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TEXAS
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DESIGNING A WATER-TIGHT TORLON CONTAINER FOR MEDICAL ISOTOPE PRODUCTION USING THE CENTRAL THIMBLE OF THE NETL NUCLEAR REACTOR

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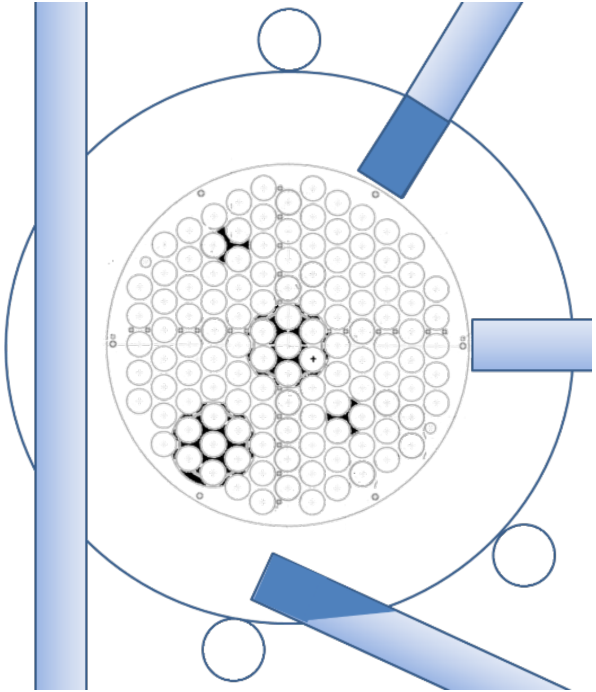
The UT-NETL Central Thimble (CT)

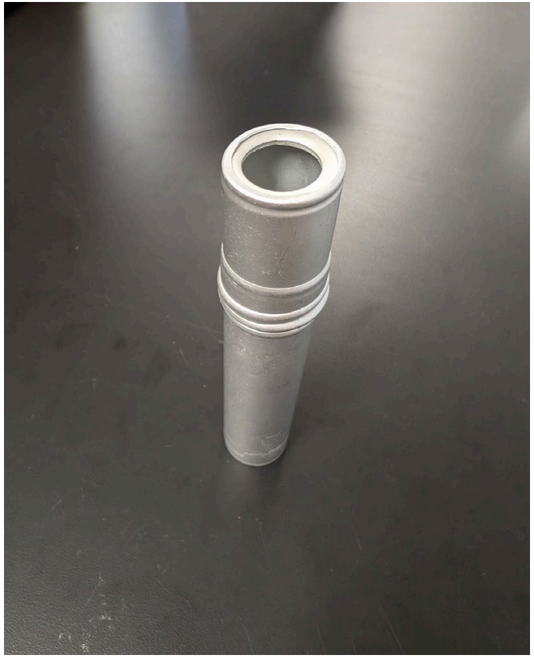
- The UT-NETL Central Thimble (CT) is our highest flux irradiator
  - 1.35”ID, water-filled tube in the center of the core
  - Thermal flux is 3.0E13 n/cm^2/sec at 1 MW
- NETL produces medical isotopes in the CT
  - including Sm-153 with 100-1000 mCi per target
- Currently no automated system for sample removal from CT
  - Samples are removed and placed into a lead transfer pig for movement to hot cells on lower research level
- This leads to potential for radiation dose to staff from exposure to sample and its container



Source of Radiation Dose

- While the medical isotope sample is a high activity,
  - the primary source of dose was from the irradiation container holding the target
- Sample packaging:
  - Target material inside an inner flame sealed quartz ampoule
  - Inner ampoule, dosimetry wire, and quartz wool (to protect sample) is packaged inside a larger outer quartz ampoule providing secondary containment
  - Sample is then placed within a container along with Pb ballast for insertion into the CT

Aluminum CT Containers



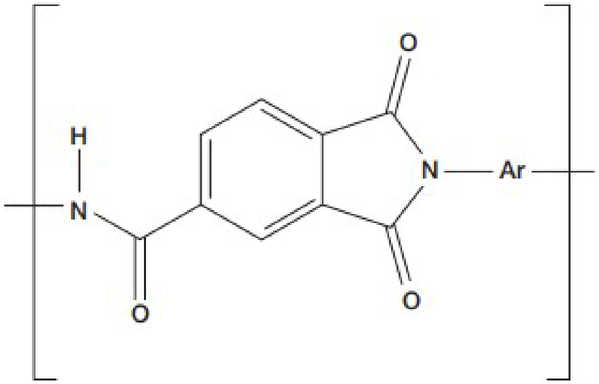
- Composed of 1100 Aluminum, General Atomics design, primary use in RSR
- Not water-tight
- Needs ballast to counteract buoyancy in CT
- Highly radioactive after isotope production irradiations in the CT
  - Initial dose readings were 1-2 R/hr at 1 foot

Q: How could we decrease dose potential to staff?

- One answer was to study alternatives to the aluminum CT tubes and the Pb ballast used
- We explored a variety of material options including several high temperature polymers (PEEK, etc.)
- At a previous TRTR, Serva Energy suggested Torlon as an excellent option

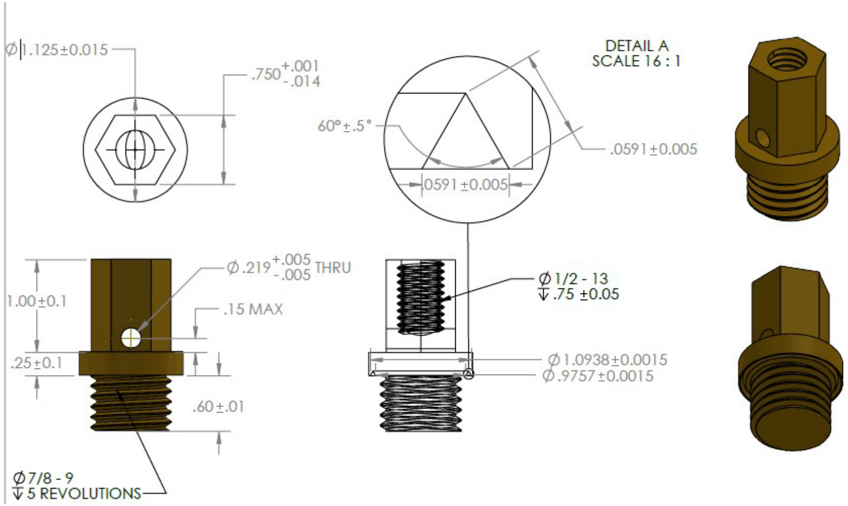
Torlon

- High-performance thermoplastic (polyamide-imide)
- High impact and mechanical strength
- Retains strength at high temperature
- We questioned its resistance to neutron and gamma-ray radiation
- Uncertain the degree of activation that would occur during long isotope production runs in the CT



General molecular structure of Torlon® PAI

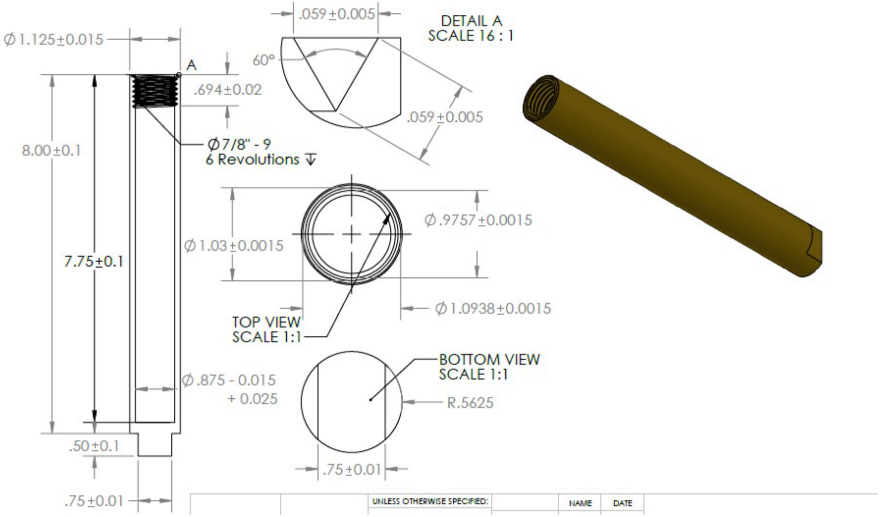
Torlon: Container Design



Unirradiated Torlon® PAI container.

First irradiation, approximately 17 hours.

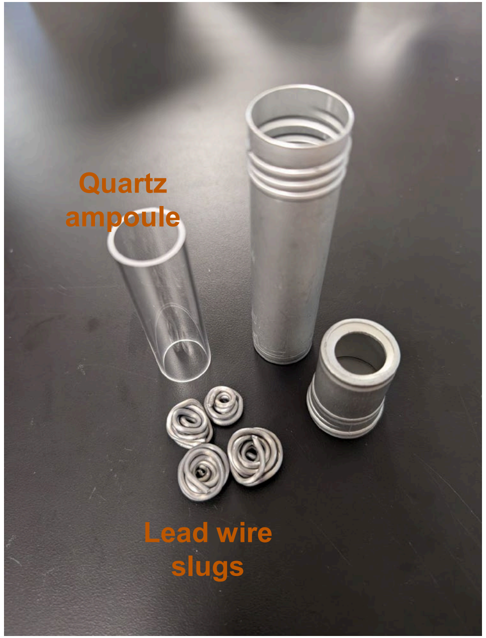
Multiple irradiations, approximately 120 hours.



Technical drawings courtesy of Rodrigo Viveros Duran

Aluminum vs Torlon Experiments

- Experimental Design:
  - Four CT runs
    - Two each with Aluminum and Torlon containers
  - One experiment would use lead wire slugs as ballast and the second would use graphite slugs

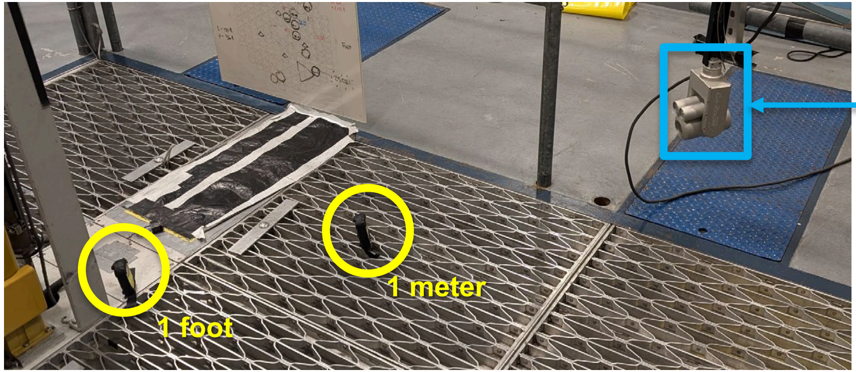


Torlon Tube Irradiation Performance

- Irradiation performance has been outstanding
  - We have irradiated tubes for over 150 hours with no significant dimensional changes, only discoloration
- Tube design with wrench flats allows for easy cap removal with manipulators inside the hot cells
- The lead crush ring has been demonstrated to provide a water-tight seal on Torlon tube

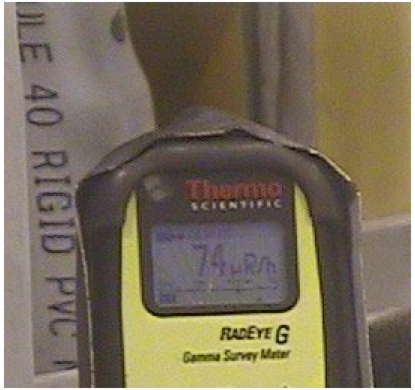
Experimental Procedure

- 8-hour irradiations at 900 kW
- Containers left to decay for 15.5 hours
- Container was suspended above CT opening via wire
- Gamma dose measured at 1 foot and 1 meter before and after removal from CT with RadEye viewed via pool camera
- Beta and beta+gamma doses measured with an ion chamber (Ludlum 9-3) at approximately 5 inches from the container

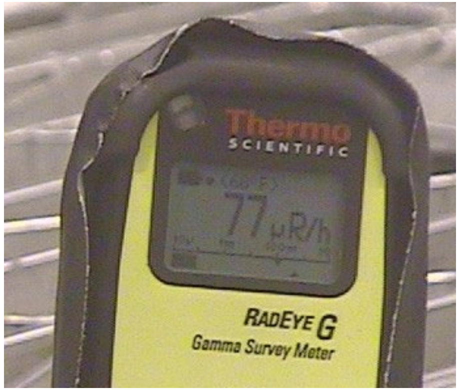


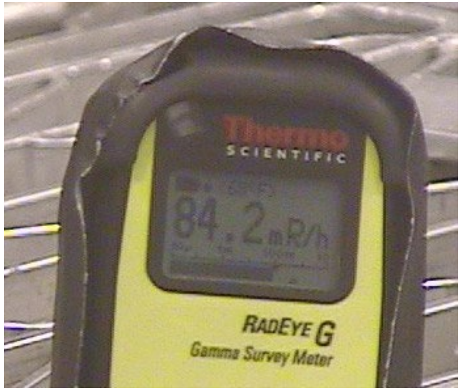
CT Exp. 1: Al tube w Quartz Ampoule & Pb Slugs

1 foot



1 meter





Aluminum vs Torlon Results

Container	One Foot (ɣ)		One Meter (ɣ)		Ion Chamber with Window (~ 5”)	
	Before* (mR/hr)	After* (mR/hr)	Before* (mR/hr)	After* (mR/hr)	Closed (ɣ) (R/hr)	Open (ɣ + β) (R/hr)
Al + Pb slugs	0.074	785	0.077	84.2	3.4	12
Al + Graphite slugs	0.056	763	0.063	51.3	2.2	14
Torlon + Pb slugs & Pb O-ring	0.042	111.5	0.044	11	0.200	0.360
Torlon + Graphite slugs & Pb O-ring	0.042	57.5	0.046	6.2	0.133	0.280

*Before = ɣ dose before pulling the container out of the CT
*After = ɣ dose after pulling the container out of the CT

mR = mrem, R = rem

Aluminum vs Torlon Conclusions

- Torlon and graphite decrease potential dose to staff by more than 13× post-irradiation vs aluminum with Pb ballast
- Torlon is easier to handle after irradiation
- Water-tight Torlon prevents increases flux to the target and removes possibility of damage to target from water
- Torlon can be irradiated in the CT for over 150+ hours without degradation to the container

Acknowledgments
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