

Idaho National Engineering and Environmental Laboratory

Preliminary FLiNaK Mobilization Measurements and Implications for FLiNaBe Safety

B.J. Merrill, T.D. Marshall, G.R. Smolik

INEEL Fusion Safety Program

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Outline of Presentation

- *Inventory*
 - *FLiNaBe Radioactivity and Decay Heat*
- *FLiNaK test data*
- *FLiNaBe Mobilization Estimates based on FLiNaK data*
- *Dose*
 - *Preliminary FLiNaBe Dose Estimates*
- *Conclusions*

FLiNaBe Radiotoxicity and Decay Heat

- Isotopes that dominate FLiNaBe dose

	FW Inventory Activity (MCi)	Amount Mobilized to reach 10 mSv ¹	Confinement Factor Req'd	Source
Na-24	18.9	27,640 Ci	690	Na
F-18	5.5	76,565 Ci	72	F Na-23, F-20, F-19
Na-22	0.14	6230 Ci	22	Na

¹ Average weather conditions (D & 4 m/s) for 1 km site boundary

NOTE: Values decrease by a factor of 10 for weather conditions of F & 1 m/s

- Comparison of FLiNaBe decay heat

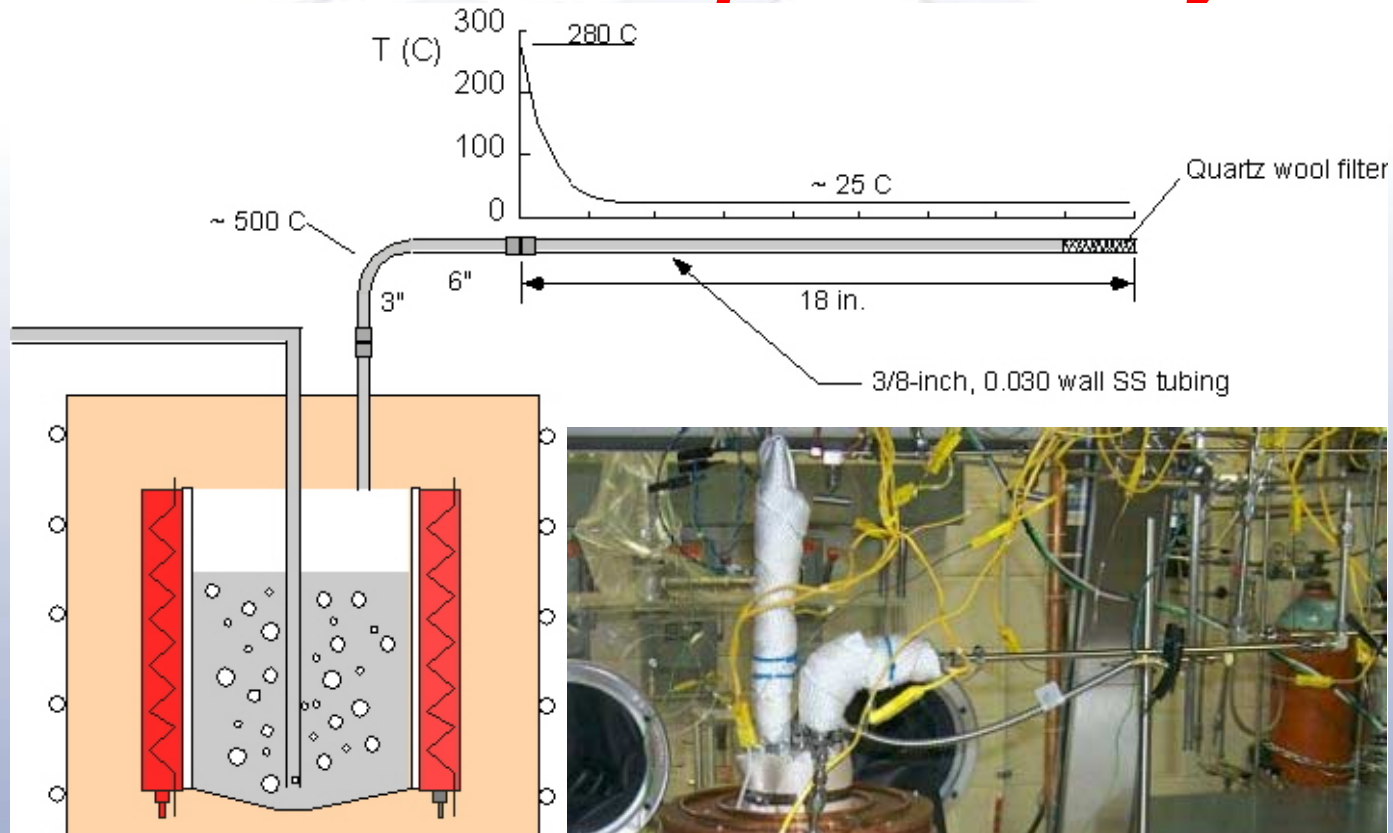
	FLiNaBe (Ed Cheng ²)	Sn (Task III)	W (EVOLVE)
Decay Heat (W/cm ³)	0.30	0.54	3.43

²Values doubled to account for higher wall loading

FLiNaBe modeled with FLiNaK data

- *The INEEL is performing FLiNaK experiments in preparation for similar tests with FLiBe under the JUPITER II program*
- *These experiments are directed at estimating mobilization from molten salts during an accidental spill*
- *Scoping experiments with FLiNaK in He were recently initiated*

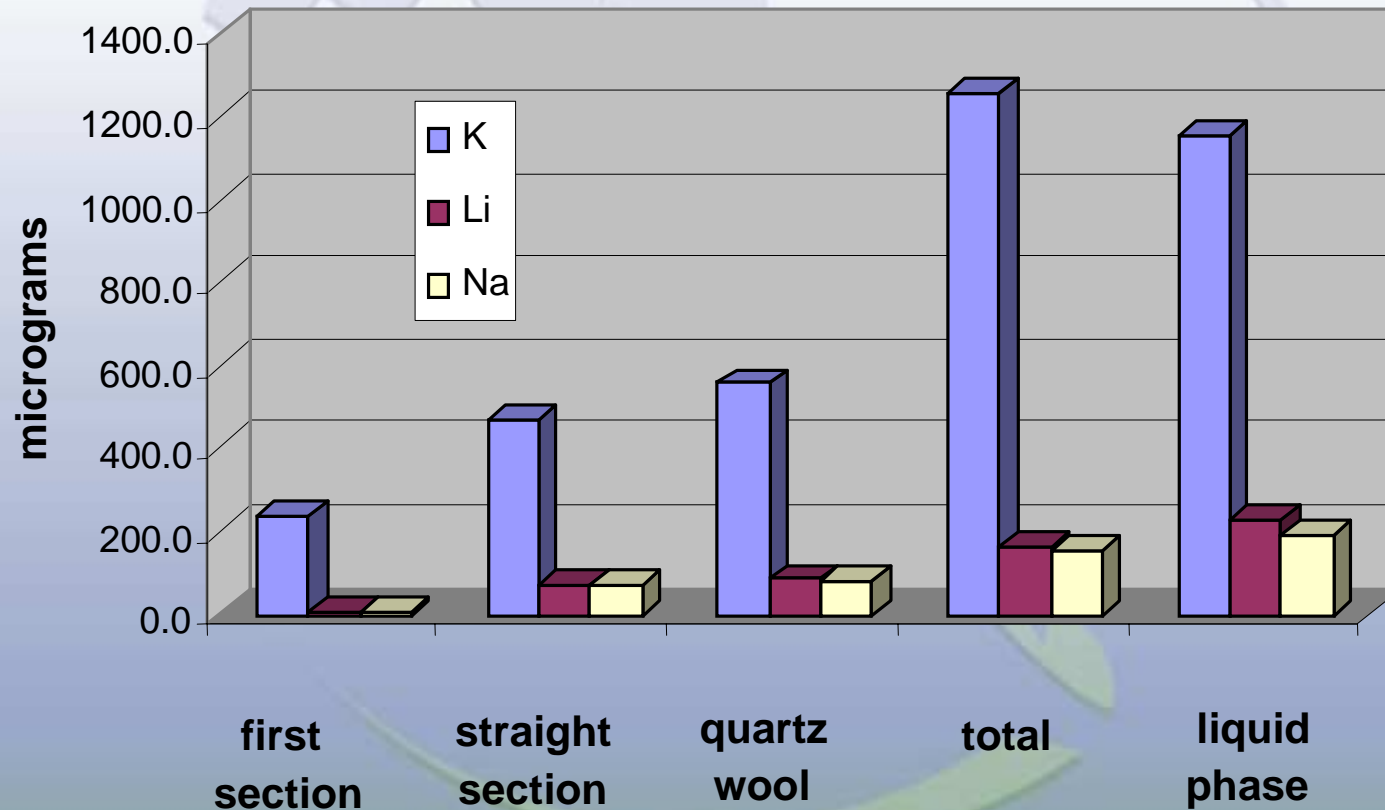
INEEL Molten Salt Experiment System



Elemental Distribution for FLiNaK Flow A

He purge over salt bath at 800 °C

1570 µg total



FLiNaK Activity Coefficient

- *Vapor pressure calculation:*
 - *Ideal Solution uses Raoult's Law*

$$p_{\text{Tot}} = \sum_i x_i p_{\text{sat}_i}$$

- *Non-Ideal Solution uses Raoult's Law and an activity coefficient*

$$p_{\text{Tot}} = \sum_i \gamma_i x_i p_{\text{sat}_i}$$

FLiNaK Mobilized Mass Calculation

- Masses for the individual species are calculated with:

$$\text{Mass}_{NaF} = \left(\frac{x_{NaF} P_{\text{vapor},NaF}}{P_{\text{system}}} \right) \times Q_{\text{He}} \times t \times n_{STP} \times M_{w,NaF}$$

- Predicted and measured vapor pressures are used to calculate the species' calculated and measured masses
- The Activity Coefficient is calculated from the mass ratios

Variable @ 800 °C	K	Li	Na
Calculated Mass (µg)	8470	88	35
Measured Mass (µg)	1260	161	150
Activity Coefficient (γ)	0.15	1.8	4.3

Retention: Analysis Assumptions

- *Assumptions about the retention behavior of FLiNaBe:*
 - *H-3 has low solubility in FLiNaBe*
 - *Complete H-3 inventory is removed by tritium clean-up system*
 - *Mobilization of BeF is to be included in future analyses*
- *It is assumed that LiF and NaF in FLiNaBe mobilizes the same as in FLiNaK*

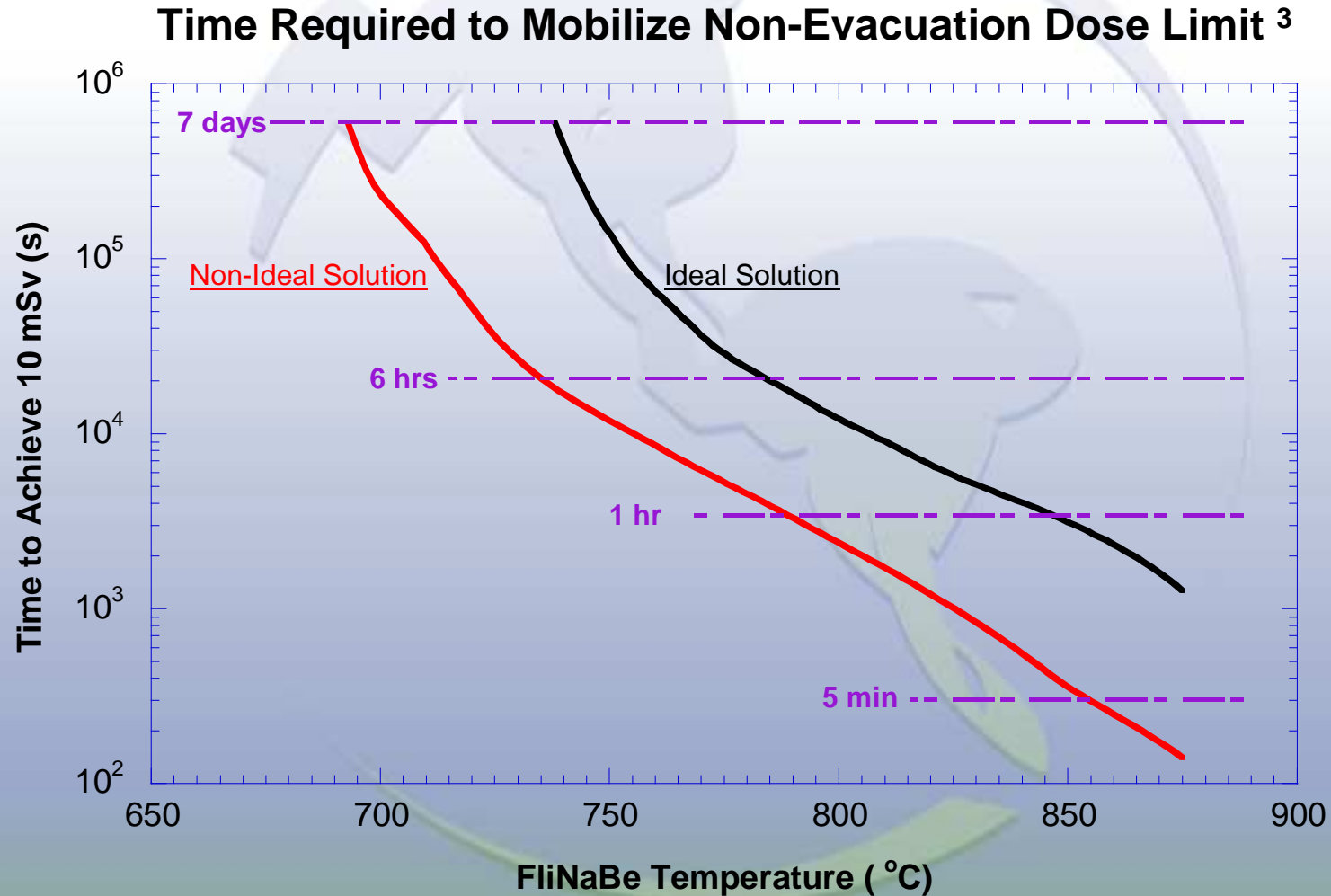
FLiNaBe Mobilization Estimates

- *Mobilization estimates were made using FLiNaK activity coefficients*

$$\Gamma_{\text{NaF}} = \left(\frac{\text{Mw}_{\text{NaF}}}{2 \pi \text{R}} \right)^{1/2} \frac{\gamma_{\text{NaF}} \text{X}_{\text{NaF}} \text{p}_{\text{sat}} (\text{T})_{\text{NaF}}}{\sqrt{\text{T}}}$$

- *This mobilization equation yields mass estimates that greatly exceed INEEL measurements. In the INEEL tests, the mobilization is expected to be limited by boundary layer diffusion.*

Preliminary FLiNaBe Dose Estimates



³ Confinement factor of 50 and surface area of 425 m²

Conclusions

- *Preliminary dose calculations for FLiNaBe show
 - Na-24, F-18, and Na-22 dominate the dose
 - For temperatures below 800 °C, there is considerable time for isolating the facility after an accident and remaining below the 10 mSv dose limit.*
- *Our FLiNaK tests suggest that for low vapor pressure liquids (e.g., FLiNaBe), mobilization estimates based on evaporation in a vacuum will over-predict the mass mobilized at atmospheric conditions.*
- *For more accurate analyses, experimental data on FLiNaBe mobilization are required.*