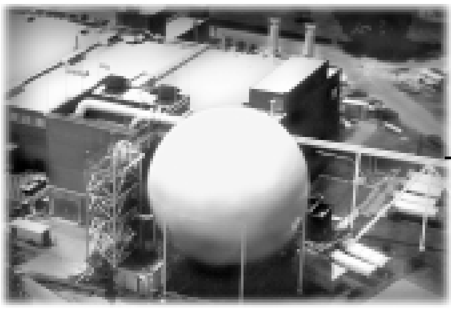


Combustion Heated Scramjet Facility

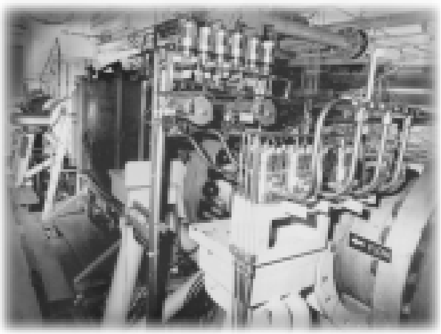
NASA Langley Research Center

The Langley Combustion Heated Scramjet Test Facility is part of the NASA Langley Scramjet Test Complex. This facility offers the capability to test subscale propulsive flowpaths of hypersonic vehicles at conditions simulating flight Mach numbers from 3.5 to 6.0.

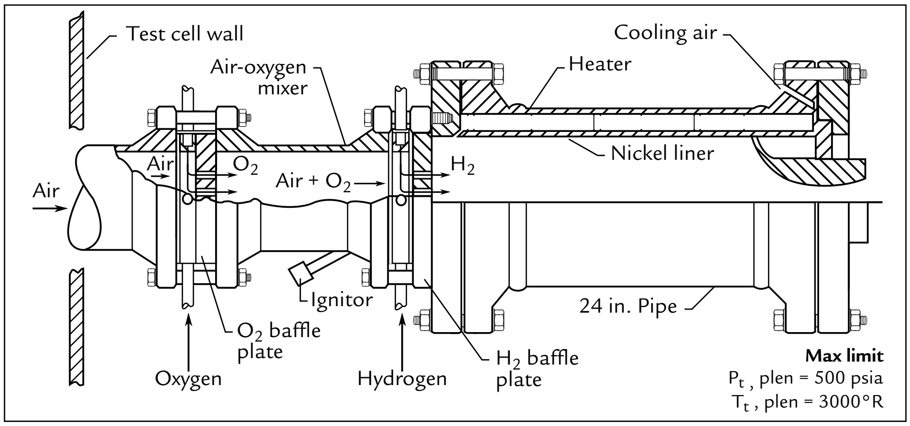
Wind Tunnel
ENTERPRISE
NASA Langley Research Center

Facility Layout and Operation

The Langley Combustion Heated Scramjet Facility (CHSTF) has historically been used to test complete (inlet, combustor, and partial nozzle) subscale scramjet component integration models in flows with stagnation enthalpies duplicating that of flight at Mach numbers from 3.5 to 6.



Combustion Heated Scramjet Test Facility.



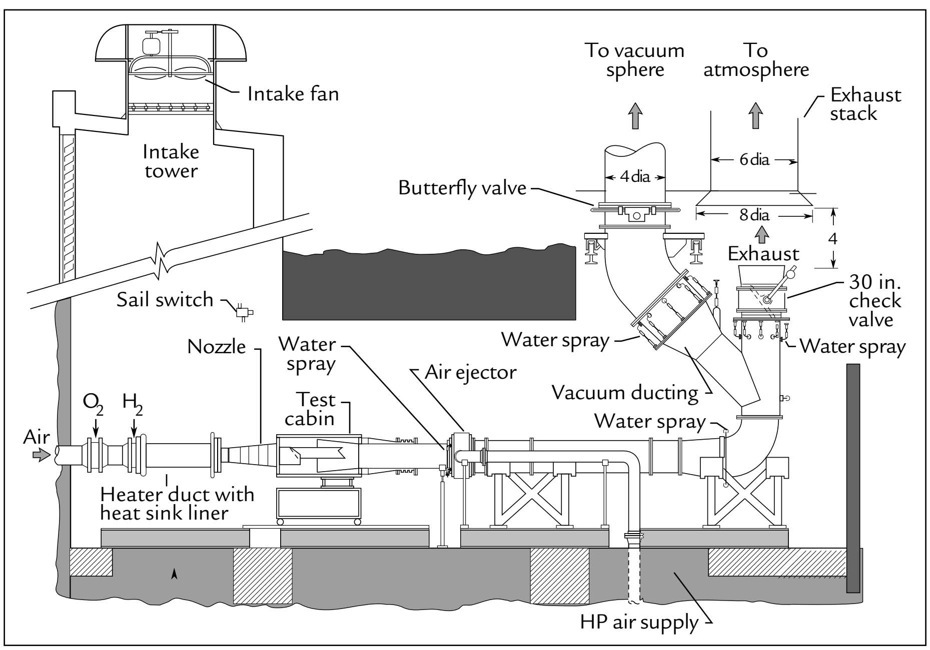
Combustion-Heated Scramjet Test Facility heater and plenum chamber.

As shown in the schematic, the CHSTF is located in a 16- by 16- by 52-ft test cell with forced air ventilation through the entire cell. This facility is adjacent to the DCSCTF and both facilities share the same gas and vacuum systems and portions of the data acquisition system. Test air is supplied from a high-pressure bottle field and is regulated to 550 psia (nominal) prior to entering the test cell. Both gaseous hydrogen and oxygen are supplied from tube trailers at a maximum pressure of 2400 psia and regulated to 720 psia prior to entering the test cell. Purge nitrogen is also supplied from a tube trailer at a maximum pressure of 2400 psia with the pressure regulated to 230 psia. Vacuum for altitude simulation is provided by a 70-ft diameter vacuum sphere and steam ejector system.

The CHSTF uses a hydrogen, air, and oxygen heater to obtain the flight stagnation enthalpy required for engine testing. The facility heater is shown in the schematic.

Oxygen is replenished in the heater to obtain a test gas with the oxygen mole fraction of air (0.2095). The facility may be operated with either a Mach 3.5 or 4.7 nozzle. Both nozzles have square cross sections and are contoured to exit dimensions of 13.26 by 13.26 in. The nozzle flow exhausts as a free jet into the test section, which is 42-in high by 30-in wide by 96-in long. The free jet passes through and around the engine model and then into a catch cone diffuser. The flow is typically exhausted into a 70-ft diameter vacuum sphere.

Either gaseous hydrogen or gaseous ethylene (both at ambient temperature) may be used as the primary fuel in the scramjet engines tested in the CHSTF. A 20-percent silane, 80-percent hydrogen mixture (by volume) is available for use in the scramjet model as an ignitor/pilot gas to aid in the combustion of the primary fuel.



Schematic of the Combustion-Heated Scramjet Test Facility. Dimensions in feet unless stated otherwise.

CHSTF Characteristics

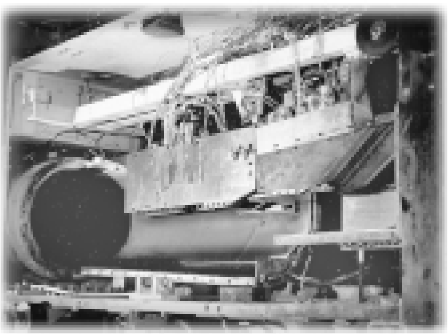
Simulated Flight Mach number . .	3.5 to 6
Nozzle Exit	
Mach number	3.5 and 4.7
Simulated Flight Dynamic Pressure, per square foot*	250 to 3500
Nozzle Exit Area, inches . .	13.26 by 13.26
Test gas	hydrogen-air combustion products with oxygen replenishment
Heater	
Total pressure, psia	50 to 500
Total temperature, degrees R	1300 - 3000

* *Depending on Mach Number*

Type of Testing

The CHSTF has been in operation since 1978. Extensive tests, a total of 1874 to date, have been conducted to investigate the operability and performance of various component integration engines. Scramjet engines tested in this facility include the NASA 3-Strut, NASA Parametric, NASA Step-Strut, NASP Government Baseline, Rocketdyne A2, Pratt and Whitney C, JHU/APL B1, and most recently, the Rocketdyne Hydrocarbon-Fueled Scramjet.

The purpose of the Rocketdyne Hydrocarbon-Fueled Scramjet test series was to establish a database for a gaseous ethylene-fueled, fixed-geometry, complete scramjet engine module. The tests were conducted at simulated Mach 4 flight conditions with the ethylene acting as a surrogate for cracked jet fuel. A photograph of the engine mounted in the test cabin is shown below. Portions of the facility nozzle extension and catch cone diffuser have been removed for engine visibility.



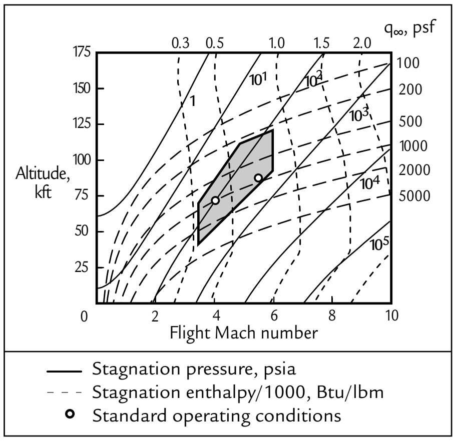
Hydrocarbon-fueled scramjet engine model.

Safety and Design Criteria

Langley's LHB 1710.15 *Wind Tunnel Model System Criteria* is available for guidance in the design and fabrication of test articles at the URL http://wte.larc.nasa.gov. Test articles shall be designed to withstand thermal, aerodynamic, and mechanical loads expected during testing. All designs and analysis shall be reviewed by the CHSTF Facility Safety Head.

Test Capabilities

The facility normally operates at heater stagnation pressures between 50 and 500 psia and at stagnation temperatures between 1300 and 3000 °R. Test gas mass flow rates range from 15 to 60 lbm/s. The range of operation is shown by the Mach number and altitude simulation envelope.



Combustion Heated Scramjet Test Facility flight simulation envelope.

The left vertical boundary of the envelope is the nozzle exit Mach number of 3.5 and the right vertical boundary reflects the maximum heater operating temperature of 3000°R. The upper inclined boundary represents the minimum operating pressure of 50 psia, up to an altitude where a simulated flight dynamic pressure of 250 psf is imposed as a limit. The lower inclined boundary reflects the maximum mass flow rate to the heater at the Mach number of 3.5 limit and the maximum heater operating pressure at the Mach number of 6 limit. The standard operating conditions of the CHSTF are shown by the symbols on the figure and are tabulated below.

M_∞	P_t	H_t	T_t	m	M_{tg}	P_{tg}	T_{tg}
	(atm)	(BTU/lbm)	(°R)	(lb_m/s)		(atm)	(°R)
4.0	6.3	430	1640	29.1	3.5	.090	523
5.5	19.7	750	2563	19.1	4.7	.055	574

Standard test conditions.

Calculated test gas compositions for the standard operating conditions are given in the table for species mole fractions of 0.0001 or greater.

M_∞	N_2	O_2	Ar	H_2O	CO_2	NO
4.0	.6970	.2095	.0083	.0849	.0003	-
5.5	.6036	.2094	.0072	.1793	.0002	.0003

Test gas mole fractions at the standard test condition.

The primary contaminant in the test gas is water vapor, which varies from 0.085 mole fraction at Mach number of 4 to 0.179 at Mach 5.5.

The normal operational schedule of the CHSTF is 2 to 3 days per week. Test runs average 20 to 30 seconds duration with multiple runs (5+) per day.

Data Acquisition and Processing

The data acquisition system consists of a commercially available software package (AutoNet) running on a Pentium processor. The DAS incorporates a NEFF 300 signal conditioner and a NEFF 600 amplifier/multiplexer capable of supporting 128 channels. In addition, up to 512 static pressure measurements can be recorded using a PSI 8400 ESP system and sixteen 32-port modules. Engine thrust and drag are measured with a load cell. Test data are typically transferred to a UNIX workstation for data analysis. Limited optical access is available for flow visualization. A secure operating mode is provided for classified projects.

Facilities Available to Users

A model preparation room is available for assembly and check out of unclassified test articles.

Model Supports

Engine models are typically attached to two overhead support beams located inside the facility test cabin. The support beams can be adjusted to position the engine at various locations within the flow at the nozzle exit.

Test Request Procedures

Contact the CHSTF facility manager to request use of the facility. Contact information is on the back of this brochure.

Document Version 1.0

Operating Hours

The CHSTF operates
one shift per day
two to three days a week
Hours 7:00 am - 3:30 pm

Trademark Disclaimer

For more information contact

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