United States Department of the Interior
National Park Service

National Register of Historic Places
Inventory—Nomination Form

See instructions in How to Complete National Register Forms
Type all entries—complete applicable sections

1. Name

historic Variable Density Tunnel

and/or common Variable Density Tunnel

2. Location

street & number Langley Research Center

city, town Hampton

state Virginia code 51 county Hampton code 650

3. Classification

<table>
<thead>
<tr>
<th>Category</th>
<th>Ownership</th>
<th>Status</th>
<th>Present Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>district</td>
<td>public</td>
<td>occupied</td>
<td>agriculture</td>
</tr>
<tr>
<td>building(s)</td>
<td>private</td>
<td>unoccupied</td>
<td>commercial</td>
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<tr>
<td>structure</td>
<td>both</td>
<td>work in progress</td>
<td>educational</td>
</tr>
<tr>
<td>site</td>
<td>Public Acquisition</td>
<td>Accessible</td>
<td>entertainment</td>
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<tr>
<td>object</td>
<td>in process</td>
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<td>government</td>
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<tr>
<td></td>
<td>being considered</td>
<td>yes: unrestricted</td>
<td>industrial</td>
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</table>

4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington

state D.C. 20546

5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington

state D.C. 20546

6. Representation in Existing Surveys

title None

has this property been determined eligible? yes no

date

federal state county local

depository for survey records
7. Description

<table>
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<tr>
<th>Condition</th>
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<tr>
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<td>unaltered</td>
</tr>
<tr>
<td>☑ good</td>
<td>ruins</td>
<td>altered</td>
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<tr>
<td>☑ fair</td>
<td>unexposed</td>
<td>original site</td>
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Describe the present and original (if known) physical appearance

The Variable Density Tunnel (VDT) is in Building 582 in the East Area of the Langley Research Center. The VDT was constructed during the period from 1921 to 1923 at the direction of the National Advisory Committee for Aeronautics (NACA).

The tank of the VDT was built by the Newport News Shipbuilding & Dry Dock Co., of Newport News, Virginia. It is capable of withstanding a working pressure of 21 atmospheres. It is built of steel plates lapped and riveted according to the usual practice in steam boiler construction, although, because of the size of the tank and the high working pressure, the construction is unusually heavy. Entrance to the tank is gained through an elliptical door 36 inches wide and 42 inches high. The tank and its contents weigh 100 tons and are supported by a foundation of reinforced concrete. The tank is 34.5 feet long and 15 feet in diameter with interior steel walls 2 1/8 inches thick. To minimize tank volume and the quantity of structural steel required (85 tons), an annular flow scheme was adopted. The test section was made 5 feet in diameter to match the National Advisory Committee for Aeronautics (NACA) Wind Tunnel No. 1. The maximum air velocity was 50 MPH at a pressure of 20 atmospheres.

The VDT was partially destroyed by fire in 1927. The interior of the tunnel was damaged but the exterior pressure tank remained intact. The tunnel was rebuilt and was operational again by 1930.

By the 1940s the tunnel was obsolete by the standards of the day and was gutted. The VDT continued to serve the needs of NACA and was used as a pressure tank to support the operation of the Vertical Wind Tunnel and the Low Turbulence Wind Tunnel. The VDT continued to serve in this capacity until it was declared potentially unsafe for further operations in 1978. Additional modifications during this time included the removal of the viewing platform and porthole from the tunnel.

The basic structure of the tunnel remains intact. At the present time there are no plans for the use of the Variable Density Tunnel.
8. Significance

<table>
<thead>
<tr>
<th>Period</th>
<th>Areas of Significance—Check and justify below</th>
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<tbody>
<tr>
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<td>archeology-prehistoric</td>
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<td>X 1900-</td>
<td>commerce</td>
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<td></td>
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Specific dates 1921-1940  Builder/Architect Max Munk

Statement of Significance (in one paragraph)

The Variable Density Tunnel was the first facility to establish NACA as a technically competent research organization. The tunnel was a technological quantum jump that rejuvenated American aerodynamic research which in time led to the best aircraft in the world.3

The success of the Wright Brothers airplane was followed by a technological backward slide by the American aircraft industry. British, French, and German designers soon surpassed the Wright Brothers and other American aircraft builders. By World War 1 the United States had slipped into a position of technological inferiority compared to the European designers.

To support their aircraft industry European designers built major wind tunnels to test new theories and to discover better methods of building aircraft. To regain for America the technological leadership in the field of aircraft design and manufacture, President Woodrow Wilson signed into law a bill establishing the National Advisory Committee for Aeronautics (NACA) March 3, 1915.

The responsibility of NACA, as the new agency was called, was to "supervise and direct the study of the problems of flight, with a view to their practical solution...." The act also provided for the construction of research facilities and a laboratory site near Hampton, Virginia. Thus the Langley Research Center came into being in 1917.

Originally called Langley Memorial Aeronautical Laboratory, later just Langley Aeronautical Laboratory, NACA Langley immediately set about the problem of building a wind tunnel to conduct aeronautical research. Because of the lack of experience in this area Langley first constructed NACA Wind Tunnel No. 1, a low speed tunnel with no return circuit for air passing through the test section. Although useful as a learning tool, this tunnel was obsolete by the standards of the day and produced no significant findings.

In June 1921 NACA's Executive Committee decided to leapfrog European wind tunnel technology and build a tunnel in which pressures could be varied. This concept was strongly advocated by Max Munk, a NACA technical assistant, who was familiar with European wind tunnel design from his days at Gottingen. The purpose of the Variable Density Tunnel, that Munk advocated, was to solve the problem of applying experimental results obtained from scale model aircraft to full size aircraft. Almost all wind tunnel tests at the time were, and still are, performed on scale model aircraft because of the expense involved in constructing full scale wind tunnels.
In a classic set of experiments, Osborne Reynolds (1842-1912) of the University of Manchester demonstrated that the airflow pattern over a scale model would be the same for the full scale vehicle if certain flow parameters were the same in both cases. This factor, now known as the Reynolds number, is a basic parameter in the description of all fluid-flow situations, including the shapes of flow patterns, the ease of heat transfer, and the onset of turbulence.4

In 1921 all wind tunnels were operating at normal atmospheric pressure using scale models. This meant that experimental results using these wind tunnels were open to question because the Reynolds number obtained did not match those encountered in using full scale aircraft. Thus the Reynolds number of a 1/20-scale model being tested at operational flight velocities in an atmospheric wind tunnel would be too low by a factor of 20. NACA engineers realized that since the Reynolds number is also proportional to air density that a solution was possible by testing 1/20-scale models at a pressure of 20 atmospheres. The Reynolds number would be the same in the wind tunnel as in actual flight.5

This was the significance of the Variable Density Tunnel. The VDT, for the first time, placed in the hands of NACA engineers a research tool superior to that found anywhere else in the world. The VDT was able to predict flow characteristics of test aircraft models more accurately than any other tunnel then in existence. The VDT quickly established itself as a primary source for aerodynamic data at high Reynolds numbers.

The result of this research led to the publication of NACA Technical Report 460 in which aerodynamic data for 78 related airfoil sections were presented. Information contained in this report eventually found its way into the design of such famous aircraft as the DC-3, B-17 and the P-38.

The VDT established NACA as a technologically competent organization and led to the production of superior American aircraft that have dominated the airways of the world since that time. All modern Variable Density Tunnels now in operation are but an extension of the original ideal first formulated and put into operation by Max Munk in 1921 with the construction of the original Variable Density Tunnel at Langley.
Footnotes


Major Bibliographic References


9. Major Bibliographical References

See continuation sheets

10. Geographical Data

Acreage of nominated property  Less than 1 acre
Quadrangle name Hampton

UMT References

\[
\begin{array}{ccc}
\text{Zone} & \text{Easting} & \text{Northing} \\
A & 1 & 8 & 3 & 9 & 0 & 5 & 2 & 0 & 4 & 1 & 0 & 4 & 2 & 4 & 0 \\
\end{array}
\]

Verbal boundary description and justification

The nominated property includes only the steel tank known as the Variable Density Tunnel.

List all states and counties for properties overlapping state or county boundaries

<table>
<thead>
<tr>
<th>state</th>
<th>code</th>
<th>county</th>
<th>code</th>
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</thead>
<tbody>
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</tbody>
</table>

11. Form Prepared By

name/title Harry A. Butowsky
organization National Park Service
date May 15, 1984

street & number Division of History
telephone (202) 343-8168

city or town Washington, D.C. 20240
state

12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

\[
\begin{array}{ccc}
\text{national} & \text{state} & \text{local} \\
\end{array}
\]

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title date

For NPS use only

I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: date
FIGURE 1.2
Combined East & West Area
Variable Density Wind Tunnel
UTM Reference:
18/380520/4104/240