K-25/K-27 Buildings Sodium Fluoride (NaF) Trap Criticality Assessment

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ETTP Site (1989) K-25 is the U shape

NaF Trap Functions

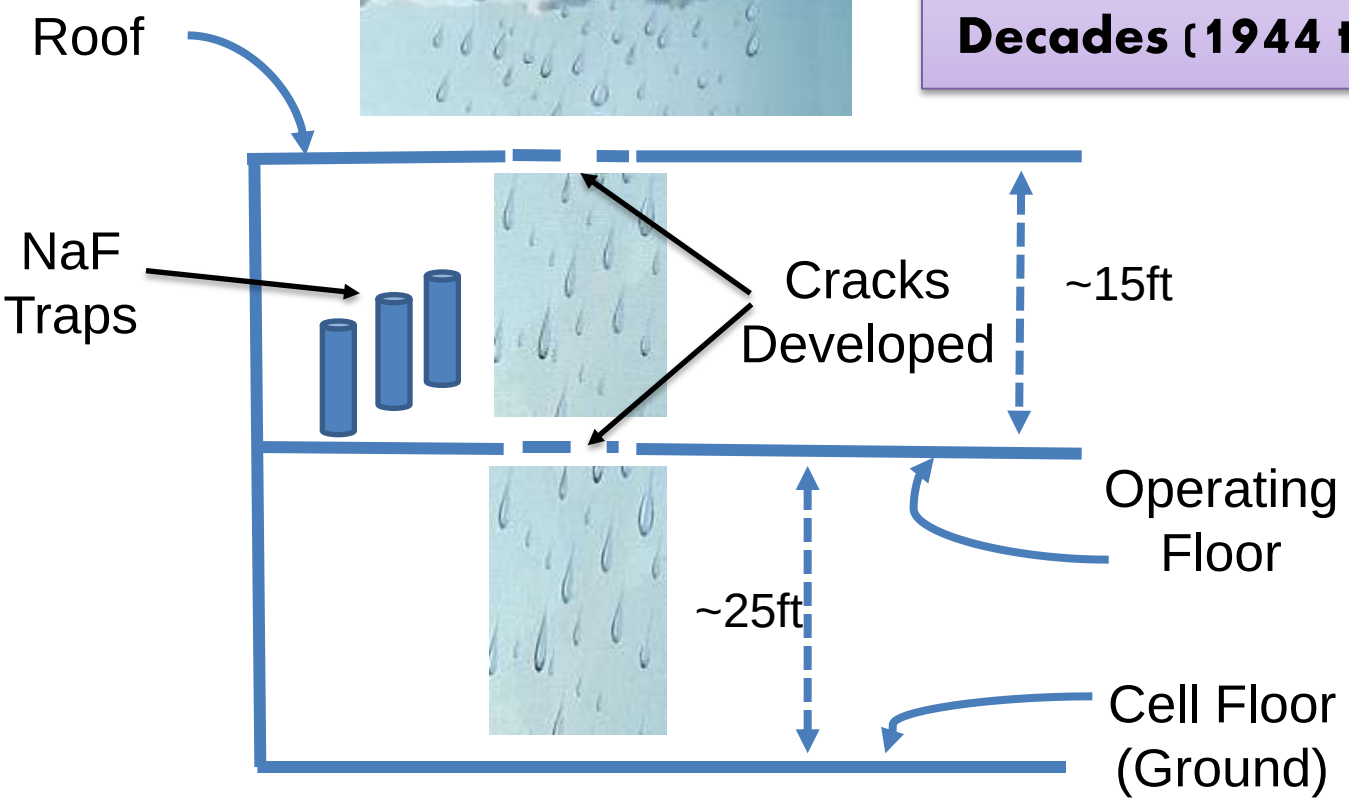
- Serve as auxiliary equipment in the Gaseous Diffusion Uranium Enrichment process
- Capture UF_6 gas in exhaust stream by chemi-sorbtion on NaF Pellets
- Purge light gases (e.g., O_2, Freon) in exhaust stream
- Provide for UF_6 product recovery

Pack of 3 NaF Traps on Sled

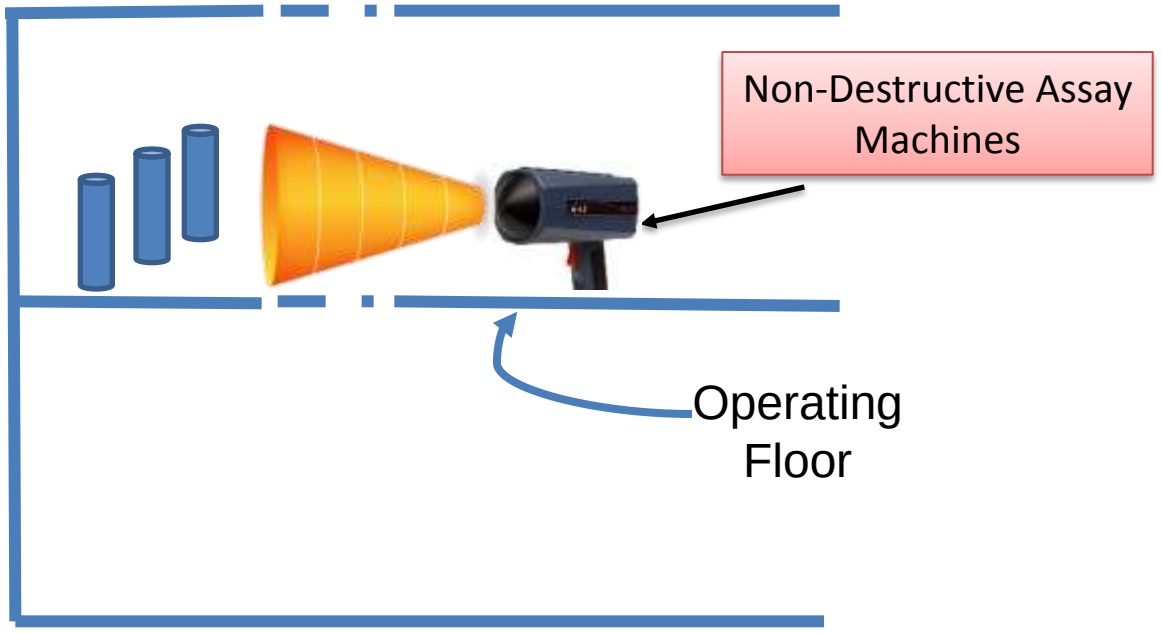
Height = 5 ft

Outer Diameter = 12 in

K-25/27 Building Roof & Operating Floor Deterioration Over the Decades (1944 to Present)



- **NDA measurement is standard method for determining U^{235} in equipment**
- **Due to floor deterioration, close positioning of NDA machines to get high confidence U^{235} mass measurements was not always possible**
- **Some U^{235} measurements were many times the minimum subcritical mass**



Criticality Safety Challenges Due to Inability to Closely Measure or Inspect High Mass Traps

- Were high U^{235} mass values real?
- Was UF_6 reclaimed prior to shutdown?
- Were NaF pellets removed prior to shutdown?
- Had water accumulated in traps?
- What is internal structure of traps?
- Is there any available NaF trap process data ?

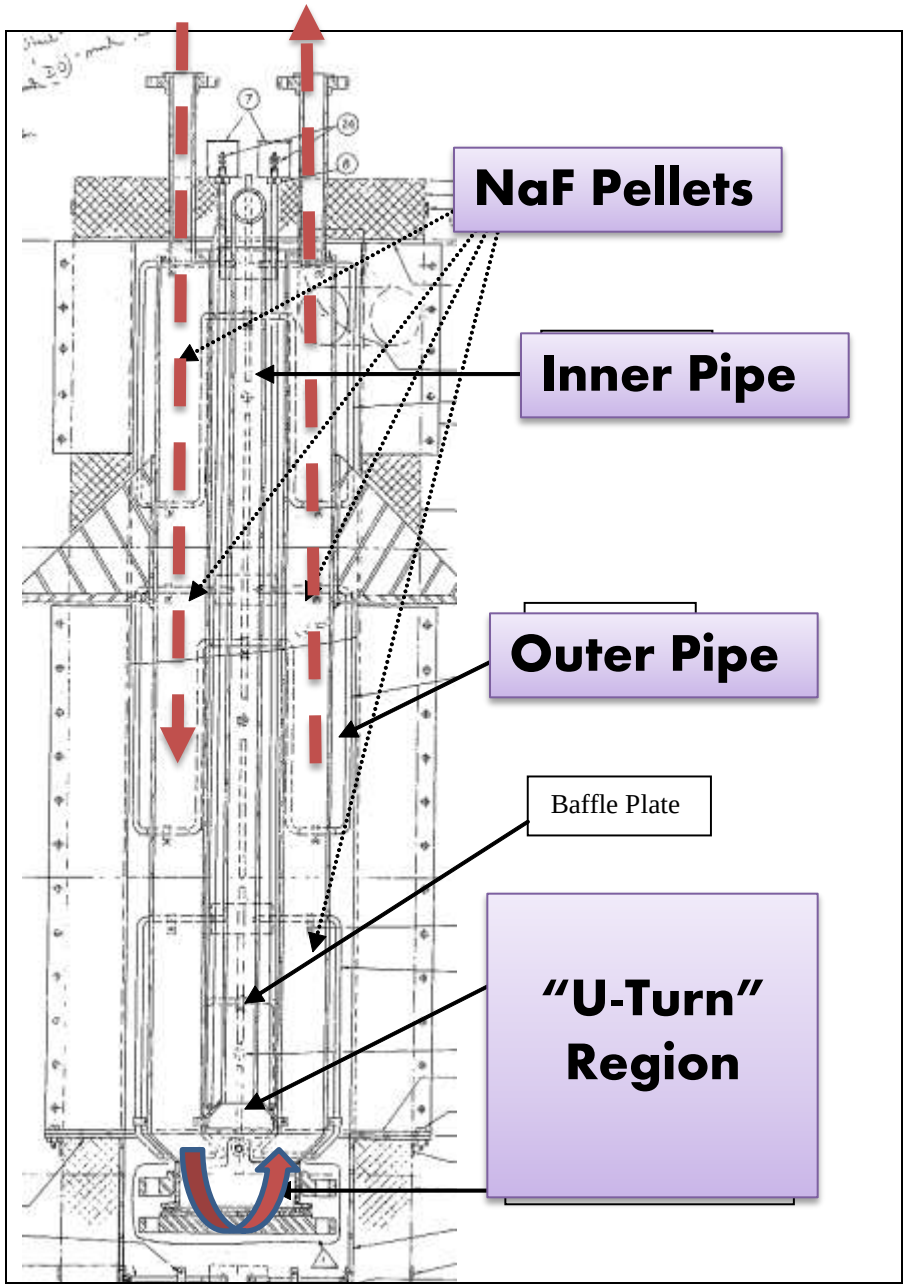
NaF Trap Drawing

Gas entered one top pipe and exited the other top pipe

Annulus is split by metal plate

Annulus width:

12.00 -5.56 = 6.44″



In lieu of reliable NDA U-235 measurements, these other data sources were used to estimate the mass

Operating Logs Data

- Enrichment exposed to (≤ 10 wt.%)
- NaF pellet density (65 lb/ft^3)
- Normal trap operation (172 lb NaF pellets)
- Data UF_6 loading on NaF pellets data (0.8 lb UF_6 per lb NaF)

Estimate = 4.2 kg U-235 (much less than NDA result)

Alternative data factoring

- Annulus volume (100L)
- Practical NaF density from other sources (2.6 g/cc)
- Max pellet packing fraction (70%)

Estimate = 8.8 kg U-235 (still much less than NDA result)

SCALE/KENO-V.a Model Results

0.8 lb UF_6/lb NaF

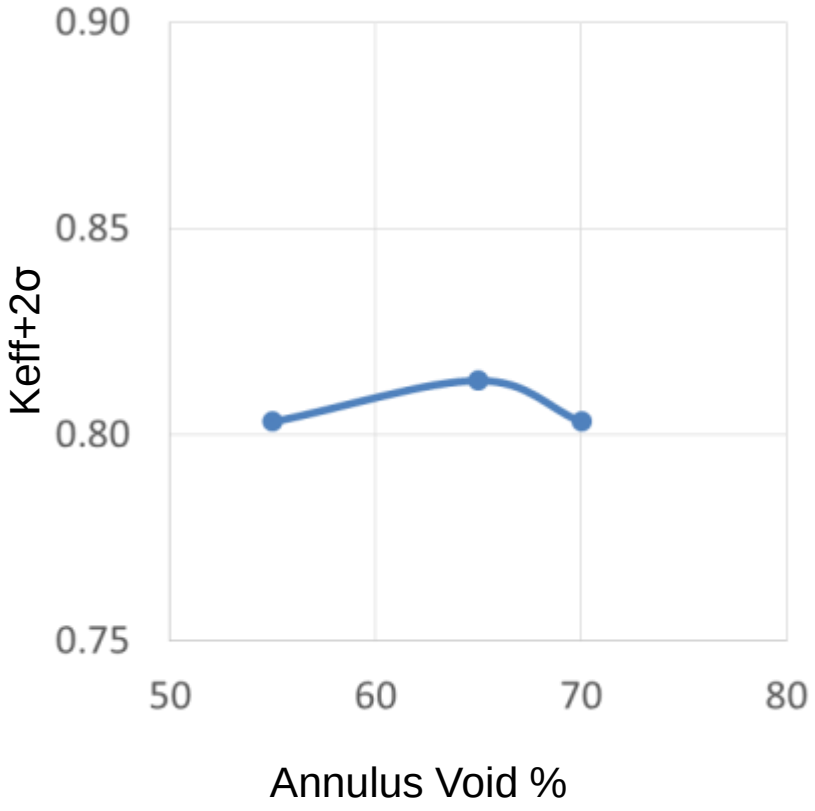
10 wt.% Enriched

Annulus Void % [water fills void]	Hyd/U Ratio	U-235 in Trap (g)	Keff + 2σ
30	8	8800	0.65
40	13	7600	0.70
50	19	6300	0.74
60	**29**	**5200**	**0.75**
70	45	3800	0.73
80	77	2500	0.66

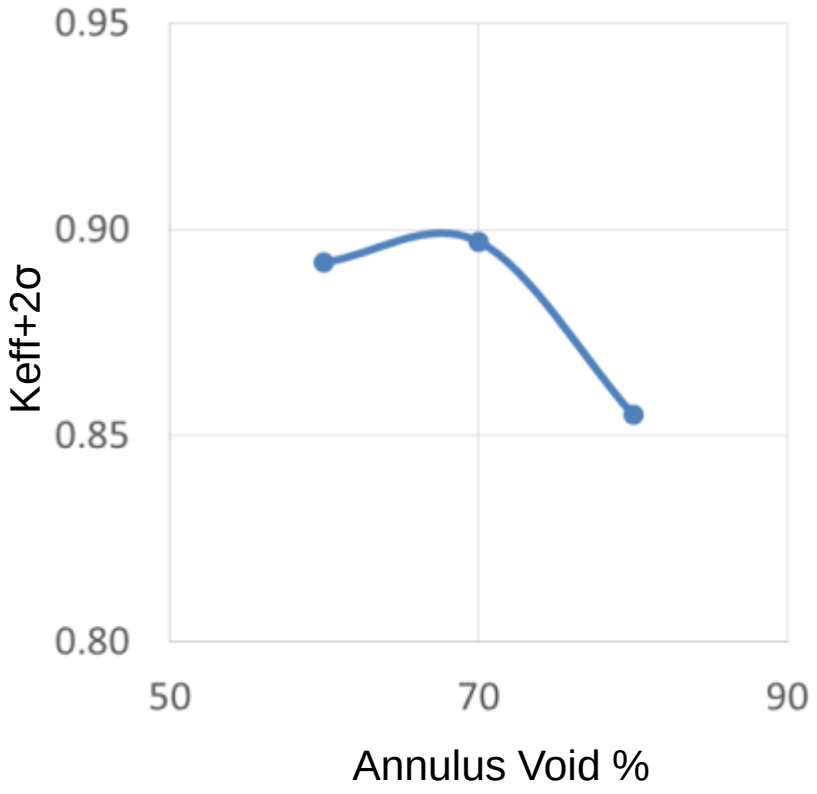
$k_{sub} = 0.93$

Loading Factor and Enrichment Sensitivity Results

Increase to 1.1 lb UF_6/lb NaF



Increase to 20 wt.% Enriched



$k_{sub} = 0.93$

UO_2F_2 ???

- Hold on a minute!!!!!!
- When the assessment had reached this point, new information was forthcoming that a process upset may have sent the UO_2F_2 compound into the part of the system where the highly loaded NaF Traps were installed.

Results for UF_6, UO_2F_2, NaF, & Water in Annulus

(Calculations @60% Void Annulus)

% of void that is UO_2F_2	Hyd/U Ratio	U-235 in Trap (g)	Keff + 2σ
100	0	34,400	0.52
50	2.1	24,700	0.65
42	5.2	17,500	0.74
17	**13**	**10,200**	**0.80**
8	18	7800	0.79
0	29	5200	0.75

$k_{sub} = 0.93$

NaF Trap Assessment Conclusions

- The keff+2σ is predicted to be only 0.75 for any amount of pellet material with the expected NaF Trap conditions of:
  - loading factor of no more than 0.8 lb UF_6/lb NaF,
  - 10 wt.% enrichment, and
  - annular construction.
- If loading factor is actually as great as 1.1 lb UF_6/lb NaF., keff+2σ is predicted to be subcritical at 0.82.
- If U-235 enrichment is actually as great as 20 wt.%, keff+2σ is predicted to be subcritical at 0.90.
- If process upset sent UO_2F_2 to traps and it was also captured, the predicted keff+2σ is 0.80 for any amount of material

Removal Authorization per Critical Safety

- Results of this assessment were incorporated into NCSE-ET-K25/27-1682.

- That Criticality Safety Evaluation concluded that all NaF Traps could be safely removed one-at-a-time and stored in isolation.

NaF Trap Extraction Process