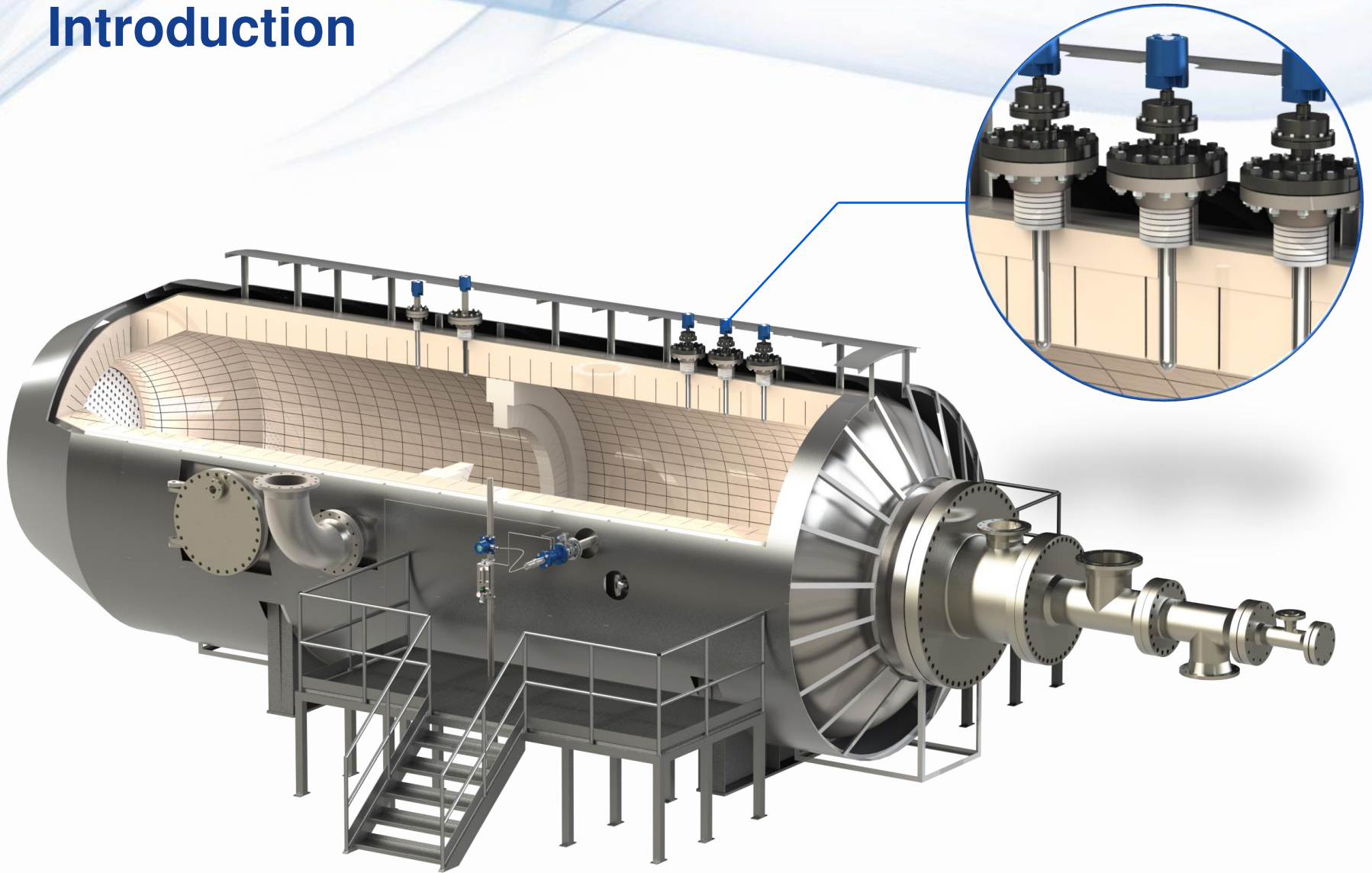


Understanding Unpurged Thermocouples in Sulfur Recovery



Delta Controls
CORPORATION

Introduction

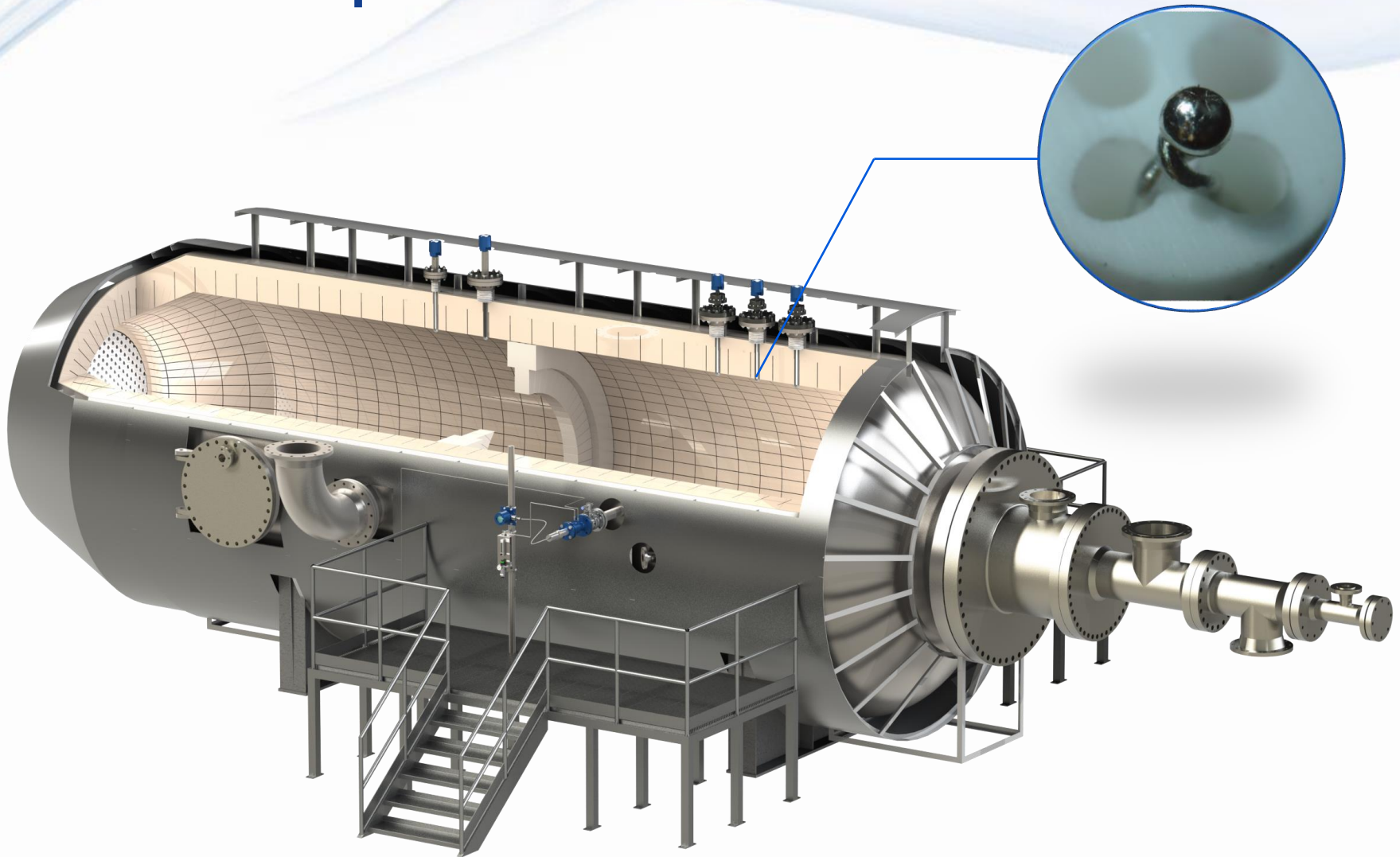


Overview

- Thermocouple Elements
- Purged Thermocouples
- Unpurged Design
- Unpurged Outlook

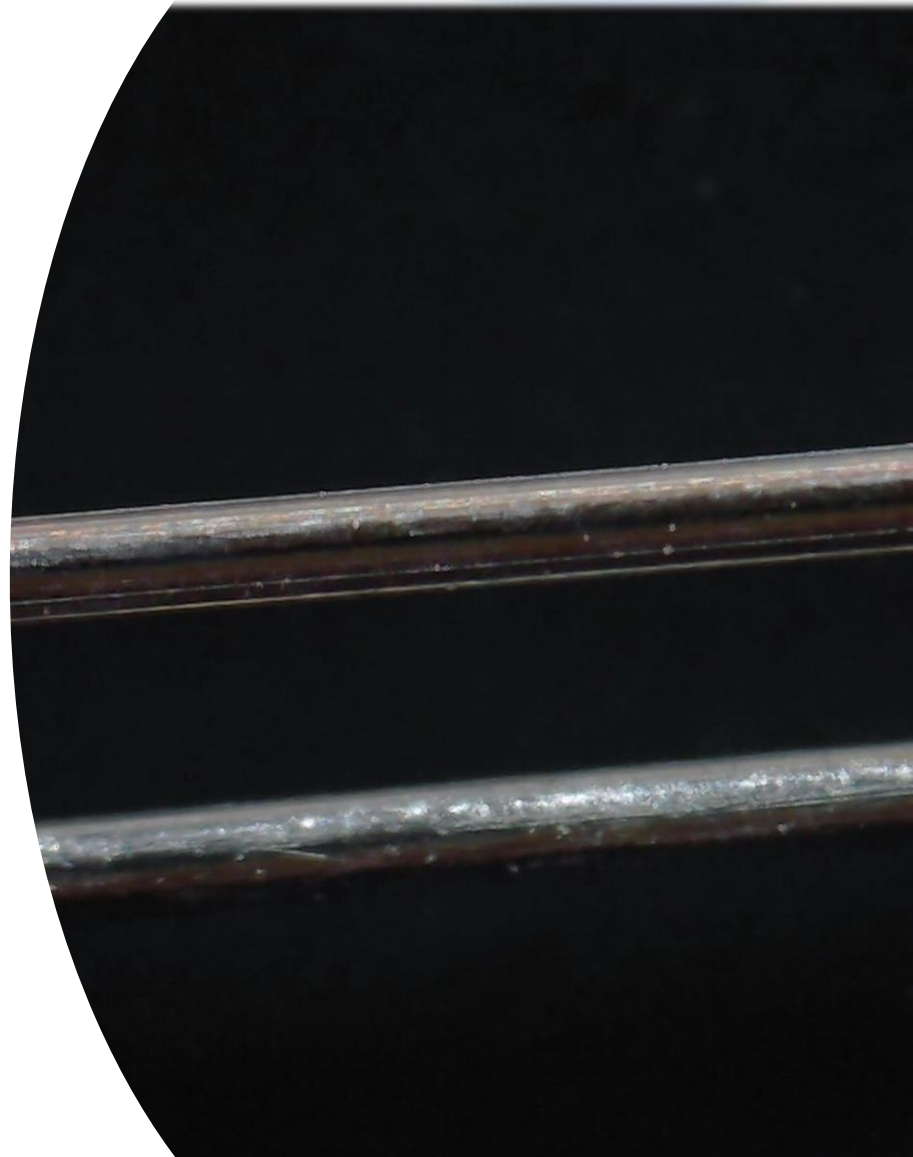


Thermocouple Elements



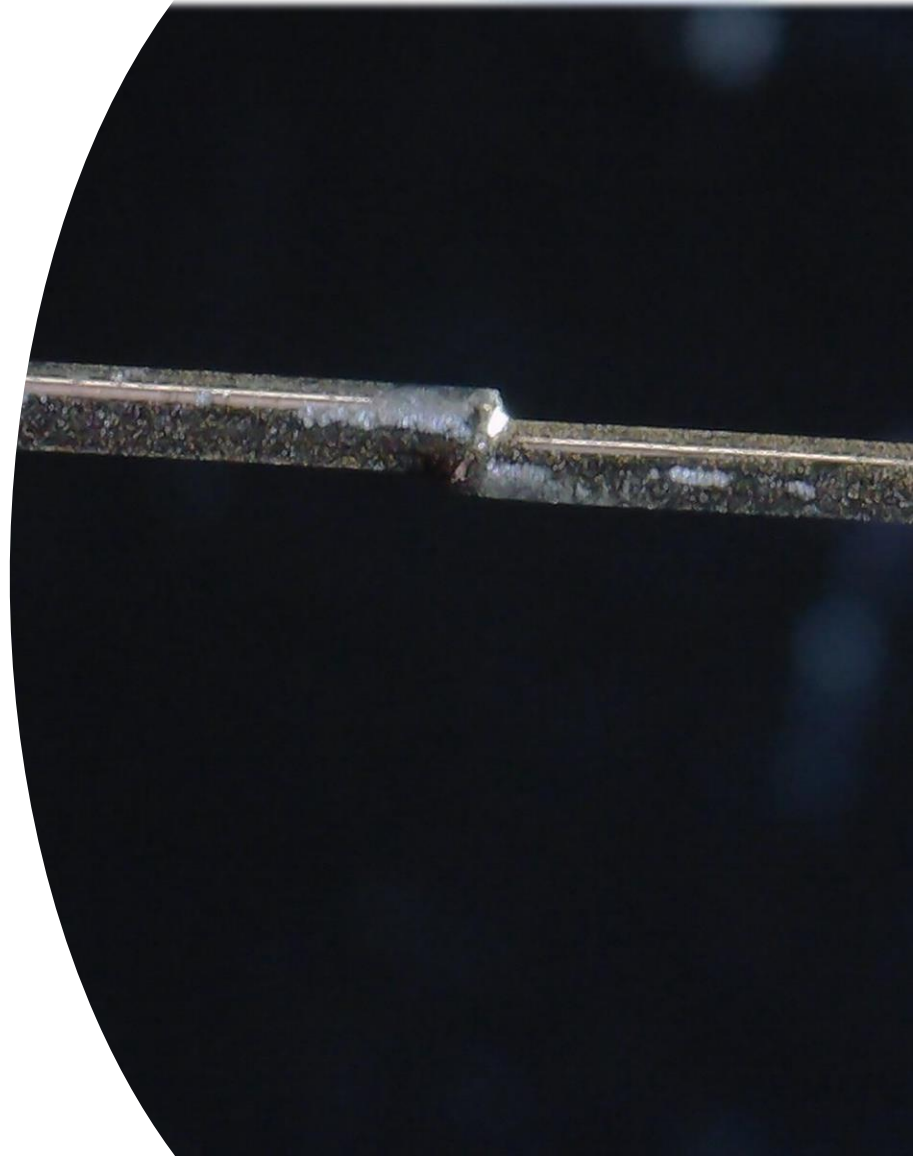
Thermocouple Elements

- Type R
 - Platinum +
Platinum with 13% Rhodium
 - 32 °F to 3214 °F
(0 °C to 1768 °C)
- Type B
 - Platinum with 6% Rhodium +
Platinum with 30% Rhodium
 - 600 °F to 3300 °F
(315 °C to 1820 °C)



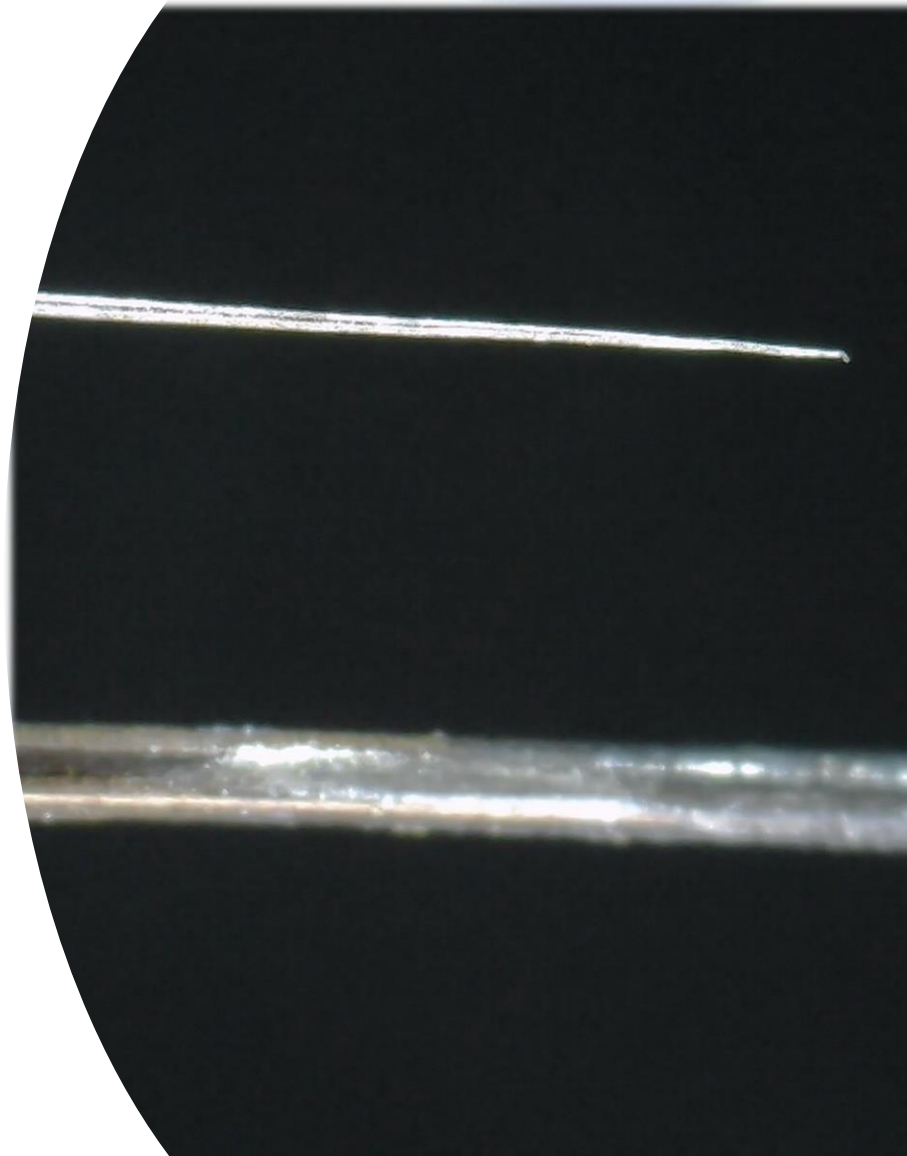
Thermocouple Elements

- Degradation Forms
 - H_2 Embrittlement



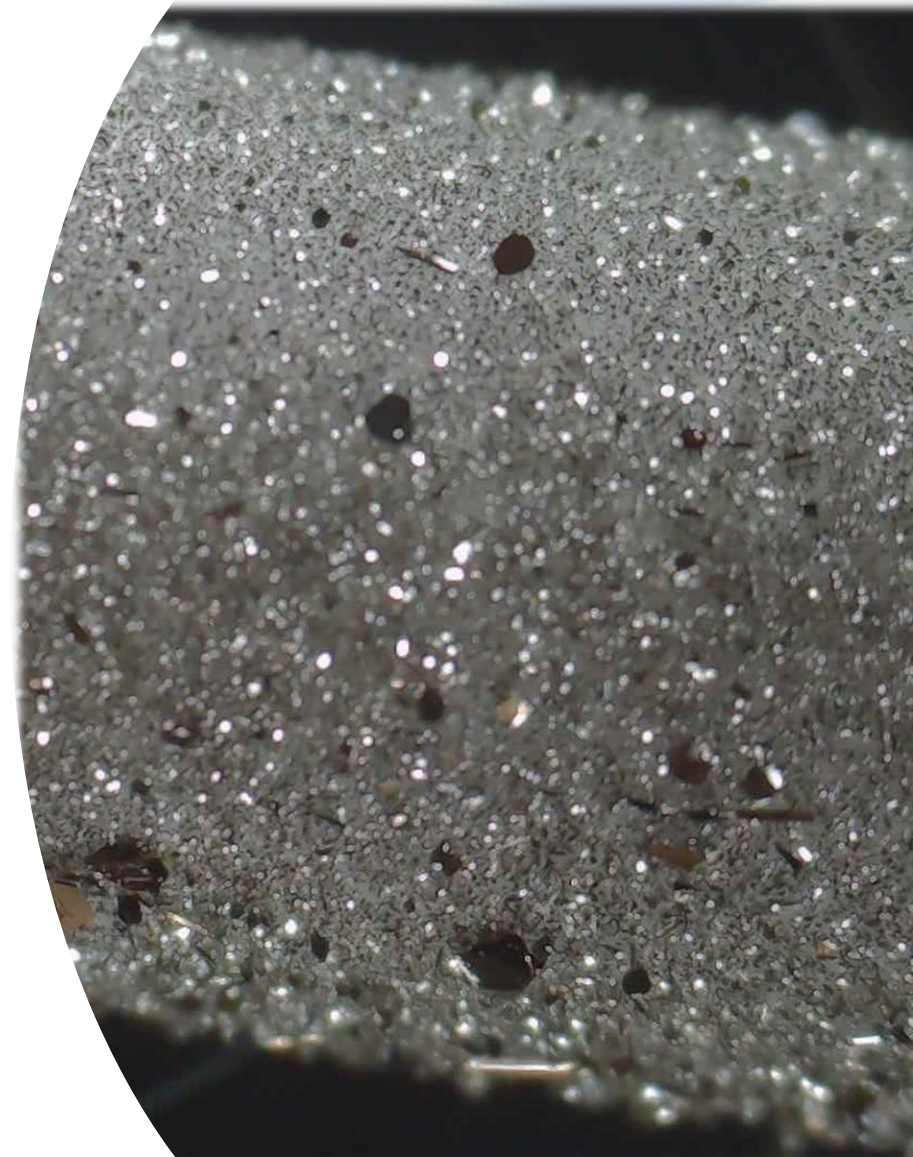
Thermocouple Elements

- Degradation Forms
 - H_2 Embrittlement
 - PtO_2 Sublimation



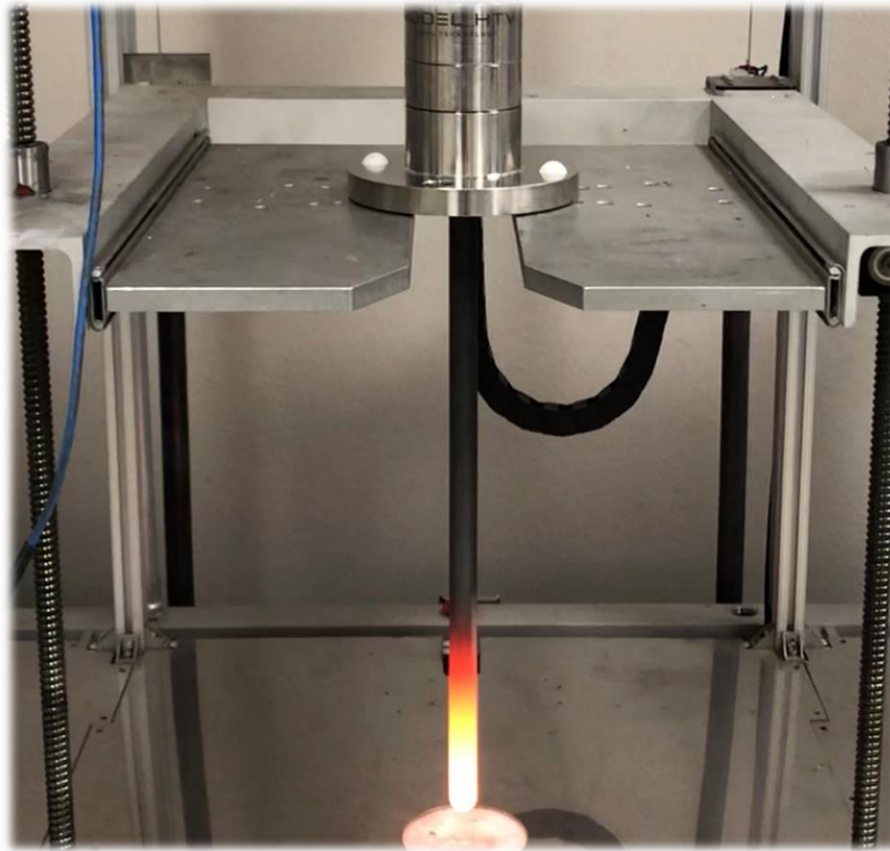
Thermocouple Elements

- Degradation Forms
 - H_2 Embrittlement
 - PtO_2 Sublimation
 - Others



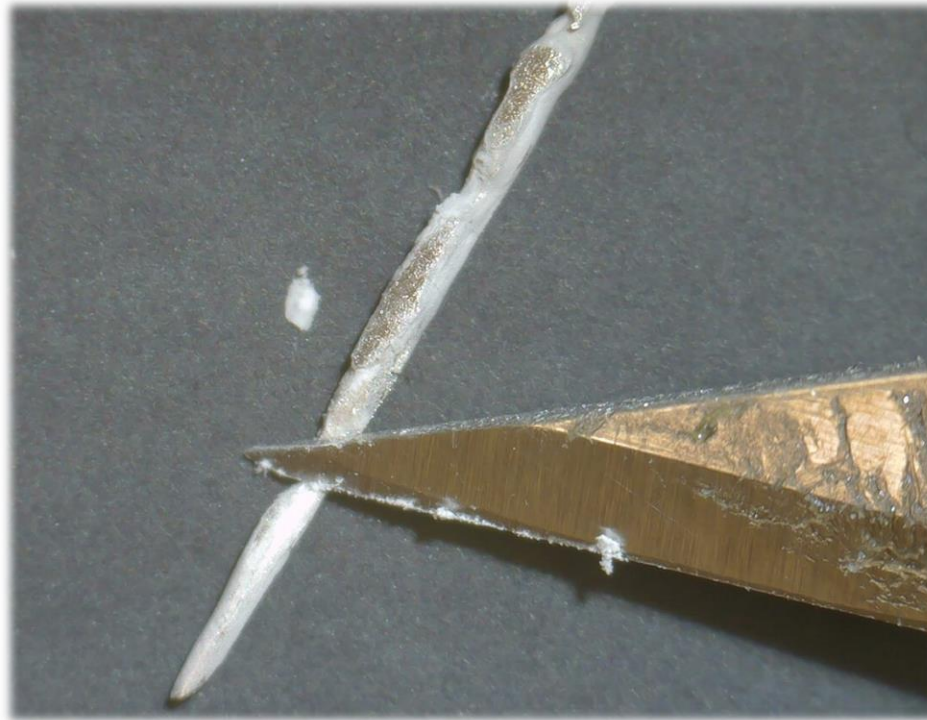
Thermocouple Analysis

- Analytical Methods
 - Thermal Testing



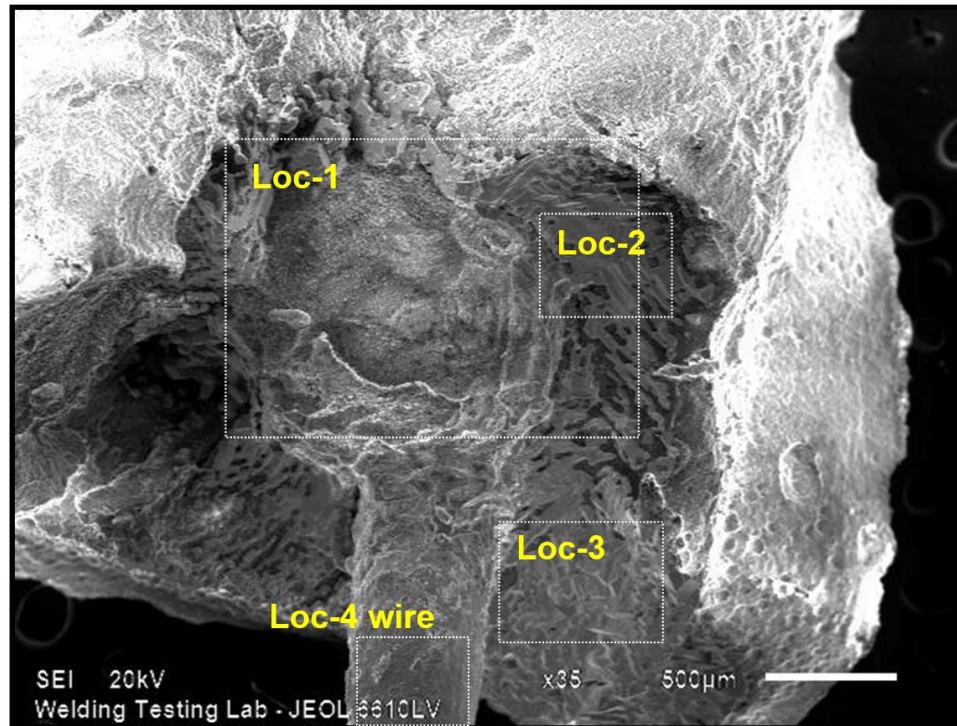
Thermocouple Analysis

- Analytical Methods
 - Thermal Testing
 - Optical Microscopy



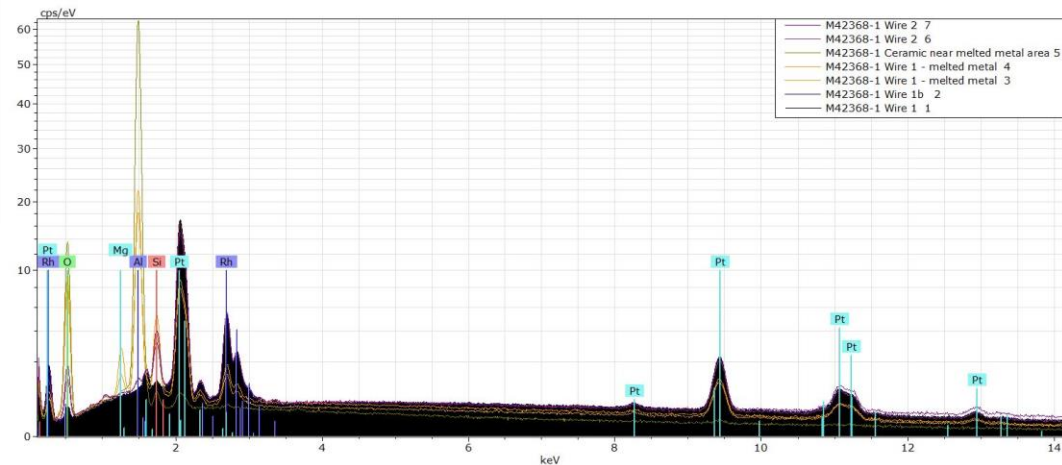
Thermocouple Analysis

- Analytical Methods
 - Thermal Testing
 - Optical Microscopy
 - SEM: Scanning Electron Microscopy

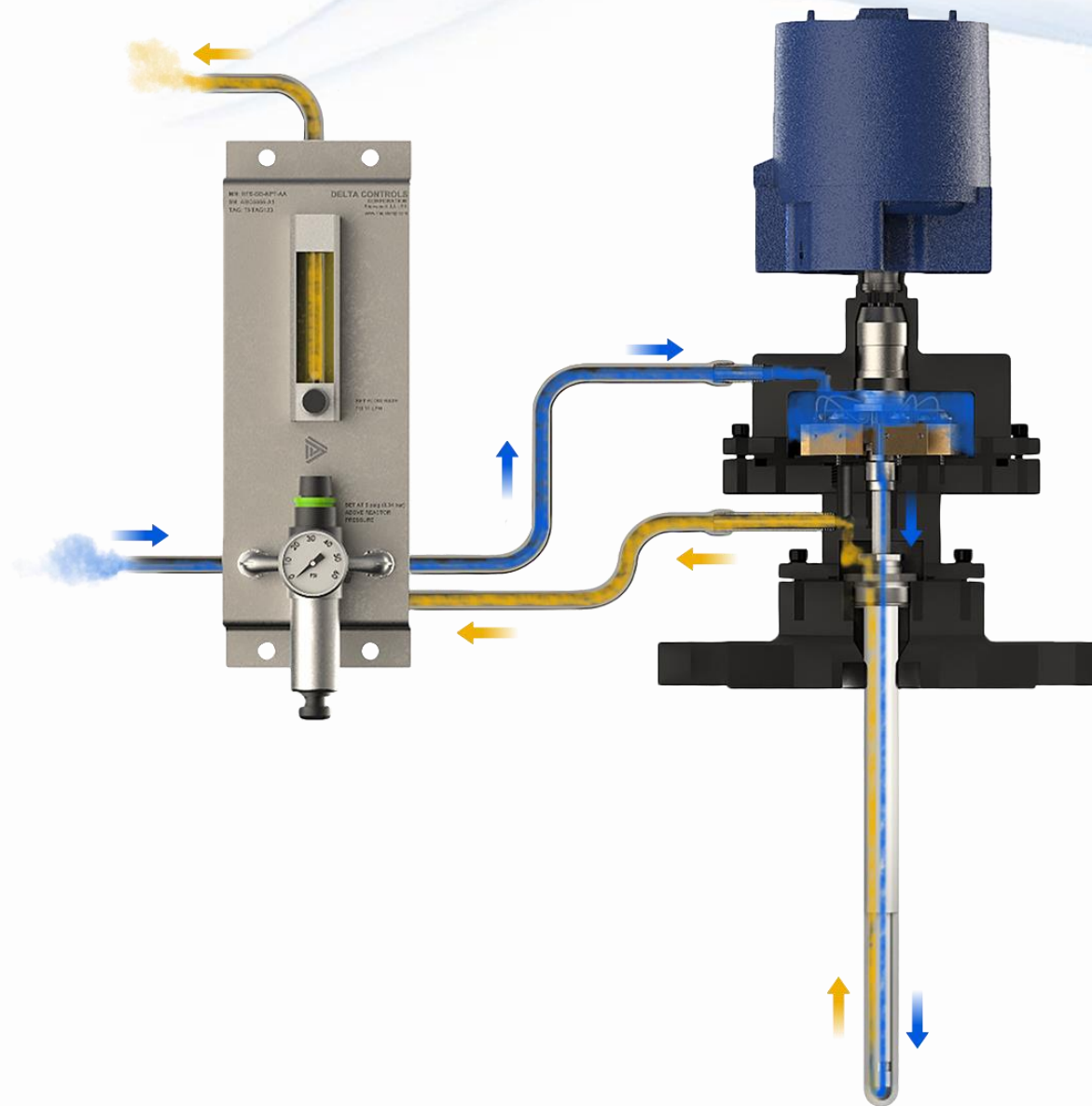


Thermocouple Analysis

- Analytical Methods
 - Thermal Testing
 - Optical Microscopy
 - SEM: Scanning Electron Microscopy
 - EDS: Energy Dispersive Spectroscopy



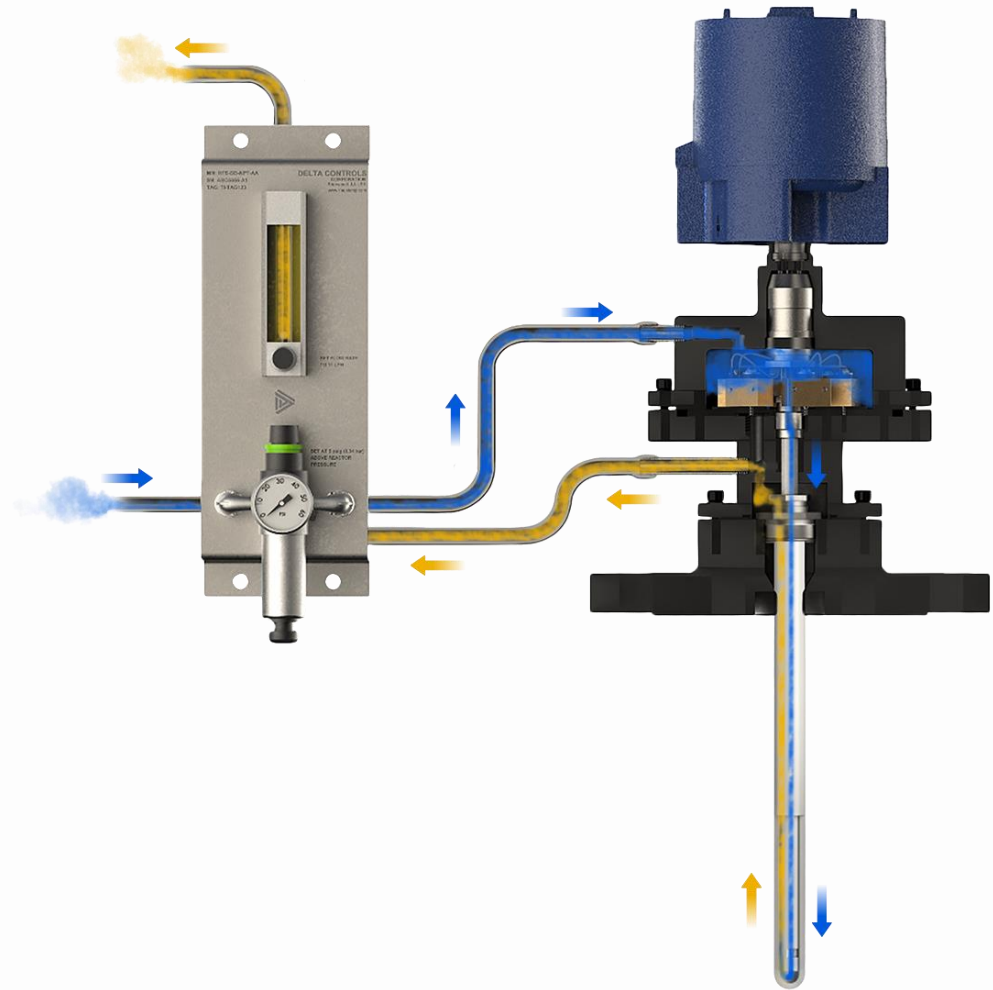
Purged Thermocouples

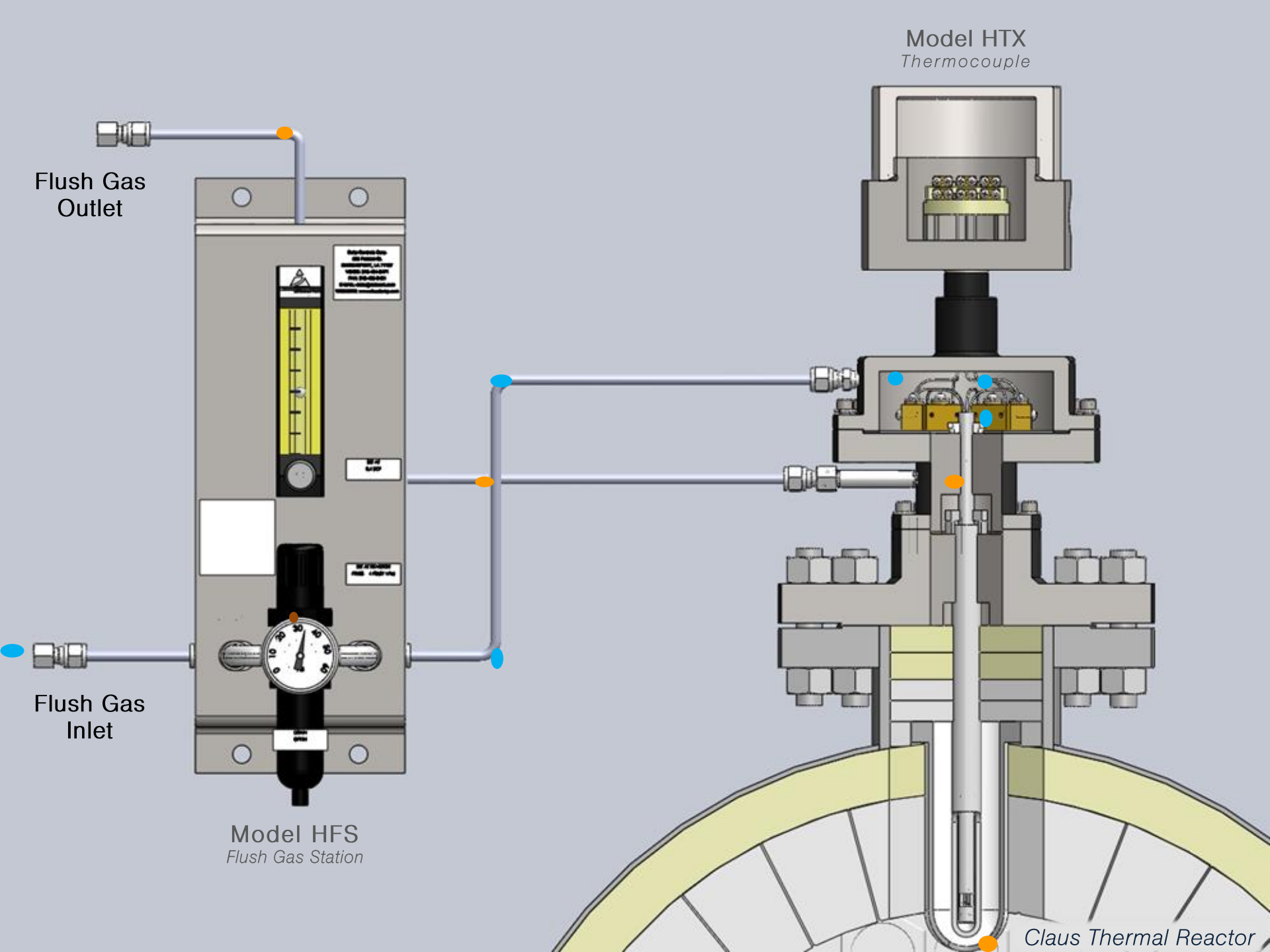


**Engineered
Reliability**

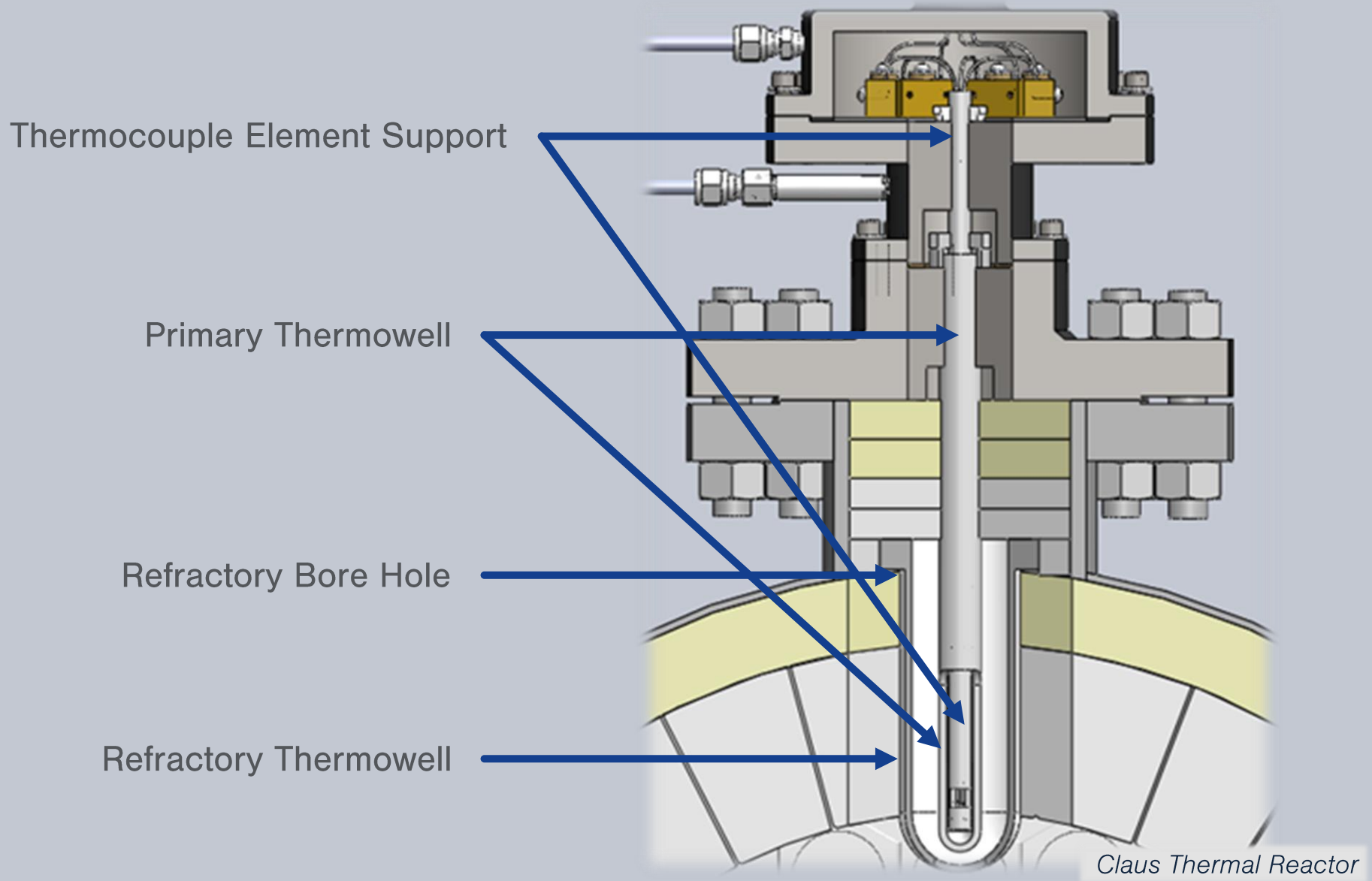
Purged Thermocouples

- Protection Mechanism
- Ceramic Porosity
- Diffusion





Purged Thermocouple Components



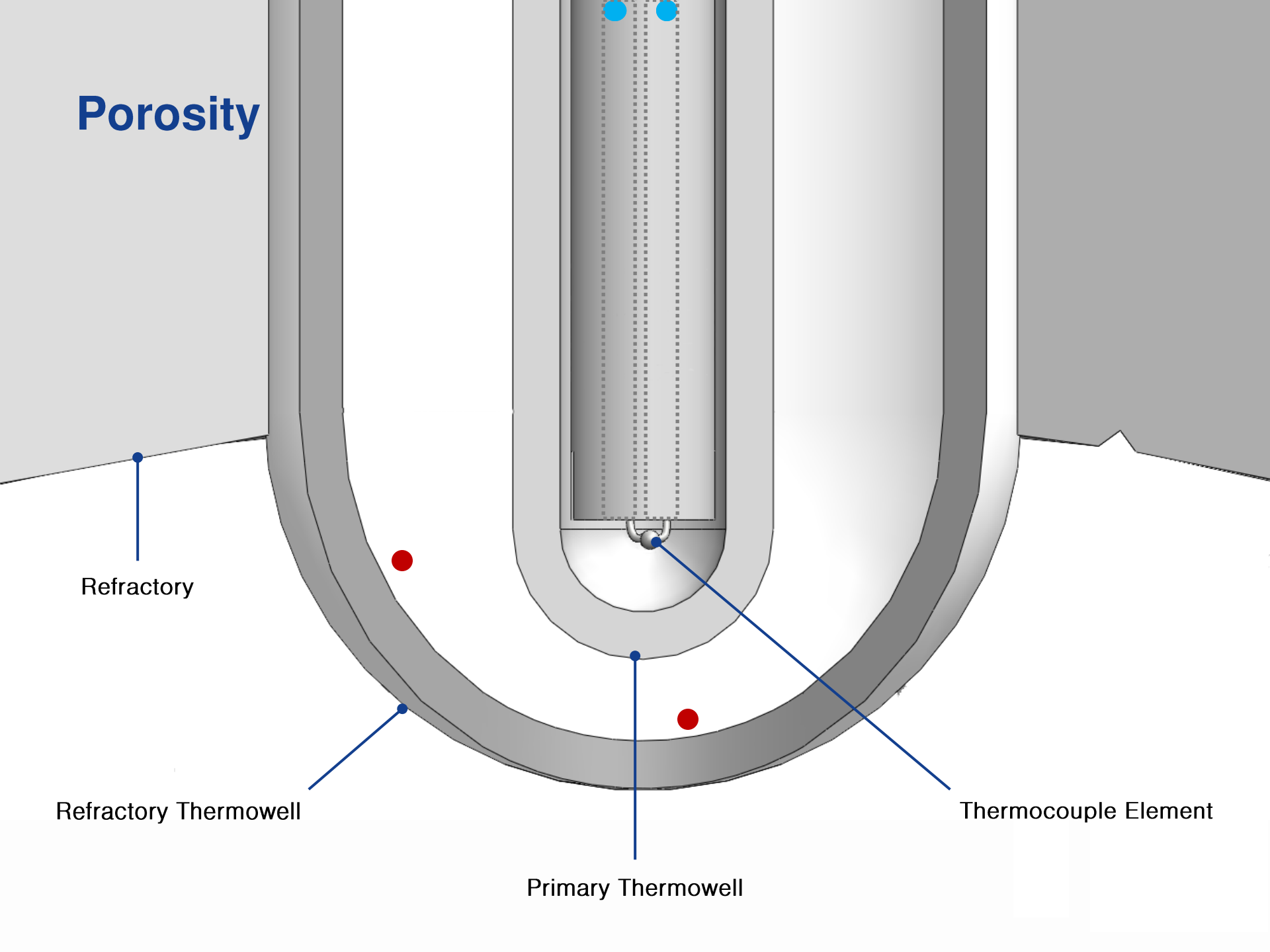
Porosity

Refractory

Refractory Thermowell

Primary Thermowell

Thermocouple Element

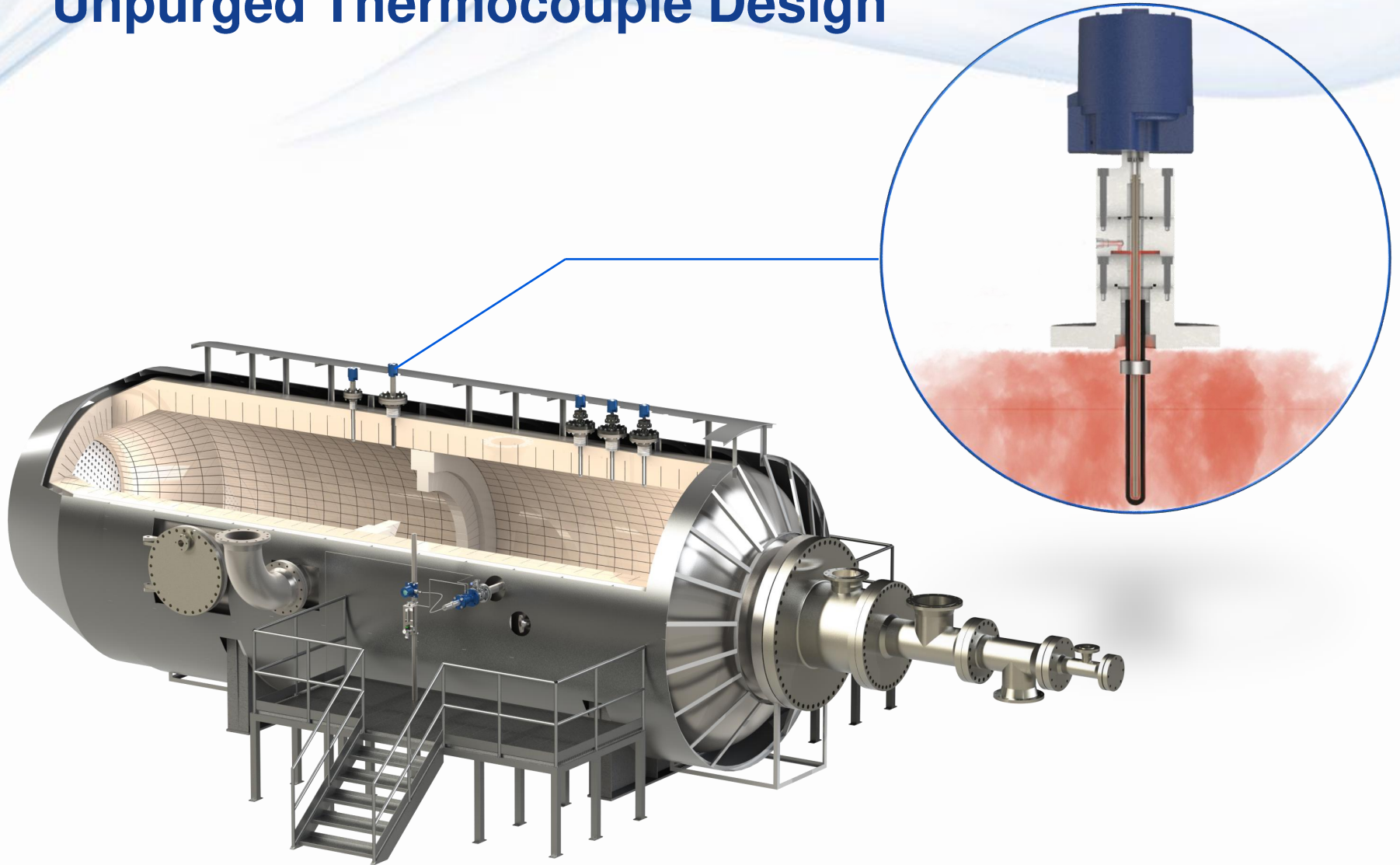


Purged Thermocouples

- Considerations
 - Purge Media
 - Utility

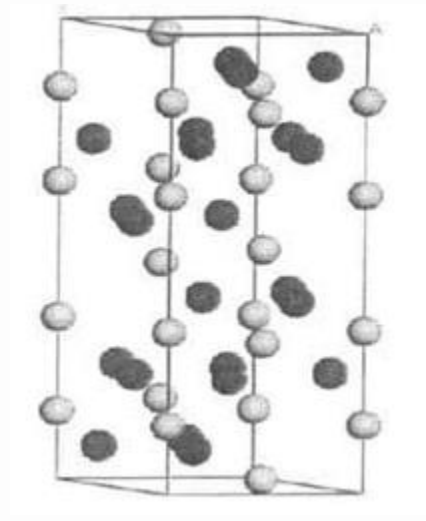


Unpurged Thermocouple Design

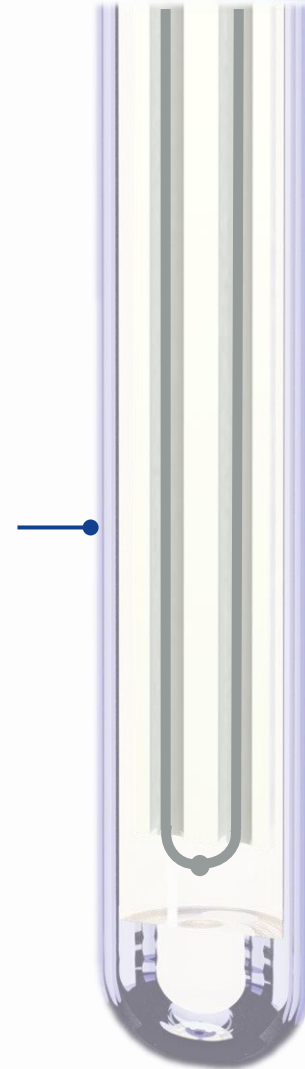


Unpurged Thermocouples

- Context
- Monocrystalline Sapphire
- Aluminum Oxide

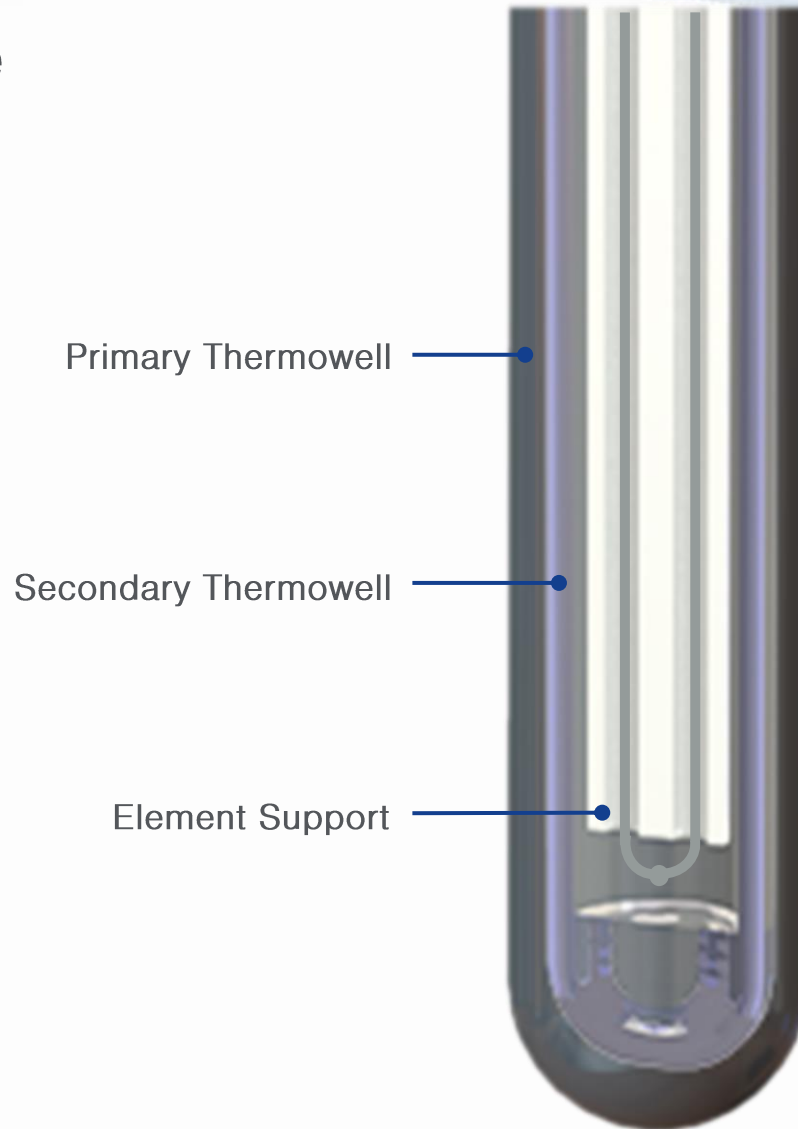


Sapphire Thermowell
Exterior to Element Support



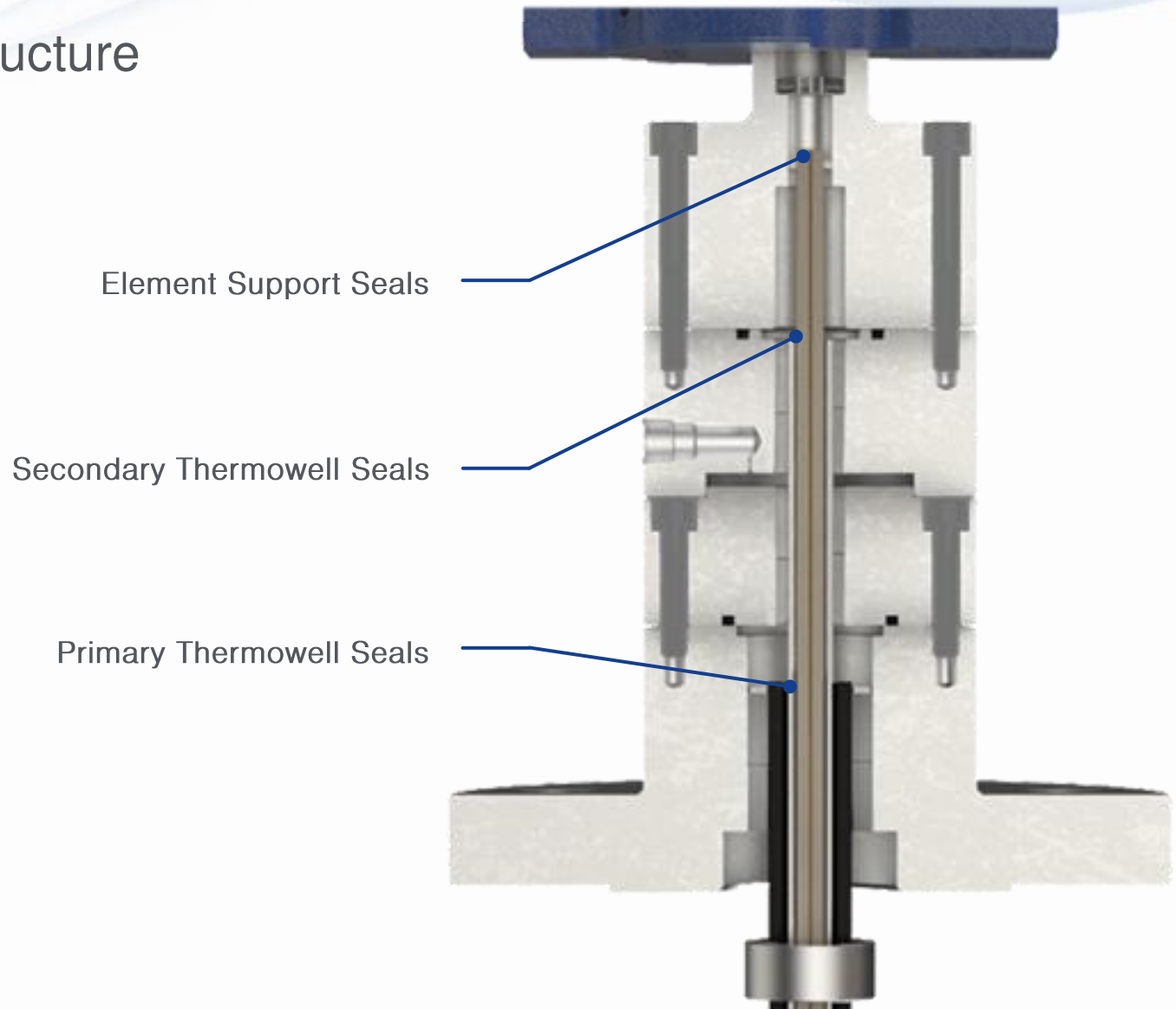
Unpurged Thermocouple Design

- Thermowell Structure



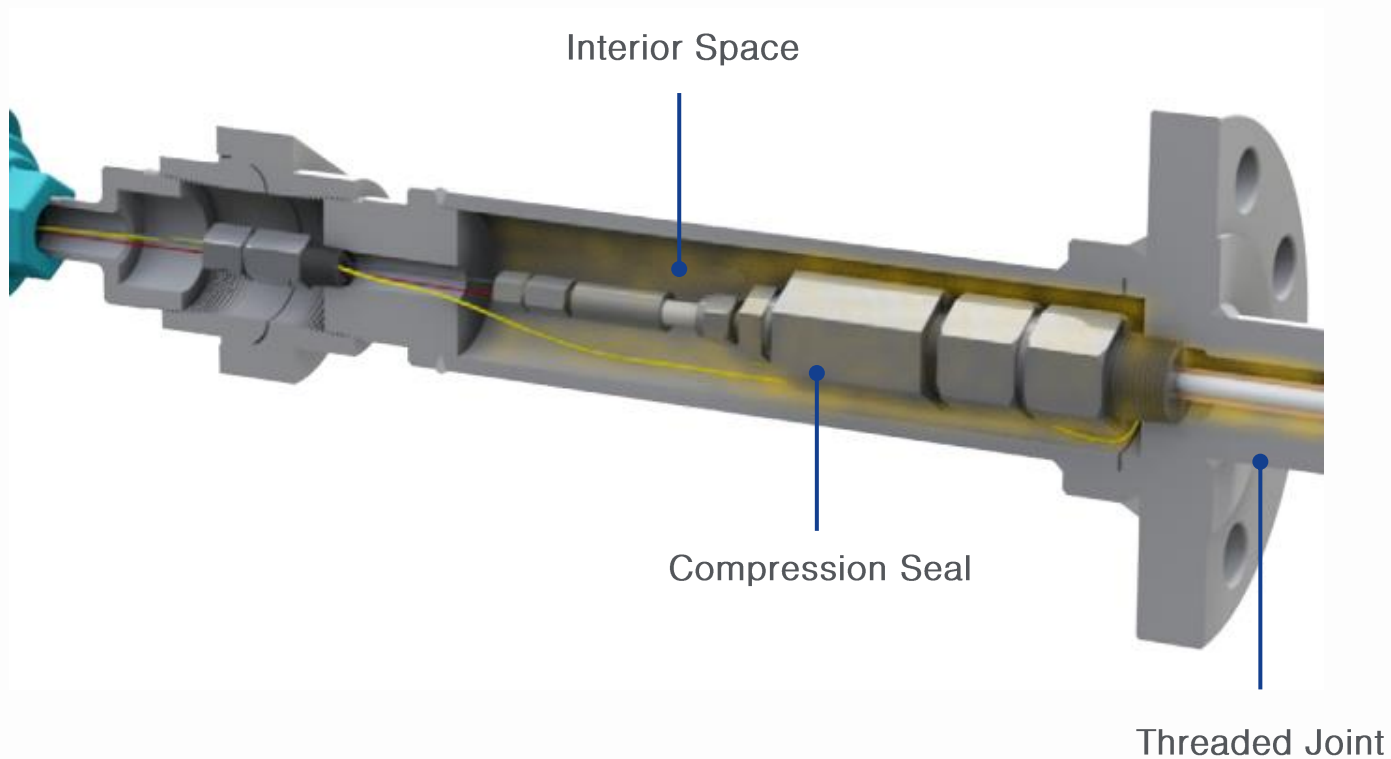
Unpurged Thermocouple Design

- Sealing Structure



Unpurged Thermocouple Design

- Trace Gas Accumulation

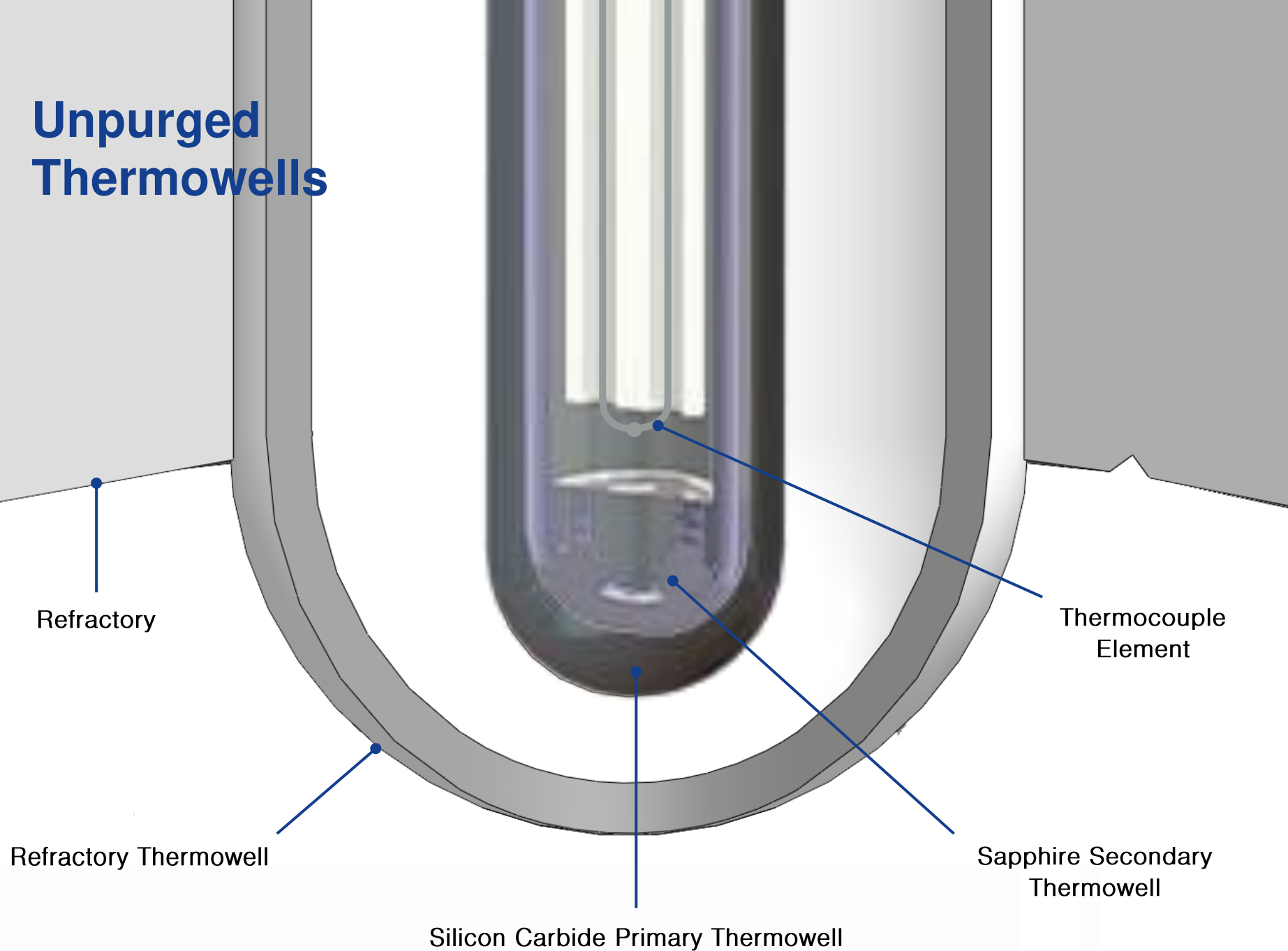


Unpurged Thermocouple Design

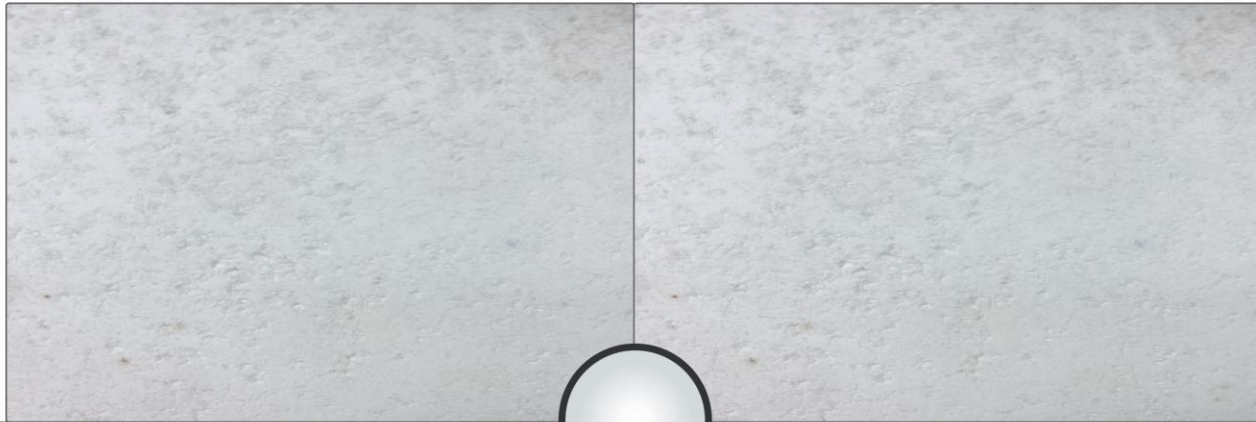
- Equilibrium Sealing System



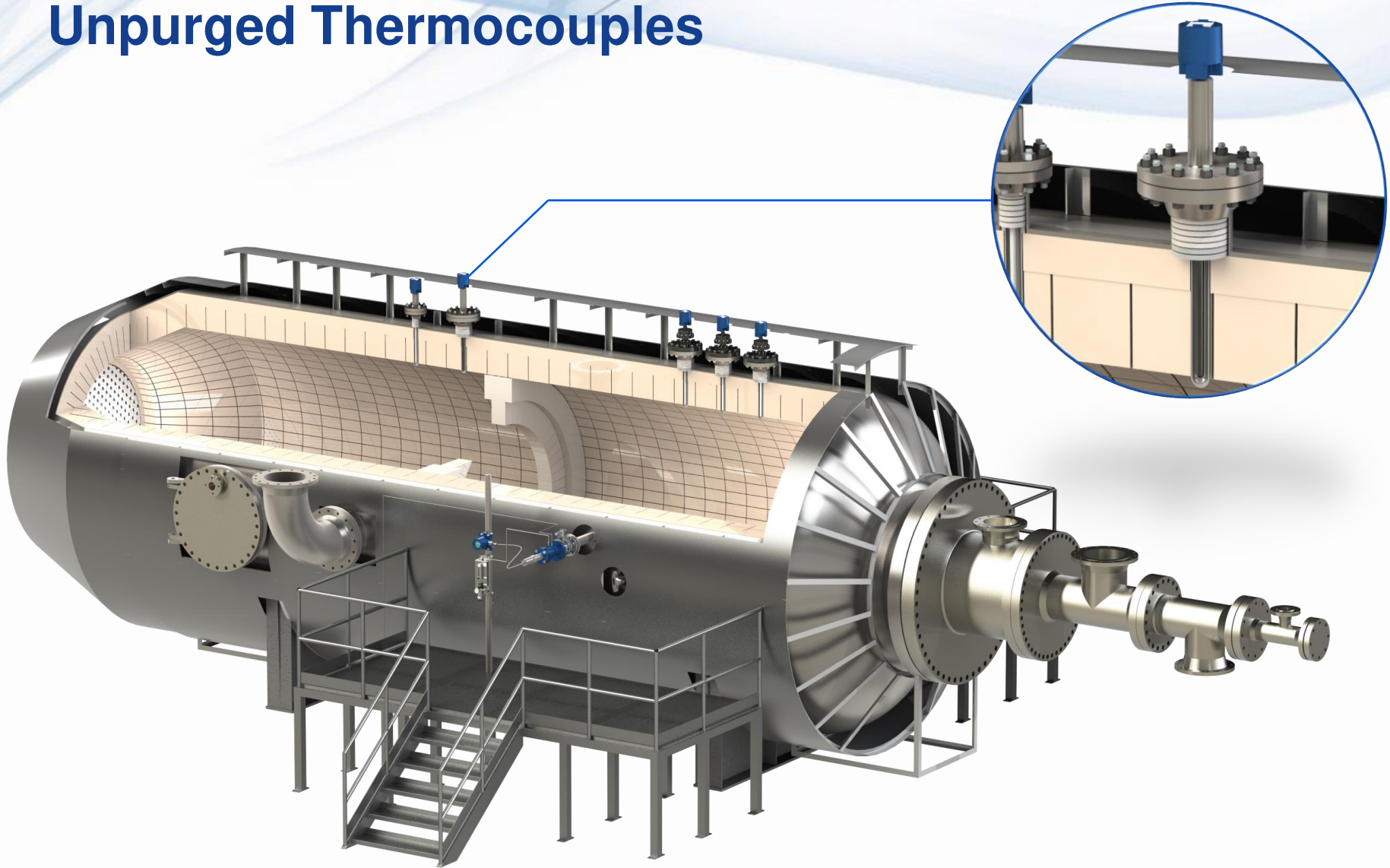
Unpurged Thermowells



Unpurged Thermowells



Unpurged Thermocouples



Conclusion

- Unpurged Outlook
- Field Data & Tests
- Importance



Model HTV



**Engineered
Reliability**