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Exposure to elevated levels of ozone have been reported to be associated with complaints of discomfort such as dry mouth, eye irritation and dryness, nasal irritation coughing, and headaches. The Federal Aviation Administration (FAA) established regulatory requirements in 1980 to limit cabin ozone levels to no more than 0.25 parts per million (ppm) at any time or 0.1 ppm averaged over a 3-hour interval for any flight over four hours in length. The FAA also published an Advisory Circular (AC), AC 120-38, to provide guidance to air carriers on how to comply with these then new ozone regulations. Methods of compliance include the use of catalytic converters, or ozone filters, designed to remove ozone, utilizing statistical methods to prove that ozone concentrations will not exceed limits for the carrier's route structure and flight planning to avoid areas of reported high concentrations of ozone. The calculations used to determine cabin ozone concentration from manufacturer's filter efficiency data and ozone levels are to be based on published ozonesonde data found in the AC 120-38 or an equivalent data set. Unfortunately, the published ozonesonde data in the AC 120-38 are outdated and the AC does not point to any other data source that is acceptable to the FAA to conduct the required statistical analysis. In addition, once compliance is shown, no follow-up measurements are required to ensure that ozone levels remain below these required levels. Actual ozone concentrations have been measured in the aircraft by several researchers that exceed these regulatory levels. Finally, FAA ozone regulations and AC 120-38 do not address cumulative effects of ozone exposure to crewmembers over multiple flights and do not offer any protection against ozone exposure for crewmembers on non-passenger carrying flights. A revision of federal regulations to afford protection to all crewmembers, account for cumulative effects, and updated compliance methods that rely on current ozonesonde data and periodic ozone monitoring should be accomplished to ensure crewmembers are not subjected to ozone levels that could potentially result in serious health concerns.

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In 1980, the Federal Aviation Administration (FAA) enacted regulations that prohibited air carriers from operating aircraft in which cabin ozone levels exceeded 0.25 parts per million (ppm) at any time or 0.1 ppm averaged over a 3-hour interval for any flight over four hours in length (Cabin Ozone Concentrations, 1980). These regulatory requirements were established after crewmembers reported experiencing headaches and respiratory issues while operating in upper latitude regions at high altitudes (FAA, 1980). Research indicated that these symptoms could be related to high levels of ambient ozone in the aircraft cabin (FAA, 1980). Subsequently, the FAA also published an Advisory Circular (AC), AC 120-38, with the intent to provide guidance to air carriers on how to comply with these then new ozone regulations. A common method of compliance amongst air carriers is the installation of catalytic converters, or ozone filters, that are designed to remove a majority of the ozone in the aircraft air circulation system before it is circulated throughout the cabin. AC 120-38 requires air carriers to initially demonstrate that "the equipment installed will reduce the cabin ozone concentration to acceptable levels" (FAA, 1980, p. 5) through analysis and/or tests that include inflight measurements or acceptable ozone statistical data. However, air carriers are not required by any regulation to continuously monitor ozone levels onboard their aircraft beyond these initial tests or analyses to establish equipment removal efficiency. Multiple studies conducted onboard aircraft in which actual ozone levels were measured indicate that ozone levels can regularly exceed these FAA-required exposure limits on U.S. air carriers (Bekö, Allen, Weschler, Vallarino & Spengler, 2015; Spengler, Ludwig & Weker, 2004). Ozone levels have routinely exceeded 0.1 ppm onboard aircraft on long-haul flights at high latitudes, even those equipped with catalytic converters (Spengler et al., 2004). Passengers have reported experiencing many health concerns, such as headache or sinus irritation, while on board aircraft, and later research has determined that these symptoms could be attributed to high levels of ozone within aircraft cabins (Bekö et al., 2015). These findings indicate a need for better supervision of air carriers by the FAA in regard to ozone compliance.

Additionally, AC 120-38 allows operators to perform calculations to determine cabin ozone concentration from manufacturer's filter efficiency data and ozone levels based on published ozonesonde data in the AC 120-38 or an equivalent data set (FAA, 1980). Ozonesonde data are measured ozone concentration at various altitudes collected with a balloon-type instrument (National Oceanic and Atmospheric Administration [NOAA], 2008). AC 120-38 states that data collected during the Global Air Sampling Program (GASP) by the National Aeronautics and Space Administration (NASA) are not acceptable because they "do not show the necessary resolution elements" (FAA, 1980, App. 2). Further, both sets of ozonesonde data were collected prior to 1980 (FAA, 1980; National Center for Atmospheric Research, 1992), so are outdated because ozone levels throughout the atmosphere have changed since then due to increased efforts from governments to prevent ozone destruction in the stratosphere (Environmental Protection Agency [EPA], 2018). The AC does not point to any other data source that is acceptable to the FAA to conduct the required statistical analysis.

Finally, FAA ozone regulations and AC 120-38 ignore the cumulative effects of ozone exposure to crewmembers over multiple flights and do not offer any protection against ozone exposure for crewmembers on non-passenger carrying flights. A revision of federal regulations to afford protection to all crewmembers, account for cumulative effects, and updated compliance methods that rely on current ozonesonde data and periodic ozone monitoring should be accomplished to ensure crewmembers are not subjected to ozone levels that could potentially result in serious health concerns.

Review of Literature

Ozone levels in the atmosphere

The highest concentration of ozone is found in the stratosphere where it is commonly referred to as the *ozone layer*. The ozone layer prevents harmful ultraviolet radiation from reaching the surface of the earth by absorbing most of the ultraviolet radiation that enters the atmosphere (EPA, 2017c). According to the NOAA (2010), the remaining 10% of ozone that makes up our atmosphere is found between 32,000 and 52,000 feet above sea level. This relatively large concentration of ozone is within the typical cruising range of commercial jet aircraft. Prior to the establishment of the Clean Air Act in 1970, surface ozone levels had also been on the rise due to increases in pollutants emitted by automobiles and industrial factories (EPA, 2017c). Since the initial implementation of the Clean Air Act, surface air pollutants overall have dropped by 70%; however, high ozone levels at the surface still threaten the health of the environment and general public (EPA, 2017c).

Adverse health effects of ozone on the human body

Although the ozone layer plays a vital role in preventing harmful ultraviolet radiation from reaching the surface of the earth, a buildup of ozone at surface level or within an aircraft cabin can be harmful to humans. Ozone primarily has negative health effects on the respiratory system when inhaled, but it can also cause eye irritation (EPA, 2017a). A large amount of ozone that is inhaled will reach the lower respiratory tract where it will be absorbed by the fluid lining of the airways entering the lung (EPA, 2017a). The absorbed ozone damages the cells of the lining causing inflammation of the lungs (EPA, 2017a). The main symptom experienced after inhaling high concentrations of ozone is decreased lung capacity, but other symptoms may include coughing, shortness of breath, chest tightness, throat irritation and wheezing (EPA, 2017a). It should be noted that not all individuals react the same to high concentrations of ozone. Factors such as age, genetics, or body mass index can play a role in how an individual will react (EPA, 2017a). Individuals with predisposed illnesses such as asthma are likely to experience more severe symptoms of the disease (EPA, 2017b). Some studies have shown a correlation between high ozone levels and increased asthma attacks and increased use of medication for asthma (EPA, 2017b).

Regulatory Standards and Guidance for Ozone

Agencies such as the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH) are responsible for establishing regulatory standards and guidance regarding toxic substances to protect American workers. It should be noted that while OSHA does not have jurisdiction over employee exposures while the aircraft is in flight (FAA, 2014), the health and safety of flight crewmembers working onboard commercial aircraft are at risk if exposed above OSHA permissible limits regardless of the location or regulatory jurisdiction. Since most commercial airliners fly at altitudes where ozone is more prevalent in the outside air, aircraft crewmember exposure to ozone should be monitored even more closely.

OSHA (2017) has established the *permissible exposure limit* (PEL) at 0.1 ppm at an 8-hour time-weighted average (TWA) and the 15-minute *short-term exposure limit* (STEL) at 0.3 ppm for ozone. The recommended exposure limit set by NIOSH for ozone is also 0.1 ppm and this exposure level cannot be exceeded at any time (Centers for Disease Control and Prevention, 2016). NIOSH (2016) has established the level at which exposure to ozone would be *immediately dangerous to life or health* (IDLH) at 5.0 ppm. This IDLH concentration was established based on a historical case in which welders developed pulmonary edema after being subjected to ozone levels at 9.0 ppm (Leikauf & Prows, 2012).

The ACGIH (2018) established threshold limit values (TLVs) based on the intensity of workload. The ACGIH TLV is 0.05 ppm for an 8-hour TWA for heavy work, 0.08 ppm 8-hour TWA for moderate work, and 0.1 ppm 8-hour TWA for light work. For all workloads, if the exposure is less than 2 hours, the established TLV is 0.2 ppm (ACGIH, 2018).

NIOSH (2016) suggests that an individual should attempt to move to an area of fresh air or be provided with 100% oxygen in the event that he or she breathes in too much ozone. Aircraft crewmembers are not able to move to an area of true *fresh air* in the cabin because aircraft air circulation systems provide a mixture of both fresh air and recirculated air to the cabin. That being said, NIOSH's recommendation to move to an area of fresh air or be provided with 100% oxygen is most applicable to situations in which an individual is exposed to ozone levels closer to the 5.0 ppm IDLH. Although supplemental oxygen is available for crewmember use, it is unlikely crewmembers would utilize supplemental oxygen in the event they are exposed to high levels of ozone because symptoms of ozone exposure are generic and can be attributed to other possible illnesses.

FAA regulations prohibit certificate holders operating transport category aircraft from allowing cabin ozone concentrations to exceed 0.25 ppm any time above 32,000 feet (Cabin Ozone Concentration, 1980). For flight above 27,000 feet, cabin ozone may not exceed 0.1 ppm (averaged over a 3-hour interval) if that flight is longer than four hours above that altitude (Cabin Ozone Concentration, 1980). AC 120-38 further clarifies that at altitudes above 18,000 feet, ozone concentration may not exceed 0.25 ppm at any time and may not exceed 0.1 ppm for flights over four hours (FAA, 1980). In other words, ozone concentrations exceeding 0.1 ppm are permissible for flights with a duration of four hours or less (FAA, 1980).

Although it is stated in AC 120-38 that current ozone regulations found in 14 CFR 121.578 were prompted by crewmember complaints of discomfort such as eye irritation, coughing and chest pains (FAA, 1980), 14 CFR 121.578 contains a caveat in which the air carrier does not have to comply with ozone regulations provided the flight contains only crewmembers (1980). Any non-passenger carrying flight, such as an all-cargo flight, maintenance ferry flight, or repositioning flight, is not subject to any ozone regulations. For the purpose of the following analyses, we will assume that the scenario flights are passenger-carrying, which affords crewmembers protection from ozone exposure according to the regulations found in 14 CFR 121.578.

Analysis of Ozone Regulations

While FAA regulations allow exposures up to 0.25 ppm for flights four hours or less, this does not necessarily indicate the employee exposure will exceed the permissible limits that have been established by OSHA since the OSHA PEL is based on an 8-hour TWA rather than a 4-hour TWA. However, it is important to note that airline pilots and flight attendants do not usually fly only one flight during their duty period. 14 CFR 121.578 and AC 120-38 ignore the cumulative effects of exposure over successive flight segments. For example, if a pilot were to fly a four-hour flight exposed to 0.25 ppm, spend two hours indoors on the ground exposed to 0 ppm, and then fly another two-hour flight exposed to 0.25 ppm, he/she would be exposed to a cumulative 0.19 ppm over an eight-hour time-weighted period. An exposure concentration of 0.19 ppm is nearly twice the established OSHA PEL and the NIOSH REL.

$$\frac{(4 \: x \: 0.25)+(2 \: x \: 0)+(2 \: x \: 0.25)}{4+2+2} = 0.19 \text{ ppm eight-hour TWA}$$

As another example, if a pilot were to fly a four-hour flight exposed to 0.25 ppm, spend one hour on the ground exposed to 0.05 ppm, which is the average ozone concentration outside at ground level (EPA, 2017d), and then fly a three-hour flight exposed to 0.25 ppm, he/she would be exposed to a cumulative 0.225 ppm over an eight-hour time-weighted period. An exposure concentration of 0.225 ppm is over twice the established OSHA PEL and the NIOSH REL

$$\frac{(4\ x\ 0.25)+(1\ x\ 0.05)+(3\ x\ 0.25)}{4+1+3} = 0.22 \text{ ppm eight-hour TWA}$$

In fact, if a pilot were to fly a four-hour flight exposed to 0.25 ppm and then spend the next four hours on duty exposed to 0.05 ppm, he/she would still be exceeding the established OSHA PEL and NIOSH REL with an exposure of 0.15 ppm over an eight-hour time-weighted period.

$$\frac{(4x0.25)+(0.05x4)}{4+4} = 0.15 \text{ ppm eight-hour TWA}$$

Therefore, there is a discrepancy between what is permitted by OSHA and what is permitted by CFR 121.578. Since OSHA does not have jurisdiction over the health and safety of crewmembers while the aircraft is in flight (FAA, 2014), the scenarios presented by the previous three examples do not violate any federal regulations; however, it does beg the question of why is it permissible to expose aircraft crewmembers to almost twice the permissible exposure limit for other American workers. It could be that more lenient permissible limits have been established for air carriers since higher levels of ozone are unavoidable at the cruise levels of typical airliners. Also, it seems that 14 CFR 121.578 may have been intended to protect paying passengers who are not regularly subjected to higher than normal ozone levels rather than flight crewmembers, especially in light of the fact that crewmember ozone exposure is not regulated at all if the flight segment is non-passenger carrying.

Approved Methods to Comply with FAA Ozone Limits

According to AC 120-38, there are several ways in which a certificate holder can comply with ozone regulations (FAA, 1980). Two of the approved techniques are utilizing statistical methods to prove that ozone concentrations will not exceed limits for the carrier's route structure and flight planning to avoid areas of reported high concentrations of ozone (FAA, 1980). These two methods may be impractical because ozone levels and location vary with seasons and weather activity. An air carrier may also comply by modifying operating procedures, such as recirculation controls, or making modifications to the aircraft itself, such as installing catalytic converters (FAA, 1980). Catalytic converters are a commonly used compliance method amongst air carriers. There are other methods of removing ozone, such as thermal decomposition or gas absorption, but catalysts have proved most effective (Lu, Zhao, Wang, Yang, Zhang & Yang, 2014). Catalytic converters are easily obtained and relatively inexpensive. This method also allows the certificate holder to flight plan through areas of high ozone concentrations. Some statistical analysis is still required when using catalytic converters because filter efficiency must be demonstrated to maintain cabin ozone below permissible levels. The following is a selected equation for determining if exposure is maintained below 0.25 ppm:

$$OZMAX = (1-E)(OZ16)(R)(P/P_O)$$

Where E = filter efficiency, OZ16 = estimated ambient ozone concentration, R = retention ratio of the ambient air that flows through the aircraft air conditioning system, and P/P_O *= the ratio of cabin pressure to sea level pressure* (FAA, 1980)

A drawback of using the equations included in AC 120-38 is that the *OZ16* value, or estimated ambient ozone concentration, is calculated using ozonesonde statistics that were collected before 1980. The air carrier is permitted to use an alternate data set as long as the data meet equivalent standards to the

AC's ozonesonde data (FAA, 1980). Similar to the limitations of the AC's data, if an air carrier were permitted to use the NASA GASP data that are discussed in the AC, it would encounter the same drawback. The NASA GASP ozone data were collected between 1975 and 1979 (National Center for Atmospheric Research, 1992). The AC does not point to any other data source that is acceptable to the FAA to conduct the required statistical analysis.

Ozone Filter Efficiency

Both 14 CFR 121.578 and AC 120-38 require the air carrier to demonstrate that installed ozone filters maintain cabin ozone levels at or below permissible limits (Cabin Ozone Concentrations, 1980; FAA, 1980). It is insufficient for the air carrier to install an ozone filter and simply assume that permissible levels will be maintained. Filter efficiency must be initially tested or otherwise demonstrated by the air carrier (FAA, 1980). Studies have been conducted over the last several decades to monitor ozone levels on United States commercial aircraft at cruise altitude. Findings from these studies indicate that, even with installed catalytic converters, ozone levels routinely exceed the exposure limits established by 14 CFR 121.578 (Bekö et al., 2015: Spengler et al., 2004; Lu et al., 2014).

1992-1993 Ozone Sampling

Spengler, Ludwig & Weker (2004) compiled ozone-sampling data from 106 flights between 1992 and 1993 primarily operated over the Pacific Ocean, Asia, and the United States. Sampled aircraft included Boeing 737, Boeing 757, Boeing 747, McDonnell Douglas DC-10, Airbus 300, Airbus 320, Fokker aircraft, and Tupolev TU-134 (Spengler et al., 2004). Sampling was conducted by placing an ozone direct-reading instrument at breathing level in the forward portion of the cabin (Spengler et al., 2004). Blank samples were also distributed at breathing level throughout the cabin as a control (Spengler et al., 2004). Findings from this study indicated that 20% of sampled flights experienced ozone levels exceeding 0.1 ppm and 11% of sampled flights experienced ozone levels exceeding 0.12 ppm (Spengler et al., 2004). These findings may indicate a prevalence of noncompliance with 14 CFR 121.578; however, the study does not indicate the flight length for each sample, which is a required value to determine noncompliance. A specific sample was cited in the study in which an ozone concentration of 0.208 ppm was measured on a Boeing 757 (B757) flying between Boston and Los Angeles (Spengler et al., 2004). The flight time between Boston and Los Angeles for a B757 is well over four hours, so this measured ozone level is in clear violation of 14 CFR 121.578. It is unclear whether this B757 was equipped with a catalytic converter because the authors (Spengler et al., 2004) stated in the study that it was impossible to determine which aircraft were equipped with catalytic converters and which were not. It is reasonable to assume that most of the aircraft sampled were equipped with ozone filters as it is fairly common now for ozone filters to be included in the standard package offered by the manufacturer. It is also likely that older aircraft that are still in operation today are equipped with ozone converters as air carriers have likely installed converters in an attempt to meet ozone regulations.

Although this paper provides the reader with little insight into ozone filter effectiveness, it does provide evidence that air carriers may not be complying with federal ozone regulations or that these compliance methods are not extensive enough to ensure continued compliance. Spengler, Ludwig & Weker (2004) suggest that remedial measures, such as proper maintenance of ozone filter equipment and close monitoring of ozone levels onboard aircraft flying at high altitudes and latitudes, should be implemented.

2006-2010 Ozone Sampling

During 2006-2007, real-time ozone monitoring was performed on 76 flight segments exceeding 3.5 hours occurred in the passenger cabin while the plane was above 10,000 feet (Nazaroff & Weschler, 2010). Ozone concentrations above 0.1 ppm occurred on eight domestic flights and ozone concentrations above 0.25 ppm occurred on one transcontinental flight, all on planes not equipped with ozone catalysts (Nazaroff & Weschler, 2010). Nazaroff & Weschler also evaluated human subject's symptoms related to air quality and comfort related to ozone concentrations, and found that complaints such as headache, eye achiness, nasal irritation and skin dryness were increased when ozone concentrations were as low as 0.06 ppm.

Between 2008 and 2010 a study was conducted by Bekö, Weschler, Vallarino and Spengler (2015) in which cabin ozone concentrations were measured on 83 U.S. domestic and international flights. This study also included a component in which passengers were asked to complete a questionnaire about any adverse health symptoms they experienced during the flight (Bekö et al., 2015). Ozone measurements were taken using a "2B Tech model 205 ozone monitor" (Bekö et al., 2015, p. 3) that was placed in the aisle or middle seat in the middle of economy class. The findings of this study indicated that 16% of the flights experienced ozone levels above 0.060 ppm and 10% of the flights experienced ozone levels above 0.075 ppm (Bekö et al., 2015). The highest average ozone level for a single flight was measured at 0.114 ppm, which is above the permissible limit of 0.1 ppm for a flight over four hours in length; however, the study did not indicate the flight time for this specific sample (about 66% of the sampled flights were over four hours in length), so it is impossible to verify if this particular flight did exceed regulatory limits set by 14 CFR 121.578. The highest peak ozone level was measured at 0.256 ppm (Bekö et al., 2015), which did exceed the 0.25 ppm FAA limit that should not be exceeded at any time. These measured concentrations are fairly lower than reported concentrations in the study conducted by Spengler, Ludwig and Wekler (2004). Bekö et al. (2015) believed that lower ozone concentrations were measured because a majority of the sampled flights, about 60%, were along equatorial routes. Ozone levels tend to be higher in polar regions at high altitudes (Bekö et al., 2015). Even though a majority of cabin ozone levels reported in this study are below the FAA limits, about 26% of the reported ozone levels are close to exceeding the allowable limits established by federal regulations (Bekö et al., 2015).

Results from the questionnaire indicated that passengers experienced multiple symptoms related to high levels of ozone (Bekö et al., 2015). Bekö et al. (2015) used regression analyses to associate higher levels of ozone with multiple passenger reported symptoms. On average, 52 passengers per flight completed the questionnaire (Bekö et al., 2015). The highest reported symptoms were dry mouth, dry eyes and irritated sinuses (Bekö et al., 2015). Approximately 25% of passengers indicated that they experienced symptoms related to headache or dizziness, and 33% of passengers indicated that they experienced symptoms related to upper respiratory irritation (Bekö et al., 2015). Although crewmembers' symptoms were not reported, it is reasonable to assume that crewmembers experienced similar symptoms during these sampled flights.

These findings suggest that, particularly for aircraft not equipped with catalytic converters or flying in regions of the world where ambient ozone levels are typically higher, cabin ozone levels can exceed regulatory limits established by 14 CFR 121.578. High ozone levels also contribute significantly to passenger and crewmember discomfort and adverse health effects that are experienced while onboard.

Discussion and Conclusions

Since the initial implementation of 14 CFR 121.578 and AC 120-38, it seems little has been done by any federal agency to oversee compliance with these regulatory limits beyond initial demonstration of filter efficiency required by AC 120-38. Three primarily pitfalls of aviation ozone regulations can be identified from this research. Firstly, the regulations established by 14 CFR 121.578 allow crewmembers to be subjected to ozone levels above what is permissible for the average American worker under OSHA regulations, and does not account for the cumulative effects of multiple flights within one duty period. Secondly, data that are required to be used by the air carrier to demonstrate compliance with ozone regulations was collected nearly forty years ago. Thirdly, research conducted on actual flights shows that air carriers are either not utilizing the required compliance methods (ozone filters, flight planning, statistical analysis, etc.) to ensure compliance, or that the compliance methods prescribed by AC 120-38 are not adequate to ensure that crewmembers and passengers are not exposed to potentially harmful ozone levels.

The exposure limits for ozone established by 14 CFR 121.578 do not address the cumulative effects of exposure to ozone over a period of several flights. Under the current regulation crewmembers can actually be exposed to ozone exceeding 0.1 ppm TWA during an eight-hour duty day. An *unaugmented crew* (a flight crew consisting of only two pilots) is restricted to eight or nine flight hours during a single duty period, but is not limited on the number of flight segments it is permitted to fly (Flight Duty Period: Unaugmented Operations, 2012). Therefore, a four-hour flight with an exposure of 0.25 ppm preceded by a flight that is four hours or less with a similarly high ozone level can cause the eight-hour TWA to be twice the established limit for flights over four hours in length, and subsequently exceed the OSHA PEL. Although OSHA PELs do not apply to crewmembers while onboard an aircraft in flight (FAA, 2014), the permissible limit established by 14 CFR 121.578 may need to be altered in order to account for cumulative effects. Furthermore, for non-passenger carrying flights, crewmembers are not afforded any ozone exposure protection under the law. There are known adverse health effects associated with high levels of ozone, and the type of operation should not dictate the applicability of the regulation.

The guidance for air carriers to comply with ozone regulations that is provided in AC 120-38 is based on very outdated data. A revision to this AC may be warranted as the document instructs air carriers to calculate ozone levels by using the data provided in the AC or by using equivalent data, but does not reference or point to appropriate sources of current equivalent data to be used for compliance. Although the FAA may grant air carriers the ability to use updated data on a case-by-case basis, the fact remains that official FAA guidance still points towards outdated data.

AC 120-38 requires air carriers to initially demonstrate compliance with testing, statistical analysis or modeling, but research suggests that ozone levels can still exceed the established regulatory limits of 0.1 ppm for flights longer than four hours and 0.25 ppm at any time. The conclusion can be drawn that either air carriers may not be using the prescribed methods, whether that be flight planning or aircraft modifications, to ensure cabin ozone is below FAA-mandated limits, or the compliance methods located in AC 120-38 are not sufficient to ensure crewmembers and passengers are not overexposed. An air carrier may not be aware that the compliance method it is utilizing to reduce ozone concentrations is not effective since the FAA does not require continuous or periodic monitoring of ozone levels onboard aircraft. A revision of federal regulations should be considered to afford protection to all crewmembers, account for cumulative effects, and updated compliance methods that rely on current ozonesonde data and periodic ozone monitoring to ensure crewmembers are not subjected to ozone levels that could potentially result in serious health concerns.

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