HIGH TEMPERATURE METALLIC SEAL DEVELOPMENT

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High Temperature Metallic Seal Development

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Outline

- Challenges
- Development Approach
- Stress Relaxation Studies
- Future Plans for Seal Testing

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Challenges

- Current Metallic Seals are Made of γ' Hardened Superalloys
- Application Limitation Above γ' solvus
- No Suitable Metallic Seal Above 1300 °F for Long-term Operation

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Current Challenges

- Stress Relaxation about γ' solvus
- Seal Compression Δh_T is relaxed as Δh_{PL} Increases with Time and Temperature
- $\Delta h_T = \Delta h_{EI} + \Delta h_{PL}$
  Sealing Force α Δh_{EI}

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Development Approach

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

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Development Approach

Candidate Materials:

- Oxide Dispersion Strengthened Alloys
  - PM 1000, MA-956, MA-754

- Refractory Alloys
  - Mo/Re, TZM, Mo/W,
    Proprietary Composite Alloy

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Development Approach

- Challenges
- Manufacturing Process Development
  Joining and Forming
- Cost-effective Oxidation Protection
  Scheme for Refractory Alloys

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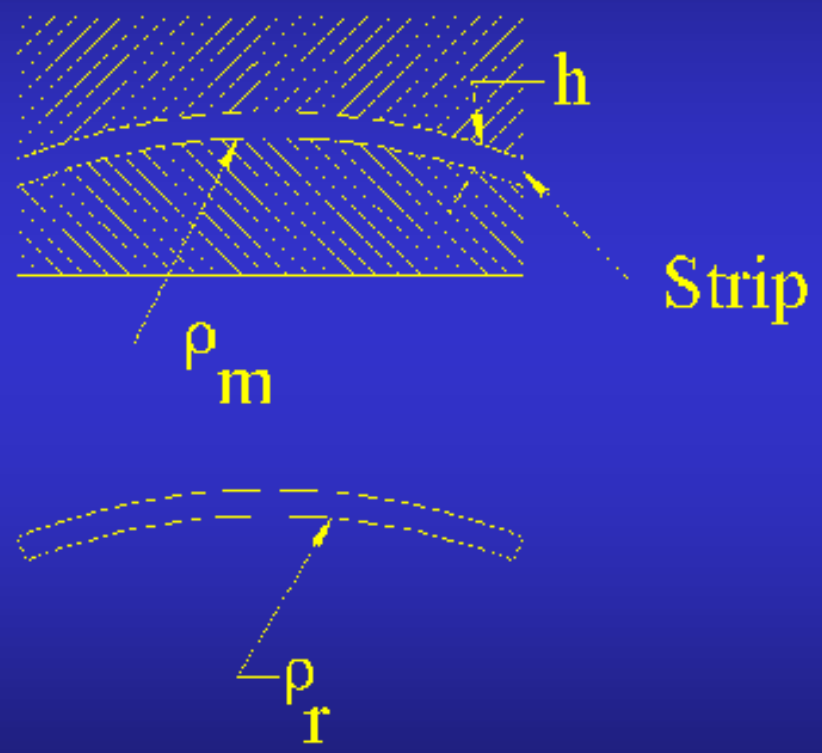
Stress Relaxation Studies

- ASTM E-328 Test:

ρ_m - mandrel radius
ρ_r - relaxed radius

Residual Stress:
$\sigma_{EI} = E.h/2\,(1/\rho_m - 1/\rho_r)$



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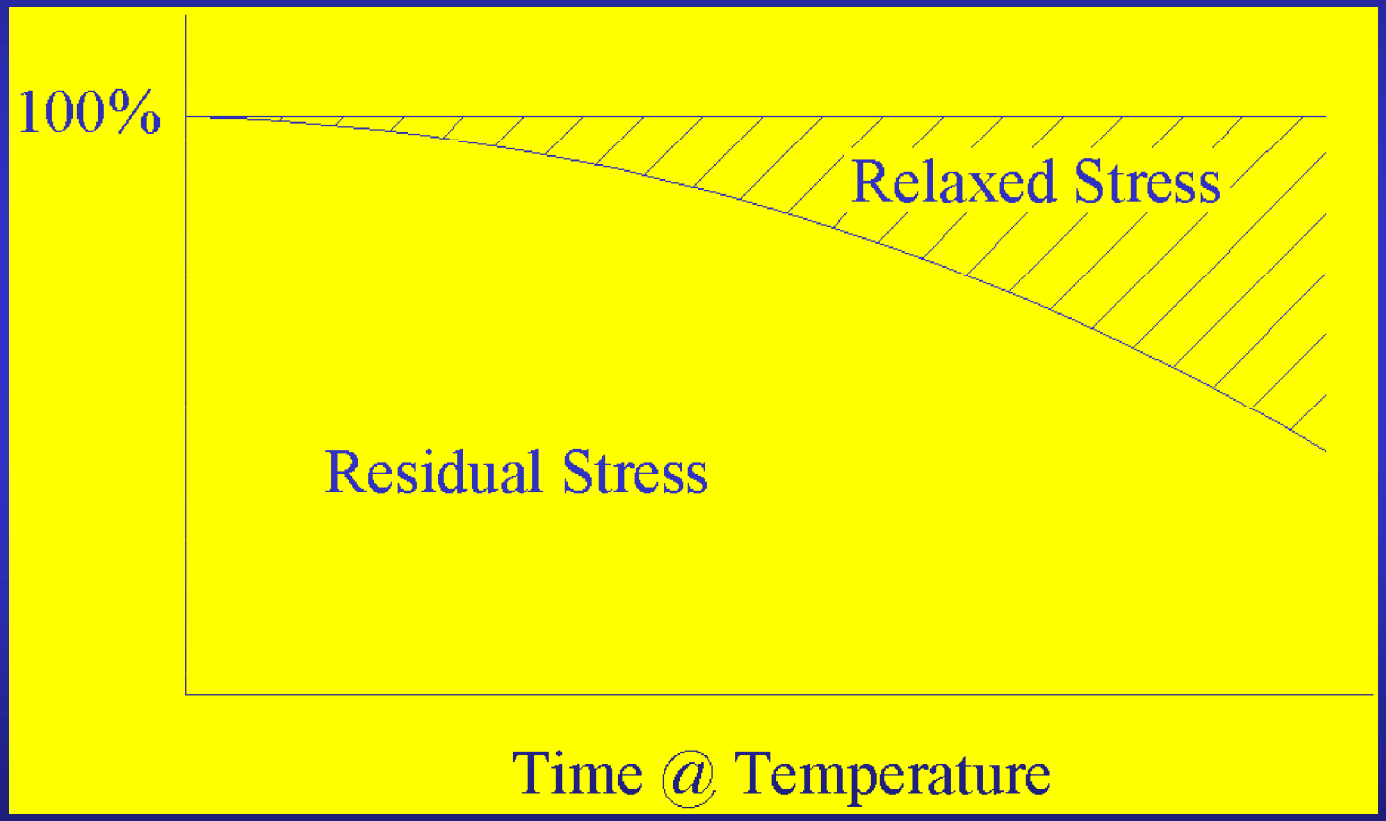
Stress Relaxation Studies



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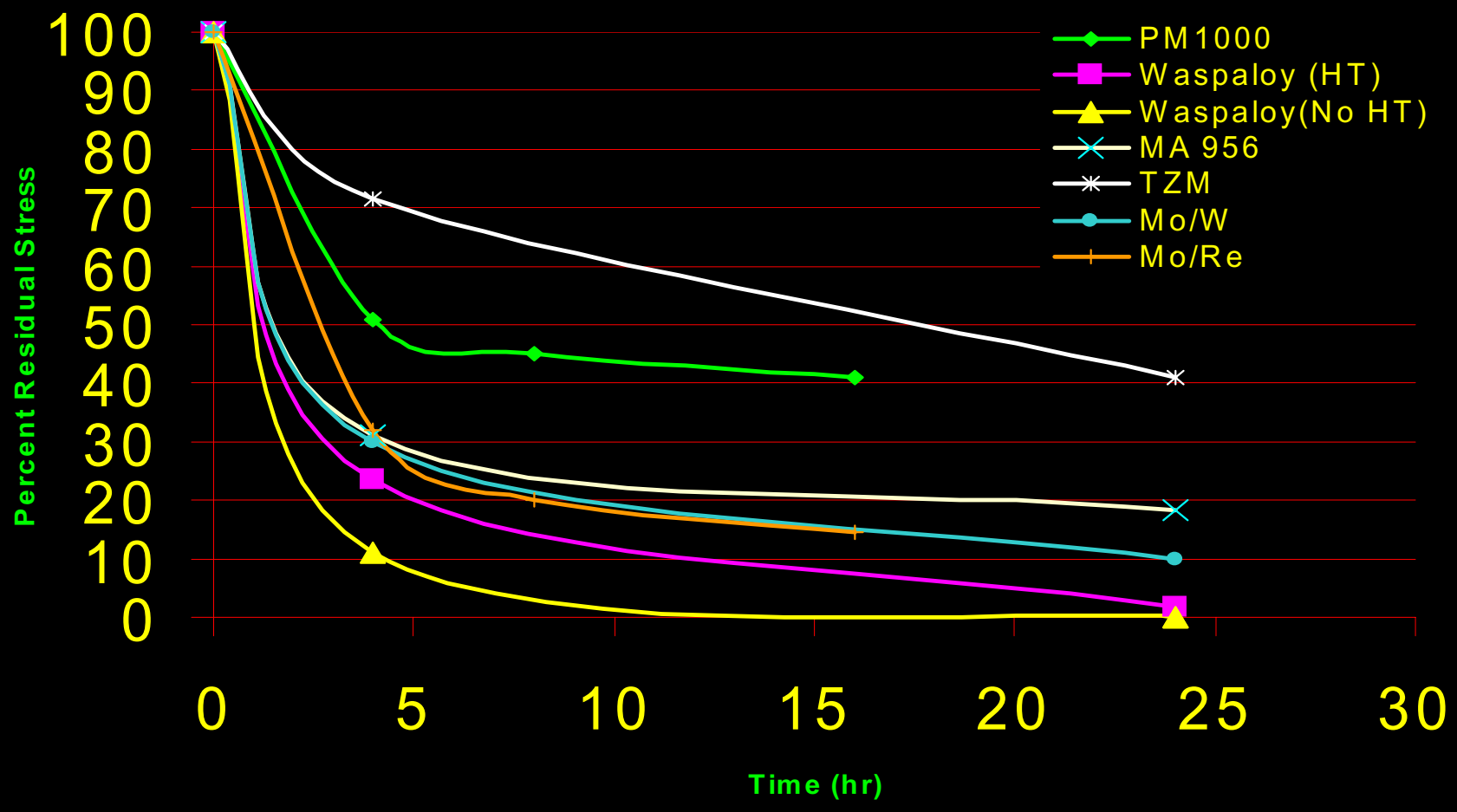
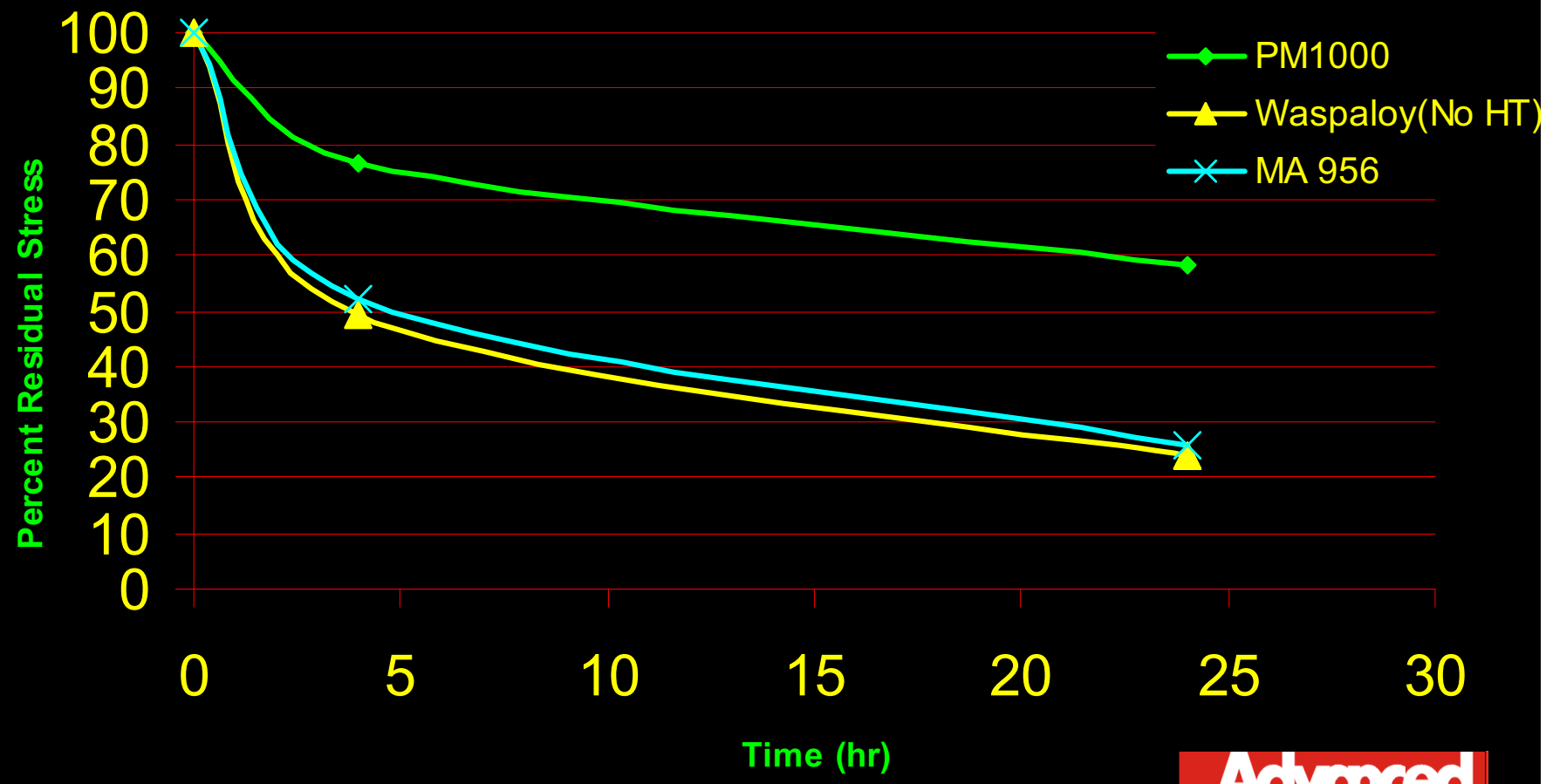
Stress Relaxation Studies at 1800 °F



Stress Relaxation Studies at 1600 °F



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Plans for Seal Testing

- Seal Cross Section will be Selected Based on Produceability
- Sealing Performance will be Evaluated in the Temperature Range 1600-1800 °F

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Plans for Seal Testing

Test Rig

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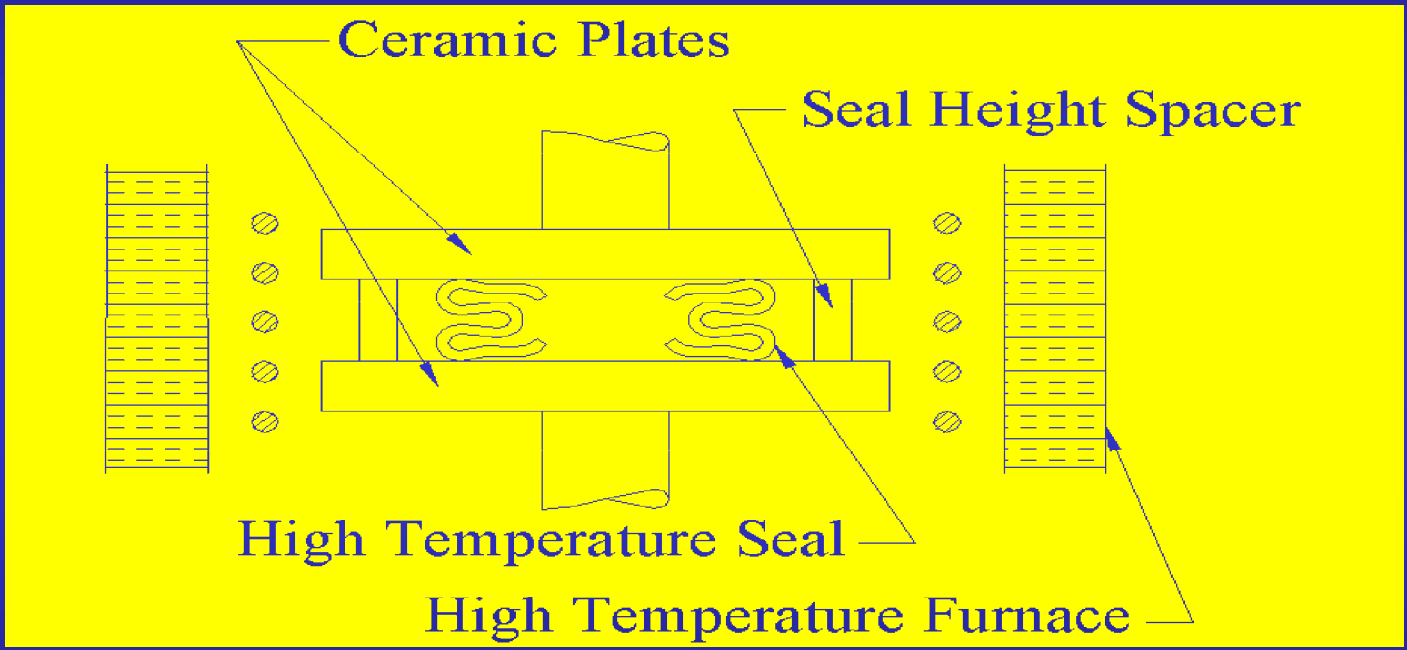
Plans for Seal Testing



- Monitor Seal Height Change and Leakage as a Function of Temperature and Time

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Ratios of Yield Strength to Elastic Modulus at 1800 °F

Alloy	σ_y (ksi)	E (ksi)	σ_y/E (10^{-3})
Waspaloy	20	21×10^3	0.95
PM 1000	28	14×10^3	2.00
MA 956	15	14×10^3	1.07
MA 754	--	--	--
TZM	80	32×10^3	2.75
Mo/W	32.4	35×10^3	0.95
Mo/Re	50	53×10^3	0.94

For short-term duration at temperature, elastic spring back increases as σ_y/E increases

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In Summary

- Completed ASTM type stress relaxation testing
- Identified several materials with superior stress relaxation characteristics
- Proceeding with high temperature seal development and testing, utilizing findings and materials from initial phases of testing

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