Novel Corrosion-Resistant & Erosion-Resistant Coating Qualified for Use in Pressure Oxidation Severe Service

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Callidus
A PON company

ALTA 2023

Philippines

Singapore

Madagascar

Darwin

Papua New Guinea

INDIAN OCEAN

Karratha

CORAL SEA

New Caledonia

Perth

Brisbane

Adelaide

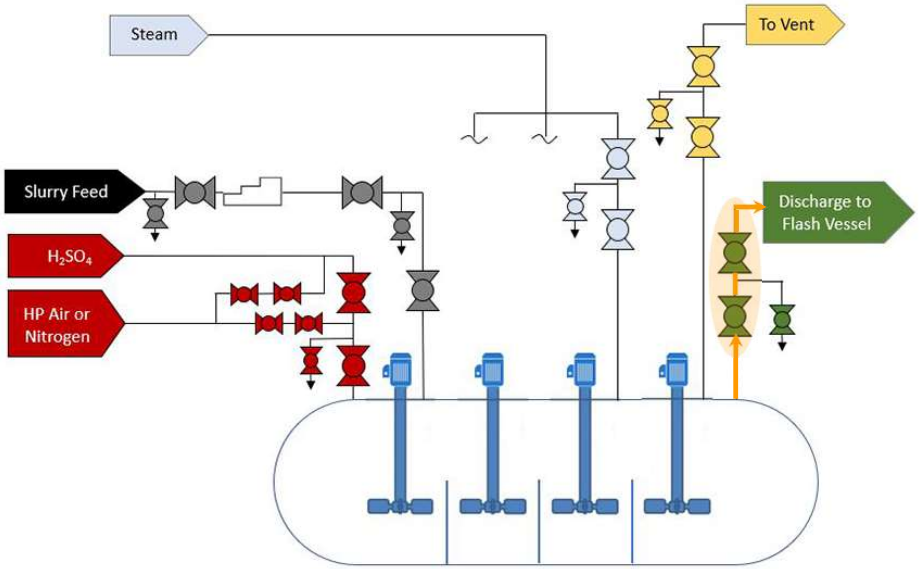
GREAT AUSTRALIAN BIGHT

Innovation at Callidus

An ongoing journey

ALTA 2022 Ni-Co-Cu

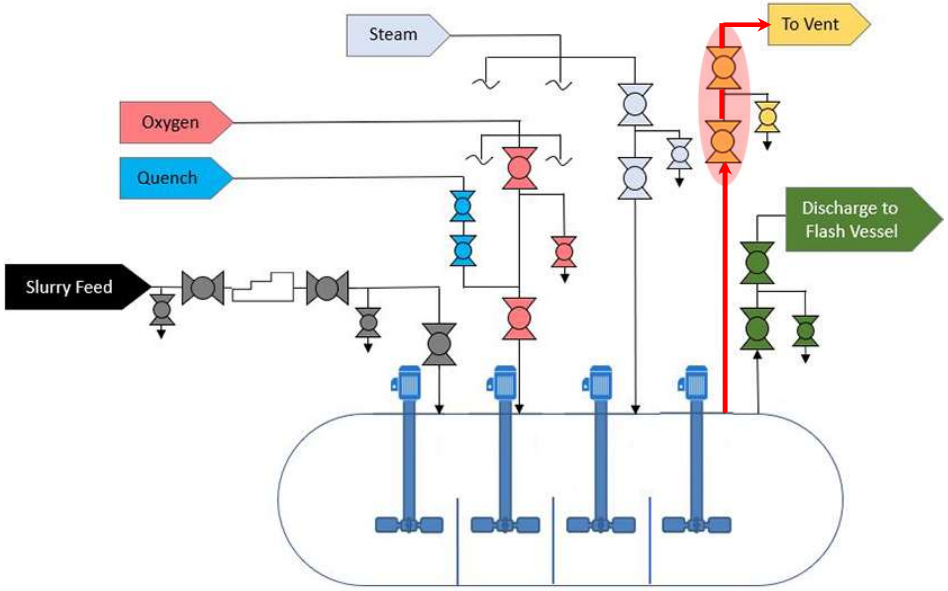
“FM-1500”



HPAL severe service

This year Gold-PM

“BM-1600”

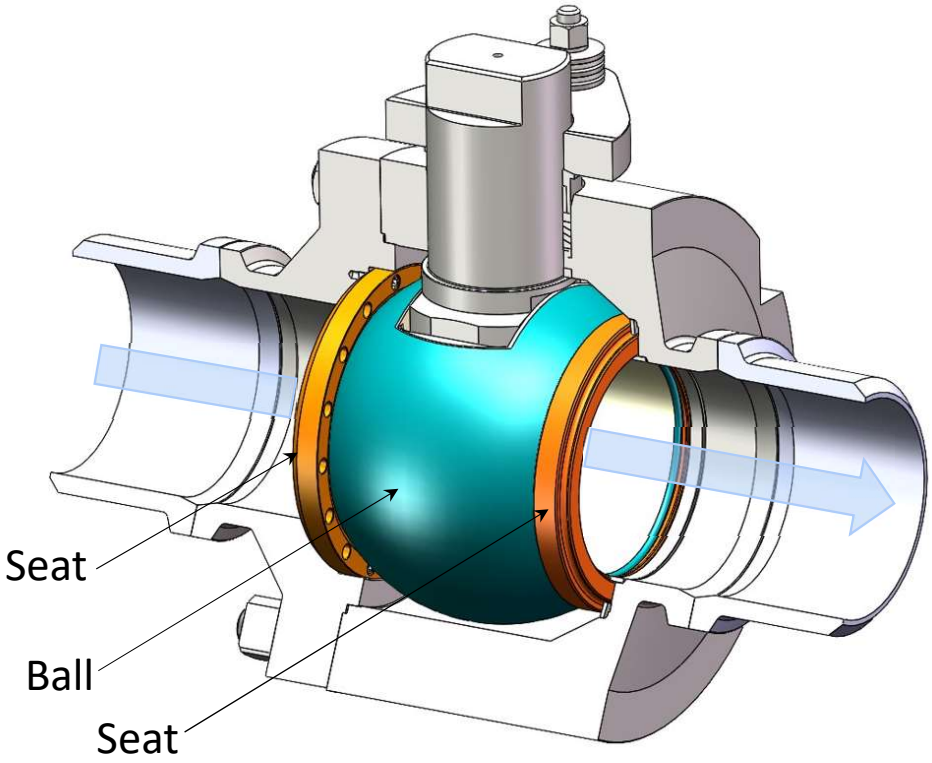


POx severe service

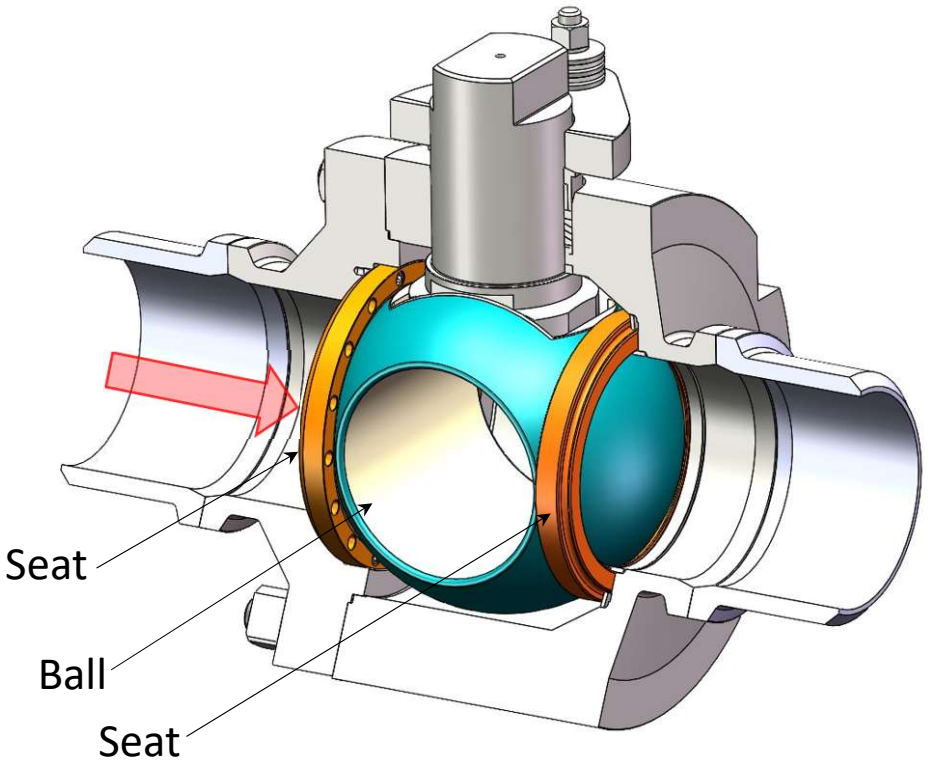
Image ref. https://www.valv.com/product/hpal_pox_autoclave/

Ball valve primer – components & isolation

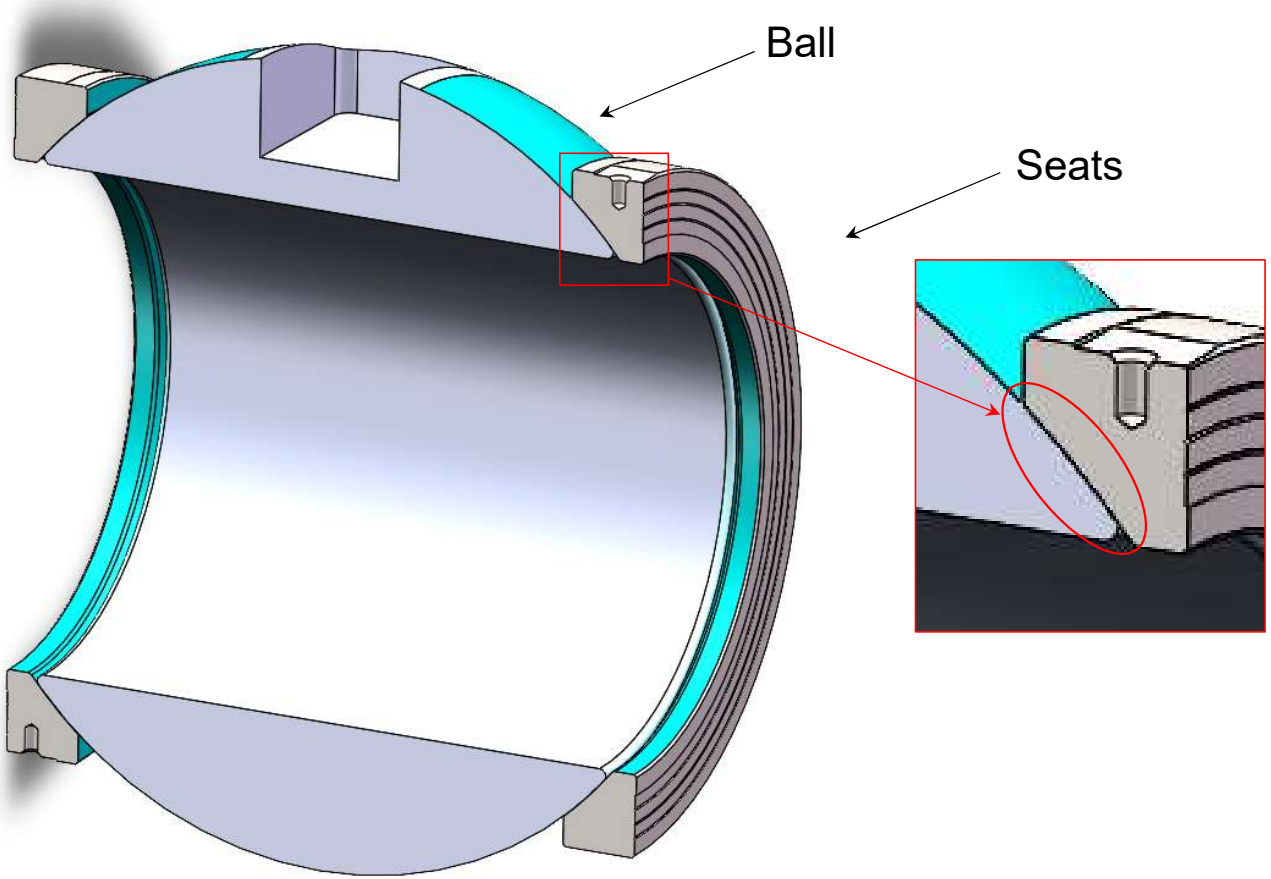
Open position



Close position



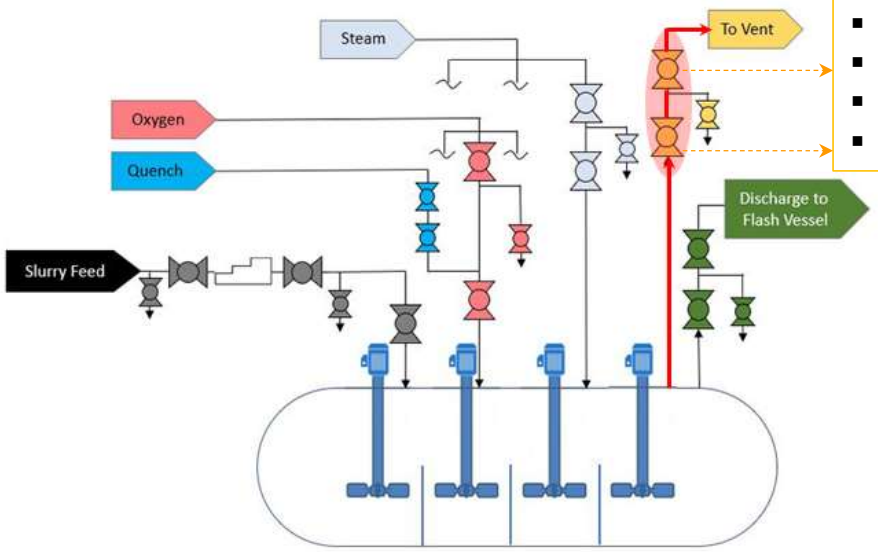
Valve trim and typical coated regions



Vent isolation location

- Ball removed after 4 weeks in-line.
- Super duplex stainless steel substrate + oxide APS coating
- Loss of sealing efficiency:
  - Loss of protective coating from erosion & corrosion
  - Mass corrosion of the substrate (SDSS)

Vent isolation requirements & challenges



Operating conditions:
- Temp. >200ºC
- Press. >3,000kPag
- Oxygen
- Steam
- Sulphuric acid

POx vent isolation challenges:
- Allowable materials qualified for use >200ºC?
- Allowable material geometry >200ºC?

Requirements:
- Adequate mechanical properties
- MSBV requirements
  - Dimensional accuracy
  - Spherical contact between ball & seats
- Corrosion-resistant
- Erosion-resistant
- Industry compliant
- Safe for use in oxygen service

Image ref. https://www.valv.com/product/hpal_pox_autoclave/

What happens with only one coating

A tale of two cities

Oxide coating via APS thermal spray

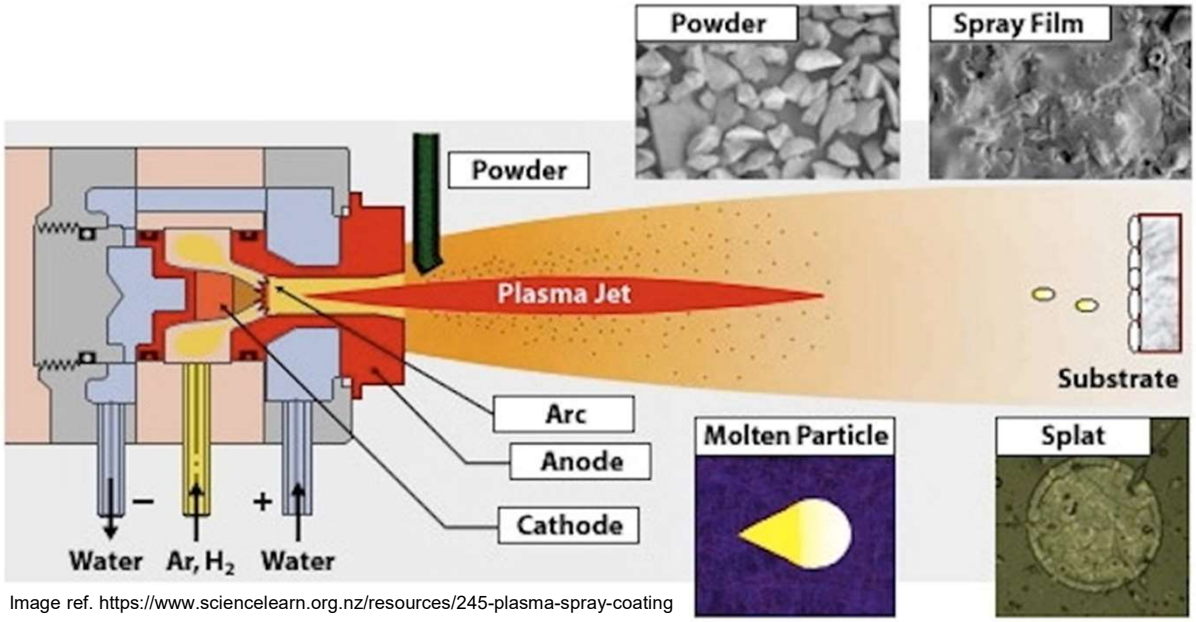
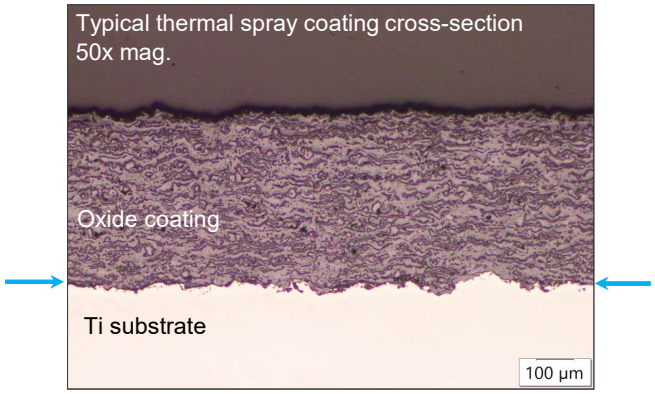
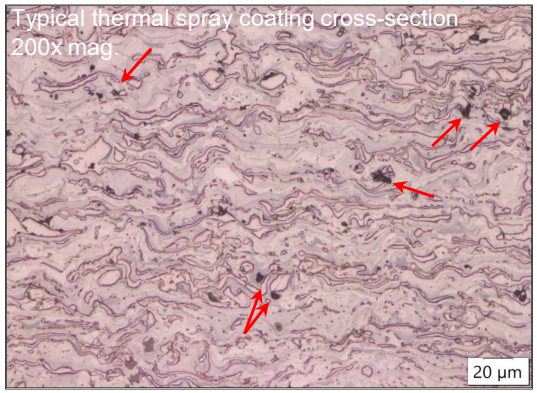


Image ref. https://www.sciencelearn.org.nz/resources/245-plasma-spray-coating

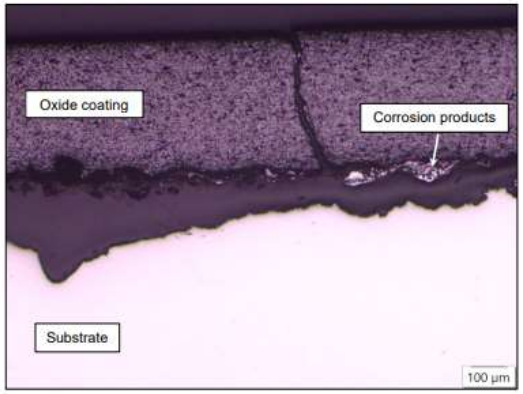
As-applied

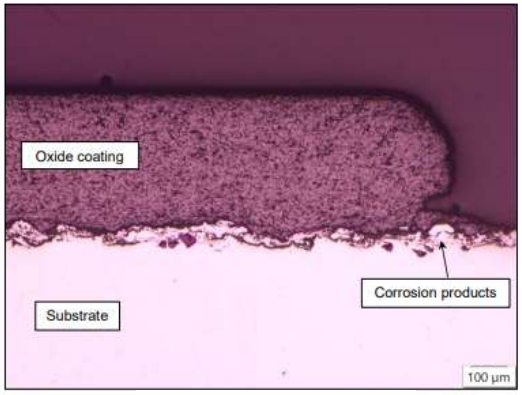
When only ceramic coating is used



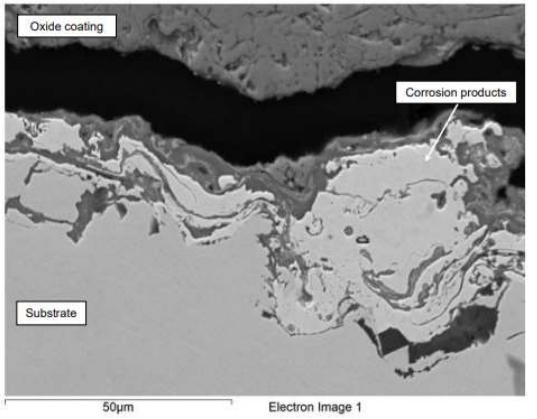


Before service





After service



Coating properties:

- Hardness – Yes
- Porosity – Yes
- Adhesion – No

Tantalum bond coat via Chemical Vapour Deposition

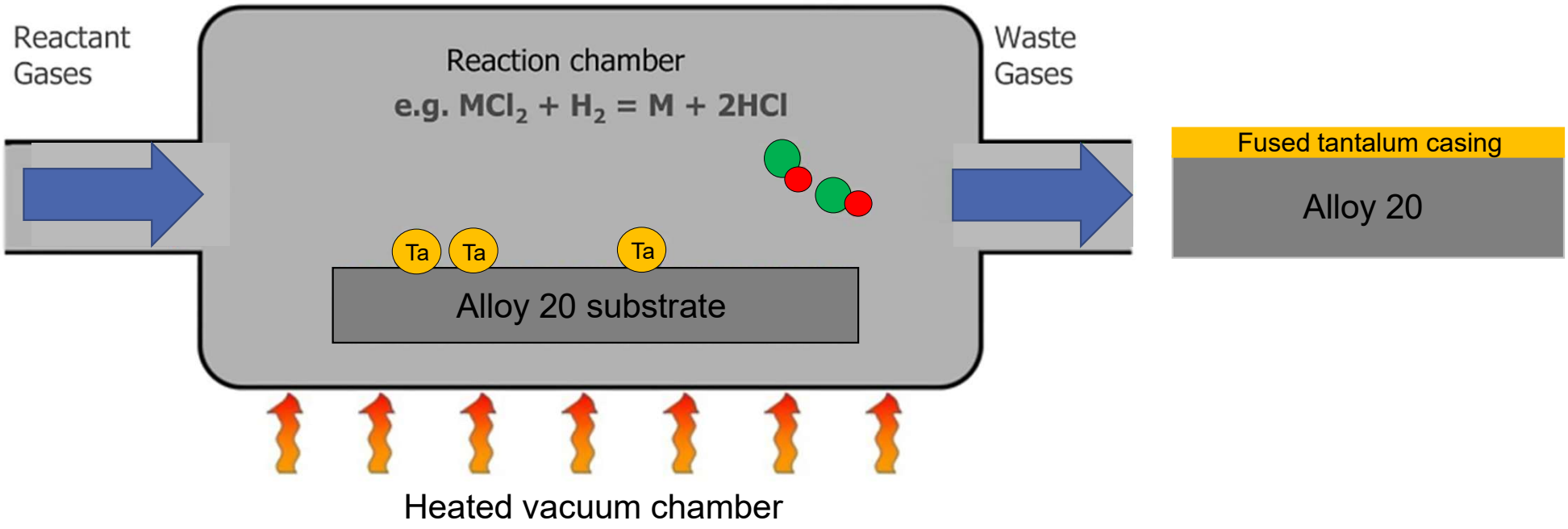
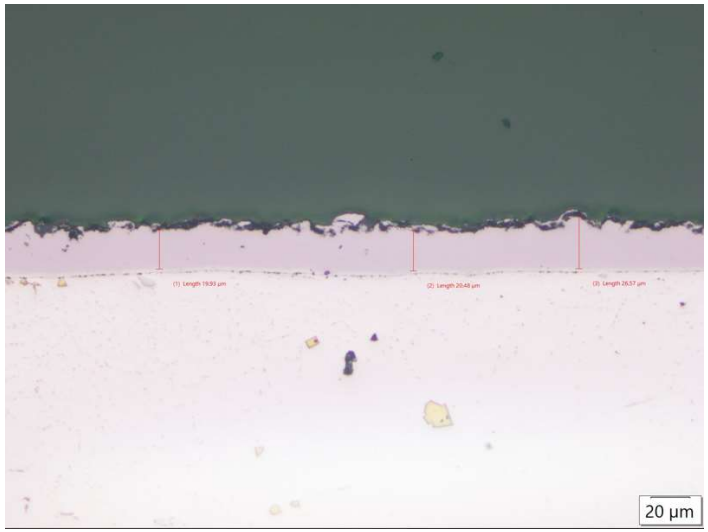
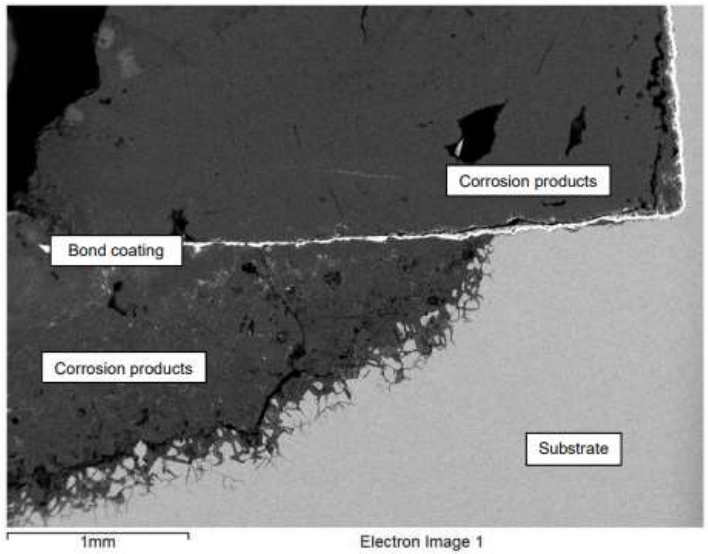


Image ref. https://www.youtube.com/watch?v=9XKGVHPXXho

When only tantalum coating is used



Before service



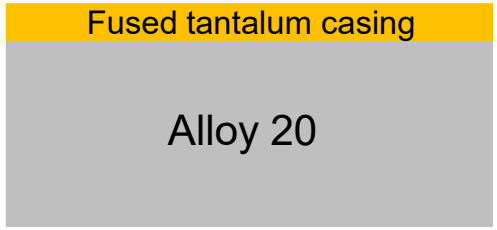
After service

Coating properties:

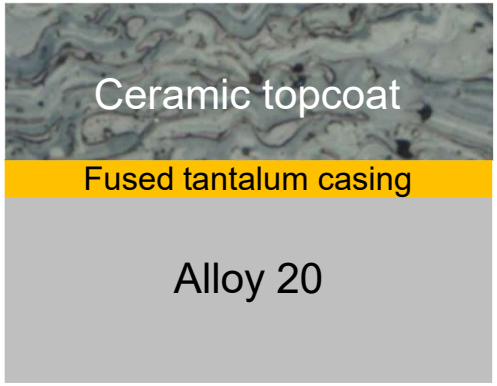
- Hardness – No
- Porosity – No
- Adhesion – Yes

An innovative two-coating system BM-1600

- ✓ Mechanical properties
- ✓ Industry compliant

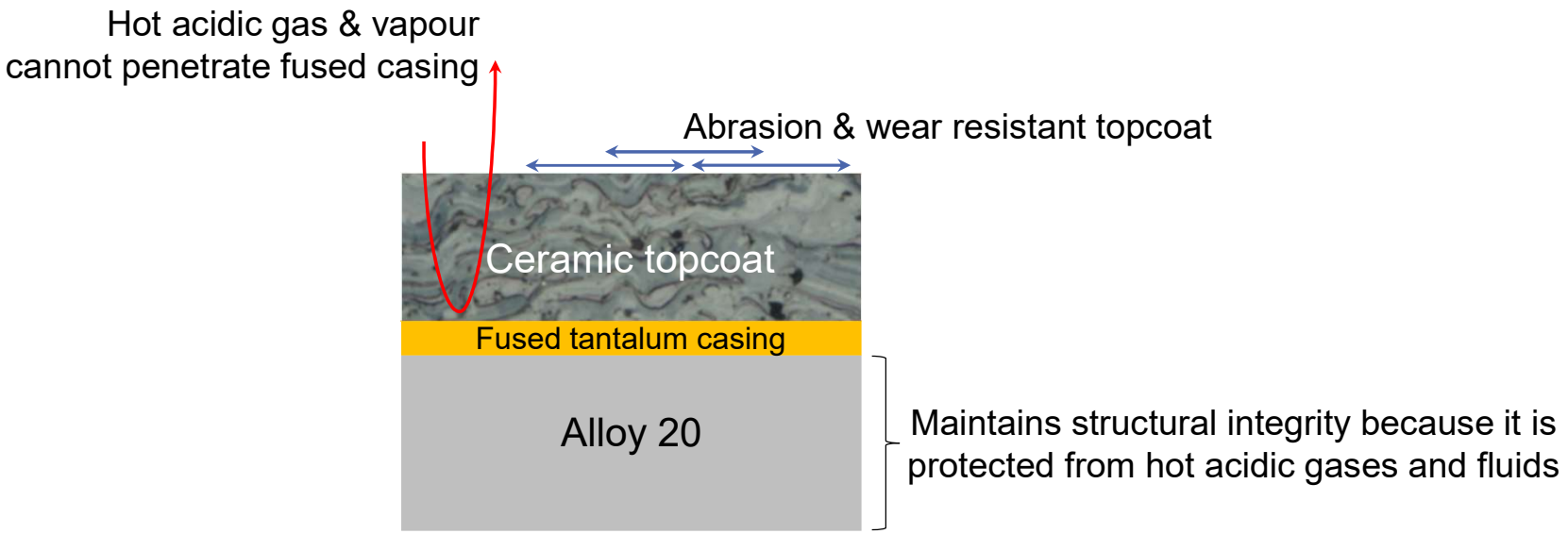


- ✓ Mechanical properties
- ✓ Industry compliant
- ✓ Corrosion-resistance from fully dense, fused & chemically inert tantalum casing



- ✓ Mechanical properties
- ✓ Industry compliant
- ✓ Corrosion-resistance from fully dense, fused & chemically inert tantalum casing
- ✓ Erosion-resistant abrasion & wear resistant ceramic topcoat

BM-1600 in theory

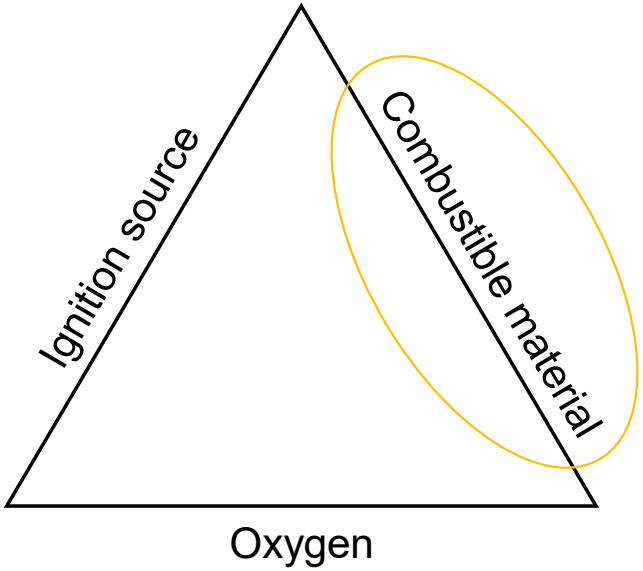


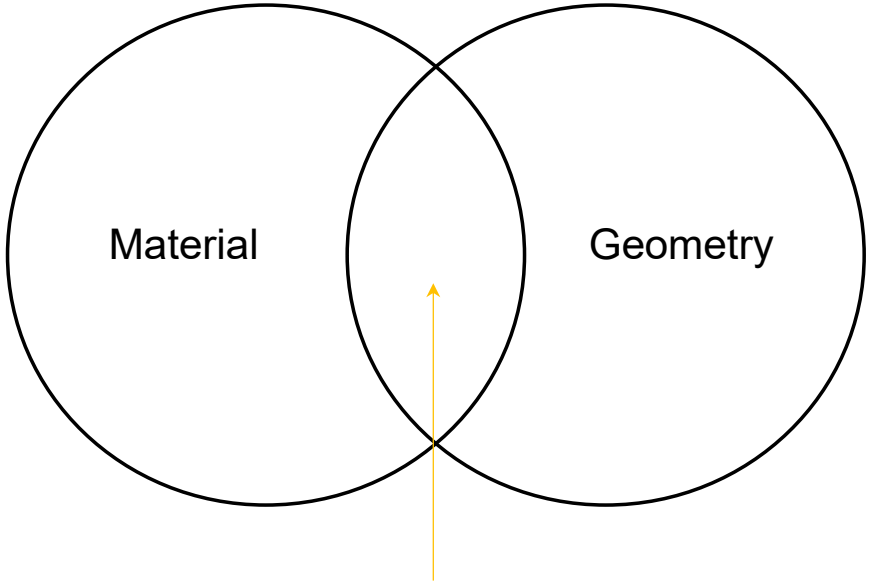
- ❑ Safe for use in oxygen service?

Qualifying for use in POx

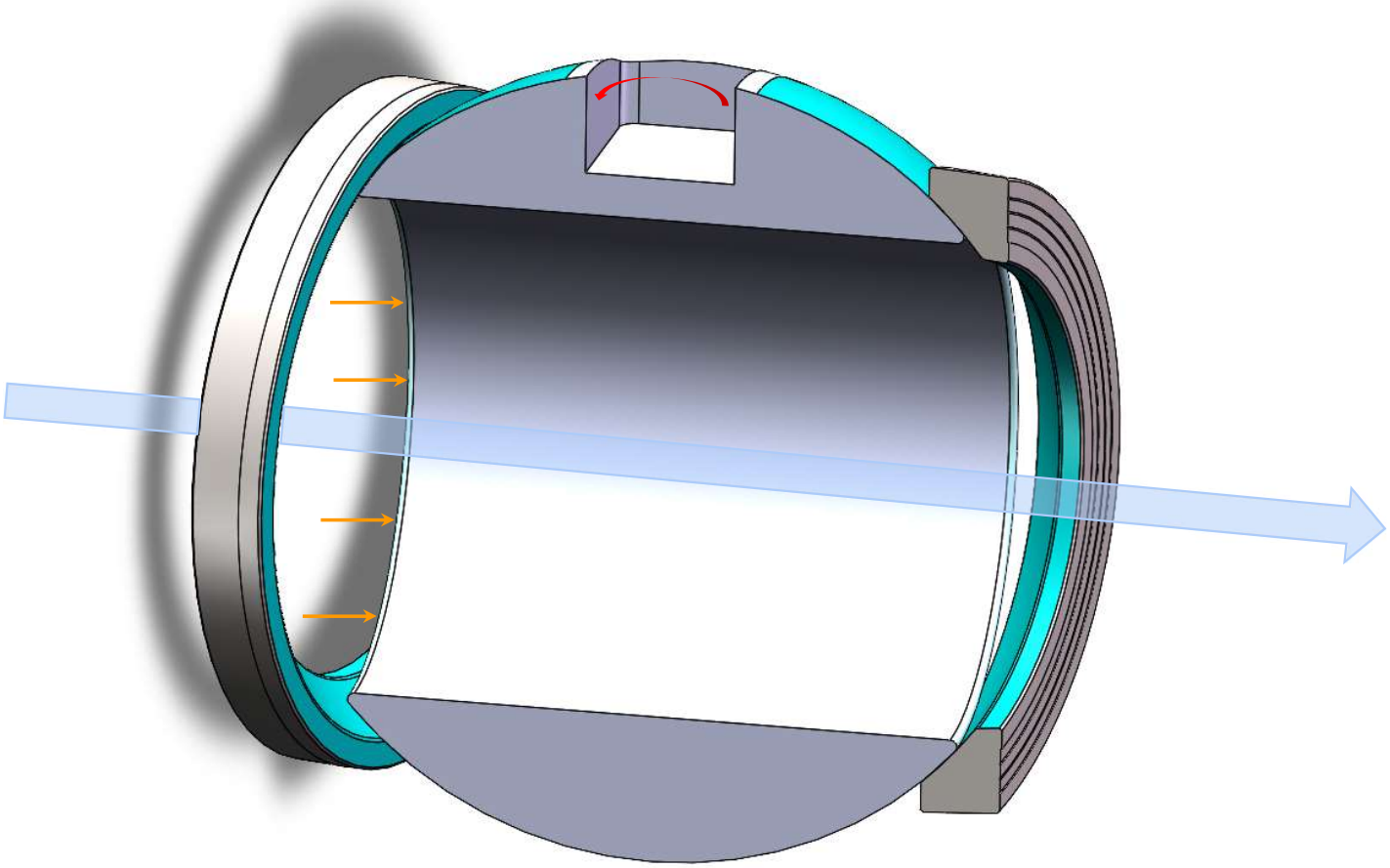
And for use in a rocket ship to space

Added challenge: POx service is unique





Thinnest geometry on valve trim is the leading edge on the ball



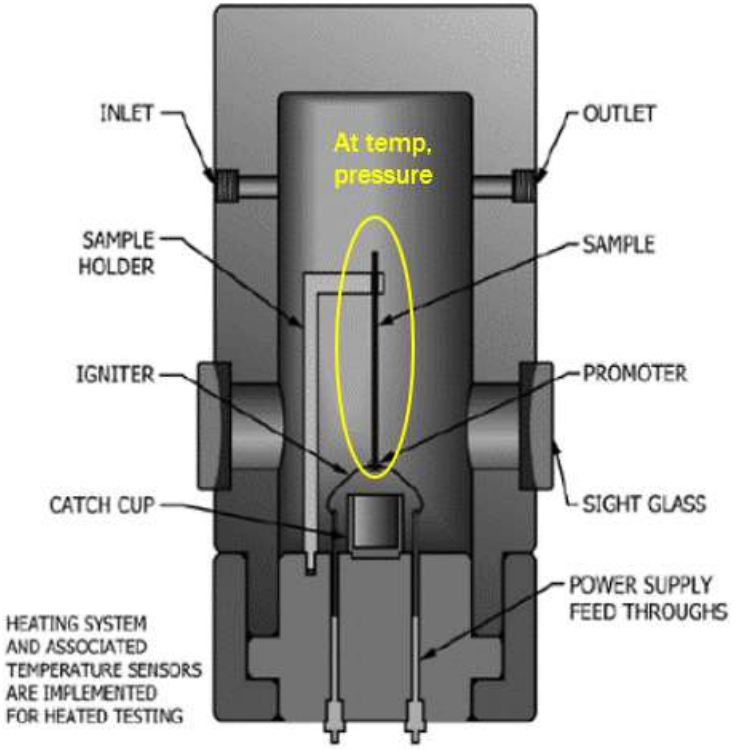
Compatibility tests to evaluate ignition & flammability

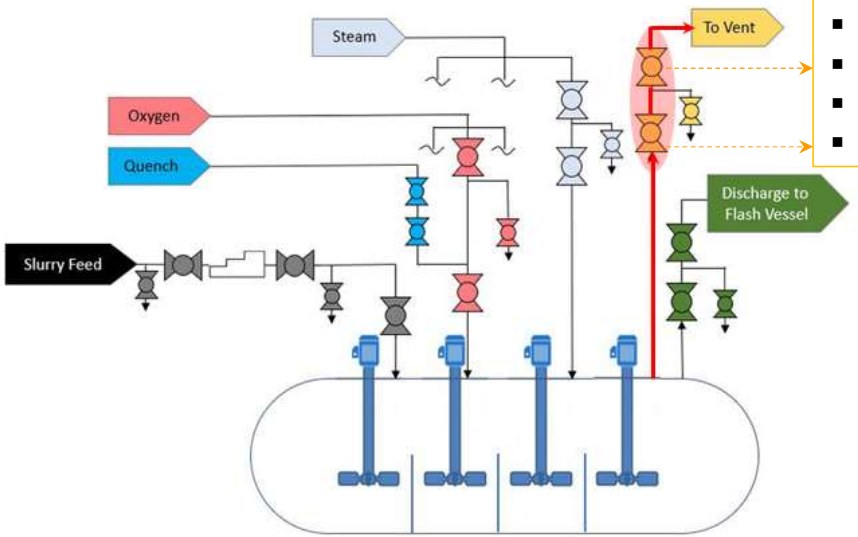
Test name	Test designation
Autogenous Ignition Temperature	ASTM G72 ISO 11114:3 ISO 21010
Heat of Combustion	ASTM D4809
Gaseous Fluid Impact Sensitivity	ASTM G86 ASTM D2512 ISO 21010 NASA Test 13A
Liquid Oxygen Mechanical Impact Testing Sensitivity	ASTM G86 ASTM D2512 ISO 21010 NASA Test 13B
Oxygen Index	ASTM G125
Aging	ASTM G114
Promoted (Heated) Combustion of Metals	ASTM G124

Specifically for testing non-metals & lubricants

Metals compatibility test in oxygen

ASTM G124 to Qualify BM-1600 for POx



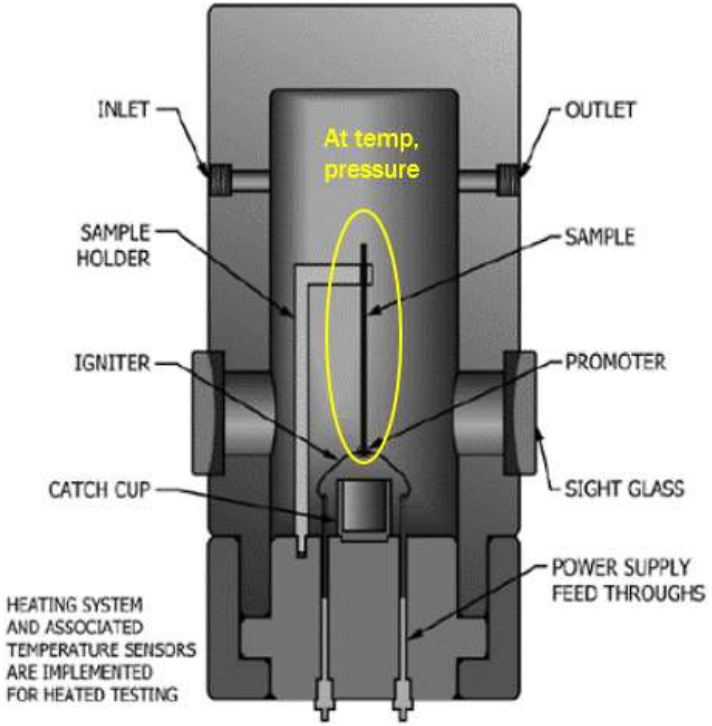


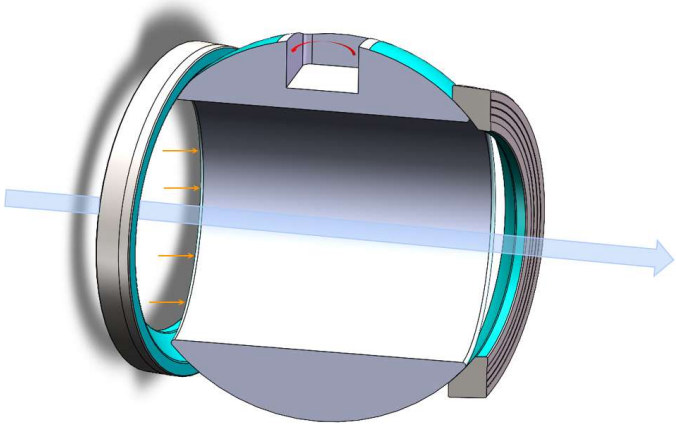
Operating conditions:

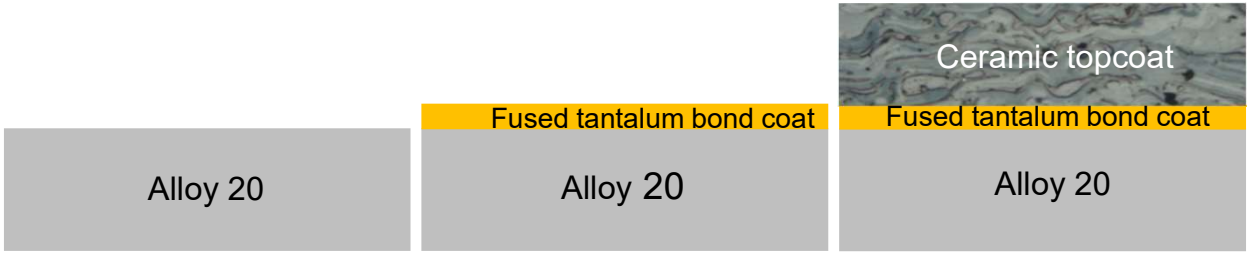
- Temp. >200ºC
- Press. >3,000kPag
- Oxygen
- Steam
- Sulphuric acid

ASTM G124 to qualify BM-1600 for POx

- No burn results 5 out of 5 in all configurations







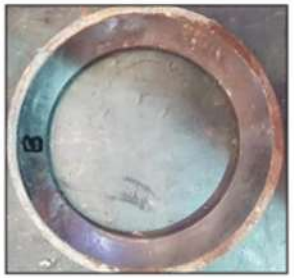
Case studies

The proof is in the pudding

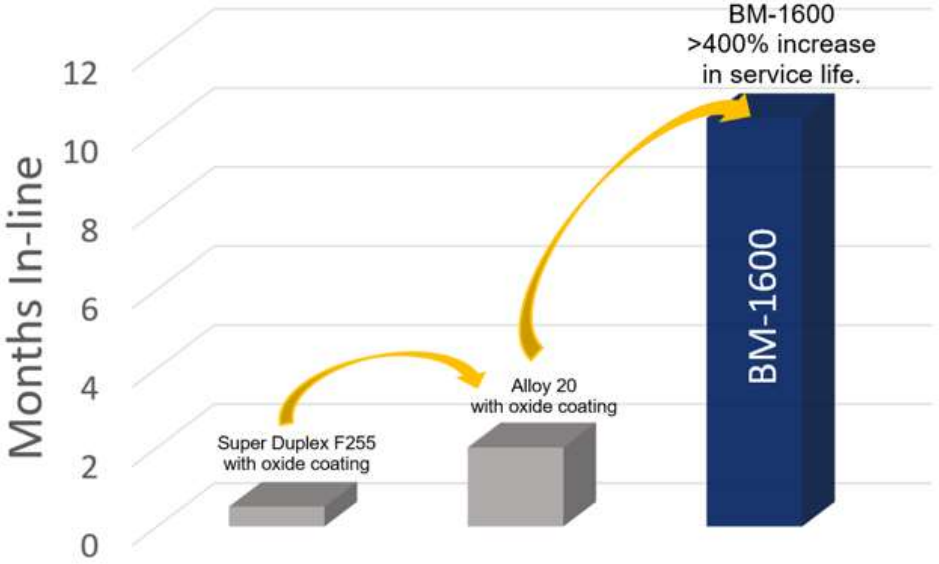
Case study I

28 days in-line
Super Duplex
w/oxide coating
Extensive corrosion on trim.
Loss of sealing capability.

58 days in-line
A20 w/oxide coating
Corrosion initiated at substrate resulting in coating delamination and loss of sealing capability.



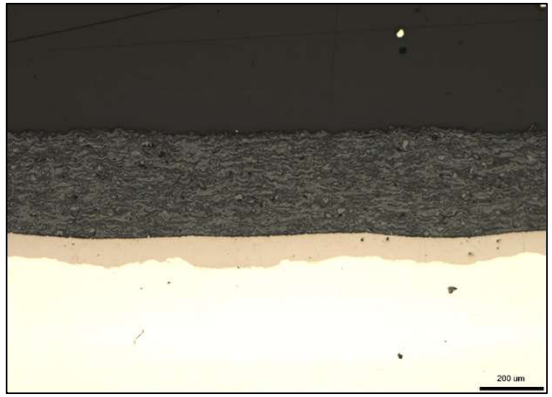
310 days* in-line
BM-1600
Coating intact, minimal to no corrosion observed. Full sealing capability.
* Valve removed for observational purposes.



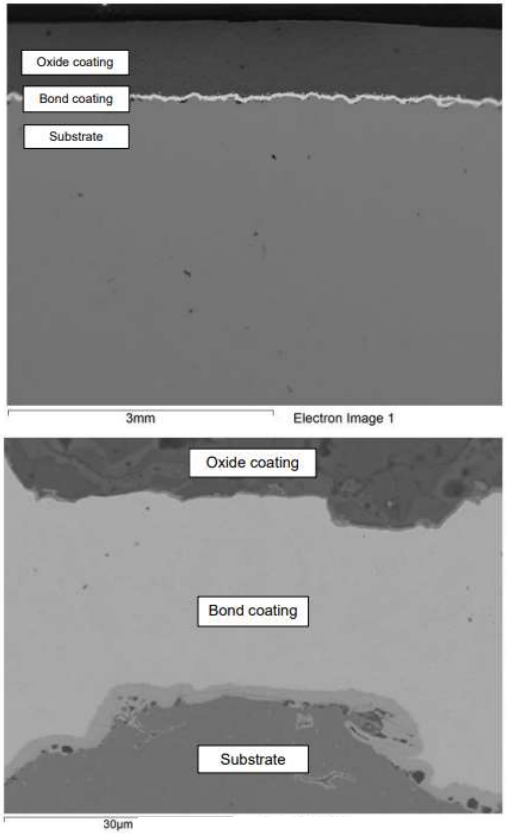
Case study II

		Traditional oxide coating on Super Duplex substrate *4 mo. post-service*	Callidus BM-1600 *12 mo. post-service*
Downstream	Ball		
	Seat		
Upstream	Ball		
	Seat		

BM-1600 performance in POx severe service



Before service



After service

Coating Property	Tantalum bond coat	Oxide Topcoat
Hardness	Up to 200HV	Up to 900HV
Porosity	100% dense	Up to 3%
Adhesion	Fused Metallurgical bond	Up to 7,000 psi Mechanical bond

Summary

- A patent-pending innovative coating system innovated to solve a client's pain point in the vent isolation location in POx.
- Qualified for use in POx service, beyond standard service parameters.
- Callidus supports the end user to achieve optimum performance in the form of technical, operational, and engineering support to key OEMs to assist with product improvements and development.

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