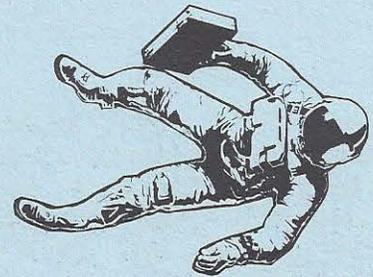


THE  
**COMMERCIAL  
SPACE REPORT**



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Dear Subscriber:

September, 1981

Oops!

G.C.H. Inc. joined the hallowed ranks of rocket test engineers by blowing up its first engine test prototype on its second test attempt. Many news articles made much of this, referring to it as the "end of a dream" rather than what is actually a rather common incident in the development of new rocket technology. The letter this month will go over some of the details of the test, including some analysis of the causes of the problems.

When we last left our rocket and crew, final countdown work was being done in preparation for the five-second test burn (the "burp test") that would initially check out the rocket's systems. The test stand was connected to the pump system that would run cooling water from the nearby pond through its structure. A transport containing liquid oxygen was connected to a pipe (a very long pipe) which ran to the test stand and connected to the oxidizer tank of the rocket. A similar setup was arranged for the kerosene tank. Rows of high-pressure gas cylinders (helium for the oxygen tank, nitrogen for the kerosene tank) were connected together by manifolds, and then connected to the tank pressurization system of the test stand.

On July 31, 1981, final checks were made for the first test. An engine igniter, resembling a fireworks "Catherine Wheel" (although more sophisticated) was mounted inside the engine chamber just below the injector. Pre-test checks were made of the cooling system (is the alligator still in the cooling pond?), propellant loading systems, valve control systems and tank pressurization systems. These checks were done by 2:00 P.M.

At 2:45, liquid oxygen was pumped into the oxidizer tank. The aluminum tank frosted up, and large quantities of oxygen gas boiled off as the tank cooled. Before the rocket was shipped from Sunnyvale, some concern was felt that this boil-off would tend to overpressurize the tank, and a very large vent valve was added to supplant the original vent system. This vented the excess cold gas out the side of the rocket at a much higher rate. The larger valve worked well, and tank pressure did not exceed 18 psi at any time during the fill, which took about an hour. At the end of the fill, the main LOX valve in the engine was cycled to test for freeze-up. The valve operated correctly.

The area was cleared of all personnel, and beginning at 4:07, kerosene was pumped into the fuel tank. At the end of the complete fill sequence, there were 3700 lb. of liquid oxygen and 1600 lb. of kerosene in the propellant tanks.

Vent valves were closed, pressurization began at 4:20 p.m. and lasted until 5:41, (over an hour and 20 minutes) when instruments showed pressures of 133 psi in the LOX tank and 138 psi in the kerosene tank. Final checks were made of all systems, and the final ignition sequence was started.

At 5:50 p.m., an attempt was made to fire the igniter prior to opening the main propellant valves. The igniter failed to ignite. A second attempt also failed. By this time, boiloff in the liquid oxygen tank had raised tank pressure to 160 psi. The continued existence of the rocket was reassuring, since design burst pressure for the tanks was 150 psi, but immediate venting of pressure was called for. The oxygen/helium gas mix was vented at intervals, in short bursts, to protect the common bulkhead from inverting itself from too high a pressure difference in the tanks. Complete depressurization of the tanks was completed by 6:43 p.m., and procedures were initiated to drain the oxidizer tank and "safe" the system for inspection.

Later inspection revealed that a small leak in the kerosene engine valve dribbled kerosene onto the igniter, soaking it and rendering it impossible to light. A procedure was established to waterproof the next igniter, and another attempt was planned.

On August 5, 1981, the second test attempt was made. At 3:00 p.m. all checkouts were made and the propellant loading sequence was begun again. Loading was completed at 4:27 p.m. with 6700 lbs. of liquid oxygen and 1900 lb. of kerosene in the tanks.

A modification to the pressurization system increased gas flow from the storage tanks, so pressurization was completed in about 20 minutes this time. Instruments showed 124 psi in the LOX tank, 127 psi in the kerosene tank.

A five-minute countdown sequence was begun at 4:52 p.m. The following sequence of events was reconstructed from instrument readings and analysis of debris:

The igniter fired successfully, which fact was established by observation. The propellant valve opening sequence was begun, with the oxidizer valve leading. This was done to prevent any accumulation of fuel in the chamber before the oxidizer entered, a situation which often results in what rocket engineers call a "hard start" leading to possible "catastrophic disassembly".

Unfortunately, the Texas humidity had apparently frozen a layer of ice over the face of the valve, a condition which for some reason had not occurred in the first test. The pneumatic valve actuator pressurized, but was unable to force the valve open. This condition did not show up on the board and the kerosene valve was opened. Kerosene poured onto the igniter and lit. A kerosene-only flame poured over the test stand, a dirty yellow flame quite unlike the expected bright yellow-white flame of an oxidized ignition. This lasted for 1.5 seconds. Before the situation could be corrected, or a shut-down initiated, the warm environment thawed out the still-actuated oxygen valve, and opened it.

By this time, of course, not only was the chamber full of kerosene, but hot kerosene and flaming gases had backed up through the oxygen ports of the injector (downstream from the cranky valve) and into the injector's oxygen plenum. This is where the newly-released liquid oxygen met the fuel for the first time. It never made it to the engine chamber. The detonation occurred in the injector itself. The bottom of the injector, (the oxygen deflector), emerged from the engine bell with considerable velocity, hit the flame deflector of the test stand, and took off for the West Coast. In the forward direction, the detonation used up its remaining energy by annihilating the recalcitrant oxidizer valve and fracturing the oxidizer feed line.

This insulated feed line runs directly through the center of the kerosene tank. A lot of liquid oxygen was introduced to a lot of kerosene inside the kerosene tank. The resulting explosion, the impressive one they showed on television, blew the rocket apart. The tank was clipped cleanly off at the interface with the rear bulkhead of the kerosene tank. The tank left the premises in a vertical direction. The rear bulkhead, still firmly attached to the test stand and filled with kerosene, stayed put and burned merrily like a giant tiki torch. The engine, attached to the bottom of the rear bulkhead, sheared loose and rolled into the grass, completely unharmed.

The rest of the rocket split at the seams as it flew upward. The center bulkhead was ripped whole from the tank wall, (apparently by a second explosion near the bulkhead,) forced toward the aft end of the rocket, and came to rest wedged inside the kerosene tank. Portions of the tank above the rear bulkhead blew into four pieces. The area of the tank around the center bulkhead split and flew nearly into the cooling pond, where the alligator was pondering how life would probably be safer as a pair of disco shoes. The main portion of the kerosene tank fell to the ground in one rather dented piece. The oxygen tank, with nose cone, flew 250 feet into the air, and plummeted to earth, also essentially in one piece.

The crew immediately set to work dousing the largest cow-chip fire of the year, and picking up the pieces. The test stand, basically unharmed, (test stands are designed to be relatively placid about explosions) sat there covered with soot. The rear bulkhead, its little pool of kerosene still burning, sat on top of it. As engineers milled around checking damage, the 500 lb. bulkhead finally melted itself loose and rebounded off the flame deflector to the ground with a resounding clang. It missed the engineers, but did nothing for their nerves. The mess was soon cleaned up and analysis began.

Conclusions? Since the propellant never made it to the engine chamber, no test results were available on engine performance. However, the test was not the total loss that the media tended to paint it as.

The basic structure of the rocket was sound, withstanding pressure in excess of design burst pressure. The test stand operated as it was supposed to, although its cooling system was never tested against the heat of an oxygen/kerosene flame. The stand will remain on the island. All systems (except the igniter) operated correctly on the first test attempt, including the oxygen valve. There is every reason to suppose that the first test would have been successful had ignition been attained.

More importantly, much information was obtained during the construction of the prototype which increased designer and engineer experience in the field of launch vehicle fabrication. A number of design changes were made in the process which could not be incorporated into the completed prototype but will be incorporated into the production vehicle. Ironically, one of these was the elimination of upstream propellant valves in favor of injector face shutoff systems, a design change which took place weeks before the tests. Much was also learned about production processes, and important sources of fabrication and raw materials were located along with sources of hardware and avionics.

In addition, useful experience was gained in the operations of a remote launch facility. Logistics problems with an island facility were far greater than most test facilities have to handle. The moving of heavy equipment, delicate

instruments, and everything else necessary for doing launch vehicle tests was a difficult task at best, especially since the only available transports were small planes and a barge. The test stand, the rocket transport, the liquid oxygen truck, and a host of other systems and vehicles had to be loaded on barges, hauled across the channel, and then unloaded on Matagorda Island. Anything that could not fit behind the seat of a small plane had to be transported this way. Even the pad that the test stand was mounted on had to be poured on site by a cement truck that also had to be barged out. The fact that everything got to the site in one piece and on schedule was an indication of considerable competence on the part of the test site personnel. Future tests will no doubt seem to go much easier from a logistics point of view, and the experience gained in this area alone was well worth the price.

An update on news articles since the last newsletter. An engineer from the Johnson Space Center came out to look at the remains of the test vehicle soon after the explosion took place. Henry O. Pohl, chief of the propulsion and power division at the space center, encouraged the Percheron people to continue the effort to produce a commercial launch vehicle. According to the Dallas Times Herald of August 12, 1981, Pohl says,

"I saw nothing in that incident that would not be easily correctable. They could build another vehicle and make a few modifications and be successful. One of these days, the rocket business is going to be a profit-making venture. I don't know if it will be this one, or when it will be, but it is just a matter of time."

Pohl has been at the Center since 1962, and worked on the development of the Jupiter and Redstone rockets. His encouragement is appreciated.

We will keep readers informed of progress towards a production system in future Reports. (Thanks to Clifton Horne for most of the data in this issue.)

Until next time...

Sincerely,

*Tom A. Brosz*

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