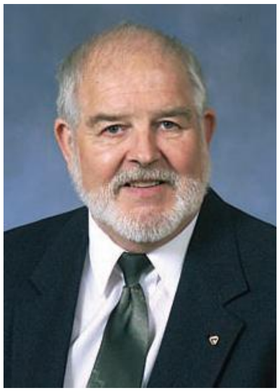
Memories for the 60th anniversary

by Ronald Dawbarn



I was fortunate to start work at AEDC when the Air Force decided to add space testing to their complex of test facilities. I studied the physics of condensation and published a paper on the topic. It was read by Ken Templemeyer who was in charge of developing the space chambers. At issue was the production of the high vacuum conditions in the various test chambers.

It was state-of-the-art to use oil diffusion pumps and the current large Mark I space test chamber was fitted with some of the largest commercially available pumps. However, the concern was that in the event of a loss of integrity of the vacuum, the oil would migrate back into the test volume and contaminate the test article. Since the chamber was designed to test complete satellites costing millions of dollars, this risk was unacceptable.

AEDC invested in some large helium refrigerators which could provide 15 degree Kelvin cooling (well below the temperature of liquid air). The hope was that the diffusion pumps could be replaced with cryogenic pumps which would freeze out the atmospheric molecules and provide an ultra clean vacuum test environment. The problem was one of the gases to be pumped was hydrogen which required much colder temperatures to freeze out. I was hired to help develop a pumping system using these refrigerators.

The space chamber facility had a research laboratory in which I, along with other physicists, worked to develop not only the cryogenic pumps but also much of the diagnostic instrumentation which eventually was used in the test chambers.

Unlike the other test facilities which focused on a somewhat restricted field of testing such as jet engines, rocket motors or wind tunnel aerodynamics, the space facilities attracted a wide variety of test requirements. During my time at AEDC the initial work on developing cryogenic pumping extended to designing and building some massive hydrogen pumps for Oak Ridge National Laboratory and also the fusion Tokamak Fusion Test Reactor (TFTR) at Princeton, N.J.

Because of the ability to provide space vacuum conditions and the specialized instrumentation for use in these test chambers, we extended the work to evaluate satellite attitude correction thrusters. The first tests were chemical thrusters using hydrazine finally resulting in testing electric propulsion engines with a whole new set of problems in maintaining a space vacuum environment and major issues in developing specialized diagnostic instruments.

At retirement I came back to design a refit of one of the larger vacuum chambers from a solar evaluation chamber to an electric propulsion test facility.

The types of tests designed and conducted over the years ranged from building space test facilities, to evaluating long wave infrared space telescopes for early warning satellites, to testing the first GPS satellite, to evaluating infrared guided interceptors for defense against intercontinental ballistic missiles.

The focus on the process of condensation also led to work beyond the vacuum chambers. NASA asked us to evaluate the potential problems with their shuttle launches where the solid rocket booster exhaust sometimes resulted in acid rain which led to problems with the Florida fruit growers. We developed a test program involving firing scale models of the thrusters in controlled environmental conditions, taking instruments developed at AEDC to NASA rocket tests at Redstone outdoor test stands and then to actual shuttle launches at Cape Kennedy. From this data we developed a set of launch constraint guidelines when acid rain was expected.

A Global Positioning System Satellite Block II test in the Mark 1 space chamber, 1985.

The Air Force also asked us to evaluate the potential contamination problems in massive fuel dumps from their refueling planes when they were required to jettison fuel after a missed rendezvous with the fighter jets.

One of the more interesting requests was to develop a test to evaluate new solid rocket fuels being developed as a low smoke propellant for aircraft launched missile systems. The problem was not just in burning the fuel but in the complex mixing of the exhaust products with the ambient atmosphere. I proposed and conducted a test using the AEDC ballistic gun range. This was an interesting test.

I suggested that the range could be used to test samples of the new fuels in scaled test rockets flying at realistic speeds through a controlled upper atmospheric simulation. The first part of preparation for the tests was to use the AEDC machine shop capabilities to make the model rockets and the special sabots used to house them in the gun.

This model consisted of three parts machined from aluminum. One component was the fins and rocket nozzle. This was threaded so that it could be screwed onto the cylindrical body of the rocket which would house the hollow cylindrical sample of the new test fuel.

The third component was the most complex and consisted of a hollow nose cone which housed the ignition mechanism, which were a tungsten firing pin and a percussion igniter cap. The proposed ignition of the fuel in the rocket body was for the tungsten pin to be forced into the firing cap by the enormous acceleration of the complete rocket as it was fired out of the launch gun. The nose cap was also screwed onto the rocket body somewhat in the fashion of a flashlight end cap.

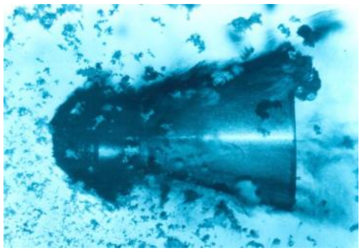
The next construction was to build a test section half way down the 1,900-foot-range which could simulate altitude, temperature and humidity. The test range itself has pumps to reduce the pressure to simulate the altitude and we had a styrofoam box built to control the temperature and humidity. This closed box was made of two one-inch thick styrofoam sheets and was a five-foot by five-foot cross section and 20 feet long. At the entrance end of the closed box, there was a one foot by one foot hole and a cover door of styrofoam was suspended over this hole with a relay operated latch which could drop this door as the test rocket approached. The far wall of the box was a single sheet of styrofoam and the test rocket pierced a hole as it passed through. There was a plexiglass window in the side of the box just opposite to one of the range's windows and its high speed camera.

Taken in 1963, this photo shows the two-stage launcher for the 1,000-foot hyperballistic Range G which uses black powder, a piston and compressed hydrogen gas to propel models velocities up to and exceeding Mach 29.

The test program was to consist of the first scale rocket loaded with the standard propellant and fired down the range. The data from the cameras were to record the rocket exhaust plume as the rocket passed through the environmental chamber, the mixing of the cold ambient air and the development of the visible plume. This data would be compared to data taken from a fighter plane launch of a full-scale rocket and the plume formation taken by a chase plane that photographed the launch and the resulting contrail.

Since there were several precise sequences which must all be accurately timed to the millisecond we allowed three launch attempts in the gun range to make any adjustments in the timing sequence.

To most everyone's surprise the first launch was a complete success. The rocket fuel ignited upon leaving the gun and the model flew down range with the initial launch velocity plus the thrust from its own fuel. The environmental door dropped on time and the rocket flew through the environmental chamber on centerline. Even with the high speed cameras we only caught one blurred frame of the rocket itself. However the remaining film recorded the first primary smoke plume and then the resulting turbulent mixing of the cold moist air and the full development of the condensation trail. This data compared favorably with the chase plane photographs of a real flight under similar altitude, temperature and humidity conditions.



Reentry vehicle material test in the hyperballistic Range G using snow. Items may be laucnhed at speeds up to 30,000 ft per second.

The rest of the test sequence consisted of building additional model rockets loaded with the various test propellants. In the sequence, there were only two failures which were due to the fact that the fuel formulations were too fragile to withstand the launch accelerations. In these models the fuel in the rocket body evidently collapsed into the nozzle and when the igniter cap fired the complete body exploded.

The final product of these tests was data that allowed comparison of the simulated flight tests to static burn tests in relatively small test chambers at the fuel manufacturer's site. This eliminated the need for the expense of further tests of additional formulations in the range.

The time spent at AEDC during these years was very rewarding in the many challenges which were met and the successes achieved in the many varied test programs. I could not have had a more congenial and helpful set of co-workers both with the contractor personnel and the Air Force staff.