INTERNATIONAL AIRCRAFT SYSTEMS FIRE PROTECTION (IASFPF) MEETING

EASA HEADQUARTERS, COLOGNE, GERMANY

MAY 14-15, 2019

AGENDA:

TUESDAY, MAY 14 2019

Welcome and Meeting/Logistics – Rob Ochs, Ph.D. (FAATC)

Attendee Introductions

Cargo MPS Watermist Testing Update – Dhaval Dadia (FAATC)

Cargo MPS Testing – Dhaval Dadia (FAATC)

Aerosol Can Simulator Pass/Fail Criteria Clarification – George McEachen (Boeing)

Break

MPS Document Review and Revision Task Group – Dhaval Dadia (FAATC)

Effects of Boundary Conditions on MPS Testing– Karsten Kirbach (Diehl)

SAE/ISO Standards on Fire Containment Covers and Fire Resistant Containers – Dhaval Dadia (FAATC)

ICCAIA Cargo Compartment Halon Replacement Advisory Group (CCHRAG) Update – André Freiling (Airbus)

Lunch

EASA Rulemaking Activities – Remi Deletain/Enzo Canari (EASA)

Engine/APU Halon Replacement Industry Consortium – Halon Alternatives for Aircraft Propulsion (HAAPS) Update – Stephane Pugliese (Airbus)

Smoke Generator Standardization for Inflight Certification of Aircraft Cargo Compartment Smoke Detectors – Matt Karp (FAATC)

University of Maryland Detection Work – Rob Ochs, Ph.D. (FAATC)

Smoke Transport Model Development Updates – Amanda Daly (Collins Aerospace)

Break

Powerplant Comparison Testing at FAATC – Rob Ochs, Ph.D. (FAATC)

SAE A-22 Committee: Powerplant Fire Test Standards Development Update – Phil Dang (Honeywell)/John Ostic (Boeing)

Study of Sonic Burner, Carlin Burner and Innovative Mapping Techniques for Powerplant Fire Testing – Mary Kelly (Resonate Labs)

Explosion Proof Testing, Requirements and Safety Considerations – Sham Hariram (Boeing)

WEDNESDAY, MAY 15 2019

Status of the G-27 Lithium Battery Packaging Committee –Doug Ferguson (Boeing)

Tests Supporting SAE G-27 – Tom Maloney (FAATC)

PED Hazards in Flight Deck and Cabin – Tom Maloney (FAATC)

UL Containment Bag Committee – Tom Maloney (FAATC)

Break

Status of Lithium Battery Activities – Al Carlo (Boeing)

The PreLIBS Project: What can be Learned from EV Battery Safety– Jonathan Buston (UK Health & Safety Laboratory)

Testing for Characterizing Lithium-Ion Battery Fires (Fire Protection Issues in All Electric Aircraft) – Mark Cummings (Joby Aviaton)

Certification of a Halon-Free Portable Fire Extinguisher- Nik Schaefermeyer (P3 Group)

Additional Discussion/Closing

WEDNESDAY, MAY 15 2:00 PM – 5:00 PM - Task Group & Industry Meetings:

TASK GROUP

Smoke Detection Certification Task Group
SAE A-22 Meeting (*ADVANCE REGISTRATION REQUIRED*)*
ICCAIA CCHRAG

THURSDAY, MAY 16 9:00 AM – 5:00 PM - Task Group & Industry Meetings:

TASK GROUP

Cargo MPS Review and Revision Task Group
SAE A-22 Meeting (*ADVANCE REGISTRATION REQUIRED**)

<u>MINUTES</u>:

<u>TUESDAY, MAY 14, 2019</u>

<u>Cargo Compartment Halon MPS - Water Mist/Nitrogen Fire Suppression System Update</u> – D. Dadia (FAATC)

An error was observed in the way the results of the 2017 MPS Cargo Compartment test were analyzed. This presentation reports the updated analysis of the results. Dhaval explained the previous analysis and updated analysis of the test results. A slide with all of the new analysis is included in this presentation. It will be available as part of this presentation on the FAA Fire Safety website (www.fire.tc.faa.gov) with the documentation from this meeting within a month of the meeting dates.

<u>Cargo Compartment Halon MPS – Boeing Sponsored Agent</u> – D. Dadia (FAATC)

The EC cutoff date for a cargo halon replacement agent in a new design aircraft is 2018. Boeing sponsored a potential cargo Halon replacement agent. Dhaval described the proof-of-concept for this agent. The test scenarios are: surface burning fire, bulk load, containerized, and aerosol can simulator. Tests remaining: 1 3-hour containerized, 4 bulk load, aerosol can simulator test, and challenge fire test. Chiesa: this is not part of the present MPS? Dadia: no, it is not. Steve Happenny has asked us to conduct that test. Carlo: has the test been run with Halon 1301? Dadia: there are plans for it in the future. Chen: were tests conducted in cargo compartment or pressure vessel? Dadia: we did both to make sure you don't have that pressure rise to destroy the container.

DOT/FAA/TC-TN12/11 is the latest version of the Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems

<u>Aerosol Can Explosion Simulation Test Proposed MPS Changes</u> – George McEachen (Boeing)

This is what our Task Group will be discussing on Thursday (May 16, 2019). FAA Tech Notes DOT/FAA/AR-00/28 and DOT/FAA/TN-12/11 were referenced for this presentation. Some clarification is needed in how to run the Short Version of the Aerosol Can Explosion Simulation Test in order to avoid unrealistic settling of the agent. The criteria in the AC Simulator test interpreted literally is unnecessarily constraining. George reviewed the typical test protocol for this test.

The current Cargo MPS document requires that the concentration at the igniter is at the minimum value. If the agent is allowed to settle to achieve this result, this will create an average concentration that is unrealistically low.

George reviewed one proposed solution to agent settling. We will discuss this further during the Task Group meeting on Thursday.

Aerosol Can Test Pass/Fail Criteria: there are several sections of the Pass Fail/Criteria paragraph in the MPS that we will discuss during Thursday's Task Group meeting. George reviewed the Criteria Proposal that will be discussed in Thursday's TG meeting. "The criterion for the aerosol can explosion simulation scenario is that there is no evidence of an explosion or reaction that would be a threat to the integrity of the cargo compartment." Pugliese: threat to integrity of the cargo compartment might be a bit subjective. Quantifiable criteria may be needed. McEachen: I would be open to discussion on that. You have to factor for the volume of the container. Colton: I am used to presentations where we see the aerosol can run in the pressure vessel. Now that we have an agent it has to be run in the cargo compartment, is that why we see that? McEachen: there are two steps with a Halon replacement agent for cargo: pressure vessel test and short version of the aerosol can test – in the document it says to do it in the 2000 cubic foot chamber.

<u>Cargo MPS Task Group – Issues and Potential Updates</u> – D. Dadia (FAATC)

Range of issues with the current MPS document: test procedures, test criteria, minor typos. These are the issues that will be discussed during Thursday's Task Group meeting. Aerosol Can Simulator Scenario: criteria for aerosol can simulator test is stricter than what was tested in the MPS development tests with Halon 1301. An issue arose as we were testing a potential Halon replacement agent and observed a brief flash. As per the current MPS document this would be considered a failure (considered flash/deflagration). Danker: deflagration definition? Dadia: can range from a small flicker from the ignition source to a large fireball. Any ignition event that is subsonic. McEachen: a flash is what you see when the deflagration happens.

Can Halon 1301 pass the MPS test method as currently written? Video of Halon 1301 Test 4 was shown. A deflagration occurred. Halon 1301 Test 9 video was shown. Video of Halon 1301 Test 10 was shown. Overpressure of 0.095 PSI was recorded in an empty compartment. This equates to 0.495 PSI if the cargo compartment was 80% full. Blowout panels in cargo compartments fail in the range of 0.5 PSI-1 PSI. Ferguson: that is generally what the blowout panels are designed to open at, however, they can open at levels lower than that.

Proposal for alternate test method: use of mixing fans in the compartment to ensure there is not a stratification effect of the agent. Increase height of setup. Mixing fans test video -Test 14 was shown.

Summary: issues with the current test methodology will be addressed in the Cargo MPS Task Group meeting on Thursday.

Surface Burning Fire Test Method: positioning of the pan can affect the peak temperatures and time-temperature integrals. MPS development testing doesn't specify the location of thermocouple in reference to the pan. Results from Boeing Sponsored Agent shows an increase when the pan is placed directly underneath thermocouple. Summary: there is an observed effect on the peak temperatures by changing the location of the pan in the compartment. Compare data with other facilities to observe similar phenomenon, if available. Dhaval also mentioned some of the other issues with the MPS document. These will be discussed during the Cargo Compartment MPS Task Group meeting, also. Buston: you showed a video where there was no overpressure measured, but there was quite a lot of movement. How does that correlate? Is it just movement from firing the device? Dadia: During testing you do observe an increase in pressure from .03 to .05 PSI. Buston: Has anyone looked at the stratification of these agents? That could be correlated with a filled compartment? Dadia: in this scenario, we are trying to see if the aerosol can simulator creates an overpressure event. It is something that can help, but I think it goes away from the intent of the test. Question: what are the changes from Test 9 and 10? Dadia: they were very similar tests that were run in exactly the same way. We didn't change anything in the test. Question: in your opinion what is the most realistic scenario then, test 9 or 10? Dadia: these are what were done during the development tests. I was creating what was done in the development tests. Pugliese: did you repeat test the mixing fans test? Dadia: we have plans to do repeat tests of the mixing fans test. Chen: the details of the system are not mentioned. If I want to run the test in China and want to build a facility, it may not be the same as your facility. Dadia: we don't want to restrict a potential agent based on a certain pipe size. Chen: the system design depends on the airplane? Dadia: the MPS is designed to see how the agent performs against the different fire scenarios. The next step would be an airplane test that would be coordinated with the FAA regulatory side. The system design would part of that step.

Effects of Boundary Conditions on MPS Testing – Karsten Kirbach (Diehl Aviation)

Motivation: For the development and certification of a halon replacement fire suppression system extensive testing in alignment with the MPS is necessary. Reference for testing and test results is the MPS Test Article at the FAA Technical Center. The MPS Guidelines include fire load. Diehl got several types of shredded paper: two supplied by FAATC and three (3) were what Diehl usually uses. There was up to 20% difference in gross calorific value. Diehl also did a comparison of the cardboard and the packed MPS boxes. There was up to 13% difference in gross calorific value of the packed boxes. Chiesa: how did you start the fire? Kirbach: nichrome wire wrapped around a sheet of paper and put into the box per the MPS.

Definition of the actual test compartment: is brief in MPS. Thermal properties of MPS test cell lining materials: lining material for MPS test cell is not specified. Up to 56% difference in thermal mass. Thermal mass may influence MPS results. Possible effects of different lining materials: damping of peak temperatures or increased thermal inertia of the test setup.

Summary:

Further investigation of macroscopic combustion behavior of common MPS fire loads is needed to better understand possible impact on MPS test results. A more detailed definition of “simulated, below-floor cargo compartment of a wide-body aircraft” and “loosely packed standard weight office paper shredded into strips” is necessary to achieve comparable boundary conditions for different test articles. Dadia: have you looked into other variables such as humidity as well? Kirbach: yes. Our compartment is not in a hanger as the FAATC compartment is, so we have looked into other variables. Dadia: can you share this information with the Task Group? Kirbach: we will look into that.

<u>FAA Update at the SAE-AGE2: Fire Containment Covers and Fire Resistance Containers</u> – Dhaval Dadia (FAATC)

TSO-C90e ULDs - Goal: release within 6 months after release of AS8992. Incorporates: AS6278/1, AS36100B, AS36102B, AIR1490C, AS6453A. It does not incorporate TSO-C203 and AS6453. AS6163 may be incorporated into a separate TSO – Hal Jensen (AIR-6B3) is working on this topic.

TSO-C203a Fire Containment Covers: Goal: release within 6 months of AS6453A.

<u>ICCAIA Cargo Compartment Halon Replacement Advisory Group (CCHRAG) Update</u>-André Freiling (Airbus)

Members: Airbus, Boeing, Bombardier, Embraer, Mitsubishi. Recommended cargo halon replacement deadline for new TC applications after 2024. ICAO supported questionnaire on halon replacement technologies (2017). CCHRAG made a technical assessment from responses received: Eight (8) participants with 9 potential replacement solutions. Technologies include chemical agents, inerting systems, and new/novel equipment. CCHRAG is optimistic that a solution will be available to meet the ICAO deadline. Assuming further development by the participants and timely government approvals. The results of the Technical Assessment were reviewed.

Summary: CCHRAG group concludes that the solutions assessed are in various states of production readiness. André reviewed all of the additional summary items.

Future Outlook: The drive for improved safety and fire protection on aircraft is increasing. Aviation authorities are challenged to ensure that all fire threats are addressed and seek opportunities to better understand the risks and investigate potential mitigations. The CCHRAG welcomes the FAA’s New Cargo Suppression MPS Task Group and will participate to ensure alignment as new technologies are actively undergoing research and testing to meet the current cargo fire suppression requirements.

The ICCAIA CCHRAG Technical Assessment Timeline was reviewed. CCHRAG will prepare an Information Paper or Technical Assessment for the ICAO General Assembly.

<u>EASA – Rulemaking Activities</u> – Enzo Canari (EASA)

Halon Replacement Status:

DG-CLIMA Discussion: clarification of EC Regulation No. 1005/2009, ie: definition of new equipment vs EASA Change Product Rules (Part 21).

Derogation process: entry point DG-CLIMA/Member State: derogation request already filed to DG-CLIMA for Engine application by a EU member State in support of EU Applicant. Halon guide (DG-CLIMA/EASA) in preparation. Chiesa: this guide is not going to be an AMC format? Canari: it will be more of a book format on EASA website and other websites.

RMT.0560: Halon: Update of Part 26 to comply with ICAO Standards: forward fit date for lavatory built-in extinguishers February 18, 2020. For Halon Replacement Rulemaking activities at EASA is Youri Auroque (Regulations Officer). Powerplant Systems: Remi Deletain. Cargo Compartments, Lavatories: Thomas Manthey.

Halon-free Portable Fire Extinguishers: EASA considers the installation of a new halon-free fire extinguisher will require the issuance of a MOC CRI and therefore has to be considered as a major change to the aircraft design. EASA has developed generic MOC CRIs to address the installation of portable halon-free fire extinguishers on large airplanes and large helicopters. The CRIs require demonstration that performance of the extinguisher is guaranteed in all applicable environmental and operation conditions.

Cargo Compartment MPS: In October 2018, EASA took the action to coordinate with the FAA and confirm that additional testing will be required beyond what is already prescribed by the existing MPS. Coordination between the FAA and EASA was finalized in March 2019, and a common position has been reached on the approach to be followed for upcoming certification projects. The FAATC experimented this concept in the tests conducted in 2018 (the so-called “challenge fire test”). The setup used in those tests is to be considered only indicative of what the final test definition could be. The detailed test conditions, including the definition of the fire load (number, type and SoC of batteries, number, type, etc.).

EASA Proposed Certification Memorandum on Smoke Propagation Testing:

EASA CRI on potential risks due to devices containing lithium batteries located on the flight deck: in May 2018 EASA released to EASA TC holders a Continuing Airworthiness Review Item (CARI) to address the higher risk of inflight lithium battery fires due to the increasing number of lithium batteries contained in equipment carried by the flight crew on commercial transport aircraft. The content and applicability of the CRI is currently under discussion at EASA. Freiling: it is critical to define a timeline when this test will be available since many manufacturers are in the process of testing. Canari: the background for this test is more the series of events in the past year with lithium batteries. The approach we want to use is to consider realistic fire scenarios. We are not saying we will remove the aerosol can test from the list. It is a critical test. The two discussions realistic fire scenarios and definition of test condition are priorities. The CRI for us is the best tool at the moment. McEachen: If it is specific to the agent and not the installation, it would make sense to bring it into the MPS. Maybe Thursday during the Cargo Compartment MPS Task Group meeting we can talk about how we pull that into the MPS.

<u>Engine/APU Halon Replacement Industry Consortium – Halon Alternatives for Aircraft Propulsion (HAAPS) Update</u> – Stephane Pugliese (Airbus)

Objective: define common non-halon fire extinguishing solution(s) for use in engine/APU fire zones that meet a number of points. HAAPS organization was explained. HAAPS Critical Milestones were reviewed. Phase III [execute activities required to produce the solution(s)] expected to end with final solutions (est.) by October 2022.

Phase II – currently in process (development of Technical Statement of Work & Industry Engagement).

<u>Methods for Characterizing Theatrical Smoke for Smoke Detection Certification (Cargo Compartments</u>) – Matt Karp (FAATC)

The test methods and test equipment were described.

Aircraft Manufacturers' Setups: three major aircraft manufacturers' smoke generators and settings are tested and compared. Matt explained how the Scanning Mobility Particle Sizer (SMPS) works. There are some potential issues with Mie Scattering Theory. Matt reviewed these potential issues.

Repeatability: the percent deviations between a minimum of three tests over 10-second periods are calculated to determine test repeatability. Future Testing: Matt described the potential future tests. Danker: is it generally accepted that large particles are indicative of false alarms and where do they come from? Karp: they can come from humidity, dust insecticide. I think it is generally agreed upon that larger particles indicate false alarm. Hariram: how does this correlate with the smoldering suitcase fires? Karp: we are looking to move away from the smoldering suitcase fire scenario. The smoke that comes out of a smoldering suitcase can vary significantly. Question: refractive index: did you measure the refractive index of the smoke generator at the end of the day? Karp: I don't think it is going to be representative of the refractive index of the particles themselves.

<u>Improvements in Aircraft Fire Detection – University of Maryland Research</u> – R. Ochs, Ph.D. (FAATC) for Jim Milke (University of Maryland)

Motivation: need for timely fire detection in cargo compartments onboard aircrafts. Reduce proportion of false alarms.

Previous progress: background study completed and initial experiments conducted. They did a full-scale test at the FAATC.

Results with Aspirating Smoke Detector: it was compared with Whittaker smoke detector.

Results of tests conducted were reviewed (with Gas Sensors). Publication of Selena Chen's thesis is in process and will be available on the FAA Fire Safety website (www.fire.tc.faa.gov) in the future.

Rob reviewed the planned upcoming research.

<u>Smoke Transport Modeling: Validation Study</u> – Amanda Daly (Collins–Kidde Fire Protection Systems)

Objective: develop a model-based tool to augment detection system design and streamline certification process. Reduce the cost of certification by having more certainty when going into inflight certification tests. Components of the model-based design tool: detection system response, smoke transport, and smoke generator. The bulk of time is spent on the smoke transport model because it is very important to model the smoke accurately.

Validation tests performed at UTRC Multiphase Injection Lab - 5 meter x 5 meter x 3 meter high with no ventilation. Two test setups: smoke generator on floor and smoke generator elevated. Tests were performed on different days. One set of smoke generator settings tested. Experimental error within 10%. We used Fire Dynamics Simulator (FCS) from NIST. Data collected from these two setups was presented. Similar velocity profiles along the plume centerline at same comparable heights. CFD accurately predicts the measured centerline data for both plume heights from the experimental data.

Ceiling jet correlation was investigated next. CFD and correlation comparison: ceiling jet temperature and velocity: CFD simulations confirms correlation trends for ceiling jet temperatures and velocities. We need to investigate the ceiling jet information a bit more.

Next step: Detection System Response: validate the detector alarm times predicted by the tool with acquired test data.

<u>Oil Burner Testing of Powerplant Components</u> – Robert Ochs, Ph.D. for Tim Salter (FAATC)

This is work supporting the SAE A-22.

Thermocouple Round Robin – initiated by Resonate Testing – testing completed in April 2019 at FAATC.

Support composite material testing round robin is in progress.

Composite Materials Evaluation (Spirit Aero): cantilevered weight installed on rear center position of 4-ply and 8-ply composite panel. Initial testing at NIAR.

Future Work: Sonic Burner Comparative Testing with Park Burner

Baker: is the comparative testing scheduled? Ochs: I think he is working on that now.

SAE A-22 and AC20-135 Revision – Status – Phil Dang (Honeywell), John Ostic (Boeing)

Phil provided background, membership and top issues this committee is working on. The SAE A-22 Subgroup Structure and tasks were outlined.

Study of Sonic Burner, Carlin Burner and Innovative Mapping Techniques for Powerplant Fire Testing – Mary Kelly (Resonate Testing)

Background: comparison of new sonic burner with existing burners carried out to add to the body of knowledge and increase consistency between labs.

Innovative R&D – Sonic Burner Modification – Round 1 and Round 2 reviewed. Data from these tests was presented. Results of comparison of baseline Carlin, Sonic (FAA), and Sonic Modified Burners were presented. Mapping plots: sonic burner with new modifications and two different fuel and air parameters going in (run with no board and with ceramic fireboard).

Summary of main observations:

Sonic can be modified from current configuration to achieve traditional burner-like output. Tools have been developed to achieve greater understanding of burner outputs. For any given burner setup we might be able to establish useful expectations in terms of time to 4500 BTU/hr and peak value – will likely rely on more data than simply average. Do not draw major conclusions from shallow data sets. This is particularly important when talking repeatability.

Future work:

Aluminum strip idea – electrical cond. – takes out difficult burnthrough assessment and is cheaper. Composite panels? Other labs' involvement? Question: you got the Marlin sonic burner and set it up and modified it and then tried to go back to the original settings? Kelly: it wasn't close to the same value.

Explosion Proof: Requirements, Testing and Safety Considerations – Sham Hariram (Boeing)

Sham reviewed the FARs that require explosion proof tests: 25.863, 25.869, 25.981, 25.1181, 25.1435, and 25.1723.

Explosion Proof – Requirements: explosion-proof is when components are installed in an airplane environment that may have flammable fluids and/or flammable vapors present during normal operation (fuel tanks), due to system leakage from component wear, and due to a single failure. Two aspects of explosion-proof requirements: explosive containment and explosive atmosphere. Two Standards: RTCA DO-160G and DoD Test Method MIL-STD-810G, Method 511.5.

Graphic of explosion-proof test chamber was shown and described. A graphic of the inside of the explosion-proof test chamber was also shown and described. Sham reviewed the typical equipment required for the explosion-proof test.

Explosion-proof testing can be very hazardous. Test chambers used for these tests can vary in size, and must be capable of safely withstanding an explosion. The chambers incorporate some type of pressure relief feature which vents the chamber to ambient in the event of an explosion. This pressure relief feature is a source of dangerous high energy, high noise, high velocity air and/or debris, high temperature, and flames. In addition to pressure relief features, the chamber will have a number of other features such as viewing windows, doors, penetrations, etc. Sham also provided a list of safety concerns that need to be addressed before the test such as verify that the pressure chamber is designed to withhold the explosive pressure, etc.

Sham provided a summary of the DO-160G, Method 511.5 Test Procedure.

WEDNESDAY, MAY 15, 2019

Status of SAE G-27 Lithium Battery Packaging Performance Committee – Doug Ferguson (Boeing)

Doug provided background for this committee and its charter. The AS6413 draft is now being worked on by the full committee. This committee was initiated in February 2016. There is one telephone/Webex conference call of the full G-27 committee per month. There have been eight (8) face to face meetings of the G-27 committee in U.S. and Europe. The next meeting is July 2019. This is to carry lithium batteries packaged on their own not in equipment. It addresses the needs to control the hazard from a failed individual cell within the package. Doug described the test. Question: has the committee seen a benign cell pass? Ferguson: I have not seen any data that the benign cell passed yet. Hariram: do they ever ship battery at zero SOC? Ferguson: no, because then you are going to introduce the potential for damage to the cell that might lead to failures down the road. Roudebush: what is the next step after the Standard is put into place. Pfund: How the Standard will be implanted is still in discussion once we figure out what the Standard has in it. It depends on how robust, detailed or cumbersome it is. It will have to go through a regulatory process in the U.S. Roudebush: would it go into a category similar to other hazardous goods shipped via aircraft? Pfund: my guess is yes, I would envision it to be a similar type of system. The shipper system is more of a self-certification system. This is still in discussion. There are third parties such as UL talking about a third-party audit process. ICAO Dangerous Goods Panel (DGP) is very interested in having some type of tracking system. Cummings: benign cell tests vs. benign battery test? Ferguson: you can ship cells or you can ship batteries. There are different ways to test a battery than a cell. You would get a benign cell by reducing the SOC. We are still looking at testing at the cell level. The concept is mostly complete, but there is still some work to be done.

A separate working group for external fire considerations has been established with monthly telephone/Webex and provides updates at each face to face meeting of the committee.

FAA G-27 Test Update – Rob Ochs, Ph.D. for Tom Maloney (FAATC)

These tests are in support of the development of an SAE battery packaging Standard. They are performed at the FAATC. Rob described the two different methods of the test. Summary: at first glance, the pressure/airflow method seems promising. However, validation is needed with other labs to verify correlation.

PED Hazards in Flight Deck and Cabin – Rob Ochs, Ph.D. for Tom Maloney (FAATC)

The background for this work was reviewed. A brief segment of the UK CAA training video on lithium battery fires in the cabin was shown. Our intention with this video series is to go into greater detail on mitigating battery fires. We intend to develop the information for airlines and operators to develop their own guidelines when dealing with PED fires. The goal is for each video to be a few minutes long. Video Clips (drafts) developed of a few of the scripts were shown.

Future work: Alaska Air and CAMI both volunteered to host some filming time with passengers to fill seats for realistic footage.

Buston: It is worth including something about power banks and e-cigarettes at least in the script? Ochs: I will mention that to Tom Maloney.

UL Thermal Runaway Containment Bags – Rob Ochs, Ph.D. for Tom Maloney (FAATC)

UL formed a committee: UL STP 5800 committee. The FAATC is sitting in on this committee. SAFO 09013 is still valid. Colton: I have sat in on that committee. The committee has looked at the different levels of batteries. The committee is looking at having different levels of bags (50 WH, etc.). The committee is still deciding on external temperatures of the bags, etc.

Status of Lithium Battery Activities – Al Carlo (Boeing)

Boeing has an internal team focused on carriage of batteries and an integrated core team. Three categories of batteries: PEDs used by passengers and crew; installed in airplane equipment, and batteries as cargo.

PEDs used by passengers and crew:

Supporting UL activities to develop a standard for fire containment bags for use on commercial transport airplanes. Regulations limit spare batteries to carry-on only, none in checked bags, limit size of batteries in carry-on. Boeing completed testing on fire containment concepts bags using both RLB and NRLB. Passed using sacrificial liquid bags to limit cell to cell propagation. FAA activity to develop improved video training material for crew.

Installed in airplane equipment:

Lithium batteries: Special Conditions and CRIs. Regulations, guidance, MOCs and test methods are in the process of being standardized, harmonized and organized to address the complete set of requirements needed for qualification and certification (cell, battery, device and installed levels). Alkaline batteries: as of early 2018, alkaline batteries now treated as electrical equipment and must be shown compliant to 25.1353. Lithium batteries: working with suppliers to test current equipment, revised equipment, new equipment and equipment with added containment provisions against DO-227A and DO-311A. Portable ELT, fixed ELT, ULB, LF-ULD, seat inflatable restraints. Alkaline batteries: working with suppliers to complete failure testing; flashlights and megaphones. Working with suppliers to encourage use of cells per standards for these batteries.

We are asking if it is possible to incorporate Special Conditions for lithium batteries into Regulations? This would be similar to what was done for Ni-cad batteries.

How about detailed test procedures for batteries in a Handbook similar to the Aircraft Materials Fire Test Handbook?

<u>The PreLIBS Project: What can be learned from EV (Electric Vehicle) Battery Safety</u> – Jonathan Buston (UK HSE)

This work is funded out of the ISCF Faraday Battery Challenge in the UK. The PreLIBS project: Project Aims: recognize that the current generations of lithium ion technology is likely to be used in EVs for the next 3-10 years. Understand these safety issues. The project partners were identified. The project outline was reviewed. Project Aims: understand consequences of thermal runaway, thermal propagation; sensing the start of thermal runaway - hindering or mitigating the effect of thermal propagation (active and passive mitigation). Thermal propagation test: new developments from the Chinese Standards. Key requirements: alarm of 'thermal event'. Reliable detection of an event. 'Managing' the event for 5 minutes. Developing a test strategy according to standards.

Work done at UK HSE to date: Jonathan showed videos of some of the battery cell tests conducted at HSE. We are trying to understand how different cell chemistries are going to work. Dadia: what was the SOC during these tests? Buston: it was 100% SOC (worst case). We are also doing some tests at 30% SOC.

HSE also did some gas detection work during these tests. We also looked at a number of different ways of initiating the event – snapshot videos of these tests were shown. Computational modeling of these results was done. We are next going to test groups of cells (6 or so cells and then larger groups) to see how well the model predicts the outcomes of these tests. We are also looking at active mitigation and passive mitigation.

Cummings: what are you trying to do by standardizing a battery fire? Buston: if you are wanting to test mitigation or an agent, in most of the arenas there is a set test you should use – with batteries it is a bit more tricky, because battery technologies change. The aim is to try and create a fire or a series of different fires with different cell formats to reasonably exemplify what that fire looks like and characterize what the fire looks like, so you can recreate that type of fire by any number of inputs. There are conceptual difficulties with that. We are trying to get the fire typical enough. Conceptually, it is not as straightforward as I had first thought. These are different fires than those that we are used to. Hariram: is carbon dioxide a good indicator that it is going to be reacting or are there other gases that come out? Buston: there are other gases that come out. The key is really looking at the real time gas measurement. Hariram: does carbon dioxide present in all the batteries that you have looked at? Buston: it is present in all of the batteries that we have looked at, but we will be looking at other batteries in the future. This makes it difficult when there is such a big variation. Carbon dioxide will come pretty much from the electrolyte decomposing. There is more work to be done there. Pfund: do you have timelines on the research project? Buston: it was a 6-month research project. Our feasibility project is a 9-month project that runs until the end of May. Leary: characterization of fires: heat, gas generation, physical force of ejecta – anything else you are looking at that would inform your risk assessment? Buston: we are looking at the materials that come out of the cell and the gases, fumes, range of forces the cell applies onto the surroundings and the jet flame, determine if the nature of the gas changes over time. Karp: have you tried overcharging the batteries? Buston: we have, but they have protection circuitry built in.

Testing for Characterizing Lithium-Ion Battery Fires – Fire Protection Issues in All-Electric Aircraft – Mark Cummings (Joby Aviation)

A large battery system that powers the whole aircraft. Everything on the aircraft is powered by this battery system. Battery system does not include distinct firewall or fire containment enclosure. DO-311A section 2.4.5.4 “single cell thermal runaway containment test” is a test for containing runaway, not containing resultant battery fire. Depending on the battery cell location a ‘contained’ thermal runaway cell could result in a fire from which the airframe needs to be protected. Joby Aviation did some development work on thermal runaway.

Battery fires are recognized as short duration. There is no Standard for a lithium-ion battery fire. There needs to be a Standard that we can test to so we can define what we can test to.

An FAA AC and/or EASA MAC would provide authoritative Means of Compliance for battery fire containment and standards. Ferguson: what sort of characteristics do you have in mind that could influence the ultimate fire characteristics? Cummings: initially, we were looking to characterize the whole battery pack. That is not a reflection of the design or mitigation of how these battery packs are designed. There is still a lack of guidance of those steps, so we can design for firewall containment. Pugliese: what type of battery did you test? Cummings: it was a prototype we tested early in the program. That is a characteristic we have seen across all of the testing we have done. Initial high intensity flame. Cummings: there is an ASTM group that is starting to look into that, but it is just starting up. Question: why would we go to a shorter period of time when we do fire testing to longer durations because we have shut off valves and mitigating systems? Cummings: the same line of thinking is going to be applied when you talk about the battery fires, too. We would still apply a level of conservatism on top of that. We are not trying to remove the conservatism, it is getting a level of protection against the event. The powerplant standard really doesn't apply here. The initial flame is close to 2000°F from what we've seen in our testing. Hariram: you have to protect it from the debris coming out of the battery system fire, right? Cummings: yes. Karp: to test the firewall, to make a Standard, use the Roman candle and some explosive powder? Cummings: that is what I'm thinking right now.

Federal Register Notice – Federal Advisory Committee – Duane Pfund (DOT PHMSA)

Lithium Battery Safety Federal Register Notice Publication date: 5/14/2019. See: https://www.federalregister.gov/documents/2019/05/14/2019-09878/hazardous-materials-lithium-battery-safety-advisory-committee-nominations. "PHMSA is seeking nominations for individuals to serve as members on the Lithium Battery Safety Advisory Committee (the Committee). This is a safety advisory committee mandated by section 333(d) of the FAA Reauthorization Act of 2018 and established in accordance with the Federal Advisory Committee Act (FACA) of 1972. The committee will facilitate communication among manufacturers of lithium ion and lithium metal batteries, air carriers, and the Federal Government. This communication will promote the safe transportation of lithium ion and lithium metal cells and batteries and improve the effectiveness and economic and social impacts of related regulation. No later than 180 days after the establishment of the Committee, the Committee shall submit to the Secretary and the appropriate committees of Congress a report that describes and evaluates the steps being taken in the private sector and by international regulatory authorities to implement and enforce requirements relating to the safe transportation of bulk shipments of lithium ion cells and batteries. The Committee will also identify any areas of regulatory requirements for which there is consensus that greater attention is needed."

Request for Member Nominations for the Lithium Battery Advisory Committee. Objective is to collect data and see how we can provide recommendations and provide these to the government. Nominations must be received on or before June 4, 2019.

Certification of a Halon-Free Portable Fire Extinguisher for Aviation Use – Nik Schaefermeyer (P3 Group)

Hafex – halon alternative fire extinguisher. Agent: Halotron BrX – this is the latest unit we had certified. Nik reviewed the EASA and FAA approval process for portable fire extinguishers. In the 4 years of development and certification process, we found some main differences between UL 2129 and ETSO 2C515. The differences were described. P3 recommends the following actions: aviation industry (preferably FAA and/or Boeing) to get involved into UL decision board to change: change bracket requirement; change toxicity warning to include PBE/ventilation; change MRBR recommendation for annual weighing to be in line with NFPA10. FAA to update AC20-42 to include new agents; define performance requirements at different pressure levels add reference to DOT/FAA/TC-14/50 (stratification and localization). FAA to publish official document showing 2-BTP passed Seat Fire Toxicity Test. FAA should include small-scale class A fire test into MPS. Aviation industry to align on standard test for class B extinguishers showing usability against lithium-ion fires (not dedicated li-ion fire extinguishers). Carlo: we tried to get standard bracket definitions into the Standard and were unsuccessful at the time. Carlo: we do need the AC revised, it is well out of date. Canari: EASA has released generic CRIs and the latest version was developed in 2018. We have things in the ETSO that are not in the issue papers.

Next Systems Meeting:

There will be no fall 2019 IASFPF meeting due to the 9th Triennial International Aircraft Fire and Cabin Safety Conference, October 28-31, 2019, in Atlantic City, New Jersey, USA.

Some IASFPF Task Groups may meet during the conference week. Check with your Task Group leader.

Smoke Detection Standardization Task Group

EASA Headquarters, Cologne, Germany

May 15, 2019

15 May 2019:

Minutes

Matt asked for input on the thresholds he discussed on 14 May 2019 during his presentation at the IASFPF meeting: Light Obscuration: is there any way I can improve upon this method?

Trevor: When we are quantifying the output of the system, we do a mass flow measurement. You do get a pretty good meaningful measurement. You may have to run it for 15 or 20 minutes to get a reasonable measurement. It gives you repeatable result. This gives you an idea of how the manufacturing community does it.

André: the Siemens generator was used with the preset programs. Calibration Values should be as independent as possible from enclosures (rooms), because every room/chamber would have the same size.

Trevor: you could take the smoke you generated and distribute it evenly throughout the room to get the obscuration.

André: I would want to purchase a calibrated device and take it to wherever the generator is that I want to use. That would be my ideal world as someone who has to do flight testing with it.

Pat: we actually tried to do that and didn't have any success. We recalibrated the smoke generators in our lab. That was our way of getting repeatable performance of the smoke generator.

Trevor: when other industries send us their generators for service, we test them to what we built them to new after they have been cleaned and serviced.

Pat: what we use is very similar to what NIST was using years ago. As long as we don't change any of the parameters, it gives us consistent results.

Ken: if you were to get agreement on how much smoke produced by that method, you could reproduce it quite easily.

Ferguson: If you had a standard calibrated machine, you would have to have a pretty good idea of how long it would stay in calibration – number of cycles of the machine or on a calendar basis.

Matt: I think maintenance would be important, too.

Trevor: are we actually considering the smoldering fire or smoldering suitcase or should we be considering a lithium battery fire?

Andre: the danger is if we start to enter into discussions of fire scenarios, this group will last forever. We can take those into consideration, but we should use density (dynamics) of the smoke in the standard.

André: we have to distinguish two things: first we have the velocity of transporting the smoke to the detection device and then we have the properties of the device. We have different smoke detectors on the market that use slightly different technologies.

George: we might not be able to separate particle size distribution from the other parameters. I agree that the buoyancy of the plume effects detection.

Pat: the transport time is really dependent on what type of smoke you have. I think we all need to make sure we are in agreement on the type of fire: smoldering fire, etc.

Matt: to represent a smoldering fire, we need to reduce the heat.

Amanda: Does the transport vary that much over time for a smoldering fire?

Ken: we need to find a way to make this test a standard test.

Matt: I agree that we need to get some type of standard.

Enzo: in one of our first meetings, I suggested that we should consider that what is certified so far is not invalidated. What has been certified so far should be considered in every discussion. We have problems in standardizing the method of generation of smoke. The first point is to agree on the method of standardization of the smoke generator settings. I think in doing that we need to study the generators. It is very important. Before going to the step of comparing the output with smoldering paper, etc., we need to agree on method of standardization of smoke generator settings. We do not want to make things tougher for anyone.

George: if I make a main deck cargo bay, and I put a small enough fire on the floor, it may not be detected on the ceiling.

Enzo: we want to ensure that the aircraft systems are certified through testing to the final version of the aircraft in flight.

Amanda: it seems like we are going to run into problems when we have generators from two different manufacturers trying to get the same smoke.

Pat: if you are getting the same quality of smoke from each detector, it should work.

Trevor: there seems to be a need for an acceptable band that we operate within.

George: the transport is very important and it is important whether you have smart detectors or not. We want to be able to say that our smoke generator produces the required smoke.

Parameters: Ambient temperature range in cargo compartment, reasonable?

Ferguson: I think there is always an intention to maintain our flight test conditions, but there is also an intent to look across the whole envelope.

Matt: we should make sure that the smoke generator we are using is not affected by the ambient temperature in the compartment.

Pat: during a flight test, we usually let the smoke generator warm up for about an hour. We do try to adjust the cargo compartment temperature where possible. This is depending on the aircraft model.

Pat Baker: I will coordinate shipment of the generator from Boeing. I will be back at the FAA Tech Center, so I should have time to work with Matt while I am there.

Rob: what is the plan for Boeing's machine? The same as Matt did with the others?

Matt: same study once more.

Post Minute Talking Points

1. Oil consumption rate can be potentially used to determine the total smoke production as outlined in EN 50131-8:2019 (E) – the standard used to evaluate fog output and performance for security applications. However, there are potential drawbacks to EN 50131-8 for aircraft smoke detection certification application. The first is that the total smoke production is only one of three essential performance components for smoke detection certification testing – the other two being the transient smoke production rate and repeatability. Oil consumption is measured over a period of approximately 15 minutes. Therefore, the transient smoke production rate over a 60 second period would be difficult to correlate with oil consumption rate. Another drawback is that this will not completely eliminate the requirement for having a testing chamber, because the purpose of the European Standard is "to determine the consumption of fog required to achieve 1 m of visibility, not to equate fog output (EN 50131:8)." Nevertheless, after determining the consumption of oil required to achieve an undetermined amount of visibility for a given smoke generator, it may be possible to eliminate the requirement for a testing chamber.

Action: Matt and Pat to align to test the Boeing smoke generator settings at the FAA Tech Center Calibration Chamber. Similar conditions as during the Siemens Generator testing shall be used. Pat will send generator to FAATC by June 1, 2019.

Action: Define heat output, heat flux.

Cargo MPS Task Group

5/17/2019

9:00 AM

EASA, **Köln, Germany**

Type of meeting: Task Group Meeting

Note taker: Dhaval Dadia

Attendees: Dhaval Dadia, Robert Ochs, Enzo Canari, George McEachen, Doug Ferguson, Pat Baker, Karsten Kirbach, Jan-Boris Philipp, Rainer Beuermann, Konstantin Kallergis, Terry Simpson, Ian Campbell, Xavier Tiger, Chen Long

Minutes

Agenda item: Size of pressure vessel in aerosol can simulator

Discussion:

The issue of varying dimensions in the document was presented. The group agreed that the simulator that has been used at the tech center through all the prior testing should be measured. The dimensions obtained from this measurement should be recorded into the document including the internal volume of the vessel.

Conclusions:

Obtain dimensions and internal volume of vessel.

Action items	Person responsible	Deadline
✓ Measurement of dimensions	Dhaval Dadia	July 10, 2019

Agenda item: Aerosol can simulator valve opening timing

Discussion:

A high speed video of the opening of the valve on the simulator was shown with the analysis of the video. The analysis showed the valve opening in less than 0.1 seconds which is in accordance to the MPS document. The part number for the pneumatic valve has changed and should be changed in the document,

Conclusions:

Change part number of the pneumatic valve in the MPS document.

Action items	Person responsible	Deadline
✓ Change part number of pneumatic valve	Dhaval Dadia	July 10, 2019

Agenda item:	Placement of pan for surface burning fire scenario

Discussion:

Look further at data available from Boeing MPS test cell. Compare data sets to see if there is any observable difference. Use temperature data from no-agent tests to see if the MPS development tests were conducted with a TC centered above the pan. Conversations in this topic led to questions whether we would have to run baseline testing and establish new criteria if we add a requirement of an added TC. Conversations about worst case scenario for the location of the pan were had. Spray patterns of the agent dispersion and what is actually meant by it. Removal of the wording “maximum horizontal distance” was agreed upon. Height measurements for the pan need to be clarified by specifying the frame of reference. The top edge of the pan will be used as the frame of reference.

Conclusions:

Use top edge of pan as the height frame of reference. Remove “maximum horizontal distance” from the most difficult location definition. Compare data from Boeing MPS test cell as well as run no-agent tests in the DC-10.

Action items	Person responsible	Deadline
✓ Add edge of pan as frame of reference	Dhaval Dadia	Enter deadline here
✓ Remove wording from criteria	Dhaval Dadia	Enter deadline here
✓ Compare Data	Dhaval Dadia	Enter deadline here

Agenda item:	Miscalculation of standard deviation in surface burning fire.

Discussion:

Mentioned that the standard deviation was calculated incorrectly and the corrected value will result in a 10 degree decrease of the peak temperature value. The table mentions 570 F to be the criteria peak temperature. The corrected value changes this to 560 F. 560 F is mentioned in some portions of the text which will remain unchanged.

Conclusions:

Update table with correct standard deviation value.

Action items	Person responsible	Deadline
✓ Correct Value	Dhaval Dadia	July 10, 2019

Agenda item:	Galvanized steel in LD3 containers

Discussion:

Concern that galvanized steel was used only due to the availability during the time of the development tests. Some test facilities might not be able to use galvanized steel in fire tests due to zinc off-gassing.

Discussions led to agreement that the mention of the galvanized steel should remain, but alternate metals that can be used in its place should be mentioned. Also, challenges in finding the right thickness for 22 gage for the steel resulted in changing the annotation for the thickness of the galvanized steel. The correct thickness with a tolerance should be mentioned in the document, Incorrect spelling for "gage" in the document should be corrected.

Conclusions:

Provide alternate sheet metal information. Change annotation used for the thickness of the material.

Action items	Person responsible	Deadline
✓ Alternate sheet metal information	Dhaval Dadia	July 10, 2019
✓ Thickness annotation of the sheet metal	Dhaval Dadia	July 10, 2019
✓ Correct spelling errors "gage"	Dhaval Dadia	Jul 10, 2019

Agenda item: Aerosol Can Simulator – Compartment Pressure Transducer

Discussion:

The pressure transducer prescribed in the MPS does not have the resolution to measure the pressure rise created by the opening of the simulator in the compartment. There is a possibility that the measurements obtained thus far could be false due to the readings not being in the measurable range. Xavier recommends using a pressure transducer with a smaller range and with a measurable range being that of the readings obtained thus far from the simulator. Recommendations were made by the task group to change the pressure transducer to a smaller range since any pressure rise would be considered as a failure for this test scenario. Measurement of the pressure rise created by the opening of the simulator can be established and subtracted from a pressure rise obtained during agent testing.

Conclusions:

Obtain recommendations of pressure transducer to be used in the MPS.

Action items	Person responsible	Deadline
✓ Find applicable pressure transducer	Task Group Members	June 13, 2019
✓ Change the pressure transducer specifications once the pressure transducer is agreed upon.	Dhaval Dadia	Enter deadline here

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Agenda item: Air Exchange Rate calculations

Discussion:

Airbus will conduct testing to determine air exchange rate calculations using two different techniques and present results to the task group. Diehl might have the capability to perform similar results and establish a correlation between the two methods – carbon-dioxide decay and positive pressure method.

Conclusions:

Awaiting testing to be conducted and analyzed.

Action items	Person responsible	Deadline
✓ Perform tests and analyze result to present to task group	Rainer Beuermann Karsten Kirbach	Enter deadline here

Agenda item: Analyzing agent test results to criteria

Discussion:

The wording in the document left the analysis open to interpretation. Averaging 5 peaks in one test and comparing it to the overall criteria versus obtaining a single peak from each test and averaging the peaks from the five conducted tests and comparing it to the criteria. A change in wording has been suggested and needs to be worked on to fit it better in the document. "average of the single highest peak temperature for each of the five tests shall". There were talks of including an example of how the data should be analyzed including a test that had a higher peak than the criteria which will show that as long as the average is less than what is required in the criteria, the agent will pass.

Conclusions:

Change the wording of the acceptance criteria as well as provide an example data set.

Action items	Person responsible	Deadline
✓ Construct a new wording scheme	Dhaval Dadia	Enter deadline here
✓ Example data set	Dhaval Dadia	Enter deadline here

Agenda item: Meetings recurrence

Discussion:

Set a date and time for future WebEx meetings so that there are more talk than just during the systems forum meetings. Follow up meeting will be on June 12, 2019 and also a WebEx every 4 weeks will be scheduled after that.

Conclusions:

WebEx meeting every 4 week from June 12, 2019

Action items	Person responsible	Deadline
✓ Setup WebEx meeting	Enzo Canari	June 12, 2019

Agenda item: Toxicity in the MPS document

Discussion:

A brief conversation regarding the possibility of including the toxicity requirements in the MPS document was had. There were comments mentioning that if toxicity is going to be required then it should be included in the MPS. Further discussion will be had on this topic in the future meetings.

Conclusions:

Further discussions to be had.

Action items	Person responsible	Deadline
✓ Continue Toxicity conversations	Task Group	Enter deadline here

Agenda item: Aerosol Can Explosion Simulation Test method

Discussion:

The slides from the presentation were shown to illustrate the unintended consequence of conducting the test as prescribed in the MPS. The agent stratifies leading to low concentration near the ceiling. The intention of the test is to ensure that there is no pressure rise at the minimum inerting concentration (MIC). Certification methods ensure that the lowest concentration will be equal to or greater than the MIC. The group looked at the data from the raised stand method and the mixing fan method and agreed upon using the mixing fan method moving forward. The method of the mixing fan involves stirring the agent in the test compartment using 3 fans until 30 seconds prior to the activation of the simulator. The simulator will be activated at a point concentration of 3% ± 0.1% measured at the ignitor height.

Conclusions:

Use the mixing fan methodology for the aerosol can explosion simulation test scenario and update the method in the MPS document. Also write up a statement regarding the changes to the method and get official agreement from the task group to pass the statement to FAA.

Action items	Person responsible	Deadline
✓ Write statement regarding change in methodology	George McEachen	June 12, 2019
✓ Get agreement from task group	Task Group	June 12, 2019
✓ Amend MPS document	Dhaval Dadia	Enter deadline here

Agenda item: Aerosol Can Explosion Simulation Acceptance Criteria

Discussion:

The concerns with the acceptance criteria were presented again as explained in the presentation from Boeing, and the task group presentation. The wording makes it so that even a small flicker would fail the test and that wasn't the intent of the test. Tests from the Boeing facility were shown using the mixed fan test method to run the aerosol can simulator. The tests showed that with 3% Halon in the compartment, 3/5 tests showed some minor flaming activity near the ignitor, 1/5 tests showed a flash that was about 2 feet long, and 1/5 tests that showed no activity. We were reminded that the MEC of Halon is 6% and below that it acts as a suppression agent and not an extinguishing agent. A possible acceptance criteria was written with some key factors in mind:

1) Intent of the test is pressure criteria. Define the pressure at which the test fails. Zero without any definition or tolerance is too vague.

2) A small flame could exist based on Halon tests in a different chamber. 5 tests will be conducted at the tech center as well to develop a set of test videos as reference for flame size for perspective. Flame size from Boeing's test facility will be inserted into criteria.

Potential Criteria

"The criterion for the aerosol can explosion simulation scenario is that there is no evidence of an explosion or reaction that would be a threat to the integrity of the cargo compartment. Evidence of an explosion is that there shall be no pressure rise (in addition to its standard deviation) more than the measurement of the baseline simulator pressure release into a compartment. The baseline test shall be conducted three times in the presence of the agent being tested without an ignition source. The baseline pressure will be calculated as the maximum value of the three tests and one standard deviation. The criteria of an unacceptable reaction is based on the observed performance with Halon 1301. With Halon 1301 it is typical to see evidence of a local flame or reaction near the ignitor in most tests and to see a small flash in 1 of 5 tests. The small flash involved a flame that separated from the ignitor and spread about 2 feet and self-extinguished in _ seconds. In the event of more than one test having a "small flash" event, it is acceptable to perform additional tests to demonstrate that the frequency of these events is not greater than 20%. In addition, when the agent concentration is below its inert concentration, the explosion intensity and peak pressures shall not be greater than the values exhibited during an explosive event when no suppression agent is present in the compartment. To find more information on this subject, refer to reference 2."

Conclusions:

Developed a potential criteria that needs to be created into a statement that will be presented to the FAA. The task group has agreed upon this criteria.

Action items	Person responsible	Deadline
✓ Write a statement mentioning the new criteria to be submitted to the FAA	George McEachen	June 12, 2019

Agenda item: Challenge Fire

Discussion:

Challenge fire was asked to be developed as a fire that is likely to occur in a cargo compartment. Concerns were brought up that a challenge fire test should be conducted unsuppressed as well as with Halon to develop a pass fail criteria. EASA suggested using surface burning fire criteria as the acceptance criteria. Intentions explained by EASA about the need to have a test with Lithium batteries as part of the fire load. It started from a potential ban of laptops from being carried in the cabin which would lead to them being transported in cargo compartments. Hence the need to show a fire suppression agent could deal with such a potential situation. The fire load doesn't necessarily have to be similar to the one conducted with the water mist/nitrogen system, but could consist of various lithium batteries of different types (pouch, 18650, battery pack), chemistries, and states of charge to represent a realistic fire load. Doug Ferguson brought up some key points from a G-27 point of view. 10 cells at 100% SOC pose a greater risk than 50 cells at 30% SOC. A test fire load would have to explain the reasoning behind the selection of batteries and their state as present in the test scenario.

Conclusions:

Continue discussions regarding intent of a challenge fire test. Will there be a potential pass fail criteria?

Action items	Person responsible	Deadline
✓ Continue discussions	Task Group	June 12, 2019

Agenda item: Other discussions during the meeting

Discussion:

Possible use of another agent or inert gas to obtain comparison data between facilities. This will help in understanding how different chambers constructed as per the MPS are than the Tech Centers DC-10. The DC-10 has alternate leak paths due to it not being a completely sealed chamber. Also the leak rate changes as the temperatures in the compartment increase due to a fire. This difference was shown when Boeing conducted their own Halon tests and unsuppressed fire tests in their compartment. Using the Halon data led to lower peak temperatures leading to a stricter criteria. Boeing proposes test facilities with their own chamber to conduct their own Halon baseline to develop the criteria for their test facility. EASA's concern with this was that there could be a facility which would want to have elevated criteria with a chamber created as per the MPS. The control over air leakage rate and data from unsuppressed fires can show that this will not be possible. Also, comparing data from a prescribed agent/inert gas system would help in answering compartment comparisons. Terry Simpson also mentioned that there were efforts made 8-10 years ago to replicate a compartment that would have fire test results similar to the unsuppressed fire tests conducted in the DC-10. Their testing showed that they would need to make the compartment leakier as well as insulate the compartment to obtain almost similar results. They will try to find the information and lessons learned from their testing.

Better definition of the chamber was requested in terms of heat loss, insulation etc. Chambers that might constructed might be stationed out in the open and might not have the control over ambient conditions like at the tech center. Also the MPS doesn't prescribe any insulation around the chamber whereas the DC-10 has an external skin that insulates the inner cargo compartment skin. There might be an effect on temperatures due to uniqueness of the DC-10 cargo compartment at the tech center. Robert Ochs recommended the usage of an unsuppressed surface burning fire as a heat loss test to develop some heat transfer criteria for compartments.

Questions about how the long version of the aerosol can explosion simulation was developed and if there is data available from the testing?

Conclusions:

Consider inert gas or agent that can be used as a comparison between different locations. Define other boundary conditions of the test chamber.

Action items	Person responsible	Deadline
✓ Obtain lessons learned from Terry Simpson's group regarding chamber leak rate and insulation of chamber to replicate DC-10 unsuppressed fire test results.	Terry Simpson	July 9, 2019
✓ Find the development of the long version of the aerosol can test.	Dhaval Dadia	June 12, 2019

Agenda item: Aerosol Can Short vs Long Version

Discussion:

There were talks about whether you truly have the option of testing a gaseous agent using the long version of the aerosol can test. Although there is the option to test either version of the aerosol can test, Boeing voiced their concern that they were asked to test the short version for gaseous agents. There could have been a misunderstanding that after initially seeing results from the short version and then making a decision to run the long version might not be acceptable. The group also agreed that there is a choice in running either version as currently stated in the document. If there is an understanding that gaseous agents must be tested to the short version of the MPS, it must be explicitly mentioned to do so in the MPS. There were also talks about the disadvantages to running the short version with the current criteria. Using the long version, the ignitor is shrouded by a layer of smoke from the cardboard box fires and most likely the concentration of the agent near the ignitor is greater than the MIC. This makes the short version a harder test for gaseous agents to pass. The group also agreed that if the proposed criteria was accepted, then the task group would accept running the short version for gaseous agents.

Conclusions:

Mention in the MPS if gaseous agents are mandated to run the short version of the aerosol can explosion simulation test.

Action items	Person responsible	Deadline
✓ Enter action items here	Enter person responsible here	Enter deadline here

Appendix

Special notes: Raw information used during discussions

- Aerosol Can Simulator Test Method
  -

Wording of the pass/fail criteria.	The criterion for the aerosol can explosion simulation scenario is that there is no evidence of an explosion or reaction. Evidence of an explosion or reaction includes deflagrations, flashes, and overpressures, etc. There shall be no overpressures (zero pressure rise). In addition, when the agent concentration is below its inert concentration, the explosion intensity and peak pressures shall not be greater than the values exhibited during an explosive event when no suppression agent is present in the compartment. • MPS development report mentions the observation of a flash in Test 4. • Detailed presentation to be given by Boeing Conducted test in the DC-10 cargo ★ Task Group Presentation

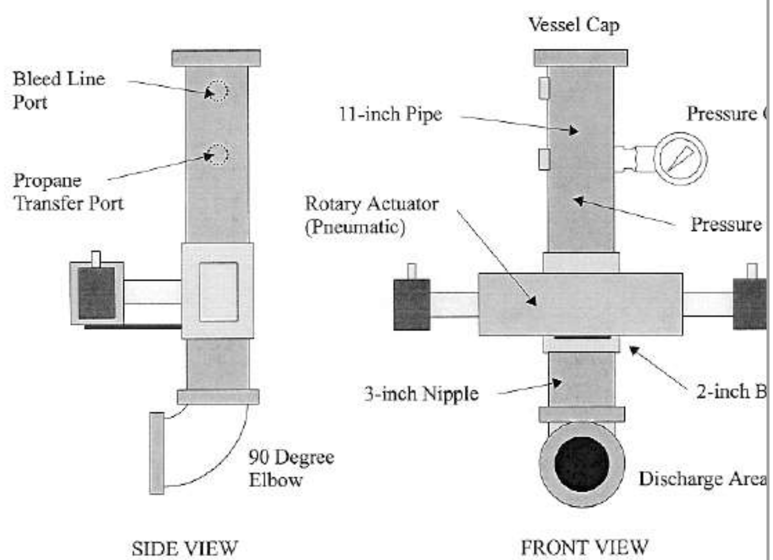
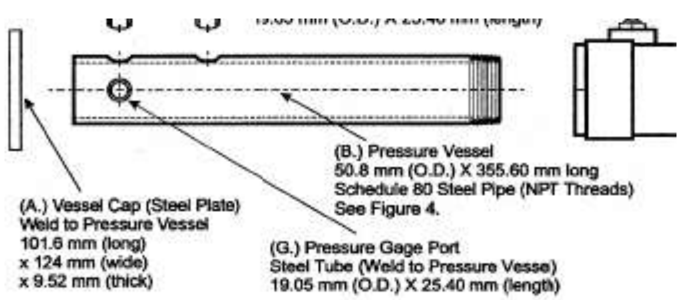
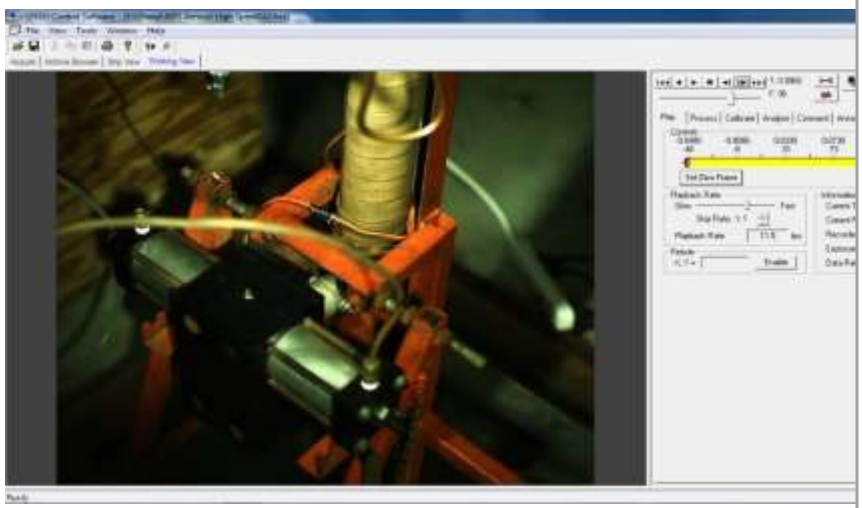
<table>
<tr><td>Test Method</td><td>Testing in the development was conducted using a bulk average concentration of 3% in the compartment. The MPS document mentions to conduct the test using the point concentration measurement at the probe near the ignitors.
New proposal for test method (Fans/height increase)
★ Task Group Presentation</td></tr>
<tr><td>Size of Pressure Vessel</td><td>Mentioned to be 11" in the wording and Figure 8. Figure B-1 mentions it to be 355.6 mm long (14 ")
The following list describes the major components of the aerosol can simulator.
• Pressure vessel. A steel 2-inch (5.1-cm) -diameter, 11-inch (27.9-cm) -long sch pipe welded or capped at one end.


Figure 8. Aerosol Can Explosion Simulator

</td></tr>
<tr><td>Ball Valve Opening Criteria</td><td>The ball valve is capable of rotating from the fully closed position to the fully open position in less than 0.1 second in order to form a vapor cloud.</td></tr>
</table>

	Conducted high speed camera test to measure timing of opening - 0.096sec <<A2.mp4>> 
Gaseous agents short version	Are gaseous agents required to conduct only the short version? Could also conduct the long version. Clarification on intentions of the short version. Is video recording mandated to observe reactions, flashes, etc…
Clarification on "overpressure"	Does it include or exclude
What would long version of aerosol can look like for Halon?	

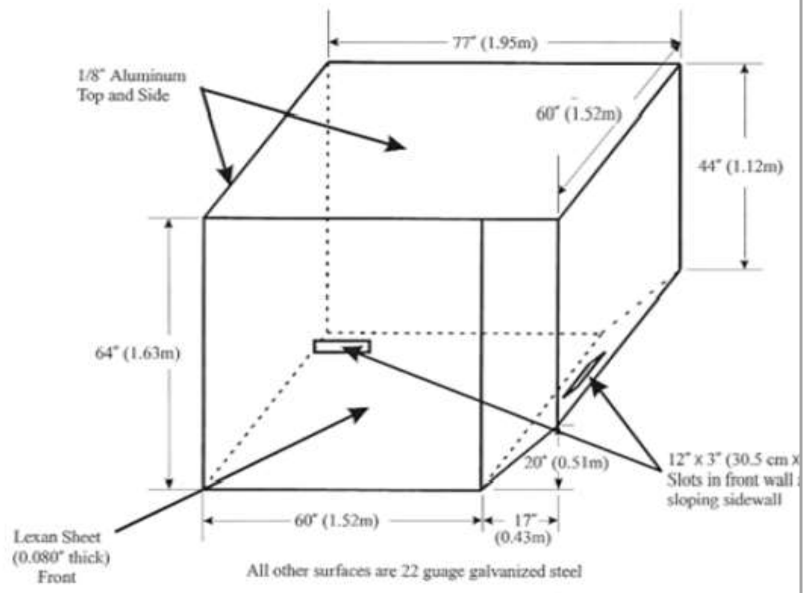
- Surface Burning Fire Test Method
  -

Placement of Pan	The pan should be positioned in the cargo compartment in the most difficult location for the particular suppression system being tested • Testing revealed that by placing in the worst case scenario you might not have a thermocouple over the middle of the pan. Not sure about the location of TCs during the MPS development testing. Testing with a pan directly underneath a TC and slightly adjacent to the TC shows different peak and time-temperature integrals.

<table>
<tr><td></td><td>⭐ Task Group Presentation
⭐ Show data from Boeing Sponsored Agent</td></tr>
<tr><td>Standard Deviation for the peak temperature</td><td>The std. dev. for the peak temperature is calculated as 16.8. It should be 15.3. Changes Peak Temp criteria from 570°F to 560°F.
Mentioned to be 560°F in the Executive summary as well as acceptance criteria. Table A-1 has the std. dev. and 570°F mentioned.
Table A-1. Results From MPS Tests Conducted With Halon 1301
<table>
<tr><td rowspan="2">Test</td><td rowspan="2">Test ID</td><td colspan="2">Bulk-Load Test</td><td rowspan="2">Test ID</td><td colspan="2">Containerized-Load Test</td><td rowspan="2">Test ID</td><td colspan="2">Surface-Burn</td></tr>
<tr><td>Max. Temp (°F)</td><td>Max. Area (°F-min)</td><td>Max. Temp (°F)</td><td>Max. Area (°F-min)</td><td>Max. Temp (°F)</td><td>(°</td></tr>
<tr><td>1</td><td>081198T1</td><td>511</td><td>7979</td><td>082898T1</td><td>607</td><td>13573</td><td>111899T3</td><td>549</td><td></td></tr>
<tr><td>2</td><td>081298T1</td><td>431</td><td>8885</td><td>083198T1</td><td>577</td><td>12998</td><td>111899T4</td><td>539</td><td></td></tr>
<tr><td>3</td><td>081398T2</td><td>450</td><td>9068</td><td>090198T1</td><td>606</td><td>13108</td><td>111999T1</td><td>549</td><td></td></tr>
<tr><td>4</td><td>081498T1</td><td>382</td><td>8939</td><td>090298T1</td><td>520</td><td>11937</td><td>111999T2</td><td>517</td><td></td></tr>
<tr><td>5</td><td>081998T1</td><td>632</td><td>9413</td><td>090498T1</td><td>498</td><td>10966</td><td>111999T3</td><td>514</td><td></td></tr>
<tr><td>6</td><td>082198T3</td><td>461</td><td>8704</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Standard Deviation</td><td></td><td>78.9</td><td>438.1</td><td></td><td>44.8</td><td>942.1</td><td></td><td>16.8</td><td></td></tr>
<tr><td>Maximum Value</td><td></td><td>632</td><td>9413</td><td></td><td>607</td><td>13573</td><td></td><td>549</td><td></td></tr>
<tr><td>Sum of Std. Dev. + Max</td><td></td><td>710.9</td><td>9851.1</td><td></td><td>651.8</td><td>14515.1</td><td></td><td>565.8</td><td>1</td></tr>
<tr><td>ACCEPTANCE CRITERIA (°F)</td><td></td><td>710</td><td>9850</td><td></td><td>650</td><td>14520</td><td></td><td>570</td><td></td></tr>
<tr><td>ACCEPTANCE CRITERIA (°C)</td><td></td><td>377</td><td>4974</td><td></td><td>343</td><td>7569</td><td></td><td>299</td><td></td></tr>
</table></td></tr>
</table>

- Containerized Fire Test Method
    -

Usage of galvanized steel in the construction of the container	Can a different material be used to construct the test LD-3 container. 1 side polycarbonate, 2 sides Aluminum, rest are 22 Ga. Galvanized steel 💡 Compare data from unsuppressed fires in DC-10 to unsuppressed fire from other construction methods.

	 Figure 5. The LD-3 Container

- Air Leak Rate Test Method
  -

Method to measure the air leakage rate	A methodology is not mentioned to calculate the leakage rate in the compartment. Airbus uses blower door method while the tech center uses carbon di-oxide leak rate. Diehl/Airbus to evaluate difference in leak rate test methods.

- Challenge Fire
  -

Is Challenge fire going to be an additional fire test **Multi Threat Fire/Combination Fire**	Challenge fire is defined as a fire likely to occur in the cargo compartment. A quantification of how Halon performs against the Challenge Fire scenario. Perform unsuppressed challenge fire test to obtain peak temperatures. EASA would like to add the challenge fire to the MPS. ☐ Enzo will get in touch with FAA TAD* to look into it. Research project by EASA funded - stating tests next year - fire risk assoc to battery fire in luggage. Should Halon be tested against this scenario - ? Different name

	One additional test that includes batteries in the fire load. - test of agent CRI results in conducting same test multiple times for different configurations. Don't want the setup mentioned before in the Water mist campaign P/F criteria could possibly be Surface burn P/F criteria G-27 fails at 3 18650 @ 100% SOC Batteries not covered by G-27 is the concern Scenario that is not addressed in any other scenario Discuss rationale behind the selection of the quantity and types of materials included in the test 10 cells at 100% SOC poses a greater risk than a box of 50 batteries @ lower SOC spread around the fire load. Design distribution of cells - Different cells types at different locations, different SOC inside luggage. Vision of P/F - no explosion Higher SOC low qty could possibly show a more dangerous scenario… Distribute batteries within a piece of fire load.

- Thermal Mass of the Compartment
    - With the rebuild of the DC-10 cargo compartment, does the change in material type and thickness affect the temperatures and time-temperature integrals?
        - Measuring the temperatures 1" below the ceiling (gas layer). What is the overall effect?
        - Could compare unsuppressed fires for changes in peak temps and time-temp integrals

- Different types of shredded paper used in tests.
    - Diehl to look into quantifying the effects of different types of paper used.
    - Presentation from Meeting

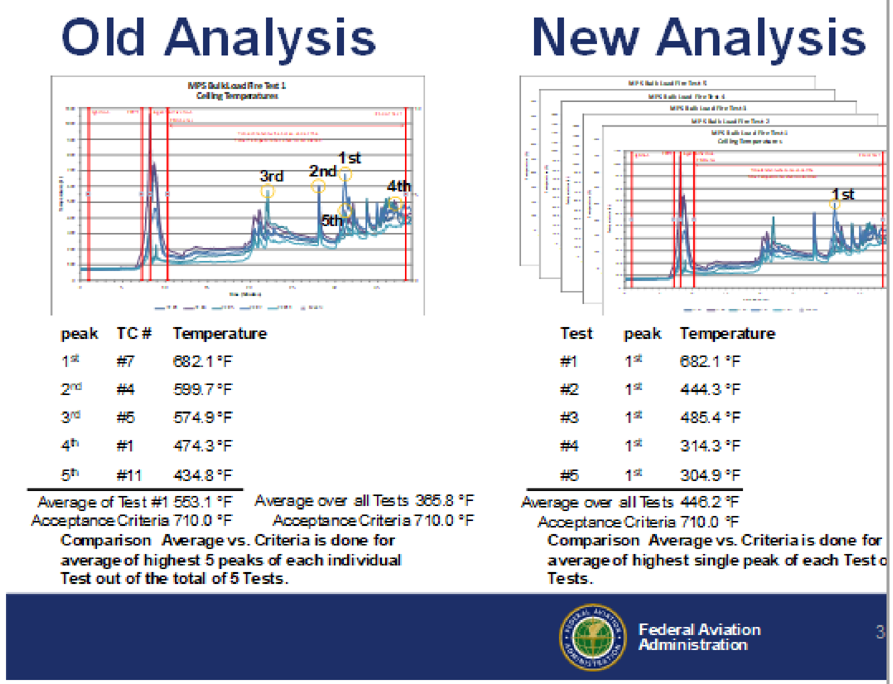
- Toxicity in MPS?
- Measurement uncertainty
    -

Analyzers are expected to have a 5% tolerance (0.15%	containerized-load fire scenarios. The accuracy of the analyzer shall be ±5% of the reading. T gas analyzer is used to measure the concentration of the gaseous suppression agent. The da sampling rate for all the temperature measurements and the gas concentrations should be at le one data point every 5 seconds. is discharged. The simulator device is activated at least 2 minutes after agent discharge. activation time is dictated by the measured volumetric concentration, within ±0.1% o minimum protection concentration. The minimum concentration is measured 2 feet (60.9

<table>
<tr><td>for 3% Halon) while short version aerosol can requires accuracy of 0.1%</td><td></td></tr>
<tr><td>Source of Error table</td><td>
<table>
<tr><th></th><th>Value</th><th>Units</th><th>tolerance / error</th><th>Suggested Instrument</th><th>Notes</th></tr>
<tr><td>Leakage Rate</td><td>50</td><td>CFM</td><td>±5</td><td>not identified</td><td>No requirement to measure in-situ during fire test</td></tr>
<tr><td>Temperature</td><td></td><td></td><td>±3.96F</td><td>Type K 22 Gauge Thermocouples 22 gauge</td><td>need spec for sheathing, grounded or ungrounded junction, exposed junction, etc</td></tr>
<tr><td>Agent Concentration</td><td></td><td>% vol</td><td>±5% of reading</td><td>Continuous Gas Analyzer</td><td>halon impurity adds error</td></tr>
<tr><td>Pressure Pulse</td><td>0-50</td><td>psig</td><td></td><td>Omega 0-50 psig @ 3000 Hz</td><td></td></tr>
<tr><td>Simulator Pressure</td><td>240</td><td>psi</td><td>±5 psi</td><td></td><td>doesn't specify gauge or absolute</td></tr>
<tr><td>Simulator Contents</td><td></td><td></td><td></td><td>None (scale)</td><td>need scale accuracy</td></tr>
<tr><td>Evidence of Explosion</td><td>0</td><td>psig</td><td>none</td><td>Pressure Transducer</td><td>how to determine other evidence (deflagrations, flashes, and overpressures) ?</td></tr>
</table>
</td></tr>
</table>

	Time Temp Integral				Thermocouples and Data Acquisition	no specification on temperature sampling frequency

- Clarification on acceptance criteria

<table>
<tr>
<td>Peak and time-temp integrals from individual tests could be higher than the acceptance criteria, but once it is averaged, the average value would pass.</td>
<td>


The acceptance criteria for the bulk-load fire scenario are that the average of the single highest peak temperature for each of the five tests shall not exceed 710°F (377°C), starting 2 minutes after the suppression system is initially activated until the end of the test. In addition, the average of the five tests areas under the time-temperature curve of the compartment thermocouples shall not exceed 9850°F-min(4974°C-min).

The criteria for the containerized-load fire scenario are that the average of the five test peak temperatures shall not exceed 650°F (343°C), starting 2 minutes after the suppression system is initially activated until the end of the test. The average of the five test areas under the time-temperature curve shall not exceed 14,520°F-min (7,569°C-min).

The acceptance criteria for the surface-burning fire scenario are that the average of the five test peak temperatures shall not exceed 560°F (293°C), starting 2 minutes after the suppression system is initially
</td>
</tr>
</table>

	activated until the end of the test. In addition, the average of the five test areas under the time-temperature curve shall not exceed 1190°F-min (608°C-min).
If one peak is greater than the test criteria?	Acceptable as long as avg. is below acceptance. Show in example.

- Diversion time criteria??
- Better resolution for Fig 1 that shows locations for the gas probes.

Agenda for 2019 Cargo MPS Task Group

☑	Size of pressure vessel	Currently used simulator dimensions and volumes with tolerance.

- ☐ Add paragraph to explain halon baselines for own chamber
- ☐ Create a set of chamber comparison tests with other agents
- ☐ Terry Facility air leakage rate, insulation, and volume to match MPS dev numbers
- ☐ Nitrogen as a baseline agent. Define method of calibration
- ☐ Define lower limits and not higher and relative to the unsuppressed fires
- ☐ Boundary conditions around cell
- ☐ Define ambient temp and humidity
- ☐ Use pan fire as a heat loss test
- ☐ Find dev of long version aerosol can test..

☑	Valve opening timing of simulator	Update part number for the valve.
☑	Short version of Aerosol can for Gaseous agents?	Reasonable to use short version for gaseous agents. (depending on the outcome of criterion acceptability). Should be explicitly mentioned in the MPS document. Clarify with FAA whether it is truly an option to run either versions of the test. (EASA, FAA)

☑	Placement of pan in pan fire	Add requirement to add T/C above the center of the pan. Back burner for now. Define worst case scenario and most comparable to halon baseline. Pan in corner scenario? Maximum horizontal distance - Take out - Agreed Height of Pan - specify it is the top edge of pan - agreed
☑	Miscalculation of std. dev. of peak temp in surface burning fire	Correct with proper calculation

Galvanized Steel on LD3 Containers	Keep info that 22 ga galvanized steel was used in the MPS dev testing. Mention alternative materials with same thickness + tolerance. Correct spelling of gage.

Aerosol can wording criteria	Concern is the elongated flame. Defining flame acceptance criteria. Add tolerance on opening of simulator pressure as a guidance. Pick a pressure transducer with a lower FS. Overpressure is a starting point and can describe the intent as threat to the compartment and define the reaction/flame size/area of flame. Tolerance for "zero" overpressure "zero" overpressure should eliminate flames Do not allow a certain reaction flame size Describe a majority of the test. Cannot allow worst case behavior for all tests. Percentage of passed tests High speed IR for looking at flames through smoke/fog Proposed criteria "The criterion for the aerosol can explosion simulation scenario is that there is no evidence of an explosion or reaction that would be a threat to the integrity of the cargo compartment. Evidence of an explosion is that there shall be no pressure rise (in addition to its standard deviation) more than the measurement of the baseline simulator pressure release into a compartment. The baseline test shall be conducted three times in the presence of the agent being tested without an ignition source. The baseline pressure will be calculated as the maximum value of the three tests and one standard deviation. The criteria of an unacceptable reaction is based on the observed performance with Halon 1301. With Halon 1301 it is typical to see evidence of a local flame or reaction near the ignitor in most tests and to see a small flash in 1 of 5 tests. The small flash involved a flame that separated from the ignitor and spread about 2 feet and self-extinguished in _ seconds. In the event of more than one test having a "small flash" event, it is acceptable to perform additional tests to demonstrate that the frequency of these events is not greater than 20%. In addition, when the agent concentration is below its inert concentration, the explosion intensity and peak pressures shall not be greater than the values exhibited during an explosive event when no suppression agent is present in the compartment. To find more information on this subject, refer to reference 2."

Aerosol can test method for short version	Add in test procedure "It is acceptable to use mixing fans in the compartment to minimize stratification of the agent during this test. The mixing fans should be turned off at least 30 seconds prior to the activation of the simulator."

Pressure Transducer change	Minimum value that is considered accurate. Absolute pressure gage Have suggestions by next meeting.

☑ Air exchange rate calculation (Airbus update?)	By end of year… Also see if Diehl can compare their compartment data sets.

☐ Challenge Fire (EASA Stance)
☐ Challenge Fire - fire load
☐ Challenge fire Halon comparison
☐ Thermal mass of compartment
☐ Type of paper used in the boxes
☐ More defining characteristic of the compartment
☐ Measurement uncertainty

☑ Analysis of results	average of the single highest peak temperature for each of the five tests shall
☑ Toxicity in the MPS document	Follow up if we should include in the MPS document.

☐ Better clarity on the drawings in MPS document
☑ Webex timeframe 7AM PST June 12 - every 4 weeks. Send Enzo list of participants to setup webex. (possible in person meeting in Seattle before triennial)