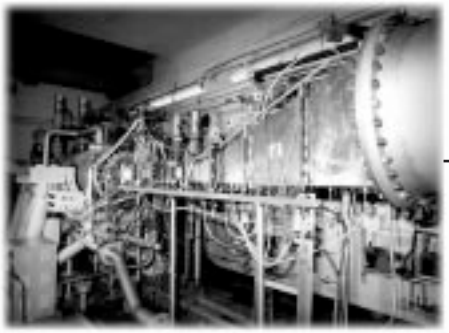


Direct-Connect Supersonic Combustion Test Facility

NASA Langley Research Center

The Langley Direct-Connect Supersonic Combustion Test Facility is part of the NASA Langley Scramjet Test Complex. The facility is used to test ramjet or scramjet combustors at conditions simulating flight Mach numbers from 4 to 7.5.

Wind Tunnel
ENTERPRISE

NASA Langley Research Center

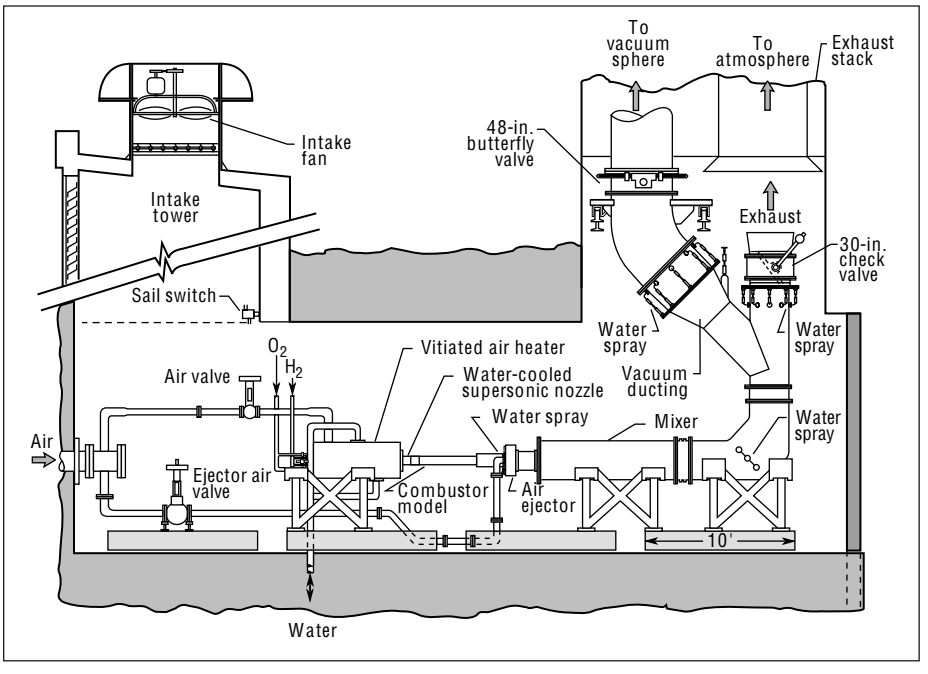
The Langley Direct-Connect Supersonic Combustion Test Facility (DCSCTF) is used to test ramjet and scramjet combustor models in flows with stagnation enthalpies duplicating that of flight at Mach numbers between 4 and 7.5.

The DCSCTF is located in a 16- by 16- by 52-ft test cell with 2-ft steel-reinforced concrete walls and forced-air ventilation. Test air is supplied from a high-pressure bottle field and is regulated to 550 psia (nominal) prior to entering the test cell. Gaseous hydrogen is supplied from 60,000 ft^3 tube trailers at a maximum pressure of 2400 psia and is regulated to 720 psia. Oxygen is supplied from trailers at a maximum pressure of 2400 psia and is regulated to 720 psia prior to entering the test cell. A 20-percent silane and 80-percent hydrogen mixture (by volume) is supplied from K-size cylinders (maximum storage pressure of 2400 psia) for use as an igniter of the primary fuel in the combustor models. Purge nitrogen is also supplied from a tube trailer at a maximum pressure of 2400 psia with the pressure regulated to 230 psia.

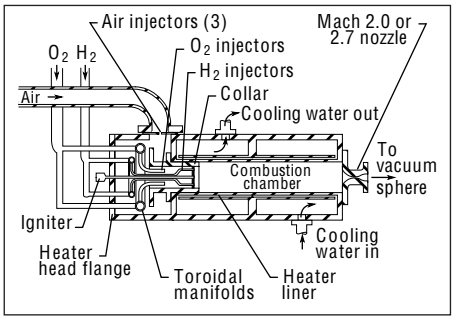
Results of the tests are typically used to assess the mixing, ignition, flameholding, and combustion characteristics of the combustor models.

The facility operates "directly connected" to the combustor model with the entire facility test gas mass flow passing through the model. The combustor model may exhaust freely (into the test cell), or directly (connected) to an air-ejector or to a 70-ft diameter vacuum sphere. Nozzle geometric simulations can also be added at the exit of the combustor models.

The high stagnation enthalpy necessary to simulate flight is achieved through hydrogen-air combustion with oxygen replenishment to obtain a test gas with the same oxygen mole fraction as atmospheric air (0.2095). The flow at the exit of the facility nozzle simulates the flow entering the combustor of a ramjet or a scramjet in flight. The DCSCTF normally operates at heater stagnation pressures between 115 and 500 psia and at heater stagnation temperatures between 1600 and 3800 °R. Test gas mass flow rates range from 1 to 7 lb_m per sec. The facility operational range is shown by the Mach number/altitude simulation envelope. The left boundary is the lower temperature limit of stable operation of the heater (~1600 °R) and the right boundary represents the maximum operational stagnation temperature (~3800 °R). The lower (diagonal) boundary reflects the maximum allowable heater pressure



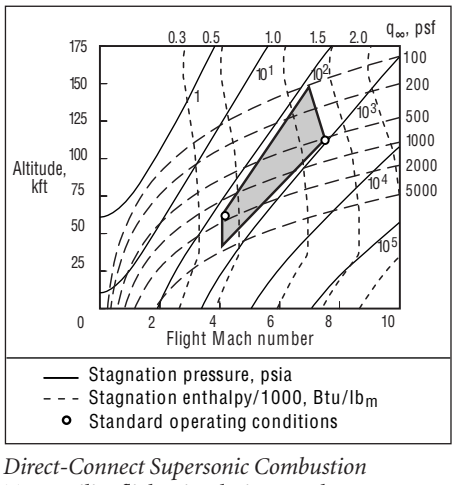
Schematic of the Direct-Connect Supersonic Combustion Test Facility.



Direct-Connect Supersonic Combustion Test Facility H_2-O_2-Air combustion heater.

(~500 psia) and the upper boundary reflects the lowest pressure for stable heater operation (~ 115 psia). However, these pressures translate into higher simulated stagnation pressures on the flight envelope when typical scramjet inlet and aircraft bow shock losses are included. (An inlet kinetic energy efficiency of 0.985 was assumed.) See figure and tables for standard operating conditions.

The normal test schedule is 2 or 3 test days per week. Run duration averages 20 to 30 sec with multiple runs (5 to 20) per day.



Direct-Connect Supersonic Combustion Test Facility flight-simulation envelope.

M_∞	P_t (atm)	H_t (BTU/lb_m)	T_t (°R)	$\dot{m}$ (lb_m/s)	M_{tg}	P_{tg} (atm)	T_{tg} (°R)
4.0	7.8	430	1640	4.34	2.0	0.990	959
7.5	26.5	1290	3780	7.21	2.7	1.021	1905

Standard test conditions.

M_∞	N_2	O_2	Ar	H_2O	CO_2	NO	OH
4.0	.6987	.2095	.0083	.0832	.0003	-	-
7.5	.4248	.2074	.0051	.3584	.0002	.0039	.0002

Standard test conditions—mole fractions.

DCSCTF Characteristics

Simulated Flight Mach number	4 to 7.5
Nozzle Exit/Combustor Inlet	
Mach number	2.0, 2.7
Reynolds number, per foot	2×10^6 to 8×10^6
Area, inches	1.52 by 3.46 1.50 by 6.69
Test gas	hydrogen vitiate
Heater	
Total pressure, psia	115 to 500
Total temperature, degrees R	1600-3800

Test Request Procedures

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

Facilities Available to Users

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

Safety and Design Criteria

Langley's LHB 1710.15 *Wind Tunnel Model System Criteria* is used only as a guideline for model design and fabrication of test articles. This document is available on the Wind Tunnel Enterprise web site at the URL http://wte.larc.nasa.gov. Test articles are typically considered expendable. Failure of a test article will not result in catastrophic damage to the facility or place any personnel at risk. Specific questions should be addressed to the DCSCTF Safety Head.

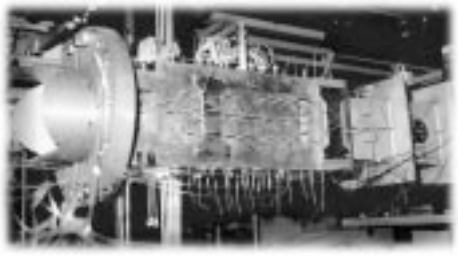
Model Supports

Test articles are typically bolted between the facility nozzle exit and the piping which connects to the air ejector or the 70-ft vacuum sphere.

Two overhead steel beams are used for additional support as required.

Type of Testing

Most recently the DCSCTF has been utilized to test a strut-ducted (H_2/O_2) rocket in support of the Rocket Based Combined Cycle (RBCC) engine program. The rocket has operated at simulated flight Mach numbers of 0, 4.0, 4.5, 5.5, and 6.5 with oxygen-to-hydrogen ratios of 4, 6, and 8 and rocket chamber pressures up to 800 psia. Previously, the DCSCTF was used to carry out mixing and combustion tests in support of Generic Hypersonics and the National AeroSpace Plane (NASP) program.



Strut-ducted rocket assembly.

Data Acquisition and Processing

The data acquisition system for the DCSCTF consists of a commercially available software package (AutoNet) running on a Pentium processor. The data acquisition system incorporates a NEFF 300 signal conditioner and NEFF 600 amplifier and multiplexer capable of supporting 128 data channels. In addition to the analog-to-digital capabilities of the NEFF data acquisition system, up to 256 static pressure measurements can be recorded using a Pressure System Incorporated (PSI) 8400 electronic sensing pressure (ESP) system and 8 32-port modules. Nonintrusive laser-based diagnostics are commonly used in the DCSCTF and the combustor test section can be mounted on a thrust-measuring system. Additional optical systems such as schlieren and shadowgraph, infrared thermography, and OH visualization are also available. Test data is visualized and may be reduced on a UNIX workstation. A secure operating mode is available for classified projects.

Test Techniques

The DCSCTF uses a hydrogen and air combustion heater with oxygen replenishment. During facility heater operation, oxygen is injected into the airstream from 12 in-stream injectors and premixed before injecting hydrogen. The hydrogen is injected into the air and oxygen mixture from 12 in-stream injectors centered in holes located in a baffle/mixing plate upstream of the water-cooled combustor section. The gas mixture is ignited by an electric-spark-activated hydrogen and oxygen torch igniter.

Calculated test gas compositions for the standard operating conditions of the DCSCTF are tabulated for simulated flight Mach numbers of 4.0 and 7.5. The data are listed only for species mole fractions that are 0.0001 or greater. These calculations were made with finite-rate chemistry during the expansion through the facility nozzle. The primary contaminant in the test gas is water vapor, which varies from 0.083 mole fraction at Mach 4 conditions to 0.358 at Mach 7.5 conditions. A small amount of nitric oxide (0.004 mole fraction) is also present in the test stream at the Mach 7.5 condition.

Supersonic nozzles are attached to the facility combustion heater to simulate scramjet combustor entrance conditions. Two nozzles are currently available for use in the DCSCTF; both are two-dimensional (rectangular) contoured nozzles. The first is a Mach 2 nozzle with throat dimensions of 0.846 by 3.46 in. and exit dimensions of 1.52 by 3.46 in.; the second is a Mach 2.7 nozzle with throat dimensions of 0.356 by 6.69 in. and exit dimensions of 1.5 by 6.69 in.

An air ejector or a 70-ft diameter vacuum sphere and steam ejector system (requiring up to 25,000 lb_m per hr of steam) provides vacuum for altitude simulation. Gaseous hydrogen (at ambient temperature) is the primary fuel used in the combustors tested in the DCSCTF, although other types of gaseous fuels are used occasionally. The hydrogen fuel for the combustors comes from the same trailers as the hydrogen for the facility heater, but may be used at the maximum trailer pressure of 2400 psia. Gaseous oxygen may also be supplied to the combustor models at the 2400 psia trailer pressure. A 20-percent silane and 80-percent hydrogen mixture (by volume) is supplied from K-size cylinders (maximum storage pressure of 2400 psia) for use as an igniter and pilot of the primary fuel in the combustor models.

Operating Hours

The DCSCTF operates
one shift per day
Monday through Friday
Hours 7:30 am - 4:00 pm

Trademark Disclaimer

For more information contact

The DCSCTF Manager • NASA Langley Research Center • Mail Stop 168 • 12 Langley Boulevard • Hampton, Virginia 23681-2199

phone: 757 • 864 • 6272 | **fax:** 757 • 864 • 6243 | **e-mail:** wte+fm_dcsctf@larc.nasa.gov | **web site:** http://wte.larc.nasa.gov