Propulsion Component Test Capabilities at MSFC's Test Stand 115

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Marshall Space Flight Center's Test Stand 115 (TS115) is a propulsion component test facility in operation since its original activation in 1964 for testing small to medium size liquid rocket engine components including injectors, channel-cooled chambers, nozzles, passively-cooled metallic and composite nozzle extensions, valves, turbomachinery, and igniters. TS115 is a "blowdown" type facility, using high pressure tankage and components to provide liquid, gaseous, and cryogenic fluid delivery at specified pressures and flowrates. The facility consists of an open steel test stand structure, a mechanical hardware preparation shop, an electrical support equipment building, a control room, and a centralized data system room. In general, the facility infrastructure is rated to 3,000 psig. TS115 can accommodate thrust levels up to 10,000 lbf in the horizontal position. The facility is actively used for various internal NASA test programs as well as test campaigns for external customers from other government agencies, commercial industry partners, and academia. The available fluid systems, electrical power and instrumentation capabilities, facility controls and data acquisition systems, test program support capabilities, and available test rig configurations for external customer use are discussed in this paper.

Nomenclature

AC	=	Alternating Current
AM	=	Additive Manufacturing
ASI	=	Augmented Spark Igniter
CASI	=	Compact Augmented Spark Igniter
Cv	=	Valve Flow Coefficient
DC	=	Direct Current
DI	=	De-ionized
FY	=	Fiscal Year
GH2	=	Gaseous Hydrogen
GHe	=	Gaseous Helium
GN2	=	Gaseous Nitrogen
GOx	=	Gaseous Oxygen
H2O	=	Water
HDPE	=	High-Density Polyethylene
Hz	=	Hertz
IR	=	Infrared
hp	=	Horsepower
KHz	=	Kilohertz
lbf	=	Pounds-force
LCH4	=	Liquid Methane
LH2	=	Liquid Hydrogen
LOX	=	Liquid Oxygen
L-PBF	=	Laser Powder Bed Fusion

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ms	=	Milliseconds
MSFC	=	Marshall Space Flight Center
NASA	=	National Aeronautics and Space Administration
PID	=	Proportional-Integral-Derivative
PLC	=	Programmable Logic Controller
psig	=	Pounds Per Square Inch, Gage Pressure
RP-1	=	Rocket Propellant-1, Kerosene
RTD	=	Resistance Temperature Detector
TEA/TEB	=	Triethylaluminium/Triethylborane
TS115	=	Test Stand 115

I. Introduction

NASA Marshall Space Flight Center has multiple test facilities and positions for liquid rocket engines. These test stands have supported numerous development and flight programs since the early 1960's. The primary stands at MSFC include Test Stand 115 (TS115) and Test Stand 116 (TS116)[1]. TS115 is located in the East Test Area of MSFC and supports a variety of liquid chemical rocket engine components and systems. Many historical test campaigns have been conducted at this facility supporting the Apollo, Space Shuttle, and Artemis programs. Additional test support has included multiple commercial space programs, government and Air Force programs, internal research and development programs, and academic hot-fire test programs. The facility offers quick component changeovers during or between tests and rapid turnaround hot-fire that is affordable at scales less than 10,000 lbf in various propellants. A historic and capable facility (Figure 1), over 200 hot-fire tests were completed at TS115 in government fiscal year 2019 across 10 separate test campaigns, accumulating over 15,000 seconds of hardware test time. In the last decade, a majority of the hardware tested at TS115 has used additive manufacturing (AM) as a fabrication technology[2,3,4]. Operations and sequences at TS115 are flexible and allow for duty cycle testing (multiple starts in a single test) as well as long duration tests up to 600 seconds (pending flow conditions). The available fluid delivery systems, electrical power and instrumentation capabilities, facility controls and data acquisition systems, test program support capabilities, and available test rig configurations for external customer use are discussed in the following sections.

Figure 1: MSFC's Test Stand 115

II. Fluid Delivery Systems

TS115 has versatility with a variety of available propellants that can be changed between various programs. The available liquid propellant systems include oxygen (LOX), methane (LCH4), hydrogen (LH2), and RP-1 kerosene. In addition to the liquid propellants, gaseous systems include nitrogen (GN2), helium (GHe), oxygen (GOX), and hydrogen (GH2). Various forms of ignition have been used at the facility including direct spark, augment spark ignition, Triethylaluminium/Triethylborane (TEA/TEB), and laser ignition[5,6]. A deionized water system is available for component coolant and calorimeter operations in addition to full regenerative cooling and bypasses to operate a closed or open cycle component or system. Facility industrial water is available for test stand deluge and pad flush operations. The capabilities of each system are summarized in Table 1 below[7]. The primary propellants operated on a regular basis are LOX/GH2, LOX/LCH4, and LOX/RP-1. There are separate fuel tanks to allow for quick turnover between test programs and to avoid system contamination. These are known as 1st, 2nd, and 3rd fuel systems. Some of the propellants can be interchangeable to allow for various pressures and flow rate conditions to the test article.

Table 1: TS115 Fluid System Capabilities

System	Media	Volume	Pressure
Liquid Oxygen	LOx	500 gal	3000 psig
1st Fuel	LH2, LCH4	2200 gal	1500 psig
2nd Fuel	LH2, LCH4, RP-1	500 gal	3000 psig
3rd Fuel	RP-1	20 gal	3000 psig
DI Water	H2O	500 gal	3000 psig
Industrial Water	H2O	n/a	150 psig
TEA/TEB	TEA/TEB	30 gal	3000 psig
Gaseous Nitrogen	GN2	n/a (cross-country)	4200 psig
Gaseous Hydrogen	GH2	600 ft^3	5000 psig
Gaseous Oxygen	GOx	237 ft^3 trailer	2400 psig
Gaseous Helium	GHe	237 ft^3 trailer	4500 psig

A. Liquid Oxygen System

The Liquid Oxygen (LOX) system consists of a 500 gallon, uninsulated steel-walled spherical run tank rated to 3,000 psig. The run line consists of insulated 2” thick-walled pipe which transitions to 1.5” tubing at the test position. This allows for reconfiguration to match the required test article interfacing, including the implementation of various cavitating and sonic venturies to meter fluid flowrates to the test article. Other flow rate measurement devices have been used on various test programs as necessary. There are several shutoff valves along the run line, with various bleed lines used for facility chill down. Various instrumentation sensors are in place along the system to monitor pressure and temperature during operations. The facility shutoff valve to the test article is a 1” electrohydraulic flow control valve (Cv = 10). The system is pressurized to the desired setting using the facility gaseous nitrogen system with a solenoid-operated dome-loaded regulator. The run tank utilizes a 2” and 3/4” auxiliary vent for pressure relief. The tank is filled by way of government furnished liquid oxygen trailers. A highly simplified schematic of the Liquid Oxygen system is shown in Figure 2.

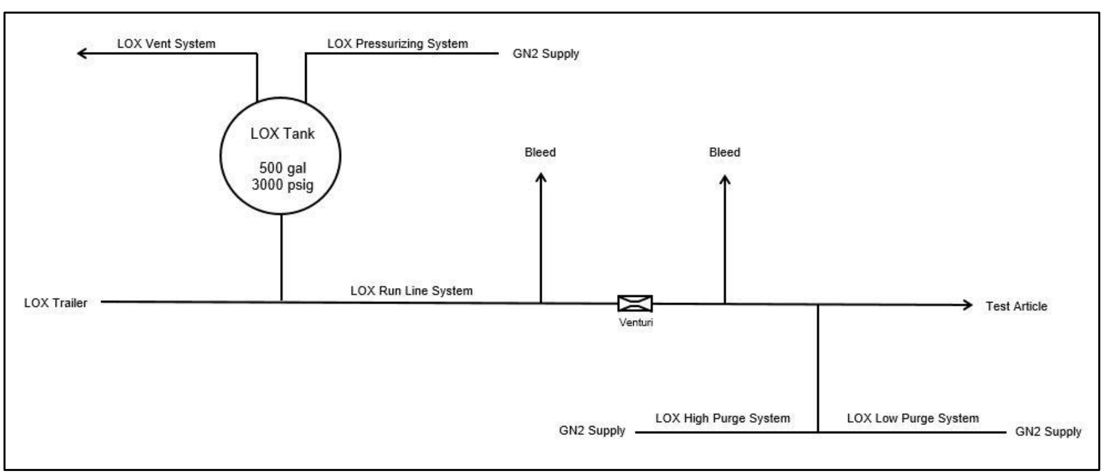

Figure 2: Simplified TS115 Liquid Oxygen System

B. 1st Fuel System

The 1st Fuel System consists of a 2,200 gallon, vacuum-jacketed cylindrical run tank rated to 1,500 psig. This system is certified for liquid methane (LCH4) and liquid hydrogen (LH2). The run line consists of 3” vacuum-jacketed pipe, transitioning to insulated 2” thick-walled pipe, which then transitions to 1.5” tubing at the test position. This allows for reconfiguration to match the required test article interfacing, including the implementation of various cavitating and sonic venturies to meter fluid flowrates to the test article. Other flow rate measurement devices have been used on various test programs as necessary. There are several shutoff valves along the run line, with various bleed lines used for facility chill down. Various instrumentation sensors are in place along the system to monitor pressure and temperature during operations that also enable facility redlines. The facility shutoff valve, located close to the test article, is a 1” electrohydraulic flow control valve (Cv = 10). The system is pressurized to the desired setting using the facility gaseous nitrogen system (for LCH4 as a fuel) and with the facility gaseous hydrogen system (for LH2 as a fuel) through a 1” electrohydraulic flow control valve. The run tank utilizes a 4” and 1” auxiliary vent for pressure relief. All vent and bleed systems are plumbed to a burnstack for disposal. The tank is filled by way of government furnished temporary fuel trailers or from the 28,000 gallon fuel storage tank, discussed later in this section. A highly simplified schematic of the 1st Fuel System is shown in Figure 3.

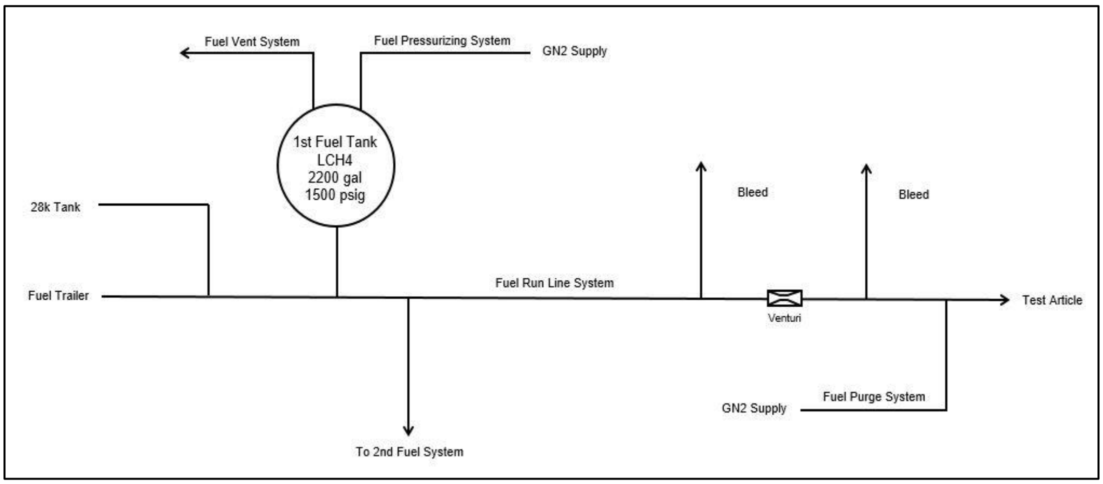

Figure 3: Simplified TS115 1st Fuel System

C. 2nd Fuel System

The 2nd Fuel System consists of a 500 gallon, spray-foam insulated steel-walled spherical run tank rated to 3,000 psig. This system is certified for liquid methane (LCH4) and liquid hydrogen (LH2). The run line consists of 2” thick-walled pipe, which then transitions to 1.5” tubing at the test position. This allows for reconfiguration to match the required test article interfacing, including the implementation of various cavitating and sonic venturies to meter fluid flowrates to the test article. There are several shutoff valves along the run line, with various bleed lines used for facility chill down. Various instrumentation sensors are in place along the system to monitor pressure and temperature during operations. The facility shutoff valve to the test article is a 1” electrohydraulic flow control valve (Cv = 10). The system is pressurized to the desired setting using the facility gaseous nitrogen system (for LCH4 as a fuel) and with the facility gaseous hydrogen system (for LH2 as a fuel) through a 1” electrohydraulic flow control valve. The run tank utilizes a 2” and 1” auxiliary vent for pressure relief. All vent and bleed systems are plumbed to a burnstack for disposal. The tank is filled by way of the 1st Fuel tank, government furnished fuel trailers, or from the 28,000 gallon fuel storage tank, discussed later in this section. A highly simplified schematic of the 2nd Fuel System is shown in Figure 4.

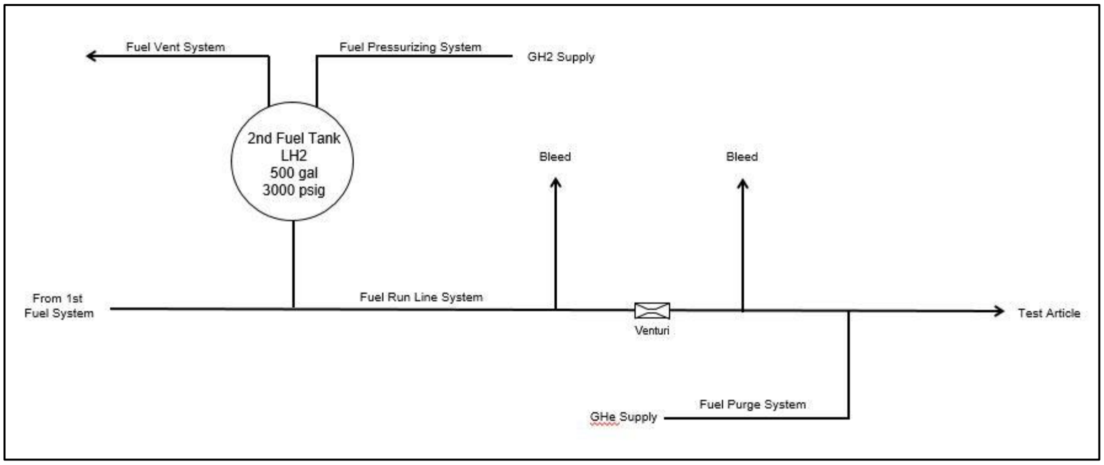

Figure 4: Simplified TS115 2nd Fuel System

D. 3rd Fuel System

The 3rd Fuel System consists of a 20 gallon, steel-walled spherical run tank rated to 3,000 psig. This system is certified for RP-1 kerosene. The run line consists 1” tubing from the tank to the test position. Like the other fuel systems, tubing allows for reconfiguration to match the required test article interfacing, including the implementation of various cavitating and sonic venturies to meter fluid flowrates to the test article. As this system is used with primarily ambient-temperature medias, it is un-insulated. An upgraded fuel tank is also being installed in 2021 to allow for larger capacity. Various instrumentation are in place along the system to monitor pressure and temperature during operations. A vent and drain system (consisting of hand valves) allows for priming the run-line prior to a test. The facility shutoff valve to the test article is a 1” remote operated pneumatic valve. The system is pressurized to the desired setting using the facility gaseous nitrogen system through a solenoid-operated dome-loaded regulator. The run tank utilizes a 1” vent for pressure relief. The tank is filled by way of transportable 55-gallon drums. A highly simplified schematic of the 3rd Fuel System is shown in Figure 5.

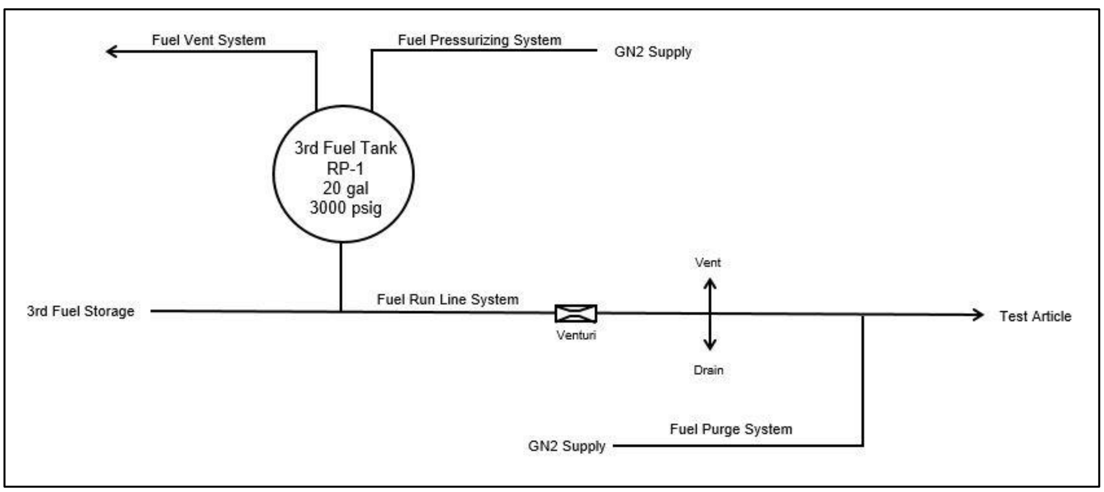

Figure 5: Simplified TS115 3rd Fuel System

E. 28,000 Gallon Fuel Storage System

The “28k” tank is a 28,000 gallon low pressure vacuum-jacketed propellant tank certified to store liquid hydrogen or liquid methane, and is rated to 80 psig. GH2 or GN2 is used for vessel pressurization depending on the fuel being stored. The tank is filled directly via vendor trailers. The 28k tank has the ability to supply both the 1st and 2nd fuel systems. Fuel boil-off from the tank is routed to a burnstack via the tank vent system. The supply lines are outfitted with several relief valves to ensure system safety.

F. GH2 System

The cross-country gaseous hydrogen system can be used as a primary fuel, a pressurizing gas for LH2, and as a fuel source in the gas igniter system. The system consists of six 100 ft^3 steel walled vessels connected to a common manifold. These vessels are located to the southwest of TS115 at MSFC's TS116, a neighboring test facility. 650 ft of 3" thick-walled pipe connects the vessels to TS115, where it transitions to 1" tubing at the test position. Pressure is regulated using a solenoid-operated dome-loaded regulator, with multiple orifice sizes to choose from depending on the desired flowrate. The vessels are pumped up via MSFC's cross-country gaseous hydrogen generation facility, which vaporizes liquid hydrogen offloaded from vendor trailers. TS115's GH2 infrastructure is limited to 5,000 psig in the pipe and 3,000 psig at the test position.

G. Gaseous Nitrogen, Oxygen, Helium, Methane, and Air Systems

Like the GH2 system, the cross-country gaseous nitrogen system is pumped up via MSFC's cross-country gaseous nitrogen generation facility, which vaporizes liquid nitrogen offloaded from vendor trailers. Several vessel batteries located across the MSFC campus and East Test Area provide (relative to typical test durations) an unlimited GN2 source at a typical operating pressure of 3,900 psig. The primary manifold located at TS115 provides the source for propellant tank pressurization, test article and facility purges, and pneumatically operated valves. Gas trailers and k-bottles of varying sizes and media are available upon request for use depending on the test program requirements. Available media includes nitrogen, oxygen, helium, hydrogen, methane, and air. Cross-country missile-grade air is also available and is pumped up via MSFC's central compressor facility with local storage via tank batteries located across the MSFC campus and East Test Area.

H. TEA/TEB System

Triethylaluminium/triethylborane (TEA/TEB) is a common ignition source used in rocket propulsion applications. The TEA/TEB system consists of a 26 gallon storage tank, a 1/4" transfer line, a section of steel tubing which acts as a run-tank (called a "TEA slug") which is pressurized to the desired conditions via facility GN2, and a run line consisting of 1/4" tubing. The flow is metered using an orifice, and the system is vented to an open atmosphere burn-box for disposal.

I. Spark and Augmented Spark Ignition System

Direct spark ignition and augmented spark ignition (ASI) systems are available for testing at TS115 in various configurations. While a few standard systems are available for the 1.2k-lbf and 7k-lbf hardware configurations, many ignition systems specific to the thrust chamber assemblies are used for spark ignition with available electronics located near the test article. Augmented spark ignition systems use the existing fuel and LOX run lines to supply propellants for the component operation. Laser ignition was tested extensively at TS115 in the early 2000s, but is not in use as a regular ignition system.

J. Water Systems

Similar to the LOX system, the Deionized (DI) Water System consists of a 500 gallon, uninsulated steel-walled spherical run tank rated to 3,000 psig. The run line consists of 2" thick-walled pipe, which then transitions to the primary 3" thick-walled manifold at the test position. Used for hardware cooling and calorimeter operations (Figure 6), the system is pressurized to the desired setting using the facility gaseous nitrogen system through a 1" electrohydraulic flow control valve. The run tank utilizes a 2" and 1" auxiliary vent for pressure relief. The tank is filled by government-furnished DI water trailers. In addition to the DI Water System, industrial water is supplied to the test facility for test stand deluge, fire suppression, and pad flush operations. The East Test Area high-pressure industrial water system consists of a loop of 30" HDPE pipe throughout the test area. Two 1-million gallon storage tanks (supplied from the Tennessee River) are located at the pump facility, which houses three 600 hp pumps. Local control of the industrial water system is maintained in the control room of each test facility, with nominal pressures of 40 psig with the pumps inactive and maximum pressure of 150 psig with the pumps active. An elevated 150,000 gallon storage tank is available in the event of power outages.

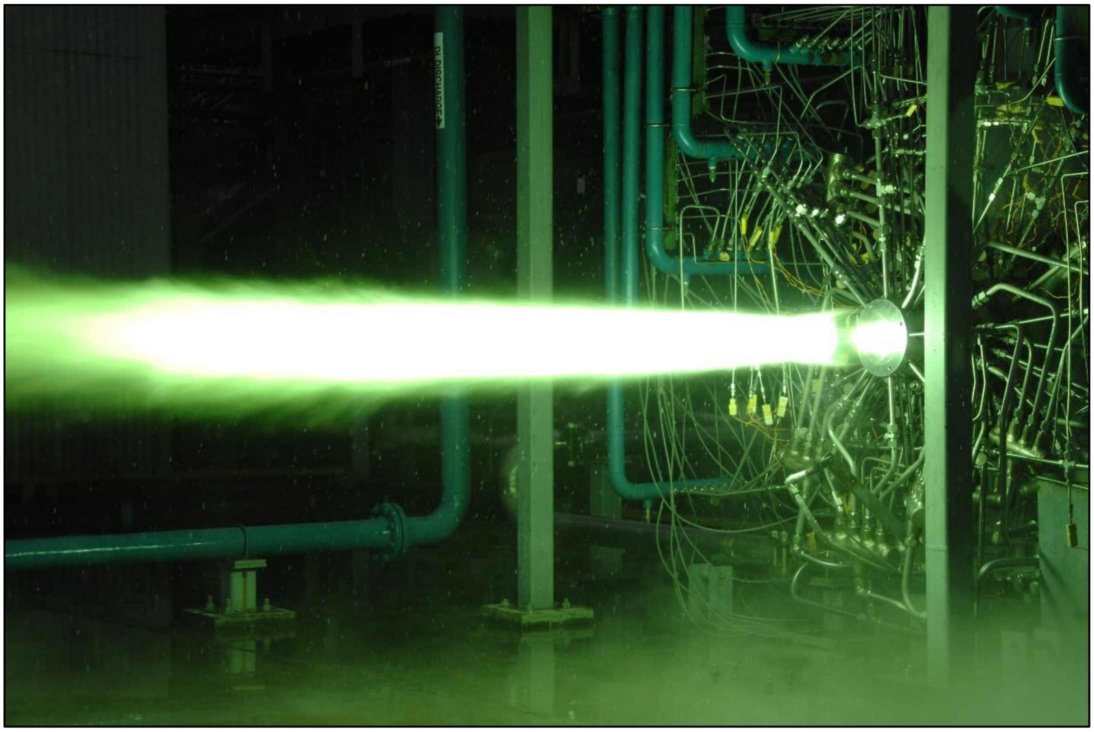

Figure 6: Calorimeter testing of LOX/LCH4 using TEA/TEB Ignition

III. Electrical Power and Instrumentation

With regards to electrical power and instrumentation capabilities, TS115 provides 480V, 208V, and 120V AC and 28V DC electrical power. Typical instrumentation include various models of Type E and Type K thermocouples, RTD thermometers, static and dynamic pressure transducers, and multi-axis accelerometers. Thrust measurement is not standard, but has been utilized for various test programs as a customer supplied system. Cavitating venturies are used to meter propellant flowrates, with an inventory of around 100 sizes to choose from, allowing for quick changes between tests. Various types of flowmeters have also been implemented, including cavitating venturi methods, turbine, ultrasonic, and Coriolis. Around 200 channels of instrumentation are available on the facility, 50 of which are available for the test article.

IV. Facility Controls and Data Acquisition

The facility control system provides discrete event recording of test sequences, proportional-integral-derivative (PID) pressure control for propellant pressurizing systems, ramp rate and position control for test article shutoff valves, and data system integration for monitoring of test sequence parameters. Facility valves possess limit switch indicators to record valve positions opened or closed. Typical data sampling rates are as follows: low speed at 200 samples per second and high speed at 250,000 samples per second. Fixed and programmable filters are available for each data recording system. Pressures can be recorded up to 20 KHz, with a 4-5,000 Hz programmable filter. RTDs can be recorded up to 10 KHz with a 10 Hz fixed filters. Thermocouples can be recorded up to 2 KHz with a 10 Hz fixed filter. High speed instrumentation can be recorded up to 200 KHz with 6p Bessel filters at 300 Hz, 1.25 KHz, 5 KHz, or 20 KHz. A Programmable Logic Controller (PLC) system is used for all digital and analog functions on the facility. Facility components and instrumentation measurements are monitored and controlled via graphical user interface in the control room. Customer test sequences, complete with events and timers, are programmed into the PLC system for automated test control. Electrical/mechanical checkouts are completed before every test to ensure control system reliability. A redline (or abort) system is programmed to monitor up to 60 parameters, 32 available via digital signal relays and 28 with software cut-off. Cutoff delays are around 5 ms and 200 ms, respectively. Redlines are employed to trigger a test cut-off and shutdown sequence.

V. Test Program Support Capabilities

In addition to the facility capabilities, numerous personnel capabilities are available to support each test program. MSFC's Special Test Equipment design branch consists of piping and structural design disciplines. The piping design team focuses on low and high-pressure liquid, gas, and cryogenic piping, tubing, and vessel systems. The structural design team focuses on structural test fixture design and analysis including load reaction, lifting hardware, and test article simulator fixtures. Through a support contract with MSFC, various technician and trade expertise is available, including mechanical, electrical, and controls systems operation and maintenance, as well as quality assurance and safety. Specialty trades, such as pipe-fitting, welding, millwright, carpentry, and precision machining are also available onsite at the MSFC test area. Various forms of photographic support are offered, including standard video, high-speed, infrared (IR) thermography, thermal, and still-frame from numerous perspectives of the test position. Standard framerates range from 30-60 frames per second, where high-speed framerates up to 1,000,000 frames per second are available, dependent upon resolution. In addition to technician and trades, specialty engineering services for mechanical, instrumentation, controls, and general test engineering support are also available.

VI. MSFC Test Rigs for Subscale Injector, Nozzle, and Chamber Development Testing

TS115 is ideal for testing quick turnaround subscale test articles, such as injectors, combustion chambers, radiatively-cooled nozzles, and regeneratively-cooled channel-wall nozzles. Two configurations are available, including a 1,200–2,500 lbf thrust level configuration (called the "1.2k configuration") and a 7,000–10,000 lbf thrust level configuration (called the "7k configuration"). The NASA-owned hardware is available for external customer use as desired and has various configurations for injectors, chambers, nozzles, and nozzle extensions for various propellant combinations.

A. 1.2k Test Rig

The current 1.2k configuration has been in use since 2014[3,8,9,10], while the heritage hardware dates back to the 1960's. This configuration (1,200–2,500 lbf thrust-class) has been tested successfully through a variety of test campaigns, offering mainstage durations over 240 seconds, nominal internal combustion temperatures up to 6000 °F, and mixture ratios as high as 8. It has been used for evaluating a variety of injectors, channel-cooled and radiatively-cooled nozzles and combustion chambers. The thruster consists of a simple coaxial injector, a water-cooled slip-jacket liner combustion chamber, and an interface for the nozzle of choice. The thruster is typically supplied with liquid oxygen and gaseous hydrogen (LOX/GH2) to create high temperature environments, though other propellant combinations have been used depending upon the desired conditions. Impinging injectors have also been tested with this configuration using LOX/LCH4 and LOX/RP-1. A cutaway of the typical 1.2k configuration is shown in Figure 7 with an uncooled nozzle.

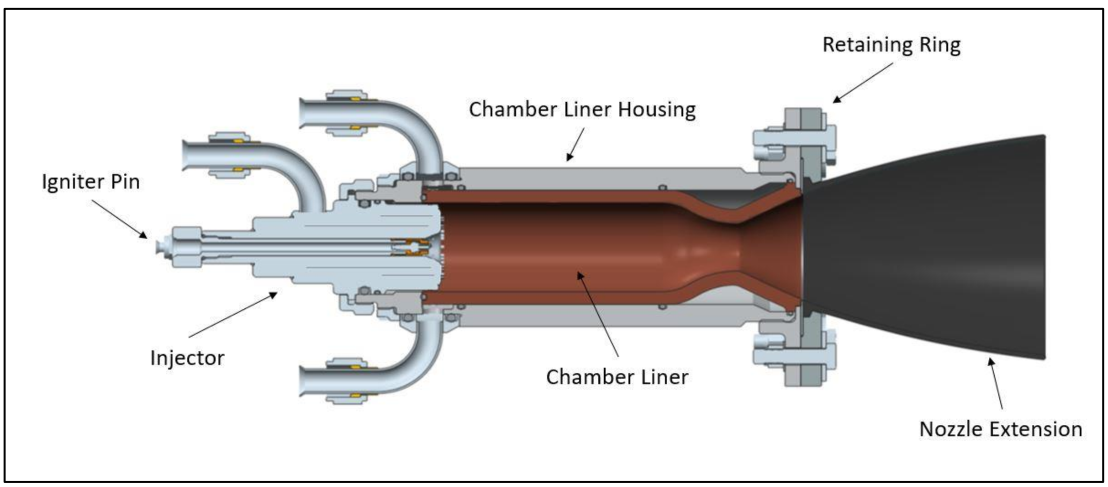

Figure 7: MSFC 1.2k Thruster Configuration

The injector design includes a simple arrangement of shear coaxial elements to provide LOX down the center posts and fuel around the annuli. Fabricated using an additively manufactured (AM) Laser Powder Bed Fusion (L-PBF) process to eliminate all braze and weld joints used in the heritage design, there are over 15 separate injectors available for use. A port in the center of the injector allows a separate tube or “pin” to be inserted to act as an igniter. The igniter pin can provide TEA/TEB or a direct spark for ignition. A newer configuration being installed in 2021 provides ignition through an ASI for multiple starts, where TEA/TEB was used in the past. One fuel inlet tube is welded to the injector to provide fuel flow. Fuel film coolant is provided around the perimeter of the injector, along with local film cooling around the igniter port depending on the design. One LOX inlet tube is welded to the injector and provides flow down each LOX post. The injector includes a collar that allows for a threaded attachment with the chamber.

The workhorse slip-jacket chamber consists of an internal liner (either NASA or customer-provided), a stainless steel housing, and a stainless steel retaining ring. The aft end retaining ring has bolt holes to accommodate subscale nozzle extensions or regeneratively-cooled nozzles. Coolant is provided to the chamber through a single inlet tube welded onto the housing at the aft end of the assembly. The exit manifold on the chamber has two exit tubes. An orifice in the coolant exit line is used to control flow rate. The chamber liner slips into the stainless steel housing, which provides the threaded connection required for the injector. The retaining ring is also made of stainless steel, and threads on to the aft end of the chamber after the liner is installed. This ring keeps the chamber liner in place, and also provides the required bolt hole flange for the nozzles. This configuration allows for rapid liner hardware changes between tests to evaluate various designs. The regen nozzles are cooled with primary or secondary propellant lines and have been operated closed cycle and also open cycle, where excess propellant is dumped to a burnstack.

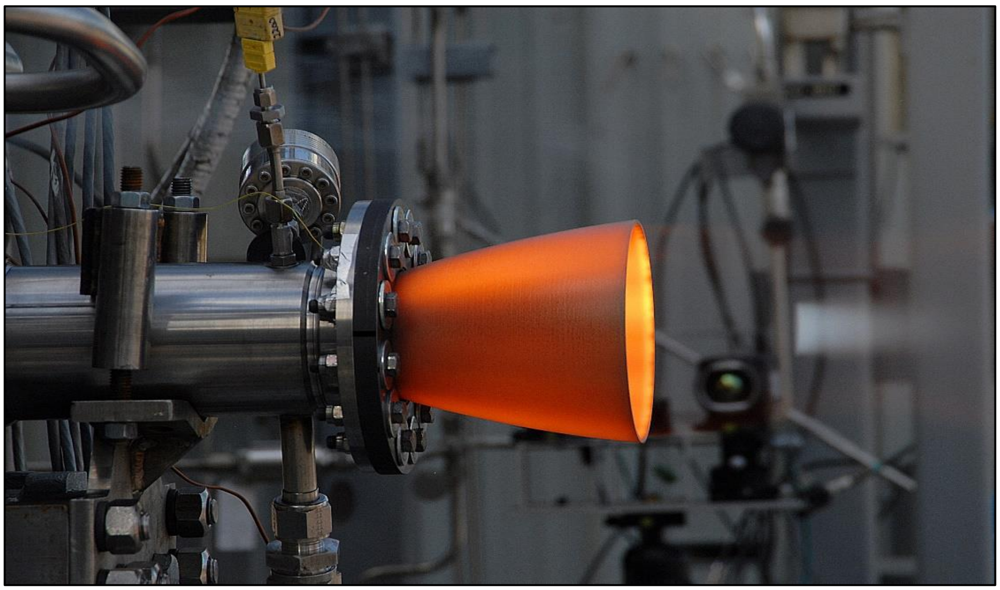

Figure 8: MSFC 1.2k Hardware Hot-fire

B. 7k Test Rig

The 7k configuration is another capability, dating back to 2015[11,12,13]. This configuration (7,000–10,000 lbf thrust class) has been tested successfully through recent test campaigns, offering mainstage durations up to 60 seconds and internal combustion temperatures up to 6000 °F with mixture ratios up to 3.2. This configuration can be used for evaluating a variety of injectors, channel-cooled and radiatively-cooled nozzles, and combustion chamber designs. Various injectors (swirl-coaxial and impinging), combustion chambers (full length and barrel section regeneratively cooled), igniters (direct spark, augmented spark, and TEA/TEB), and interfaces for the nozzle of choice are available for use. The thruster is typically supplied with liquid oxygen and methane (LOX/LCH4), though other propellant combinations can be used depending upon the desired conditions, including liquid hydrogen (LH2) and kerosene (RP-1). Several campaigns are currently planned for testing at TS115 using this configuration. The 7k test rig is shown in Figure 9.

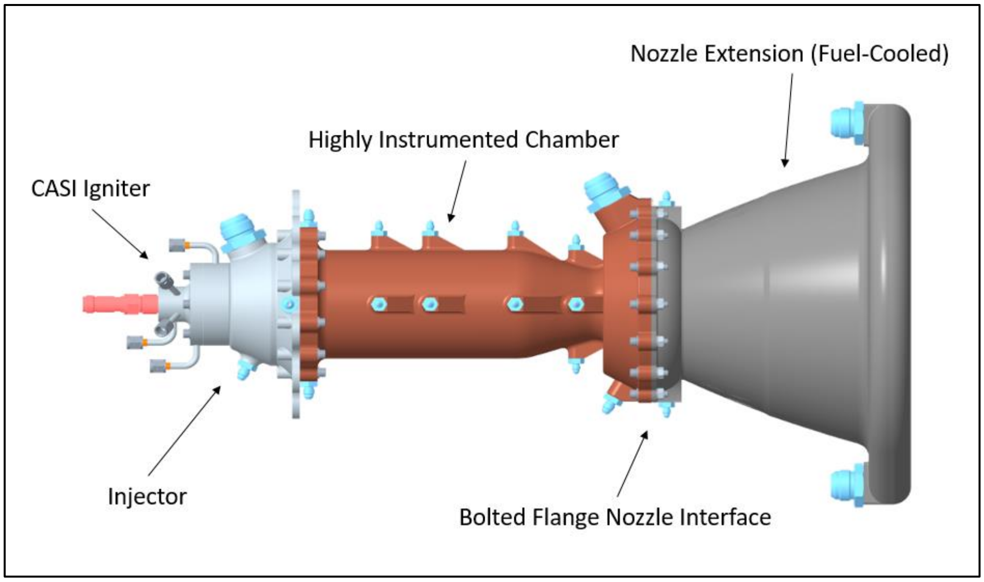

Figure 9: MSFC 7k Thruster Configuration

The compact augmented spark igniter (CASI) uses a spark plug to ignite small flows of oxygen and fuel supplied to an interior chamber at the head end of the igniter. The resulting torch passes down the center tube to produce a small flame in the main chamber, which ignites the flows traveling through the injector. Additional fuel flow is directed down the outside of the torch tube for cooling via an igniter adapter plate, which closes-out the LOX dome assembly on the injector. The housing of the igniter includes access for measuring the igniter chamber pressure, which allows confirmation that the igniter is working prior to initiating flows to the injector. In addition to the CASI configuration, adapter plates can be used to provide TEA/TEB as an ignition source if preferred.

Various injectors are available for use, including swirl-coaxial and impinging type. The current swirl-coaxial design includes a separate, machined LOX dome to provide access to change the LOX orifices which are threaded into the injector body to control the LOX flow. The body of the injector is additively manufactured, allowing the LOX posts and fuel sleeves to be printed into the body, which also includes the interpropellant plate and fuel manifold. Some of the original swirl-coaxial injectors include threaded fuel sleeves and facenuts that can be replaced if desired, while the newer printed assemblies have fixed flow areas on the fuel side that cannot be changed. The LOX flow is metered through the orifices which thread onto the interpropellant plate of the injector body, providing tangential flow to each LOX post with a swirl effect. The fuel accumulates in the fuel manifold of the injector body and flows into each element through the distribution holes in the integral fuel sleeves, and through the annulus created around each LOX post at the faceplate.

The impinging injector design features an element pattern on the faceplate. For each element, LOX enters from the manifold through a straight hole in the middle of the element, while the fuel enters from the manifold through surrounding holes. The fuel streams are angled to impinge on each other, as well as the center LOX stream. The impinging injectors are compatible with both the CASI and TEA/TEB igniter systems.

The chamber components are made of AM GRCop-84 and GRCop-42 and created with the L-PBF process. Both full-length and modular chamber assemblies are available. The two-section chamber assembly provides flexibility in which a new throat section can be made independent of the barrel section and vice-versa. Both the full-length and modular assemblies are regeneratively cooled via coolant channels that are printed into the barrel and throat sections. A bolted flange on the aft end of the chamber allow for the nozzle installation of choice.

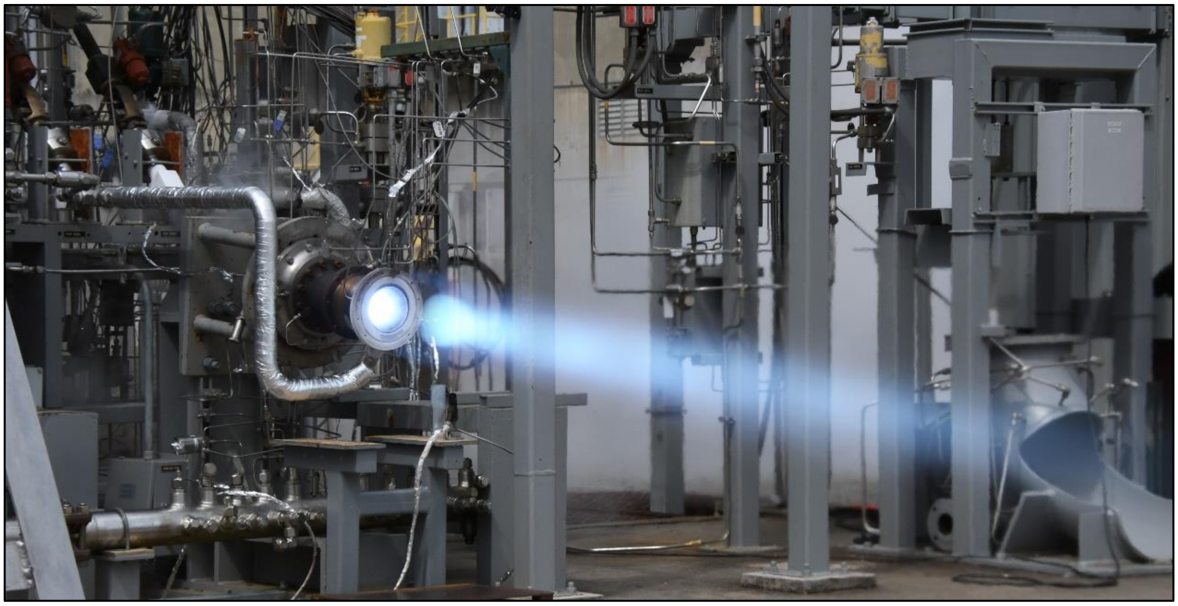

Figure 10: MSFC 7k Hardware Hot-fire

VII. Conclusions

Marshall Space Flight Center's Test Stand 115 is a very capable and efficient propulsion component test facility for testing small to medium size combustion devices including injectors, combustion chambers, nozzles (active cooling and radiatively), valves, turbomachinery, and igniters. TS115 is a "blowdown" type facility, using high pressure tankage and components to provide liquid, gaseous, and cryogenic fluid delivery at specified pressures and flowrates. The facility is actively used for various internal NASA test programs, and is open to test campaigns for external customers from other government agencies, commercial industry partners, and academia. The common interfaces and simplicity of the facility make it highly adaptable to new configurations and test articles, allowing for quick turnaround time between tests and hardware changeouts, all of which saves cost and schedule. Two standard configurations are also available for customer use, including a 1,200–2,500 lbf thrust level configuration and a 7,000–10,000 lbf thrust level configuration. These test rigs serve as a low-cost test bed for the development of small to medium-scale combustion devices.

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