Additional Information on ARC100 Fuel Qualification

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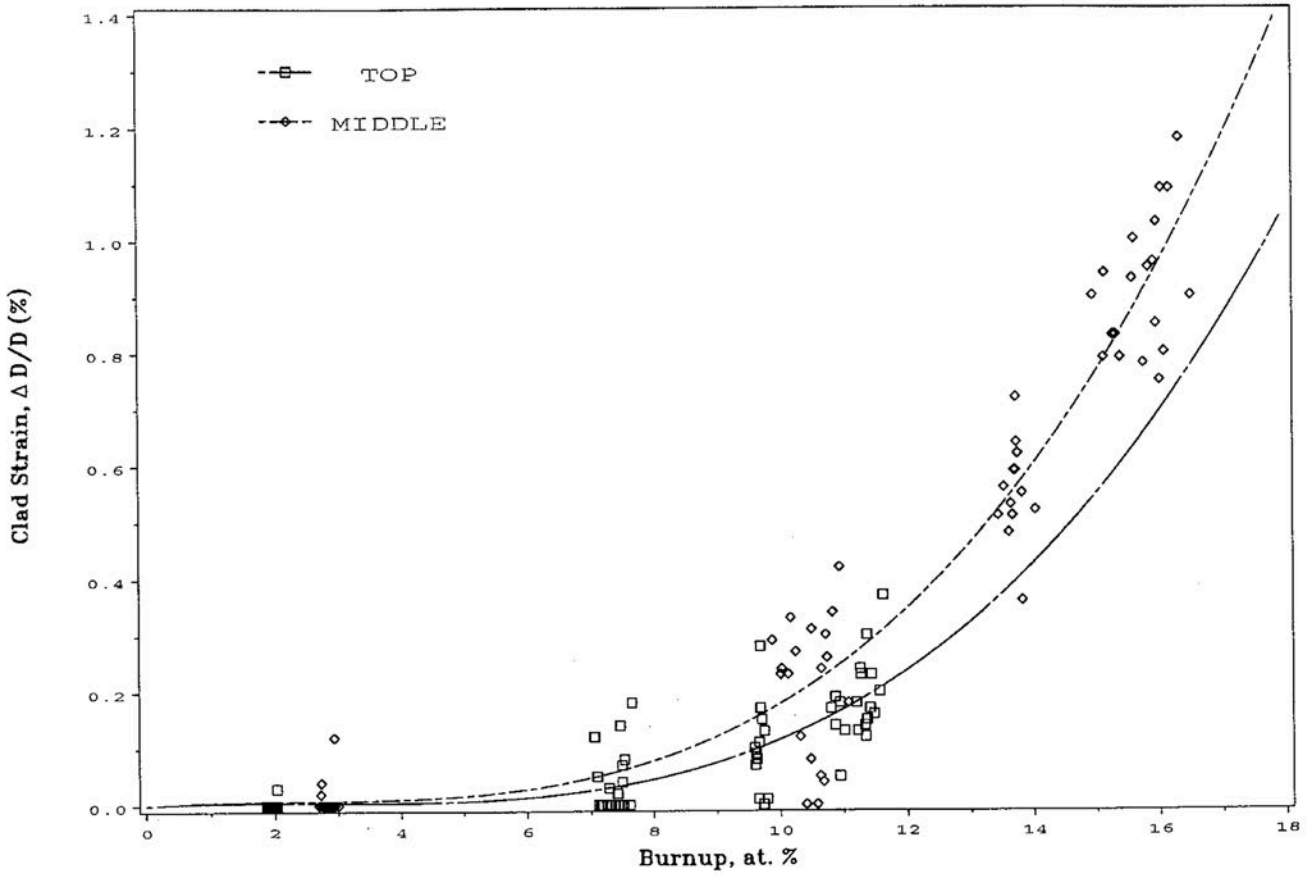
On slide 7, ARC presented [[ ]] irradiation tests and provided a comparative evaluation. The staff inquired about the details in the graph and the meaning of the [[ ]]. ARC clarified that the [[ ]]. ARC further emphasized that, in its FEA, it used the actual geometry and irradiation history of the pin. Citing the comparative evaluation, ARC stated that the experimental and modeling results were in good agreement. In response, the staff asked for a clarification on a [[ ]]. ARC stated it is still trying to understand the difference and had two initial rationales: [[ ]]. ARC stated that there is currently reasonable agreement for these preliminary results, but the results will be refined in the future

Effect of burnup on cladding hoop strain

- Investigated effect of burnup on cladding hoop strain using 1680 published cladding strain measurements for EBR-2 experiment X425
- Observed significant increase of cladding strain when burnup exceeds 10%

X425 experiment: 1680 cladding strain data points



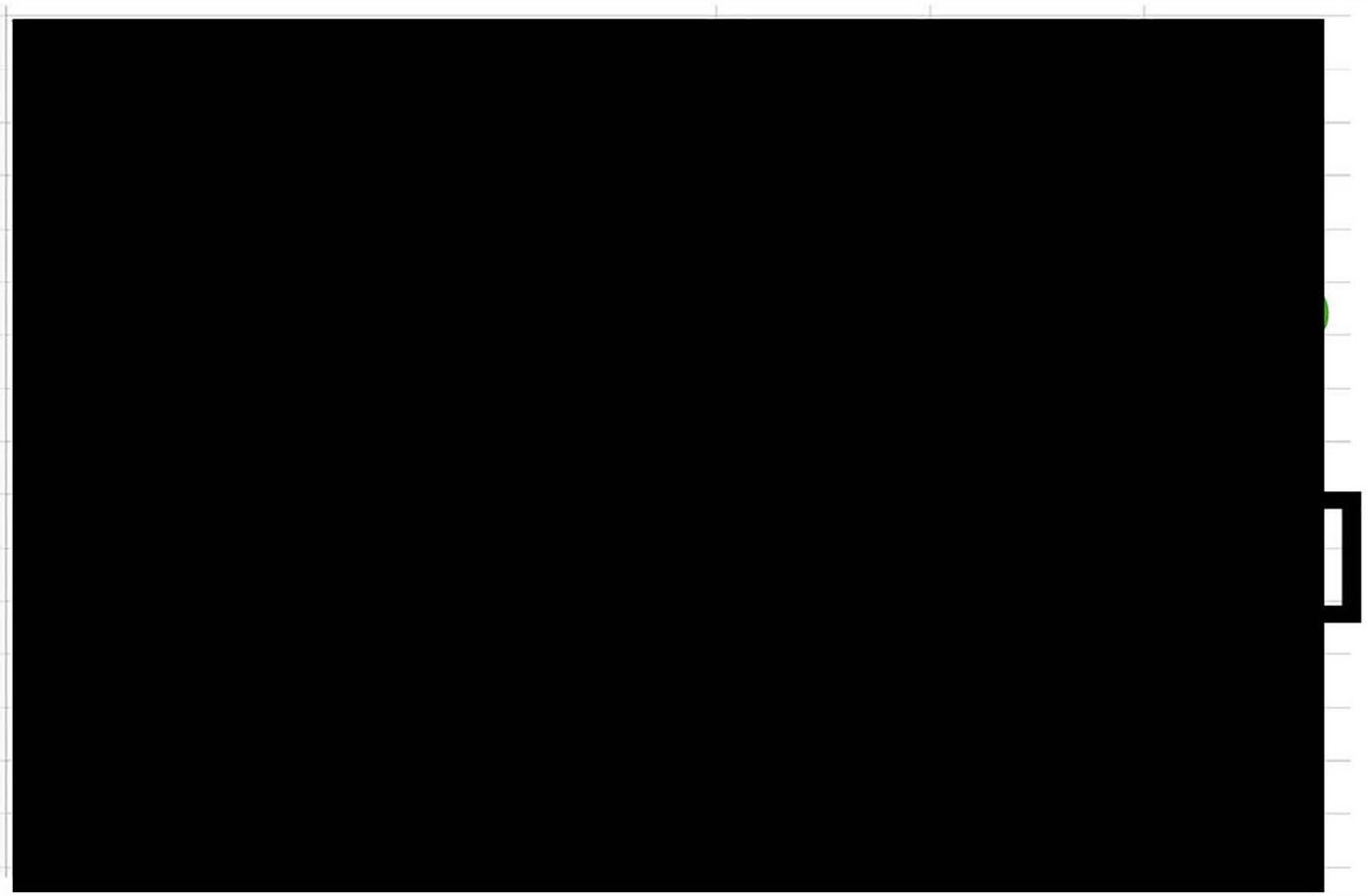
A. M. Yacout, Y. Orechwa,
Analysis of Cladding Strain Data from the Lead IFR Test Subassembly X425,
ANL-IFR-172

Use cladding profilometry results to determine fuel porosity

- [fuel swelling] = [gas swelling] + [solid swelling]
- [[ ]]
- [[ ]]

Example calculation

[[ ]]



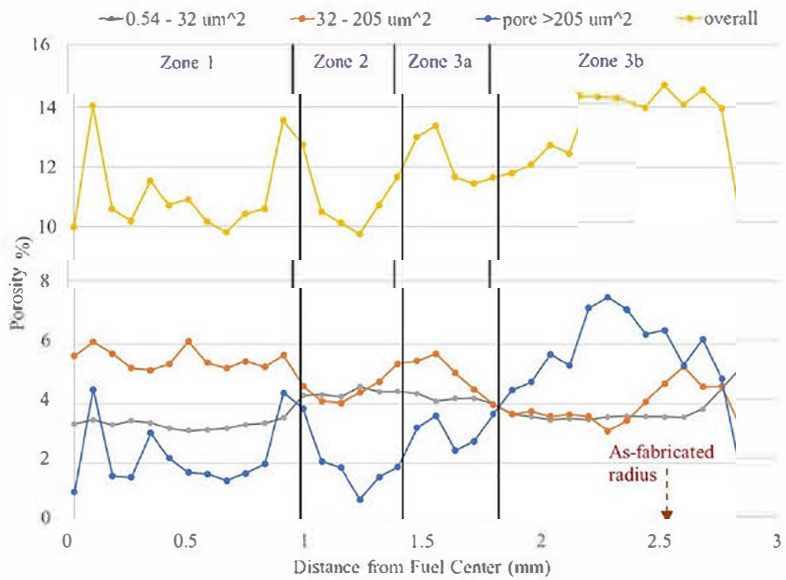
Fuel densifies from decreasing porosity within a limit

- Using cladding strain measurements and burnup data, calculated evolution of solid fission product swelling, gaseous swelling, total swelling, and porosity
- [redacted]
- PIE measurements of porosity as a function of burnup would be extremely useful to confirm these new findings

[[ ]]

[redacted]

[[ ]]



Wang, H. et al. A fine pore-preserved deep neural network for porosity analytics of a high burnup U-10Zr metallic fuel. *Sci. Rep.* **13** (1), 22274 (2023).

Considering a limit in fuel densification increases BISON modeling accuracy

- This approach resolves underprediction of cladding strain
- Good agreement with cladding profilometry

[[ ]]

[[ ]]

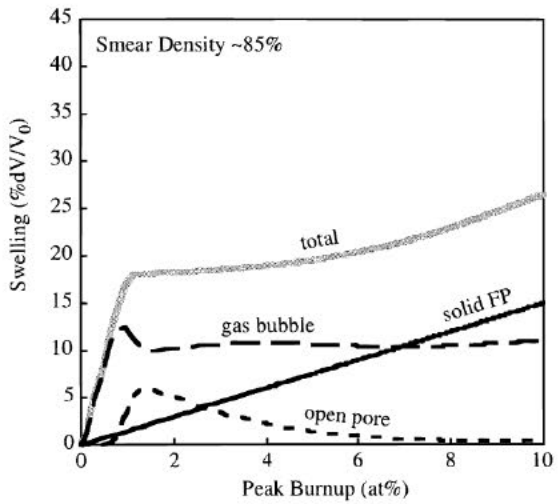
Understanding behavior of 90% smeared density pins (X430-800)

- [[[redacted]]]

BISON result using 25% porosity interconnection

[[ ]]

BISON result using 16% porosity interconnection



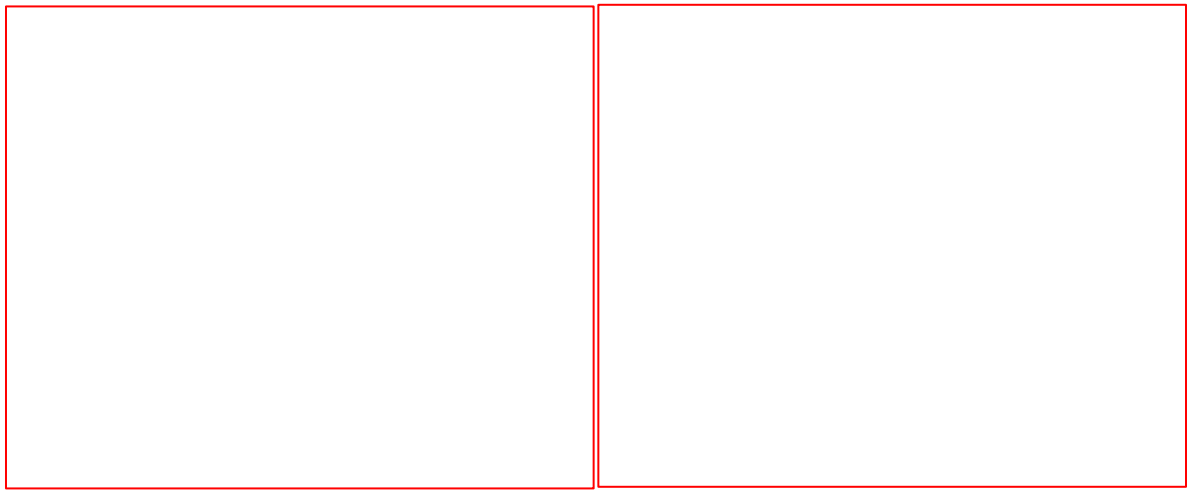
Ogata (1998) proposed lower porosity interconnection threshold for 85% smeared density for X441pins

[[ ]]

Figure 7 from July 23 Presentation

Predicted vs measured EOL cladding strain

[[



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[[[redacted]]]

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Conclusions

- BISON Application to Metal Fuel Design Basis addresses G2, G2.1 G2.1.1 G2.1.2 of NUREG 2246
- Cladding thermal creep strain, and consequently cladding lifetime, is primarily controlled by plenum pressure and FCCI, rather than Fuel-Cladding Mechanical Interaction (FCMI)
- FCCI and plenum pressure can be readily measured by post-irradiation examination (PIE), whereas FCMI stress is extremely complex to quantify
- By demonstrating that plenum pressure and FCCI do not cause cladding thermal creep strain to exceed 1%, it provides a clear and measurable pathway for assessing fuel performance and ensuring cladding integrity. This approach simplifies the qualification process, focusing on parameters that can be accurately measured and controlled, thereby enhancing the reliability and safety of nuclear fuel.
- [[ ]]
  - PIE measurements of porosity as a function of burnup would be extremely useful to confirm these new findings
- PIE of 90% smeared density pins indicates that porosity interconnection threshold may be as low as 16 % (vs 25%)