Taylor & Francis
Taylor & Francis Group

AVIATION
ISSN 1648-7788 / eISSN 1822-4180
2017 Volume 21(3): 92–101
doi:10.3846/16487788.2017.1380081

AN ALGEBRAIC MODEL OF HIGH-ALTITUDE AIRCRAFT DECOMPRESSION AND EMERGENCY DESCENT

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Received 20 July 2017; accepted 12 September 2017

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Abstract. An emergency descent maneuver initiated by pilots shortly after the onset of the decompression recognition was developed for subsonic, supersonic and hypersonic cruisers. Among other findings, the times when a passenger cabin is exposed to altitudes above 25,000 and 40,000 ft and the maximum cabin altitude reached are estimated. An airplane descent aerodynamic model was incorporated for high-speed and low-speed high-drag emergency descents. Airplane cabin atmosphere is assumed to be isothermal. The environmental atmosphere is simulated using the NLPAM nonlinear atmospheric model valid up to 47 geopotential kilometers. Rapid and slow decompressions at several discrete cruising altitudes ranging from 12 to 40 km and varying pilot reaction times in initiating the emergency descent were simulated. The main motivation for this work was to estimate times and altitudes a cabin reaches during depressurization for various flight conditions. This model can be utilized in optimizing the emergency-descent piloting techniques, calculating oxygen supplies, evaluating aeromedical factors, estimating harmful exposures to low pressures, and for other important high-altitude aircraft operations.

Keywords: aircraft decompression, emergency descent, atmospheric models, limiting aircraft airspeeds, unsteady descent, aviation regulatory limits, time of useful consciousness, supplemental oxygen.

1. Introduction

The risk of high-altitude airplanes, orbital and suborbital spaceplanes, and spacecraft decompressions poses a great risk to the crew and passengers as well as for an aircraft's structural integrity. Future Supersonic Transport (SST) and extreme-altitude hypersonic transport (HST) will be exposed to extreme (space-like) environmental conditions. The Anglo-French Concorde and the Soviet/Russian Tupolev TU-144 commercial transport SSTs operated successfully at altitudes between 50,000 and 60,000 ft. There will always be a risk of cabin decompression caused by human life-support system equipment failures and structural failures (Macarthur 1994), micro-meteorite impacts (Whipple 1963), uncontained engine damage (e.g., blade separation), etc. In fact, the early jet-age (1950's) was plagued by catastrophic structural failures and explosive/rapid decompressions at high altitudes (Macarthur 1994). In the case of explosive and rapid decompressions, the aircraft's cabin will equalize with the ambient pressure before the flight crew can initiate an emergency descent (ED). However, in the case of slower decompressions, the ED dynamics plays an important part in the local cabin-atmosphere evolution. Hence, to account for all important temporal effects during aircraft decompressions, the aircraft's ED flight mechanics must also be considered.

The purpose of this research paper is to present a simple and useful algebraic model of aircraft decompression

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