DEVELOPMENT OF A TESTING PROCEDURE TO EVALUATE THE PERFORMANCE OF AVIATION FIRE CONTAINMENT SOLUTIONS FOR LITHIUM-ION BATTERY FIRES

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Degree of Master of Engineering in Manufacturing Systems Engineering

Department of Mechanical Engineering

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature: Date: 04/12/2022

The above candidate has carried out research for the master's thesis under my supervision.

Name of the supervisor: Dr. L. U. Subasinghe

Signature of the supervisor: Date: 05/12/2022

ABSTRACT

Fire containment is an important element within the air cargo industry when transporting lithium-ion batteries (LIBs). Existing fire suppression systems and fire detection methods used in aircraft are seen as incapable of preventing fires that are originating within the Unit Load Devices (ULD) especially fires originating inside ULD containers. Halon based fire extinguishing systems presently available in aircraft cargo compartments are not enough to put down lithium-ion battery fires. The development of Container Fire Containment Covers (CFCCs) is a latest innovation that has a large impact on the safety of both passenger and freighter aircraft. CFCCs which use a passive fire suppression system are becoming a global norm that can be used to protect each individual ULD container separately and prevent fire from spreading to the adjacent cargo loads. However, there is a lack of evidence on an experimental method to determine the capability of industrial fire containment solutions used in aircraft for containing LIB fires initiated inside ULD containers. Therefore, this study proposes an experimental test method to evaluate the fire containment performance of CFCCs under a LIB fire. The fire containment capability of CFCC designs developed for two different ULD container configurations (AKE and AMJ) are assessed using the developed test method with 2000 and 5000 18650-sized LIB cells respectively with each CFCC design validating the test method. The condition of the ULD containers is also assessed to guide container manufacturers on damages caused by a LIB fire. The results and observations of the fire tests show that ULD containers alone cannot withstand a LIB battery fire and the CFCCs are capable of containing a LIB battery fire for the tested magnitude. Based on the results CFCCs can be considered an acceptable solution to safely transport LIB shipments in commercial aircraft.

Keywords: Fire containment, Lithium-ion battery fire, fire tests, Fire containment cover

DEDICATION

I am dedicating this thesis to two beloved people who have meant and continue to mean so much to me. Although they are no longer of this world, their memories continue to regulate my life. First, to my maternal grandfather, Austin Dias whose love for me knew no bounds and, who taught me how to patiently achieve goals in life. And to Rev. Fr. Bonnie Fernandopulle who taught me the value of hard work and the need for a good education to live a good and happy life. May you both find peace and happiness in heaven.

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LIST OF ABBREVIATIONS

Abbreviation	Description
AS	Aerospace Standard
BOI	Board of Investments
CFCC	Container Fire Containment Cover
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Administration
FCB	Fire Containment Bag
FCC	Fire Containment Cover
FRC	Fire Resistant Container
HDPE	High-Density Polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
PFA	Perfluoroalkoxy
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
SAE	Society of Automotive Engineers
SOC	State of Charge
T&C	Touch and Close
ULD	Unit Load Device