

Bleed Air Contamination Financial Related Costs on Board Commercial Flights

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ABSTRACT

This paper reviews reportable aviation incidents and associated cost losses. Aviation incidents include visible smoke incidents inside aircraft passenger cabins, occurrences of fumes and oily smells, and illness cases reported by flight crew members in 2012, for US based carriers for domestic flights and all international flights that either originated or terminated in the US. Cost losses include direct and indirect costs endured by different airlines due to diversions from the scheduled flight route, returns to departure airport, expedited arrival procedures, and cancellation of flights on ground. Two case study scenarios are presented to illustrate minimum and maximum costs limits. Sources used to collect data for this article include the Bureau of Labor Statistics, Federal Aviation Administration online database, Research and Innovative Technology Administration database (RITA), and official airline websites.

Average financial loss is estimated to be approximately \$32,000 to \$47,000 per aviation incident totaling approximately \$4.5M to \$7M US dollars in 2012. This figure could be doubled when under-reporting of such incidents is taken into consideration.

KEYWORDS: aviation incidents, aircraft cabin, fume odor-illness losses, risk assessment

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INTRODUCTION

This report discusses estimated expenses and financial losses endured by airlines due to unplanned flight diversions or cancellations incurred by oil, fume or illness incidents reported on flights operating inside the United States in 2012. The reports were extracted from the service difficulty reports (SDR) on the US Federal Aviation Administration online database [1].

Bleed air contamination events onboard flights are estimated between 0.09 to 3.9 incidents per 1,000 flight cycles [2]. According to data collected between 2007 and 2012, the Bureau of Transportation Statistics reports a total of approximately 64 million domestic flights in the United States serving approximately two million passengers per day (30,000 flights per day) [3,18]. Thus, considering the lowest limit of bleed air related incidents about 0.09 events per 1000 flight cycles [2], there might be an average of 2.7 incidents per day which can affect an average of two million passengers. A review of data from the FAA service difficulty reporting system (SDR) for the period between Jan. 1999 - Nov. 2008 indicated that there had been 252 events of air contaminants of which 33% were due to fuel leaks, 23% were due to engine oil leaks, 18% were due to APU oil leaks, 13% were due to hydraulic fluid leaks and the remaining 13% (33 events) were due to air cycle machine oil leaks [4]. Murawski and Supplee [5] conducted a survey on the incidents reported by the SDR system within the FAA database and by the Association of Flight

Attendants over the period January 2006 to June 2007. The survey reported 470 incidents over an 18 months period yielding an average of 0.87 incidents per day.

Flight crew members around the world have reported neurological illness after reports of exposure to oil fume, but there were no exposure data to investigate [6]. According to Murawski and Supplee [5], in 2007 the International Transport Workers' Federation Civil Aviation Section in London indicated that flight crew around the world are reporting chronic health effects consistent with exposure to tricresyl phosphates (TCPs), oil aerosols, and carbon monoxide.

Concentrations of volatile and semi-volatile organic compounds (VOCs and SVOCs), airborne particulates, and carbon monoxide (CO) in aircraft cabin air have been suggested as potential indicators of bleed air contamination. The use of these indicators is limited by the background levels from other sources. There have been several additional studies not addressed specifically at bleed air contamination events but that do provide useful baseline information. Malmfors [7] measured CO on 48 Scandinavian Airline System (SAS) routine revenue flights including DC-9 and MD-80 aircraft models. O'Donnell et al. [8] conducted a study on 45 routine revenue flights from seven identical aircraft. The study showed a maximum of 4 ppm for CO; 200 µg/m³ for total particulates; and no VOCs were detected. Waters et al. [9] conducted a study on 36 commercial transport routine revenue flight segments including 11 different aircraft. Average levels of carbon monoxide over the full flight duration were generally less than 1 ppm and during 5 minutes

sampling the average was as high as 9.4 ppm. The predominant volatile organic compound was ethanol. Toluene and limonene were also detected. Toluene levels ranged from less than 0.3 to 130 ppb, limonene from 3 to 12 ppb, and ethanol from 0.8 to 2.4 ppm. Inhalable particulates had an average $120 \mu\text{g}/\text{m}^3$ over the full flight time whereas total particulates had $86 \mu\text{g}/\text{m}^3$.

Guan et al. [10] conducted in-flight measurements on 107 commercial revenue flights operating between August 2010 and August 2012. Most samples were collected prior to take-off, during cruise, and upon landing phases of the flights. The selected aircraft included Boeing models B737, B747, B777, B757, B767, and Airbus models A319, A320, A321, A330, A340, and A380. On average, 59 volatile organic compounds were identified in each flight and were 41% alkanes and alkenes, 15% esters and alcohols, 11% ketones and aldehydes, 20% aromatics (mostly benzene), 6% halides, and 6% of other volatile organic compounds. It was concluded that among the three investigated flight phases, landing showed the lowest exposures compared to prior to take-off and cruise phases. The Institute of Environment and Health (IEH) at Cranfield University reported that the most abundant chemicals measured on 100 revenue flights in 2007, based on mean values, were toluene and limonene. The highest concentrations of tributyl phosphates, limonene, m+p-xylene, and undecane were detected during first engine start, while that for tetrachloroethylene (TCE) occurred at the instant when the sampling kits were opened. On the other hand, the highest levels of triorthocresyl phosphates (TOCP), tricresyl phosphates (TCP), and toluene occurred during climb, pre-landing, and take-off phases, respectively. More than 500,000 particles per cubic centimeter ($\text{particle}/\text{cm}^3$) of ultrafine particles were measured on five flights and more than 10 ppm of volatile organic compounds were measured on 19 flights with the majority being detected during taxi-out phase of the flights [11].

METHODS FOR IDENTIFYING AVIATION INCIDENTS

This report focuses on the costs associated with reported incidents that were related to oil smoke and fumes on board a wide range of commercial aircraft that originated or terminated in the US. The reported incidents were extracted from the US Federal Aviation Administration service difficulty service system [1]. The extracted reports were individually reviewed, case by case, to determine whether or not it qualified as a bleed air event (smoke/fume, illness, or others). Obviously, some degree of judgment had to be applied in many cases. In very general terms, approximately 75% of the incidents included were clearly attributable to bleed air contamination. The remaining 25% were less clear and may have been classified differently by different reviewers. Some incidents were represented more than once within a given database and duplicates were removed from the numbers reported. The bulk of the actual work for the research reported in this paper consisted of identifying and individually reviewing all these incidents reports.

The rates and the costs used were extracted from the Bureau of Labor Statistics [14], airline's websites, and aircraft manufacturers' published technical reports.

In the case of smoke or fume detection, the assumption was made that the flight would divert to the nearest available airport, the airplane would be evacuated, and passengers would be transferred to another airplane for continued travel. In the case of an illness incident, the assumption was made that the flight would divert to the nearest airport to seek medical care for the patient/s and then continue its flight with no changes in the plane. Therefore, many expenses were not included for illness-reported incidents, as indicated in the following sections.

DIRECT AND INDIRECT COSTS

Direct and indirect costs are analyzed in this report to provide an estimate for the cost of reported aviation incidents and events in 2012. Direct costs include costs that may arise due to diversion or cancellation of the flight, such as:

Landing fees: Many airports charge landing fees in order for an aircraft to land on their ground, regardless of whether or not the landing is a result of an emergency. Landing fees vary over a wide range that differ from one airport to another. Scheduled flights contracted between the airline and airport include special rates in a yearly contract for landing, parking, fuel handling, and facilities' equipment usage. However, in the case when there is an aviation incident, the flight would undergo an emergency landing including return to the departing airport or diversion to an alternate; therefore, agreed rates were assumed non-applicable and higher rates were considered.

Parking: Costs associated with parking the airplane in an alternate airport until relocation to maintenance facilities, if available, may be incurred. (Does not apply to illness cases.)

Leasing: While it is unlikely that an airline would make a one-time lease to replace an aircraft sidelined by an air quality incident, the net effect of multiple incidents could reduce the available fleet for an airline. Therefore, leasing a replacement airplane to transfer passengers from the "new-alternate" airport to their final destination may be reasonable. (Does not apply to illness cases.)

Maintenance fees: Maintenance fees incurred to inspect the airplane after a reported smoke smell or smoke detection (Do not apply to illness cases.)

Expenses for flight crew salaries: Flight crew maximum working hours and rest also contribute to the decision when diverting. If a flight crew exceeds maximum working hours as set by the US Federal Aviation Administration (FAA) [17], while the flight is on the ground, the flight cannot take off with that person on duty. (Does not apply to illness cases.)

Expenses and financial losses for extra fuel: Extra fuel used due to diversions, has two scenarios. In the first case scenario, if the incident was an emergency, the airplane would have landed directly without delay so the incurred expenses included the cost of fuel consumed from the point at which the plane began diversion to the temporary airport and then from the airport to the original route toward the intended destination. In the second scenario, depending on the plane