

HIGH TEMPERATURE METALLIC SEAL DEVELOPMENT

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Based on the ASTM stress relaxation studies, UHT seals have been fabricated using a candidate superalloy, an oxide dispersion strengthened (ODS) alloy and a proprietary composite structure. Seal characterization tests are being conducted in the temperature range 1500 °F to 1800 °F by monitoring the change in the seal free height as a function of the exposure time. Results of an advanced superalloy seal, obtained so far, will be presented and compared with those of standard Waspaloy seals.

An innovative knowledge-based seal design and application engineering software has also been developed by Advanced Products. This Integrated Product Engineering (IPE) approach will be explained and demonstrated.

The logo for Advanced Components & Materials, Inc. features the word "Advanced" in white, bold, sans-serif font, centered within a red rectangular background.

High Temperature Metallic Seal Development

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Objective

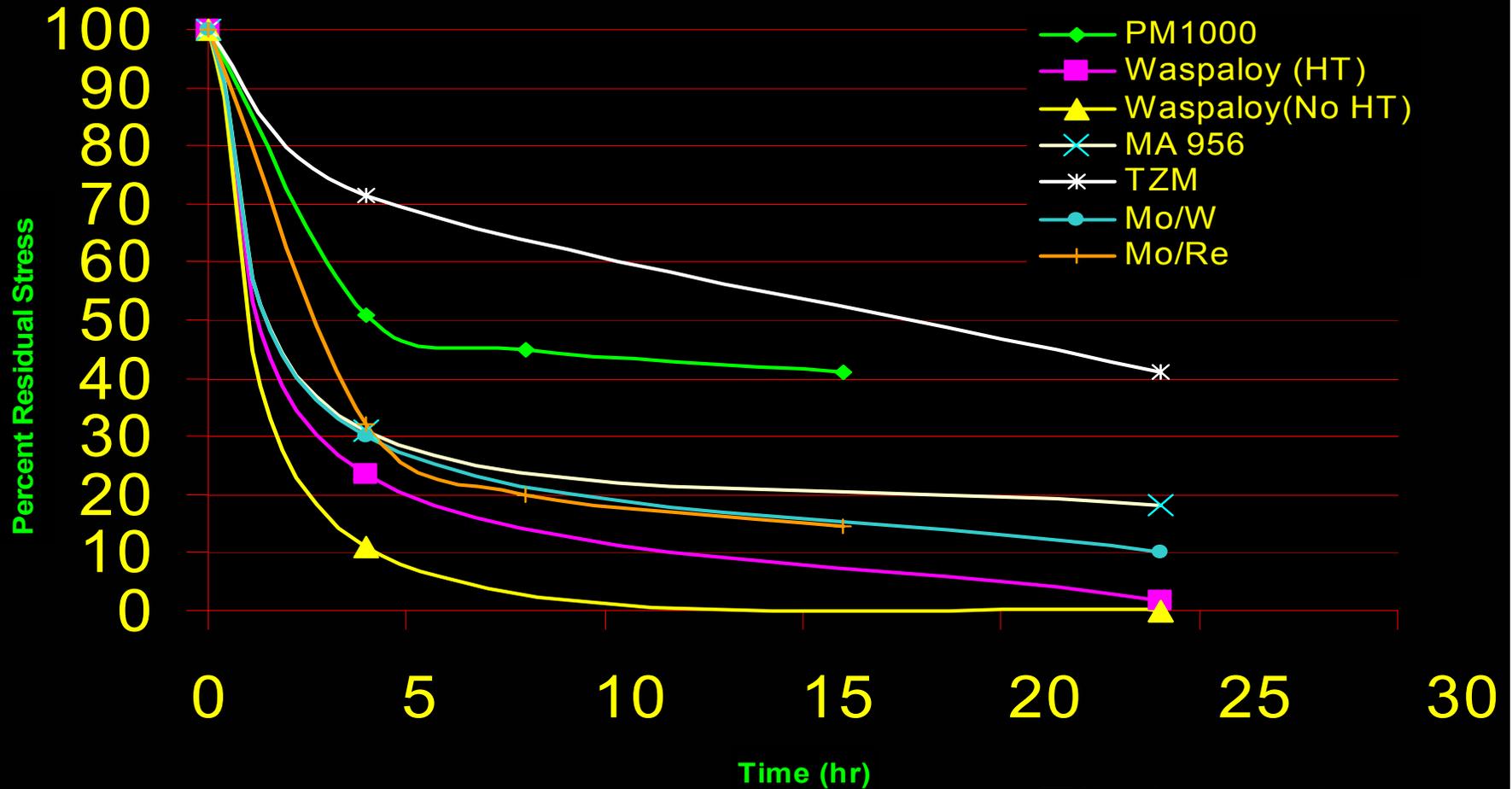
- Develop a high temperature static seal capable of long term operation at temperatures ranging from 1400°F to 1800°F

Development Approach

- Screen Metallic Alloys using ASTM E-328 Stress Relaxation tests in the 1600 - 1800 °F Range
- Fabricate seals from alloys that performed the best in the generic screening test
- Performance test seals at elevated temperatures in simulated application cavities at temperatures ranging from 1400 - 1800 °F
- Candidate alloys include - Superalloys, ODS alloys, Refractory alloys, composite alloy structures

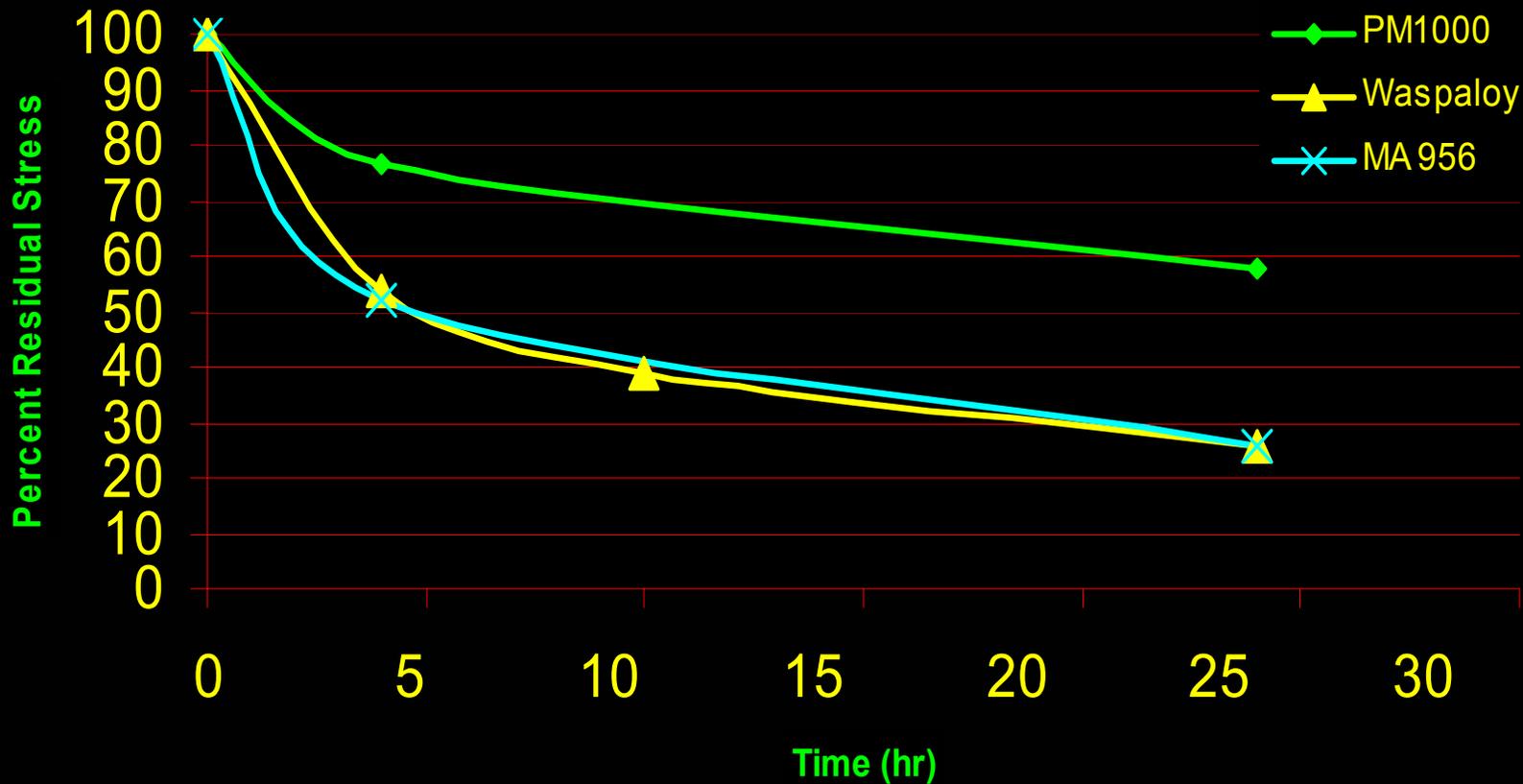
Screening Stress Relaxation Studies at 1800 °F

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* TZM is not being considered as a candidate seal material due to its poor oxidation resistance.

Screening Stress Relaxation Studies at 1600 °F



Stress Relaxation Studies

- ASTM Style Testing
 - Primary focus has now shifted to alloys capable of operating at 1600 - 1800 °F
 - We now have a good understanding of short term material behavior in the 1400 - 1600 °F temperature range

UHT Seal Test Stand

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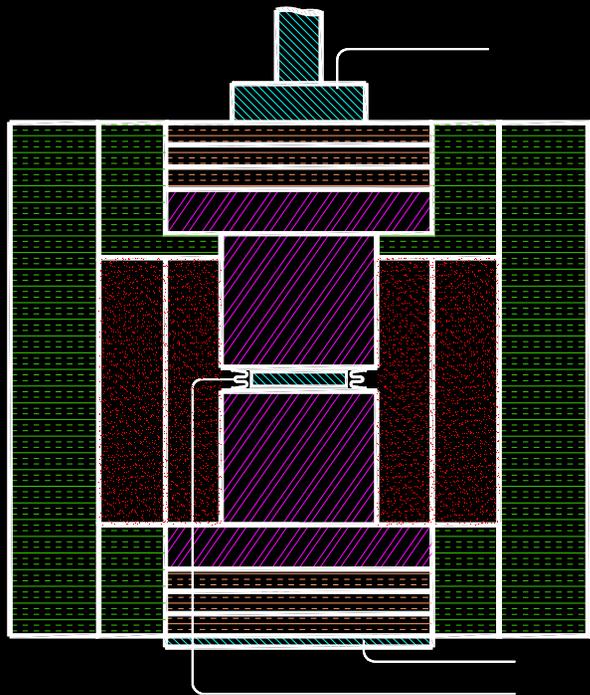


Performance Requirements

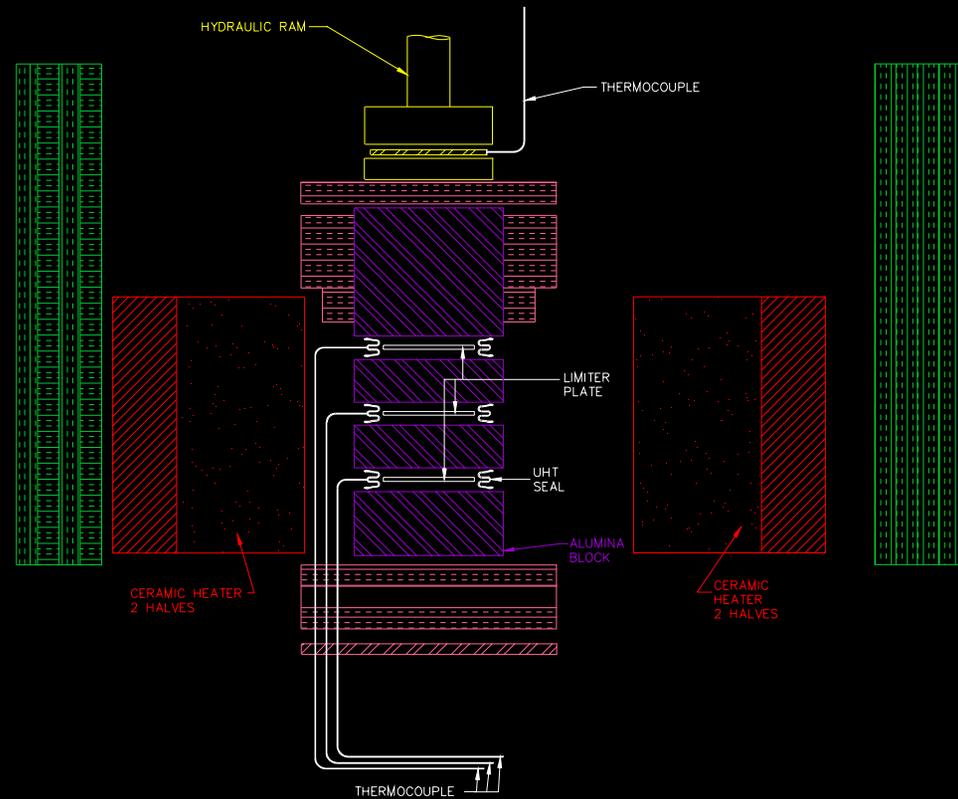
- Room Temperature through 1800 °F continuous test temperature
 - Test Stand has demonstrated operation at 2200 °F
- PLC controls with built in safety mechanisms
- Multiple thermocouple locations for accurate seal temperature monitoring
- Capable of extended test duration's to examine long term seal performance

UHT Seal Test Rig

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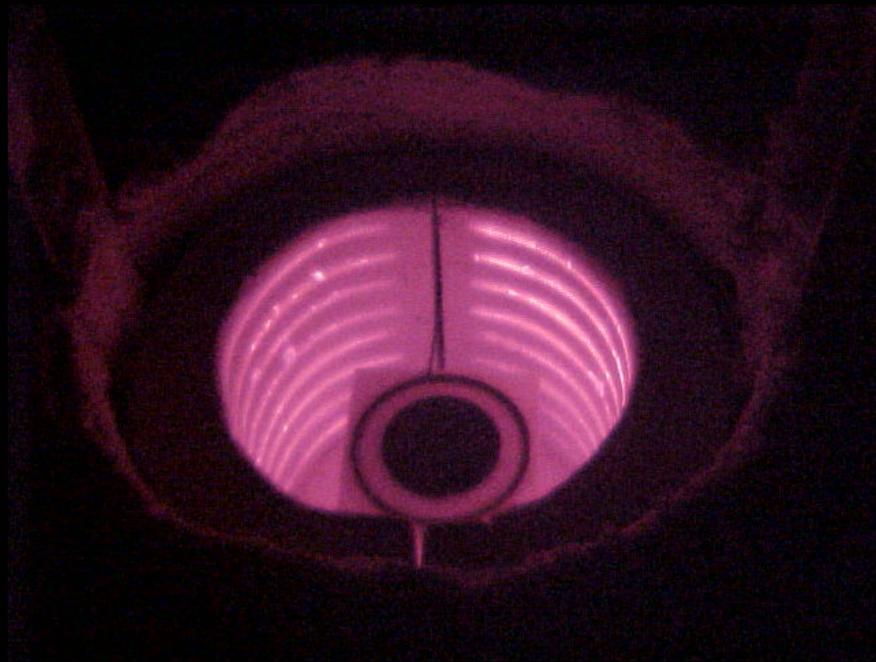
Compact View



Exploded View

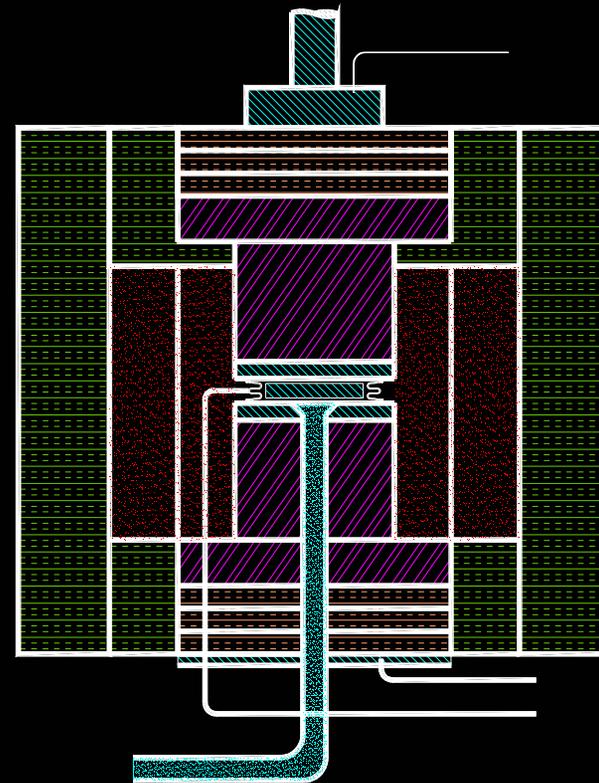
UHT Seal Test Stand

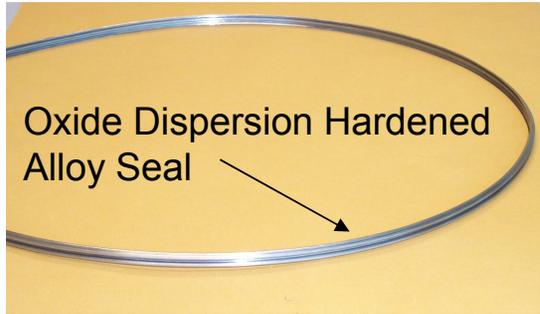
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UHT Seal Test Rig Future Modifications

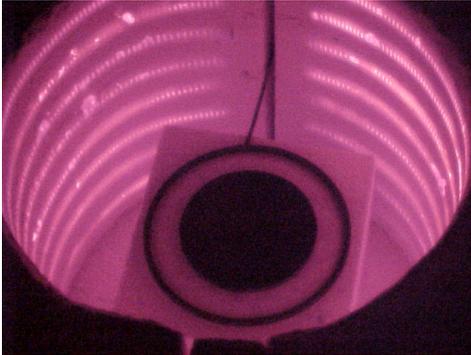
- Seal leak testing at temperature
 - Rig will be modified to determine leakage
 - Metallic plates will be used as seal seat
 - Mass flow meters will be used to measure leakage
- Flange movement to simulate engine cyclic motions or vibrations
 - For a potential program with an engine OEM





UHT Seal Design

- Seal cross section designed to minimize stress levels
- Seals from the following materials have been manufactured and tested in UHT test stand
 - Waspaloy - Baseline
 - Precipitation hardenable alloy with a higher precipitation temperature than Waspaloy
 - Solid solution hardened alloy
 - Oxide Dispersion Hardened Alloy(1800 °F)
 - Composite superalloy
- Thermomechanically processed material to enhance mechanical properties

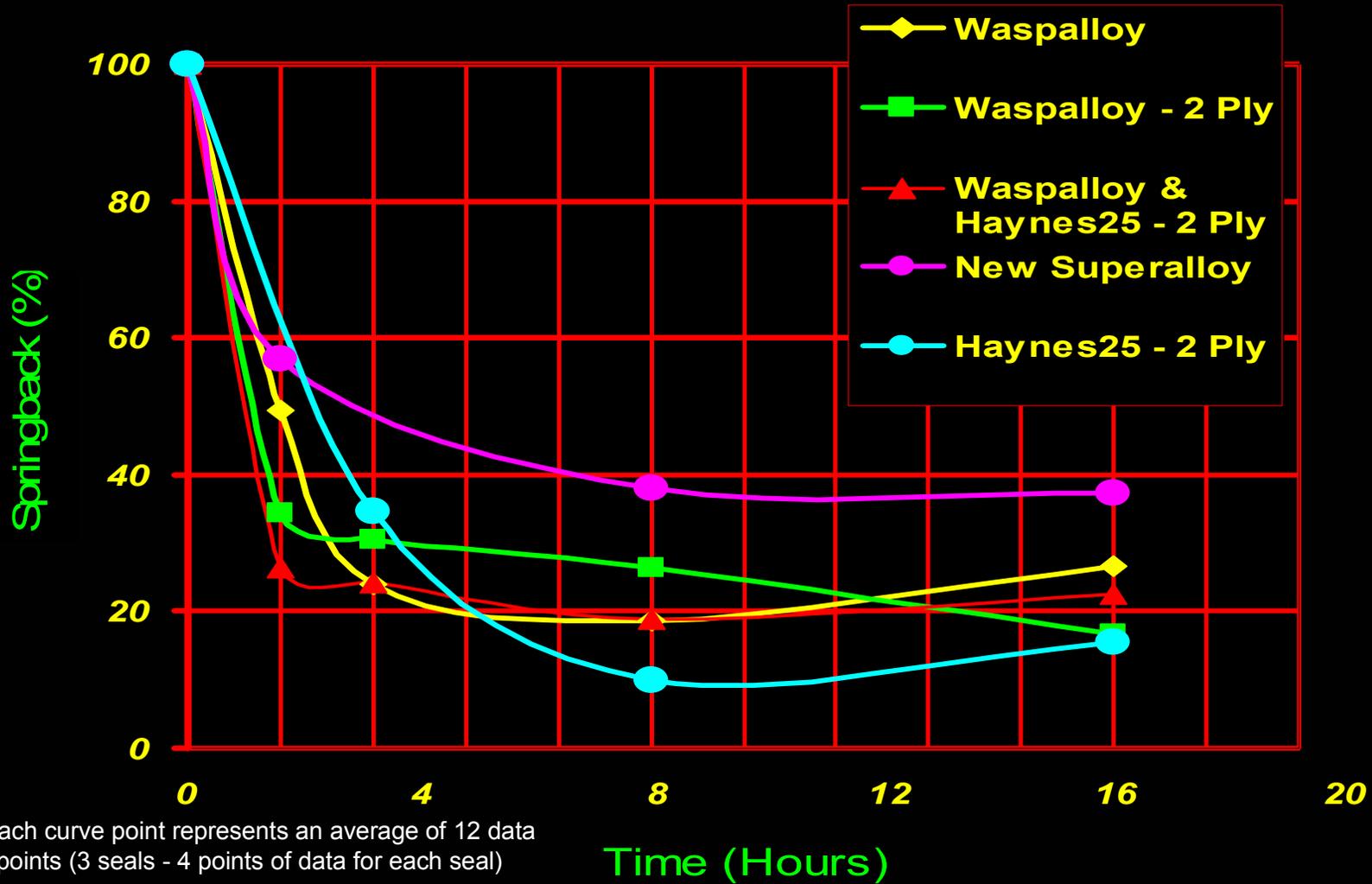


UHT Seal Testing

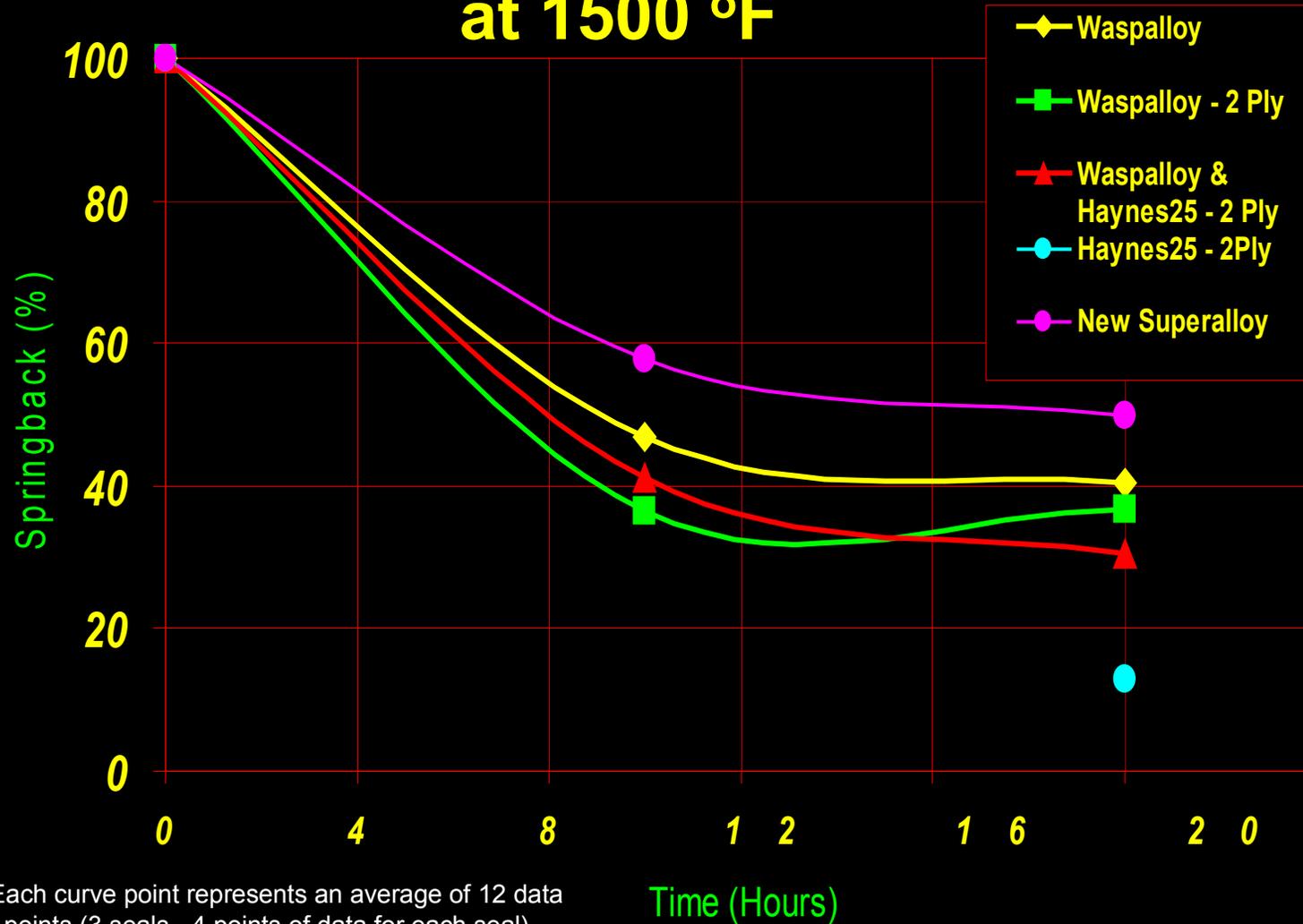
- Seal testing procedure
 - A standard seal cross section has been selected for testing to maintain constant strain levels
 - Measure seal free height prior to test
 - All seals are manufactured to the same nominal free height dimensions
 - Compress seal 15% in UHT test stand
 - Hold at temperature for a controlled time
 - Cool and measure seal height
 - Calculate percent loss in seal free height
 - Calculate usable springback after long term high temperature exposure

Seal Springback vs. Time at 1600 °F

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Seal Springback vs. Time at 1500 °F



* Each curve point represents an average of 12 data points (3 seals - 4 points of data for each seal)

Summary

- UHT test rig is being used extensively to demonstrate the performance of seals at Ultra High Temperature conditions
- UHT Seal testing has been successful in demonstrating the performance of seals produced from new alloys in UHT conditions
- Several materials have demonstrated superior characteristics when compared with traditional high temperature seal materials
- Focus is now shifting from 1400 - 1600 °F temperature range to 1600 - 1800 °F
- Efforts have been initiated for sealing materials at 1800 - 2200 °F