The problem has to do with freezing of copper water heat pipes. We want to know if these heat pipes can handle repetitive freezing and thawing in operation (over 10,000 life cycles) as our spacecraft goes in and out of the Earth’s shadow during orbit. Below is a picture of one of our heat pipes that we have designed into a low earth orbiting mission. Inside the copper tube is a copper sintered wick (heat pipe shown below split open) that is saturated with water. The concern is that the water will form an ice plug that will cause the heat pipe to burst. The vendor states that they “under charge” the heat pipe so that there is enough water to satisfy our thermal performance requirement, but not enough to fully saturate the wick and cause pooling of water. A published journal paper showed that when one side of the heat pipe is powered or heated, and the opposite side is forced cold below the freezing point of water, the water in the heat pipe forms a ice plug that caused rupture. Our vendor stated that heat pipes of the study were commercial off the shelf and not treated to mitigate against rupture due to freezing. We did
test a sample of heat pipes by powering one side and bringing the other end below freezing (to ~-35°C) across 10 cycles, we did not see burst or degradation of performance.

We want to know the following:

- Do we need to devise a full 10,000 freeze/thaw test to show that these pipes will not fail over time either by bursting or by degradation of the wick. If so, would speed of heating and cooling (e.g. cool/heat to fast) induce a failure not otherwise experience in the true operation? To do 10,000 cycles, we may need to accelerate the freeze/thaw speeds in order to reduce the time of test.
- Is there something else that we are missing that can happen across several years? Some one suggested that a water molecules could deposit themselves across several years to form an ice plug that could burst the pipe should you apply heat to the heat pipe and force cool the other end. We actually employ a freeze/thaw test where we cool the entire heat pipe to -35°C, and then slowly heat it up to 100°C; we do this 100 times and have never seen a heat pipe rupture.
- An internal JPL peer review study indicated that there is more concern with the water in the wick spalling the wick with repetitive freeze/thaw cycles. We have measured test data that these heat pipes have handled about 3,000 freeze/thaw cycles without degradation of performance. Our vendor has stated that these sintered copper wicks are compliant and not susceptible to freeze/thaw causing the wick to physically degrade.