Valve Operated Low-Leakage Cryogenic-Connector (VOLC)

Joshua Leary | Juan Valencia | Jackson Herrod | Mika Kuschnitzky

Marshall Space Flight Center

FAMU-FSU College of Engineering

Team 513

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Systems
Engineer

Juan Valencia
Thermal Fluids & Design
Engineer

Jackson Herrod
Test
Engineer

Mika Kuschnitzky
Materials/Manufacturing
Engineer

Sponsor and Advisor

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NASA Marshall Space Flight Center

Shawn E. Brechbill

NASA Marshall Space Flight Center

Mark Vanderlaan

FAMU-FSU College of Engineering

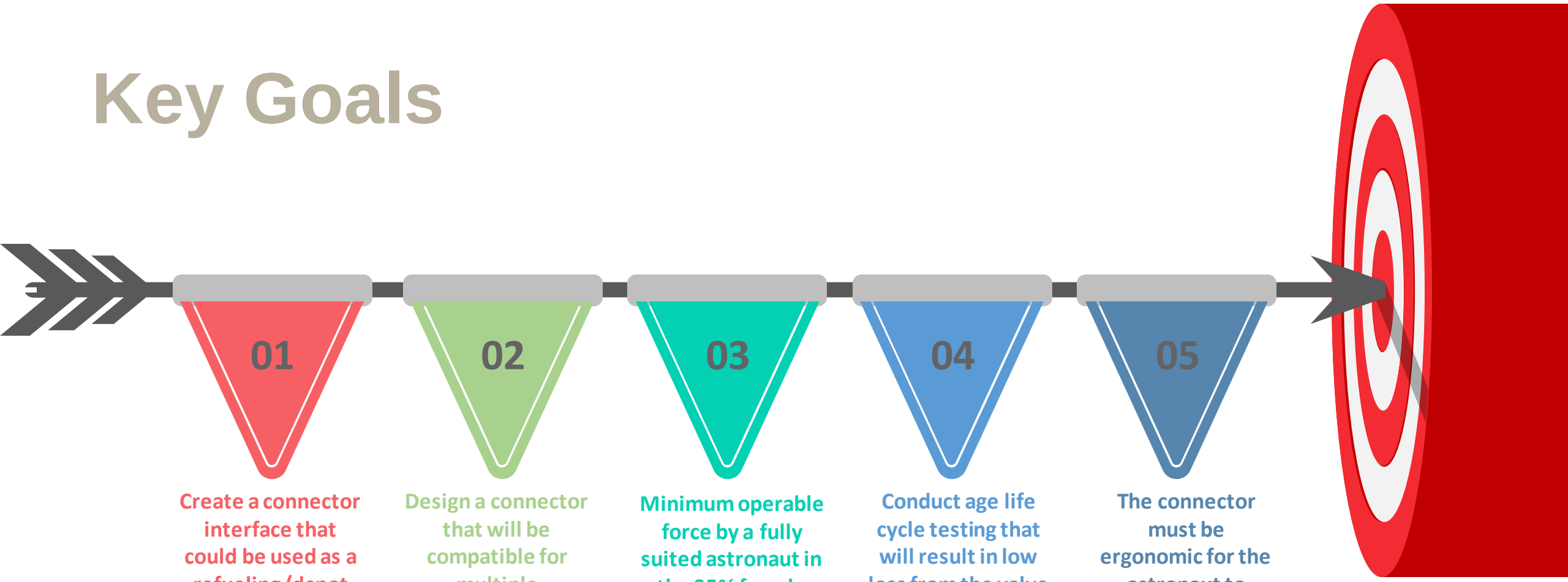
Mika Kuschnitzky

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



Create a connector interface that could be used as a refueling/depot station for cryo-fluids (90 K range).

Design a connector that will be compatible for multiple applications.

Minimum operable force by a fully suited astronaut in the 95% female strength percentile.

Conduct age life cycle testing that will result in low loss from the valve design.

The connector must be ergonomic for the astronaut to operate with thick gloves.

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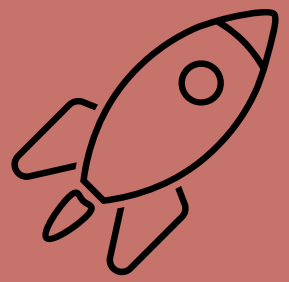
Targets and Metrics

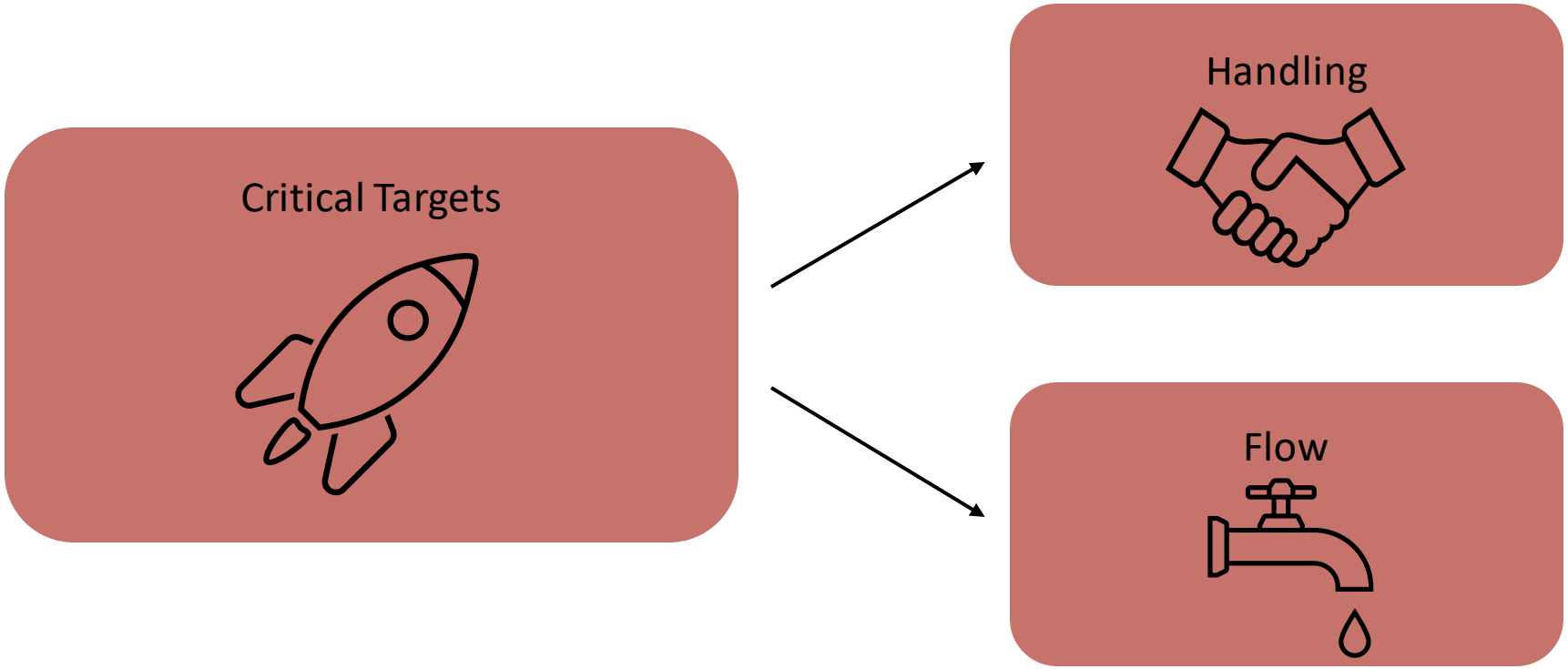
Critical Targets



Secondary Targets

Joshua Leary

Targets and Metrics



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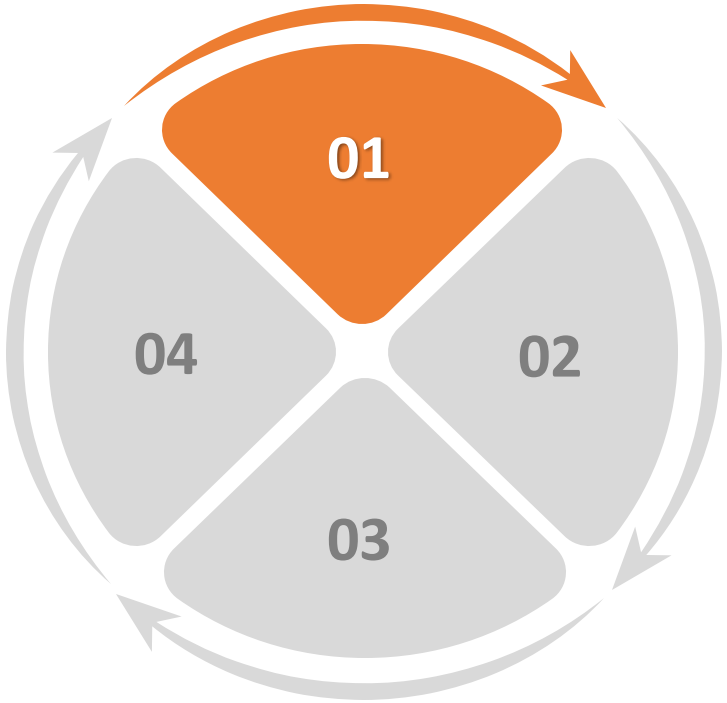
Targets and Metrics - Critical



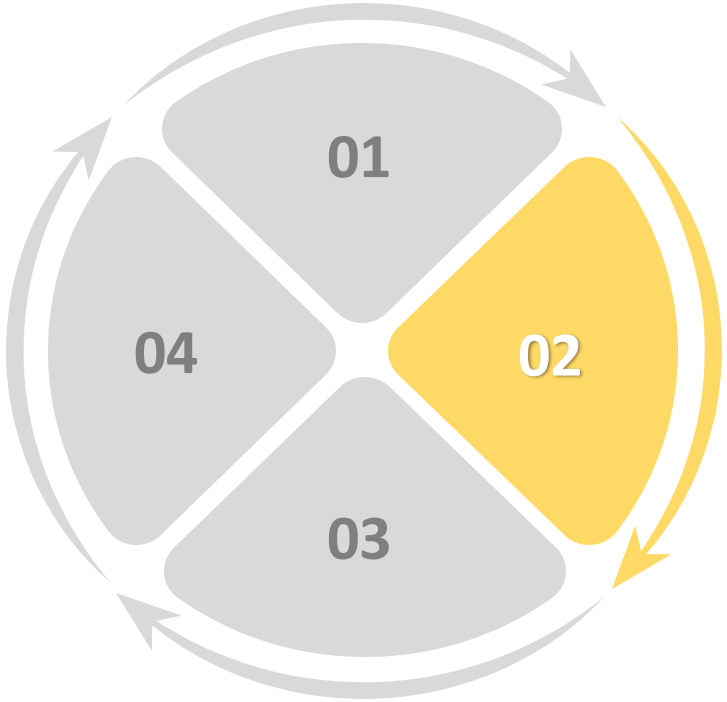
Ergonomic	Connector Diameter	2.57 – 3 cm
Strength	Activation Force	< 48 N
Fluid Transfer	Volumetric Flow Rate	0.1 in^3/min
Lock and Seal	Permissible Leakage	0.001 in^3/min

Handling

Flow

Joshua Leary

Targets and Metrics - Critical



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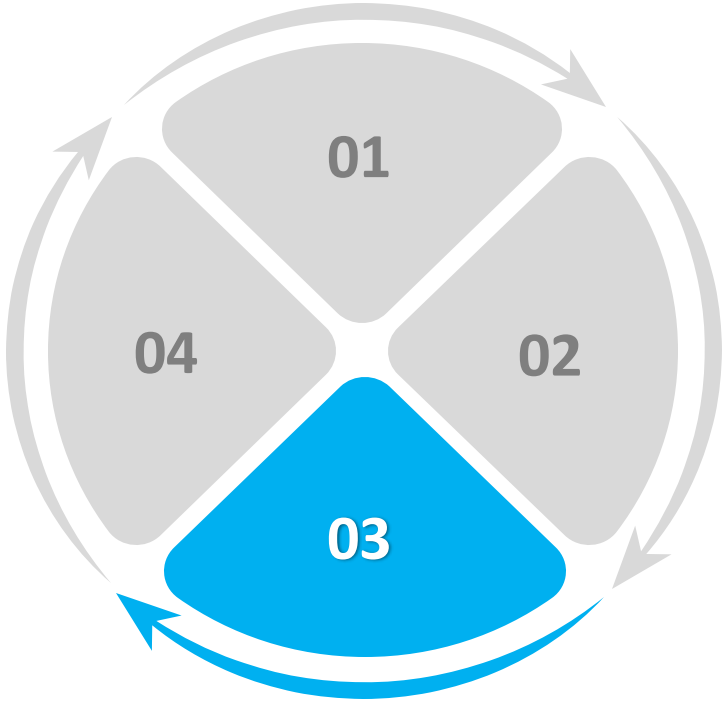

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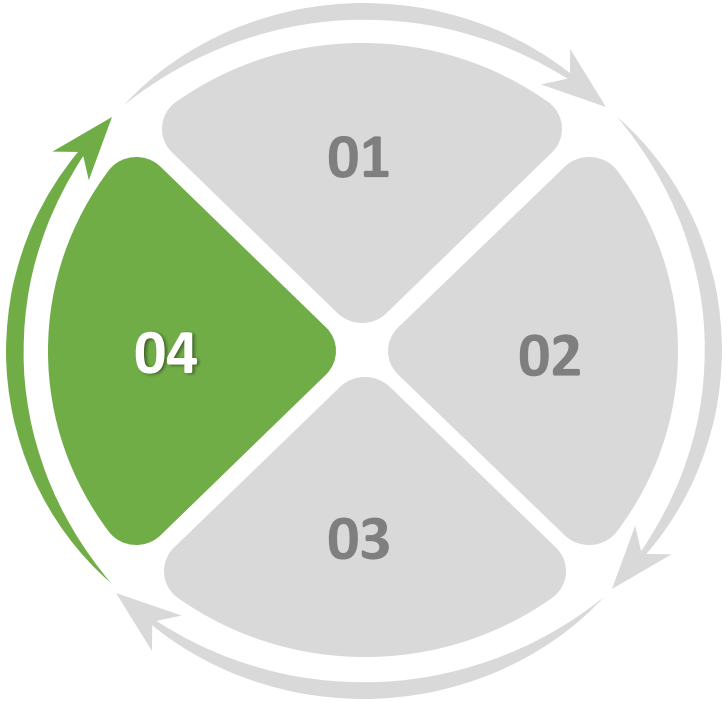

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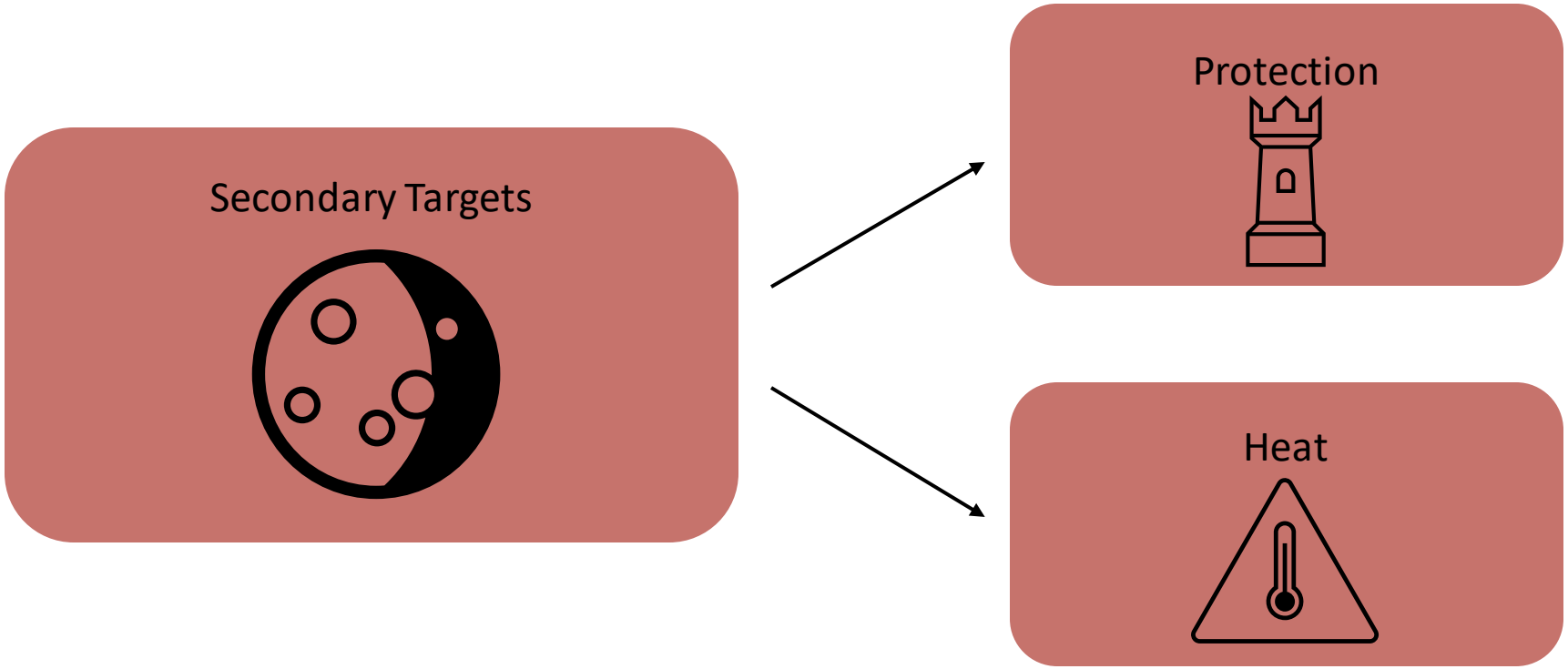

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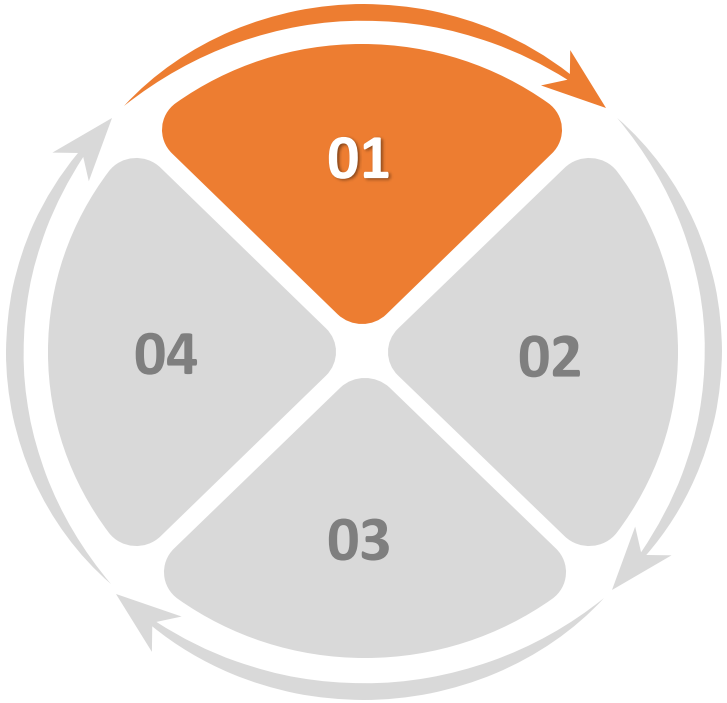
Targets and Metrics - Secondary



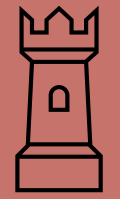
Shield
Ingress Protection
IP64

Prevent Breaking
Ultimate Tensile Strength
500 MPa

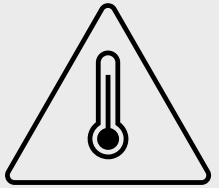
Thermal Expansion
Expansion Difference
Negligible

Control fluid
Boil off Rate
0.023 in^3/min

Protection



Heat



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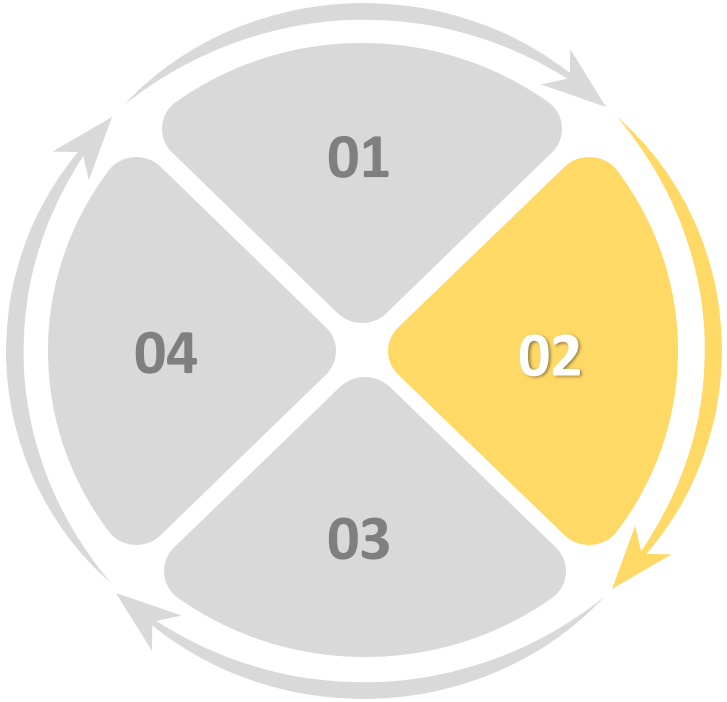

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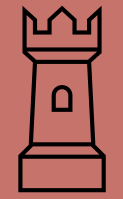

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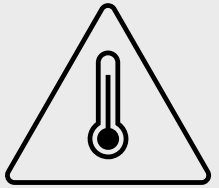

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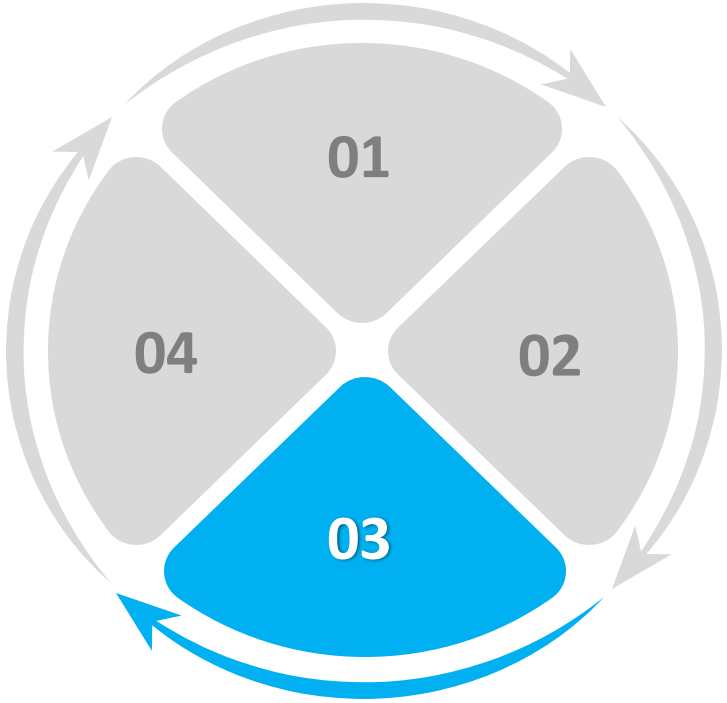

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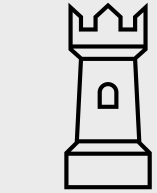

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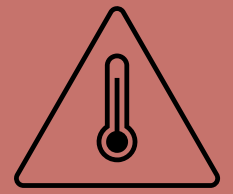

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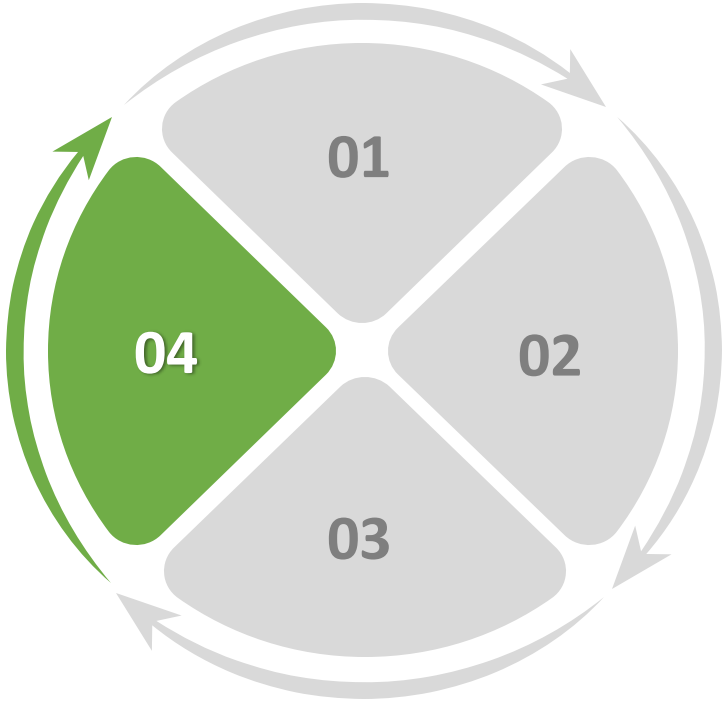

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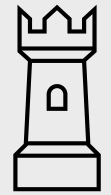

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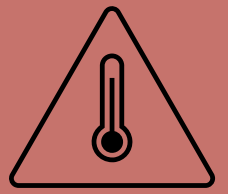

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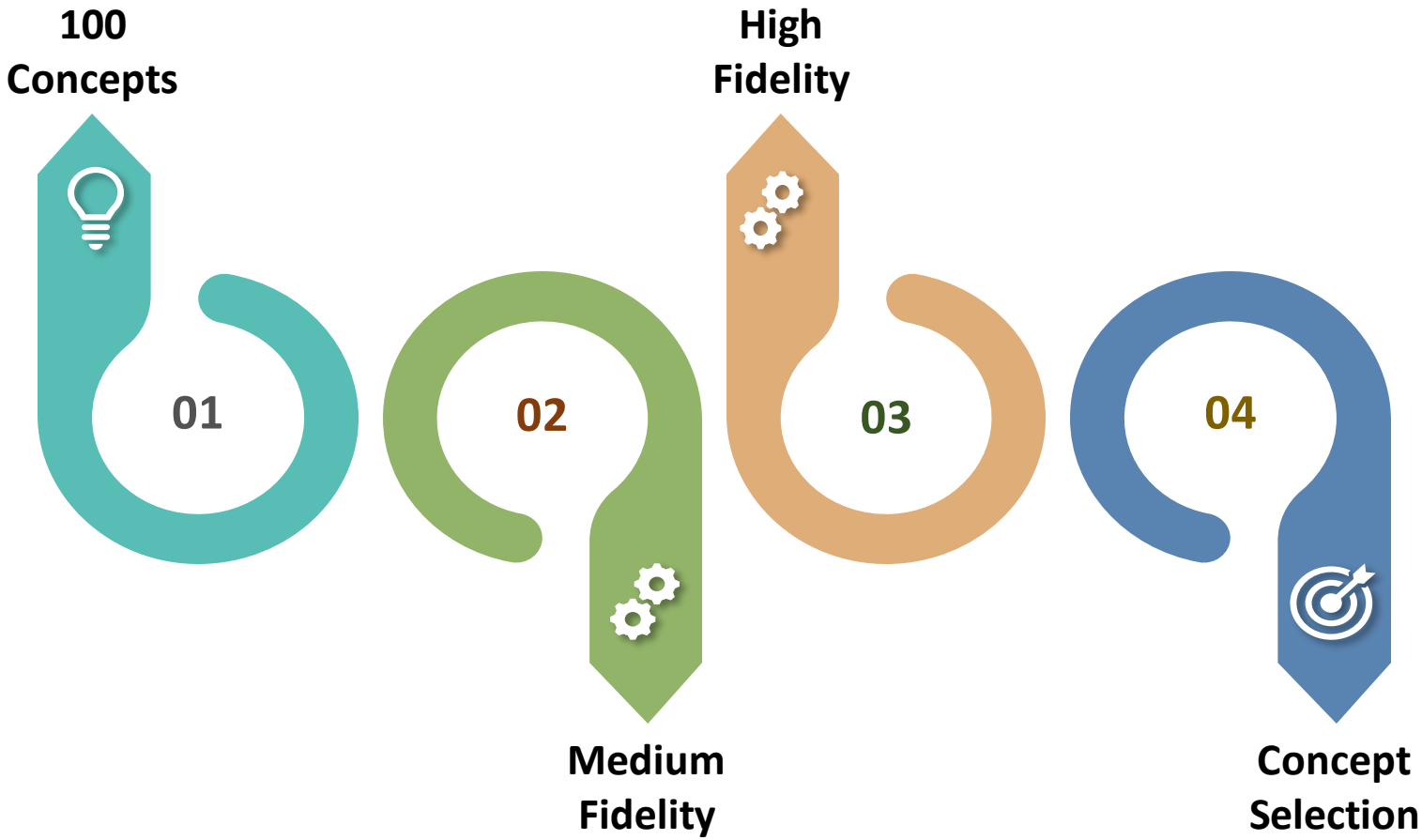
Concept Generation



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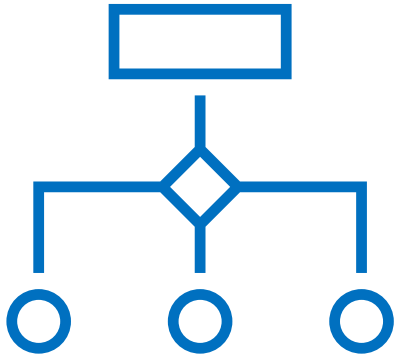
Concept Generation: 100 Concepts

Ideation

Biomimicry



Morphological Chart

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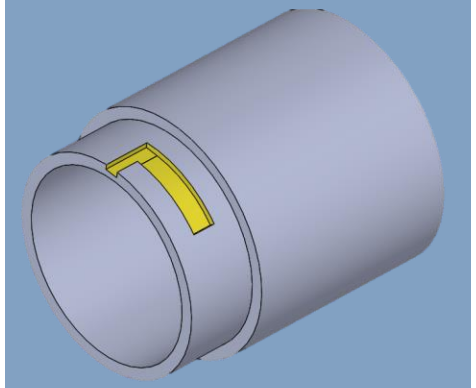
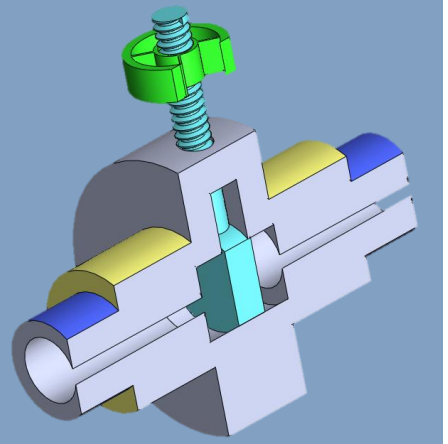
Concept Generation

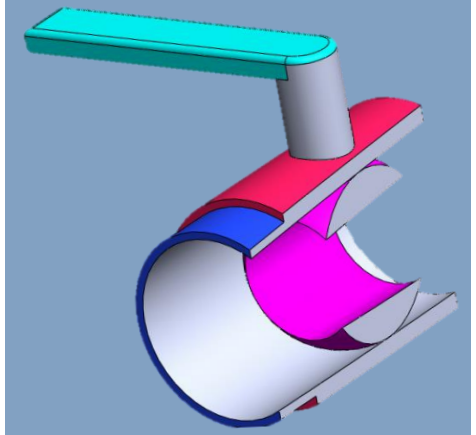
The Key



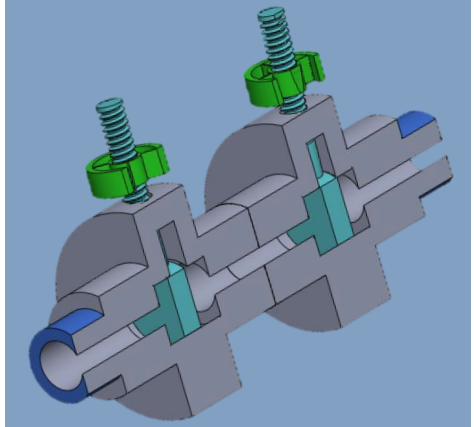
MLI Gate Valve



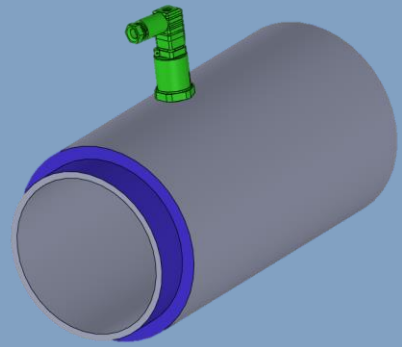
Fiber Glass Ball Valve



Non-insulate Double Gate



The Sensor



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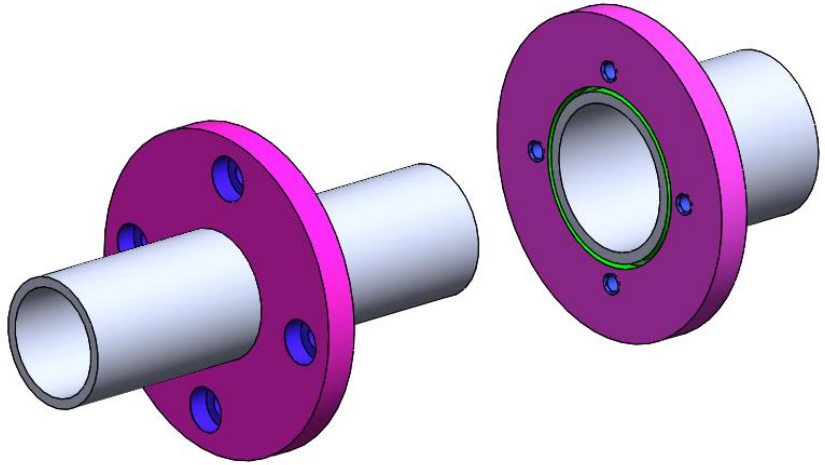

Cryogenic Bayonet

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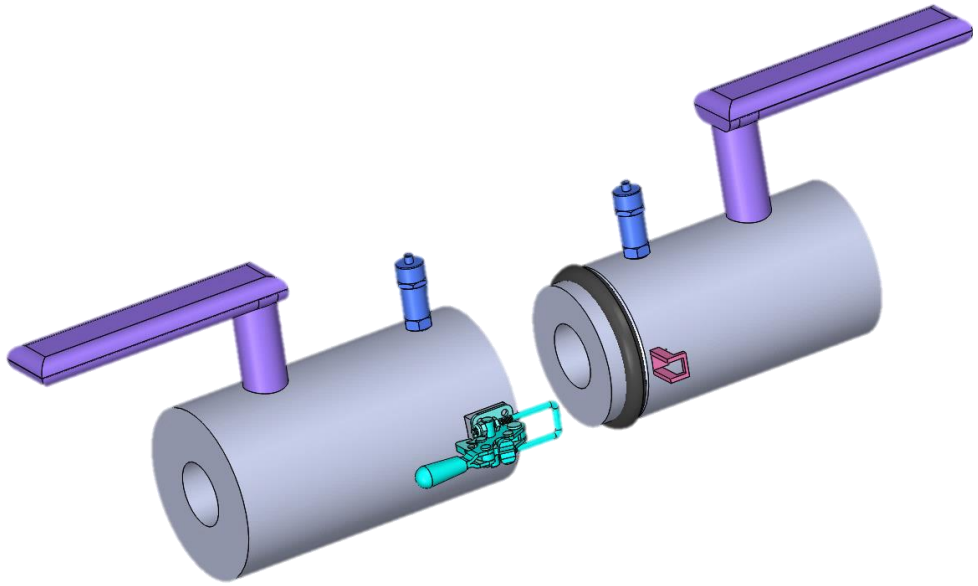
Concept Generation



Latch Sealing

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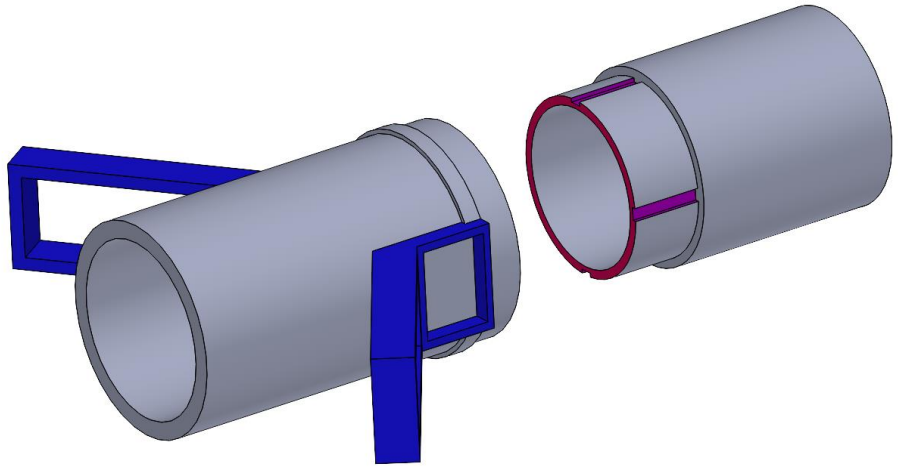
Concept Generation



Cryogenic Dry Connect

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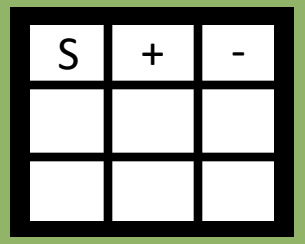
Concept Selection

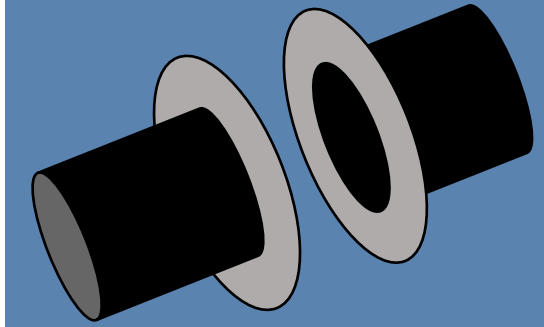
HOQ

Pugh



AHP

Selection



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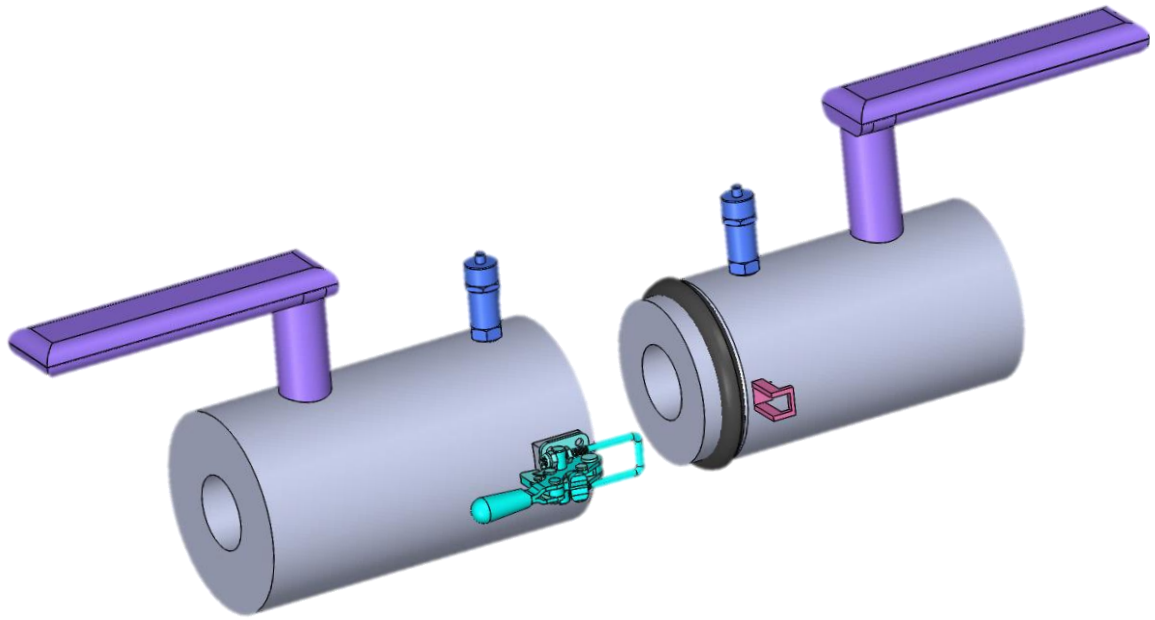
Concept Selection

Most Important Targets

- Diameter
- Force
- Leakage

Latch Sealing



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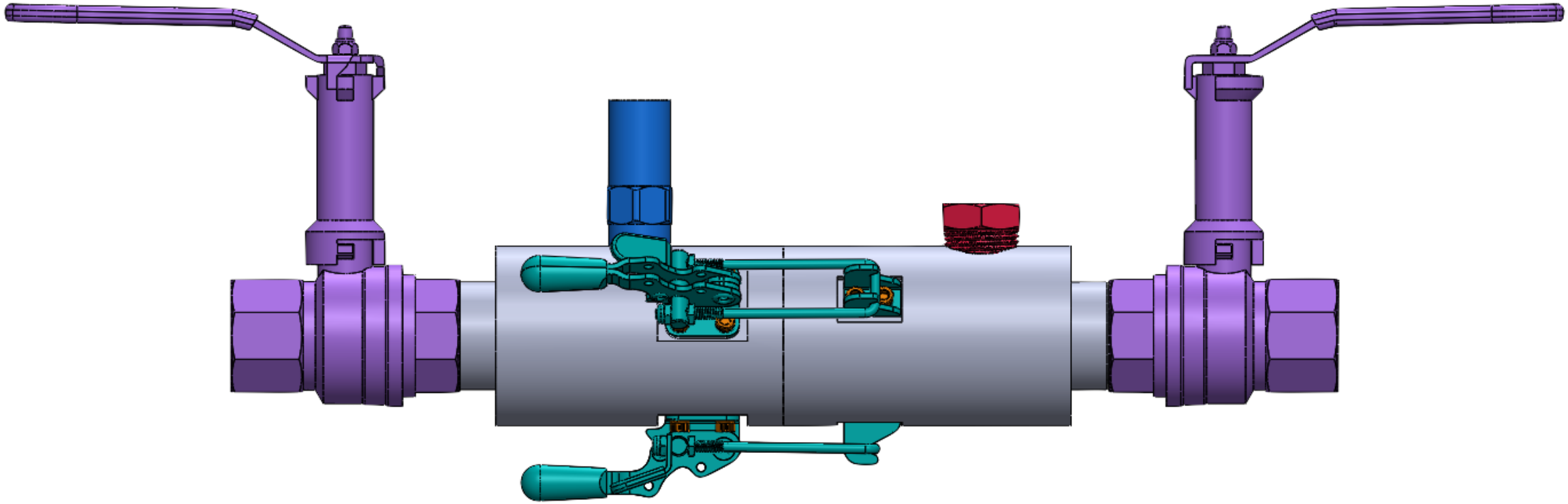
Final Design



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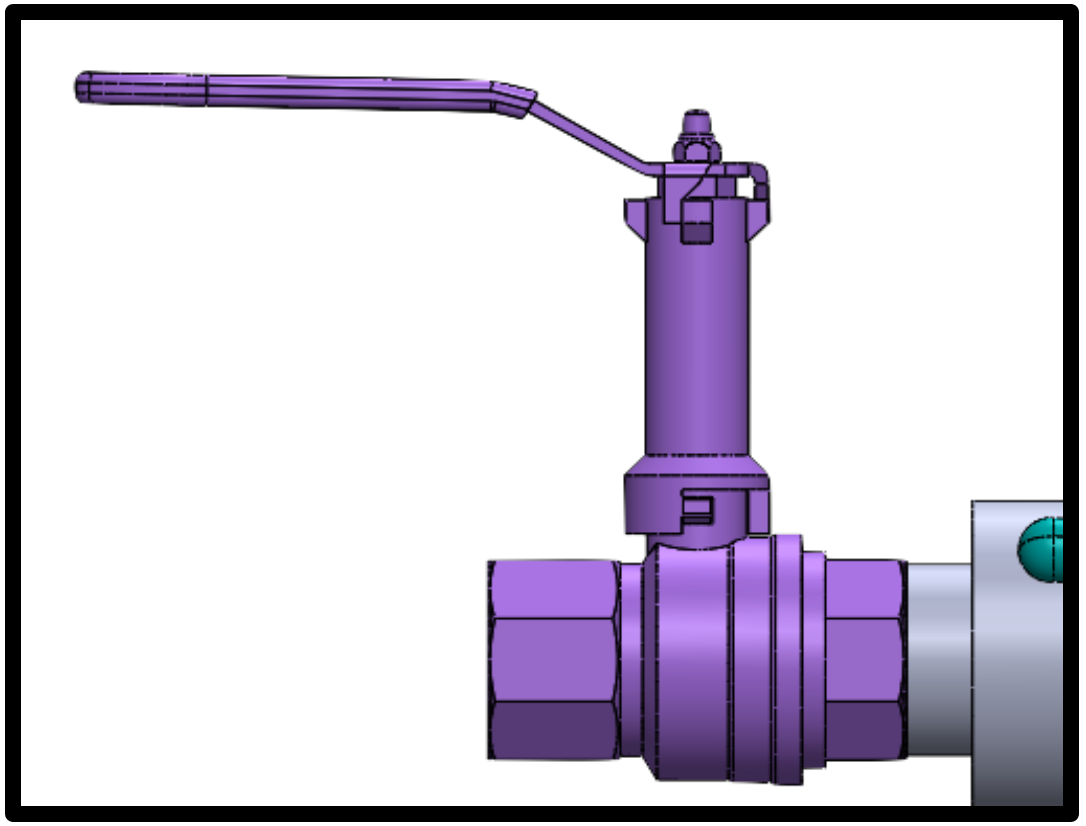

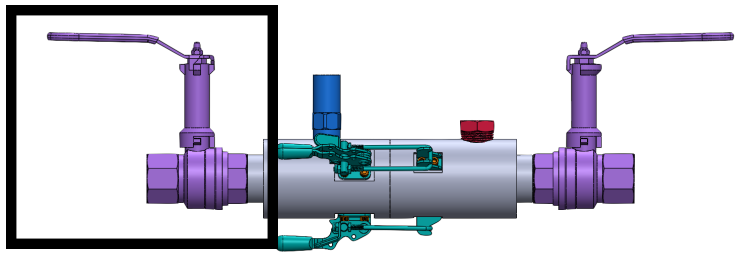

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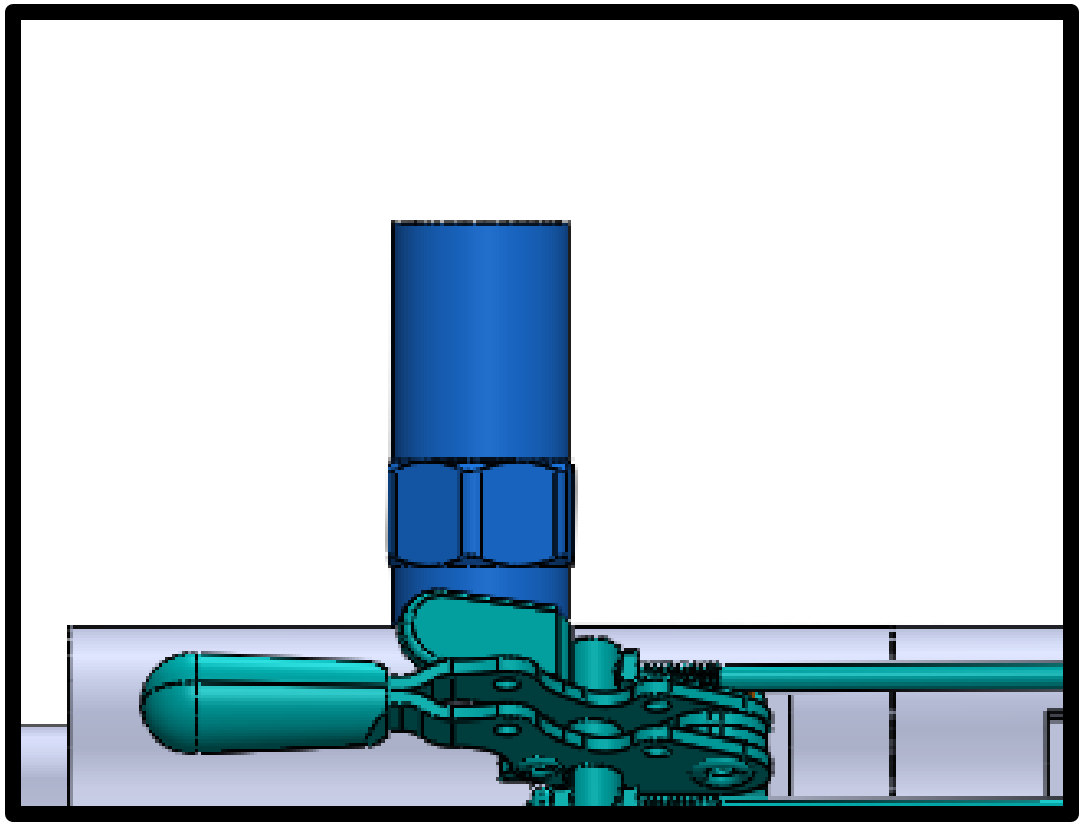

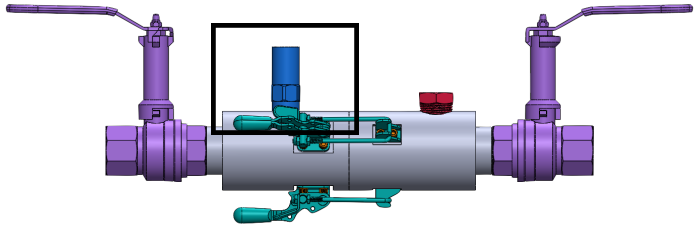

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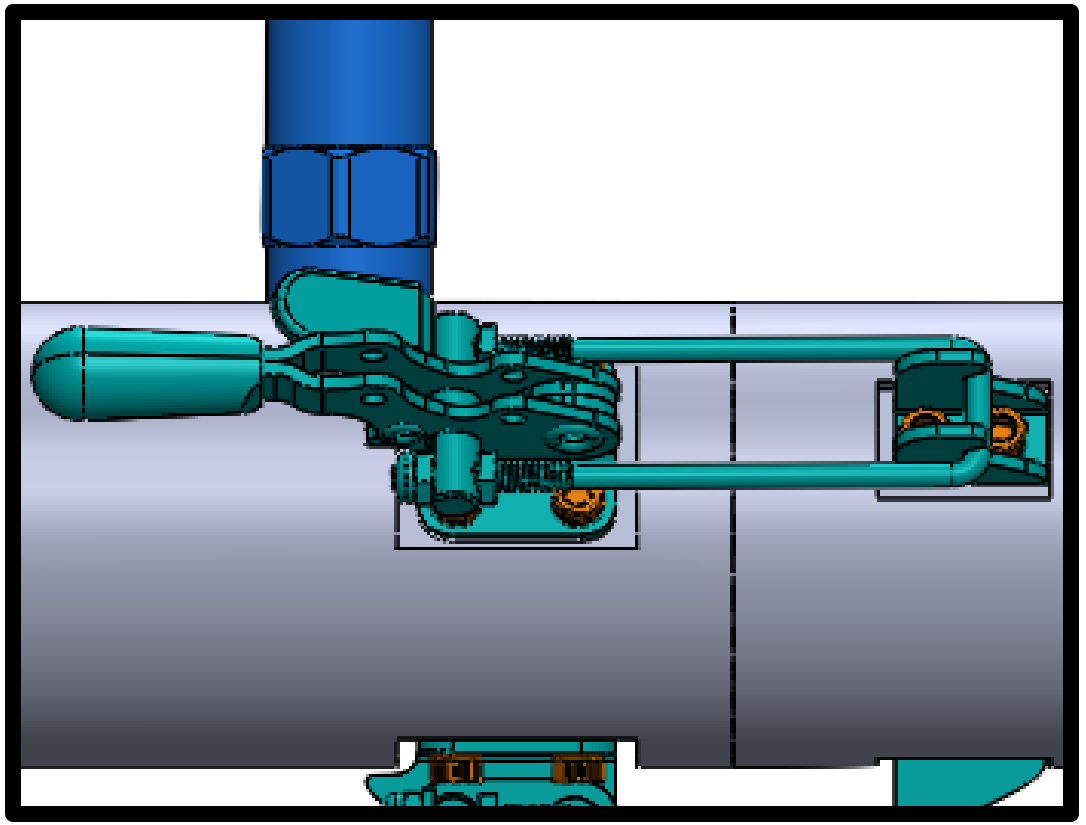

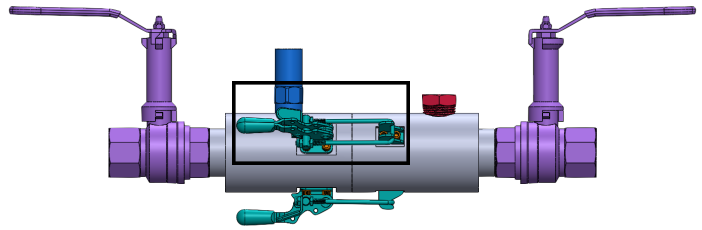

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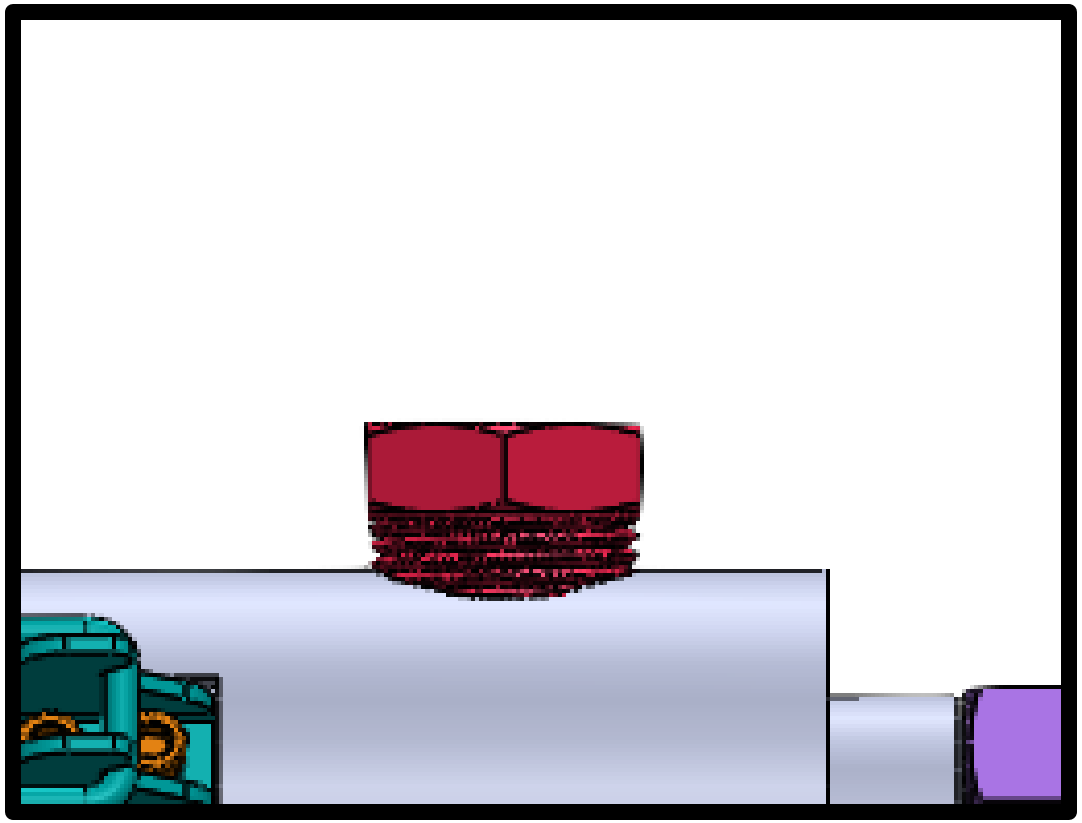

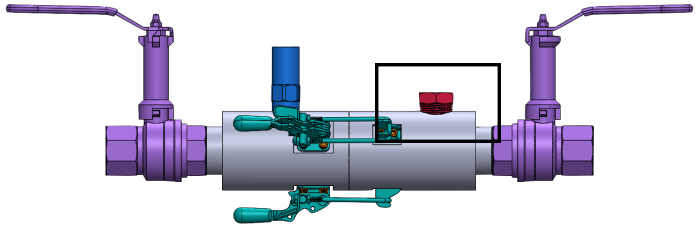

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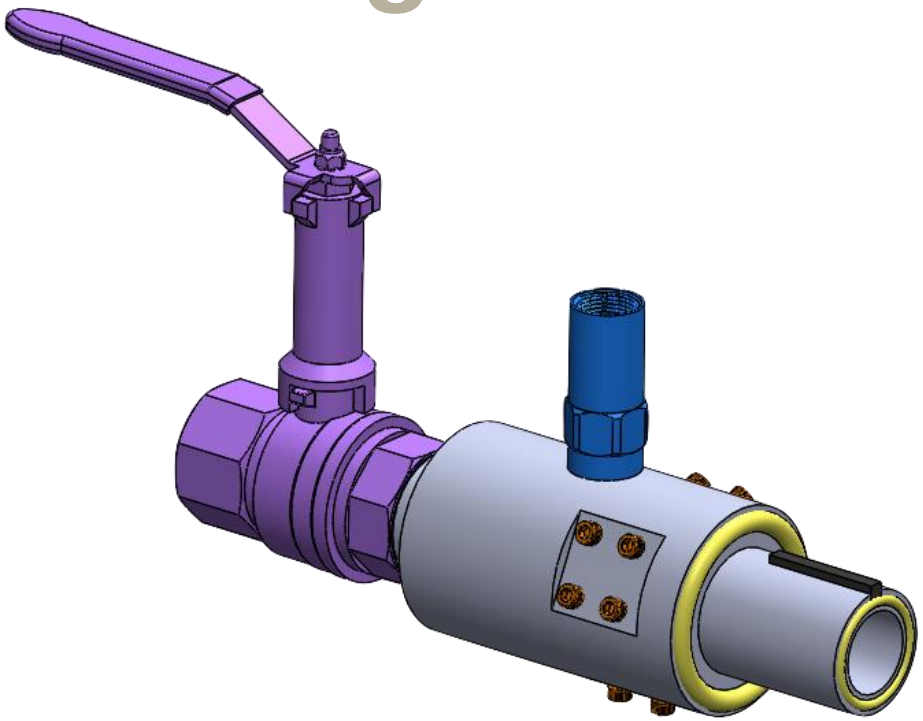

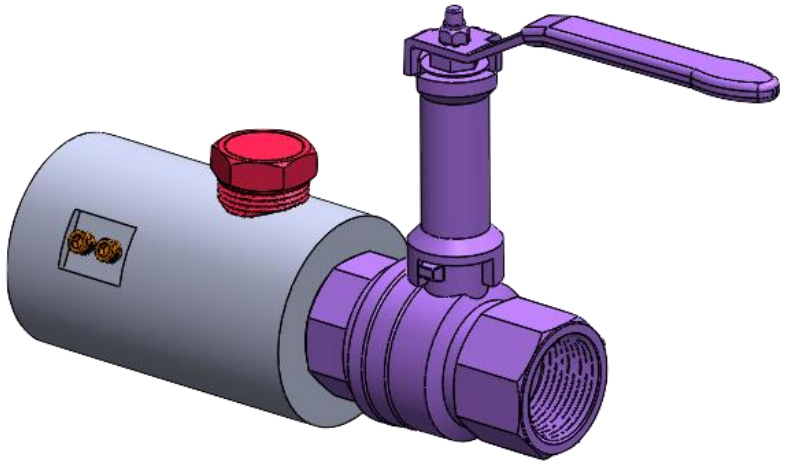

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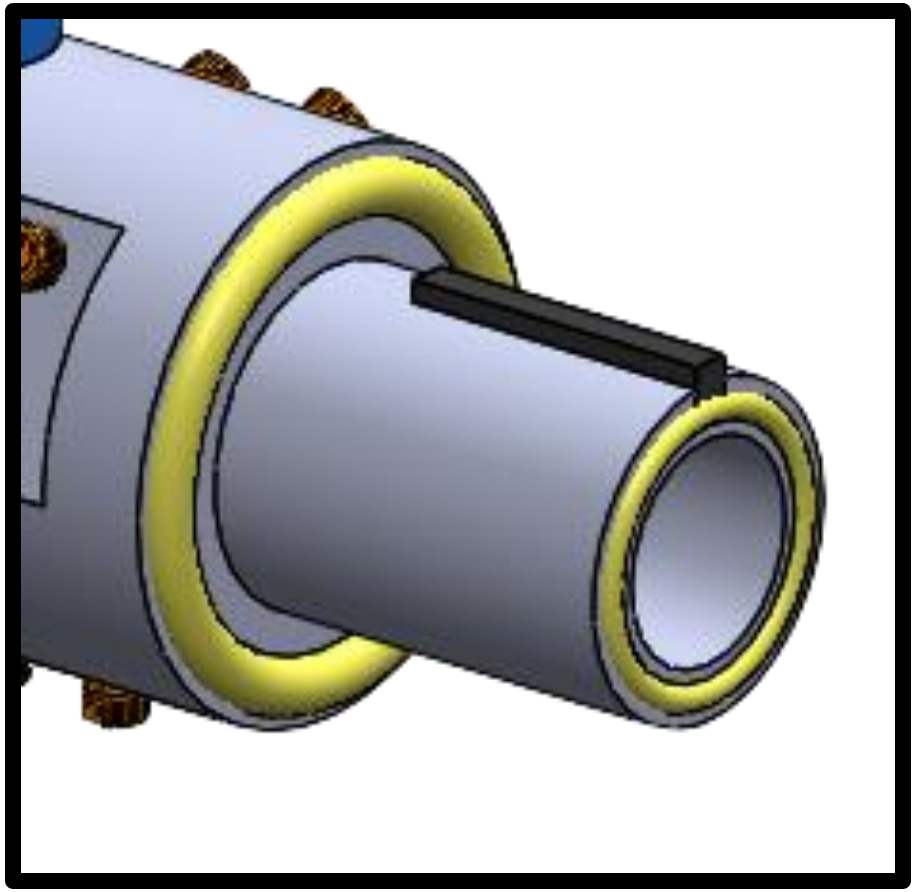

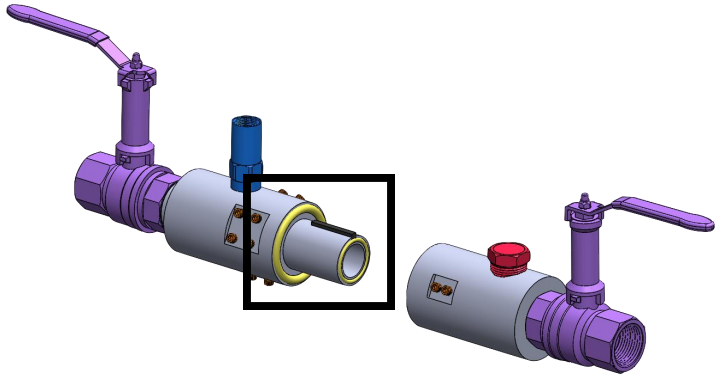

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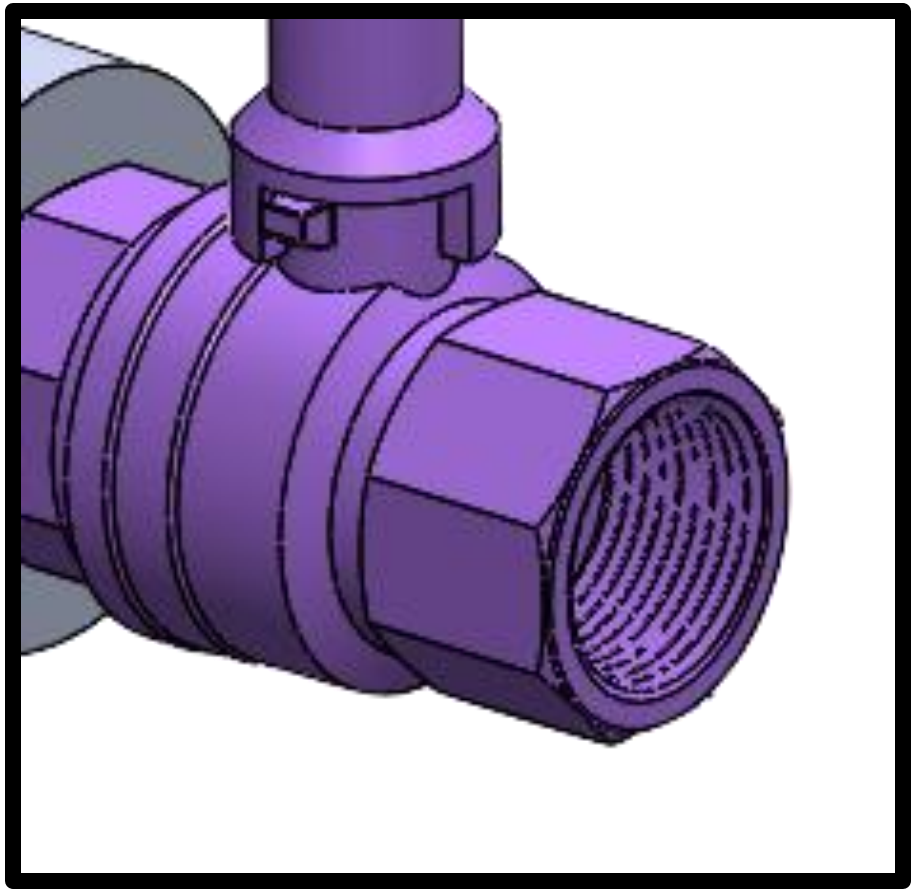

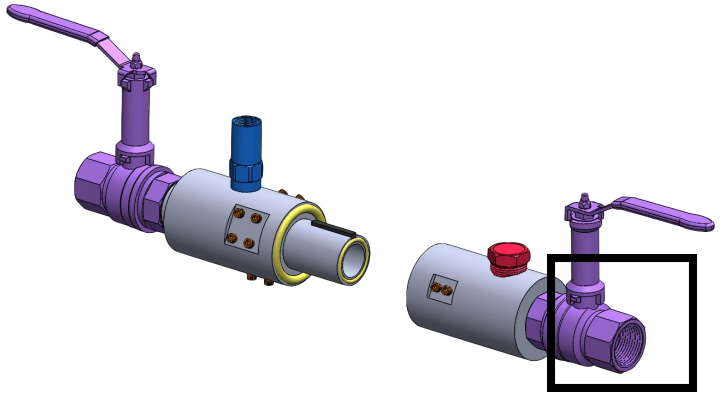

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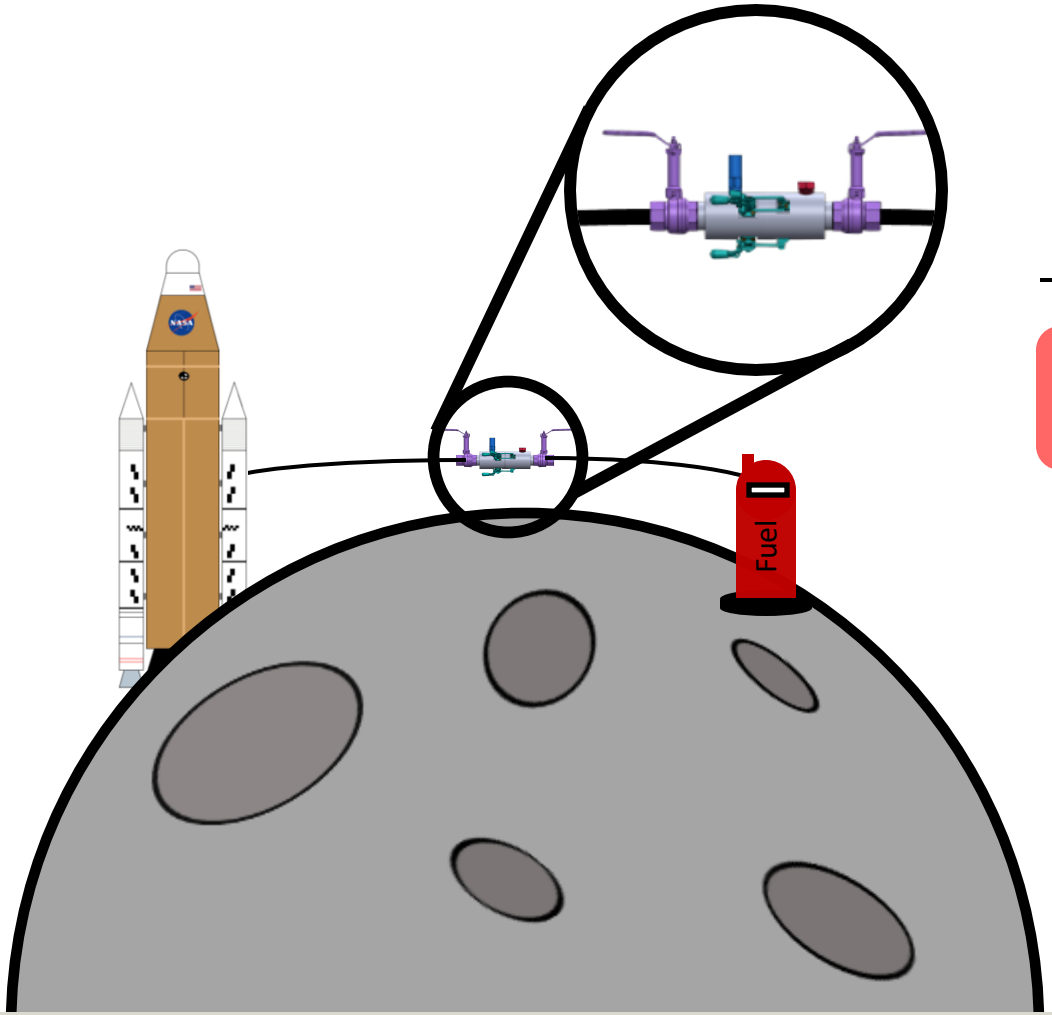
Testing Conditions

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 in^3/min

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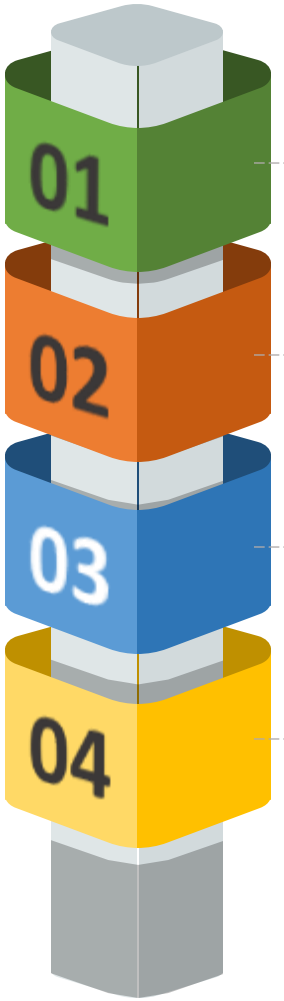
Methods of Validation



Nitrogen Bath

1. Submerge
2. Check Valves
3. Pump Helium Gas

Nitrogen Flow

Liquid Nitrogen @ 20 psi
Calculate Volumetric Flow Rate

Leak Check

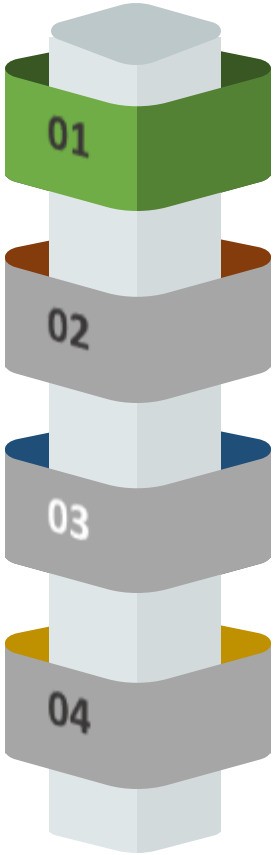
Leybold Phoenix L300i

Cycle Testing

100 Cycles with flow

Joshua Leary

Methods of Validation



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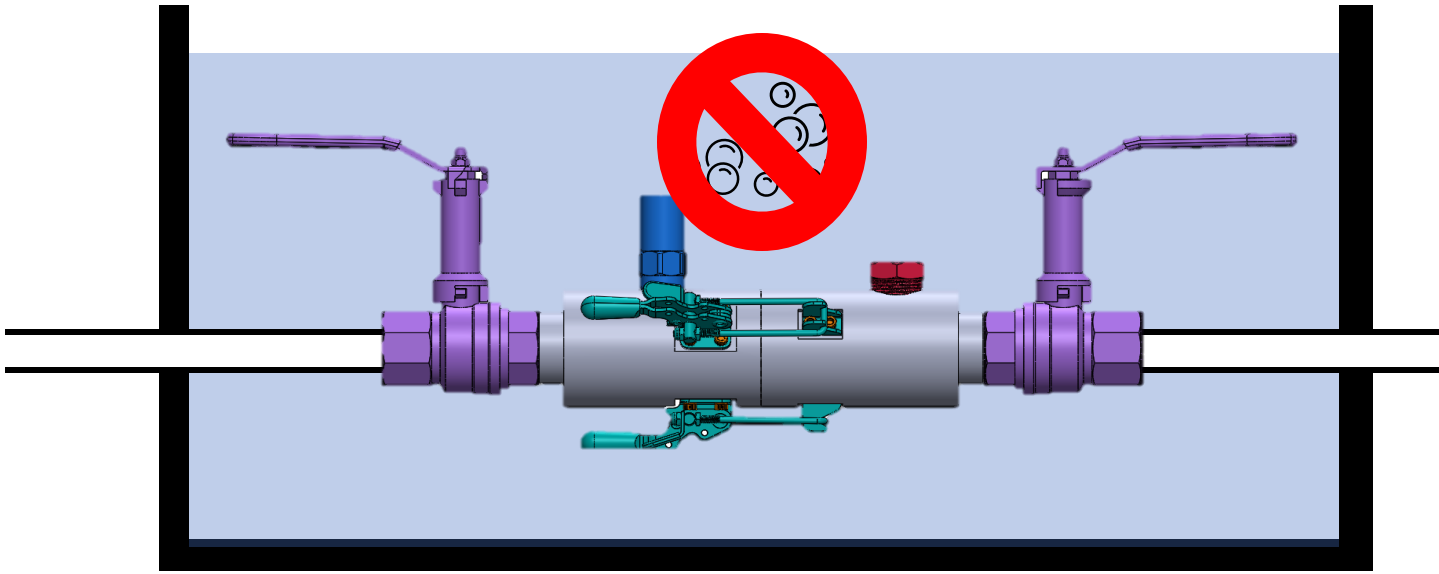
3. Pump Helium Gas

Helium Gas



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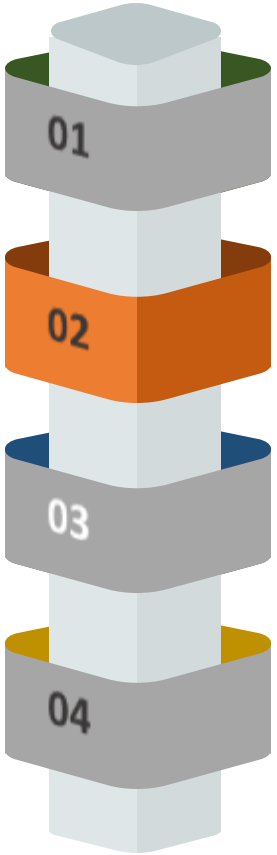
Methods of Validation



Leak Check ☑

Leybold Phoenix L300i

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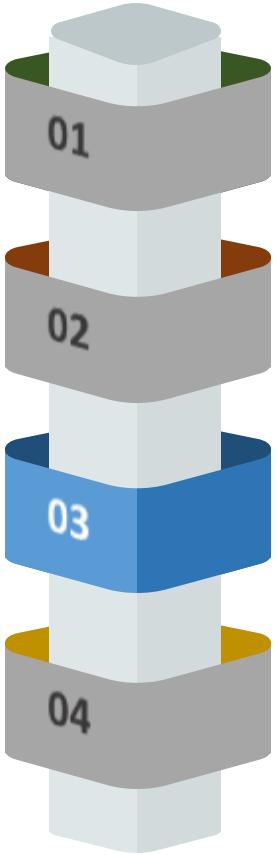
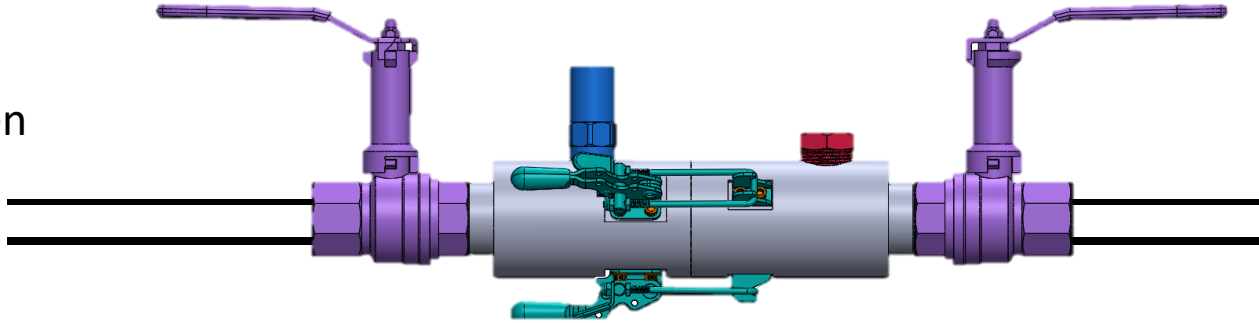
Methods of Validation



Nitrogen Flow

Liquid Nitrogen @ 20 psi
Calculate Volumetric Flow Rate

Liquid Nitrogen



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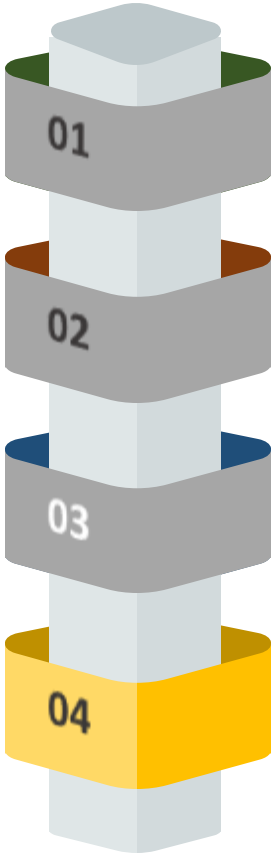
Methods of Validation



Liquid Nitrogen

Cycle Testing

100 Cycles with flow

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Purchasing

Purchased

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

Needed

- O-rings
- Manual Relief Valves
- 8-32 Screws
- 1” NPT -> ½” Flair Fitting

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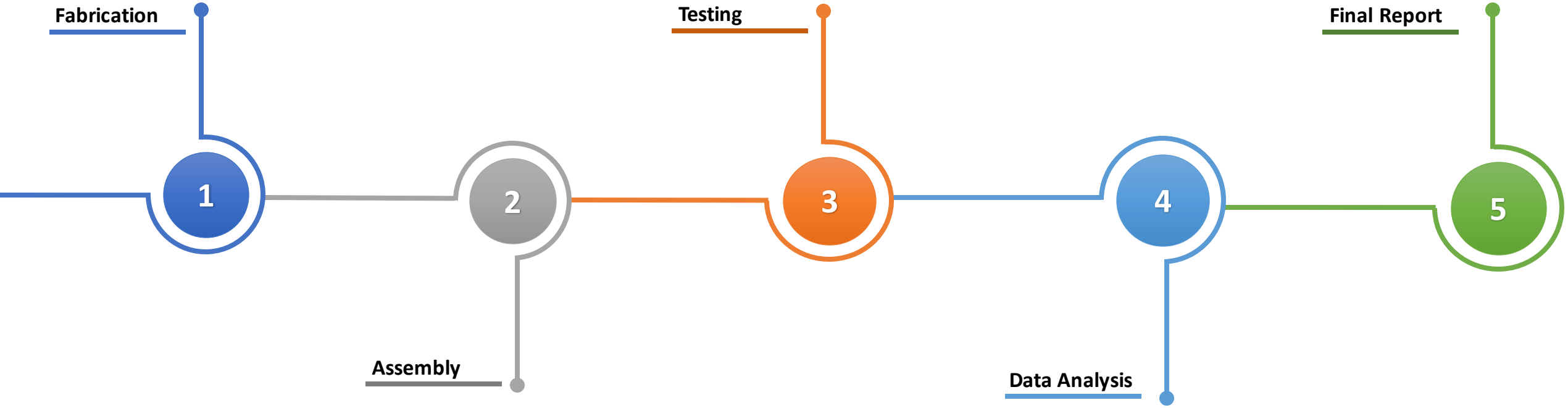
Future Work



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Upcoming Work

Lessons Learned

NASA- Nerds of Average Science Ability


V O L C

Valve Operated Low-Leakage Cryogenic-Connector

Joshua Leary
Systems
Engineer

Juan Valencia
Thermal Fluids & Design
Engineer

Jackson Herrod
Test
Engineer

Mika Kuschnitzky
Materials/Manufacturing
Engineer