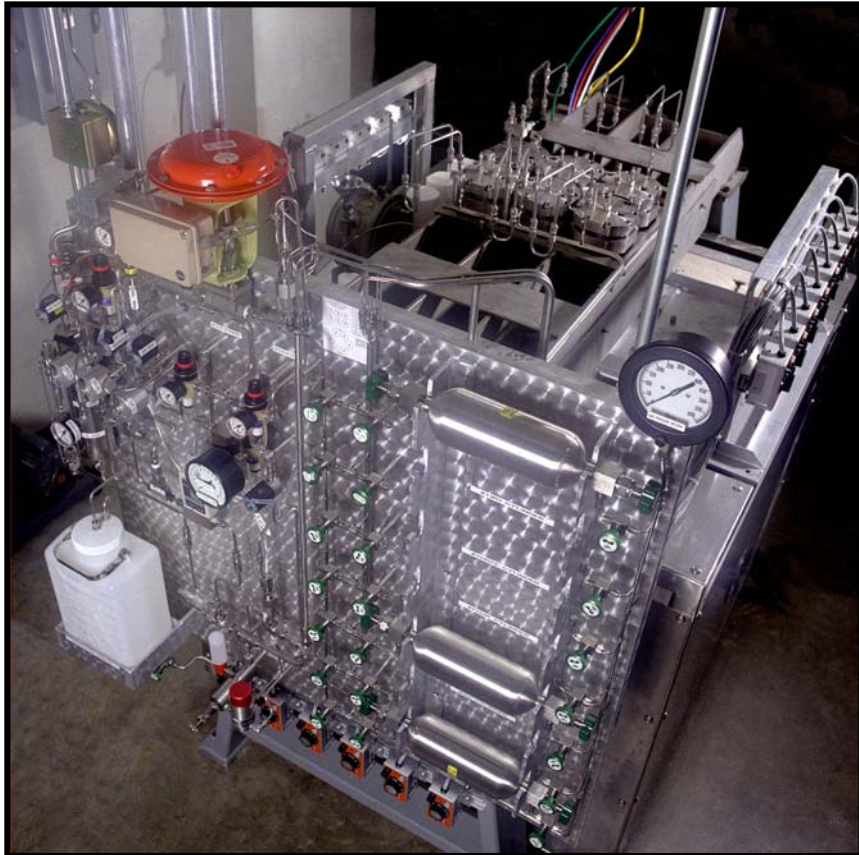


Evaluation Of EBCs In The Keiser Rig



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EBC Workshop

Nashville, Tennessee
November 19, 2003

We Continue To Expose And Evaluate Candidate EBCs (As Well As Si_3N_4 , CFCCs) In The Keiser Rigs

- 0.3-2 atm H_2O , 10 atm total pressure, 1200-1315°C
- Approximately 30 EBC formulations, >300 specimens, and ~20,000 specimen-hours of exposure in past year
- In context of the workshop, reviewing specific results or constructing a “scorecard” based on this work is not the purpose of this presentation

Nor Will We Discuss How The Keiser Rigs Are Typically Used

- This was the subject of last year's presentation at EBC Workshop

- Documented in IGTI 2003 paper

“Verification of an EBC’s Protective Capability Using 1st Stage Evaluation in a High Temperature, High Pressure Furnace,” K.L. More, P.F. Tortorelli, and L.R. Walker, ASME Paper #GT-2003-38923.

This Presentation Focuses On Where We Are Going Rather Than Where We Have Been

- Use of Keiser Rigs to screen a material's volatility resistance in typical gas turbine or microturbine environments (*currently in exploratory stage*)
- Provide a more comprehensive analysis of EBC stability
(*subject of IGTI 2004 paper*)
 - Correlations with equilibrium thermodynamic predictions
 - EBC damage assessment based on progress and morphology of oxidation reaction front

To Effectively Protect A Ceramic Substrate In A Gas Turbine Environment, An EBC Must:

Sintering of EBC

Interface degradation

20 μm

Silica formation

500 h in Keiser Rig, 1315°C, 0.3 atm H₂O

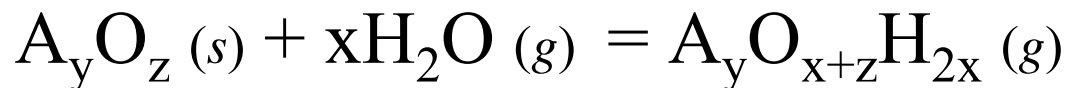
- ✓ Be *thermally stable* at 1100°C
- ✓ Have no *interactions/reactions* with underlying substrate
- ✓ Provide a *permeation barrier* to oxidizing species

Be *volatilization-resistant* in H₂O-containing, high-velocity gas turbine environment

To Date, Keiser Rig Exposures And Subsequent Analyses Have Been Used To Evaluate The First Three Issues Regarding Potential EBCs


Can We Expand The Use Of Keiser Rigs To Evaluate The *Volatility* Of Candidate EBC Compositions?

Generalized volatility reaction:



Flux of volatile species, $A_y O_{x+z} H_{2x}$, = J

$$J \propto v^{0.5} \cdot \exp(-\Delta G/RT) \cdot P_{H_2O}^x / \sqrt{P_{tot}} \cdot a_{A_y O_z}$$

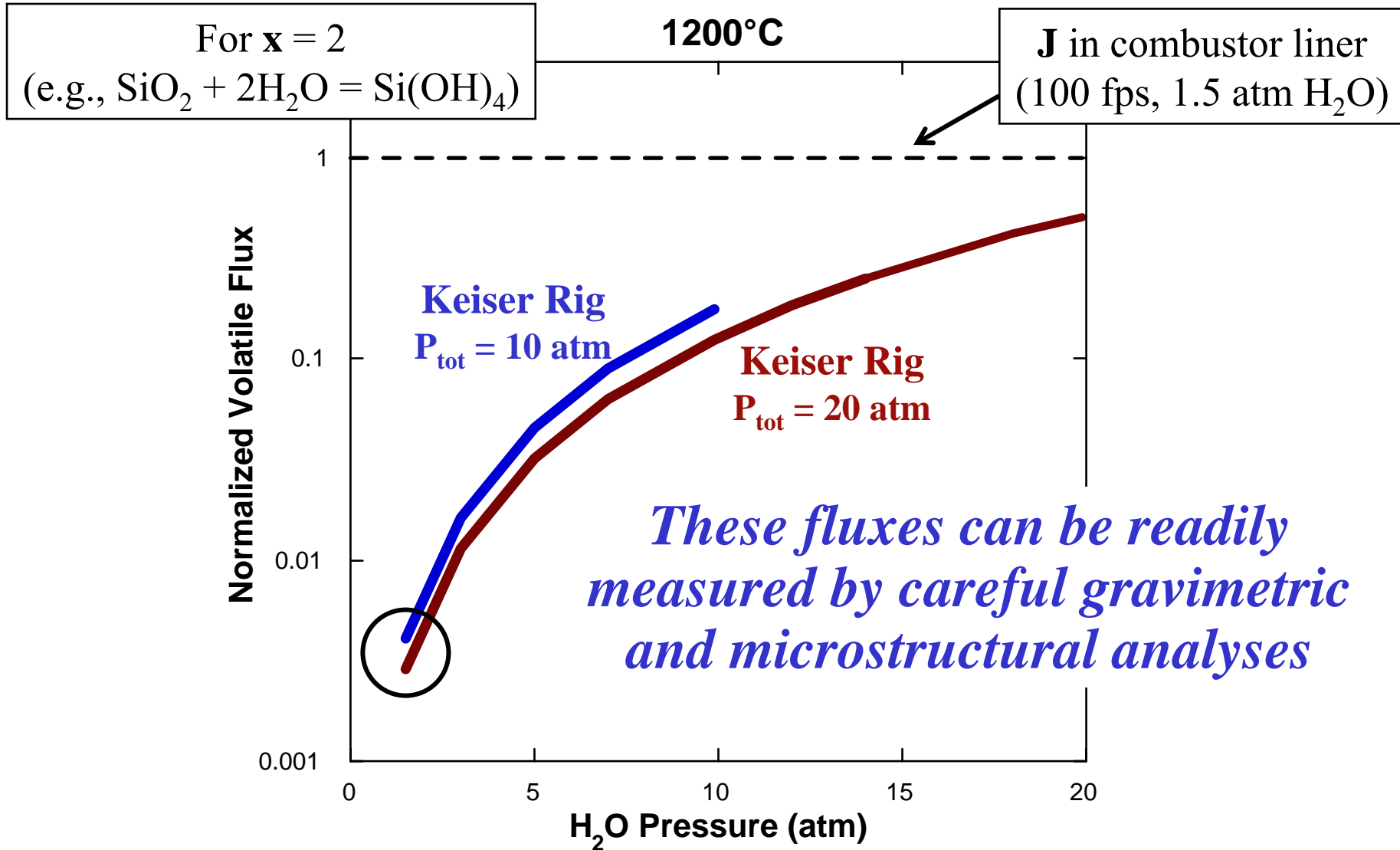


Can We Expand The Use Of Keiser Rigs To Evaluate The *Volatility* Of Candidate EBC Compositions?

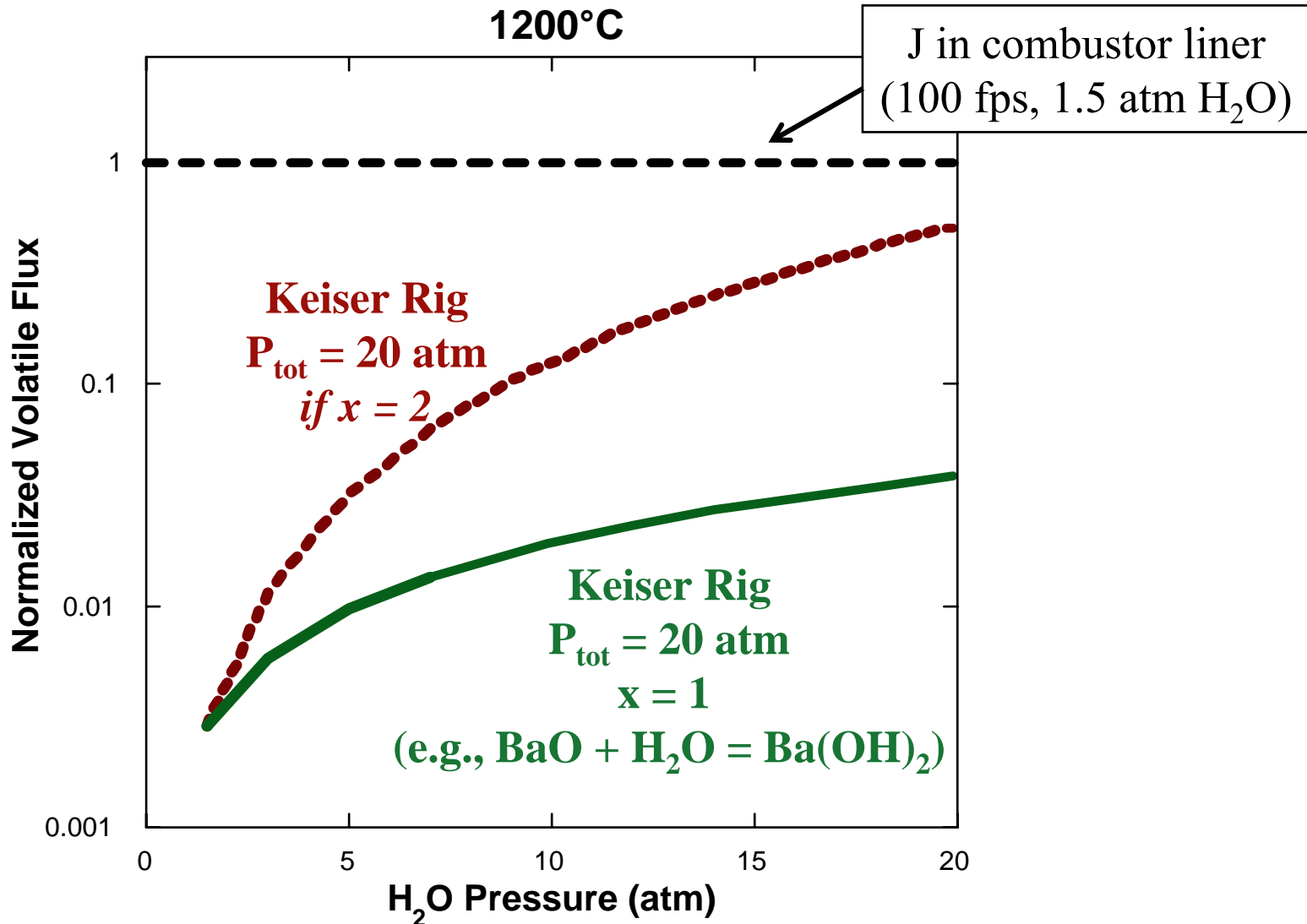
$$J \propto v^{0.5} \cdot \exp(-\Delta G/RT) \cdot P_{\text{H}_2\text{O}}^x / \sqrt{P_{\text{tot}}}$$


- Using high H₂O pressures to compensate for low gas-flow velocities in Keiser Rigs
- Can provide low-cost initial screening of volatility of certain potential EBCs in water vapor (plus permeability, thermal and interfacial stability)
- Initial collaboration with UTRC

Substantial Volatile Fluxes Can Be Obtained In This Manner



Care Must Be Taken In Analyzing Volatility Results From Different Oxides



Care Must Be Taken In Analyzing Volatility Results From Different Oxides And Environments

$$J \propto v^{0.5} \cdot \exp(-\Delta G/RT) \cdot P_{\text{H}_2\text{O}}^x / \sqrt{P_{\text{tot}}} \cdot a_{\text{A}_y\text{O}_z}$$



- Activity differences
- Contributions from more than one volatile species

Summary

- The Keiser Rigs continue to be used to evaluate the stability of candidate EBC compositions and their ability to act as permeation barriers.
- We are exploring getting more out of Keiser Rig exposures by using much higher H₂O pressures to examine issues related to volatilization of potential EBCs.