IMPACT AND LEAK RATE TESTING OF COMPOSITES FOR SPACESUIT STRUCTURES

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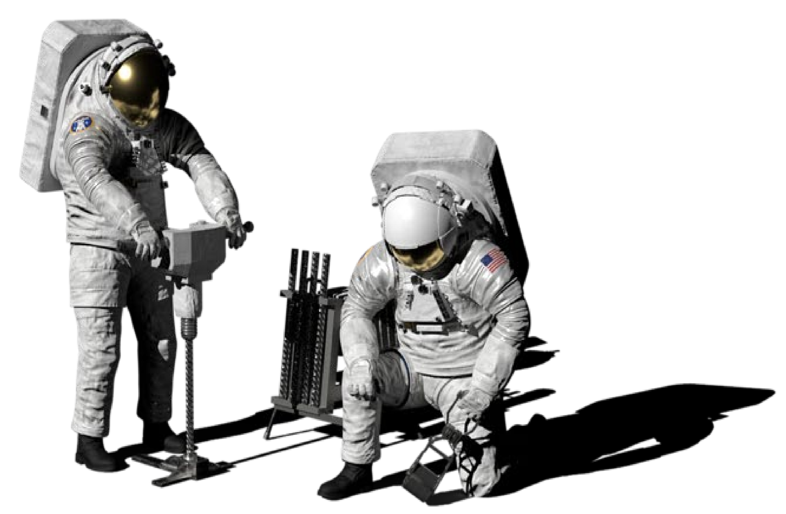
Introduction

- For the future of space exploration, a new spacesuit is necessary so that astronauts will have the **mobility** they need to complete their research on missions such as those prescribed by the Artemis program.



https://www.nasa.gov/suitup/spacesuit-gallery

- Impact testing simulates **realistic scenarios** which could occur and potentially damage the spacesuit, such as falling over or dropping a tool!
- Leak testing is conducted to **observe the effects** of the damaged areas after the initial impact has occurred. We seek to find out if the damage is large enough to cause an air leak!

Exploration EMU (xEMU) Development Unit | NASA

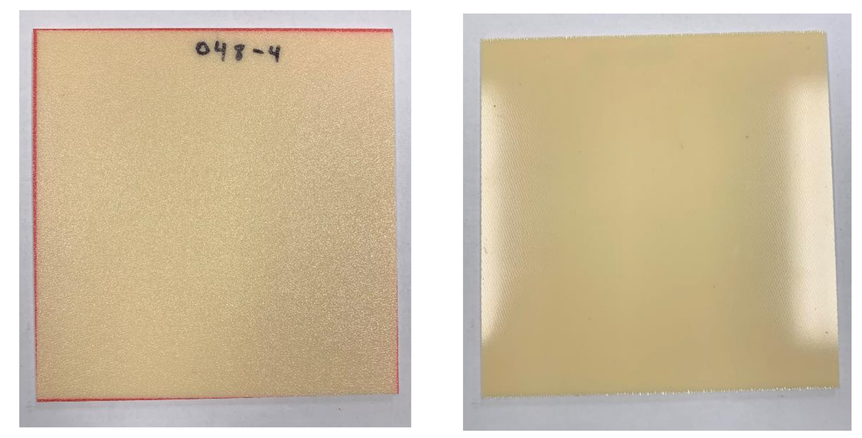
20191015 Artemis Generation Spacesuit Event | Flickr

Problem Specification

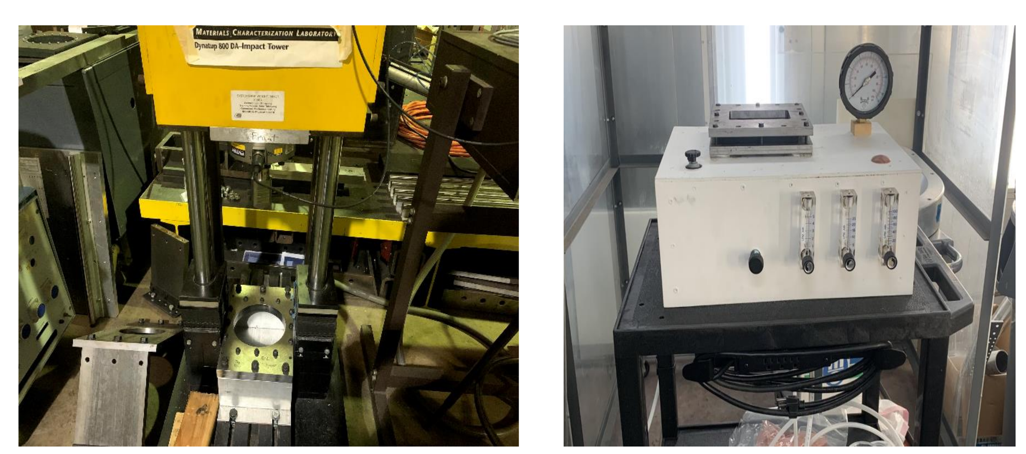
How does the composite structure in the suit behave post-impact in an environment with a pressure differential?

Methodology

- Step 1: **Manufacture impact coupons** based on suit composite construction, such as the one shown below!

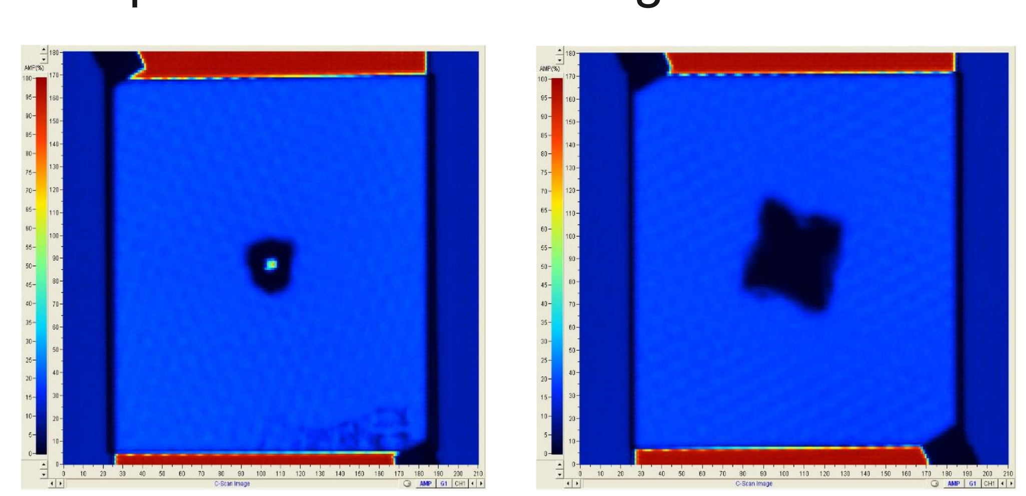


- Step 2: Perform impact tests in drop tower (a) to **simulate different drop events** that have potential to occur in real-life situations.
- Step 3: Perform leak tests in air pressure control box (b) to quantify air leaks. Pressure tested at 4.3 and 10.6 Psi, **which represent the critical rates at which the suit can maintain internal pressure** long enough for the astronaut to return to base.

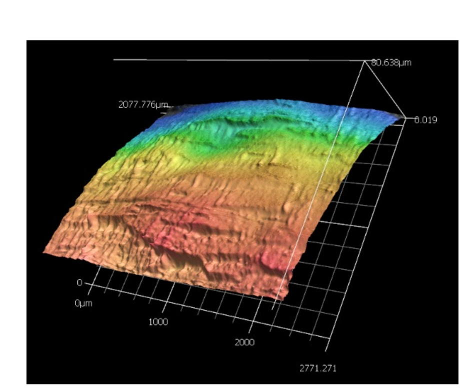


(a) (b)

- Step 4: Analyze damage area. Damaged panels are C-scanned to observe the **total area of the damaged impact zone**. Examples of ultrasonic images shown below.



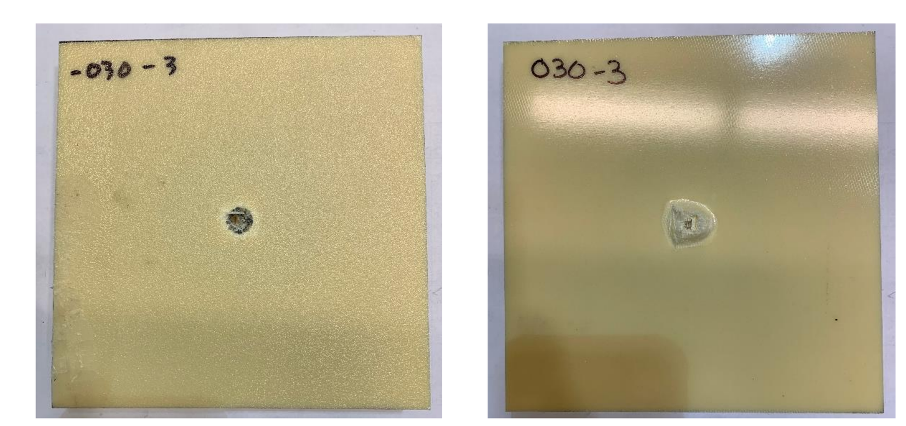
- Samples are then potted in a resin and the damage is observed underneath a **confocal microscope**. Profile of cross section shown on right.



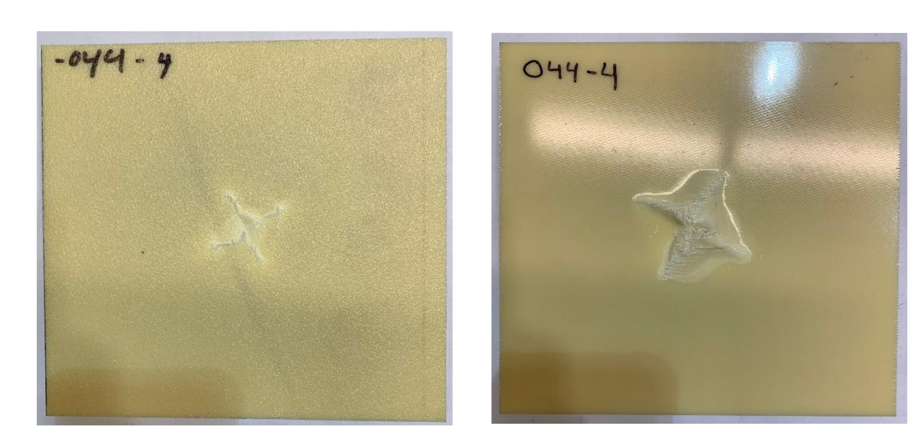
Results and Discussion

- **Impactor heads vary in size and shape**, as seen below (left to right: 0.5", 2", Cube). Their masses were used to calculate force upon impact, which was determined by the suit's operational requirements and the scenarios being simulated.

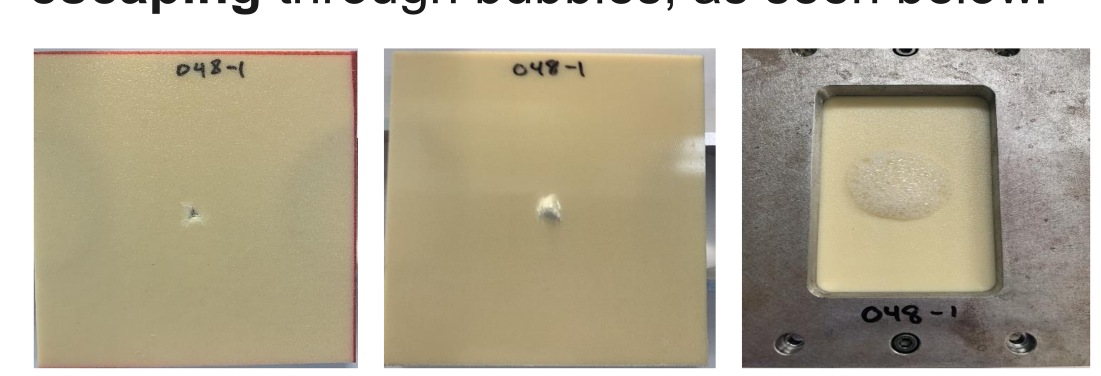
- Front and back of panel after impact with **0.5" diameter impactor**. This simulates a tool being dropped onto the suit.



- Front and back of panel after impact with **2" diameter impactor**. This simulates a larger impact surface area, as if the astronaut were to fall over.

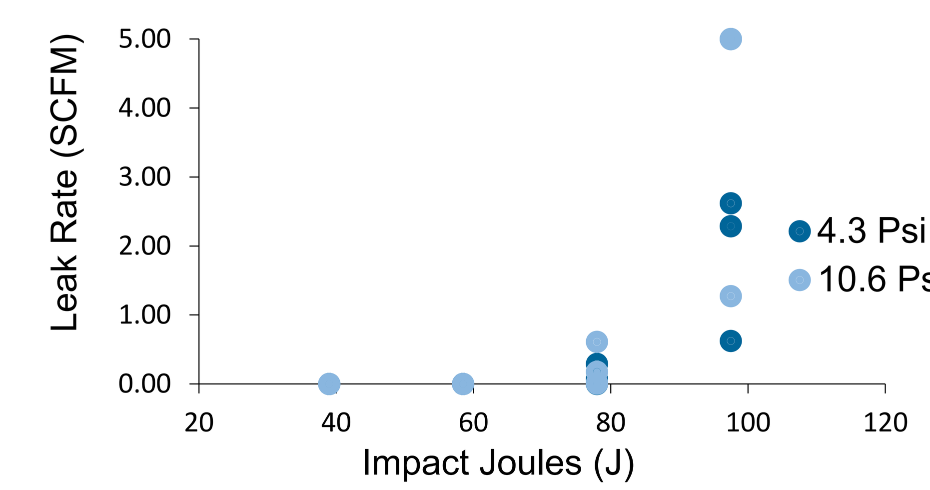


- Front and back of panel after impact **with cube impactor.** This piece simulates another tool being dropped. If air pressure leak is too small to register on the control valve, then soap is applied to the damage area to **observe if air is escaping** through bubbles, as seen below.

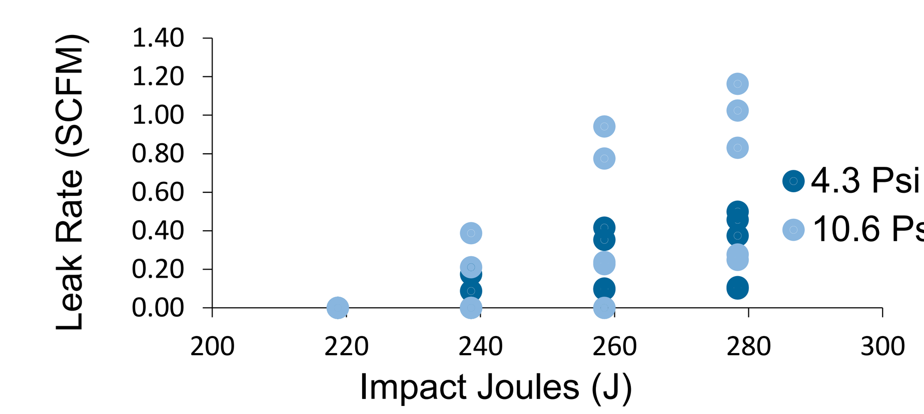


Summary and Conclusion

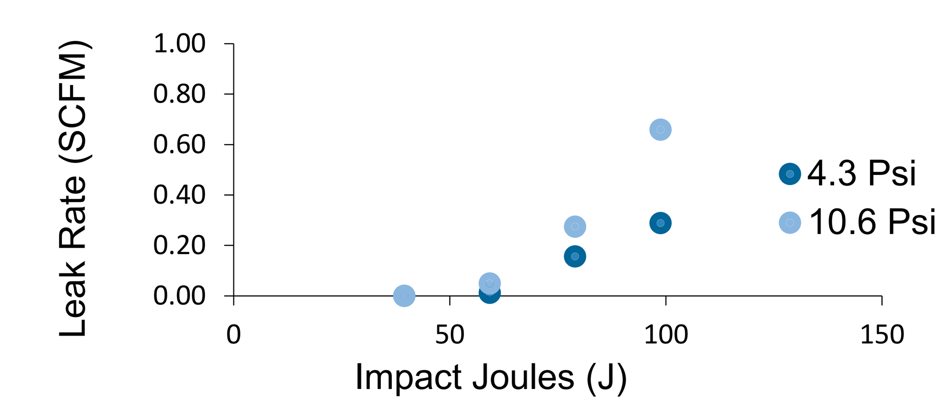
- Leak rate is **dependent on impactor geometry, impactor energy, and composite damage** to the impact face**.**
- Leak rate relationship with impact and damage parameters allows suit designers to **establish operational safety margins.**



Leak rate vs. impact force for 0.5" impactor head.



Leak rate vs. impact force for 2" impactor head.



Leak rate vs. impact force for cube impactor head.

- Samples that experienced the simulated **tool drops failed at the highest energy** level. Samples that experienced the **large surface area impact fell within the tolerances** permissible by NASA spacesuit engineers**.**
- Next stage would be to determine a way to quickly repair failing damage to **minimize the leak rate** in emergency situations.

Acknowledgements

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