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A study of the effect of CPCs on fatigue crack propagation in a representative fuselage lap joint specimen

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ABSTRACT

This paper investigates the effect of corrosion preventive compounds (CPCs) on the growth of cracks emanating from fastener holes in a typical (pressurised) fuselage lap joint. To this end we present the results of a series of fatigue tests in room temperature dry conditions as well as tests where the specimen has been treated with CPCs. The results of these tests reveal that although CPCs do not significantly affect the stresses in the joint they can have a detrimental effect on fatigue crack growth in a representative structural joint when tested in laboratory air.

1. Introduction

It is well known that metallic aircraft structural components are susceptible to corrosion, including general corrosion and localized corrosion, such as stress corrosion cracking, corrosion pitting and exfoliation, and corrosion fatigue interaction. This degradation can adversely affect structural integrity and significantly increase the maintenance costs. As a result corrosion preventive compounds (CPCs) are now widely used with the intention of preventing, retarding and controlling corrosion, as well as for extending service life and reducing life cycle costs.

As documented in [1,2] many of the previous studies [2–14] on the effect of CPCs on fatigue performance have concentrated on using either simple joint configurations or asymmetric joints where the crack growth histories do not reflect that seen in any particular aircraft. Some of these studies have indicated that CPCs can have a detrimental effect on the fatigue life of the joints. Others have shown either a little effect or a small increase in the fatigue life. Refs. [1,2,10,11,13,14] concluded that the main cause for the observed reduction in the fatigue life is most probably due to the change in the local stress states as a result of the lubricative nature of the CPCs used changing the load path in the joint. However, [2] also stated that there could be a reduction in the fatigue life in joints in which friction in the joint plays an insignificant role in load transfer and suggested that the reduction in the fatigue life may be due to the effect that CPCs have on crack closure.

Since the prior researchers have studied the effect of CPCs via relatively simple joint specimens or using specimens where the crack growth history was not correlated to fleet data this paper focuses on a fuselage lap joint specimen that is representative of that seen in a civil transport aircraft and uses a specimen geometry that is known to produce a crack length versus cycles history that is similar to fleet observations [15,16]. This study reveals that for this particular joint configuration

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Nomenclature

CPCs	corrosion preventive compounds
a	crack length
r	radius of the hole
σ_{11}, σ_{22}, σ_{33}	principle stresses
N	number of cycles
α	coefficient in the exponential crack growth relationship
C	a constant in the exponential crack growth relationship

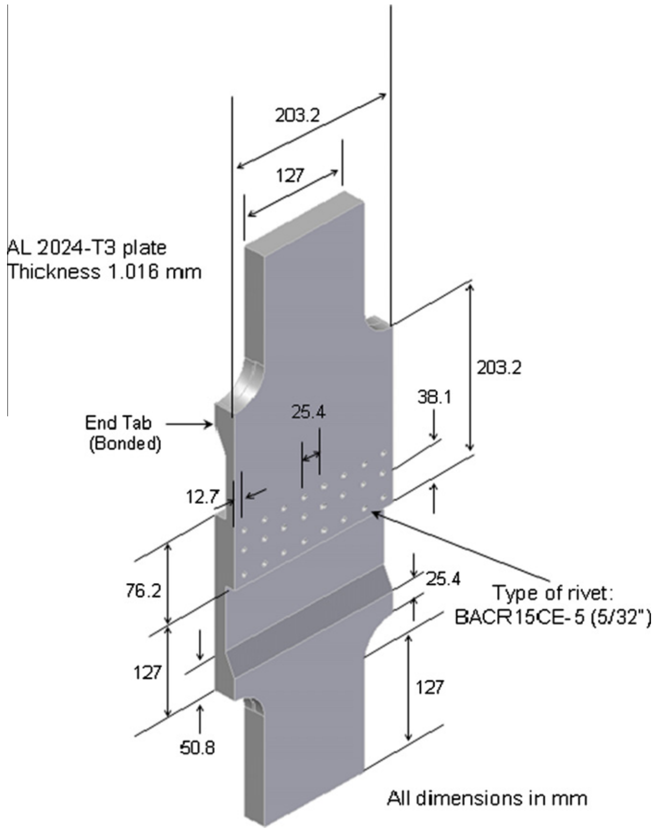

Fig. 1. Schematic of a fuselage lap joint specimen, all dimensions in mm.

CPCs only have a small effect on the load transfer in the joint. Nevertheless, when tested in laboratory air[1] the experimental results reveal that CPCs can have a detrimental effect on fatigue crack growth. As such until this observation is fully understood it is recommended that tests to establish the damage tolerance of joints treated with CPCs should involve tests both with and without CPCs and that these tests should be performed in the appropriate environmental conditions.

2. The experimental test program

To investigate the effect of CPCs on fatigue crack growth in a "real life" structural joint we began by examining cracking in a specimen representative of a typical Boeing 737 fuselage joint, see Figs. 1 and 2. The specimen design adopted followed that used in [15], as part of the FAA Aging Aircraft Program, which was shown to reproduce the crack length history seen in Boeing fleet data [15,16]. The basic specimen used consisted of two 2024-T3 clad aluminium alloy sheets 1.016 mm (0.04 in.) thick, fastened with three rows of BACR15CE-5, 1000 shear head counter-sunk rivets, 3.968 mm (5/32 in.) diameter,

[1] It should be noted that laboratory air is an environment, although not necessarily and aggressive environment.