Oxygen Hazards Analysis of External Tank Gaseous Oxygen Pressurization System

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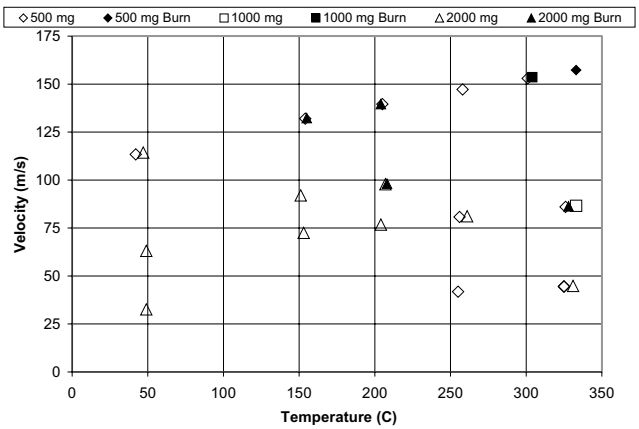
White Sands Test Facility (WSTF) has, since 1988, been conducting particle impact ignition testing using the WSTF subsonic particle impact test apparatus. Testing began with concerns about NASA's Space Shuttle oxygen flow control valves (FCVs) and continued with determining the resistance of various metals to particle impact. This paper presents previously unpublished data and demonstrates how these data can be used to assess materials flammability and ignition probabilities through hazards analyses.

In November 1999, the WSTF Oxygen Hazards Analysis Group evaluated possible particle impact ignition hazards in the Space Shuttle gaseous oxygen (GOX) pressurization system components. Because of a failure in a quick disconnect, two particles were thought to have been released into the Space Shuttle External Tank (ET) pressurization system.

To complete this evaluation, WSTF conducted a hazards analysis on the individual components to determine material flammability, the presence of active ignition mechanisms, and potential secondary and reaction effects. Because the focus of this analysis was to determine the fire hazards associated with the presence of the two particles in the ET pressurization system, particle impact ignition was the primary ignition mechanism considered; kindling chain was also considered because of its propagation characteristics. These were the only credible ignition mechanisms that could be caused by adding particulate to the system.

Particle impact ignition occurs when flammable particles with a velocity of at least 50 m/s impact a flammable material and the collision results in the ignition of either the particle or the impacted surface. To thoroughly analyze the particle impact ignition probability, WSTF used the unpublished data collected from the 1988 Flow Control Valve Study. Because the total heat release of particles used in the 1988 tests was nine times greater than the heat release available from the larger of the two chromium particles considered in this analysis, WSTF was able to conservatively apply these data to the analysis. Discovered in the previous study: the design and materials of the FCVs are resistant to particle impact. Likewise, the data from the

Particle Size Range (µm)	Percent by Weight		
	Aluminum 2219	Inconel 718	Stainless Steel 21-6-9
Less than 25	23.9 – 26.1	13.8 – 15.1	15.4 – 16.8
25 – 44	7.2 – 8.1	4.2 – 4.7	4.6 – 5.2
44 – 88	8.6 – 10.8	4.9 – 6.2	5.5 – 7.0
88 – 49	2.0 – 2.5	1.2 – 1.4	1.3 – 1.6
149 – 177	0.7 – 1.1	0.4 – 0.7	0.4 – 0.7
177 – 250	0.7 – 1.1	0.4 – 0.7	0.4 – 0.7



Flow Control Valve Study indicate the conditions necessary for particle impact ignition do not exist in the Space Shuttle GOX pressurization system components.

The final conclusion drawn from the Space Shuttle GOX ET pressurization system analysis was that there was no need to disassemble and clean the system. Investigators determined that the chromium particles suspected of being in the pressurization system would not produce a particle impact ignition threat. In all cases, data were available to verify that particle impact ignition would not occur.

This paper demonstrates that the hazards analysis process, as published in ASTM Manual 36 (2000), can be successfully used to make significant operational decisions based on flammability and ignition data obtained from the literature. In many cases, there are not enough data to specifically determine the ignition and burning hazards in an oxygen system. Fortunately for NASA, some previously acquired but unpublished data were available to determine that particle impact ignition was not a credible threat in this case, thus averting a costly disassembly and cleaning operation. However, this instance illustrated the need to obtain more particle impact data. Plans are currently in place at WSTF to perform particle impact testing to determine the effect of velocity and pressure on the ignition of various particles and test sample materials.