National Aeronautics and Space Administration

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Failure of Pyrotechnic Operated Valves with Dual Initiators

Investigation of recent pyrovalve failures reveals timing of redundant initiator firings is crucial for reliable operation of pyrovalves. Simultaneous firing, i.e., within a very narrow time frame, was found to be the primary cause of the valve failing to operate. Testing of both single and dual initiators revealed important design characteristics affecting pyrovalve device performance. They include Primer Chamber Assembly (PCA) geometry and material properties, as well as operational effects on combustion product flow, and resulting energy transfer to the booster.

The CONAX PCA design has evolved slowly over time undergoing incremental changes to correct known issues. These piecewise changes were verified by limited test, without a full understanding of the overall system impact or effect on margins. Adequate system performance margins may be adversely affected in existing or future systems incorporating a pyrovalve actuated by simultaneous firing of dual initiators.

Applicability

Pyrovalves are used frequently in propulsion systems built by NASA and industry.

Background

Four spacecraft propulsion system pyrovalve "no-fire" failures were recently investigated by the NESC (NASA Engineering and Safety Center). In all four cases, a normally-closed pyrovalve failed to actuate during tests in which simultaneous firing of dual initiators failed to ignite the booster charge. In each failure, a common aluminum Y-shaped PCA (Y-PCA) manufactured by CONAX was used to mechanically accommodate the two initiators and to direct the individual output products of each initiator towards the booster charge. Booster charge ignition is intended to generate sufficient pressure to actuate the pyrovalve.

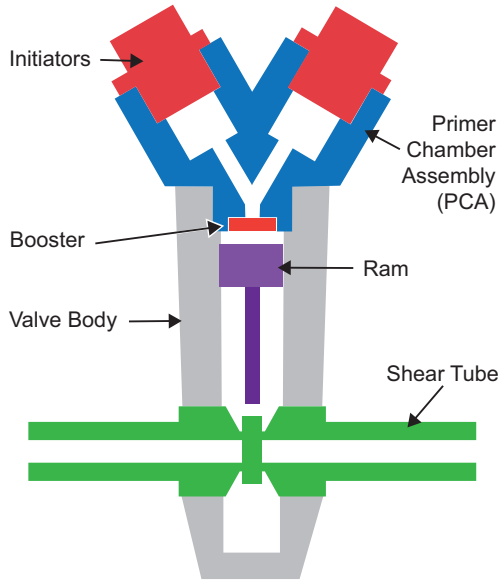
Findings and Conclusions

The primary finding from this investigation is that dual simultaneous firing (< 10 microseconds skew) is not as robust as a single firing and should be avoided. When close sequential firing of the redundant initiator is necessary, the NESC recommends the skew time between initiator firings should ideally be longer than the flow duration for single fire. Thus the NESC recommendation that use of the device should be constrained to single fire operation (or dual with skew greater than 2 milliseconds) to ensure robustness of booster ignition.

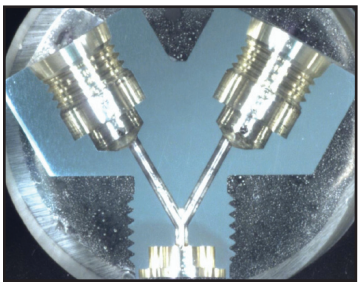
The NESC has forwarded this finding, and others related to critical PCA parameters and device qualification issues, to projects using the current design. In addition, the NESC contributed to a new stainless steel PCA design activity initiated by the Mars Science Laboratory project. Recommendations outlining other follow-on tasks have been communicated to the NASA Pyrotechnic Working Group.

References

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



A normally closed pyrovalve



Unfired PCA sectioned at midline

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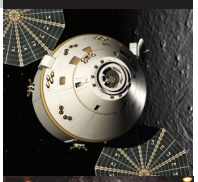
For information contact the NESC at www.nesc.nasa.gov

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