Particle Impact Test Results on Stainless-Steel, High-Pressure Manual Valve

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An HiP® 20A-11HF9 valve failed in the closed position during oxygen venting and transfer operations, and a second valve of the same type had internal leakage. The Oxygen Compatibility Assessment (OCA) Team, at the request of the failure investigation team, assessed the oxygen compatibility of the valve components. The valves are within a 316 stainless-steel body and have a 17-4PH stainless-steel stem; 316 stainless steel is recognized as being flammable at pressures greater than 111 pounds per square inch absolute (psia), and 17-4PH stainless steel at pressures greater than 200 psia.

The OCA review concluded that particle impact was the only credible ignition mechanism for this valve. Particles entering the valve from the lower port would impact directly on the body first and then possibly the flat geometry of the stem. Particles entering the valve from the upper port would most likely impact the stem first but have a lower probability of igniting it due to the small location of 90-deg impact points. However, a particle, or particles, could miss the stem altogether and still impact the body of the valve. Therefore, particle impact is considered possible when the valve is constructed with a 316 stainless-steel body. The history of use is significant for normal operation at NASA Johnson Space Center's White Sands Test Facility (WSTF) in that no known particle impact ignitions of stainless-steel body valves have occurred. The reason that these valves have been used successfully is thought to be due to system cleanliness levels at WSTF.

Because of concerns, WSTF performed particle impact testing in 100% oxygen on identically constructed HiP 20A-11HF9 valves to determine whether there is a particle impact ignition hazard in these manual valves. Multiple series of particle impact tests were performed at 4000 pounds per square inch gauge (psig) with approximately 1400 psig backpressure in each flow direction using various sizes and amounts of iron powder particulate mixtures. Each particulate mixture consisted of 50% -50+100 mesh iron powder and 50% -60 mesh iron powder. No ignitions occurred during

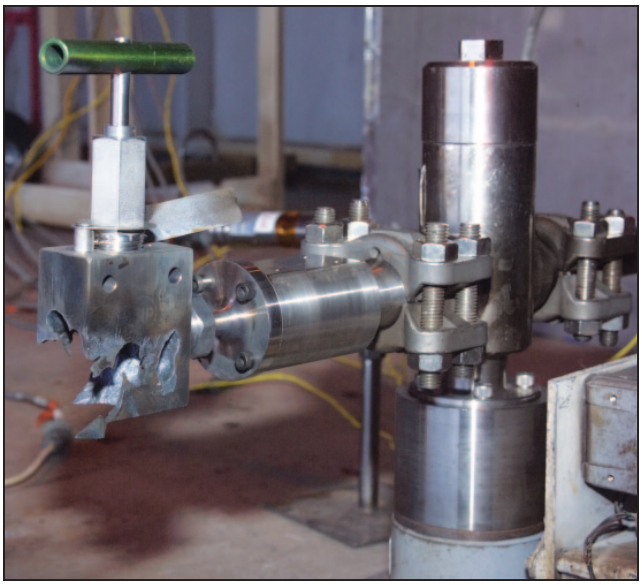

Fig. 1. *Outlet of valve impacted with 1000-mg iron powder.*

Fig. 2. *Inside of valve impacted with 500 mg iron powder.*

the first test series with 100 mg of iron powder, but ignitions occurred with greater amounts of particulate mixtures on the first impacts of both test series 2 (1000 mg) and 3 (500 mg). Figure 1 shows a valve after impact and ignition with 1000 mg of iron powder; figure 2 shows damage with 500 mg.

The results of the 250-mg iron powder testing were deemed invalid after attempts to duplicate the 500- and 1000-mg ignitions were unsuccessful. During disassembly of the valve, a difference in the internal valve configuration was discovered. The valve used for the 250-mg test had a tapered edge seat, but it is assumed that the valve used in the previous series had a sharp edge seat. When the 250-mg test series was repeated with the identical configuration (valve with sharp edge seat), no ignitions occurred in either direction. The valve exhibited no ignitions in 120 tests (60 in each flow direction) with the following particulate mixture: 125 mg of -50+100 mesh iron powder and 125 mg of -60 mesh iron powder, for a total of 250 mg per test.

It has been determined that HiP® model 20A-11HF9, stainless-steel body and 17-4PH stem valves do not pose a fire hazard when the design of the system and maintenance performed precludes the simultaneous impact of 250 mg or more of iron-containing particulate on any oxygen-wetted surface and as long as the inlet pressure to the valve is less than 4000 psig. If the inlet pressure is greater than 4000 psig, the particular application must be assessed to determine whether these data can be used to predict the risk of a particle impact ignition.