B–1 and B–3 Test Stands

NOTE: This text-only version of the B–1 and B–3 Web site has been created to facilitate printing of the text. The index below links to sections within this document. Please refer to the actual Web site for more.

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Historic Facilities at NASA Glenn

The High Energy Rocket Engine Research Facility (B–1) and Nuclear Rocket Dynamics and Control Facility (B–3) test stands were constructed at NASA Glenn Research Center's Plum Brook Station in the early 1960s to test full-scale liquid hydrogen fuel systems in simulated altitude conditions. Over the next decade each test stand was used for two major series of liquid hydrogen rocket tests: the Nuclear Engine for Rocket Vehicle Application (NERVA) nuclear rocket program and the Centaur second-stage rocket program. The different components of these rocket engines could be studied under flight conditions and adjusted without having to fire the engine. Once the studies were complete, the entire engine could be fired in larger facilities such as the Spacecraft Propulsion Research Facility (B–2).

The U.S. War Department created the sprawling Plum Brook Ordnance Works near Sandusky, Ohio, in 1941. In September 1955, the National Advisory Committee for Aeronautics (NACA, the predecessor of NASA) acquired 500 acres at the 9000-acre site to build a test reactor. Within a few years it became apparent that NASA would need additional facilities to test rocket engines and their components. The large unused tracts of land at Plum Brook were perfect for the dangerous rocket fuels work. An additional 3000 acres were acquired from the Army to build the Pilot Lab and the multifacility Rocket System Laboratory, which would eventually include B–1 and B–3.

The Mark IX turbopump was studied extensively at B–1 and B–3 for the Kiwi phase of the NERVA program. B–1 tests demonstrated that the reactor could be started under its own power, and follow-up tests in B–3 established the proper startup procedure.

The second generation Centaur rocket, Centaur D, also was studied in both test stands. B–1 tests of the fuel system led to a permanent redesign of the tank insulation. The tests were also an important early step in the eventual elimination of the boost pumps from the Centaur feed system. NASA researchers conducted a number of tests in B–3 leading up to the first Titan-Centaur launch and the Viking mission to Mars. Unlike the previous testing at the site, these focused on the protective shroud, not the turbopumps. The structural integrity and jettison system were verified in a cold space environment, and tests led to a redesign of the insulation system.

Documents: *Plum Brook Tour Brochure*

Historic American Engineering Report
Historic American Engineering Report (HAER) documentation of the High Energy Rocket Engine Research Facility (B–1) and the Nuclear Rocket Dynamics and Control Facility (B–3) will be submitted by the National Park Service to the Library of Congress. The report details the physical history of the site, event history of the facility, contemporary facilities, and architectural and operational descriptions of the facilities and their support buildings. It includes numerous photographs, blueprints, and drawings.

Documents: *Complete HAER Report* *[PDF]*
B–1 and B–3 Overview *[PDF]*

Exhibit Display
An exhibit display was created to highlight the some of the physical attributes and important tests at B–1 and B–3. Click the following image for a full-size version of this display panel.

Image: *Photograph of B–1/B–3Exhibit Display*

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I. History

The NASA Glenn Research Center (which has had several names, including the Lewis Research Center) has been a leader in rocket propulsion since the 1940s. In the 1950s the center was at the vanguard of developing high-energy fuels such as liquid hydrogen for rocket engines. With the advent of the national space program in the late 1950s the Center established the Plum Brook Station to build several large test facilities. The center was heavily involved with the development of a nuclear rocket engine and the Centaur second-stage vehicle in the 1960s.

The High Energy Rocket Engine Research Facility (B–1) and the Nuclear Rocket Dynamics and Control Facility (B–3) were built to study the critical liquid hydrogen feed systems for both of these engines. Although NERVA was canceled before it came to fruition, B–1 and B–3 made significant contributions to the Centaur D propellant and shroud jettison systems. Plum Brook Station and the two test stands were shutdown in 1974 after NASA canceled NERVA.

Image: [C1962-61077 New Plum Brook Facilities, alt: Photograph of researcher pointing to photographs of new facilities.]

Read more about the history of B–1 and B–3:

I. Design and Construction: NASA Lewis expanded its holdings at Plum Brook in the late 1950s to build a series of rocket testing facilities. Construction of B–1 began in 1960, and it was operational by 1964. B–3 was built between 1963 and 1965. The test stands were part of a large complex of test sites.

II. NERVA Engine Testing: Both facilities studied the Mark IX turbopump for the NERVA nuclear engine. The tests focused on the engine's ability to restart itself on long-duration space missions.

III. Centaur Rocket Systems: The test stands were used to study the propellant feed system and shroud jettison system for the Centaur D second-stage rocket. The tests were important to the success of the Viking missions to Mars.

IV. Shutdown and Demolition: Plum Brook Station was shutdown during 1973 and 1974. Some facilities were temporarily mothballed, but others, including B–1 and B–3, would never be utilized again. The test stands were demolished in 2010.

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A. Design and Construction (1960–1965)

The NASA Lewis Research Center expanded its property at Plum Brook Station in the late 1950s and early 1960s to accommodate its increasing array of rocket test facilities. Most of the facilities were geared to liquid hydrogen research for the NERVA and Centaur engines. The B–1 and B–3 test stands were built in the early 1960s to study the propellant flow systems for both of these liquid hydrogen-fueled engines. After making a number of contributions to the NERVA and Centaur programs, Plum Brook was shut down in 1973. Although Plum Brook Station reopened in the 1980s, the B–1 and B–3 test stands were never restored.

Plum Brook Station

The Glenn Research Center was established (as the Aircraft Engine Research Laboratory) in 1941 by the National Advisory Committee for Aeronautics (NACA) in Cleveland, Ohio. It was the NACA's third research laboratory and the only one dedicated to propulsion. The lab quickly became involved in the new types of propulsion that emerged during World War II—the turbojet, ramjet, and rocket. Researchers in the rocket field concentrated on the study of fuels or propellants. The rocket work grew in the 1950s, and liquid hydrogen came to be regarded as the optimal propellant. The lab also began expanding its research into nuclear and electric propulsion during this period.

Five hundred acres at Plum Brook Station in Sandusky, Ohio were acquired in 1955 to build a test reactor. With the advent of the space program in 1958, the NACA became the National Aeronautics and Space Administration (NASA). The new agency acquired 3000 additional acres at Plum Brook to build a series of rocket test facilities known as the Rocket Systems Laboratory. This site would eventually include B–1 and B–3. In the fall of 1959 NASA requested the use of another 3500 acres to build what would be the Spacecraft Propulsion Research Facility (B–2) and the Space Power Facility (SPF).

Documents: Acquisition of Plum Brook (1958)
Rocket Test Site Set for Plum Brook (1958)
Plum Brook Tour Brochure

B–1 Construction

NASA engineers developed the design for the B–1 test stand during 1959. Excavations for the foundation began in early 1960, and the test stand structure is visible in photographs from later that year. In April 1961 the massive 140-ton steam accumulators arrived by rail from New Jersey. The accumulators were a key component of the steam system that produced the test stand's simulated altitudes.

In the summer of 1961, NASA Lewis management decided to alter the B–1 design specifically to handle turbopump testing of a NERVA nuclear engine. By July 1962 the design work was mostly completed and the contracts were let, but several months passed before the steam exhaust system functioned properly. The summer and fall were spent integrating the NERVA engine and its instrumentation into the test stand and various test runs were conducted through the end of the year. Tests of the liquid hydrogen system took place throughout the winter and spring of 1964, but the first official test runs were in August 1964.

Documents: Accumulators Arrive at Plum Brook (1961)
B–1 Status Report (1963)
B–1 Stand Operational (1964)

B–3 Construction

Lewis engineers likely began planning the B–3 Test Stand, along with other new facilities, shortly after President Kennedy's famous "Urgent National Needs" speech in late May 1961. Kennedy not only called for the lunar landings, but also advocated an increased nuclear rocket program. B–3 and the other new facilities were in a budget approved by the President in January 1962 and by Congress that September.

Excavations for the B–3 test stand and its infrastructure began in mid-March 1963, structural supports and the concrete foundation were set in early May, and the steel framework was assembled between July and September 1963. The structure itself was complete in mid-November 1963, but the next year and a half were spent installing the other infrastructure and support systems. The test stand was tied into B–1's steam ejector system and the multi-facility B Control and Data Building. This phase was complete by April 1965. The next year was spent installing the NERVA test equipment and running facility checkout tests. The first official test was in March 1966.

Documents: President Kennedy's "Urgent National Needs" speech (1961)
B–3 Stand Ready Next Year (1963)
Plum Brook Project Given Green Light (1962)
Site Building Active at Plum Brook (1965)

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B. NERVA Engine Testing (1964–1967)

The Nuclear Engine for Rocket Vehicle Applications (NERVA) was a joint NASA and Atomic Energy Commission endeavor to develop a nuclear-powered rocket for both long-range missions to Mars and as a possible upper-stage for the Apollo Program. Los Alamos possessed the primary test facilities in Nevada and New Mexico, but NASA Lewis had been involved from the start with both the design of the engine's reactor and the liquid-hydrogen fuel system. The turbopump, which pumped the fuels from the storage tanks to the engine, was the primary tool for restarting the engine in space. The complex system had to operate flawlessly in a hostile environment. Variations in flow pressure would affect the engine's performance and ability to return from Mars. B–1 and B–3 would test the turbopump system extensively in simulated space conditions.

NERVA Program

NERVA began as Project Rover in 1955 as the Atomic Energy Commission instituted a study to develop nuclear-powered missiles for the U.S. Air Force. In 1959 NASA replaced the Air Force in this role, and the mission changed from a nuclear missile to a nuclear rocket for long-duration space flight. The Rover portion of the program consisted of basic reactor and fuel system research. This was followed by a series of Kiwi reactors built to test basic nuclear rocket principles in a non-flying nuclear engine. The next phase, NERVA, would create an entire flyable engine. The final phase of the program, called Reactor-In-Flight-Test, would be an actual launch test.

A series of 300-megawatt Kiwi-A reactors were tested at the Nevada Test Site in 1959 and 1960. The Kiwi-B reactors, which dramatically increased the power without increasing the overall size, were tested between 1961 and 1964. Aerojet was simultaneously incorporating one of the Kiwi-B reactor designs into its NERVA NRX (NERVA Reactor Experiment) engine. The first NERVA NRX test was run in September 1964 in Nevada, just months after B–1 became operational.

While work progressed on the reactor itself, other non-nuclear components and systems for the engine had to be checked and studied. The engine's propellant feed system consisted of a Rocketdyne Mark IX pump driven by a Mark III turbine. Hot gas from the nozzle was cooled by cold hydrogen then passed through the turbine to spin the pump. By February 1962 NASA Lewis had made extensive plans to test the NERVA engine in the B–1 test stand.

Documents: To the End of the Solar System: by James Dewar
The NERVA Nuclear Rocket Program (1965)
Historical Perspective on the NERVA (1991)

Bootstrap Tests

The NERVA rocket had to be able to restart in space on its own using a safe preprogrammed startup system. Lewis researchers endeavored to design the system. The B–1 cold flow (non-fission) nuclear rocket simulation test program was created to obtain the data at the initiation and in the immediate aftermath of propellant flow. The tests were designed to start an unfueled Kiwi B–1-B reactor and its Aerojet Mark IX turbopump without prechilling the pumps or propellant lines. It was crucial for the planned long-term missions that the NERVA rocket be able to vary its speed and restart its engine without any external power. The latter was called bootstrapping.

Bootstrapping was accomplished by allowing a small amount of liquid hydrogen to flow through a valve into the reactor. The hydrogen vaporized then started the turbine that drove the turbopump. The turbopump then pumped additional liquid hydrogen to the reactor. B–1 test runs in September and October 1964 determined that the turbine could achieve bootstrap acceleration during flow initialization. This was also successfully demonstrated at Los Alamos in October. Further B–1 studies in early 1965 showed that the Mark IX turbopump accelerated as needed and did not stick. The expected pressure fluctuations in the reflector and nozzle were not as severe as in other tests. The separation of flow from the nozzle surface resulted in a large amplitude vibration in the nozzle.

Documents: Nuclear Rocket Evaluation at B–1 (1962)
Flow System Startup of a Full-scale Simulated Nuclear Rocket Engine
Nuclear Rocket Simulator Tests Flow Initiation (NASA TM X-52066)

Startup Sequence

In April 1965 Lewis management decided to transfer the second series of NERVA tests from B–1 to the newly completed B–3. The goal of the program was to identify the best way to start a nuclear reactor in space. Delays in setting up the equipment at B–3 and pre-test runs pushed the tests back to February 1966. A series of turbopump tests that spring were followed by chilldown and bootstrap tests during the summer and fall.

The B–3 tests established the proper startup procedure, which included liquid hydrogen flow rates, power-cycle time delay, and the powering of the turbine. The use of a realistic feed system helped define the centrifugal turbopumps' overall system performance and mechanical characteristics. During the tests a reheater system was installed at B–3 to quickly return the test stand to ambient temperatures following the cryogenic test runs. It was determined that the $3000 reheater shortened the estimated length of the program by 3 months and saved $50,000 worth of propellants.

Documents: B–3 Stand Readied for NERVA (1967)
B–1 and B–3 Work Schedules (1962)

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C. Centaur Rocket Systems (1968–1974)

Centaur was a 15000-pound thrust second-stage rocket designed for the military in 1957 and 1958 by General Dynamics. It was the first major rocket to use the liquid hydrogen technology developed by Lewis in the 1950s. Centaur suffered numerous problems before being transferred to Lewis in 1962. Lewis was able to rectify those problems, and Centaur performed key missions for Apollo. A second generation of Centaur was developed in the mid-1960s and would go on to have a long career. B–1 and B–3 were used to study Centaur's boost pumps and shroud jettison system, respectively.

Documents: Taming Liquid Hydrogen: The Centaur Upper-Stage Rocket
Centaur Program Overview (1963)

Centaur Program

The Centaur Program was originally managed by Werner von Braun at the Army Ballistic Missile Agency which would become the NASA Marshall Space Flight Center. There was internal debate regarding the selection of the upper-stage for the new Saturn booster. A 1959 committee led by Abe Silverstein reviewed the options and concluded that a stage using high-energy propellants such as liquid hydrogen was the only solution. Von Braun was skeptical but approved their decision. Marshall was preoccupied with the Saturn booster and wary of Centaur's unconventional design. Von Braun recommended cancelling the program before a single flight. The loss of the first launch in May 1962 only deepened his doubts.

Following congressional hearings and internal NASA deliberations, the Centaur Program was transferred to Lewis in September 1962. Silverstein was now the NASA Lewis Research Center Director and would personally oversee the program. Numerous test facilities at Lewis' main campus and Plum Brook were built or modified specifically for Centaur. The rocket was put through an intensive 2-year checkout.

The next Centaur launch in November 1963 was a success. By the seventh launch in April 1966, Centaur's initial problems had been resolved. On May 30, 1966 Centaur successfully sent the first Surveyor spacecraft on its way to the Moon. Three days later it became the first spacecraft to soft land on the Moon. Although the Surveyor flights completed Centaur's primary mission, their success led to the planning of further launch assignments and upgraded versions of the rocket. This required additional tests and studies during the late-1960s and early-1970s at Lewis' main campus and Plum Brook Station. B–1 and B–3 were involved in two of these.

Advanced Centaur Tests

In August 1967 Plum Brook technicians began readying the B–1 test stand for to test the Centaur that November. The tests would focus on tank outflow and tank pressurization to determine if the boost pumps could be removed from the system. The series, referred to as the Advanced Centaur tests, were aimed at testing the next generation Centaur, the Centaur D. The studies obtained data on the pressurization and outflow of propellants from a "battleship type" Centaur tank. After months of preparation, a series of outflow tests were run from March to June 1968. In the fall of 1968 the second phase of testing focused on tank pressurization and a redesign of the propellant tank duct. The final series of tests in early 1969 analyzed a flight-type liquid hydrogen pressurization panel. The panel was chilled to simulate test conditions for future tests in the soon-to-be-completed B–2 facility.

The Advanced Centaur tests led to a redesign of the tank insulation that eventually became the standard for the Centaur D, a launch vehicle that performed 65 successful missions between 1966 and 1989. The tests were also an important early step in the eventual elimination of the boost pumps from the Centaur feed system. Followup full-scale tests in the B–2 facility led to the eventual removal of the boost pumps from the design. This produced a less complicated system and significantly reduced the cost of a Centaur rocket.

Shroud Jettison Tests

In the late 1960s NASA engineers were planning the ambitious new Viking mission to send two rover vehicles to the surface of Mars. The $1 billion Viking Program was vital to NASA's future. The Viking rover was the heaviest payload ever attempted in a launch and was over three times the weight of Atlas-Centaur's previous heaviest payload. Consequently, NASA engineers sought a more powerful booster to mate the Centaur with the Titan III rocket. Concurrently, General Dynamics was in the process of introducing a new Centaur model for Titan—the D-1T. The biggest change for the D-1T was a completely new shroud designed by Lockheed, called the Centaur Standard Shroud (CSS).

The conical two-piece covering encapsulated the payload to protect it against adverse conditions and improve the aerodynamics as the launch vehicle passed through the atmosphere. Once at the edge of space, the shroud would be jettisoned. Even a minor error in the jettison system could result in a launch failure. Lockheed was looking to test the jettison system for its new CSS before the launch. The shroud, its insulation, the Centaur ground-hold purge system, and the hydrogen tank venting system would all be studied in B–3.

After more than two years of preparations, the tests were run between April and July 1973. Structural load tests determined the ultimate flight loads on two axes, established the Centaur load sharing, and combined spacecraft loads with the CSS. The next series was run at cryogenic temperatures. These included determining the level of propellant boiloff during launch holds, verifying the vent system capacity, and conducting unlatch tests to ensure separation, and determining separation loads, and clearances. The final series included jettison tests run both at sea level and simulated altitude. Follow-up proof tests were run in early 1974.

The CSS performed flawlessly during the August 20 and September 9, 1975 launches. Each spacecraft took over 300 days to reach Mars. The missions were huge successes. Viking 1 and 2 operated on the Martian surface until November 1982 and April 1980, respectively. With Surveyor and Viking, Centaur had helped launch the first vehicles to soft land on the Moon and Mars.

Documents: Centaur Standard Shroud Test Setup
Centaur Standard Shroud (CSS) Cryogenic Unlatch Tests
Centaur Standard Shroud Full Jettison Test Dynamic Analysis
Centaur Standard Shroud articles (1972)

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D. Shutdown and Demolition (1974 - 2010)

NASA's budget had been declining steadily since its peak in 1965. During Apollo's final years from 1969 to 1972 there was intense debate in Washington regarding two costly NASA programs: the proposed space shuttle and the existing NERVA rocket. The flight-testing phase of NERVA had been cancelled years before, and the timetable for the anticipated missions to Mars slipped indefinitely into the future. In the end, the shuttle was approved, and NERVA was be omitted from NASA's fiscal year 1973 budget. The cancellation, along with other budget restrictions, resulted in the closure of Plum Brook Station. For several years the B–1 and B–3 test stands were mothballed, but they were soon left to deteriorate.

Documents: Plum Brook Closure press release (1973)

Shutdown

Neither the Atomic Energy Commission nor NASA Lewis had been given any indication of the NERVA cancellation until the budget was officially announced on January 5, 1973. It was 1 year to the day after the approval of the shuttle and just 17 days after the splashdown of the final Apollo mission. Lewis Director Bruce Lundin personally told the staff that Plum Brook Station would be closed down. The reactor would be first, and the other facilities would follow by fiscal year 1974. Over the next 18 months the staff was reduced from 600 to 54. By the mid-1970s, there were only about a half dozen personnel at Plum Brook Station.

B–1 had completed its last test in July 1969, but B–3, which was in the midst of its Centaur Standard Shroud tests when the shutdown announcement was made, would be among the last sites to be mothballed. An End Condition Statement report was issued for each facility stating what steps had been taken to deactivate the various systems. Steps included deenergizing electrical systems, deactivating boilers, shutting down gas systems, depressurizing air service, etc. Technically the mothballed test stands could be reactivated within 3 months. The structures were grouped into three categories to prioritize their readiness for reactivation with

Readiness Category 1 being the most important. B–1 and B–3 were listed as Readiness Category 2.

Documents: Lundin Shutdown Speech (1973)
NASA Slashes Plum Brook (1973)
Plum Brook Phased Down (1974)

Standby

Continental Aircraft Engine (Teledyne) in nearby Toledo, Ohio was interested in using B–3 or B–1 as a vertical-takeoff-and-landing engine test stand. NASA felt that this would change the nature of the facility and not fully optimize its capabilities. NASA suggested using the facilities to test turbopump systems for the electric power industry, as a fluidized bed combustor, for turbine research, for coal gasification, or for fuel oil cracking. Pratt & Whitney and the Air Force suggested using B–1 for high-powered laser work.

In the mid-1970s NASA decided not to keep all the facilities in standby condition. Those not preserved were cannibalized for research and test equipment, but the overall structure and systems remained in place. B–1 was initially placed in Readiness Category 2, but its Pump and Shop Building was placed in Readiness Category 1. In December 1977, the B–1 freight elevator was removed for NASA's new Michoud Assembly Facility in New Orleans. In January 1978 B–1's 300-foot liquid hydrogen vacuum-jacketed transfer line was removed for a NASA Langley Research Center hydrogen spill test conducted by the Jet Propulsion Laboratory at the China Lake Naval Facility. In 1982 the B–1 and B–3 test stands were demoted to Readiness Category 3.

Documents: Potential Use of Plum Brook Facilities (1973)
Potential Programs for Plum Brook (1973)
Plum Brook Station Review (1976)

Demolition

NASA Glenn's Facilities Division planned and carried out the demolition of the B–1 and B–3 test stands. The Pinnacle Construction & Development Group was hired to complete the task. Pinnacle subcontracted with Brandenburg Industrial Service Company to perform the actual demolition. These companies also managed the containment and disposal of the waste materials.

All of the main systems had been disconnected in the 1970s, but the site still required significant planning and selective demolition work. The base of each test stand was structurally weakened so that they would collapse onto their sides. On September 8, 2010, the B–1 test stand was brought down. Two weeks later, the B–3 test stand was demolished. The wreckage was scrapped, the infrastructure materials were recycled, and the site was restored by grading the soil and planting grass.

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II. FACILITIES

The High Energy Rocket Engine Research Facility (B–1) and Nuclear Rocket Dynamics and Control Facility (B–3) were rocket test stands at NASA Glenn Research Center's Plum Brook Station. The test stands were vertical towers with cryogenic fuel and steam ejector systems that permitted rocket fuel systems to be studied in simulated altitude conditions. Each test stand had several levels, a test section, and ground floor shop areas. The test stands relied on an array of support buildings to conduct their tests, including a control building, steam exhaust system, and fuel storage and pumping facilities.

Physical Descriptions:

I. B–1 Test Stand: Description of the B–1 tower, levels, base, and test section.
II. B–3 Test Stand: Description of the B–3 tower, levels, base, and test section.
III. Support Buildings: Description of the B Control and Data Building, Steam System, Water System, and Propellant Storage

A. B–1 Test Stand

The B–1 test stand could test 6000–pound thrust engines for 6 minutes. The original design allowed for the fivefold expansion of this capability with only minor modifications. The test chamber was a 13-foot diameter, 30-foot tall space within the tower. B–1 included cryogenic fuel tanks, exhaust gas scrubbers, and large storage trailers for gaseous and cryogenic materials. A two-stage steam ejector provided vacuum pumping to create the low pressures of space. The facility was tied into Plum Brook Station's data acquisition system.

The B–1 tower faced two rectangle retention ponds to the southwest. The steam accumulators and a steam ejector stack were linked to the southeast wall of the test stand. A rectangular single-story Pump House and a smaller Valve House stood between the test stand and the large retention ponds. A water tower was to the west of the ponds. In1965 a railroad spur was added to the facility to supply additional liquid hydrogen.

Documents: Nuclear Rocket Simulator Tests, Facility NASA TM X-52043 (1964)
B-1 Facility Resume

Structure
The B–1 test stand was a 135-foot tall vertical tower elevated on steel trestles. It was enclosed above the 68-foot level, and an enclosed elevator shaft extended to the ground in the west corner. Initially each of the walls in the upper section contained three sets of 12-paned windows and a narrow vent window. By 1964, however, roll-up doors replaced the windows on the southeast, southwest, and northwest walls. The doors provided ventilation in the event of a hydrogen leak. The walls and roof were corrugated galvanized steel. A ridge vent ran along the peak of the roof.

Document: B–1 Elevation Drawing

Ground Level
The base of the test stand was approximately 34 feet across and 42 feet deep. This was an open concrete slab except for a narrow stairwell and elevator shaft and equipment room at the west end. The elevator and stairs terminated at the test section on the 68-foot level. The 40.5- by 27.25-foot and approximately 11-foot-tall shop area with 1-foot thick concrete was adjacent to the northwest side of the test stand. It contained a terminal room and restroom, and a monorail crane ran across the ceiling. Adjacent to the shop area was a concrete shelter with two bays for parking liquid-hydrogen tankers. The sides of the structure were open to provide adequate ventilation for the fuel trailers.

Document: B–1 Floor Plan

Test Section
B–1 had several access levels in its tower. The stairwell, elevator shaft, and pipe chases ran up the western wall. The first partial level, at 55 feet, was rimmed by steel-grated platforms with the center area open for the exhaust pipe and diffuser. The enclosure of the test stand began at the 68-foot main test area. There was a grated floor along one side, but the center area had flooring that could be removed depending on the test setup. It was on this level that the engine and nozzle being tested were mounted with the turbopump above.

The level above the test section, at 84.75 feet, allowed access to the turbopump assembly. Near the center was the turbopump and propellant feed assembly linking the propellant tank on the level above and the engine on the level below. A catwalk provided access to the bottom of the 18-foot-long liquid hydrogen tank suspended above from the 98.25-foot level. A staircase connected the three levels.

A crane rail across the top of the test stand reached down to the test section. A venting system, vacuum lines, and tanking system were also at the top of the 117.5-foot tower. The vent exited the roof of the test stand. The liquid-hydrogen, gaseous-hydrogen, and liquid-nitrogen supply lines and the helium purge line ran down the length of the northwest side of the test stand.

Documents: B–1 Test Section

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B. B–3 Test Stand:

B–3 was used to study tanking and flow systems for complete rocket systems at simulated altitudes. The rocket's combustion chamber was pressurized to simulate an actual launch, but the engines were not fired. Researchers could study the effect of combustion chamber pressure on flow dynamics. B–3 was connected to the B–1 ejector system by a 54-inch diameter vacuum line. The B–1 steam-powered altitude exhaust system reduced B–3's pressure at the exhaust nozzle exit to 0.5 pounds per square inch for up to 4 minutes. A smaller boiler building was added for the B–3 test stand, and a large liquid hydrogen tank and several smaller trailer facilities were used to supply the test stand with cryogenic fuel. The facility was tied into Plum Brook's Station's data acquisition system.

Documents: B-3 HAER Report Description (PDF, 397KB)
B-3 Facility Resume

Structure
At 210 feet in height, the 50- by 50-foot tower was the tallest structure at Plum Brook Station. The upper section, 32 by 27.5 feet in area, was enclosed above the 74-foot level. The test stand faced south and had removable corrugated metal walls on three sides and movable floors to assist the mounting in the test section. The entire north wall, which contained the stairwell, elevator shaft, and cable chases, was enclosed for the entire height of the test stand.

An overhang extended from the front of the tower. A 65-ton crane was installed at the 176-foot level to load the test articles inside. The double-girder crane spanned 28 feet and could travel outside the test stand to access the railroad line adjacent to the facility and reach the main test area at 74 feet. The main working levels of the test stand were accessible by a 3-ton elevator. The 110-foot-tall rolling doors, which vented excess hydrogen, were cited as the largest ever built.

Documents: B–3 Elevation Drawing

Ground Floor:
The first floor contained a shop area, mechanical equipment room, tool crib, manifold-purge control room, and instrumentation rooms. The shop and mechanical equipment room were adjacent to the east side of the test stand. The forward instrument room was adjacent to the north side of the test stand.

A little over half of the 50- by 50-foot square base was unenclosed. The 5-foot diameter altitude exhaust pipe entered this area along the ground from the west, and then ran upward through the test stand to the test section. The remainder of the base was an enclosed structure between the forward instrument room and shop area. The stairwell and elevator shaft were here as well.

Document: B–3 Floor Plan

Test Section:
The B–3 test stand had several access levels. The lowest was a balcony at the 42-foot level for accessing the electrical panels and cable chase. Like B–1, B–3 had three main enclosed working levels, at 73.5, 94.5, and 115.5 feet. The two lowest levels were identical in layout with removable steel plate flooring and an adjustable opening in the center. The 115.5-foot level

had a 14.5- by 14.5-foot square opening in the center of the steel plate floor. The cable and pipe chases terminated at this level.

The B–3 test area began at the 74-foot level and extended to the crane bottom at 176 feet. There was a 24- by 36-foot open area inside the test stand. A 46,000-gallon tank stored the hydrogen above the test section. Access to the tank was provided by platforms at the 126- and 147-foot levels.

Document: B–3 Test Section drawing

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C. Support Buildings:

The B Complex included a number of components housed in external structures which allowed the B–1 and B–3 facilities to study rocket engines in an altitude environment. Elements of this infrastructure were also used by the Hypersonic Test Facility (HTF) and Space Propulsion Research Facility (B–2). The main components were the B Control and Data Building, Steam Plant, Pump and Shop Building, and propellant storage tanks.

B Control and Data Building:

The B-Control and Data Building was constructed in 1960 to remotely control the operation of the B–1 test stand. By January 1963 plans were made to expand the facility to include control rooms for B–3 and HTF. Later, when B–2 began operating, its control room was also added. The reinforced concrete structure was located approximately 2300 feet southwest of B–1, and 2600 feet west of B–3. The distance protected the staff from possible explosions at the test site.

The B–1 control room was an L-shaped room that was separated off the eastern corner of the building. Two operators at the main facility control panels ran the test. Three technicians at the servo control panels monitored the pumps, servo controllers, amplifiers, servo control programmer, and over-speed indicators. B–3 and HTF shared a large area for both of their control rooms. The responsibilities and control panels were similar in nature to those of B–1.

Eventually the B Control and Data Building contained five control rooms, a terminal and instrument room, an office, equipment storage, a utility room, and a turret-like observation tower to view the test facilities. After being shutdown in 1974, the B Control and Data Building was reactivated in the late 1980s for B–2 and HTF testing. In the mid-2000s the B–2 control room was modernized as part of an overall modernization of the B–2 facility.

The H Control and Data Building, 5500 feet from B–1, contained the data acquisition equipment for all the Plum Brook facilities. The tapes from the analog and digital recording systems were sent to NASA Lewis' main campus to be processed. There an IBM 360 computer transformed the signals into plots and columns of tabular arrays.

Documents: B Control Floor Plan
B Control elevation drawing

Steam System:
A large steam-powered altitude exhaust system reduced the pressure at the exhaust nozzle exit of each test stand. This allowed B–1 and B–3 to test turbopump performance in conditions that matched the altitudes of space. The steam system included boilers, accumulators, valves, and ejectors. The Boiler House, located approximately 1000 feet west from the B–1 test stand contained four boilers that were similar to those used on World War II era battleships. A second boiler building was added during the construction of the new B–3 test stand.

Three 53.5-feet-long steam accumulators could store 42,000 gallons of steam and hot water. The steam stored in the accumulators was used to operate two large steam ejectors located outside B–1's southeast wall. A pressure regulating system in the nearby Valve House reduced the pressure at the exhaust duct to simulate the altitudes of space. The steam system could furnish approximately 100,000 pounds mass of steam to the B–1 ejector system at B–1 which could support ejector operation at B–1 facility for approximately 6 minutes. A 54-inch diameter vacuum line was extended from to the ejector to the B–3 test stand. The B–2 facility was later connected to the system. B–1's steam system was rehabilitated in the early 1990s for B–2 testing.

Documents: Steam accumulator drawing

Water System:
The Pump and Shop Building was a rectangular structure at the eastern edge of the two large water basins. The 142- by 300-foot pond to the west supplied fresh water and the 136- by 200-foot one to the east was used for waste water. Water from the basin entered the structure through gates in three concrete bays. Two pumps were located in the southern half of the basement. Their 12-inch diameter intake lines were tied to a single inlet bay. Water was pumped through these lines then a single 18-inch-diameter line to the test equipment. Two larger pumps were located in the northern half of the basement. Each of these had its own 42-inch-diameter intake line and bay. The exit lines merged into a 54-inch-diameter pipe.

The B–1 test stand was originally designed to hot-fire rocket engines, but it was never used in this capacity. The Pump and Shop Building and the two rectangular basins were intended to cool the rocket exhaust, but they were never utilized.

Documents: Pump House floor plans
Retention Ponds drawing

Propellant Storage:
A number of ground level semi trailers, fixed gas storage bottles, and mobile liquid dewars were used to store the gaseous and cryogenic materials for the B–1 and B–3 test stands. The cryogenics were used primarily to fuel the rocket engines, and the gases were used to pressurize and inert the system. The liquid hydrogen was pumped through a vacuum-jacketed line to the tank at the top of B–1. It was pumped from the tank through the engine during the test runs. Initially B–1 used two trailer truck dewars and 100,000 cubic feet of permanent storage to supply each test run with cryogenic fuels. An external pump was used to transfer the fuels to the top of the test stand.

Vacuum jacketed lines could supply 800 gallons per minute to the test stands. A 200,000-gallon dewar, the world's largest liquid hydrogen dewar at the time, was installed at the B Complex in 1963. The $382,000 tank was 37 feet in diameter with a volume of 26,800 cubic feet.

Four 4500-gallon tanker trailers supplied the liquid nitrogen for B–3. They connected to a manifold at the test stand's base. Gaseous nitrogen was used to purge the liquid nitrogen lines and electrical equipment after each test run and to pressurize the shroud payload area and valve operators. B–1 included a large nitrogen system to purge the exhaust duct, a vent stack, a pump, a reactor, and a terminal. A single helium trailer was used for each test run to purge the test equipment and keep the reactor and observation windows free of frost. At B–3, two 780,000 cubic foot railroad car tanks and four 70,000 cubic foot trailer tanks were used for each test. A gaseous nitrogen bottle farm was a backup for the valve operators. A similar setup was used for gaseous helium. The helium was used to pressurize the shroud tank section and to inert the liquid hydrogen lines.

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III. Historical Research

Technical reports, correspondence, facility reports, specifications, articles, and other documents regarding the High Energy Rocket Engine Research Facility (B–1) and Nuclear Rocket Dynamics and Control Facility (B–3) test stands at NASA Glenn Research Center's Plum Brook Station tests stands were collected during the research effort. Included here are some reference materials for researchers. In addition, a timeline of B–1 and B–3 tests and related events is included.

I. Documents: This page contains PDF files of original documents, articles, pamphlets, reports, and speeches. These materials span from 1948 to 2007.

II. Technical Reports: This page provides links to NASA technical reports regarding the NERVA turbopump and Centaur Standard Shroud tests conducted in B–1 and B–3.

III. Rocket Systems Division Status Reports: This page contains monthly updates on the work being performed at the B–1 and B–3 test stands from 1963 to 1974.

A. Historical Documents

The following are digital versions of various historical documents related to the B–1 and B–3 test stands. These include newspaper articles, correspondence, speeches, reports, and other documents.

Plum Brook Station
Acquisition of Plum Brook (1958) (PDF, 2.90MB)
Rocket Test Site Set for Plum Brook (1958) (PDF, 1.28MB)
NASA May Take Over Area (1959) (PDF, 1.28MB)
Plum Brook Today (1959-60) (PDF, 1.68MB)
Plum Brook Facilities Operations Report (1961-62) (PDF, 1.95MB)
$12 Million for PB Expansion (1963) (PDF, 1.44MB)
Plum Brook Facilities (c1970) (PDF, 1.95MB)
Plum Brook Tour Brochure (PDF, 5.06MB)

B–1 Construction Articles
Accumulators Arrive at Plum Brook (1961) (PDF, 196KB)
Plumber Strike at Plum Brook (1961) (PDF, 1.23MB)
Rockets Scrutinized by Remote Control (1962) (PDF, 888KB)
B-1 and B-3 Work Schedules (1962) (PDF, 3.20MB)
Ohio Industry NASA Contracts (1963) (PDF, 482KB)
B-1 Stand Operational (1964) (PDF, 552KB)
Site Building Active at Plum Brook (1965) (PDF, 687KB)
B-1 and B-3 Descriptions (1967) (PDF, 2.04MB)
B-1 Facility Resume (PDF, 95.9KB)

B–3 Construction Articles
Plum Brook Project Given Green Light (1962) (PDF, 1.39MB)
B-3 Stand Ready Next Year (1963) (PDF, 1.31MB)
NASA Lets Contracts for B-3 (1963) (PDF, 1.20MB)
Plum Brook Gets New Test Stand (1963) (PDF, 601KB)
Plum Brook Gets Improvements (1964) (PDF, 621MB)
NASA Awards Contracts (1964) (PDF, 445KB)
B-3 Facility Resume (PDF, 114KB)

B–1 and B–3 Tests
Nuclear Rocket Evaluation at B-1 (1962) (PDF, 265KB)
NERVA Nozzle for Plum Brook (1964) (PDF, 309KB)
Hydrogen Rules Rocket Division (1965) (PDF, 1.91MB)
B-3 Stand Readied for the NERVA Program (1967) (PDF, 801KB)
Centaur Shroud Passes Cryo Test (1973) (PDF, 883KB)

NERVA
Aerojet Proposal for NERVA Rocket (1961) (PDF, 66.5MB)
An Historical Perspective of the NERVA Program by Robbins and Finger
Nuclear Propulsion—State of the Art 1962 by Rom and Finger
Proposed NERVA Turbopump Study at Plum Brook (1962) (PDF, 310KB)
Managing the Rover/NERVA Program by Harold Finger (PDF, 2.05MB)
One Up on Buck Rodgers (article, 1963) (PDF, 1.19MB)
Nuclear Rocket Program Revised (press release, 1963) (PDF, 177KB)
Message to Congress on Urgent National Needs by President Kennedy

Centaur
Centaur Program Overview (1963) (PDF, 1.00MB)
Taming Liquid Hydrogen: The Centaur Upper-Stage Rocket (2.16MB)
Centaur Standard Shroud (articles, 1972) (PDF, 1.29MB)
Lewis Launch Vehicle Experience (c1974) (PDF, 2.58MB)

Shutdown
Future Space Goals Contested (article, 1969) (PDF, 491MB)
Plum Brook Closure (press release, 1973) (PDF, 48.6KB)
Bruce Lundin's shutdown speech (1973) (PDF, 39.3KB)
NASA Slashes Plum Brook (article, 1973) (PDF, 305KB)
Plum Brook Phased Down (article, 1974) (PDF, 702KB)

Demolition and Mitigation
Section 106 of the Historic Preservation Act (PDF, 149KB)
B-1 and B-3 Ohio Inventory (PDF, 247KB)
B-1 and B-3 HAER Report (2010) (PDF, 25.6MB)
B-1 and B-3 Project Overview (PDF, 338KB)
B-1 HAER Report Description (PDF, 398KB)
B-3 HAER Report Description (PDF, 397KB)

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B. Test Reports

The following are links to NASA technical reports related to tests in the B–1 and B–3 test stands. Also included are monthly status reports on work that was performed to prepare for the tests, run the tests, and remove hardware.

B–1 NERVA Test Reports

Component Flow and Fluid Properties in a Nuclear Rocket System(NASA TM-X-1366, 1967)
Cooldown of Regenerative Nozzle in Nuclear Rocket Test Facility (NASA TN-D-3931, 1967)
Flow System Startup of a Full-scale Simulated Nuclear Rocket (NASA TM-X-52139, 1967)
Nuclear Rocket Simulator Tests, Flow Initiation with No Turbine Gas (NASA TM-X-52044, 1964)
Nuclear Rocket Simulator Tests, Flow Initiation (NASA TM-X-52066)
Performance of Axial Flow Liquid-hydrogen Pump at Startup (NASA TM-X-1213)
Unfueled Nuclear Rocket Core Assembly (NASA TM-X-1231, 1966)

B–3 Centaur Standard Shroud Test Reports

Centaur Standard Shroud Test Setup
Centaur Standard Shroud (CSS) Cryogenic Unlatch Tests (NASA TM X-71455, 1973)
Centaur Standard Shroud Full Jettison Test Dynamic Analysis (NASA TM X-71537)

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C. Rocket Systems Division Reports

Plum Brook facilities managers were required to contribute updates to station management on the activities at each facility during a given month. This narrative reports were compiled as Monthly Status Reports. The reports pertaining to the B–1 and B–3 test stands are presented here.

Reports:

- B1 Test Operations Reports (1962-63) (PDF, 5.80MB)
- B1 Test Operations Reports (1964) (PDF, 2.11MB)
- B1 Test Operations Reports (1965) (PDF, 3.10MB)
- B3 Test Operations Reports (1965) (PDF, 7.45MB)
- B3 Test Operations Reports (1966) (PDF, 8.12MB)
- B1 and B3 Test Operations Reports (1967) (PDF, 22.5MB)
- B1 Test Operations Reports (1968) (PDF, 9.08MB)
- B1 Test Operations Reports (1969) (PDF, 3.72MB)
- B3 Test Operations Reports (1971) (PDF, 27.8MB)
- B3 Test Operations Reports (1972) (PDF, 8.30MB)
- B3 Test Operations Reports (1973) (PDF, 12.0MB)
- B3 Test Operations Reports (1974) (PDF, 1.14MB)

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D. Events Timeline

1941
War Department seizes property for Plum Brook Ordnance Works (PBOW)
The NACA begins construction of its Aircraft Engine Research Lab

1943
AERL officially begins operations

1945
PBOW closes down after producing record amounts of ammunition

1946
Matthew-Lavio and Sons oversees idle Plum Brook property

1947
Rocket Lab complex begins operation at the AERL

1949
Plum Brook property transferred to General Services Administration
Lewis research divisions reorganized under Abe Silverstein

1954
Ravenna Arsenal utilizes portions of Plum Brook until 1958

1955
Congress approves funding for NACA test reactor at Plum Brook
Air Force and Atomic Energy Commission begin Project Rover
Rocketdyne and Aerojet begin design work on turbojets
Project Bee commences

1956
Groundbreaking ceremony for Plum Brook Reactor in September

1957
Project Bee aircraft performs liquid-hydrogen powered flights
Lewis researchers begin work on tungsten reactor
Sputnik is launched on October 4
General Dynamics begins design of the Centaur second-stage rocket

1958
Lewis acquires additional 500 acres at Plum Brook for B-1 and Pilot Lab
AEC approves Rocketdyne axial-flow turbopump
NASA is officially founded on October 1
Construction of I-Site begins in December 1958

1959
First low-power test of the Kiwi-A reactor on July 1
Abe Silverstein-led committee recommend high-energy fuels for upper-stages
NASA requests additional 3500 acres at Plum Brook from the Army for additional sites
NASA replaces Air Force in the Rover program in December

1960
Architects complete drawings for B-1 test stand in March
B-1 construction underway
First full-scale Kiwi-A reactor test conducted on July 8
Space Nuclear Propulsion Office (SNPO) created on August 31
NASA-AEC issue request for bids on NERVA nuclear rocket

1961
Steam accumulators arrive at B sites in April
President Kennedy delivers his Urgent National Needs address on May 25
Aerojet-Westinghouse NERVA proposal accepted in June
Modifications begin in July to prepare B-1 stand for NERVA testing
Four rocket sites and control building operational in the fall
Abe Silverstein named Director of Lewis Research Center in October
Kiwi-B1 run on gaseous hydrogen during December test in Nevada

1962
NERVA test program for B-1 formalized in February
Plum Brook's E Stand begins testing in February; I Site and J Site soon begin operation
Alan "Hap" Johnson named Plum Brook director in March
Congress approves $40 million in May for B-3 stand, vacuum chamber, and B-2 expansion
Surveyor program substitutes Centaur for Agena rocket
First attempt to launch an Atlas-Centaur rocket fails on May 8
Centaur Program transferred from Marshall to Lewis in September
Lockheed Martin designs Titan III booster
Kiwi-B4-A test in Nevada Test Site fails in November
President Kennedy tours Nevada Test Site on December 8

1963
Architects complete B-3 drawings and excavations begin in March
Remainder of Plum Brook property transferred to NASA in March
Hundreds of PBOW structures razed
Mark IX reactor installed in B-1 test stand during April
B-1 facility checkout tests run throughout the fall
B-3 facility complete
Second attempt at Atlas-Centaur vehicle successful in November

1964
Engineering Bldg, ATS, B-2, B-3 under construction
Kiwi-B4 reactor design tested at Nevada in July
First NERVA test conducted in B-1 in September 1964
NERVA NRX-A2 engine run successfully in September at Nevada
NERVA NRX-A2 bootstrap test in October in Nevada.

1965
NERVA test equipment moved from B-1 to B-3 in May
NASA budget peaks during 1965

1966
A reheater system was added in February
First test runs in B-3 conducted in March
Atlas-Centaur 8 successfully completes two-burn launch in April
Atlas-Centaur sends Surveyor spacecraft to lunar surface on June 2

1969
Final test conducted at B-1 on May 28
Abe Silverstein retires and is replaced by Bruce Lundin
Six month period of inactivity at B-1 and B-3 begins in June
NERVA XE engine tested in June at Nevada

1970
B-2 and Space Power Facility begin operations

1971
B-3 setup begins in January for Centaur shroud tests
NERVA redesigned as smaller rocket engine

1972
Space shuttle program approved by President Nixon in January
NASA FY1973 budget submitted in September without NERVA
Apollo 17 mission in December is final Apollo flight

1973
Lundin announces on January 6 that Plum Brook would shut down
NERVA nuclear rocket program cancelled in January
B-3 commences preparations for Centaur Standard Shroud testing in January
B-1 mothballed and put into readiness status Category 1

1974
Final test conducted at B-3 in May
B-3 mothballed and put into readiness status Category 1

1977
Cannibalization of B-3 underway

1982
B-1 and B-3 readiness status reduced to Category 3

1987
Plum Brook begins reactivating its large test facilities

1998
Demolition of Plum Brook Reactor Facility commences

2004
NASA offers centers funding to remove unused facilities

2009
Historical documentation of the B-1 and B-3 stands begun in October

2010
B-1 and B-3 stands demolished on September 8 and 22, respectively

D. Tests Timeline

NERVA Engine Propellant Feed Tests (B-1 Facility: 1964-66)

Bootstrap Test	September - October 1964
Steam Ejector Test	October 1964
Chilldown Test	October 1964
Bootstrap Test	November 1964 - February 1965

NERVA Propellant Feed System Tests (B-3 Facility: 1966)

Turbopump Test	February - June 1966
Chilldown Test	June 1966
Bootstrap Test	July - December 1966

Advanced Centaur Tests (B-1 Facility: 1967 - 1969)

Helium Burp Test	December 1967 - March 1968
Outflow Test	March - July 1968
Helium Blowdown	August 1968
Outflow Test	November - December 1968
Outflow Test	January 1969
Outflow Test	May 1969

Centaur Standard Shroud Tests (B-3 Facility: 1972 -1973)

Half-Scale Test	March 1972
Hinge Test	June 1972
Jettison Test	September 1972 - February 1973
Tanking and Seal	January 1973
Structural Test	April - July 1973
Twang Test	April 1974
Structural Test	May 1974

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IV. Mitigation Project

The NASA Glenn Research Center has a number of historic facilities, and some, like B–1 and B–3, have recently had to be demolished. The NASA Glenn History Program, Historical Preservation Officer, and facility managers have worked with the Ohio State Historic Historical Preservation Officer to develop strategies, budgets, and work plans to record the history of these facilities.

Although they had not been used for decades, the B–1 and B–3 tests stands had an interesting history and contributed to NASA's space achievements in the 1960s and 1970s. Glenn felt it important to document the facilities prior to their 2010 destruction.

The Glenn History Office maintains a collection of historical materials, assists researchers, and documents historical topics through websites, documentaries, and publications. It has been involved with several other recent historical mitigation projects. These include the Plum Brook Reactor Facility, Rocket Engine Test Facility, the Altitude Wind Tunnel, and the Propulsion Systems Laboratory No. 1 and 2.

Documents: Programmatic Agreement Among NASA, NCSHPOs, and ACHP
NASA's Historic Preservation Program (2010)
Protection of Historical Properties

I. B–1 and B–3 Mitigation Project: Description of this latest effort to document the B–1 and B–3 test stands.
II. NASA Glenn History Office: Introduction to the Glenn History Office and its services.
III. Other Glenn Mitigation Projects: Overview of previous historical mitigation projects at Glenn.

A. Historical Mitigation Effort

This Web site is part of a wider effort to document the history of the B–1 and B–3 test stands. Section 106 of the National Historic Preservation Act requires that Federal agencies document their historic facilities before any significant structural changes, demolitions, or relocations. Although B–1 and B–3 were not eligible to be National Historic Landmarks, Glenn felt that their contributions to the Nation's space program warranted permanent documentation before their demolition. This project formally began in October 2009 after the finalization of the Statement of Work for the Glenn History Office.

Documents: *B-1 and B-3 Ohio Inventory (2009)*
B-1 and B-3 Project Overview
B-1 HAER Report Description
B-3 HAER Report Description

Documentation: The documentation includes the collection of documents from the Plum Brook Station archives, the Glenn History Office archives, retirees, NASA Technical Reports Server, newspaper databases, and other sources. It also includes the scanning and captioning of hundreds of negatives and blueprints. The documents, many of which were scanned, are available on this website and will be permanently stored in the Glenn History Office.

Dissemination: The collected information is being distilled into several different products to be shared with the public and NASA employees. These include this Web site, an exhibit display, and Historic American Engineering Reports.

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B. Other Mitigation Projects:

The NASA Glenn History Office has undertaken the task of documenting many of its historic facilities, including the Plum Brook Reactor Facility, Rocket Engine Test Facility, Altitude Wind Tunnel, Propulsion Systems Laboratory No. 1 and 2, and the B-1 and B-3 test stands at Plum Brook. The History Office and Historic Preservation Officer have worked with the Ohio State Historic Preservation Officer to develop strategy to record the history of these facilities that both document the facility and disseminate that information to the public. This documentation includes the collection of documents, photographs, and films; photographic surveys and artistic renderings of the facilities were also created. The information is distilled in several different products including publications, documentaries, exhibit displays, and websites.

Plum Brook Reactor Facility

The Plum Brook Reactor Facility located on Plum Brook Station in Sandusky, Ohio, operated from 1962-1973, but the history of the land stretches back to the 19th Century when War of 1812 veterans were given the property. The federal government seized 9000 acres of this land in 1941 to construct a sprawling Ordnance Works facility that operated throughout World War II. The National Advisory Committee for Aeronautics purchased the land in 1956 to build a test reactor to support atomic aircraft studies being conducted by the Atomic Energy Commission. Although that concept was shelved before construction of the reactor was completed, President Kennedy breathed new life into the facility by supporting a national nuclear rocket program in May 1961. The 60 megawatt Plum Brook Reactor conducted over 70 experiments, most of which studied the effects of radiation on various materials. The nation's nuclear rocket program was cancelled during the post-Apollo budget cuts. The reactor was mothballed in 1973 and was monitored by NASA until decommissioning was begun in 1998.

Science in Flux: NASA's Nuclear Program at Plum Brook Station
NASA's Nuclear Frontier: The Plum Brook Reactor Facility
PBRF Decommissioning Site
Of Ashes and Atoms: A Documentary on the Plum Brook Reactor Facility

Rocket Engine Test Facility

The RETF was a National Historic Landmark located at the NASA Glenn Research Center in Cleveland, Ohio. Throughout most of its 46-year history (1957–2003), the facility played an integral part in the development of NASA rocket technology. This website was designed to preserve the legacy of the RETF. You can see photographs and videos of RETF and take interactive lessons on rocket engine testing. You can also learn about the traveling exhibit and how to bring it to a museum in your area.

RETF Website
Ideas into Hardware: A History of the Rocket Engine Test Facility
Fueling Space Exploration: The History of NASA's Rocket Engine Test Facility

Altitude Wind Tunnel

When constructed in the early 1940s, the Altitude Wind Tunnel (AWT) was the nation's only wind tunnel capable of studying full-scale engines under realistic flight conditions. It played a significant role in the development of the first U.S. jet engines as well as technologies such as the afterburner and variable-area nozzle. In the late 1950s, the tunnel's interior components were removed so that hardware for Project Mercury could be tested in altitude conditions. In 1961, a portion of the tunnel was converted into one of the country's first large vacuum tanks and renamed the Space Power Chambers (SPC). SPC was used extensively throughout the 1960s for the Centaur rocket program.

AWT Website
Revolutionary Atmosphere: History of the Altitude Wind Tunnel and Space Power Chambers (SP-2010-4319)
A Tunnel Through Time: The History of NASA's Altitude Wind Tunnel

Propulsion Systems Laboratory No. 1 and 2

When constructed in the early 1940s, the Altitude Wind Tunnel (AWT) was the nation's only wind tunnel capable of studying full-scale engines under realistic flight conditions. It played a significant role in the development of the first U.S. jet engines as well as technologies such as the afterburner and variable-area nozzle. In the late 1950s, the tunnel's interior components were removed so that hardware for Project Mercury could be tested in altitude conditions. In 1961, a portion of the tunnel was converted into one of the country's first large vacuum tanks and renamed the Space Power Chambers (SPC). SPC was used extensively throughout the 1960s for the Centaur rocket program.

PSL Website: A website dedicated to PSL's history and facility. Includes related documents and reports, an interactive layout, and students' section. Coming soon, photographs and videos.
Pursuit of Power: History of NASA's Propulsion Systems Laboratory No. 1 and 2

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C. Glenn History Office:

The Glenn History Office was created in 1999 to preserve and promote our rich heritage for current and future researchers. Services include basic and indepth reference and research; documentation of facilities, projects, and people; publications in NASA's Historical Publications Series; management of the Glenn archives; oral history interviews; development of historical programs, exhibits, and handouts; appraisal of historical materials; and coordination of conferences and special events.

Collections:

The archives contain complete sets of the Center's newsletter and telephone directories back to the early 1940s, copies of files from the Director's Office dating back to the 1940s, a collection of oral histories of former employees, historic artwork, photographs, and film, press kits from most of the major NASA missions of the 1960s and 1970s, and many other documents regarding the Center, its facilities, programs, and employees.

Publications:

The Glenn History Office has sponsored and written a number of publications on the Center's history. In addition, Virginia Dawson wrote *Engines and Innovation: Lewis Laboratory and American Propulsion Technology*—a history of the Center from the 1940s through 1990. The History Office has created several websites, two video documentaries, and numerous exhibit displays.

Events:

The Glenn History Office has also hosted several booksigning events and the 2003 Realizing the Dream of Flight Conference. In addition, the History Office participates in open houses, community meetings, and Center events.

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VI. Additional Resources

NASA History
Glenn History Program
Headquarters History Office
Altitude Wind Tunnel history
Rocket Engine Test Facility history
Propulsion Systems Laboratory history

NASA Facilities
Glenn Research Facilities
Plum Brook Station Test Facilities

Historic NASA Glenn Facilities Publications
Science in Flux: NASA's Nuclear Program at Plum Brook Station (PDF, 3.42MB)
NASA's Nuclear Frontier: The Plum Brook Reactor Facility
Revolutionary Atmosphere: Altitude Wind Tunnel and Space Power Chambers (PDF, 13.4MB)
Ideas Into Hardware: A History of the Rocket Engine Test Facility (PDF, 2.13MB)
We Freeze to Please: A History of NASA's Icing Research Tunnel (PDF, 3.15MB)
NASA History Series Publications

Additional Research Tools
Glenn ImageNet Online Collection
NASA Technical Reports Server

Historical Preservation
Ohio State Historical Preservation Office
Advisory Council on Historic Preservation
National Park Service Historic Documentation Programs

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