Health Physics Aspects of Cryogenic Liquid Activation Targets

Tracy N. Tipping
Nuclear Engineering Teaching Laboratory
What are Activation Targets?

• Raw material bombarded with neutrons
  – Neutron capture results in radioactive product
Important Activation Parameters

\[ A = N \sigma \Phi \]

- **A** - activity of product at saturation
- **N** - number of target atoms
- **\( \sigma \)** - neutron capture cross section of the target
- **\( \Phi \)** - neutron fluence
How Do We Get More A?

\[ A = N \sigma \Phi \]

\( \sigma \) and \( \Phi \) are fixed

Therefore, increasing \( N \) will increase \( A \).
How Do We Increase N?

Physical size (volume) is fixed.

Must increase density to increase N.
Density Comparisons

At Room Temperature – Density = X
At Cryogenic Temperature – Density = ~ 700 X

What about increasing pressure?
Density Comparisons

At Room Temperature – Density = X
At Cryogenic Temperature – Density = ~ 700 X

What about increasing pressure?
Would require > $10^4$ psi
On a Good Day

- Cooling system condenses target gas in irradiation volume.
- Target is activated (~ 1 Ci $^{41}$Ar)
- After irradiation, activated target is expanded into shielded shipping container.
On a Bad Day

- Cooling system fails and liquid boils off.

- Gas expands out of the irradiation volume.

- Activated gas is captured in shielded emergency reservoir.
  - $1 \text{ Ci} \; ^{41}\text{Ar} = 700 \text{ mrem/hr @ 1 meter}$
On a Really Bad Day

- Cooling system fails and liquid boils off.
- Gas expands out of the irradiation volume.
- System leaks releasing activated gas into building.
On a Really Bad Day

- Release of 1 Ci $^{41}\text{Ar}$ into reactor room results in 81 times the DAC.
On a Really Bad Day

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- Ventilation system purges room in about 30 minutes...worker exposure mitigated.
On a Really Bad Day

- Release of 1 Ci $^{41}$Ar into environment results in dose to maximally exposed individual of about 1 $\mu$rem.
On a Really Bad Day

- Release of 1 Ci $^{41}$Ar into environment results in dose to maximally exposed individual of about 1 µrem.

- Catastrophe avoided (assuming the news media doesn’t find out).
Any Questions?