Crew Survivability after a Rapid Cabin Depressurization Event

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Anecdotal evidence acquired through historic failure investigations involving rapid cabin decompression (e.g. Challenger, Columbia and Soyuz 11) show that full evacuation of the cabin atmosphere may occur within seconds. During such an event, the delta-pressure between the sealed suit ventilation system and the cabin will rise at the rate of the cabin depressurization; potentially at a rate exceeding the capability of the suit relief valve. It is possible that permanent damage to the suit pressure enclosure and ventilation loop components may occur as the integrated system may be subjected to delta pressures in excess of the design to pressures. Additionally, as the total pressure of the suit ventilation system decreases, so does the oxygen available to the crew. The crew may be subjected to a temporary incapacitating, but non-lethal, hypoxic environment. It is expected that the suit will maintain a survivable atmosphere on the crew until the vehicle pressure control system recovers or the cabin has otherwise attained a habitable environment.

A common finding from the aforementioned reports indicates that the crew would have had a better chance at surviving the event had they been in a protective configuration, that is, in a survival suit. Making use of these lessons learned, the Constellation Program implemented a suit loop in the spacecraft design and required that the crew be in a protective configuration, that is suited with gloves on and visors down, during dynamic phases of flight that pose the greatest risk for a rapid and uncontrolled cabin depressurization event: ascent, entry, and docking.

This paper details the evaluation performed to derive suit pressure garment and ventilation system performance parameters that would lead to the highest probability of crew survivability after an uncontrolled crew cabin depressurization event while remaining in the realm of practicality for suit design. This evaluation involved: (1) assessment of stakeholder expectations to validate the functionality being imposed; (2) review/refinement of concept of operations to establish the potential triggers for such an event and define the response of the spacecraft and suit ventilation loop pressure control systems; and (3) assessment of system capabilities with respect to structural capability and pressure control.

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