

Aperture Valve for the Mars Organic Molecule Analyzer (MOMA)



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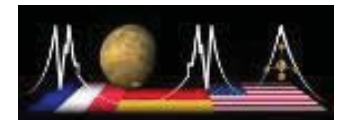
Overview: ExoMars Mission



Description	Details
Launch Date	2018
Launch Vehicle	Proton
Mission Cruise Duration	10 months
Operation Duration	180 sols (~6months)
Nominal Science	~80 sample analyses
Rover Mass	300 kg
Rover Mobility Range	Several km
Planetary Protection	Class IV
Power System	Solar Panels



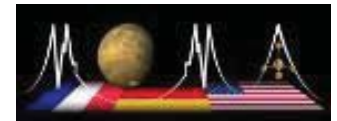
- Managed by ESA
- Instrument Payload being built by Thales Alenia Space – Italia (TAS-I)



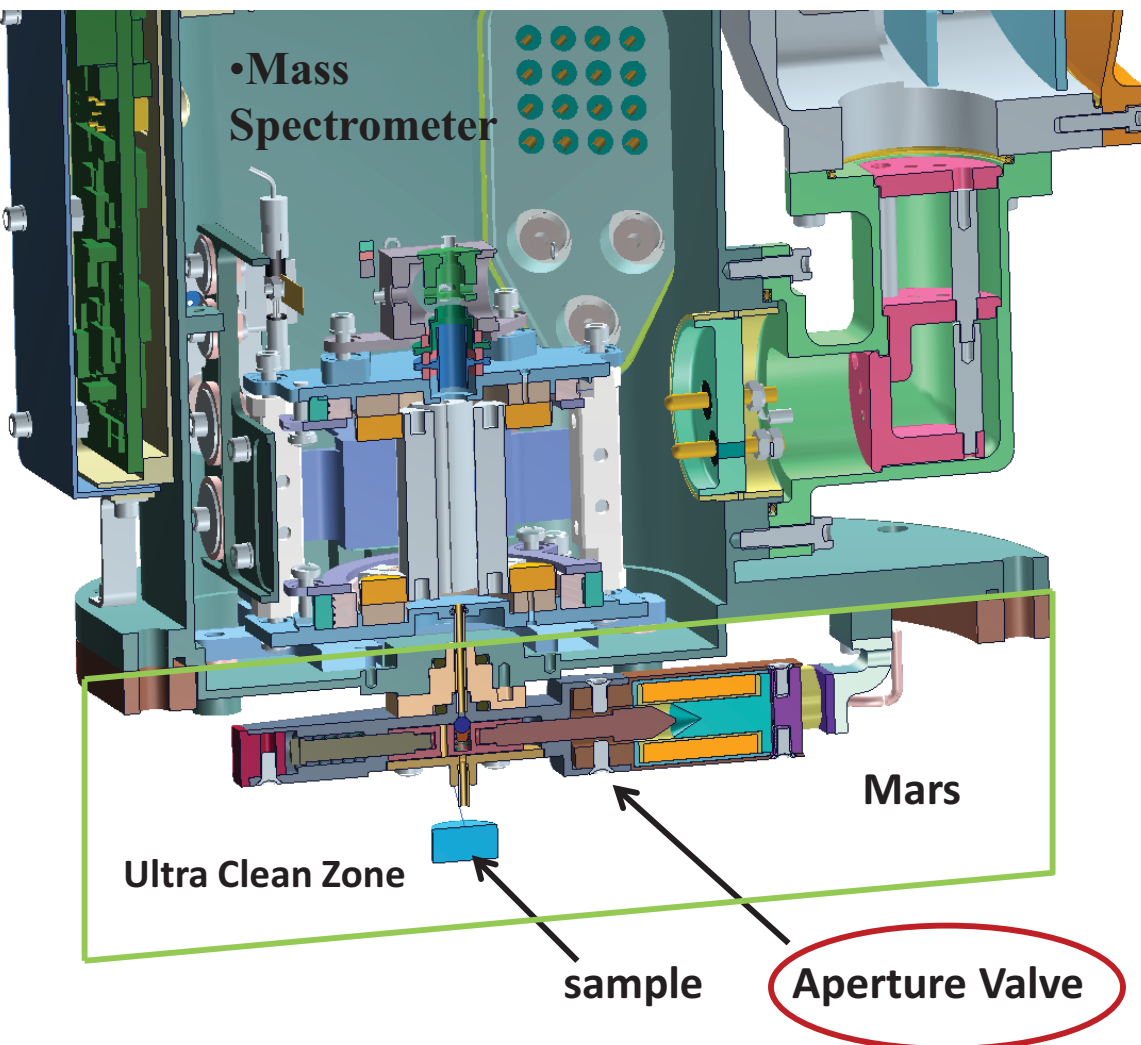
Mars Organic Molecule Analyzer



- MOMA is a Mass Spectrometer designed to look for a wide range of organic molecules on Mars
- Led by the PI in Gottingen Germany
 - Includes partners from United States, Italy, Germany
- GSFC is delivering a portion of MOMA designated: MOMA-MS
 - Includes the Mass Spectrometer, plumbing and supporting Electronic boxes.



Overview- Aperture Valve placement within MS

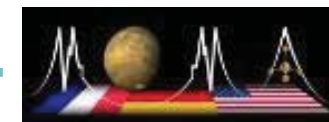


Functional purpose:

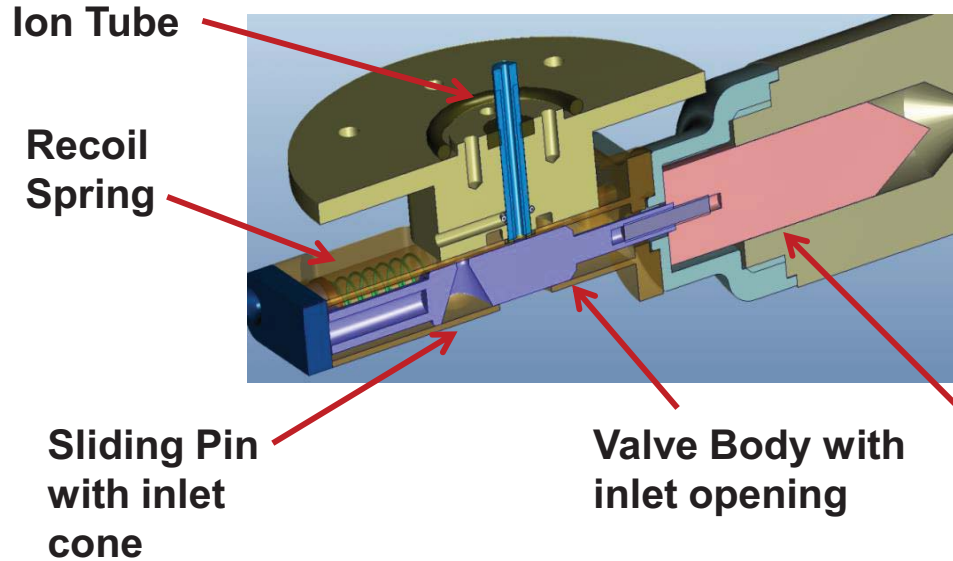
Provides a path to the ion trap that can be opened or closed on-demand.

Transfers ions formed from laser desorption from Mars ambient (7 Torr) into the ion trap via a conductance limiting capillary (Ion Tubes)

Provides a seal to the mass spectrometer during mass measurements.



MOMA Aperture Valve

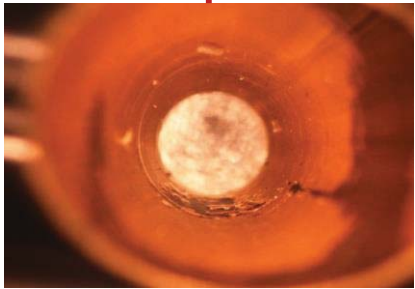
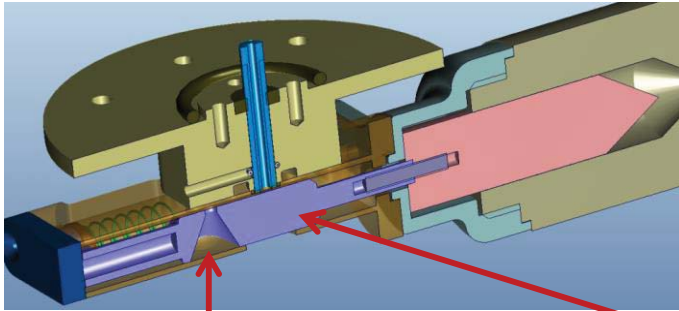


Valve Body with inlet opening

Pull-type Solenoid

Driving Requirements	
Pressure leak rate	10E-3 cc/sec He
Operational cycle life	125,000 cycles
Operational temperature	-20°C to 50°C
Valve open/close time	<50ms
Mass	90 grams
Failure Mode	Fail closed
Power	5 watts peak
Material limitations	Non-magnetic

Issue: PVD Coatings on titanium base material



Advantages of PVD coatings

- TiN and DLC exhibit desirable combination of low coefficient of friction and high micro-hardness >80Rc - above the hardness of tool steel.
- Thin coating (.0001") produces negligible change in part dimension.

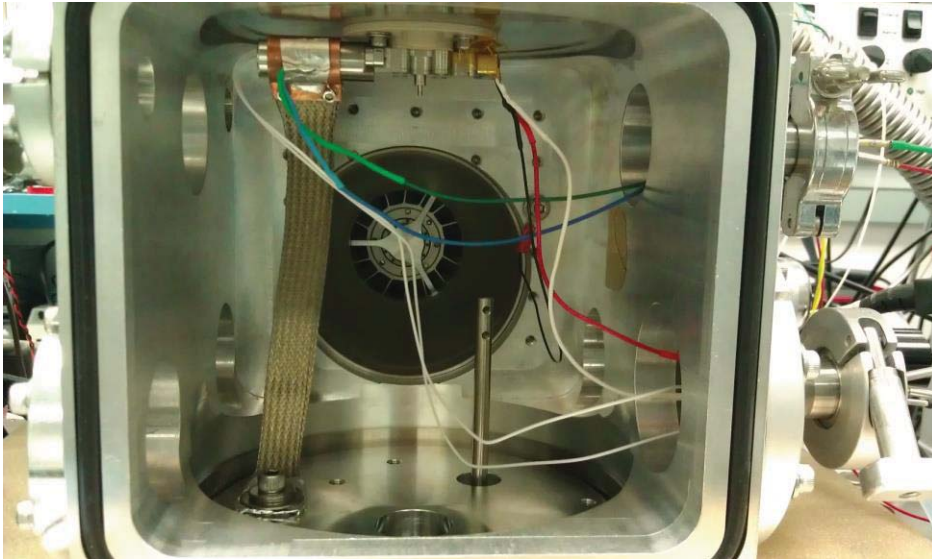
Problems discovered during early breadboard design

- Delamination of TiN coating within the bore of the valve body.
- Multi-layer PVD coatings such as TiN over DLC produced poor adhesion.

Lessons learned

- The PVD process used to apply TiN onto internal cavities and bore holes does not produce acceptable adhesion of the TiN film
- Consider having the vendor provide a witness sample prior to coating parts.

Issue: Solenoid thermal control in near vacuum



Solenoid thermal control

- Operating profile generates .27W average which must be dissipated.
- Size thermal strap for hot case then cold case to verify the valve does not become too cold.

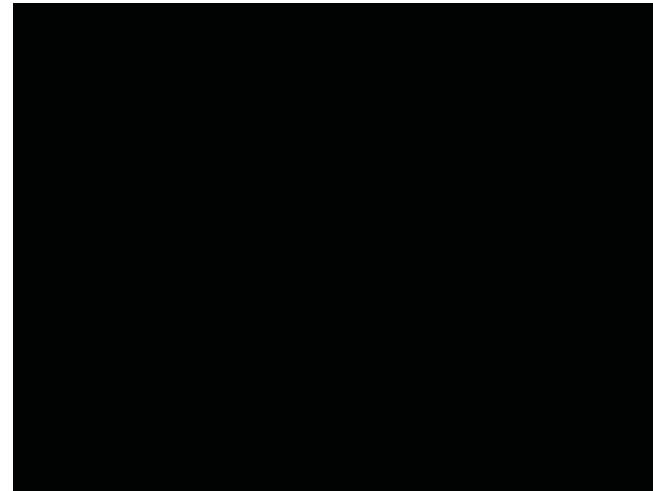
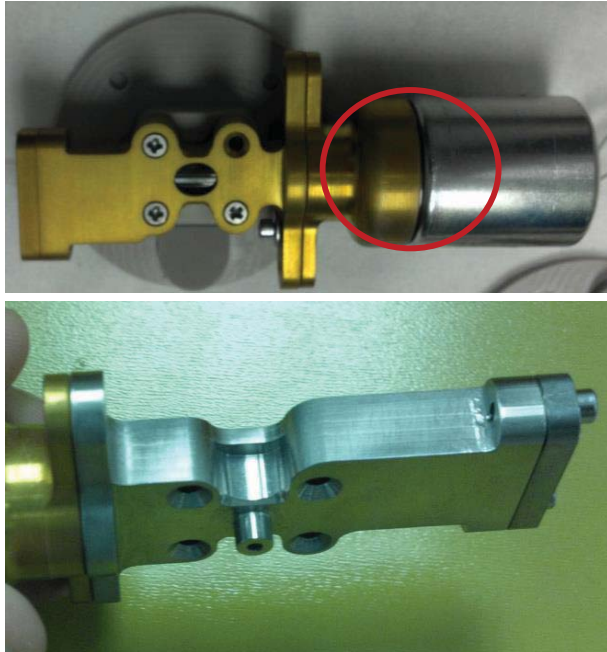
Problems discovered during initial vacuum chamber testing

- Thermal isolation of the valve from the test chamber at 7 torr caused the solenoid to overheat.
- Non-metal solenoid parts warped from excessive heat causing solenoid failure.

Lesson learned

- Thermal strap was necessary to avoid solenoid failure.
- Thermal heat sink was incorporated into ETU and Flight valve designs.

Issue: Mechanical assembly using Small fasteners



Sine vibration test 20g, (5-100 Hz.) 2 min.

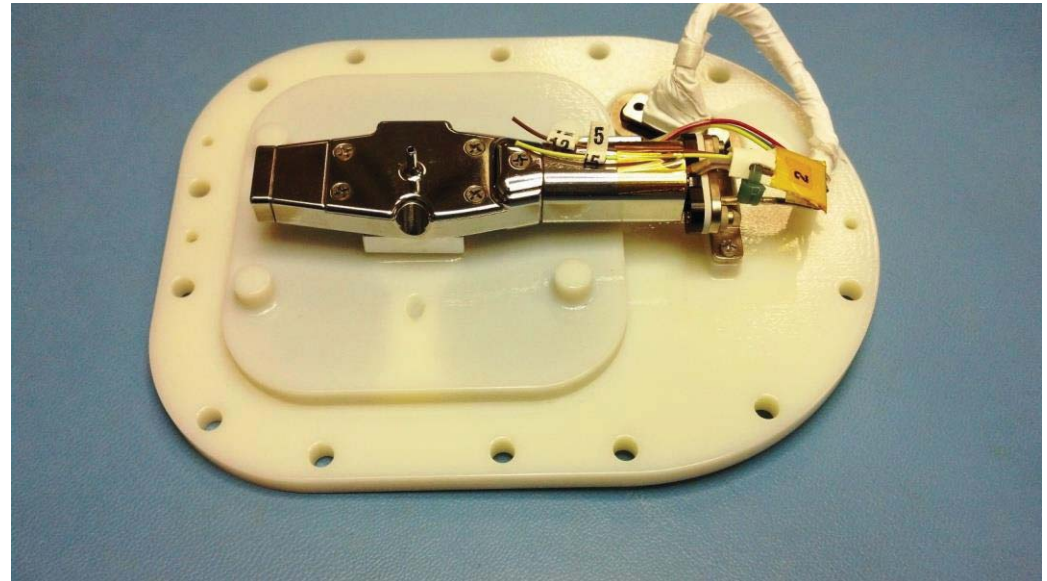
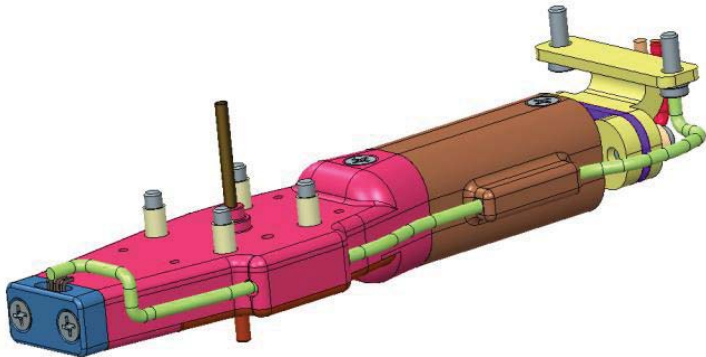
Problems discovered during vibration and life testing

- Estimating proper preload of #1, #2 size fasteners was not exact.
- Threaded solenoid lost preload during repeated open /close cycles of the valve.

Lesson learned

- Arathane 5753 A/B applied to threads eliminated loss of fastener preload.
- Locking Helicoils were successfully used when Arathane was prohibited.

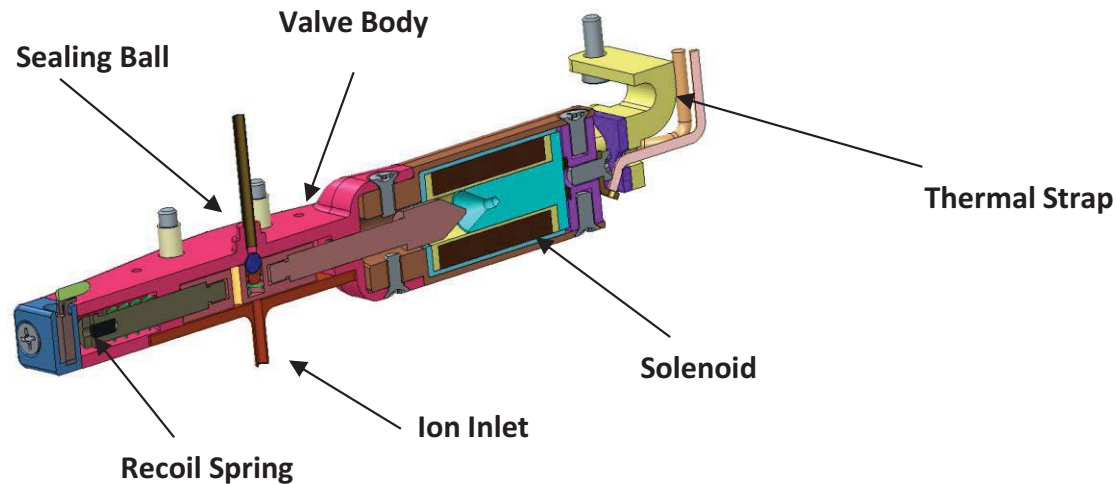
ETU /Flight Aperture valve design



Incorporation of lessons learned

- All threaded features are secured with locking helicoils.
- PVD coatings (TiN and DLC) eliminated in favor of CRES alloy steels.
- Thermal strap was engineered into valve design.
- Plastic solenoid components eliminated in favor of metal parts.

ETU /Flight Aperture valve design



Salient features of ETU /Flight Aperture Valve

- Efficient sealing feature accomplished using check-ball type design.
- Compact footprint 96mm x 24mm x 20mm (L x W x H). @ 102g.
- Sealing capability $> 1\text{E-}6$ cc/sec He.
- High reliability $> 280,000$ cycles.

Conclusions- Lessons Learned



Coatings

- The PVD process used to apply TiN onto internal cavities and bore holes does not produce acceptable adhesion of the TiN film
- Consider having the vendor provide a witness sample prior to coating parts.

Thermal control

- Thermal control was necessary to avoid solenoid failure at 7 torr atmosphere.
- Thermal heat sink was incorporated into ETU and Flight valve designs.

Mechanical fasteners

- Arathane 5753 A/B applied to threads eliminated loss of fastener preload.
- Locking Helicoils were successfully used when Arathane was prohibited.