



Date: 2022-10-17

File / dossier : 6.02.04

Edocs pdf : 6892447

Oral presentation

Exposé oral

Presentation from Paul Sedran

Présentation de Paul Sedran

CNSC staff update on elevated hydrogen equivalent concentration discovery events in the pressure tubes of reactors in extended operation

Mise à jour du personnel de la CCSN sur les événements liés aux découvertes de concentrations élevées d'hydrogène équivalent dans les tubes de forces de réacteurs en exploitation prolongée

Commission Meeting

Réunion de la Commission

November 3, 2022

Le 3 novembre 2022

Review of Bruce Power Submissions on [H] and [D] Distributions in B6S13 and B3F16

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November 3rd, 2022

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1. Introduction

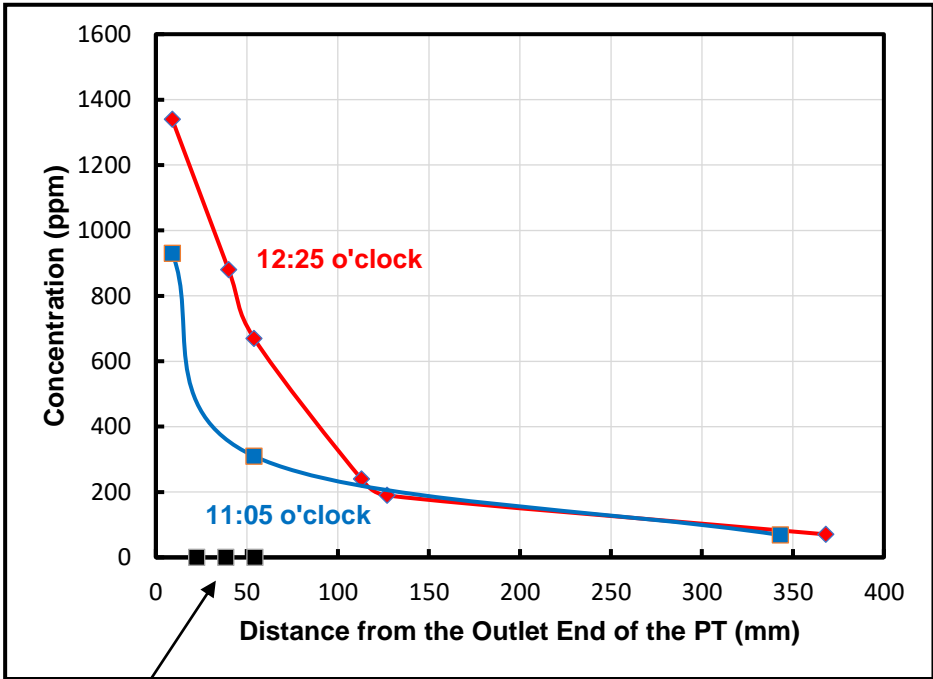
- From previous experience, thermal gradients in operating PTs are minor
- Intuitively, significant circumferential diffusion of H and by thermal diffusion implies large temperature gradients
- Bruce Power's thermal diffusion theory provoked an interest in testing the theory by simple first principles analysis
- No definite conclusions could come from these simple assessments
- However, observations and indications were generated

2. Inspection of Outlet PT RJ Concentration Distributions

Circumferential Distribution of [H], [D], and [Heq] at the Outlet PT RJ of B6S13 at 271, 729 HH



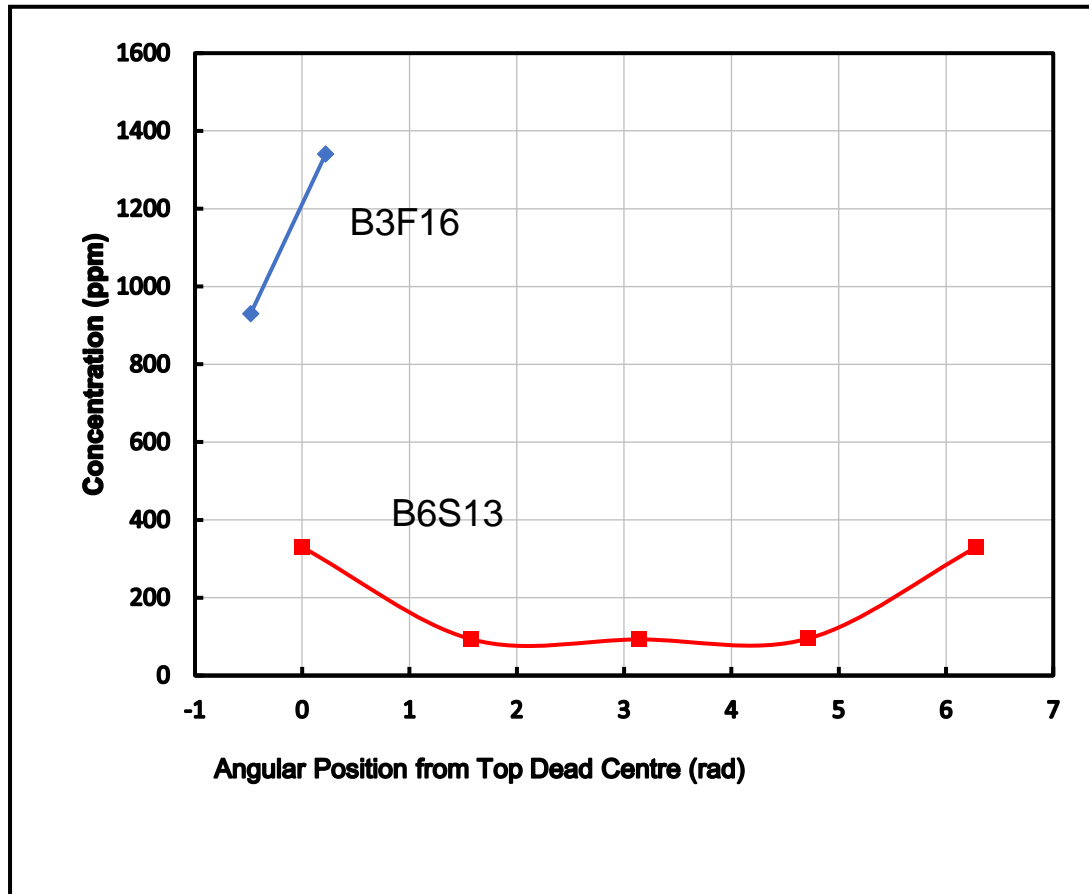
[D] Measurements versus Distance from the Outlet End of the PT in B3F16 at 2 Circumferential Locations



H/D gradients are steep and peaks appear near EF RJ groove locations

2. Inspection of Outlet PT RJ Concentration Distributions

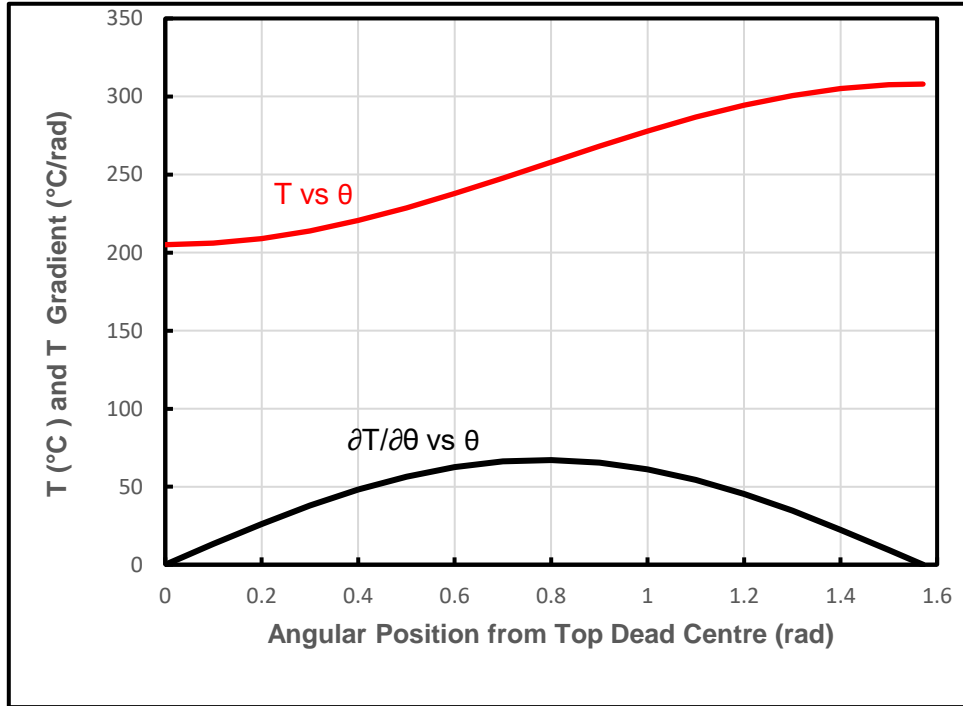
[D] Measurements versus Angular Position
For the Outlet PT RJ in B6S13 and B3F16



- Concentration Distributions are different
- B6S13 and B2F16 appear to act as individuals
- Implies an ingress mechanism with individual PT behaviour
- A significant radial concentration gradient in B6S13

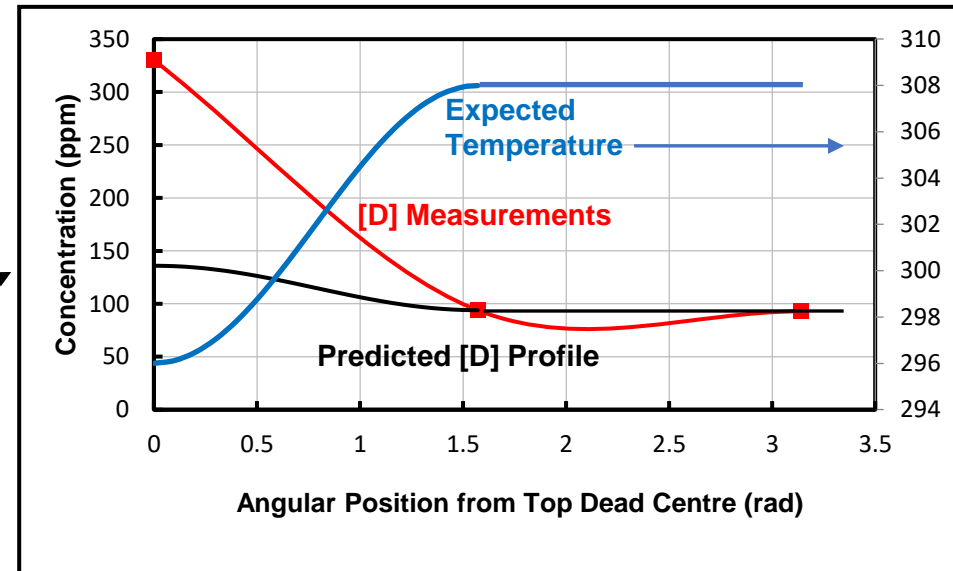
3. Test of Bruce Power's Thermal Diffusion Theory

Predicted T and T Gradient Required for the [D] Concentration Gradient Observed in the B6S13 Outlet RJ



- Diffusion First Principles - $\partial T/\partial \theta$ causes $\partial C/\partial \theta$
- Thermal Diffusion Theory was tested by Predicting the Necessary Temperature Gradient
- Intuitively, a Temperature of 205 °C at the top of the PT seems too low

Expected Circumferential T & Predicted [D] Profiles For the B6S13 Outlet RJ versus Measured [D] Profile



Measured [D] gradient is too steep to have been caused by the expected temperature profile

4. Alternative Hypothesis and Test

- Steep H and D concentration gradients were caused by electrochemical diffusion from the EF onto the PT through bare PT to EF contact at the RJ groove corners
- Test of the hypothesis in B6S13:
 1. Electrochemical D flux into the top of the PT predicted to be $9.471\text{E-}12 \text{ kg s}^{-1}$
 2. Fick's diffusion flux of D out of the top of the PT predicted to be $1.217\text{E-}12 \text{ kg s}^{-1}$
- The above are not definite proof but indicate that electrochemical diffusion could have generated the observed [D] profiles in B6S13 and B3F16.

5. Concluding Remarks

- As outlined, no definite conclusions are claimed in this assessment
- However, there are 2 indications:
 1. Thermal diffusion alone may not have been sufficient to produce the circumferential concentration gradients seen in B6S13 and B3F16
 2. It is possible that electrochemical diffusion from the EF to the PT caused the concentration gradients in B6S13 and B3F16; this theory requires an explanation for why the diffusion source was at the top of the PT