NASA WHITE SANDS TEST FACILITY

PYROVALVE BLOWBY TESTS
SPECIAL TEST DATA REPORT

WSTF # 03-37670
November 26, 2003

1.0 INTRODUCTION

The NASA White Sands Test Facility (WSTF) was requested to perform pyrovalve blowby tests in support of the Mars Observer Propulsion and Corrective Actions Test Program. Fifty-three tests were conducted in an attempt to characterize the blowby of commercial pyrovalves. Those pyrovalves used on NASA spacecraft are well represented, and the test data reported provide a basis for evaluating the performance of similar valves in other propulsion systems.

The three test series conducted are subsequently described. All testing was done in the same test facility, with periodic changes that enhanced the test methodology.

1.1 SERIES A: OEA VALVES

Thirty-four tests evaluated OEA valves with clearance-fit of rams in sleeves; O-rings were not used in order to maximize the amount of blowby. The ram/sleeve bore clearance was varied in an attempt to correlate blowby mass with clearance. Measurement of blowby constituents also allowed the correlation of other parameters, such as mole fraction of hydrogen gas, that has been shown to accelerate the decomposition of hydrazine.

1.2 SERIES B: CONAX VALVES

Sixteen tests evaluated 0.25-, 0.375-, and 0.5-in. Conax valves with interference-fit ram/sleeve systems that are intended to reduce blowby.

1.3 SERIES C: INTERFERENCE-FIT RAM EVALUATIONS

Eleven tests with a pyrovalve simulator evaluated a new interference-fit ram/sleeve design developed at WSTF. Four tests of the new design and seven tests of a baseline Conax-type ram/sleeve design were conducted.

The goal of this testing was to develop a database that provides pyrovalve system designers information for minimizing blowby of hot pyrotechnic product gases into a fuel line and, thereby, minimize the attending risk of catastrophic fuel decomposition.

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2.0 TEST DOCUMENTS

JSC Form 2035 (Appendix I) and WSTF Document No. TP-WSTF-854A[1]

3.0 TEST SYSTEM DESCRIPTION

The WSTF Blowby Test System uses a high-speed data acquisition system, a gas chromatograph, and a mass spectrometer, residual gas analyzer (RGA). Typical measurements include pressures and temperatures above and below the ram, accelerometer signals from the valve body, initiator voltage and current readings, and a VISAR data signal. Figure 1 shows the test system and Figure 2 shows the pyrovalve simulator components showing both single- and dual-port heads that were used.

Figures 3 and 4 are schematics of the test system as modified and used for tests of Conax valves at design temperature extremes in February 2001.

4.0 TEST PROCEDURES

Figure 5 shows a flow chart for pyrovalve blowby evaluation. Although not part of the actual blowby measurement process, pretest valve measurements are taken to allow posttest investigation of valve-to-valve performance variations. These measurements include the ram/sleeve clearance, ram starting position, and cylinder diameter.

Brief descriptions of individual steps taken during testing are given here in sequence. The steps necessary to assure personnel protection that do not affect data quality have been eliminated for purposes of clarity.

1. Disassemble test article, measure dimensions, and clean parts to Class 100 condition. Reassemble in Class 10,000 clean room, without O-rings for the worst-case condition.

2. Place test article in test system and attach all connections for data measurement.

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[1] Saulsberry, R., R. Moreland and K. Rathgeber. *Mars Observer Propulsion and Pyrotechnics Corrective Actions: Propulsion System Test Program (MOCATP), Interim Control Module Pyrovalve Test*, TP-WSTF-854A, NASA White Sands Test Facility, Las Cruces, NM, November 3, 1997.

3. Start vacuum pump and open GN_2 line outside of test cell for cycling of ECVs and ROVs.

4. Turn on cold junctions located outside of the test cell.

5. Turn on computers and begin PVT program.

6. Allow the vacuum pump to evacuate the valve for approximately 20 min.

7. Close ROV to perform initial leak check.

8. Begin temperature conditioning to heat the valve body to 120 ± 10° F.

9. If no leaks exist, and the pressure under vacuum is acceptable, perform the blowby test, e.g.,

   - Make announcement that initiator is to be installed
   - Install initiator per safety instructions
   - Start PVT program with appropriate test titles
   - Fire the initiator
   - Start the GC program
   - Perform a leak check to make sure the valve cycled.

10. When firing is complete, remove valve from the test system and take it to Class 100 clean room for flush procedure.

5.0 RESULTS AND DISCUSSION

Table 1 identifies each test by file name for easy reference to an ASCI II database available on the CD.[2] Measured system pressures and temperatures can be plotted using Excel®[3] for each test; however, a standard set of plots is given in this test report.

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[2] Pyrovalve Data. *Volume 1, Blowby Test Data and VISAR Data. Volume 2, Ignitability Data.* NASA White Sands Test Facility, Las Cruces, New Mexico, October 2002.

[3] Excel® is a registered trademark of the Microsoft Corporation.

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Individual tests are described and test results, including blowby gas and particulate analyses, are presented along with plots of transient data in this test report.

Test data are reported for each test under the appropriate subheading below. A brief description and objective of the test is given, followed by pretest measurements and recorded data, including selected plots of transient data.

Typical transient data reported include:

- Voltage and Current – measured for initiator firing circuit
- Pressures - transducer located above and below the ram
- Blowby Temperatures – measured by thermocouples located directly in the blowby gas path (High) and further away (Low) in the simulated fuel line
- Acceleration – measured by an accelerometer located on the valve holding fixture
- Irradiance – measured output of a photo cell located in the simulated fuel accepting the blowby charge. positive measurement indicated flash of light present

Traces for up to two time scales are presented for each test reported.