National Aeronautics and Space Administration

NASA Engineering and Safety Center Technical Bulletin No. 10-02

Potential Failure of Dual Simultaneously Initiated Pyrotechnic Operated Valves

The NASA Engineering and Safety Center (NESC) Technical Bulletin No. 09-01 reported an independent investigation of four pyrovalve failures that occurred while using aluminum (Al) pyrovalve primer chamber assemblies (PCAs) during ground testing. The investigation revealed that simultaneous firing (within a few microseconds) of the NASA Standard Initiators (NSIs) was the primary reason why the booster charge failed to ignite and the pyrovalves subsequently failed to operate. A second investigation of a new stainless steel (SS) PCA design with separate flame channels was completed in 2010. The new SS configuration was found to be improved in most respects; however, no improvement was noted in the temperature delivered to ignite the booster during dual simultaneous NSI firings. Simultaneous firings should be avoided when using either the Al or the SS PCA design.

Applicability

NASA and industry frequently use pyrovalves in propulsion systems and other types of applications.

Background

In 2008, the NESC investigated four instances when normally closed pyrovalves did not actuate after simultaneous firing of dual NSIs failed to ignite the booster charge. In each anomaly, an Al PCA with NSI flame channels in a Y configuration (Y-PCA) was used to direct the output energy to the booster charge. The booster charge generates most of the force to actuate the ram and open the pyrovalve. Based on assessment findings that the Al PCA channels eroded during firings, reducing energy for booster initiation, and that the "Y" flow passage had potential flow issues, the Mars Science Laboratory propulsion system team chose a new SS PCA with independent V-shaped flow passages (see figure). The NESC conducted an additional independent assessment to compare the booster interface temperature for the two configurations and quantify the improvements.

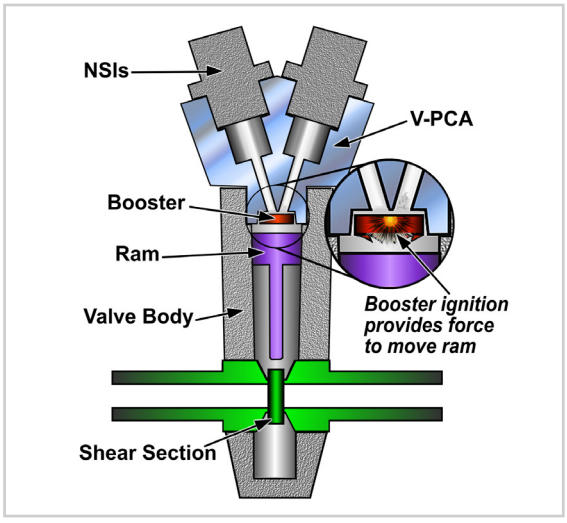


Diagram of a Normally Closed (NC) Pyrovalve Block

Findings and Conclusions

Based on testing to date, the SS V-PCA produced an average temperature of 2300°F at the booster interface versus 1400°F for the legacy Al Y-PCA during a single initiator firing indicating that both are reliable in this firing mode. However, the SS V-PCA did not improve the pyrovalve performance during simultaneous firings (skew within 5 microseconds). Although the NSI firings were nominal, neither configuration produced a temperature at the booster that was significantly above the auto-ignition temperature of the booster propellant. Doubling the diameter of the flow passages in the SS V-PCA above the standard diameter (four times the cross-sectional area) was also evaluated and did not eliminate the simultaneous firing anomaly.

As in the legacy Al Y-PCA, test results for the SS V-PCA indicated firing commands for the two initiators should be separated by at least 2 milliseconds (ms) to guard against potential operational failure. When separated by 2 ms or more, both the legacy Al design and the new SS design produced booster interface temperatures adequate for reliable booster ignition.

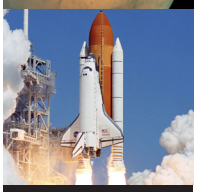
References

NESC Technical Bulletin No. 09-01, Failure of Pyrotechnic Operated Valves with Dual Initiators. NASA Engineering and Safety Center.

Jet Propulsion Laboratory, Disclosure for the Steel Primer Chamber Assemblies for Dual Initiated Pyrovalves. New Technology Report #46302, California Institute of Technology, July 7, 2008.

CONAX Y-PCA Booster Anomaly Investigation Report, NESC Document Number RP-08-111, NASA Technical Memorandum (TM) Number TM-2008-215548.

For more information contact the NESC at www.nesc.nasa.gov



NESC tech bulletin