

Cold Injury-Chilblains/Frostbite CLIFF Peer Review

This CLIFF characterizes cold injuries such as frostbite and chilblains that might occur during spaceflight. Frostbite refers to the freezing of tissue. While frostbite can be painful and can result in the loss of digits or extremities, it is seldom fatal. Chilblains refer to localized inflammatory lesions that occur when there is repetitive exposure to damp cold conditions that are above the freezing point of water. Grade 1 frostbite occurs when there is no cyanosis and is limited to the extremities. Grade 2 frostbite is associated with cyanosis isolated to the distal phalanges. Grade 3 frostbite is characterized by cyanosis over the intermediate and proximal phalanges. Grade 4 frostbite involves cyanosis over the carpal or tarsal bone and predicts amputation of the limb. Frostbite occurs terrestrially in cold environments where there is inadequate protection from the cold and there is prolonged exposure. During spaceflight, however, a low temperature environment should only occur in the event of vehicle system failures. Space vehicles are designed to maintain a comfortable cabin or EVA suit temperature. Cold injuries can only occur when these systems fail either when a drastic power down is required (such as on Apollo 13) or when there is a failure of the thermal control systems. EVA suit failures have been considered elsewhere and are thought to be an extremely unlikely possibility given the redundancy built into the suit. Thus, only vehicle system failures were considered.

After having a series of meetings on these conditions with engineers and PRA analysts, it was decided to defer inclusion of this CLIFF as well as a second CLIFF dealing with hypothermia. Subject matter experts, reviewers and ExMC management unanimously agreed to do so. The rationale is that: 1) there is not enough data available about failure modes leading to cold ambient temperatures to make a well-informed incidence calculation. 2) The risk of becoming hypothermic or having cold injury is very much dependent on the mission phase and the dynamics of the thermal environment that might be encountered. This is not yet well-characterized for all mission segments. 3) There are operational workarounds available for possible failure modes (e.g., if Gateway loses temperature control, the crew can use Orion as a lifeboat). 4) A scenario (such as multiple electrical bus failures or total failure of the electrical system) that could lead to these conditions would probably result in the loss of the crew. 5) The loss of thermal control systems or atmospheric revitalization equipment is more likely to lead to elevated cabin temperatures rather than low temperatures.

Of note, the scenario that led to the Apollo 13 power down and low temperature conditions is not felt to be applicable to Orion because there are no fuel cells with O₂/H₂ supply tanks that could leak..

Reviewed by:

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