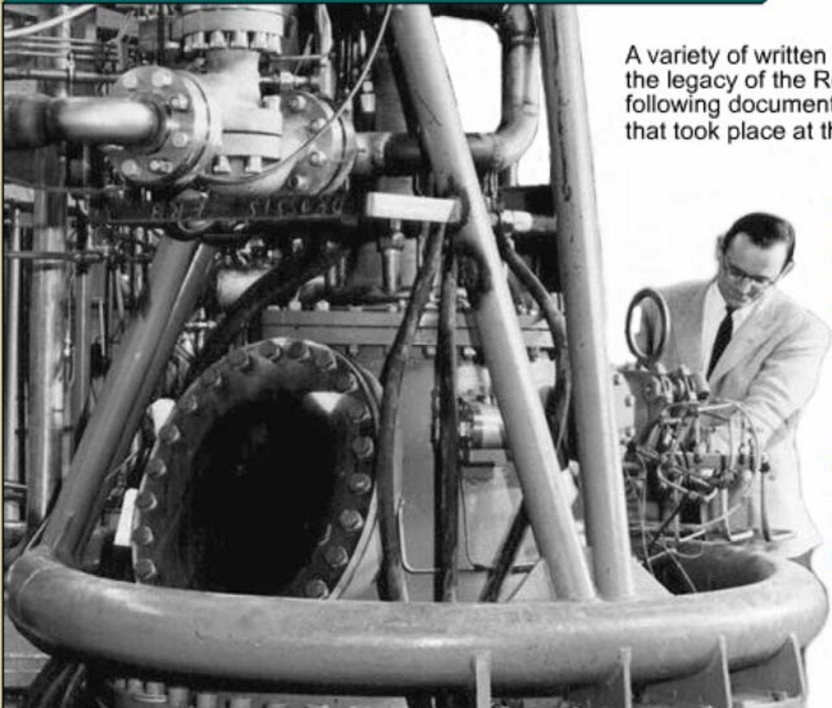
Research



A variety of written materials were produced to preserve the legacy of the Rocket Engine Test Facility (RETF). The following documents record the historic accomplishments that took place at the of the RETF:

- A brief history of RETF.
- A brief description of this project.
- A peer-reviewed historical text titled, IDEAS INTO HARDWARE: A History of the Rocket Engine Test Facility at the NASA Glenn Research Center, by Dr. Virginia Dawson.
- Historic American Engineering Record (HAER) documentation, completed by Hardlines Design Company.
- A list of links to other documents and government Web sites to provide additional research opportunities.

Research

A Brief Description of This Mitigation Project

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- Two videos covering the history of the RETF
- Restoration of an existing three-dimensional scale model of the RETF
- Archiving of RETF files and offering of RETF artifacts to museums
- Construction of a museum-quality display

Credits:

The Federal Aviation Administration (FAA), The National Aeronautics and Space Administration (NASA), The Ohio State Historic Preservation Office (OSHPO), and the Advisory Council on Historic Preservation (ACHP) established the scope of the recording project and monitored its production. The City of Cleveland and the Program Management Team guided the development of this recording project. Middough Consulting Inc, of Cleveland, Ohio served as the Project Manager. Hardlines Design Company of Columbus, Ohio, was subcontracted by Middough Consulting to oversee the production of all aspects of this documentation. Hardlines Design Company completed the HAER drawings and reports, molded content materials for this Web site, the videos, and the museum display. Historical Technologies of West Suffield, Connecticut, provided technical assistance and wrote the historical texts for the HAER documentation. The peer-reviewed history was written by Dr. Virginia Dawson of History Enterprises, Cleveland, Ohio. The museum display and restoration of the scale model was completed by Lucarelli Designs & Displays, Inc. of Brunswick, Ohio. The retiree videos and five- and twenty-

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Research

IDEAS INTO HARDWARE:
A History of the Rocket Engine Test Facility at the NASA Glenn Research Center

Available Online

A peer-reviewed historic text titled, *IDEAS INTO HARDWARE: A History of the Rocket Engine Test Facility at the NASA Glenn Research Center*, by Dr. Virginia Dawson. This text details the experimental history of the facility through the eyes of the engineers and scientists who worked there. Dr. Dawson's text can be viewed on-line or downloaded in *.pdf format.

Click here to Download: ***Ideas Into Hardware*** (2 MB approx.)

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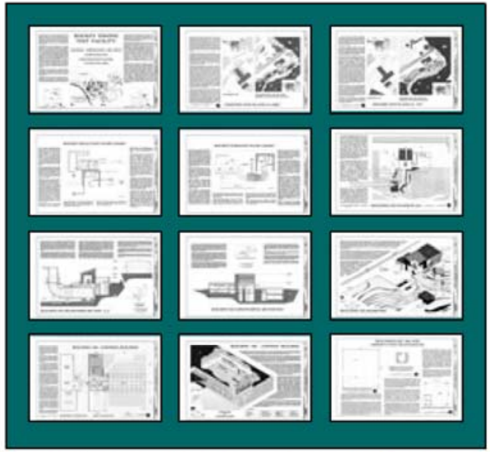
HAER Documents

Historic American Engineering Record (HAER) documentation, completed by Hardlines Design Company. This documentation includes detailed text about the overall context of the RETF and the individual buildings that made up the complex. Eleven drawings of the complex and its buildings are also included. All documentation can be viewed on-line or downloaded in a *.pdf format.

These documents are available for download

- ContextReport.pdf - 8.5 MB - approx.
- Bldg100Report.pdf - 9 MB - approx.
- Bldg202Report.pdf - 26 MB - approx.
- Bldg205Report.pdf - 2 MB - approx.
- Bldg206Report.pdf - 2.6 MB - approx.
- BlockhouseReport.pdf - 2.7 MB - approx.



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Research

Links

NASA Main Page:
http://www.nasa.gov

Popular Topics:
http://www.nasa.gov/topics/highlights/index.html

NASA for kids
http://www.nasa.gov/audience/forkids/home/index.html

NASA news/events
http://www.nasa.gov/news/highlights/index.html

About NASA
http://www.nasa.gov/about/highlights/index.html

NASA 45 th Anniversary Page
www.nasa.gov/externalflash/NASA45th/index.html

NASA Education Page
http://education.nasa.gov

NASA Glenn Research Center
http://www.grc.nasa.gov

NASA Glenn Research Center Visitors Center

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NASA Glenn Research Center Educational Opportunities
http://www.grc.nasa.gov/Doc/educatn.html

Beginner's Guide to Model Rockets
http://www.grc.nasa.gov/WWW/K-12/airplane/bgmr.html

Centaur Rockets
http://www.grc.nasa.gov/WWW/PAO/html/centaur.htm

Liquid Hydrogen as a Propulsion Fuel
http://www.hq.nasa.gov/office/pao/History/SP-4404/cover.html

SBIR Fuels and Space Propellants Web Site:
http://sbir.grc.nasa.gov/launch/foctopsb.htm

Learning Technologies Project - Student Videoconferencing Web Sites:
http://www.grc.nasa.gov/WWW/K-12/CoE/history_of_rocketry_videoc.htm

http://www.grc.nasa.gov/WWW/K-12/CoE/history_of_humans_in_space.htm

http://www.grc.nasa.gov/WWW/K-12/CoE/apollomoonlandingsvideocon.htm

http://www.grc.nasa.gov/WWW/K-12/CoE/the_moon_videoconference.htm

http://www.grc.nasa.gov/WWW/K-12/CoE/asteroidsvideocon2.htm

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http://www.grc.nasa.gov/WWW/K-12/CoE/the_moon_videoconference.htm

http://www.grc.nasa.gov/WWW/K-12/CoE/asteroidsvideocon2.htm

http://www.grc.nasa.gov/WWW/K-12/CoE/meet_a_nasa_aeronautics_ex.htm

Other Institute Links

Smithsonian National Air and Space Museum
http://www.nasm.si.edu/

Ohio Aerospace Institute
http://www.oai.org

The Science, Engineering, Mathematics and Aerospace Academy (SEMAA)
http://www.semaa.net/

The Ohio Historic Preservation Office
http://www.ohiohistory.org/resource/histpres/

The Advisory Council on Historic Preservation
http://www.achp.gov/

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The Science, Engineering, Mathematics and Aerospace Academy (SEMAA)
http://www.semaa.net/

The Ohio Historic Preservation Office
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The Advisory Council on Historic Preservation
http://www.achp.gov/

National Park Service Links

National Park Service
http://www.nps.gov/

National Historic Landmarks
http://www.cr.nps.gov/nhl/

NHL – Man in Space Nomination Description
http://www.cr.nps.gov/history/online_books/butowsky4/space5.htm

RETF listing as a National Historic Landmark
http://tps.cr.nps.gov/nhl/detail.cfm?ResourceId=1918&ResourceType=Building

Historic American Building Survey/Historic American Engineering Record
http://www.cr.nps.gov/habshaer/

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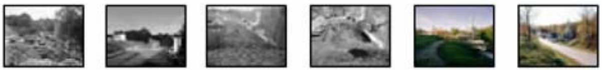
Photos & Videos

Photo Categories

Aerials Through the Years | From the Blockhouse | Graphic Through the Years
Construction of RETF | Trial and Error | Items Tested at RETF | People at Work
Tests | Demolition

Aerials Through the Years

From the Blockhouse



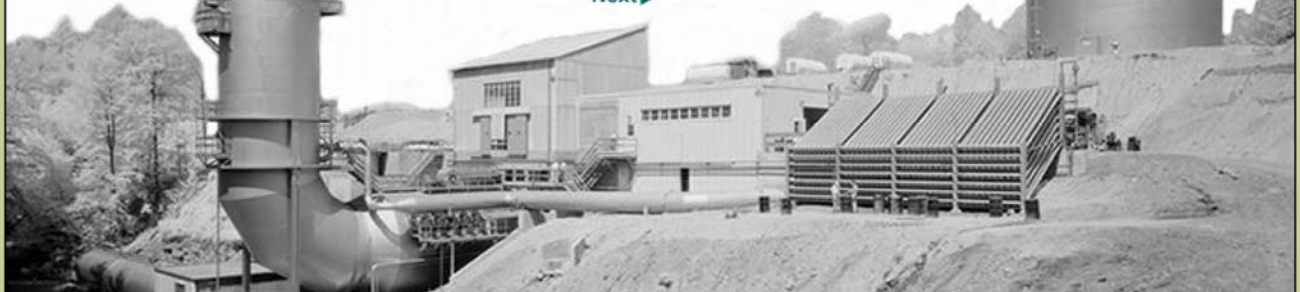
Next

Video Categories

RETF Staff Interviews | RETF Rocket Tests
Five Minute Video

RETF Staff Interviews

Next



Photos & Videos

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Tests Demolition

Aerials Through the Years

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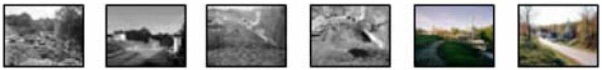
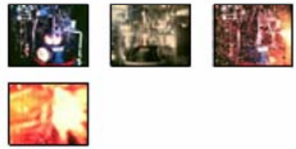


Video Categories

RETF Staff Interviews RETF Rocket Tests
Five Minute Video

RETF Rocket Tests



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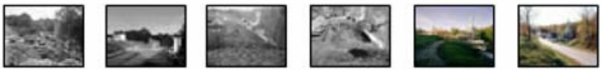

Video Categories

RETF Staff Interviews | RETF Rocket Tests | Five Minute Video

RETF Five Minute Video

Standard

Close Captioned

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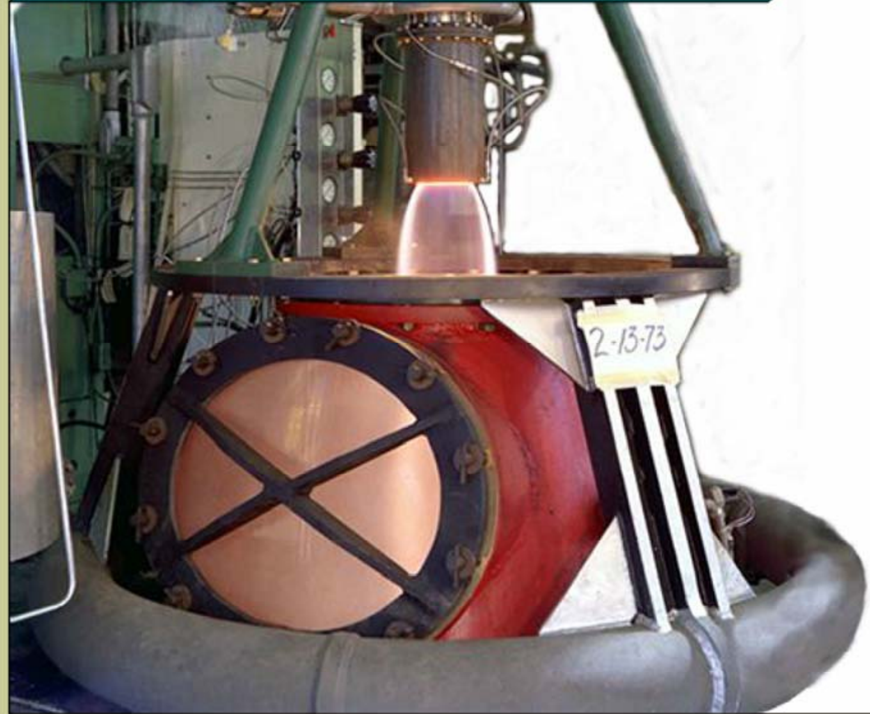
Interactive Lessons



The Rocket Engine Test Facility (RETF) was instrumental in NASA's journey into space.

The following pages include:

- Rocket Engine Testing 101
- Rocket Exhaust Scrubbing
- Rocket Test Components
- RETF Buildings & Structures
- History & Significance
- Take the Quiz

Research

A Brief Historical Background of RETF

The Rocket Engine Test Facility (RETF) made a number of significant contributions to the U.S. aerospace industry in the area of rocket-engine propulsion, primarily with their development of the technology required to use high-energy liquid propellants, such as liquid hydrogen, as rocket-engine fuel. The results of their testing proved invaluable to the manned Apollo program and the unmanned programs for exploring the solar system, in particular to the RL-10 engine for the Centaur rocket and the Rocketdyne F-1 and J-2 engines for the Saturn rockets.

In general, the RETF was designed to be a research facility in which innovative solutions were developed in a field of study with many unknown factors. Scientists tested new designs and concepts, analyzed both successful and failed designs, and then used the results to develop better designs. For testing, they often used model and sub-scale engines, which minimized the use of expensive fuels and oxidizers. Designs that proved to be viable were then transferred to other research facilities for scale-up and possible production. During its lifetime, the RETF helped greatly to advance U.S. knowledge of rocket engines with both theoretical developments and practical applications.

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Research

The Development of Lewis Lab

The RETF was located on the southern portion of the Lewis Laboratory, which itself came into being during World War II. Although government laboratories in England and Germany had been conducting research into advanced aircraft-engine design by the late 1930s, the U.S. government and American corporations had hesitated to commit major funding to similar types of engine development. This situation changed with World War II and the increased awareness of the critical role that aircraft play in warfare.

In 1940, the National Advisory Committee on Aeronautics (NACA) opted to build a new laboratory devoted to engine research. Several American pioneers of aeronautical engineering, including George W. Lewis, had successfully lobbied for federal funding to establish a national laboratory dedicated to engine research and military applications for World War II. Cleveland, Ohio, was selected as the site, in part because it was not located on the more strategically vulnerable coasts. The facility was built on 200 acres of land next to the municipal airport near Lake Erie and was named the Aircraft Engine Research Laboratory.

This name, however, would change over the years, either to reflect a shift in focus for the laboratory or to honor significant leaders in the aeronautical industry. In April of 1947, the name changed to the Flight Propulsion Research Laboratory to more accurately reflect the role the lab was playing in propulsion research. In 1948, the facility was renamed as the Lewis Flight Propulsion Laboratory, or the Lewis Laboratory, in honor of George Lewis, the former Director of Aeronautical Research at NACA. In 1958, when NACA was formed into the National Aeronautics and Space Administration (NASA), the name changed to Lewis Research Center. And finally, in March of 1999, the center was given its current name, the NASA John H. Glenn Research Center at Lewis Field, to honor both George Lewis and the astronaut John Glenn.

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Research

Liquid hydrogen as rocket fuel

The American military establishment witnessed the performance of the German medium-range, V-2 rocket-powered missile against Britain during World War II.. After German documents and hardware were captured, the U.S. military became convinced that for the sake of national security, they needed to more vigorously pursue advanced rocket research. After the end of World War II, during the late 1940s and early 1950s, the U.S. military aggressively pursued research in rocket propulsion. In 1951, the U.S. government had formally appropriated funding for rocket research, possibly in response to intelligence reports of Soviet advances in rocket technology, and during this time, the Lewis Laboratory conducted intensive research on rocket fuels. Their research was circulated to such organizations as the Navy Bureau of Aeronautics and the Air Force at Wright Field. At that time, the Lewis Laboratory facility consisted of a series of cinder-block, World War II-era cells used for rocket testing, plus four larger cells that were built later using funds from laboratory operations.

Liquid hydrogen was sought out for use as a fuel because it had a high exhaust velocity, excellent cooling characteristics, and a high reaction rate. The use of liquid hydrogen as a fuel had been presented before—the Russian scientist Konstantin Tsiolkovsky proposed it as early as 1903, and researchers at The Ohio State University experimented with liquid hydrogen as a potential rocket fuel from 1945 to 1950. Aerojet General Corporation and the Jet Propulsion Laboratory also had run similar tests in the late 1940s. There were problems, however, with this type of research. Just after World War II, the U.S. had no laboratories or plants available that were capable of leading serious research with hydrogen-fueled rocket engines, and there was no steady supply of liquid hydrogen during these years. In the early to mid-1950s, even the U.S. Army was still using relatively unsophisticated or interim test stands for its research on rocket-fired missiles and atomic warheads.

In addition, testing hydrogen-fired rocket engines was a potentially dangerous activity that required special facilities. A static test stand was needed to test rocket engines, and the stand had to be securely anchored while the engine performance was measured and evaluated. The test stand also had to be housed in an appropriately secure facility with an infrastructure built to deliver reactants to the stand, as well as support the instruments that monitored the rocket's performance. The reactants

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The Rocket Engine Test Facility

In 1952, NACA authorized the scientists at Lewis Lab to build a test facility to evaluate high-energy propellants and rocket-engine designs. In the early 1950s, scientists there had acquired a hydrogen liquefier and had tested hydrogen/fluorine engines in a cell equipped with a scrubber to control toxic emissions. As they continued their research, they began to plan a rocket-engine test-complex better suited to their testing needs. Although the initial plan was to locate this facility on a remote site in the western United States, they instead decided to develop a smaller test facility at Lewis Laboratory.

Drawings for the facility were produced in 1955 and 1956, and it was built from 1955 to 1957 on a 10-acre site at the southern end of Lewis Laboratory. Called the Rocket Engine Test Facility (RETF), the complex was unique in that it was an integrated laboratory developed for highly focused research into the functions of individual rocket engines. At that time, the existing propulsion laboratories were geared toward more general missile development.

Construction of the RETF cost $2.5 million and originally included two major components: a control center in Building 100, and a test cell in Building 202. The test engine was mounted vertically in the test cell, and exhaust was channeled into a duct system. Environmental precautions were essential because the facility was located in a densely populated urban area—the facility used an innovative exhaust scrubber that removed toxic byproducts from the exhaust and muffled the roar of the firing test engine. Wastewater from the scrubber was piped into a reservoir where it was treated with chemicals, and the inert calcium fluoride residue was transported off-site.

The initial plans for the center also included an obser-

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The initial plans for the center also included an observation blockhouse that protected the researchers while they observed the tests. Support structures were added later. Building 205, a propellant transfer and storage facility, was built circa 1962-1965, and Building 206, a structure to house a cryogenic vaporizer and compressor, was built in 1968. When the facility was completed in 1957, it was the largest high-energy test facility in the United States that was capable of handling liquid hydrogen and other liquid fuels.

Most engines tested at the RETF had 4.8" chambers with 2.62" throats, or 10" chambers with 7.6" throats. In spite of the small engine size, the use of high-pressure reactants allowed some of these small engines to produce thrusts of 75 kilonewtons (17,000 pounds). The test facility was eventually able to accommodate up to three minutes of engine operation at a thrust of 89 kilonewtons (20,000 pounds). On rare occasions, tests were run at 178 kilonewtons (40,000 pounds) of thrust.

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Research

Notable RETF projects

In the early years, research at Lewis Laboratory had focused largely on military applications, but in October 1957, just after the construction of the RETF, the Soviet launch of Sputnik spurred new U.S. efforts in rocket-engine research for space exploration. Some of their most significant projects included:

•**RL-10 engine:** In the late 1950s, Pratt & Whitney developed the RL-10 engine but were having serious trouble with their injector. Pratt & Whitney visited RETF to learn about a new injector developed at Lewis, the concentric tube injector. This injector was subsequently adopted for the RL-10 engine. The RL-10 engine was the world's first liquid-hydrogen rocket engine and was used to fire the Centaur rocket. The Centaur was first used in the second stage of the Atlas rocket that carried a robotic probe to the moon. In October 1962, the management of the Centaur program was transferred to Lewis Research Center from the Marshall Space Flight Center in Hunts Alabama. Lewis continued to manage the Centaur program for the next thirty years.

•**J-2 engine:** Research completed at the RETF also influenced the decision to use a liquid-hydrogen engine for the upper stage of the Saturn launch vehicle for the Apollo Program. It is now widely accepted that use of the Rocketdyne J-2 liquid hydrogen engine in the upper stages of the Saturn rocket gave the United States a decisive advantage in the race to complete a manned mission to the moon.

•**F-1 engine:** Between 1962 and the early 1970s, the RETF investigated the problem of combustion instability, also sometimes referred to as "screech." This instability was caused by pressure changes in the engine-combustion chamber during firing, and it could lead to the deformation of the chamber wall and, ultimately, engine failure. The F-1 engine used for the first stage of the Saturn launch vehicle experienced serious problems with combustion instability, and research completed at the RETF may have contributed to a 1965 redesign of the F-1 engine's injector.

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•**M-1 engine:** From 1962 to 1966, research at the RETF focused on combustion instability in the M-1 engine. The M-1 was an upper-stage hydrogen engine for the Nova rocket, a launch vehicle that would be more powerful than that for the Saturn rocket, and which was planned as a launch vehicle for sending a manned mission to the moon,. However, the decision to use a lunar-orbit-rendezvous approach for the moon rather than a direct-ascent approach meant that the more powerful Nova would not be needed for the moon project, and the M-1 program was cancelled in 1966. However, the Nova rocket was kept on the drawing board for future missions beyond the moon.

After the end of research for the Apollo Program, scientists at the RETF undertook a number of research programs in the 1970s and 1980s that greatly contributed to the development of propulsion systems for the space shuttle and other important NASA programs:

•In 1975, RETF engineer Richard Quentenmeyer developed a water-cooled "plug-nozzle" rocket thrust chamber that could test the problem of low-cycle thermal fatigue in reusuable rocket engines.

•RETF also undertook a program to reduce the wall temperatures of rocket engine liners. By studying and developing high-aspect ratio cooling channels, RETF was able to demonstrate that they could reduce wall temperatures from 1000°F to between 400°F and 600°F.

•In the late 1970s and 1980s, engineers at the RETF tested the first liquid-oxygen-cooled engines built by NASA and explored the problems of using this unique cooling concept.

•During the early 1990s, RETF worked with TRW to demonstate the feasibility of operating a Coaxial Pintle Injector Rocket Engine using liquid oxygen and liquid hydrogen as propellants. The purpose of this effort was to demonstrate technology that would significantly reduce the cost of launching payloads into space.

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Research

Upgrades to the RETF

The buildings and equipment at the RETF were upgraded numerous times over the years to keep pace with the demands of their research. During the 1960s, the original gas bottles were upgraded to test more powerful engines. Building 205 was constructed circa 1962-1965 as a hydrogen vaporizer and liquid oxygen storage area, and Building 206, the liquid hydrogen vaporizer building, was constructed in 1968. Mobile "dewars," or tanks, could transport liquids to these facilities, where vaporizers converted the liquids into high-pressure gases.

The exhaust scrubber stack at Building 202 was also extended in the late 1960s to guarantee thorough removal of toxic exhaust and to muffle the sound of the firing engines. The test facility control room in Building 100 was repeatedly upgraded during this period to keep current with advances in instrumentation and computer technologies. By 1972, the gas bottles had been upgraded from 2,200 psi to 6,000 psi for helium and nitrogen, and 5,000 psi for liquid oxygen. The higher pressures allowed the facility to test sub-scale engines with thrusts equivalent to full-size or larger model engines.

During the 1980s, the RETF was significantly upgraded. In 1982, Building 206A, a liquid hydrogen vaporizer facility, was added to the facility. A second test stand was added to Building 202 in the 1980s, and a third test stand was built in 1991. The RETF continued to play an important role in propulsion technology development during the 1980s and the first half of the 1990s, including tests on hydrogen-oxygen engines used in the space shuttle and tests in 1991 to 1995 on a low-cost rocket engine developed by the TRW Space and Technology Group.

Previous Next

Research

The Closing of the RETF

Although NASA developed plans in the 1990s for an extensive rehabilitation of the RETF, the City of Cleveland had their sights set on the land that RETF occupied. The City announced plans to expand Cleveland Hopkins International Airport and construct an extended runway that would require demolition of the RETF. NASA management reassessed the situation and decided against further investment in the RETF. The Space Propulsion Technology Division at NASA did not have programs that exclusively required the RETF at that point in time, and no future program funds were anticipated that could offset operational costs at the facility. NASA subsequently canceled their plans to rehabilitate the facility, and announced that the RETF would close permanently. The last tests were completed at the facility during the first half of 1995, and the official shutdown date was July 1, 1995. The entire RETF site was demolished in 2003.

To record its significance for U.S. aerospace history, the RETF was listed on the National Register of Historic Places in 1984-1985. The RETF was noteworthy for its role in the development of lightweight, regeneratively cooled hydrogen engines and for its role in facilitating the overall progress of propulsion technology used in NASA missions and programs. The National Park Service also designated the facility as a National Historic Landmark.

◀ Previous

RETF Buildings & Structures

The Rocket Engine Test Facility (RETF) was located within the South 40 area of the NASA Glenn Research Center.

Because of the experimental nature of the testing that took place at RETF, the facility was constructed on a site built a safe distance away from the main facilities at NASA. Most of the buildings in the RETF were constructed in 1957, with a few additional

RETF Buildings & Structures

RETF, the facility was constructed on a site built a safe distance away from the main facilities at NASA. Most of the buildings in the RETF were constructed in 1957, with a few additional components added over the next fifteen years.

Click the yellow arrows at the top to see different views and hold you mouse over orange arrows in the pictures for more information.

RETF Buildings & Structures

Building 100

This Rocket Operations Building housed the operations and control room, as well as the data recording and control computers.

Building 100 was located 1,600 feet north of the test stand on flat ground. Test engineers ran their rocket tests from this safe distance.

RETF Buildings & Structures

Blockhouse

Constructed in 1957, this building was a plain concrete-reinforced bunker located approximately 260 feet north of Building 202.

The blockhouse held test observers during engine testing, protecting them from flying debris in case of catastrophic engine failure during the tests.

RETF Buildings & Structures

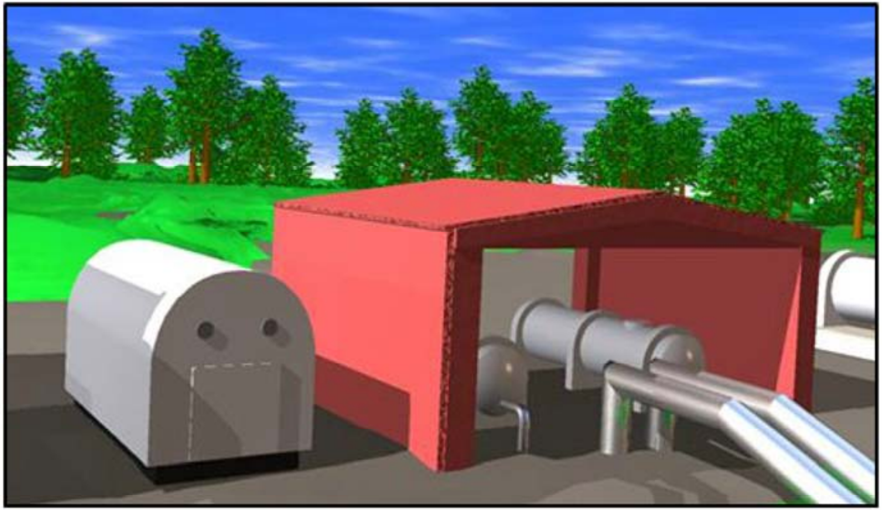
Click an arrow to see a building up close

Building 206

Constructed in 1968, this facility was known as the Cryogenic Vaporizer Facility. It housed a liquid hydrogen vaporizer.

The liquid hydrogen that was brought into this facility was vaporized and piped to the Bottle Farm where it was used to force the liquid hydrogen into the test engine.

RETF Buildings & Structures

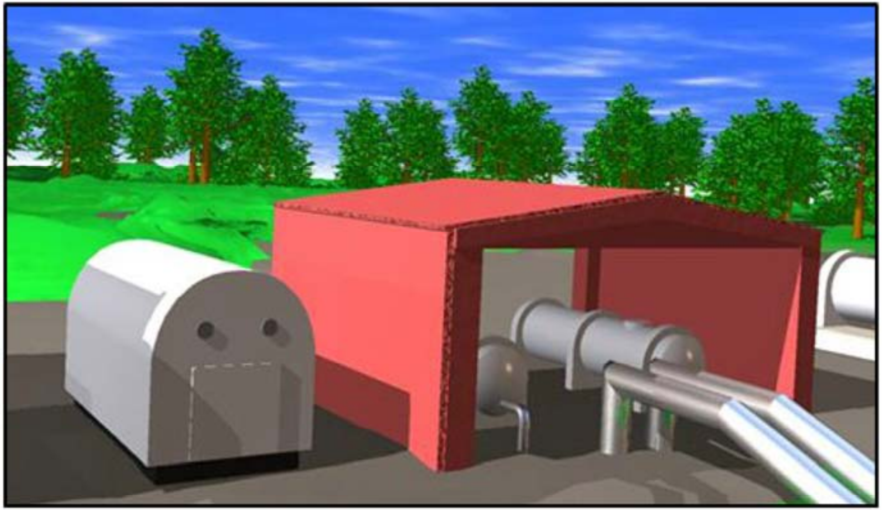


Building 205

Building 205 operated as the Helium Gasification and Pressurizing facility. Liquid helium would be delivered to the site, vaporized into a gaseous state, and pressurized by Building 205's equipment.

Gaseous helium was used at RETF to push liquid oxygen through a piping system into the

RETF Buildings & Structures

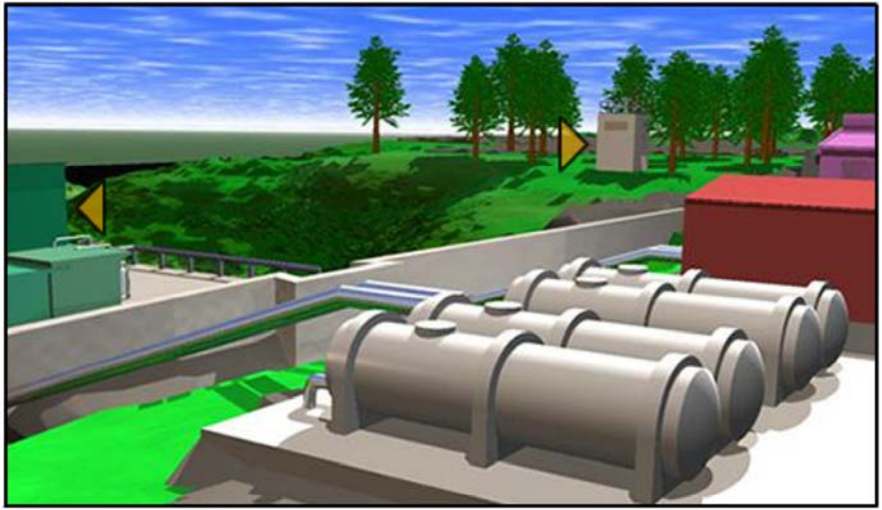


state, and pressurized by Building 205's equipment.

Gaseous helium was used at RETF to push liquid oxygen through a piping system into the rocket engine chamber.

Gaseous helium was also used to purge or clean out the same piping system, and to pressure -check the piping system to identify any leaks.

RETF Buildings & Structures

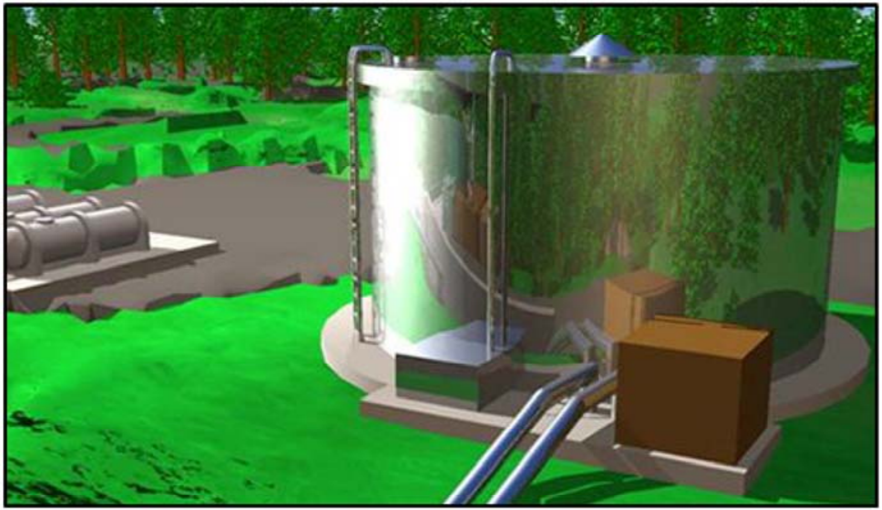


The Bottle Farm

These tanks stored high-pressure gaseous hydrogen for the testing of Liquid Hydrogen engines.

Gaseous hydrogen was used to force the liquid hydrogen into the test engine.

RETF Buildings & Structures



500,000-Gallon Water Reservoir

This reservoir supplied the water needed during an RETF test run, at rates as high as 50,000 gallons per minute. The water was piped through 55-inch diameter pipes to the Exhaust Scrubber to remove by-products from the engine exhaust.

RETF Buildings & Structures

Click an arrow to see a building up close

Building 202

This building was the primary facility where the engines were tested. The key components in this building were:

●A-Stand Test Cell● Rocket engines were tested in this section of the building. The cell was equipped with large doors and blast shutters that could open during

RETF Buildings & Structures

testing. In the event of catastrophic engine failure and explosion, the sheathing panels blew away, relieving pressure within the cell while preserving the structure of the cell.

- Liquid Hydrogen Tanks
-

Mobile dewars brought liquid hydrogen to the RETF and deposited it in these tanks. The liquid

RETF Buildings & Structures

Click an arrow to see a building up close

Mobile dewars brought liquid hydrogen to the RETF and deposited it in these tanks. The liquid hydrogen in these tanks then ran through pipes into the A-Stand Test Cell and provided the fuel for various rocket-engine tests.

●Fuel Pit●
Fuel was stored in mounted tanks in this room.

RETF Buildings & Structures

●Ox Pit●
Liquid oxygen was stored at this location and then piped to the Test Cell.

●Shop●
This wing contained a terminal/observation room, office, and a small machine shop.

●Rocket Exhaust Scrubber●
This device removed combustion by-products

RETF Buildings & Structures

This device removed combustion by-products from the rocket engine exhaust and lessened noise levels by directing the hot gas exhaust through a heavy spray of water.

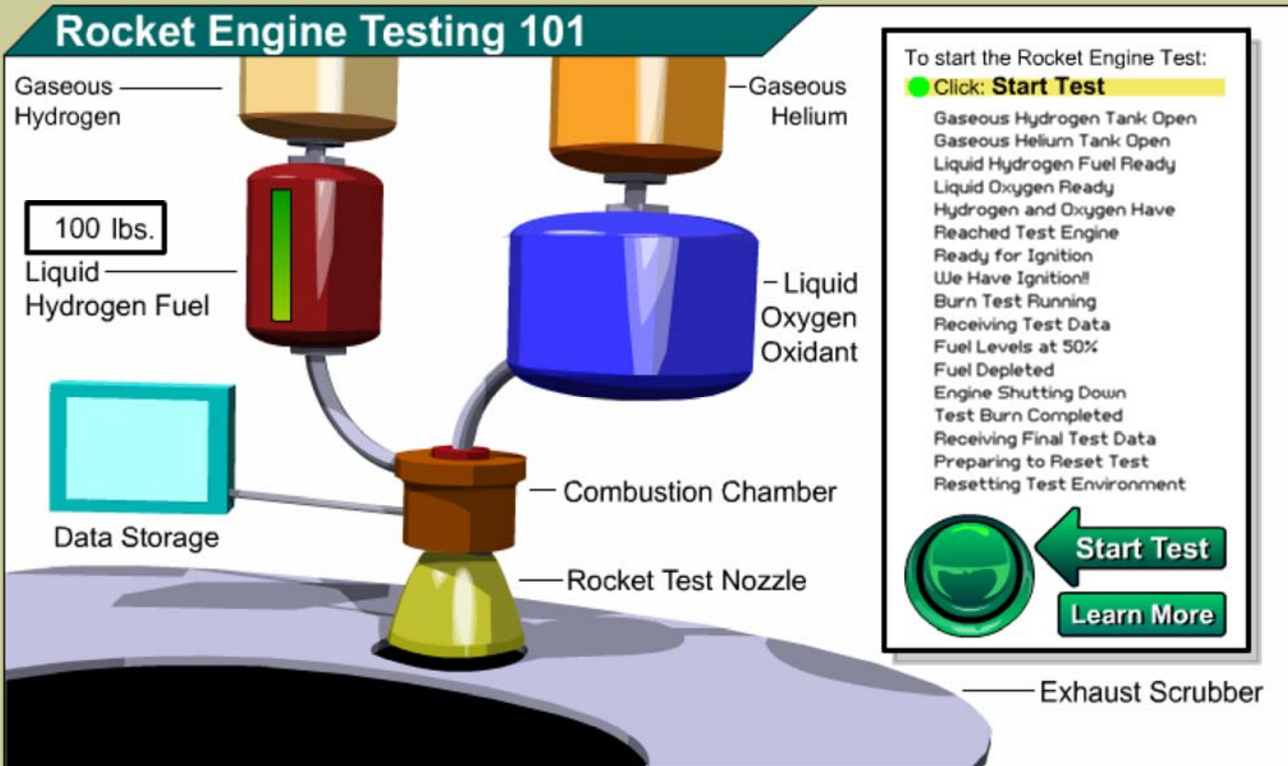
●Detention Tank●
This tank held the wastewater from the scrubber/silencer operation.

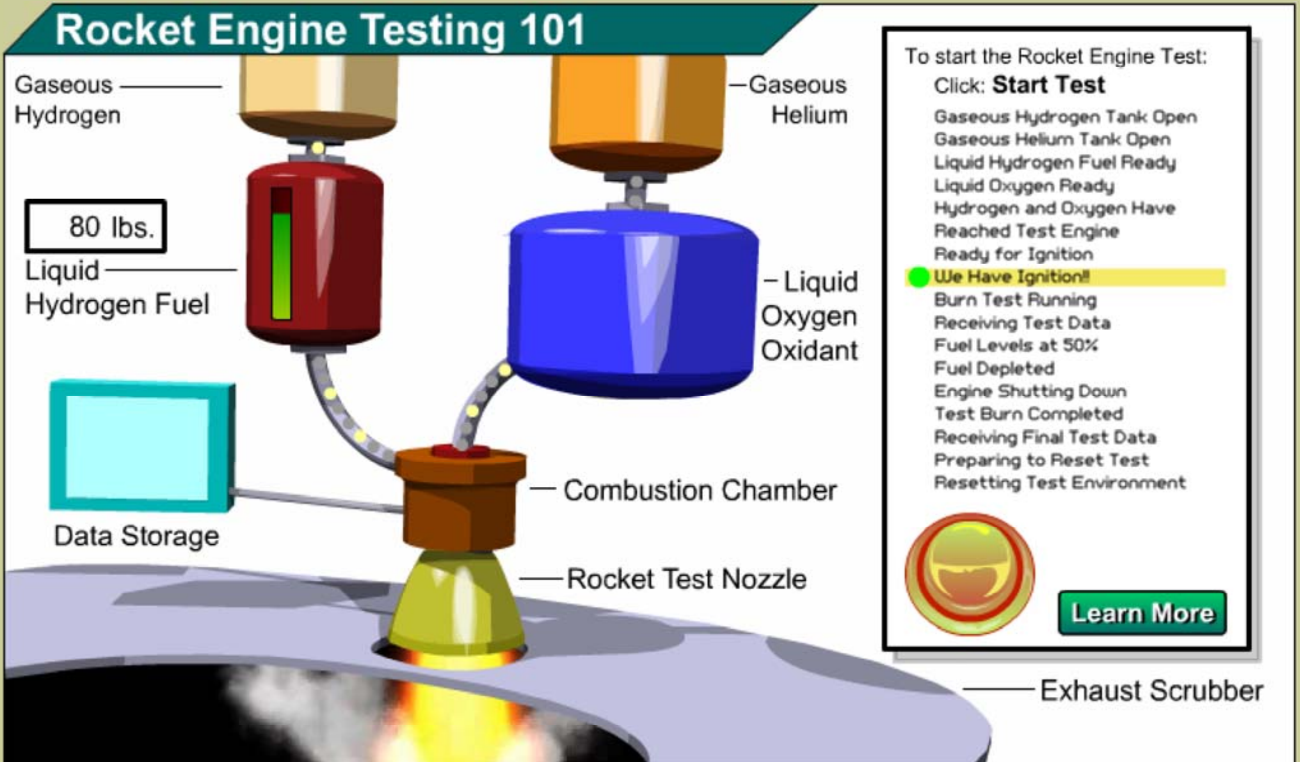
RETF Buildings & Structures

scrubber/silencer operation.

●Pump House●
The pump house pumped wastewater to the treatment basins.

●Treatment Basin●
Here chemicals were added to the wastewater to neutralize this water for safe transportation to the municipal sewage treatment center.


Rocket Engine Testing 101
Gaseous Hydrogen
Gaseous Helium
100 lbs.
Liquid Hydrogen Fuel
Liquid Oxygen Oxidant
Data Storage
Combustion Chamber
Rocket Test Nozzle
Exhaust Scrubber
To start the Rocket Engine Test:
Click: Start Test
Gaseous Hydrogen Tank Open
Gaseous Helium Tank Open
Liquid Hydrogen Fuel Ready
Liquid Oxygen Ready
Hydrogen and Oxygen Have
Reached Test Engine
Ready for Ignition
We Have Ignition!!
Burn Test Running
Receiving Test Data
Fuel Levels at 50%
Fuel Depleted
Engine Shutting Down
Test Burn Completed
Receiving Final Test Data
Preparing to Reset Test
Resetting Test Environment
Start Test
Learn More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Gaseous Hydrogen
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Liquid Hydrogen Fuel
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Data Storage
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To start the Rocket Engine Test:
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Gaseous Hydrogen Tank Open
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Liquid Hydrogen Fuel Ready
Liquid Oxygen Ready
Hydrogen and Oxygen Have
Reached Test Engine
Ready for Ignition
We Have Ignition!!
Burn Test Running
Receiving Test Data
Fuel Levels at 50%
Fuel Depleted
Engine Shutting Down
Test Burn Completed
Receiving Final Test Data
Preparing to Reset Test
Resetting Test Environment
Learn More

Rocket Engine Testing 101

Rocket Engine Testing @ RETF

The next sections describe different stages of a sample test-run at the Rocket Engine Test Facility (RETF). This theoretical engine test uses liquid hydrogen as the fuel and liquid oxygen as the oxidizer. The stages that are examined include:

- Setting up the test site
- Running the test
- Scrubbing the rocket exhaust
- Handling problems during the test
- Setting up the test site

The researchers at RETF were performing complex experiments that required specially designed equipment and sensitive instruments, and a great deal of attention went into preparing the test site to achieve the best results.
Precision and accuracy were crucial, and researchers followed standard procedures when conducting a test run.

Close

Rocket Engine Testing 101

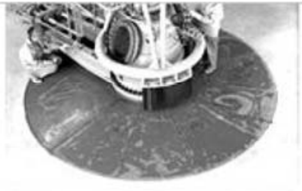
To start the Rocket Engine Test:

To prepare the fuel source, pressurized liquid hydrogen flowed from a mobile tanker-trailer into the cylindrical tanks that were housed in the fuel pit. These tanks were mounted in a special framework that contained sensors called "load cells" in the suspension. The load cells measured the weight of the tanks, which enabled the researchers to measure the amount of fuel in them. By comparing the weight of a full tank with the weight of the tank after a test, researchers could accurately determine the amount of fuel burned during the test. They could then calculate the rate of fuel use by plotting the weight of the tank against the time length of the test.

When liquid oxygen was used as the oxidizer, it was transferred from a mobile tanker-trailer through a pipe into a tank in the oxidizer pit. Special equipment was needed to keep the oxygen in a liquid state as it traveled through the pipe and was stored in the tank. Each tank, called a "dewar" was vacuum insulated and double walled. A liquid-nitrogen bath was circulated between the two walls of the tank to keep the oxygen cool and in its liquid form. The pipe to the tank also had an outer covering that contained a liquid-nitrogen bath.

Close

Rocket Engine Testing 101



To gather data from the experiments, researchers used numerous sensors on the engines, such as load cells, strain gages, thermocouples, and pressure gages. The wires from the sensors were connected to terminal blocks and amplifiers in the terminal room of Building 202. Because the magnitude of some of the electrical signals was quite small, the signals needed to be amplified before they were transmitted to the control room. Once amplified, the electrical signals were transmitted over data-transmission cables to the readout devices in the control room in Building 100, some 1,600 feet away.

Great care was taken to make sure that the test was completed with the utmost safety, and RETF used a number of different systems to help warn people to stay away from the site during a test. They positioned signs and barriers around the perimeter of the test facility, and they flew flags over the test area, using green, yellow, and red flags to indicate different alert levels. The facility had a public address system that could be used to warn workers in the surrounding areas, and most important, they turned on a siren thirty seconds before they fired a rocket and continued the siren until the test was complete.

Close

Rocket Engine Testing 101

To start the Rocket Engine Test:

Running the Test

Once the test site was prepared and safety precautions completed, it was time to run the test. Procedures were divided into carefully choreographed periods called "zones" for accomplishing specific tasks, with the test itself running for between 2 and 3 seconds.

At the pre-test zone, engineers prepared the rocket equipment:

- Pressurized and test-fired the igniter system
- Used liquid helium to chill the liquid hydrogen line leading into the injector
- Pressurized the propellant tanks

After the pre-test, during the first 15-second period, the engine was readied for firing:

- The test engineer-in-charge pushed the start button.
- Data systems automatically calibrated the instruments and started recording pressure and temperature data on strip charts.
- Gaseous nitrogen, used to purge the propellant lines, and water started to flow into the

Close

Rocket Engine Testing 101

- Data systems automatically calibrated the instruments and started recording pressure and temperature data on strip charts.
- Gaseous nitrogen, used to purge the propellant lines, and water started to flow into the scrubber.
- After 11 seconds, a 2-second flow of oxygen began in order to cool the engine.
- At 13 seconds, gaseous nitrogen purges cleared the engine of liquid oxygen.

The most critical time was this next 3- to 5-second period, when these events occurred:

- The test engineer-in-charge turned on the igniter and checked the pressure of the combustion chamber.
- Two propellant valves automatically opened, allowing the fuel (liquid hydrogen) and the oxidant (liquid oxygen) to flow into the rocket engine.
- After 450 milliseconds, propellant and combustion chamber pressures were checked. If they were within limits, the test continued, though the test conductor kept his hand near the **ABORT** button.
- After 2.5 seconds had lapsed, the fire valves were closed and the engine was shut down. The propellants were flushed from the lines beyond the fire valves, the purges were restarted, and finally, test shutdown was initiated.

Close

Rocket Engine Testing 101

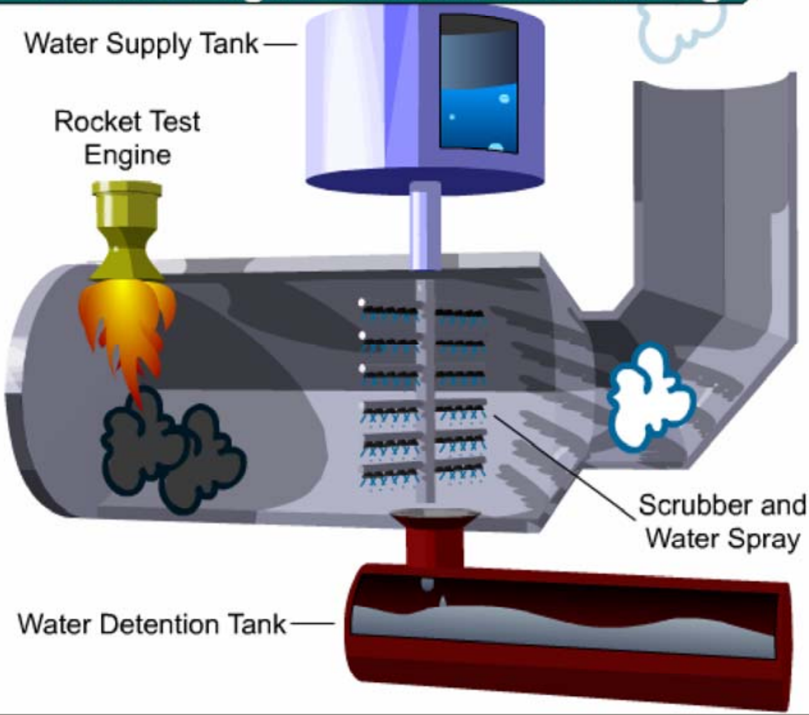
In the final 120 seconds of the test, the engineers:

- Completed the engine shutdown.
- Rendered the area safe for inspection.
- Took calibrations again.
- Turned off the scrubber.
- Turned off all data systems.

At any time during a test, if the engineers monitoring data in the control room noted abnormal propellant and chamber pressures, the engineer-in-charge could immediately abort the test by pressing the ABORT button. However, it was more

Close

Rocket Engine Exhaust Scrubbing



The exhaust from a rocket-engine test needed to be cleaned before it entered the atmosphere.

This is how the exhaust was scrubbed:

Hot gases entered the scrubber through a narrow opening in the test cell.

The gases were trapped in the water spray coming from the aerosol nozzles.

Learn More

Rocket Engine Exhaust Scrubbing

Scrubbing the Rocket Exhaust

The exhaust from a rocket-engine test needed to be cleaned before it entered the atmosphere. Exhaust was scrubbed in this manner:

- Hot gases from the rocket engine nozzle entered the scrubber through a narrow opening in the test cell. These gases were traveling at velocities of 9,000 to 12,000 feet per second (fps) (1.7 miles per second to 2.3 miles per second) and at temperatures up to 6,000°F.
- The exhaust stream entered the large scrubber tank (25' wide by 100' long) at a speed of 25 fps.
- The gases contacted the water spray coming from the nozzles.
- Much of the exhaust was converted to steam and escaped through the vertical portion of the scrubber at a velocity of approximately 20 fps and a temperature of 160°F. Several burners on top of the scrubber ignited any hydrogen or other fuel not consumed by the engine

Close

Rocket Engine Exhaust Scrubbing

- Much of the exhaust was converted to steam and escaped through the vertical portion of the scrubber at a velocity of approximately 20 fps and a temperature of 160°F. Several burners on top of the scrubber ignited any hydrogen or other fuel not consumed by the engine. These burners prevented unburned fuel from building to explosive levels inside the scrubber.

- Combustion by-products, water, and condensed steam were trapped by the scrubber and drained into a 20,000-gallon detention tank. Wastewater was retained in this tank until the day's test program was completed, when the wastewater was pumped to a neutralizing tank

- Chemical technicians analyzed the wastewater and determined the quantity and type of additives they needed to neutralize either acidity or alkalinity.

- Chemicals were added so that the pH value would meet municipal wastewater standards

- The wastewater was pumped to a municipal wastewater treatment plant.

Close

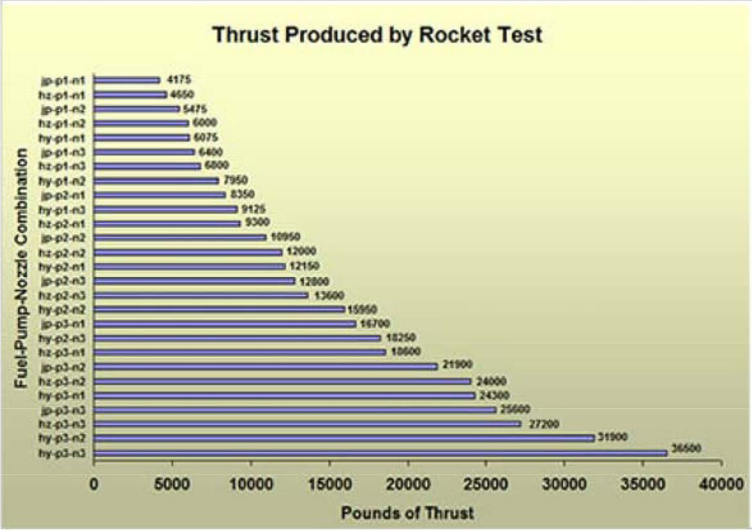


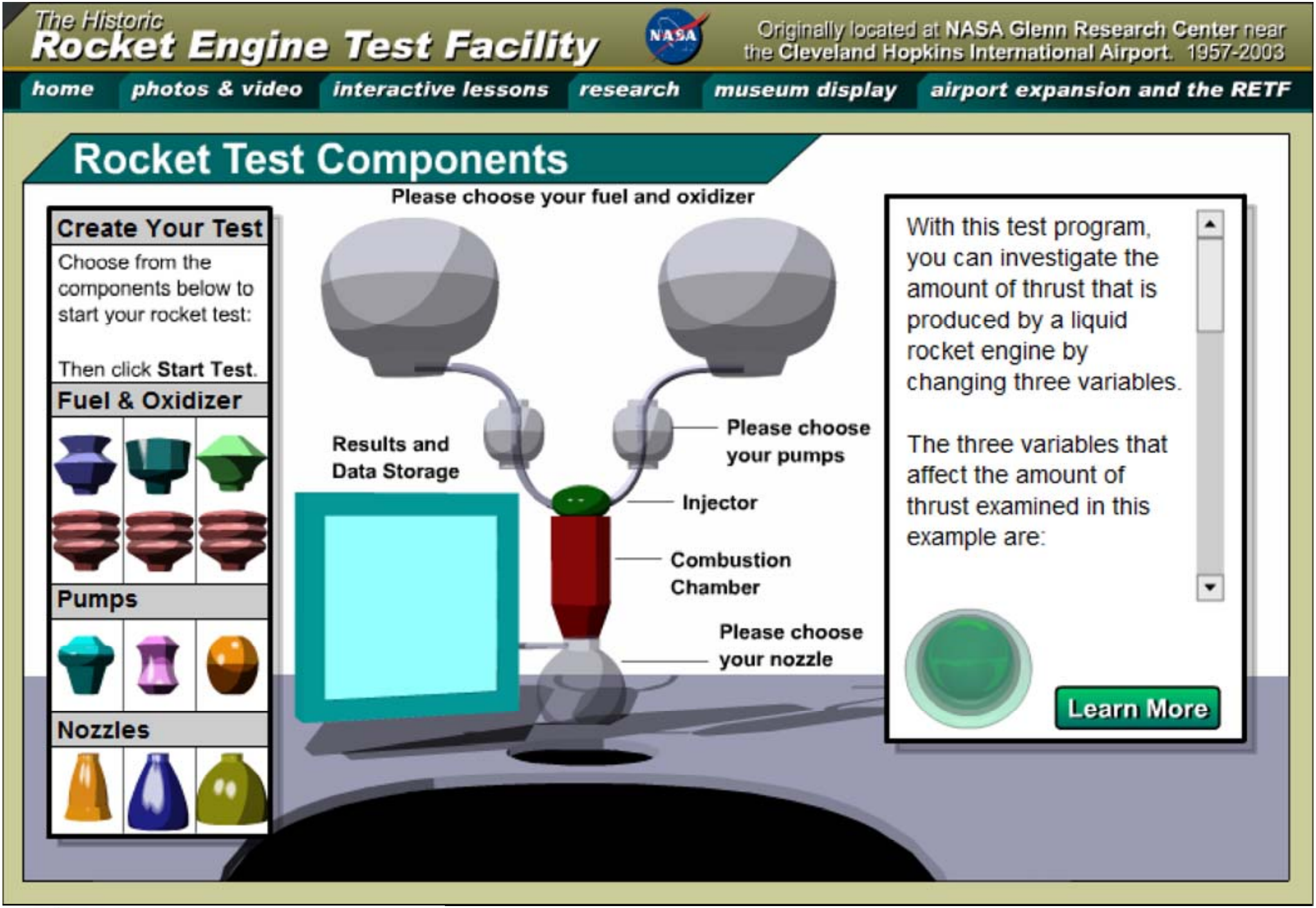
Chart Legend

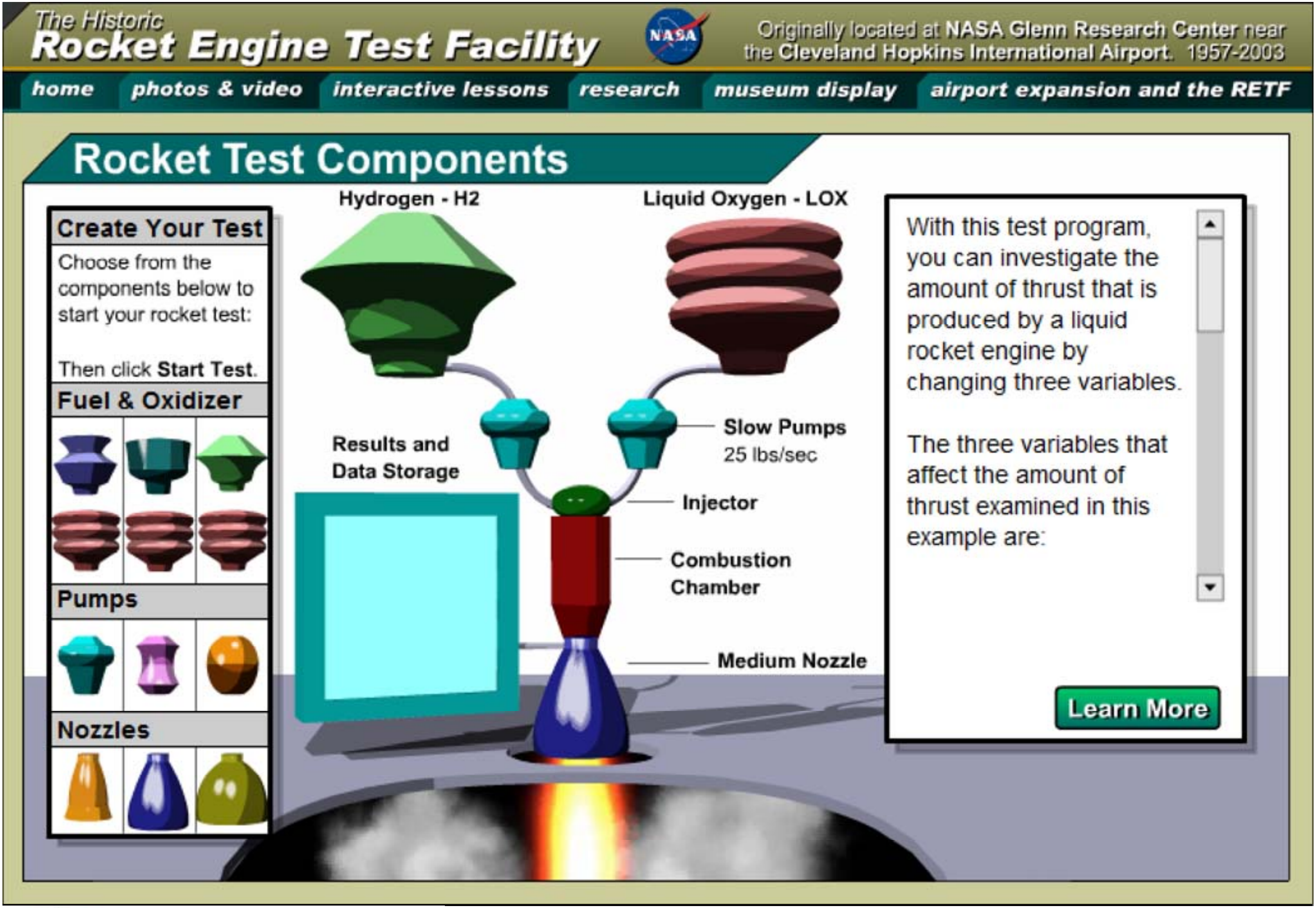
- hz = Hydrazine (Nitrogen-Hydrogen)
- jp = Hydrocarbon Mixture (JP-10, Rocket Fuel)
- hy = Liquid Hydrogen

- p1 = Pump 1 (25 lbs/sec)
- p2 = Pump 2 (50 lbs/sec)
- p3 = Pump 3 (100 lbs/sec)

- n1 = Nozzle 1 (2)
- n2 = Nozzle 2 (10)
- n3 = Nozzle 3 (100)

Nozzle area ratio is the area-at-exit / area-at-throat.


The Historic
Rocket Engine Test Facility
Originally located at NASA Glenn Research Center near the Cleveland Hopkins International Airport. 1957-2003
home
photos & video
interactive lessons
research
museum display
airport expansion and the RETF
Rocket Test Components
Please choose your fuel and oxidizer
Create Your Test
Choose from the components below to start your rocket test:
Then click Start Test.
Fuel & Oxidizer
Pumps
Nozzles
Results and Data Storage
Please choose your pumps
Injector
Combustion Chamber
Please choose your nozzle
With this test program, you can investigate the amount of thrust that is produced by a liquid rocket engine by changing three variables.
The three variables that affect the amount of thrust examined in this example are:
Learn More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Create Your Test
Choose from the components below to start your rocket test:
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Fuel & Oxidizer
Pumps
Nozzles
Hydrogen - H2
Liquid Oxygen - LOX
Slow Pumps
25 lbs/sec
Results and Data Storage
Injector
Combustion Chamber
Medium Nozzle
With this test program, you can investigate the amount of thrust that is produced by a liquid rocket engine by changing three variables.
The three variables that affect the amount of thrust examined in this example are:
Learn More

Rocket Test Components

Hydrogen - H2 | Liquid Oxygen - LOX

Rocket Engine Component Testing

Thrust is the force that moves a rocket through the air. Thrust is generated by the propulsion system of the rocket using Newton's third law of motion. For every action there is an equal and opposite re-action. In this test, a selected fuel and an oxidizer (Liquid Oxygen) are pumped into a combustion chamber where they are mixed and the fuel is burned. The combustion produces great amounts of exhaust gas at high temperatures and pressures. The hot exhaust is passed through a nozzle that accelerates the flow (action). Thrust is produced in the opposite direction (re-action). The amount of thrust depends on the exit velocity from the nozzle and on the mass flow rate through the nozzle. By changing the fuel type, the pump output, or the nozzle shape, the amount of thrust produced can be modified.

The selection of the rocket propellants (fuel and oxidizer) determines the mass of the exhaust gas and the energy that can be derived from the fuel. The nozzle converts the energy into exhaust velocity. The selection of the fuel, combined with our oxidizer (Liquid Oxygen), affects the amount of thrust produced by the rocket engine.

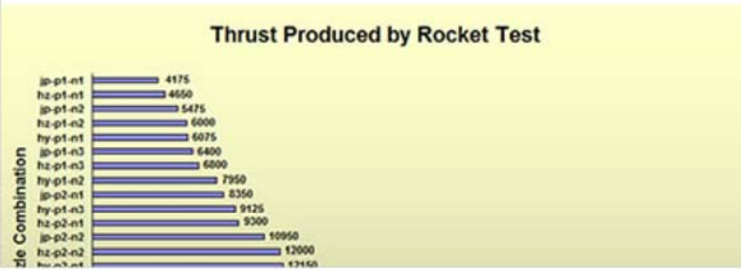
The pumps determine the rate that the propellant flows through the engine. The pumps force the fuel and oxidizer into the igniter and combustion chamber. The flow rate set by the pumps affects the amount of thrust produced by the rocket engine.

Close

Rocket Test Components

The pumps determine the rate that the propellant flows through the engine. The pumps force the fuel and oxidizer into the igniter and combustion chamber. The flow rate set by the pumps affects the amount of thrust produced by the rocket engine.

The nozzle shape determines the exhaust velocity, and the exhaust velocity affects the amount of thrust produced by the rocket engine. A nozzle with a large area ratio from the exit of the nozzle to the throat of the nozzle produces a large exhaust velocity.



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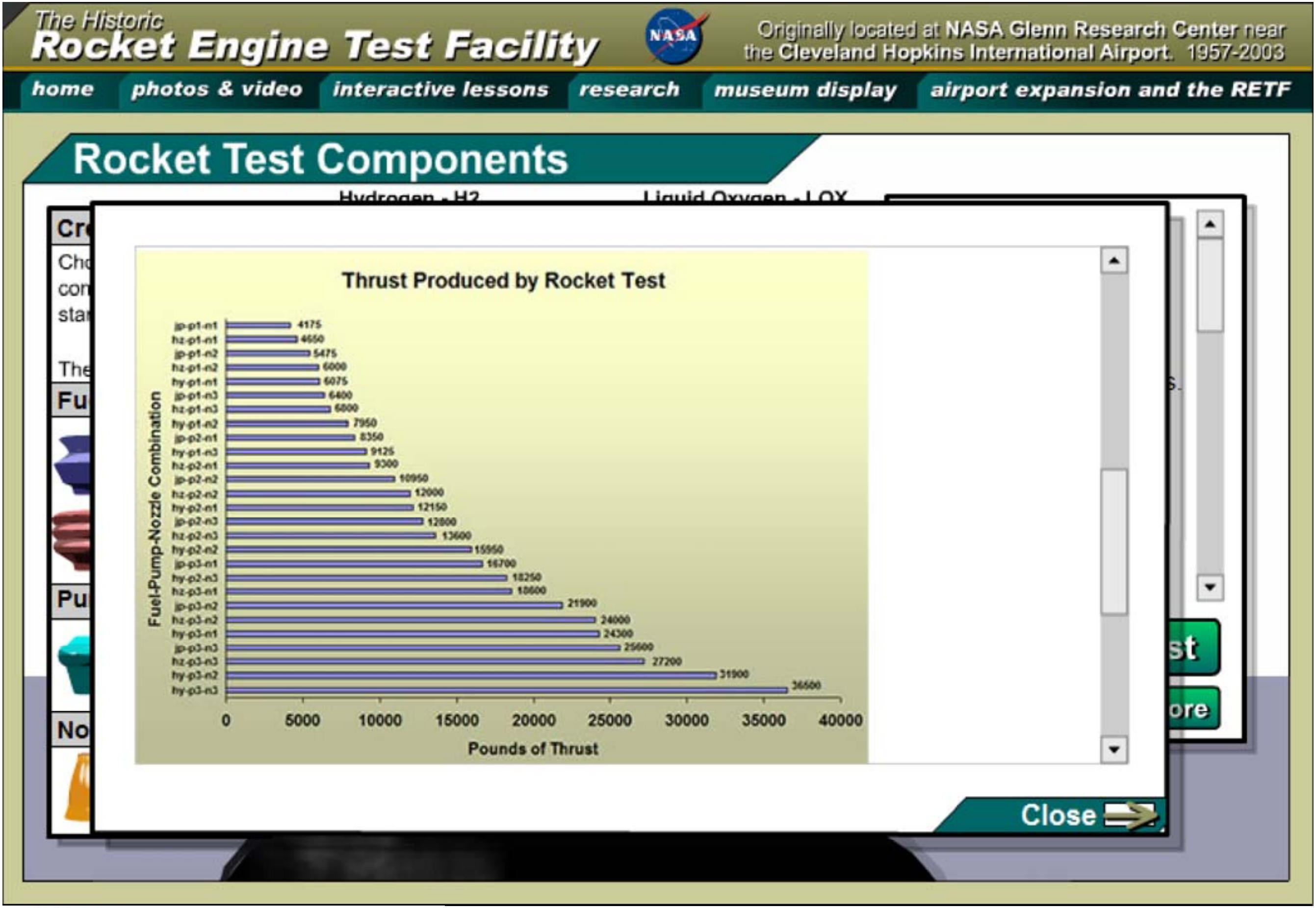

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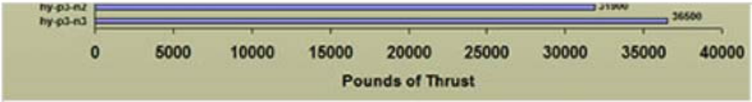
The Historic
Rocket Engine Test Facility

Originally located at NASA Glenn Research Center near the Cleveland Hopkins International Airport. 1957-2003

Rocket Test Components



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Close

About the Museum Display

History Module

A Brief History of the RETF

The Rocket Engine Test Facility (RETF) was built in 1955–1957 at the Lewis Flight Propulsion Laboratory, a research facility for the National Advisory Committee for Aeronautics (NACA), located in Cleveland, Ohio. The RETF was constructed as part of a United States' mission to develop rockets. This mission was motivated largely as a response to the German advancement of rocket technology during the war and to the Russian success in launching Sputnik. Because the U.S. needed a rocket that was powerful enough to propel payloads into space, the U.S. dedicated facilities like the RETF to the research and testing of rocket engines. Scientists here focused on testing new engine designs with various combinations of high-energy liquid fuels. Although kerosene was the standard rocket fuel used by others, researchers at the RETF took the greater risk to work with the volatile liquid hydrogen, a fuel that promised much more power if they could safely harness it.

At the RETF, engineers returned to the basic components of rocket engineering and proceeded to design, build, and test hundreds of different engines. Their challenges were to make an engine body that would endure the high temperatures

About the Museum Display

liquid hydrogen, a fuel that promised much more power if they could safely harness it.

At the RETF, engineers returned to the basic components of rocket engineering and proceeded to design, build, and test hundreds of different engines. Their challenges were to make an engine body that would endure the high temperatures generated by their new fuels and to design an injector that would consistently mix the fuel and the oxidizer in the combustion chamber so their engine would burn smoothly. No one had successfully used liquid hydrogen as a rocket fuel before. The RETF scientists knew liquid hydrogen had tremendous potential, and they devoted themselves to finding a way to make it work.

One of the most outstanding achievements at the RETF during the 1950s and 1960s was the development of liquid hydrogen as rocket fuel. The knowledge gained at RETF on how to use liquid hydrogen was an essential contribution to the Pratt and Whitney RL-10 engine that was used in the Centaur rocket. The Centaur rocket's first mission was as an upper-stage launch vehicle for the unmanned Surveyor spacecraft that went to the Moon. The Centaur rocket has more recently served as the upper stage for probes and fly-by missions to other planets, notably Mercury, Venus, Mars, Jupiter, Uranus, Neptune, and the Cassini mission to Saturn.

The RETF tested and also contributed to the development of the J-2 engine that was used for the second and third stages of the Saturn V rocket that powered the Apollo program to the moon. It is widely accepted that the use of the Rocketdyne J-2 liquid hydrogen engine in the upper stages of the Saturn Rocket gave the United States a decisive advantage in the race to complete a human mission to the moon.

About the Museum Display

Corner Column

This panel and electronic equipment controlled the speed at which the valves were opened to allow the fuel and oxidizers into the test cell.

This is a ramp generator panel. According to former RETF Engineer Doug Bewley, "These ramp-generators were used to provide reference electrical signals to the controllers who then positioned the valves that provided the liquid oxygen and liquid hydrogen to the rocket engine being tested."

This panel was used to monitor the liquid oxygen at the test cell.

About the Museum Display

RETF Contributions Module

HOW ROCKETS WORK

A rocket is made up of many parts, including the engine, the propellants, and the payload, which is the cargo for the trip, such as a satellite. Propellants power the rocket and can be in the form of a solid, liquid, gas, or gel, depending on the rocket. In rockets propelled by liquid fuel, separate containers hold the fuel and the oxidizer. The oxidizer is a substance that must be present for the fuel to burn. (In the RL-10 and J-2 engines, the oxidizer was liquid oxygen.) Just before the engine is ignited, the fuel and oxidizer are sprayed from the injector into the combustion chamber where they mix for combustion. The injector and combustion chamber are the two main components that make up the core of the rocket engine. When the propellants are ignited and burn, the temperatures and pressures build up in the combustion chamber, and the hot gases escape backward through the nozzle, propelling the rocket forward.

ROCKET PARTS

About the Museum Display

ROCKET PARTS

The key components of a liquid propelled rocket are listed below:

Payload: The cargo that is launched into orbit.
Fuel: The chemical burned in the engine. Kerosene is a common rocket fuel. RETF tested liquid hydrogen, a higher-energy fuel.
Oxidizer: A chemical that enables the fuel to burn. Liquid oxygen was an oxidizer at RETF.
Pumps: A turbine, or rotary engine, that forces the fuel and oxidizer into the injectors and combustion chamber.
Injectors: Engine part that controls fuel and oxidizer and sprays these propellants mixture into the combustion chamber where they are mixed. A good injector controls the mix consistently so that the engine burns smoothly and powerfully.
Combustion Chamber: The engine container where the propellant mixture is ignited and burns. The hot gases that result will expand and push the rocket forward.
Nozzle: An opening at the lower end of the rocket that allows the hot gases to escape.
Igniter: Device that lights the propellant.

SIGNIFICANT RETF CONTRIBUTIONS

About the Museum Display

SIGNIFICANT RETF CONTRIBUTIONS

- Proved that liquid hydrogen could safely be used as a rocket fuel
- Solved engine design problems so liquid hydrogen could be used
- Tested components of the J-2 engine

LIQUID HYDROGEN AS A PROPELLANT

The Russian scientist Konstantin Tsiolkovsky proposed liquid hydrogen as a fuel as early as 1903, but only after World War II was liquid hydrogen fully developed as a propellant. After witnessing the German V-2 rocket-powered missiles, the U.S. military was prompted to develop American rocket-powered missiles as a way to help maintain national security. Although kerosene was the standard rocket fuel in the U.S. at this time, it produced significantly lower energy than liquid hydrogen could produce. More research on high-energy liquid and solid propellants was begun throughout the country at various Air Force, Navy, and NASA locations, including Lewis Research Center. Liquid hydrogen once again came into the spotlight.

Lewis Research Center took the lead in the research and testing of a variety of high-energy fuels, including the extremely cold and volatile liquid hydrogen, as they tried to find the one that would provide the most power. They examined oxidizers such as liquid fluorine and liquid oxygen, and after hundreds of tests, scientists at RETF determined that a combination of liquid hydrogen and liquid oxygen provided the greatest propulsion

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Using much skill and ingenuity, they found ways to successfully and safely use the combination as fuel for a rocket engine.

Liquid hydrogen is an ideal fuel source for several reasons:

- It results in the highest exhaust velocity of all the chemical fuels. A high exhaust velocity makes the rocket more powerful, and it then can send heavier payloads into space.
- It has a high reaction rate with the oxidizer. Liquid hydrogen combines quickly with the oxidizer and therefore is better than other fuels for injection into the combustion chamber.
- As an extremely cold liquid at -400 ºF, liquid hydrogen can help cool the engine as it flows through. RETF engineers developed this ingenious idea because an engine using liquid hydrogen burns much hotter than an engine using kerosene, and they could use their cold propellant to cool the metal of the engine so that it would not melt or deform.

However, despite its many valuable qualities, the use of liquid hydrogen had some early drawbacks:

- It has a low fuel density, which means that less quantity of liquid hydrogen can be stored in a standard fuel tank than other types of fuel. Therefore larger and heavier tanks are needed on the spacecraft.
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- Since there was little market for liquid hydrogen prior to these developments, it was not readily available from suppliers during the late 1940s and early 1950s.

Many of the design problems of liquid-hydrogen fuels were solved at RETF. RETF engineers persisted with hundreds of tests until they solved the problems inherent in burning the potent fuel. They discovered how to cool the combustion chamber and nozzle by using the cold liquid hydrogen. They experimented with many designs for the injectors and combustion chambers until they achieved an efficient, smooth-burning, high-energy engine. By 1958, they were testing a fully cooled, liquid-hydrogen–liquid-oxygen combustion chamber at 20,000 pounds thrust.

Rocket scientists soon realized that the high energy of liquid hydrogen was useful for the upper-stage of rocket launching. It provided tremendous thrust and the extra weight of the larger fuel tanks was not as detrimental because of the lessened effect of gravity during the upper stage of flight.

The development of liquid hydrogen and liquid oxygen at RETF has contributed greatly to the exploration of space.

About the Museum Display

Design Column

This illuminated, metal panel is a graphic representation of the RETF scrubber and exhaust stack and was used to monitor the A-Stand scrubber facility. The rocket exhaust was treated inside the scrubber, where the hot gas passed through a heavy spray of water. This original panel was mounted in the RETF Control Room in the Operations Building.

THE RETF FACILITY

The RETF was designed as a complex of buildings spread over ten acres. The test cell, within Building 202, was sited on the east side of the narrow Abram Creek gorge. Building 202 was cleverly designed to take full advantage of the topography of this valley site. The test cell and rocket engine blast were directed toward an opposing wall of the gorge, which formed an ideal barrier to protect the area from blasts.

Building 202 housed not only the test cell, but also the fuel and oxidant pits, a terminal/observation room, offices, and a small shop. The RETF also used an exhaust scrubber, which removed potentially polluting byproducts, cooled the exhaust gases, slowed the speed and force of the exhaust gases, and muffled the roar of the firing test engine.

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A 500,000-gallon water reservoir was located high atop the eastern hillside, allowing the engineers to use the force of gravity to send the enormous volumes of water through the exhaust scrubber.

Additional facilities located around the RETF included an observation blockhouse, a "bottle farm" of tanks filled with high pressure gaseous hydrogen, an area for the transfer and storage of propellants, a cryogenic vaporizer facility, and wastewater-treatment facilities.

The Operations Building was located 1,600 feet north of the test cell and housed the RETF control room, offices, and a shop. Data recording and control computers were located in the Control Room, allowing the engineers to control the tests at a safe distance from the test itself.

About the Museum Display

THE FUTURE OF ROCKET ENGINES MODULE

THE FUTURE OF ROCKET ENGINES

Chemical rocket engines like those tested in the RETF have been the work-horses of the "space age" of the twentieth century. Missions from Apollo to the Space Shuttle have all relied on chemical combustion. While these engines will remain the main method of getting from Earth into space, new rocket engines are emerging to provide safe, reliable, and affordable trips for travel beyond Earth's orbit. Now known as the NASA Glenn Research Center, researchers at the Cleveland, Ohio, facility are continuing to develop rocket engine techno-logies for future exploration missions.

ADVANCED CHEMICAL PROPULSION

Researchers at NASA Glenn are continuing research into the advanced fuels and rocket-engine technologies that will improve the performance of chemical rockets. One technology uses a high-energy, gelled propellant with a higher-density aluminum additive mixed into the fuel. (The above image shows a rocket engine with this propellant firing in Glenn's Research Combustion Lab).

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NUCLEAR THERMAL ROCKETS

Bimodal Nuclear Thermal Rockets conduct nuclear-fission reactions similar to those that are safely employed today at nuclear power plants, including submarines. In these rockets, the energy from the nuclear power plant is used to heat the liquid-hydrogen propellant. Advocates of nuclear powered spacecraft point out that at the time of launch, the nuclear reactors release almost no radiation. These nuclear-thermal rockets are used to generate power during the trip, not to lift off from the Earth, and they offer great performance advantages

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ELECTRIC PROPULSION

Towards the end of the twentieth century, electric propulsion emerged as a method for controlling the position of the spacecraft and as the primary system for propelling the spacecraft while it is in space. Electric propulsion systems use an electrical field to ionize a gas, typically xenon, and then electrostatically discharge the ion stream to generate a low level of thrust. Although the thrust of electric propulsion systems is significantly smaller than that of chemical rocket engines, it can operate nearly continuously, unlike the brief high-powered thrust of chemical rocket engines. This operation provides a nearly continuous ability that can be used to steer the spacecraft or even to change target destinations. When coupled with a nuclear power source, larger and more powerful electric propulsion systems can be developed. Future missions could include the Jupiter Icy

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PROPULSION BREAKTHROUGHS

While our current understanding of physics doesn't allow for travel beyond the speed of light, researchers at NASA continue to monitor and investigate near-term, credible technologies for space travel. They have made measurable progress in these areas, paving the way for the breakthrough technologies that would revolutionize space travel and enable interstellar voyages. One such technology is a hypothetical spacecraft with a "negative energy" induction ring. Inspired by recent theories that describe how space could be warped with a negative energy, this spacecraft would be a hyperfast transport able to reach distant star systems.

About the Museum Display

STAND-ALONE CONSOLE

You are standing at the original Control Panel that Research Scientists used to fire their rockets in the Rocket Engine Test Facility (RETF). This Control Panel was located in the center of the Control Room in the Operations Building Number 100, a safe distance away from the RETF in case the test cell exploded during the test. This main control and instrument console was positioned to be accessible to the test engineer. The control console and the vertical model board show schematic representations of the physical layout of the RETF system. Color-coded lines and symbols represent the pipes that conveyed propellant to the engine being tested. Pilot lights in the various schematic lines show the locations and operating position of control valves, actuators, and motors in the system. Other small lights would indicate if a system was working or not. If an emergency arose that required immediate shut down, engineers could push a "shutdown button" on the console to end the test. Closed-circuit television and dedicated telephone lines allowed control-room personnel to observe tests and to communicate with operating personnel at the test cell.

The vertical model boards (across the way) show the operating status of all major valves, pumps, motors, actuators, and exhaust scrubbers in the system. This board faced the engineer's position at the control console.

About the Museum Display

FREE STANDING ARTIFACT DISPLAYS

A-STAND ROCKET ENGINE

This artifact is a wire-wrapped, stainless-steel channel nozzle that was used for actual testing of the A-Stand rocket in the years from 1957 to 1969, the period that the National Park Service defines as being the most historically significant period of the RETF. George Repas, Retired RETF Engineer, talks about the piece:

"In the early 1960s, our fabrication shop experimented with building a rocket by stacking up channels on a mandrel (a vertical bar that is inserted into a workpiece to hold it during machining) and closing the outside by wrapping wire and braze material and putting it all in a furnace. After many tries, they got the process down pat and built several engines for testing at Stand A. This engine was dump-water cooled and ran at a chamber pressure of 300 psi (pounds per square inch) with a thrust of 20,000 lbs."

This engine also has a non-metallic curved sleeve on the outside.

MOCK-UP MODEL OF ROCKET ENGINE

About the Museum Display

MOCK-UP MODEL OF ROCKET ENGINE

Made of silver plastic, this model is a mock-up of a rocket engine and represents a type of engine that Pratt and Whitney was scheduled to build during the 1970s. The model appears to be accurate in its scale.

CUTAWAY OF PLUG ENGINE ASSEMBLY

This artifact is a cutaway of a Plug Engine design and consists of a stainless steel injector, a copper spool piece, and a ceramic-coated copper plug. George Repas, Retired RETF Engineer, describes this engine as a unique one that was tested at the RETF from 1972 through the 1980s:

The engine has "a liquid oxygen-gaseous hydrogen injector with a hole down the center. Into this hole was mounted an hourglass-shaped cooled plug. The plug was ceramic-coated to provide more cooling margin. Bolted to this injector/plug combination was a cylindrical liquid hydrogen-cooled copper engine, which we called the spool piece. We would run liquid hydrogen through the spool piece and fire the engine, shut it off, fire it again, in a cyclic fashion, often doing 85 firings before the liquid hydrogen tank was starting to get empty."

The piece was tested until it began to leak, and Repas indicated that the number of cycles the spool piece could take before it leaked was used "to gauge the low cycle fatigue characteristics of the spool-piece material." Some spool pieces were fired as many as 300 cycles. He also indicated that he built a total of 135 spool pieces, and that many different copper alloys were used for the spool pieces, including one piece with a silver liner. They also experimented with differing cooling passage configurations and ceramic coatings. Their successful

Airport Expansion and the RETF

The Cleveland Hopkins International Airport needed to construct an additional runway to better serve the public of Northeast Ohio. Their new runway necessitated the demolition of the neighboring NASA Glenn Research Center's Rocket Engine Test Facility (RETF).

Click below to view aerials that show the progress of the runway during its construction near the RETF site.

2000

September 2002

July 2003

September 2003

November 2003

February 2004

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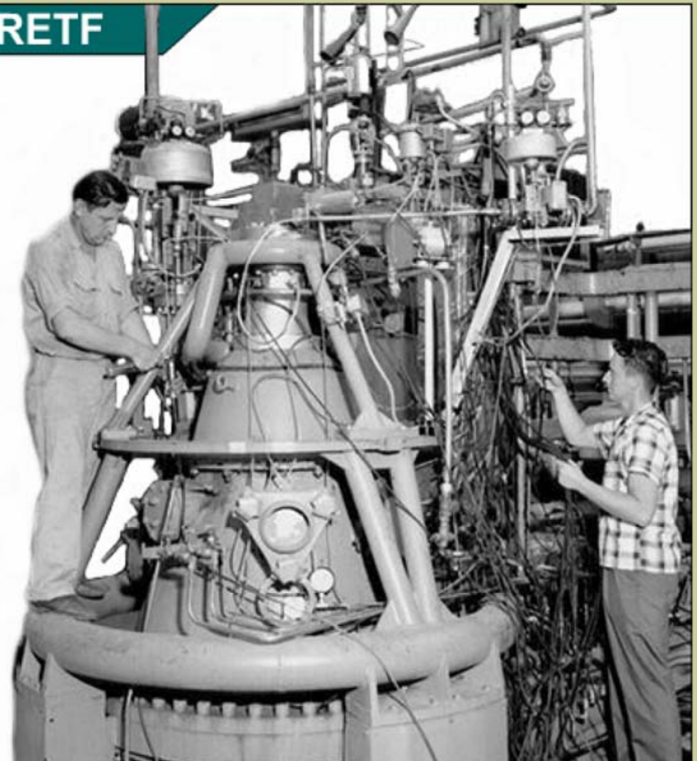

Airport Expansion and the RETF

More About the RETF and Airport Expansion

The RETF was located immediately adjacent to the Cleveland Hopkins International Airport. As early as 1977, a proposed expansion of the airport threatened to utilize the land occupied by the RETF.

Throughout the 1980s, negotiations between the City of Cleveland and the City of Brook Park failed to reach an agreement on an alternative plan that would allow the airport to expand toward a direction that would not affect the RETF.

A decision was finally made by the City of Cleveland in 1995 to plan for the construction of a new runway toward the southwest, meaning that this planned runway would need to cross over the RETF site. Due to this and various other reasons, NASA canceled its plans to improve RETF and closed the facility on July 1, 1995. The RETF was demolished in 2003, and the new runway opened in 2004.

The City of Cleveland is designing a new building within NASA's campus to house critical test equipment from RETF that will become operational in 2006.

Close

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