

UNITED STATES GOVERNMENT

Memorandum

Response Date
Dec. 7, 1967

GILBERTH- mfw

Nov 22 1 23 PM '67

TO : PA/Manager, Apollo Spacecraft Program

DATE: November 22, 1967

FROM : EP/Chief, Propulsion and Power Division

SUBJECT: LM-1 Engine Recommendation

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11-25

In response to the John Lee Meeting October 23, 1967, action item number 10, the Propulsion and Power Division recommends that the E2B injector presently on LM-1 be utilized for that mission. The E2B is not a dynamically stable injector as experienced by four instabilities in an ablative chamber when bombed and by one instability (E2B-43) that occurred from a pop. However, the following rationale is presented which is considered sufficient justification for use of E2B on LM-1:

PA-MGR ✓
PA-M,CSM ✓
PA-M,LM ✓
PA-AstMgr ✓
PA2 ✓
PD ✓
PE act ✓
PF ✓
PK ✓
PP ✓
PR ✓
Files orig ✓
886 ✓
Pk-Simpson ✓

a. To date, the E2B injector has accumulated 37,776 seconds of firing time including 70 full mission duty cycles, 481 sea level starts, and 98 high altitude starts.

b. E2B-43 failure has been evaluated and the following observations are summarized herein:

(1) This injector was unique insofar as it had been dispositioned "for ground-service only" because of nonconformance with drawing requirements. Discrepancies consisted of an annular undercut in the injector, approximately 0.11" wide and 0.06" deep; adjacent and perpendicular to this groove was an additional undercut of .0126" and 0.15" long along the flange of the injector face. Both discrepancies provided an easy path for propellant to reach and accumulate in the lower push holes located in the ablative liner holder.

(2) A high-order disturbance occurred approximately 293 seconds into the 460-second, horizontal attitude firing run. This saturated all accelerometers. Combustion instability was sustained subsequent to this occurrence.

(3) No evidence of structural failure, either in the injector or the baffle, has been identified as a contributing factor in causing the chamber pressure disturbance or the subsequent instability.

(4) The most probable cause of the high-order disturbance was the detonation of fuel which had accumulated in the liner holder pushout holes, probably at shutdown of the preceding 15-second test. This 50-50 UDMH/N₂H₄ mixture vaporized and finally detonated when the thermal

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conditions became appropriate. This position is based on the following observations:

(a) A disturbance generator outside the combustion chamber is indicated by the fact that the longitudinal accelerometer saturated about 20 milliseconds later than those for the other two axes. When baffle leaks were induced on injector E2A1AC, the resulting pressure pops caused all three accelerometers to move simultaneously.

(b) The pushout hole locations at the 3 o'clock and 6 o'clock were clearly evident on the injector flange. They were defined by dark coloring and a 0.0001" depression.

(c) A small amount of black residue was noted in the undercut area adjacent to the 4 o'clock baffle position.

(d) Small sections of the ablative were sheared along the grain lines at the headend, especially behind the baffle legs. This is more typical of the action of a high velocity stream than the effects of unstable operation. The latter usually causes "chunking" of the ablative.

(5) The S/N 43 test was, of course, conducted under sea level conditions. It is inferred that the occurrence of such a high magnitude disturbance due to the specific cause hypothesized is not very probable in the LM-1 engine, since the injector-thrust chamber joint is specifically designed to prevent propellant accumulation.

c. To date the E2B injector has been bombed a total of 68 times in an ablative chamber, only four of these were unstable.

d. Only four firings of the 579 starts have experienced pops which were dispositioned as follows:

(1) E2B-6 experienced a pop 321 seconds into run. The accelerometer recorded 2000 g's. The pop was attributed to the valve. The hardware for this test was a streak liner.

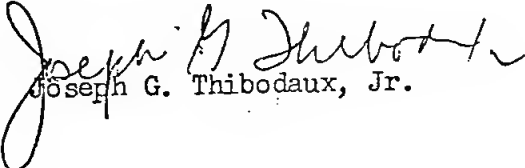
(2) E2B-1B experienced a pop during DVT S/L-5 which was attributed to low purge setting at shutdown.

(3) E2B-1B experienced a pop 80 to 90 seconds after fire switch one. This pop attributed to a wet injector.

(4) E24-43 experienced a pop which resulted in instability.

From the testing to date the E2B engine is known not to be dynamically stable. The test also concludes that only four pops have been experienced during 579 starts. In addition, the engine has been bombed 68 times in

ablative chambers with only four instabilities. From this data one concludes that the engine has a very high probability of not going unstable.


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