IAASS-PP-00217-WA

POSITION PAPER

APPLICABILITY OF PRESSURE SUITS FOR SUBORBITAL FLIGHTS

Statement of Position:

The IAASS considers that pressure suits should be worn for suborbital flights due to the risks involved in the event of a loss of cabin atmospheric pressure.

In the case where a suborbital designer/operator decides against the use of pressure suits they should undertake systematic design and safety analysis to justify this position to provide assurance that the residual risk has been mitigated to a tolerable level of risk and inform the flight participants accordingly. This justification should then be presented to the spaceflight participants and flight crew as part of the informed consent process.

Substantiation:

a) **Background**: The Scaled Composites flight test accident on 31st October 2014 highlighted that accidents can happen and, in some instances, safety measures such as parachutes and pressure suits could be the difference between life and death.

b) **Context**: During flights in commercial suborbital space vehicles, emergency protection from the very low density of air of the upper atmosphere and the near-vacuum of space should be a requirement since suborbital vehicles may be operating above 50,000 ft. Depending on the flight profile and vehicle design (from rocket-powered vehicles to near-space balloon flights) the time spent above 50,000ft could be from a few minutes at altitudes around 100km to over an hour at altitudes around 30km. In the event of cabin pressure loss without personal protection, catastrophic loss of crew and passengers could result. The suborbital commercial spaceflight industry has a unique problem when it comes to the wearing of pressure suits since there is a lack of a certifying agency or guidance from international or national aviation authorities to create safety standards or guidance material. This position paper therefore presents a case for the use of pressure suits for suborbital flight, or where a decision is made not to provide pressure suits then this has been made with consideration to the design trade-off, in terms of safety risks.

c) **Rationale**: There have been several examples of the need for full pressure suits in space and suborbital flights (see Appendix 1 for accidents and Appendix 2 for Pressure Suit Design Features). Accidents and malfunctions have affected Soviet/Russian and American missions and the study of these problems can serve as a platform to provide an estimate of the use of pressure suits for commercial vehicles. The diversity of systems the industry is considering for suborbital flights, with its corresponding differences in launch and landing methods, implies that a variety of life-threatening failures can occur. These include depressurization, crash and fire protection, protection from volatile organic compounds (VOCs) along with the potential of egress during an emergency if a catastrophic failure should occur. A pressure suit could provide an effective recovery measure to some of the hazards of suborbital spaceflight and thereby reduce the outcome for those on board.

In the case where a suborbital designer/operator chooses not to incorporate pressure suits and associated support equipment, then they should justify this. It is of no use (in a court of law) to merely state that having pressure suits with oxygen introduces additional hazard so it is not worth the effort. Hence this position paper proposes that a systematic design and safety approach is used, as part of explicit risk assessments to justify the design decisions (to the spaceflight participants).

Recommendations:

1. Suborbital Vehicle Designers/Operators should provide flight crew and spaceflight participants with pressure suits to avoid loss of life during high altitude flights. As a minimum, flight crew must wear pressure suits during flight tests above 50.000 ft.
2. In the case where spacesuits are not provided then the designer/operator should undertake design and safety analysis to justify this position to provide assurance that the residual risks have been effectively mitigated to. This justification should then be presented to the spaceflight participants and flight crew as part of the informed consent process.

References:

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7. MIL-F-27628C NOT 1 Flying Outfit, Full Pressure, High Altitude A/F22s https://webstore.ansi.org/RecordDetail.aspx?sku=MIL-F-27628C

8. Wikipedia entry, Joe Kittenger, https://en.wikipedia.org/wiki/Joseph_Kittinger

Appendix 1: List of Accidents Associated with Lack of Oxygen

1. Soyuz 11. Cosmonauts Lt. Col. Georgiy Dobovolskiy, Flight Engineer Vladislav Volkov and Test Engineer Viktor Patsayev died when the spacecraft depressurized during reentry. Due to the rapid onset of anoxia, the cosmonauts lost the capacity to save themselves in 10– 15 s and were dead by 35–48 s. Following this tragedy, the Russians no longer launched crews without pressure suits.
2. After the American Apollo-Soyuz (ASTP) capsule separated from the Soviet counterpart, the crew were contaminated by a toxic reaction from gases produced by the reaction control system (RCS). While not fatal, the fumes caused skin, eye and respiratory system irritation to the crew.
3. There was at least one occurrence of partial decompression during the Soyuz TMA-6 mission. The spacecraft instruments started to show a partial pressure drop even before undocking with the International Space Station (ISS). Mission Control in Russia thought it was a sensor instrument malfunction and gave the order to proceed with the undocking. Soyuz commander, Sergei Krikalev, US astronaut John Phillips and spaceflight participant Greg Olsen were onboard. A source stated that during the three-hour coast following separation from the ISS to the firing of the reentry engine the cabin pressure dropped from 765 to 660 mmHg. The crew was instructed to increase the pressure using on-board oxygen bottles and to be prepared for an emergency pressurization of the Sokol suits.
4. "On August 16, 1960, Joe Kittinger made the final high-altitude jump at 102,800 ft (31,300m) …Incurring yet another equipment malfunction, the pressurization for his right glove malfunctioned during the ascent and his right hand swelled to twice its normal size… but he rode the balloon up to 102,800 feet before stepping off."

Appendix 2: Example of Pressure Suit Features

A space vehicle intravehicular (IVA) pressure suit differ from those used outside the space vehicle (extravehicular activity suits). Such an IVA suit should ensure at a minimum crew survivability and unpressurized comfort. Unpressurized comfort, because the suit will be worn unpressurized for most of its lifetime (being pressurized only for brief periods in an emergency or test). One such suit is the Final Frontier Design (FFD) Suit. Final Frontier Design IVA Suit. This suit can be used with an open-circuit, vented, life support system or converted to a closed-loop system. It features minimum pressure drop, adequate ventilation flow, minimal carbon dioxide build-up and good thermal comfort. It uses a helmet with swing-up hermetic face visor. The don/doff closure of the FFD suit is rear entry.