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www.ariane.group

ARIANEGROUP
ORBITAL PROPULSION
ROBERT-KOCH-STRASSE 1
82024 TAUFKIRCHEN
GERMANY

SUSANA CORTÉS BORGMEYER
SUSANA.CORTES-BORGMEYER@ARIANE.GROUP
PHONE: +49 (0)89 6000 29244
WWW.SPACE-PROPULSION.COM

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PYROVALVES
FILL, DRAIN AND VENT VALVES
LATCH VALVES
FLOW CONTROL VALVE

ORBITAL PROPULSION FLUIDIC EQUIPMENT

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PYROVALVES
FILL, DRAIN AND VENT VALVES
LATCH VALVES
FLOW CONTROL VALVE

To assure the highest possible quality, reliability and performance of our spacecraft propulsion systems and thrusters, ArianeGroup designs, develops and produces its own valves for the control of propellants and pressurant's. These space qualified valves, proven over again in major international programs, are available separately or as part of a complete propulsion system.

The range of valves available include:

- Pyrovalves
- Fill, Drain and Vent Valves
- Latch Valves
- Flow Control Valve

Pyrovalve

Fill and Drain Valve

Ground Half Coupling

Latch Valve

Flow Control Valve

PYROTECHNICAL VALVES

Pyrovalves are widely used on spacecrafts and launchers where reliable one shot devices are needed for permanent opening or closing of a fluid circuit. Due to its excellent leak tightness capability prior to and after firing in combination with its low mass and low complexity, the pyrovalve presents state of the art propulsion system equipment suitable to fulfil the various mission needs.

ArianeGroup offers a family of Normally Closed (NC) and Normally Open (NO) Pyrotechnical Valves with various different interfaces in order to fulfil the specific customer needs. The available product portfolio covers screwed as well as weldable interfaces (1/4" and 3/8"). All valve types are provided with redundant ESA standard initiators (squibs) which provides the energy needed for actuation.

The main function of the Pyrotechnical Valve is to definitely shut down or open a fluid circuit. Furthermore, as part of the propulsion subsystem they must ensure a minimal pressure drop as well as perfect external and internal leaktigthness prior to and after actuation. The latter is achieved by an all welded design in combination with a flexible titanium membrane, which pysically separates the combustion chamber from the hydraulic flow section. This membrane ensures a perfect pressure tightness between the pyrotechnic chambers and the fluid circuits before, during and after the actuation.

The Pyrotechnical Valve provides a highly reliable, fast acting, zero liquid leakage compact design at low equipment mass. Only a small pulse of electrical power is required for valve actuation.

Pyrovalve Key Technical Characteristics	
Initiators	Redundant ESA Standard Initiators
Design	All-welded Titanium design
Fluid Compability	Helium, Argon, Xenon, Nitrogen, MON, MMH, Hydrazine, Deionized Water, IPA
Response Time (Mechanical)	< 7ms
Mass	< 0.160 kg (depending on type)
Qualified Operating Temperature	-90°C ≤ T ≤ 100°C
Qualified Operating Pressure (MEOP)	310 bar
Proof Pressure	1.5 x MEOP (465 bar)
Burst Pressure (NO and NC)	
Pre firing	> 4x MEOP (rupture pressure: > 1240 bar)
Post firing	> 2.5x MEOP (rupture pressure: > 775 bar)
Leakage	
Normally Open	Internal leak after firing: < $1x10^{-6}$ scc/s (GHe) External leak before/after firing: < $1x10^{-6}$ scc/s (GHe)
Normally Closed	Internal leak before firing: < $1x10^{-6}$ scc/s (GHe) External leak before/after firing: < $1x10^{-6}$ scc/s (GHe)

Pyrovalve Heritage and Future Missions

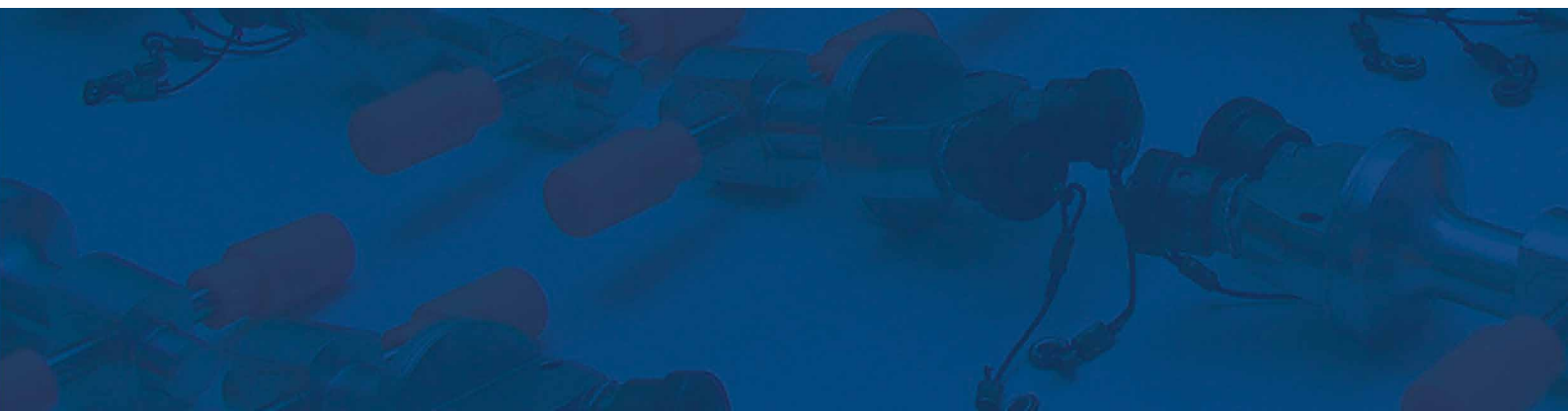
The heritage of ArianeGroup regarding Pyrotechnical Valves goes back to 1984, when the 1st generation has been developed by Aerospatial Les Mureaux with support from ESA. Following successful qualification in 1987, the first generation of Pyrovalves was produced until the year 2000. In 1999 a harmonisation and improvement of the first Pyrovalve generation was introduced and successfully qualified in 2001. Following 2 years of production all Pyrovalve activities were transferred from ArianeGroup Les Mureaux to ArianeGroup Lampoldshausen in 2004. The transfer was finished in 2006 with a successfully performed First Article validation program.

As of today, ArianeGroup has delivered more than 600 NC and more than 600 NO Pyrotechnical valves to leading satellite manufactures. More 500 FM units were already sucessfully actuated on various spacecrafts without any failure. The production stability is continuously monitored and verified throughout specific Destructive Lot Acceptance Test (DLAT) campaigns. Meanwhile more than 200 units were successfully actuated during extensive DLAT testing including vibration and shock testing, low and high temperature firings as well as under- and overcharge testing. This demonstrates the excellent reliability of the Pyrotechnical Valves manufactured by ArianeGroup.

Spacecraft	Launch Year
Ariane-5	since 1996
Arabsat 4B	2006
Anik F3	2007
Skynet 5B	2007
Arabsat 4 AR	2008
Astra 1M	2008
ATV FM1	2008
HotBird 9	2008
Nimiq-4	2008
Skynet 5C	2008
Amazonas-2	2009
Eutelsat W7	2009
HotBird 10	2009
MILSAT-A	2009
Palapa D	2009
Spirale 1	2009
Spirale 2	2009
Thor-6	2009
Alsat 2A	2010
Nilesat 201	2010
RASCOM-2	2010
MILSAT-B	2010

Spacecraft	Launch Year
Arabsat 5A	2010
Arabsat 5B	2010
COM-5	2010
Alsat 2B	2010
Eutelssat W3B	2010
KA-SAT	2010
ATV FM 2	2011
Ekspress AM4	2011
Arabsat 5C	2011
SSOT (Myriade)	2011
YAHSAT 1A	2011
YAHSAT 1B	2011
Astra 1N	2011
Elisa FM1	2011
Elisa FM2	2011
Elisa FM3	2011
Elisa FM4	2011
Atlantic Bird	2011
Eutelsat W3C	2011
Apstar 7A	2012
Astra 2F	2012
ATV FM 3	2012

Spacecraft	Launch Year
Eutelsat W5A	2012
Eutelsat W6A	2012
METOP-B	2012
Skynet 5D	2012
VEGA	2012
Yamal 402	2012
ATV FM 4	2013
Alphasat	2013
AMOS 4	2013
Astra 2E	2013
GAIA	2013
SES-6	2013
ARSAT 1	2014
Astra 2G	2014
Astra 5B	2014
ATV FM5	2014
Arabsat 6B	2015
LISA-Pathfinder	2015
BepiColombo	2016
ExoMars	2016
METOP-C	2017



FILL AND DRAIN VALVE

ArianeGroup offers a wide range of Fill and Drain / Vent valves for spacecraft applications incorporating either two or three inhibits against leakage pending on customer demand. Propellant loading / venting valves are designed to provide three independent inhibts, while gas type or test port FCVs provide
2 independent ones.

With regard to the selected materials, the propellant type and test port FDVs provide an excellant compatibility with state of the art storable propellants such as MMH / Hydrazine / MON-1 as well as MON-3. Special high pressure gas type FDV are available for operation with Helium (He) and Xenon (Xe). In general all types are compatible with standard test agents (IPA / HFE 7100 / deionized water) and gases (He, N2).

In general six different valves types are available, each providing a different interface to prevent misconnection on spacecraft level. These types differ mainly in thread size and orientation.

The following design attributes and features are common to all six FDV types:

- All piece parts of the valve are machined from titanium alloy (Ti6Al4V) leading to a light weight unit with 0.25 inch/ 6.4mm outlet diameter tube stub which forms a weldable connection to the titanium tubing of the subsystem
- The interface to the subsystem structure is provided by a triangular flange with triple-screw attachment (thread size M4)
- An all welded housing containing a spring supported guided valve poppet equipped with the primary seal. This ensures that the valve is kept closed in non actuated contions
- In flight configuration the valve poppet sealing will be additionally protected and sealed by mounting a cap, thus providing a metal-to-metal seal (secondary seal)
- Low pressure drop even at high mass flows ensured by design. The flow area is at least as large as the connected tubing

For servicing a dedicated Ground Half Coupling (GHC) has to be mounted. For each FDV type there is a respective GHC permitting only mating of the correct type. By this means a safe and easy to handle, leak-tight connection between the propulsion system and the ground support equipment is guaranteed.

Each GHC provides a robust specific opening / closing mechanism to safely operate the FDV. No specific tooling is required.

Fill and Drain Valve Heritage and Future Missions

Since their original qualification in 1983, thousands of fill, drain and vent valves have been produced and delivered for a variety of spacecraft programmes including Eutelsat W3A, Amazonas, Inmarsat 4 F1, Anik F3, Skynet 5A, Skynet 5B, Amos 2, Astar, Star 1, Galaxy 17, Hispasat, MSG-4, Microsats, Herschel Planck, Pleiades, Spacebus, Eurostar communication satellites, Mars Express, Venus Express and ESA's Automated Transfer Vehicle. The outstanding flight heritage underlines the excellent reliability of the Ariane-Group Fill and Drain / Vent valves.

Ground Half Coupling

Fill and Drain Valve Propellant Loading

Fill & Drain Valves - 2 Failure Tolerant (3 inhibits against external leakage)	
Operating Media	Various fluids (Propellants and Pressurants)
Mass	< 0.09 kg
Total Length	109 ± 1 mm
Standard Tube Dimensions	
- outer diameter	6.4 ± 0.02mm
- inner diameter	4.9 + 0.01mm
- inner diameter (at weld i/f)	5.58 ± 0.02mm
Tube Length	43 mm
Adapter Thread	Fuel Loading 9/16" - 18 UNJF - 3A - RH. Fuel Venting 7/16" - 20 UNJF - 3A - RH. Ox Loading 9/16" - 18 UNJF - 3A - LH. Ox Venting 7/16" - 20 UNJF - 3A - LH. Note: All of the above threads require corresponding ground half couplings
MEOP - Fuel / Ox Loading / Venting	Up to 33 bar
Burst pressure	1240 bar
Sinusoidal Vibration	Up to 20 g
Random Vibration	Up to 5 g^2/Hz (56.3g RMS)
Pyrotechnic Shock	Up to 3250 g
All European	Yes

FDV Fuel Venting

Low Pressure Helium Valve

FILL AND DRAIN VALVE

TECHNICAL CHARACTERISTICS.

	Fuel Fill Valve	Fuel Vent Valve	High Pressure Helium Valve
Operating Media	Monomethyl Hydrazine (MMH)	Monomethyl Hydrazine (MMH)	Helium (High Pressure)
Mass	≤ 0.09 kg	≤ 0.09 kg	≤ 0.06 kg
Total Length	108.8 ± 1 mm	107.2 ± 1 mm	94.5 ± 1 mm
Standard Tube Dimensions - outer diameter - inner diameter	 6.4 ± 0.02mm 5.58 + 0.11 mm	 6.4 ± 0.02 mm 5.58 + 0.02 mm	 6.4 ± 0.02 mm 4.98 + 0.02 mm
Tube Length	43 mm	43 mm	43 mm
Adapter Thread	9/16" - 18 UNJF - 3A - RH. Requires corresponding ground half coupling	7/16" - 20 UNJF - 3A - RH. Requires corresponding ground half coupling	M 12 x 1.5 - RH. Requires corresponding ground half coupling
Life - Operational Life - Storage Life	 About 16 years Up to 5 years in a protected environment	 About 16 years Up to 5 years in a protected environment	 About 16 years Up to 5 years in a protected environment
Open/Close Cycles	40 Cycles	40 Cycles	40 Cycles
Standard Operating Temp.	-30°C to 80°C	-30°C to 80°C	-30°C to 80°C
Leakage - external Leakage - internal Leakage	 < $1x10^{-6}$ scc/sec GHe < $2.8x10^{-4}$ scc/sec GHe	 < $1x10^{-6}$ scc/sec GHe < $2.8x10^{-4}$ scc/sec GHe	 < $1x10^{-6}$ scc/sec GHe < $2.8x10^{-4}$ scc/sec GHe

Low Pressure Helium Valve	Oxidiser Fill Valve	Oxidiser Vent Valve	High Pressure Xenon Valve
Helium (Low Pressure)	Nitrogen Tetroxide (MON)	Nitrogen Tetroxide (MON)	Xenon (High Pressure)
≤ 0.06 kg	< 0.09 kg	< 0.09 kg	≤ 0.06 kg
94.5 ± 1 mm	108.8 ± 1 mm	107.2 ± 1 mm	115 ± 1 mm
6.4 ± 0.02 mm 5.58 + 0.02 mm	6.4 ± 0.02 mm 5.58 + 0.02 mm	6.4 ± 0.02 mm 5.58 + 0.02 mm	6.4 ± 0.02 mm 4.9 + 0.1 mm
43 mm	43 mm	43 mm	61 mm
7/16“ - 20 UNJF - 3A - RH. Requires corresponding ground half coupling	9/16“ - 18 UNJF - 3A - LH. Requires corresponding ground half coupling	7/16“ - 20 UNJF - 3A - LH. Requires corresponding ground half coupling	M 14 x 1.5 - RH. Requires corresponding ground half coupling
About 16 years Up to 5 years in a protected environment	About 16 years Up to 5 years in a protected environment	About 16 years Up to 5 years in a protected environment	About 16 years Up to 5 years in a protected environment
40 Cycles	40 Cycles	40 Cycles	40 Cycles
-30°C to 80°C	-30°C to 80°C	-30°C to 80°C	-30°C to 80°C
< $1x10^{-6}$ scc/sec GHe < $2.8x10^{-4}$ scc/sec GHe	< $1x10^{-6}$ scc/sec GHe < $2.8x10^{-4}$ scc/sec GHe	< $1x10^{-6}$ scc/sec GHe < $2.8x10^{-4}$ scc/sec GHe	< $1x10^{-6}$ scc/sec GHe < $2.8x10^{-4}$ scc/sec GHe

LATCH VALVE

The ArianeGroup low pressure latching valve (named hereafter LPLV or LV) is a solenoid-operated, bi-stable valve constructed essentially of stainless steel and qualified to operate with a number of different working media, including hydrazine and its most common derivatives.

The LPLV provided by ArianeGroup represents the switchable, fully reliable safety barrier in the propellant flow between tank and thrusters. It is equipped with a back-relief-function protecting the downstream lines and equipment against over-pressure (e.g. due to environmental effects).

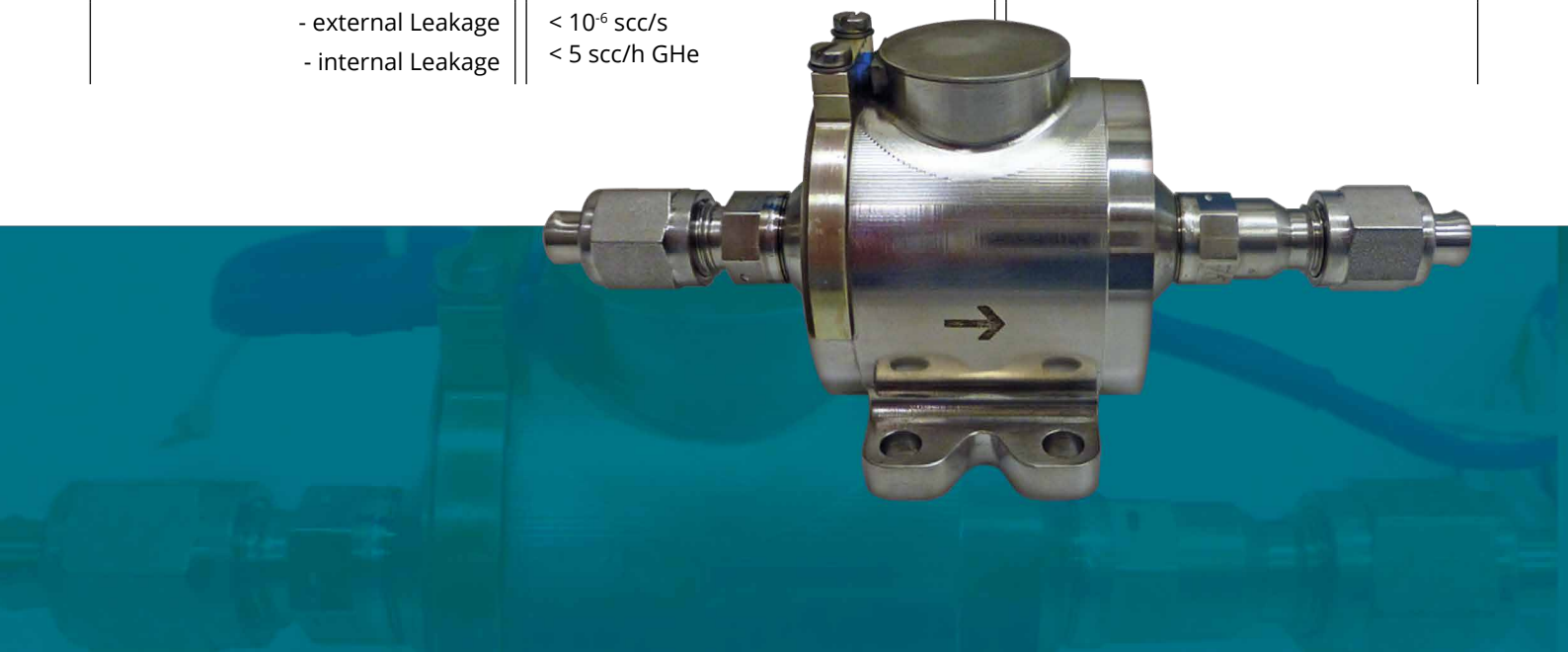
For switching 2 electromagnetic coils are to be activated to change the status of the valve to open or closed. Switching can be performed by using a non-regulated supply within a range of 22VDC < 28VDC ≤ 38 VDC. At room-temperature the LPLV can be closed or opened within a switch-time of 30ms while the cycle-time is defined to 50ms.

A microswitch is installed for position indication, activated by a pin, which is directly mounted on the LPLV-anchor.

The variant with welded interface is identical to the screwed-interface one except for the tubing connection.

Latch Valve Technical Characteristics

Characteristics	Nominal Value	Remarks
Tubing Interface	1/4 inch	Screwed or welded versions available
Mass	545 g	
Operating voltage	22-32 VDC	Up to 50VDC for 50ms switching pulses
Response time	< 30 ms	Opening and Closing;
Coil resistance	37,5 Ω ± 1,5 Ω	At ambient temperature
Max.operating pressure	24,25 bar	Specified value; higher values possible
Back-Relief Pressure	8 to 14 bar	
Flow Rate and Pressure Drop	< 0.15 bar at 4.5 g/s	Flow rates up to > 20g/s usable
Fluid Compatibility	Water, hydrazine, MMH, NTO, IPA, He, N_2, Xe and others	
Opening/Closing cycles	> 500	
Operating Temperature	9° C to 50° C for use with hydrazine	
Electrical connection	Flying leads AWG26, 2m long	
Leakage		
- external Leakage	< 10^{-6} scc/s	
- internal Leakage	< 5 scc/h GHe	



400N APOGEE ENGINE FLOW CONTROL VALVE

The 400N flow control valve is an electromagnetic controlled, normally closed valve with a non sliding fit suspended armature design and has redundant electric coils. The moving part, called magnetic plunger, is actuated with the magnetic force induced by the coil when supplied by direct current voltage.

With no voltage applied, the magnetic plunger returns to closed position thanks to the two preloaded membrane springs. The spring preload compresses the PTFE poppet on the metallic seats and enables to meet the required tightness level. After energizing of the coil, the valve opens and the flow passes through an annular gap. At the inlet of the valve a 40µ filter is located to protect the PTFE seat for any pollution.

More than 100 units were successfully build and more than 80 successfully used on ArianeGroup 400N engine in orbit.

400N Apogee Engine Flow Control Valve (FCV) Key Technical Characteristics		
Valve type		Dual-coil-solenoid monostable bipropellant engine valve (Normally-Closed), non sliding fit
Operating Voltage per Coil	VDC	21 to 27
Coil resistance	Ohms	20 ± 1 at 21°C
Power dissipation	Watt	38.4 at 27 VDC
Response time (20°C)	ms	< 30
Pull-in	VDC	≤ 18,3
Drop-out	VDC	> 1.5, < 5
Holding Voltage per Coil	VDC	≥ 7.5
Max inlet pressure (operational domain)	bar	34
Burst pressure	bar	88
Flow Rate / Pressure Drop		max 1.1 bar at 70 g/s H2O
Compatible Media		NTO, MMH, water
Seat material		PTFE
Other materials in contact with media		AISI 430, AISI 347, Elgiloy
Leakage		
- external Leakage	scc/s	$< 1x10E^{-6}$
- internal Leakage	scc/s	$< 5x10E^{-4}$
Electrical connection		AWG24 flying leads acc. ESA ECSS 3901.002 1.7m (4 single wires)
Media inlet connector		AN4 7/16 - 20 UNJF - 3A
Inlet filter		Mesh type, stainless steel, <40µm
Temperatures		
Operating	°C	0°C to 115°C
Acceptance	°C	-5°C to 120°C
Qualification	°C	-10°C to 125°C
Number of open/close cycles		5000
Life time	years	16