

Valve Operated Low-Leakage Cryogenic-Connector (VOLC)

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Marshall Space
Flight Center



FAMU-FSU
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Team 513



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Systems
Engineer



Juan Valencia
Thermal Fluids & Design
Engineer



Jackson Herrod
Test
Engineer



Mika Kuschnitzky
Materials/Manufacturing
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Vanderlaan

*FAMU-FSU
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Mika Kuschnitzky

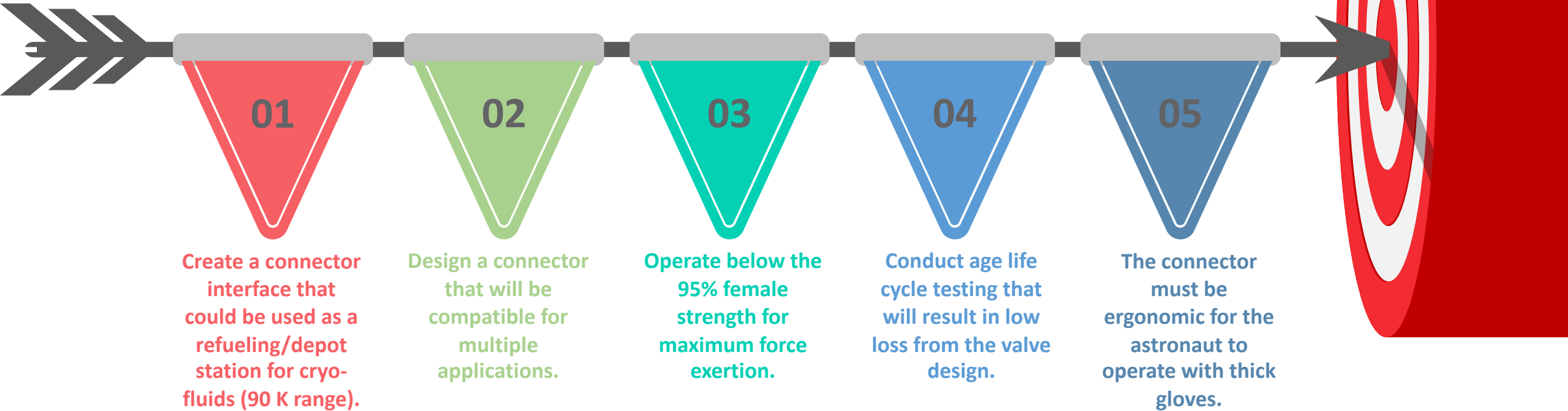
Objective



To design, build, and test a cryogenic connector interface and conduct life cycle testing with a focus on the seal/joint design.

Mika Kuschnitzky

Key Goals



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Customer Needs



01

Material Selection

The metal must maintain its ductility, at cryogenic temperature.



02

Seal Design

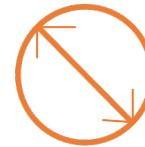
Limit fluid loss through the connector.



03

Strength

Withstand a pressure of 50 psi.



04

Diameter

Range of 1-3 cm as the inner diameter.



05

Reusability

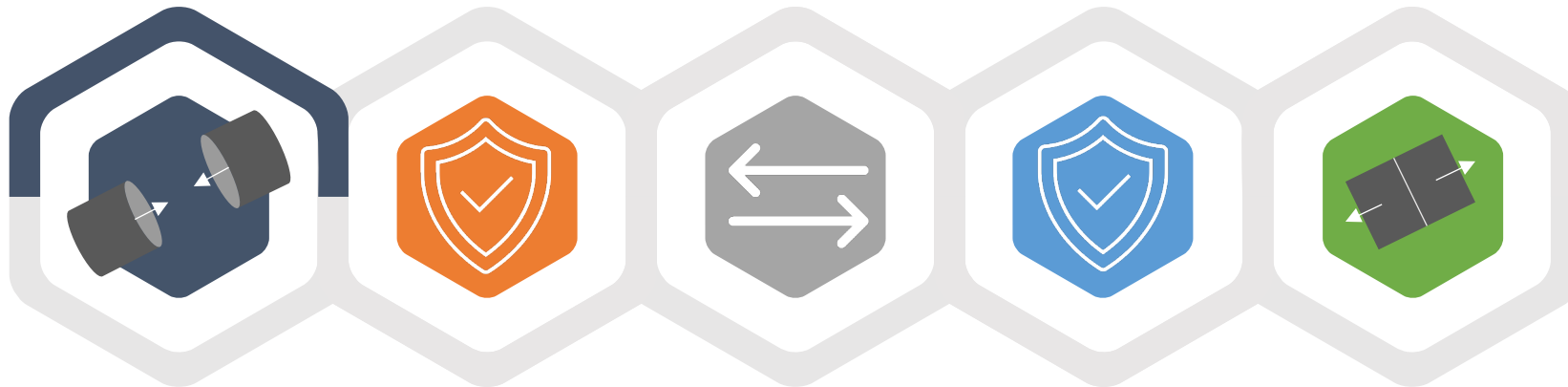
Handle multiple cycles to represent multiple missions

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Functions

Connecting

- Manipulate two ends
- Lock and seal



Mika Kuschnitzky

Functions

Connecting

- Manipulate two ends
- Lock and seal



Protect

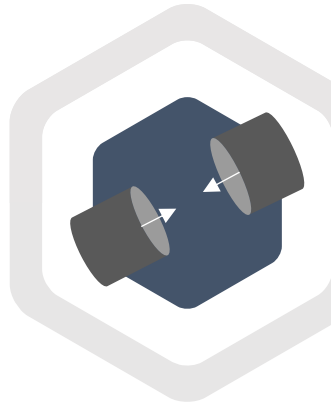
- Prevent environment (dust and dirt) from entering system

Mika Kuschnitzky

Functions

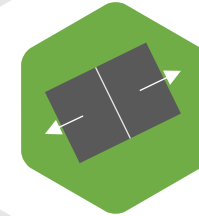
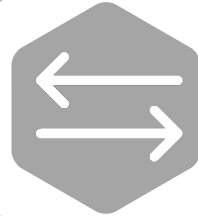
Connecting

- Manipulate two ends
- Lock and seal



Fueling

- Transfer cryo-fluid across connection
- Control fluid dynamics



Protect

- Prevent environment (dust and dirt) from entering system

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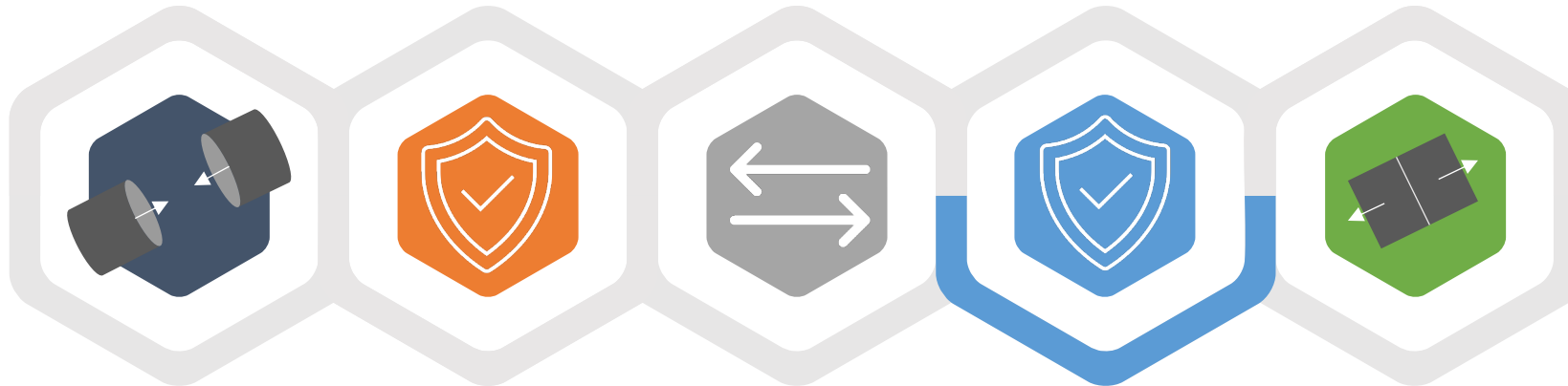
Functions

Connecting

- Manipulate two ends
- Lock and seal

Fueling

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- Control fluid dynamics



Protect

- Prevent environment (dust and dirt) from entering system

Resist

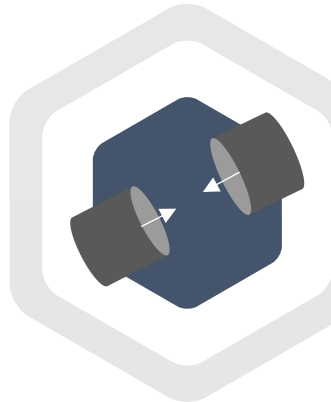
- Prevent breaking between uses
- Mind thermal expansion wear

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Functions

Connecting

- Manipulate two ends
- Lock and seal



Fueling

- Transfer cryo-fluid across connection
- Control fluid dynamics



Protect

- Prevent environment (dust and dirt) from entering system



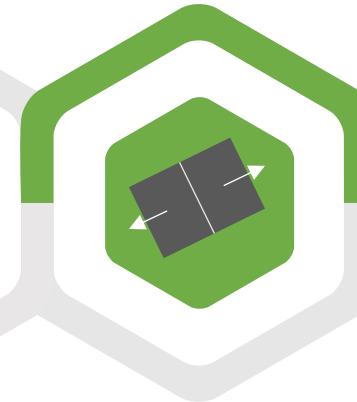
Resist

- Prevent breaking between uses
- Mind thermal expansion wear



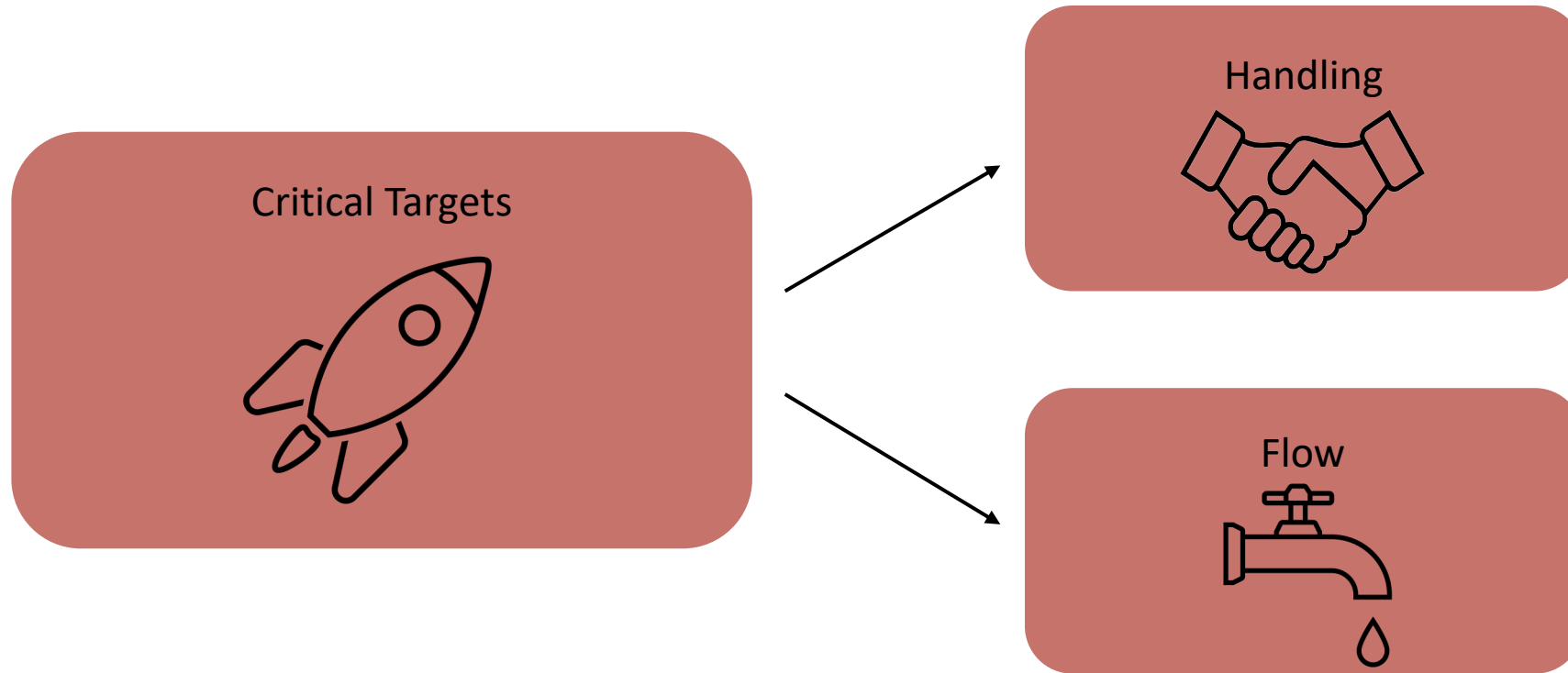
Disconnecting

- Unlock the two ends
- Release seal between connector faces



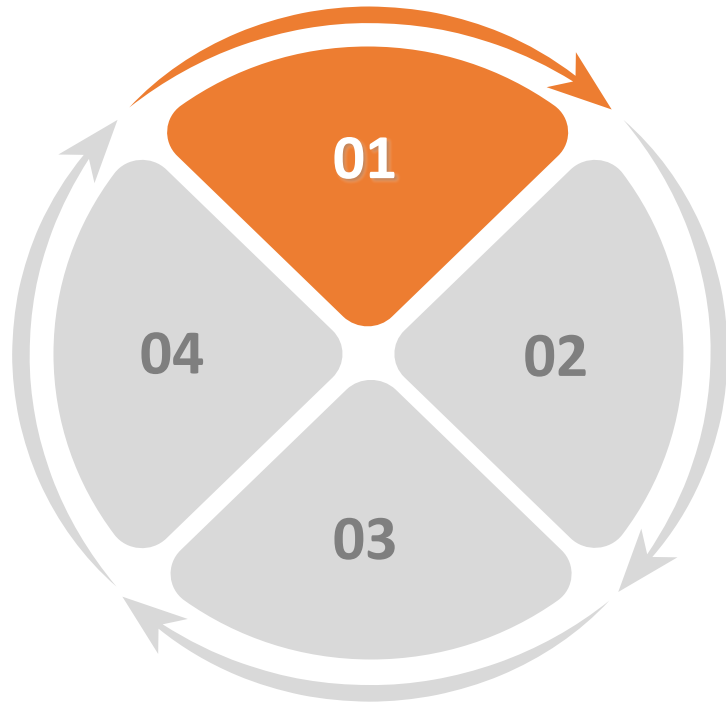
Mika Kuschnitzky





Targets and Metrics

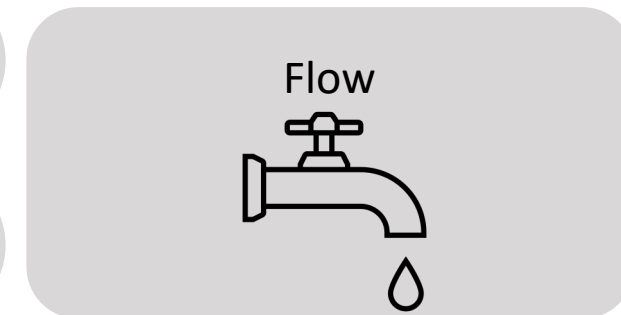


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Targets and Metrics - Critical

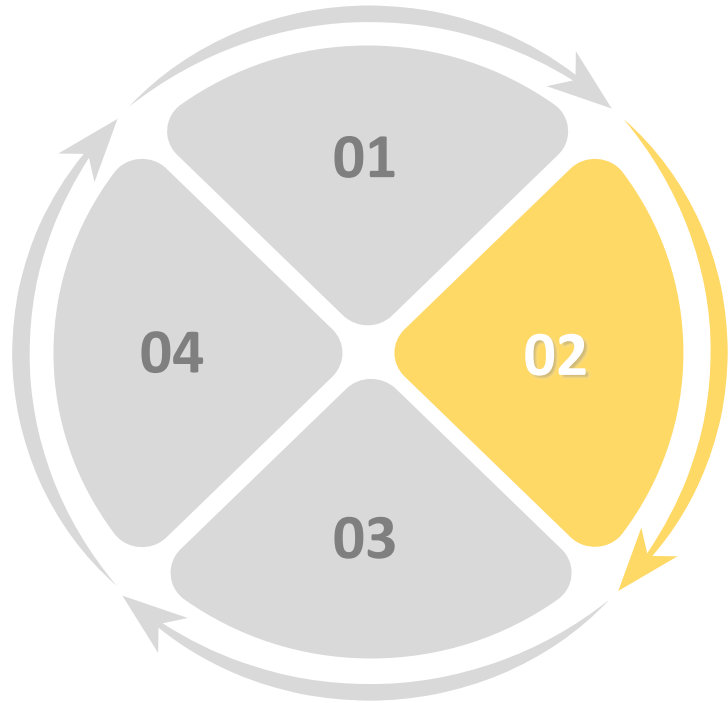






	Ergonomic Connector Diameter	2.57 – 3 cm
	Strength Activation Force	< 48 N
	Fluid Transfer Volumetric Flow Rate	0.1 in ³ /min
	Lock and Seal Permissible Leakage	0.001 in ³ /min



Joshua Leary

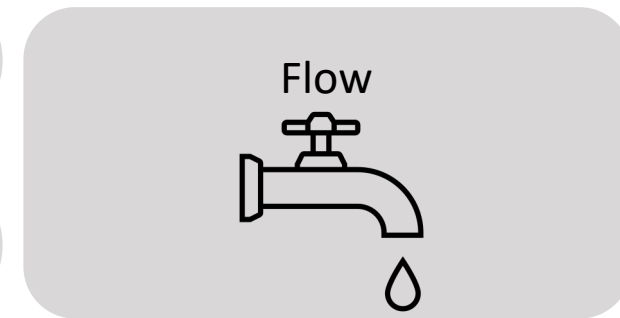
Targets and Metrics - Critical



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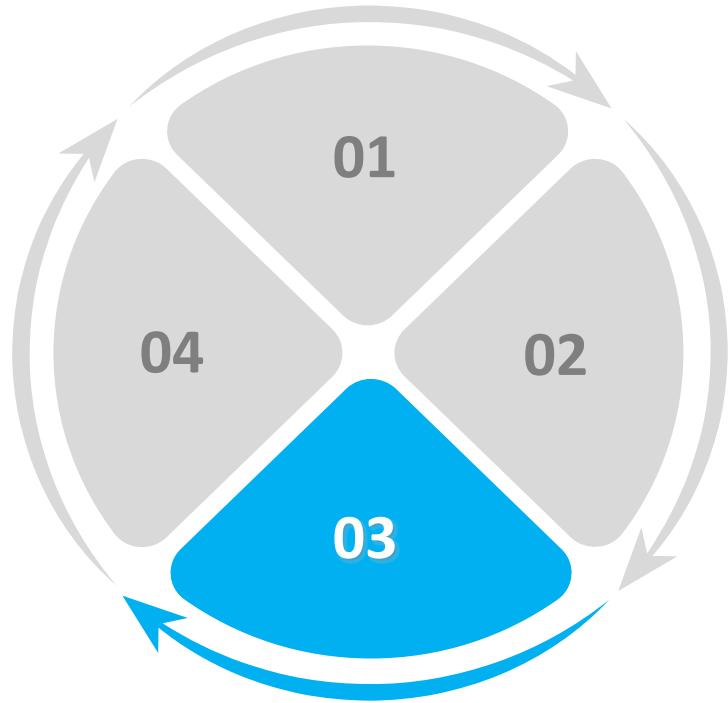
Handling







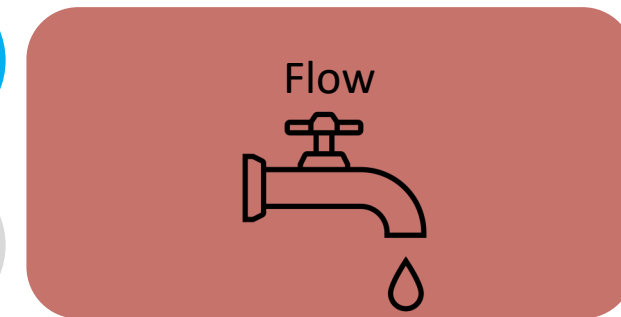
Flow

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Targets and Metrics - Critical

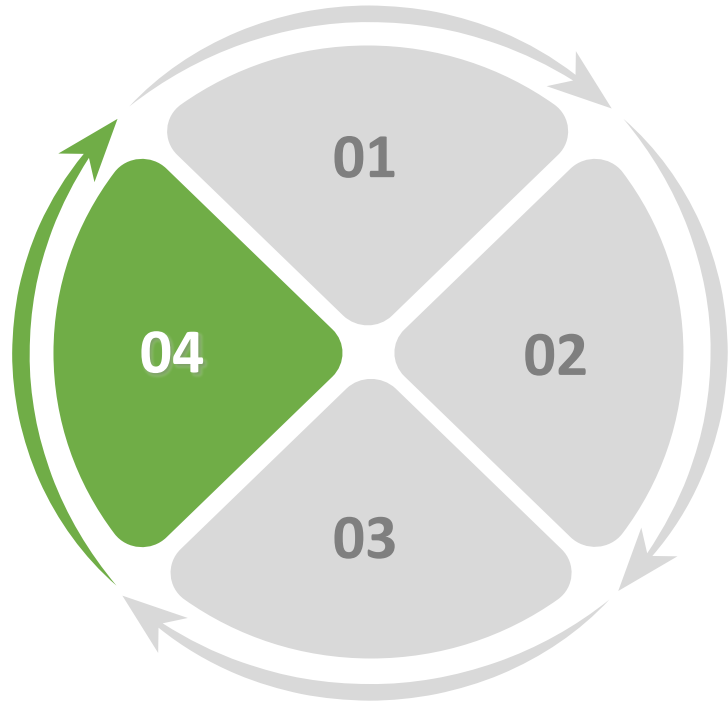






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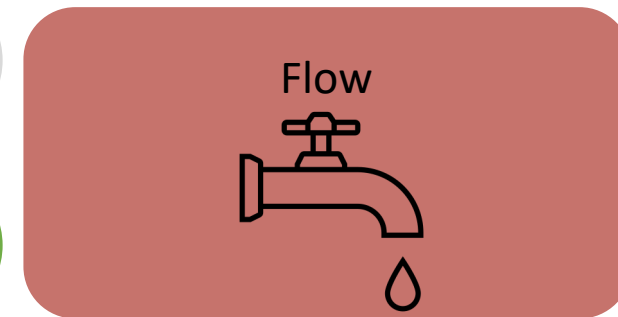


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Targets and Metrics - Critical

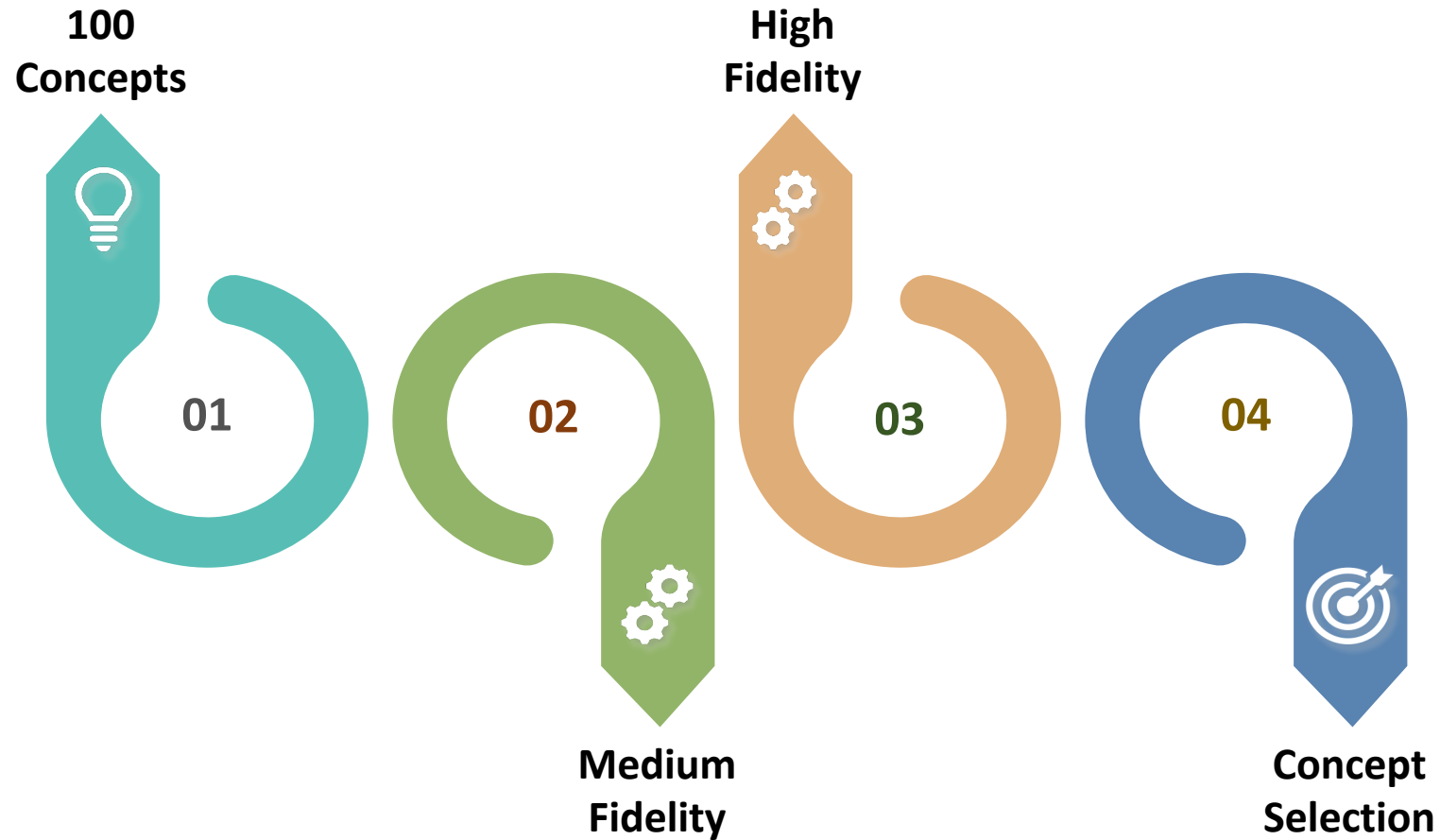


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Joshua Leary

Concept Generation



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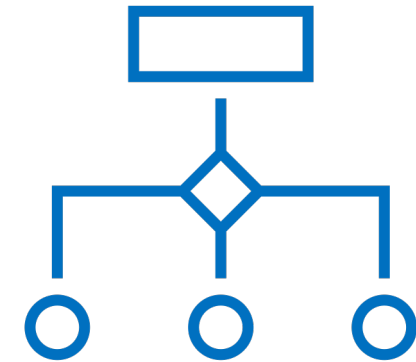
Concept Generation: 100 Concepts



Ideation



Biomimicry

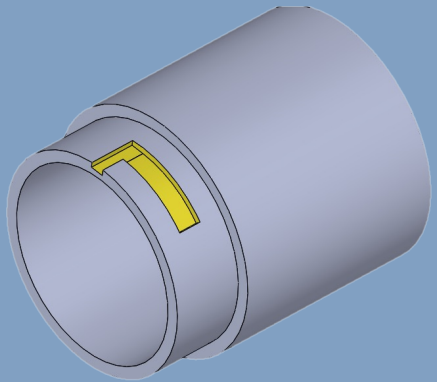


Morphological
Chart

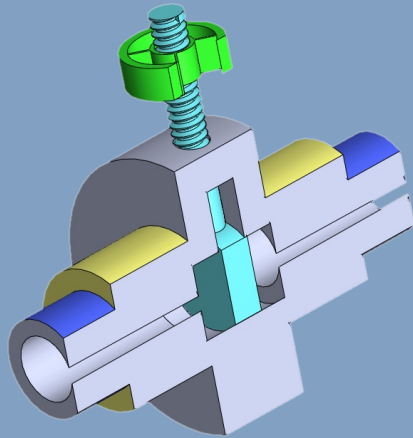
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Concept Generation

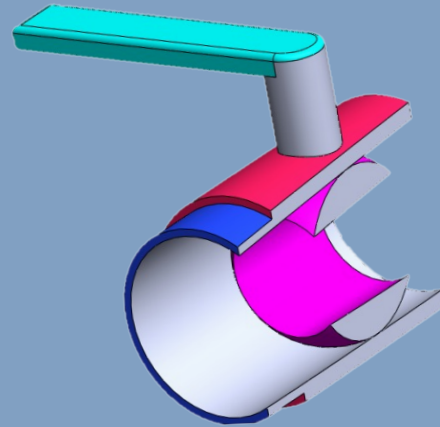
The Key



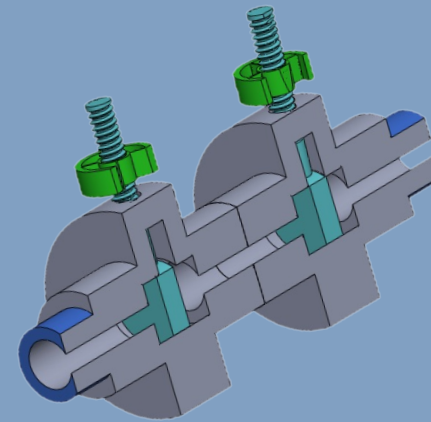
MLI Gate Valve



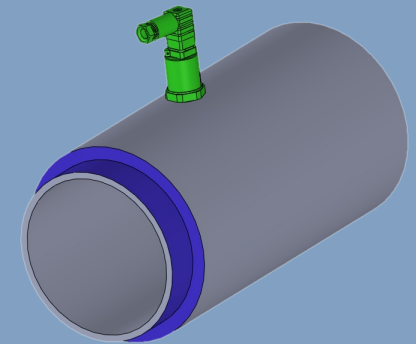
Fiber Glass Ball Valve



Non-insulate Double Gate

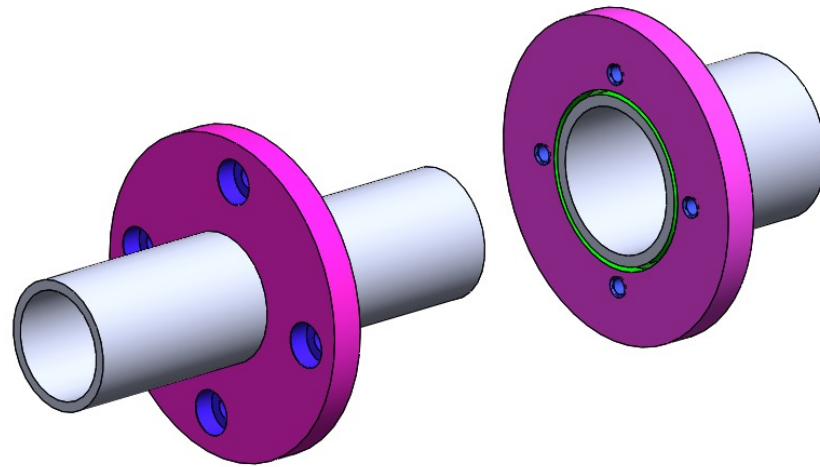


The Sensor



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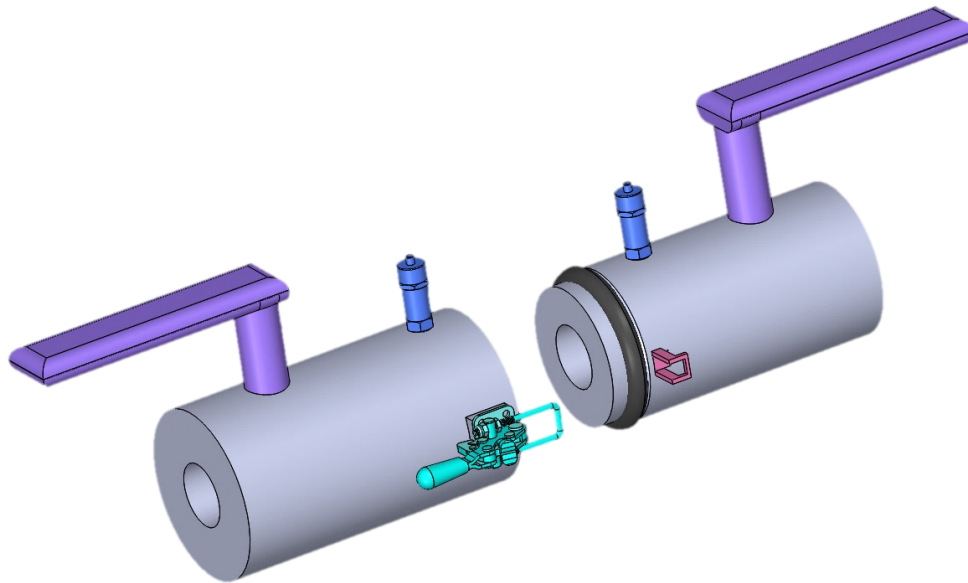
Concept Generation



Cryogenic Bayonet

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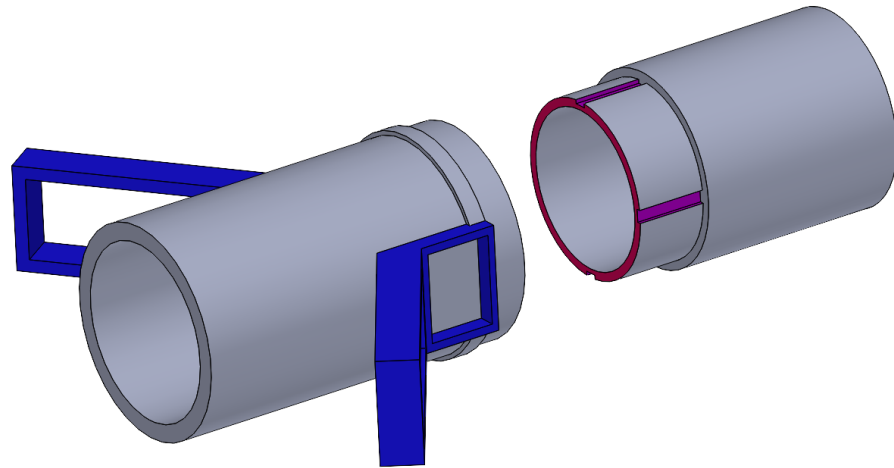
Concept Generation



Latch Sealing

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Concept Generation



Cryogenic Dry Connect

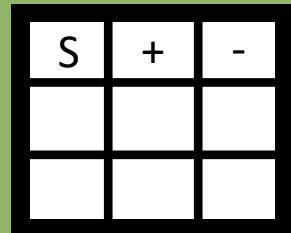
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Concept Selection

HOQ



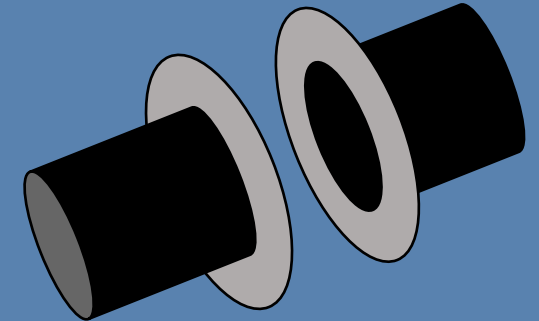
Pugh



AHP



Selection



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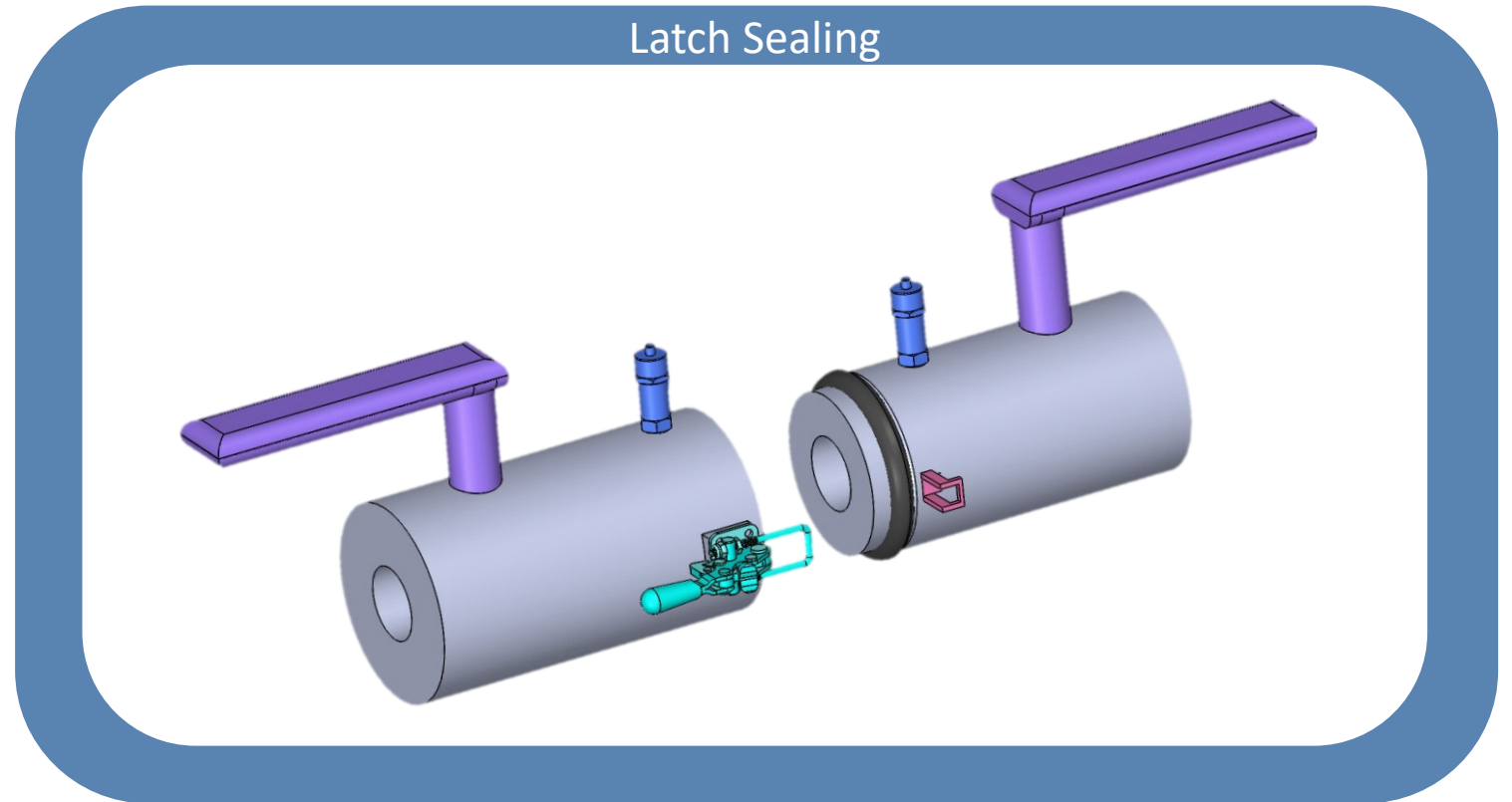
Concept Selection

Most Important Targets

Diameter

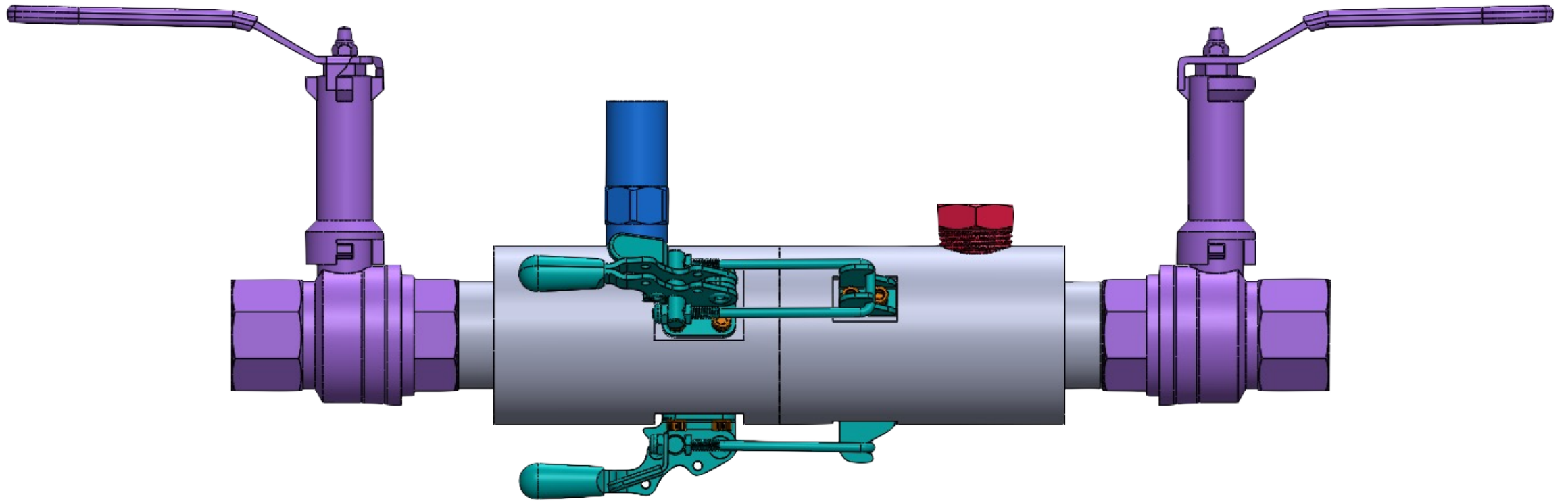
Force

Leakage



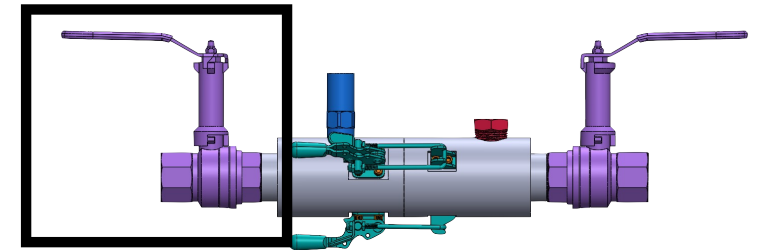
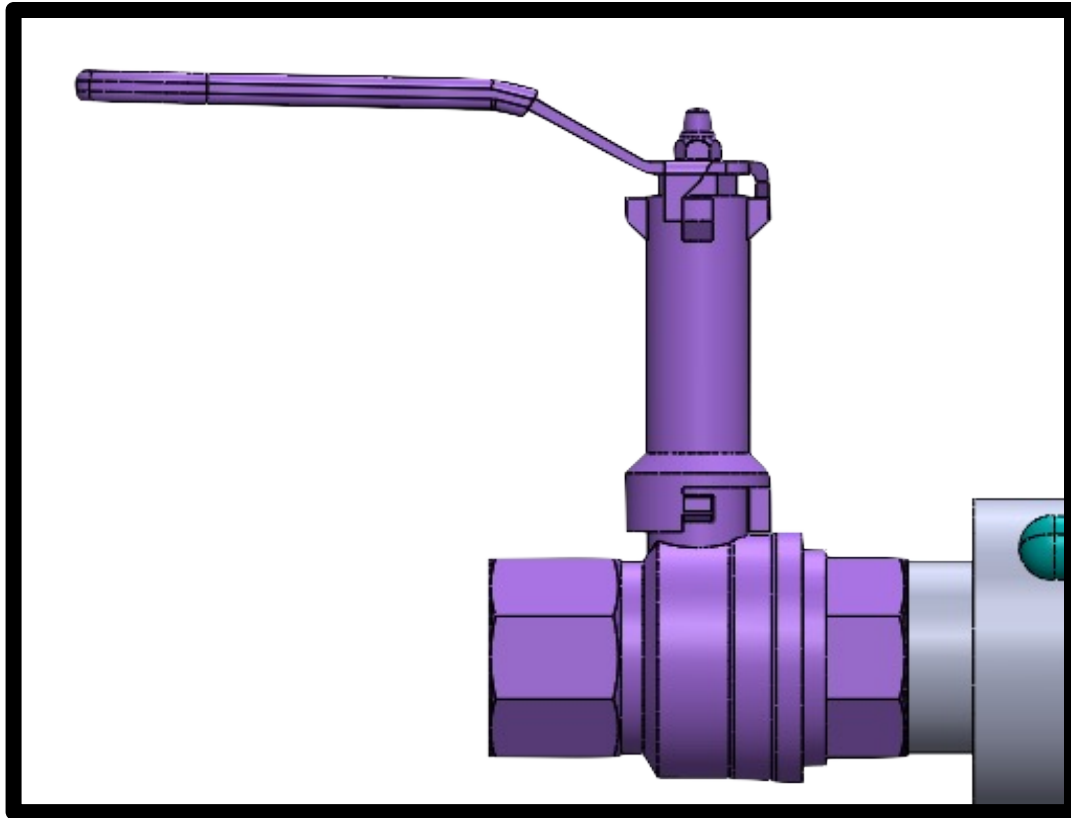
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Final Design



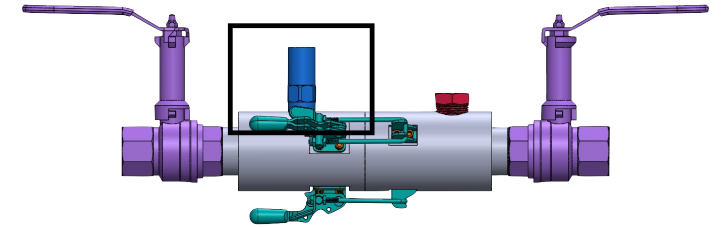
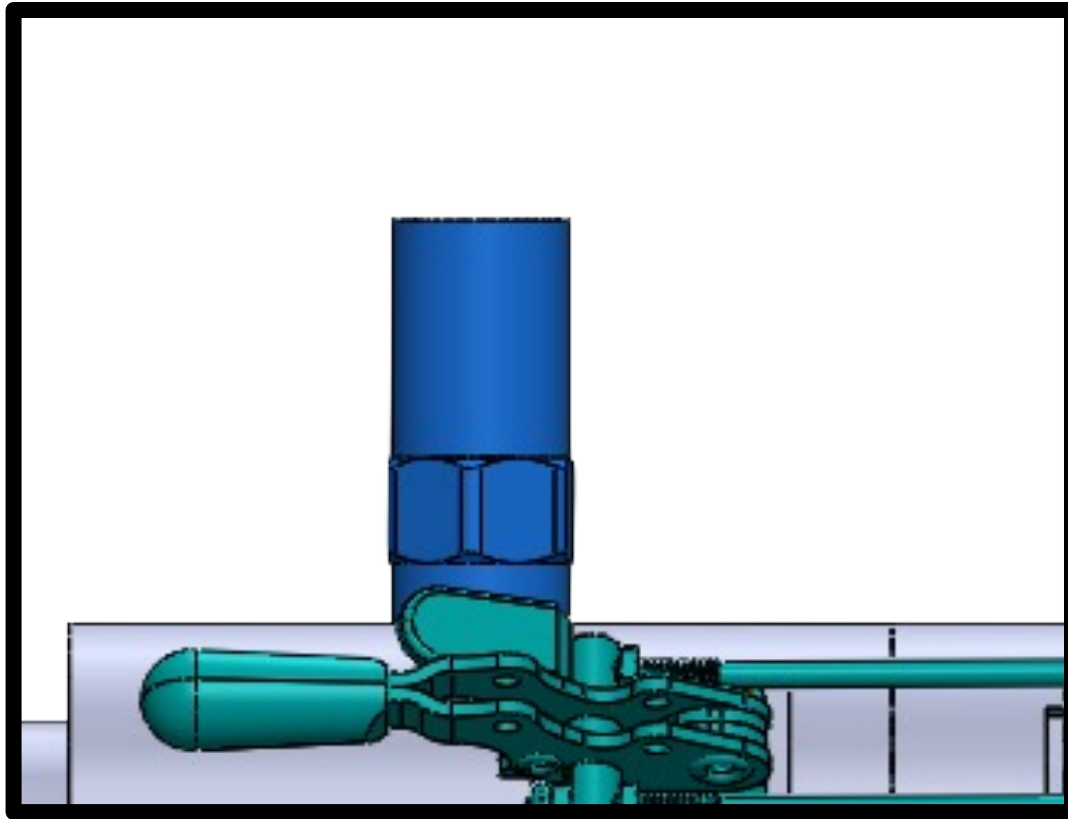
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Final Design – AVCO Ball Valves



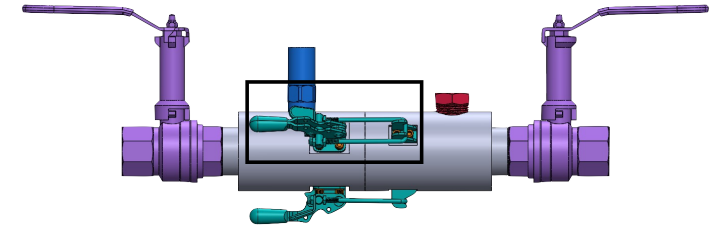
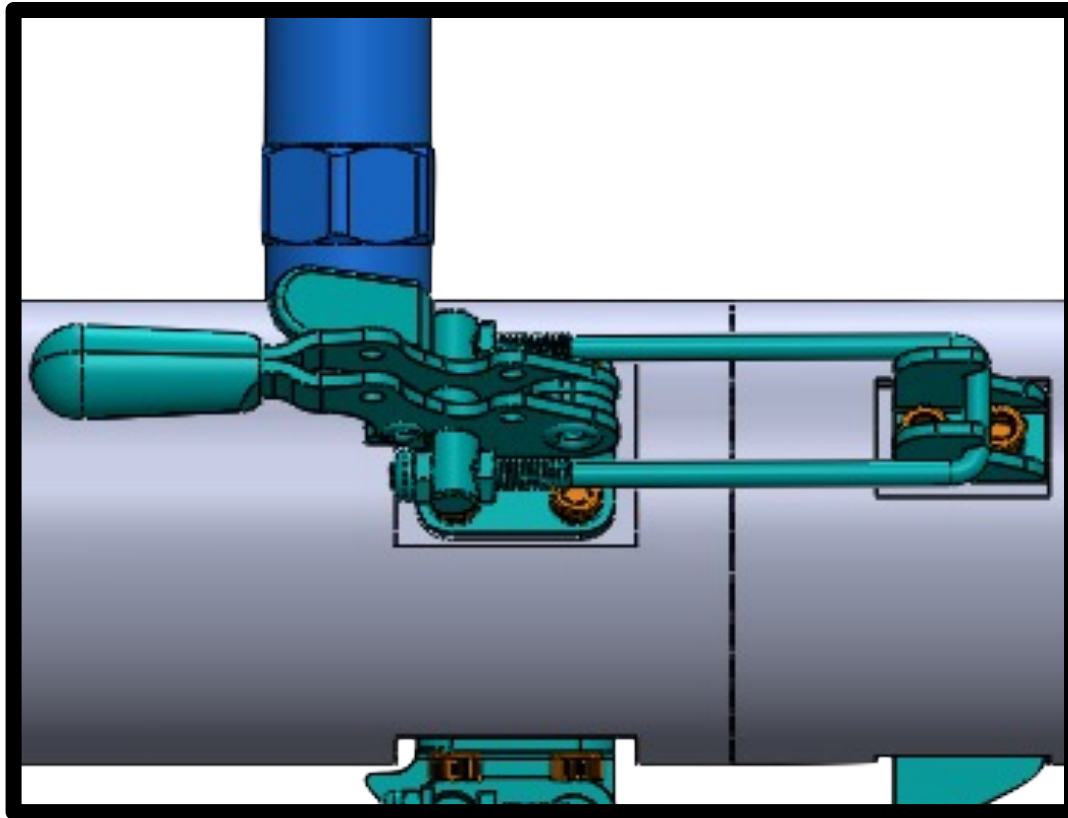
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Final Design – Automatic Relief



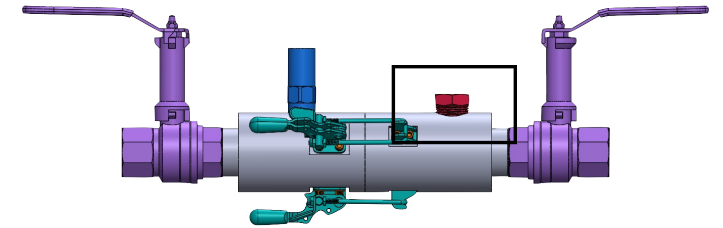
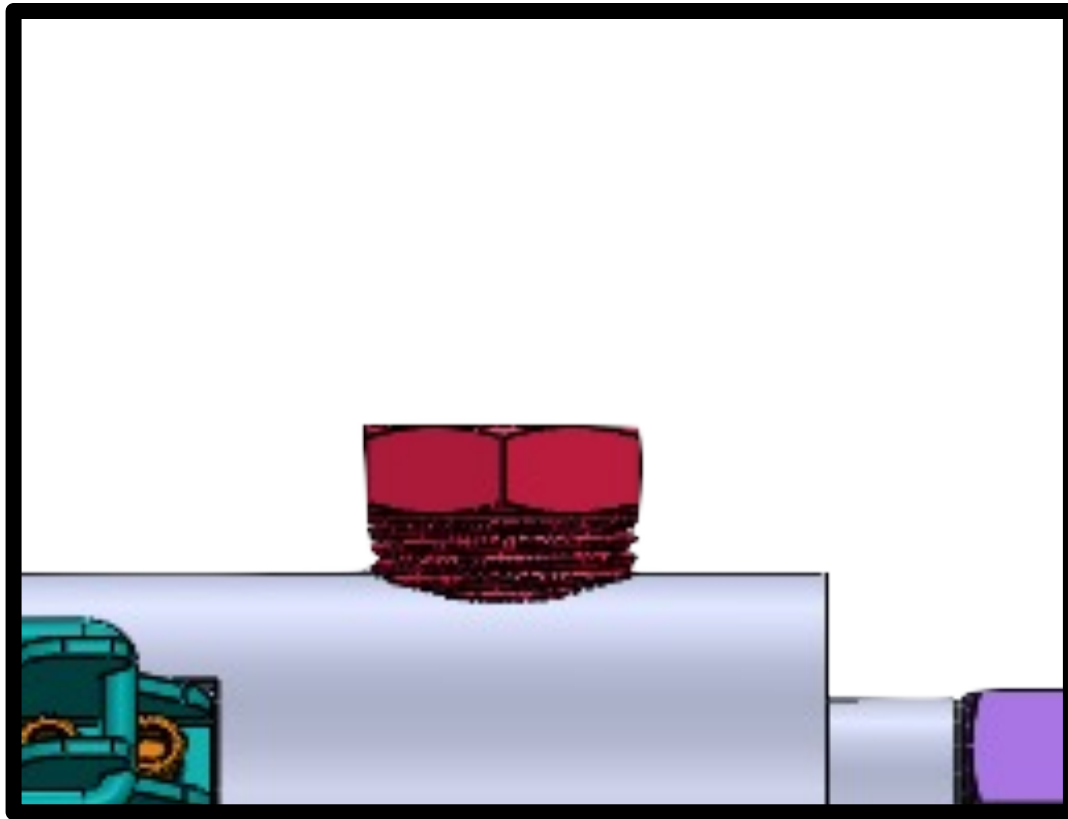
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Final Design - Latches



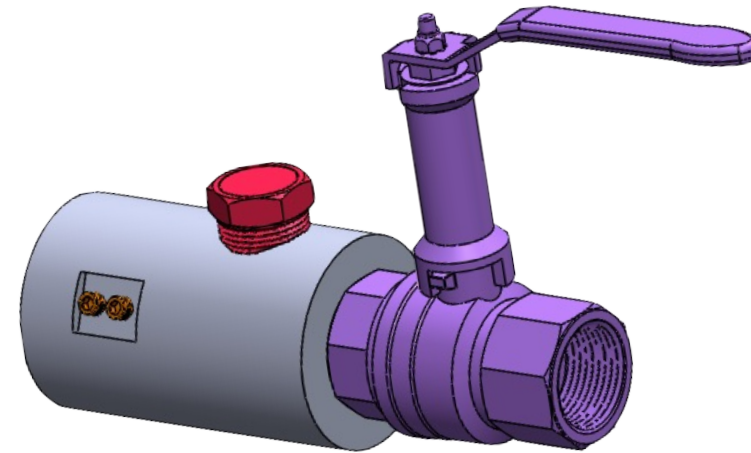
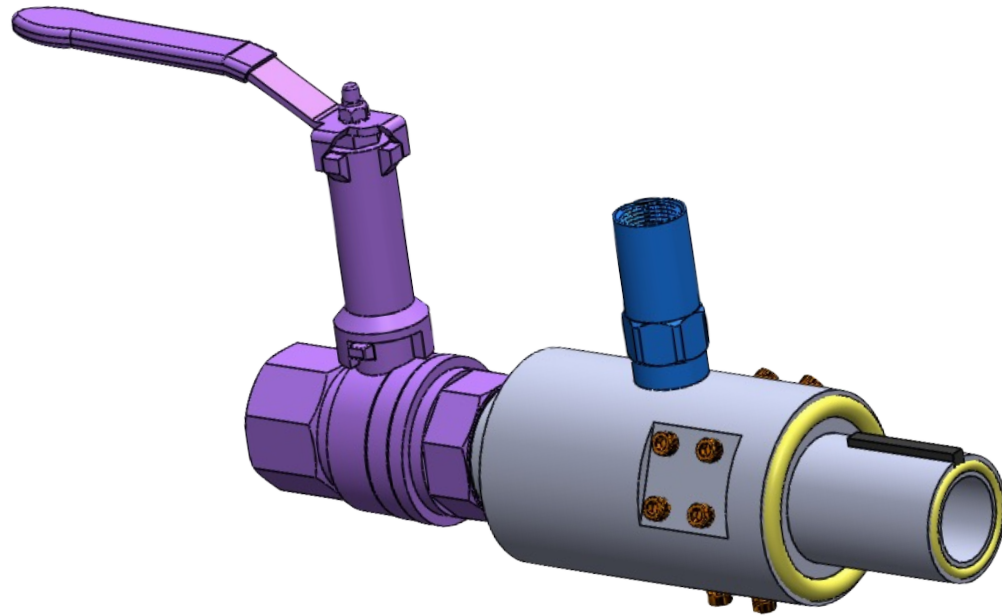
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Final Design – Manual Relief



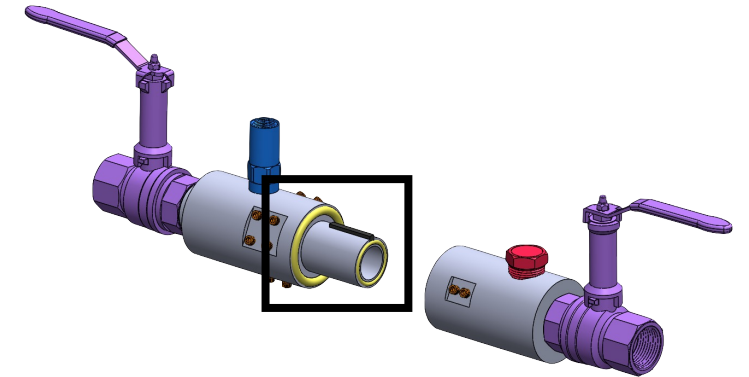
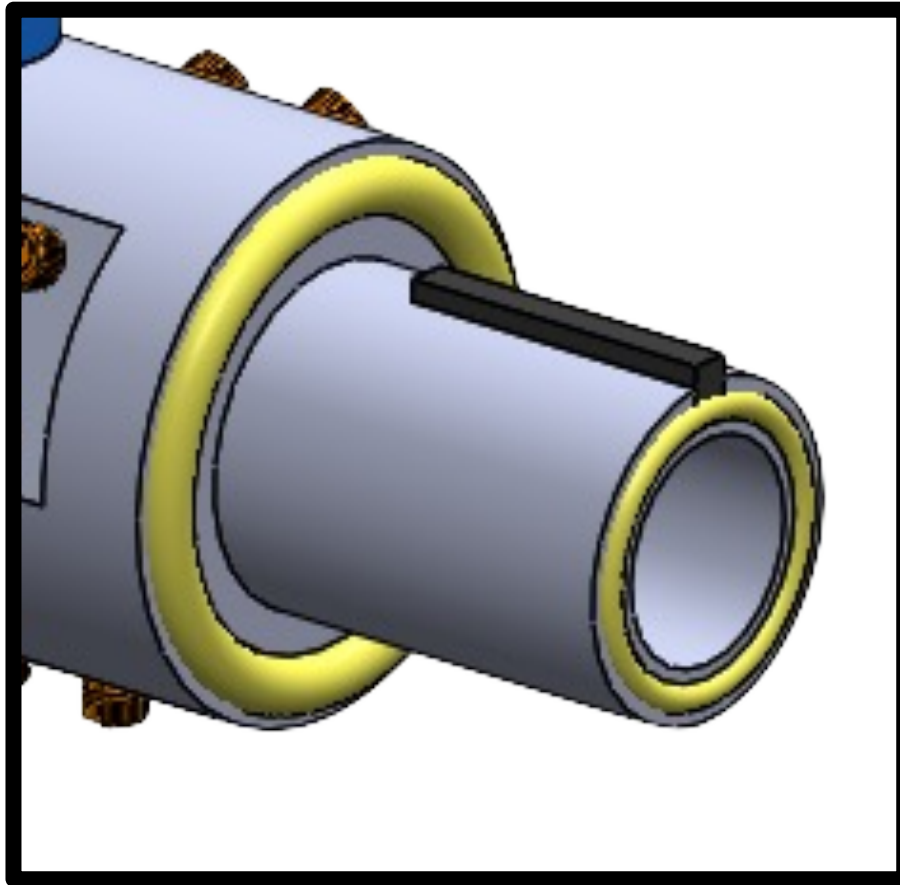
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Final Design



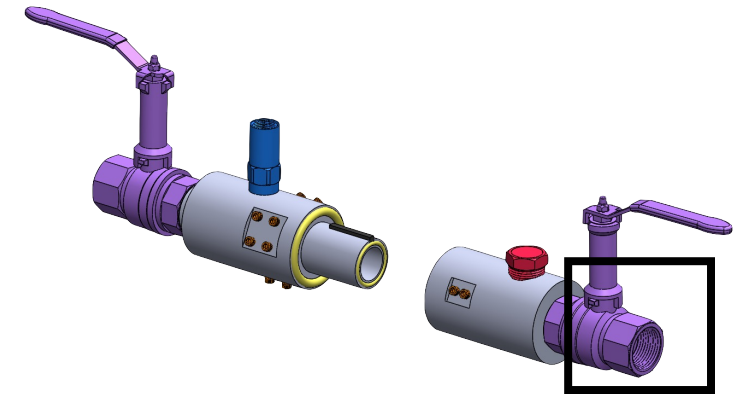
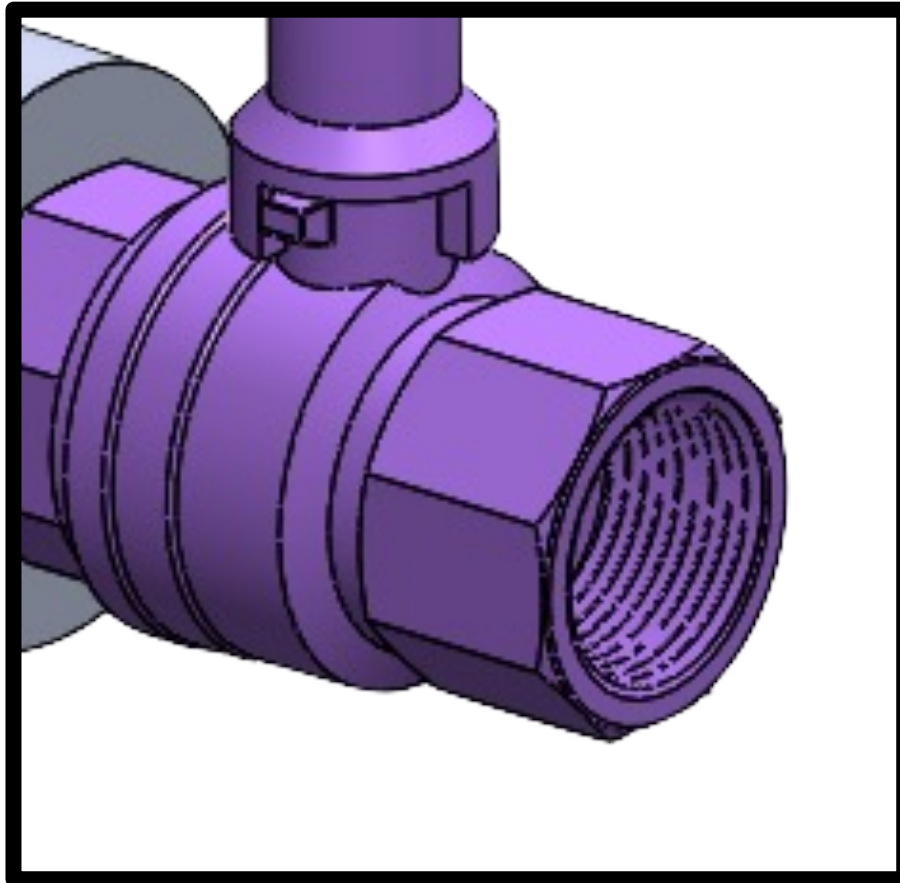
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Final Design – O-rings and Key



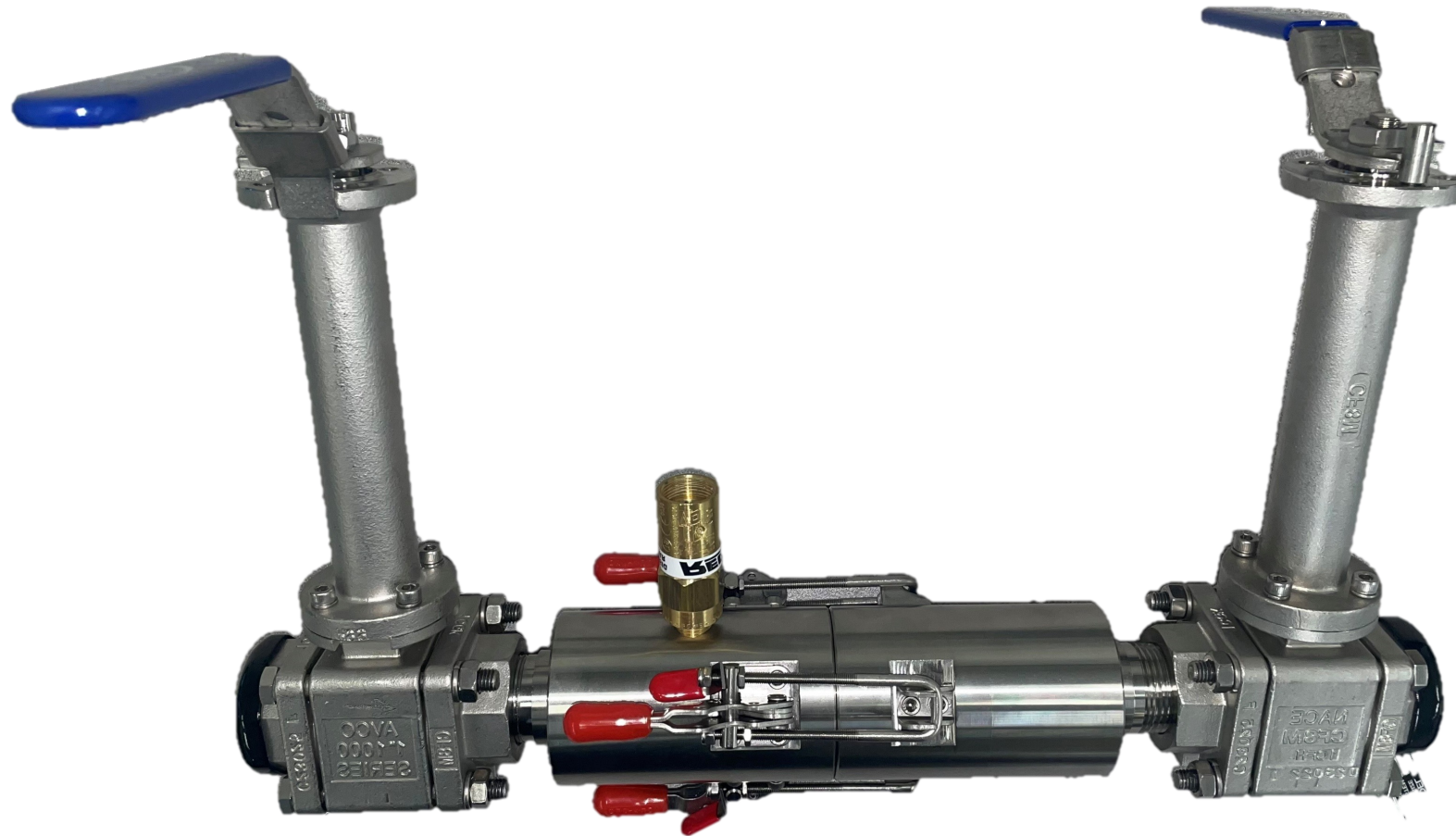
Juan Valencia

Final Design – 1" NPT



Juan Valencia

Final Design



Juan Valencia

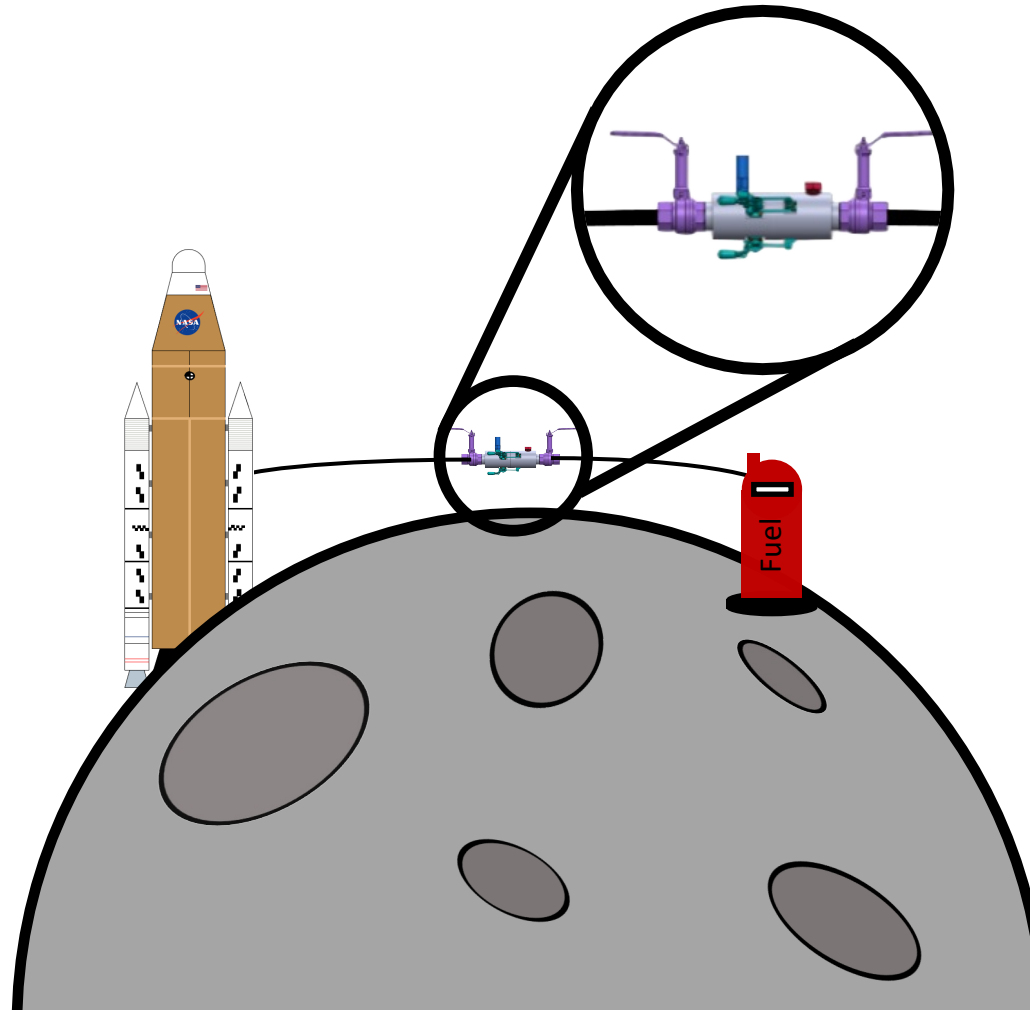
Testing Conditions

Lunar

Atmosphere = 0.3 nPa

Temp in Sunlight = 400 K

Temp in Shade = 140 K



Fuel

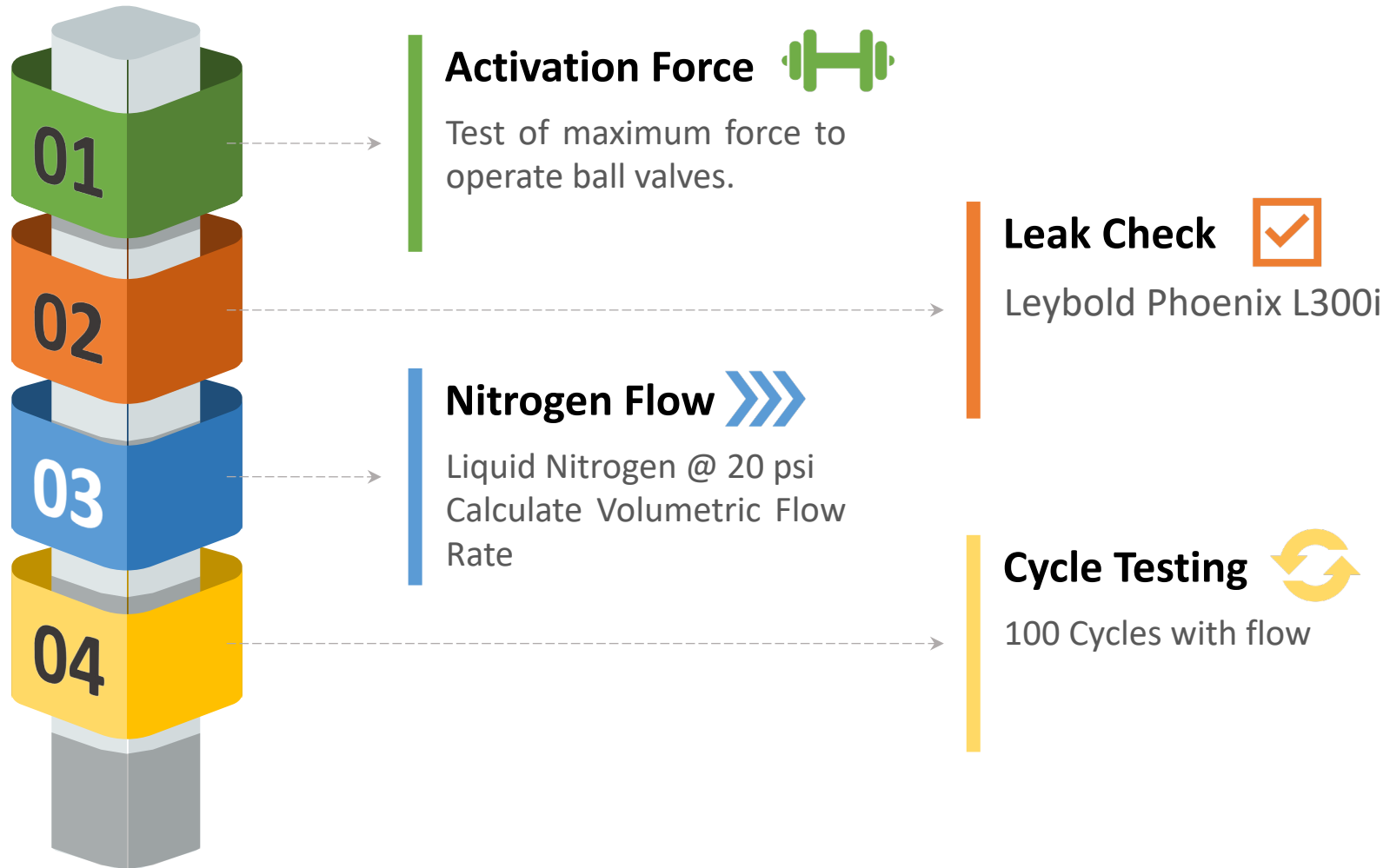
Fluid Pressure = 50 psi

Temperature = 90 K

Flow Rate = 0.1 in³/min

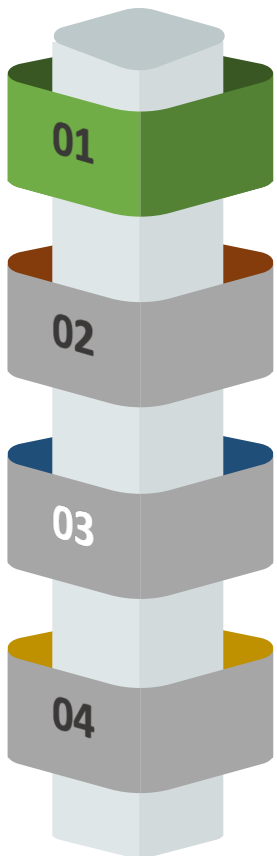
Jackson Herrod

Methods of Validation



Jackson Herrod

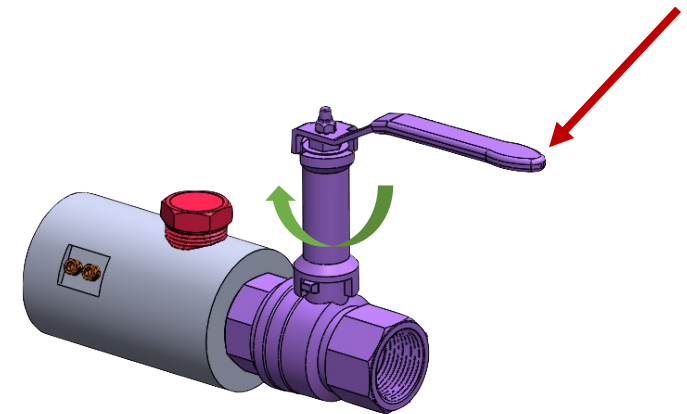
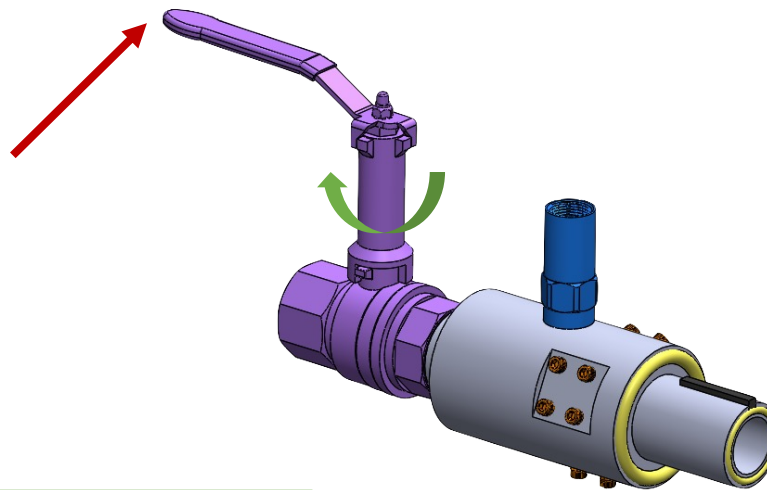
Methods of Validation



Activation Force

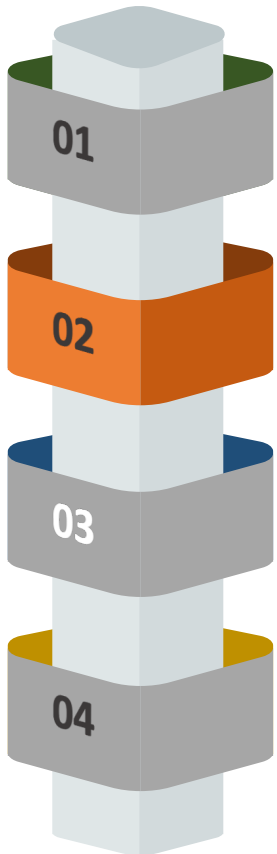
Test of maximum force to operate ball valves.

Target Operation Force	Experimental Operation Force
< 48 N	44 N



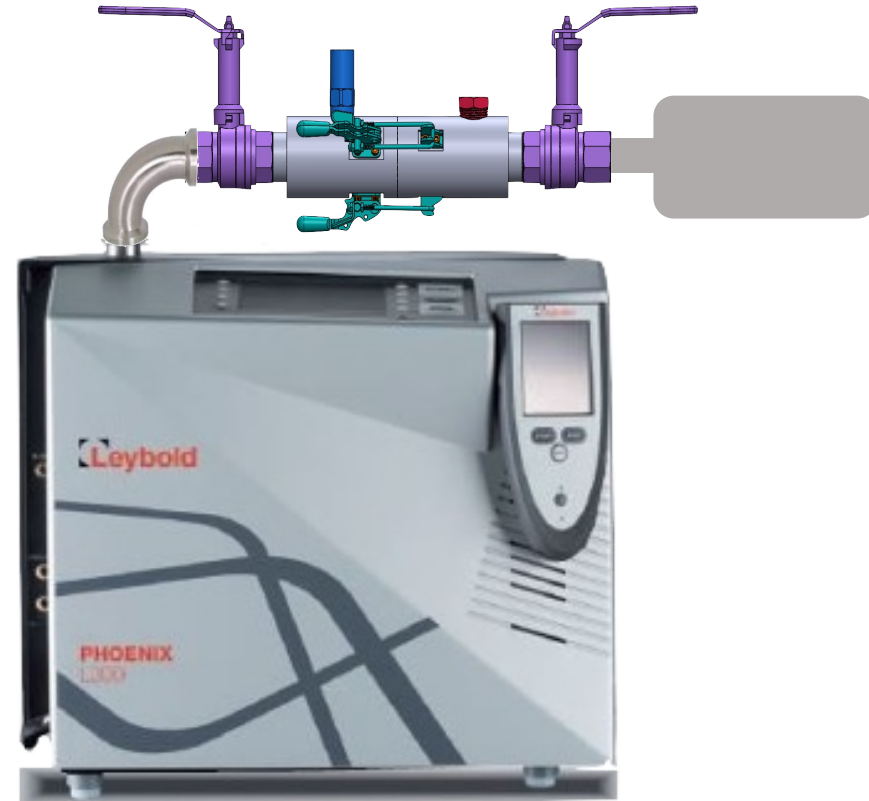
Jackson Herrod

Methods of Validation



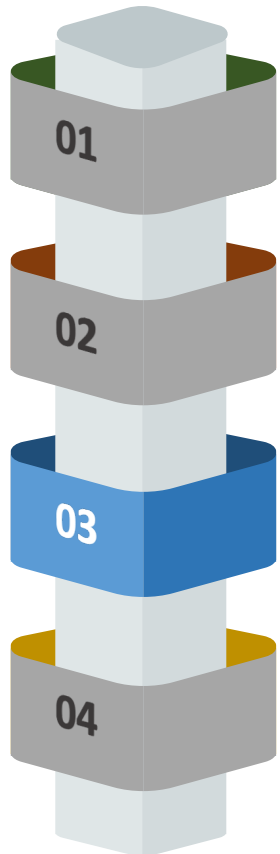
Leak Check

Leybold Phoenix L300i



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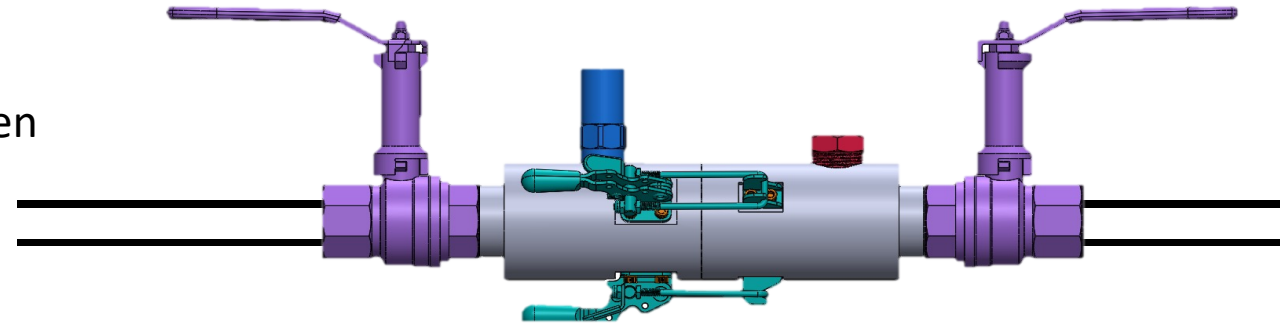
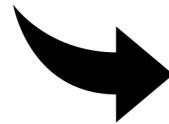
Methods of Validation



Nitrogen Flow >>>

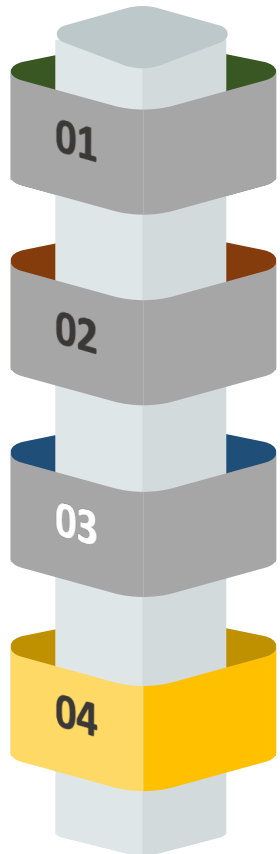
Liquid Nitrogen @ 20 psi
Calculate Volumetric Flow
Rate


Liquid Nitrogen



Jackson Herrod

Methods of Validation



Cycle Testing 
100 Cycles with flow

Disconnect

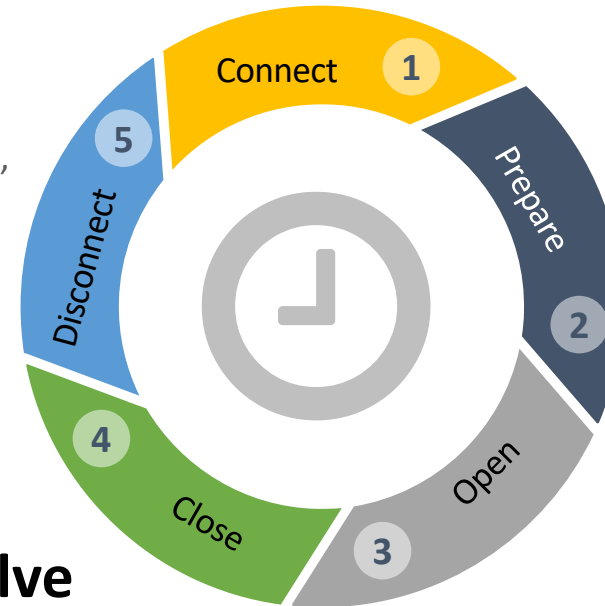
Unhook latches and move the two connector ends apart, relieving the O-ring of its compression.

Close valve

Operate both valves into the closed position, preventing flow across the O-ring boundary.

Connect

Bring both ends of connector together. Lock in place with latches.



Open valves

Operate both valves into the open position allowing flow across O-ring boundary.

Prepare flow

Ensure that the cryogenic fluid is ready for flow.

Jackson Herrod

Purchasing

Purchased

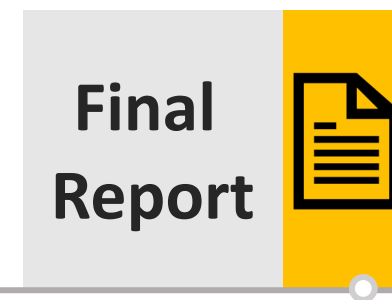
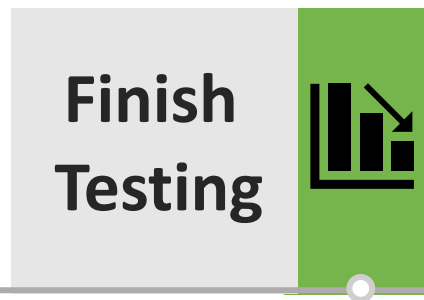
- 304 Stainless Steel Rod
- 3 Latches
- 8-32 Screws
- Automatic Relief Valve
- 18-8 Machine Key
- Avco Ball Valves
- 8-32 Screws

Needed

- O-rings

Jackson Herrod

Upcoming Work



Mika Kuschnitzky

Lessons Learned

Keep more consistent updates with sponsor and advisor

Spend more time on design iterations earlier

Take advantage of professional contacts

Mika Kuschnitzky

VOLC

V_{alve} O_{perated} L_{ow-Leakage} C_{ryogenic-Connector}



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Engineer