

HIGH TEMPERATURE METALLIC SEAL DEVELOPMENT

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High Temperature Metallic Seal Development

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Objective

- Develop a high temperature static seal capable of long term operation at temperatures ranging from 1400°F to 1800°F

Outline

- Development approach
- Stress relaxation curves
- High temperature seal test rig
- High temperature seal design
- High temperature seal testing

Development Approach

- Screen Metallic Alloys Using ASTM E-328 Stress Relaxation Tests in the 1600-1800 °F Range
- Fabricate and Evaluate Seals in the 1400-1800 °F Range

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Stress Relaxation Studies

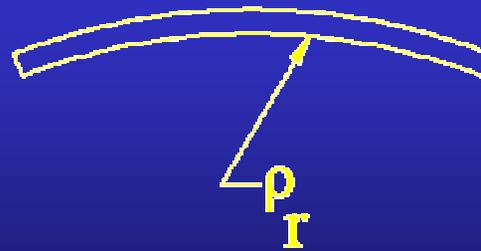
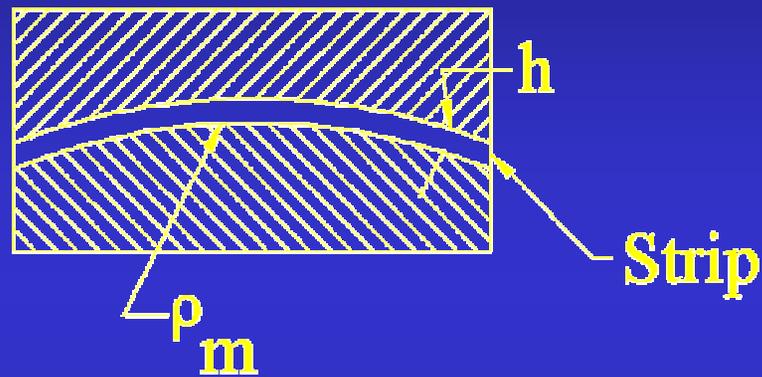
- ASTM E-328 Test:

ρ_m - mandrel radius

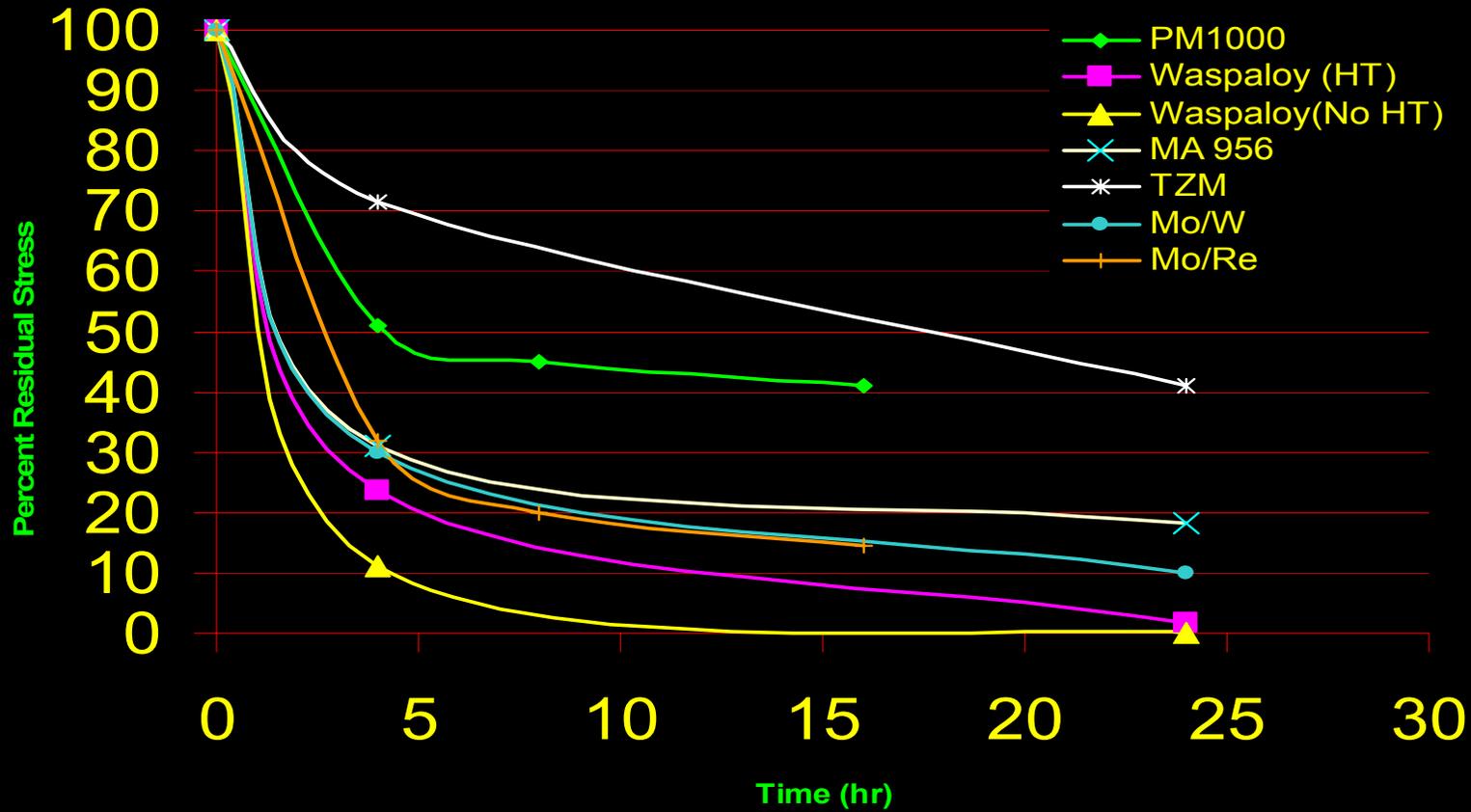
ρ_r - relaxed radius

Residual Stress:

$$\sigma_{EI} = E \cdot h/2 (1/\rho_m - 1/\rho_r)$$



Stress Relaxation Studies at 1800 °F



Stress Relaxation Studies at 1600 °F



Stress Relaxation Studies

- ASTM Style Testing
 - Continuing to perform testing of currently used and new seal alloys at temperatures ranging from 1000°F to 1800°F
 - This testing is necessary to properly select materials for specific temperature ranges

UHT Seal Test Rig

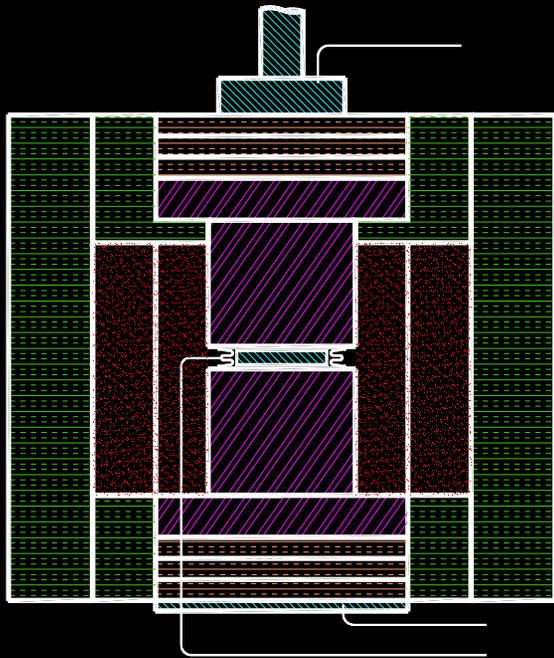


Performance Requirements

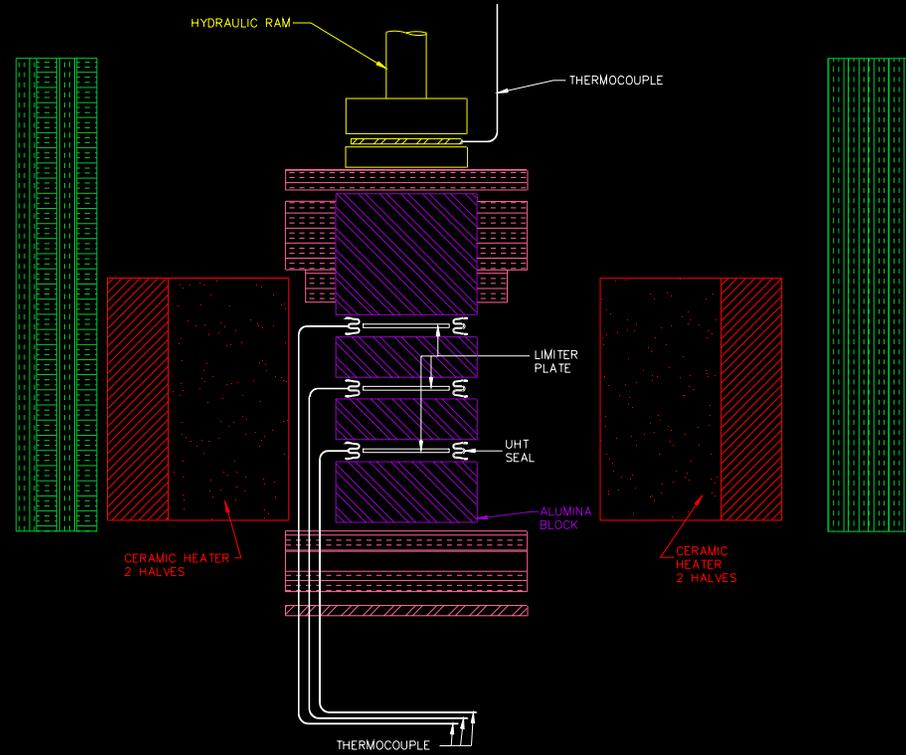
- Room Temperature through 1800°F continuous test temperature
- PLC controls with built in safety mechanisms
- Multiple thermocouple locations for accurate seal temperature monitoring
- Capable of extended test duration's to examine long term seal performance

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UHT Seal Test Rig

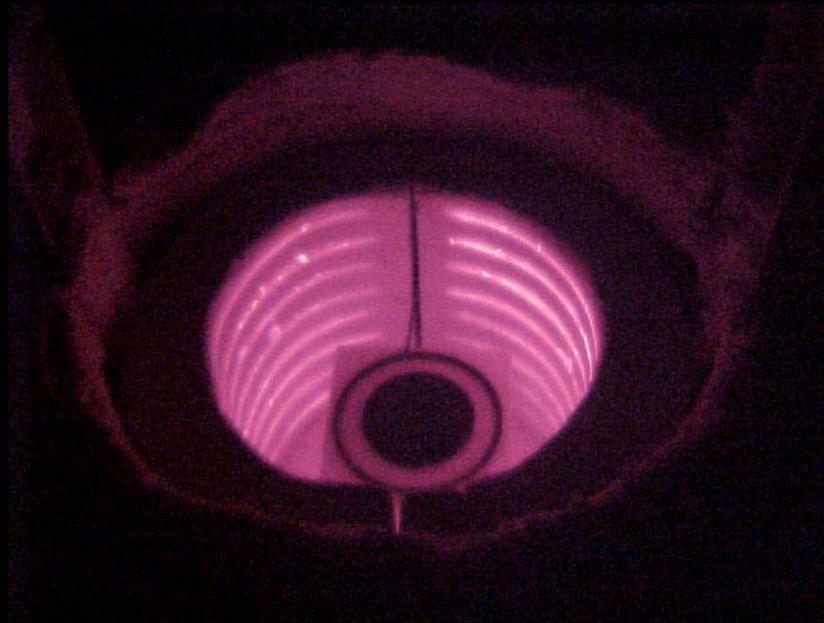


Compact View



Exploded View

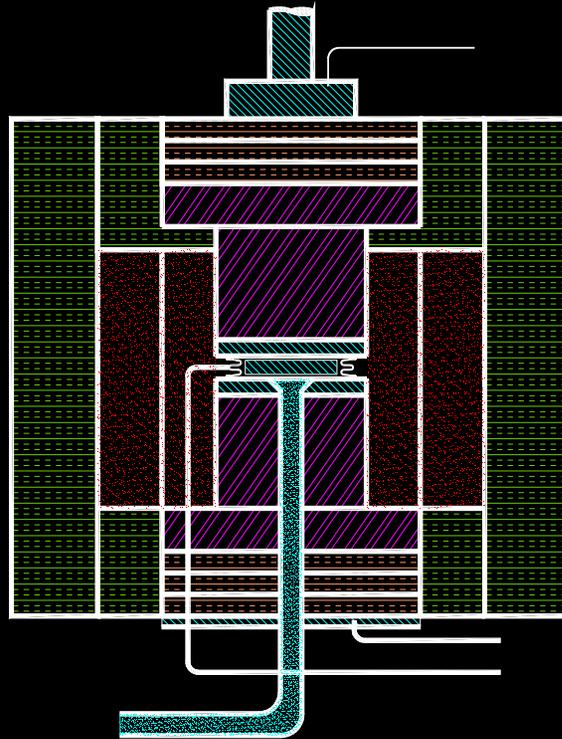
UHT Seal Test Rig



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UHT Seal Test Rig

- Seal leak testing at temperature
 - Rig will be modified to determine leakage
 - Inconel 718 plates will be used a seal seat
 - Mass flow meters will be used to measure leakage



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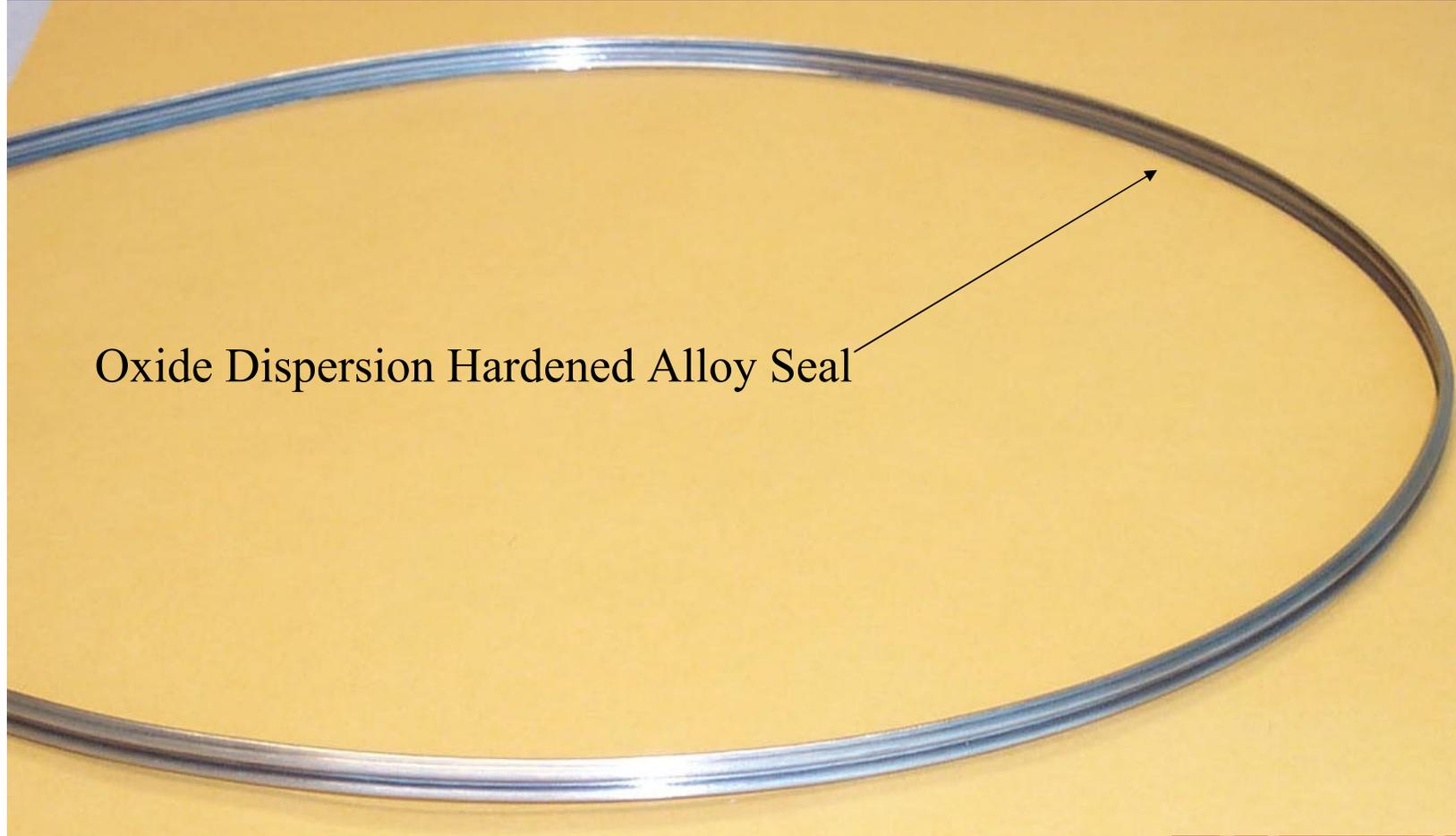


UHT Seal Design

- Seal cross section designed to minimize stress levels
- Manufactured seals from
 - Waspaloy - Baseline
 - Precipitation hardenable alloy with a higher precipitation temperature than Waspaloy
 - Solid solution hardened alloy
 - Oxide Dispersion Hardened Alloy(1800 °F)

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UHT Seal Design



Oxide Dispersion Hardened Alloy Seal



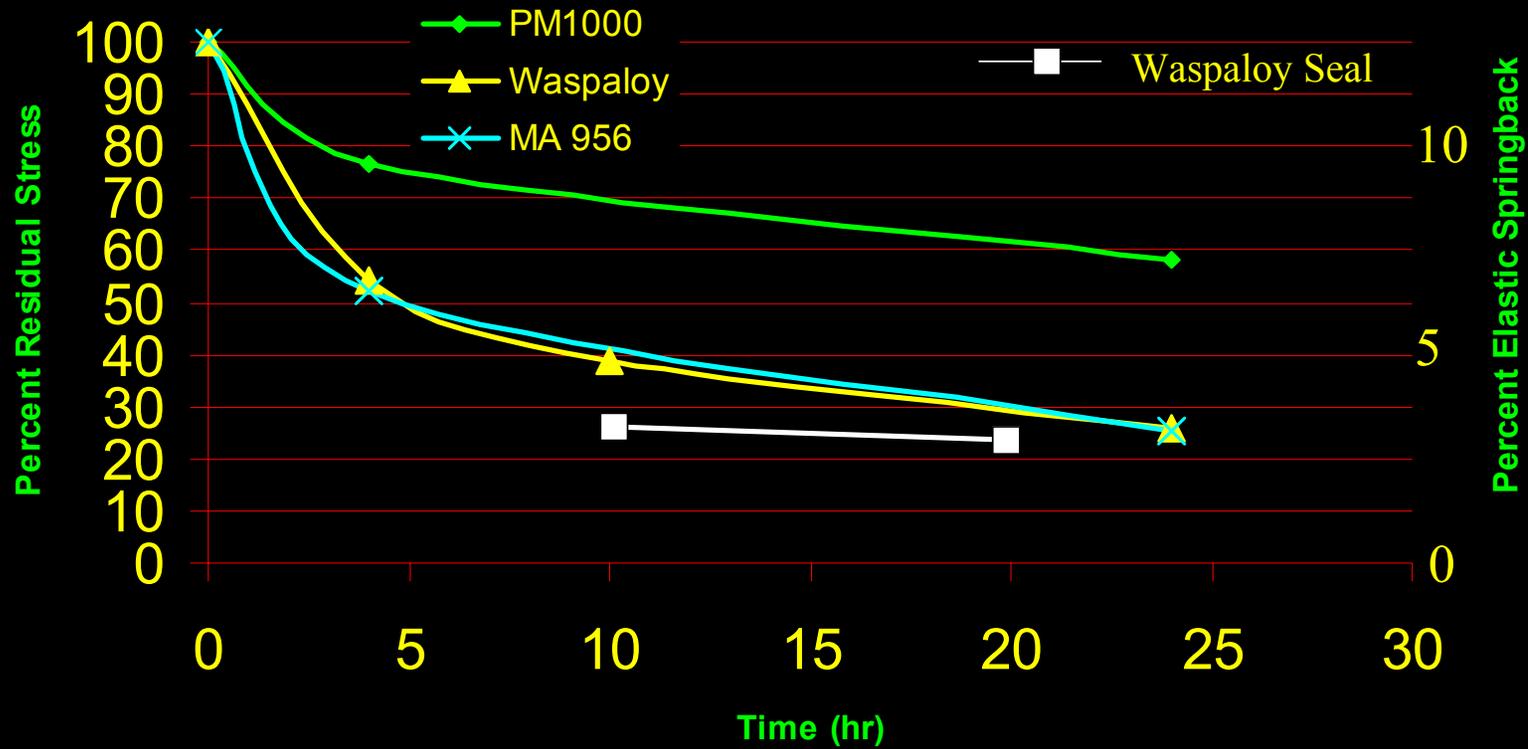
UHT Seal Testing

- Performed preliminary testing on baseline(Waspaloy) material
- Over the next several months tests of additional material and seal cross section configurations will undergo basic stress relaxation testing
- Additional phases to include high temperature leakage testing

UHT Seal Testing

- Seal testing procedure
 - Measure seal free height prior to test
 - Compress seal 15% in UHT rig
 - Hold at temperature for a controlled time
 - Cool and measure seal height
 - Calculate percent loss in seal free height

Stress Relaxation Studies at 1600 °F



Summary

- ASTM Style testing continues for basic material screening
- UHT test rig is completed and is operational
- UHT Seal testing underway and will continue over the following months