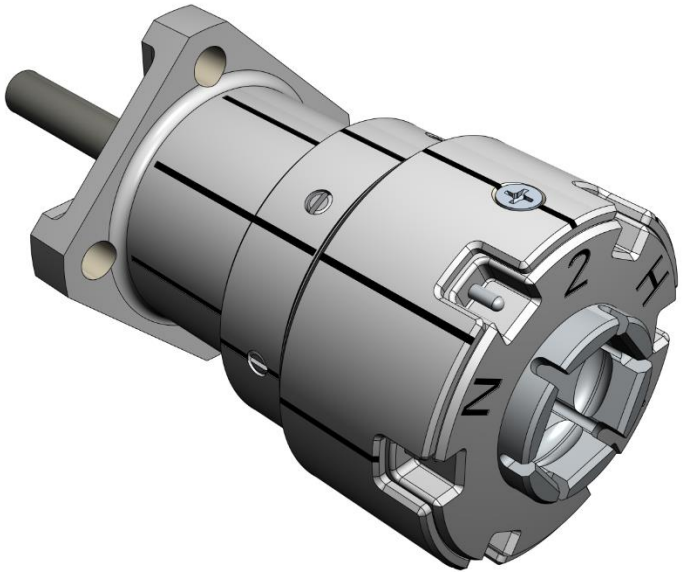
Cooperative Service Valve

Description

NASA's Satellite Servicing Projects Division (SSPD), based at the Goddard Space Flight Center (GSFC), has designed and developed the Cooperative Service Valve (CSV) to facilitate on-orbit tele-robotic resupplying of media, such as propellants and pressurants, to a cooperative satellite. Because legacy satellites that were not designed with on-orbit servicing in mind pose unique difficulties and challenges, cooperative satellites with features like the CSV enable on-orbit servicing with less risk and cost and higher success.

SSPD has designed four configurations of the CSV for different working fluids. Although each configuration has been designed for a specific working fluid, the geometry and mechanics of the CSV is essentially unchanged between configurations. Unique keying of the mating interface prevents mixing of media where more than one configuration of the CSV is used.

The CSV leverages technology development from SSPD's Robotic Refueling Mission (RRM) and Remote Robotic Oxidizer Transfer Test (RROxiTT) and other studies to address the desire to refuel a satellite on-orbit as a means of extending the satellite's operational life. The CSV offers various advantages over standard service valves: a robotic interface, three individually actuated seals, a self-contained anti-back drive system, and built-in thermal isolation. When mounted to a spacecraft as designed, the CSV transfers all operational and induced robotic loads to the mounting structure.



Hydrazine configuration of the SSPD Cooperative Service Valve

Key Features

- Designed for robotic interfaces
- Two fault tolerant to leakage when closed
- Single fault tolerant to leakage during fueling
- Self-locking against inadvertent actuation
- Compatible with different propellant media
- Can be fully disassembled on ground while mounted
- MEOP of 650 psig for all hypergol propellants
- MEOP of 3000 psig for pressurant version
- Integral thermal decoupling from mounting flange
- 1.7 in² (11 cm²) surface area available for heater
- Small overall envelope dimensions
- Low mass optimized
- Passive system
- Reacts actuation torques into mounting structure
- Can be used manually with the Ground Connector
- Can replace or supplement standard fill and drain valves

Design Operating Parameters*

CSV Configuration	-301	-303	-305	-307
Working Fluid	Pressurant	Hydrazine	MMH	NTO
Operating pressure (psig)	3000	650	650	650
Proof pressure (psig)	4500	975	975	975
Design burst pressure (psig)	7500	1625	1625	1625
Minimum Flow Rate	9.62 SCFM GHe	10 lbm/min H_2O	10 lbm/min H_2O	10 lbm/min H_2O
Outlet Size (inch)	0.250 / Ti 6AL-4V	0.250 / Ti 6AL-4V†	0.250 / Ti 6AL-4V†	0.250 / Ti 6AL-4V†
Leakage Rate (sccs GHe)	<1 x 10-5	<1 x 10-5	<1 x 10-5	<1 x 10-5
Mass in lbm (kg)	0.6 (0.27)	0.6 (0.27)	0.6 (0.27)	0.6 (0.27)

*Values shown shall be qualified in 2017
†Can be replaced with UNS S30400

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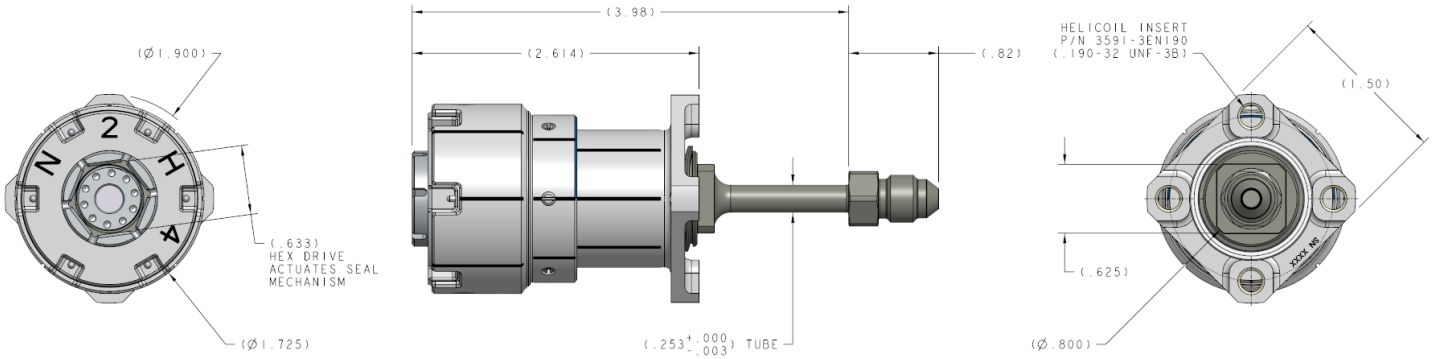
Reference Envelope Dimensions



Robotic and Human Actuation

SSPD Ground Connector

On-orbit, the CSV interfaces with the Hypergol Refueling Tool (HRT), which is actuated by the SSPD Advanced Tool Drive System (ATDS) 2.0, which in turn is mounted on a dexterous robotic system. The CSV interface allows for direct coupling of the HRT without the removal of other extraneous parts or hardware of a client refueling system in order to ready the interface.

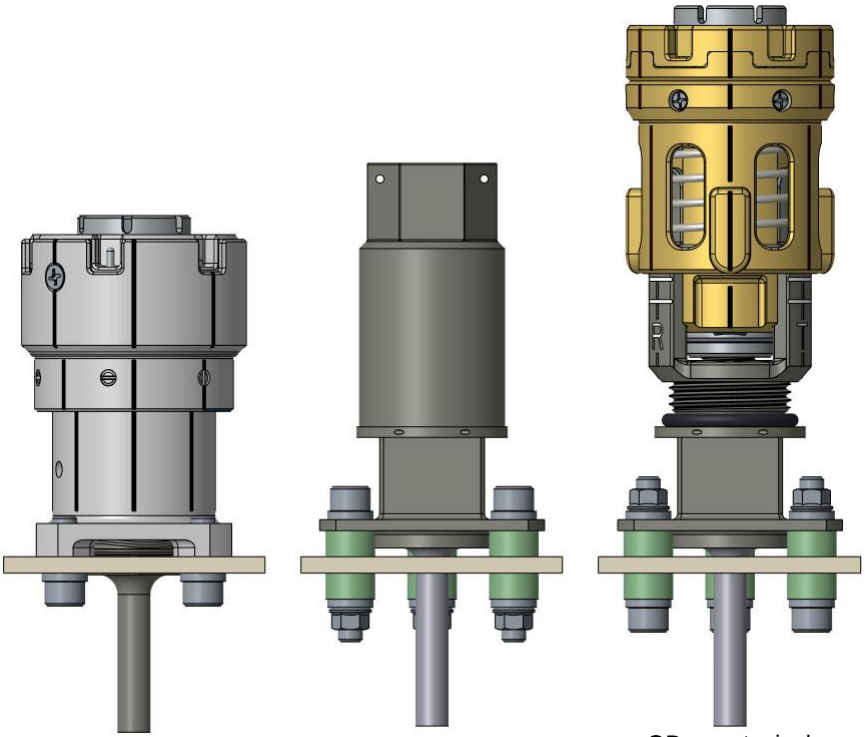
Human-actuated, ground-based fueling through a CSV can be achieved with the Ground Connector for the CSV, an adapter designed to interface between the CSV and a standard 37° flared fitting. The Ground Connector, which mimics the HRT's front end drive, is designed to allow SCAPE suit hand actuation. It is used to mate/seal to the CSV, to disengage the anti-back-drive mechanism, and turn the stem of the CSV in order to open and close its seals during propellant transfer. The Ground Connectors utilize labeling, color, and keying (unique to media specific configurations of the CSV) to prevent interconnecting incompatible propellant systems.

Standard Installation

The image on the left shows the standard mounting configuration for the CSV and that for a typical service valve shown to scale with the CSV for reference. Because the CSV features integral thermal isolation, it does not require thermal spacers (shown in green) unlike the representative service valves.

The valve in the middle is a typical service valve with all safety caps installed. The valve on the far right shows the SSPD Quick Disconnect (used during RROxiTT for a legacy satellite refueling demonstration) attached to the same service valve after removal of all safety caps in preparation for servicing.

Unlike the representative service valve, the CSV does not have any extraneous caps that need to be removed prior to mating to the valve or lock wire to cut. Not taking into account a thermal blanket or environmental closeout covering the worksite, the CSV only requires one tool for refueling. Currently, a standard service valve requires lock wire cutting, tertiary cap removal, fitting end cap removal, conical seal removal, and an interface adapter (4 additional specialized tools) for refueling.



Cooperative Service Valve | A typical service valve | QD on a typical service valve

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