause, the pilot should consider the possibility of encountering high ozone concentrations, especially during the ozone season. In this case, paragraphs 3d and 3e below should be considered during preflight fuel planning. Additionally, it may be possible to use the following general guidelines during preflight planning to choose a route and altitude which would minimize exposure to ozone:

(1) The area on the equatorial side of a jet stream generally has less ozone than the area on the polar side.

(2) In the northern hemisphere, areas associated with anticyclonic curvature of the high altitude winds; i.e., the turning of the streamlines to the right, tend to have less ozone. The opposite applies in the southern hemisphere.

(3) Regions of high tropopause (generally associated with high surface pressure; i.e., a "high") tend to have less ozone. Conversely, regions of low tropopause (generally associated with low surface pressure; i.e., a "low") tend to have more ozone.

b. If the occupants of an aircraft at high altitude experience an irritation of the eyes, mouth, nose, and throat, the pilot should consider the possibility of ozone irritation caused by flight in a region and altitude of high ozone concentration. However, before concluding that ozone is the source of the irritation, the pilot should eliminate other more serious possibilities such as an air conditioning malfunction or electrical smoke. In addition, combinations of other factors have been reported to cause symptoms similar to those of ozone irritation; these factors include the low humidity typical in high altitude cabins, reduced air circulation, and consumption of alcoholic beverages.

c. If symptoms of ozone irritation are experienced in the cabin, this should be reported to the pilot in command by a cabin crewmember. If conditions in the cabin and/or cockpit warrant, the pilot in command should instruct the flight and cabin crew to minimize nonessential physical activity during the exposure period, since such activity may tend to aggravate the irritation.

d. It is generally possible to fly out of the high ozone region by requesting a lower altitude. The amount of descent required is variable; 4,000 feet may be a reasonable amount to try at first. Descending below the tropopause will almost always solve the ozone problem.

e. If the higher fuel flow at the lower altitude presents another problem, the region of high ozone concentration may have been passed after 10 to 30 minutes of flight time, and the higher altitude can again be requested. (This is most likely to be the case on a southbound flight.)

f. When requesting a lower altitude from air traffic control due to encountering a high ozone concentration, pilots should indicate the reason for this request, which can be used as advisory information to other aircraft.

g. It has been reported that alcohol tends to increase the irritation due to ozone. Therefore, consumption of an alcoholic beverage may be inadvisable for a passenger who is experiencing this irritation.

h. Breathing through a warm, moist towel or equivalent, which is held firmly around the nose and mouth, may partially relieve the symptoms of ozone irritation.

i. As discussed in paragraph 2c, exposure to ozone should be minimized by using the recommended procedures of this section. In the unusual event that overriding circumstances preclude such actions, and ozone irritation is experienced for several hours, the following should be noted.

(1) The research study mentioned in paragraph 2c, which reported some decrease in night vision ability for exposure times in excess of three hours, did not deal with the recovery time to regain full night vision ability after the ozone concentration decreases. In the absence of data to substantiate a full recovery during the interval between the start of descent and the landing, it is recommended that the flightcrew use 100 percent oxygen some time prior to the descent if ozone irritation has been experienced for a period of about three hours or more, and if the landing is to be made at night.

(2) This recommendation is based on the fact that breathing 100 percent oxygen is known to improve night vision.

4. FUTURE CONSIDERATIONS AND ACTIONS.

a. During the season of high ozone concentration, only a very small percentage of the more than 10,000 daily flights of United States airliners encounter ozone irritation. This percentage is reduced to nearly zero during the rest of the year. Procedures outlined in paragraph 3 should further reduce encounters with noticeable concentrations of ozone.

b. In order to find a complete solution to all problems associated with ozone irritation, the Federal Aviation Administration (FAA) has initiated several broad programs. As more information is gained, this advisory circular will be updated and other appropriate actions will be taken.

c. Much work on the ozone problem is being accomplished outside FAA. The FAA would appreciate receiving significant new information on this subject as it becomes available. All such information should be sent to:

Federal Aviation Administration
Flight Standards Service
Flight Technical Programs Staff
AFS-203
800 Independence Avenue, S.W.
Washington, D.C. 20591

d. Persons who normally deal with FAA through an FAA region or Principal Operations Inspector (POI) should pass the information to the region or POI, who should then forward it to the above address.

J. A. Ferrarese

J. A. FERRARESE
Acting Director
Flight Standards Service