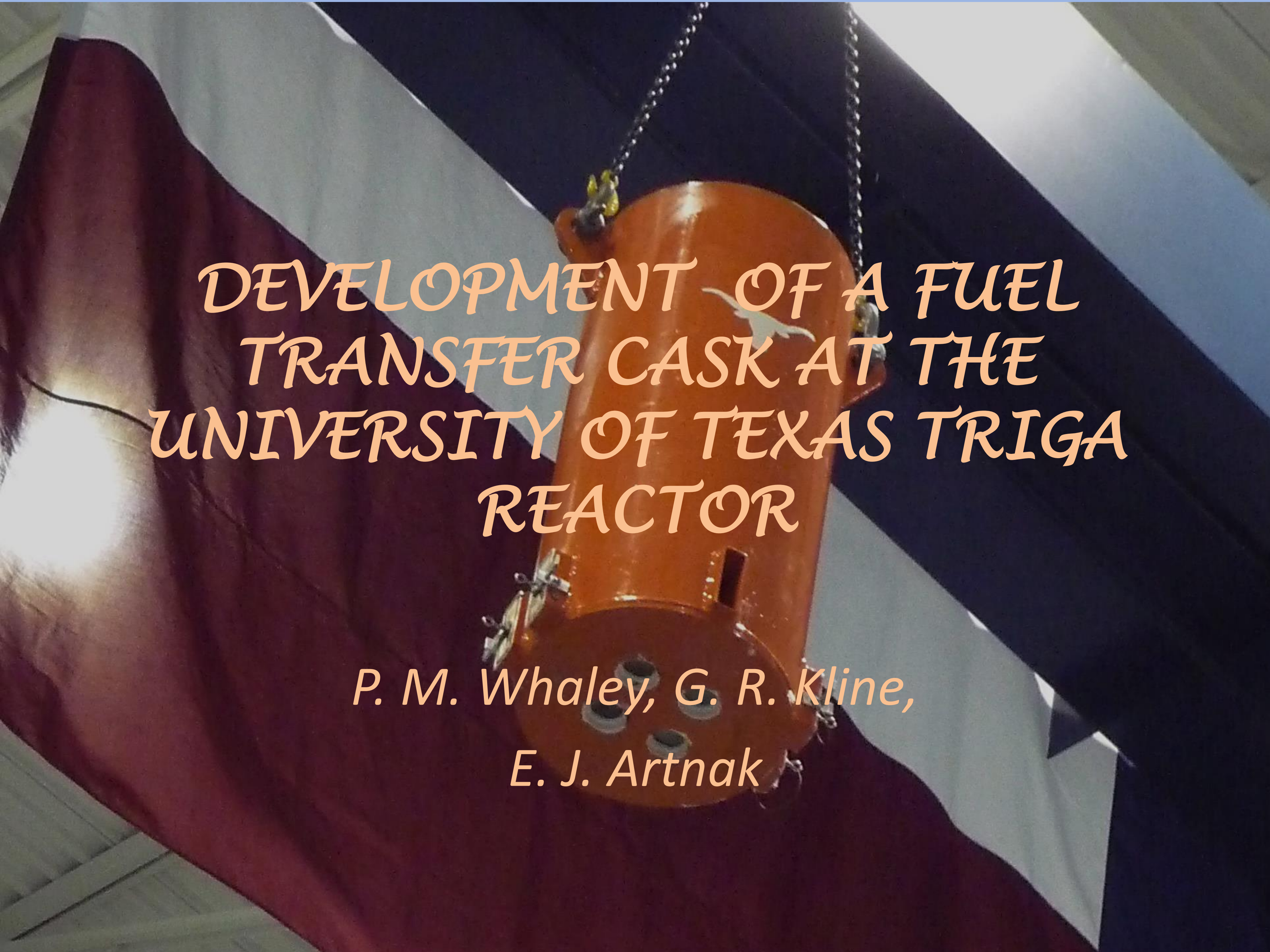

DEVELOPMENT OF A FUEL TRANSFER CASK AT THE UNIVERSITY OF TEXAS TRIGA REACTOR

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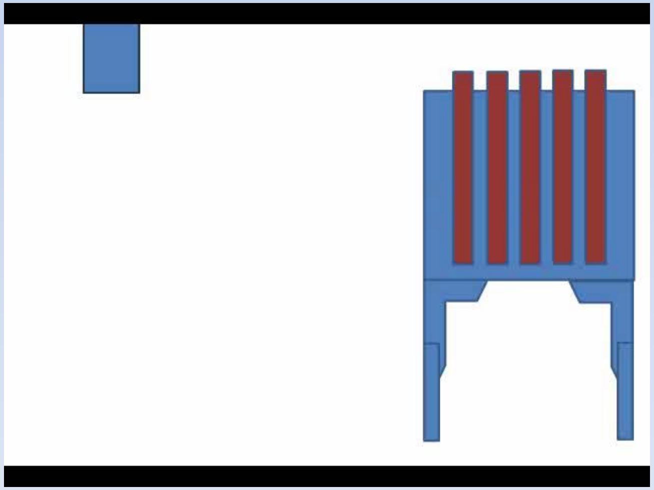
E. J. Artnak

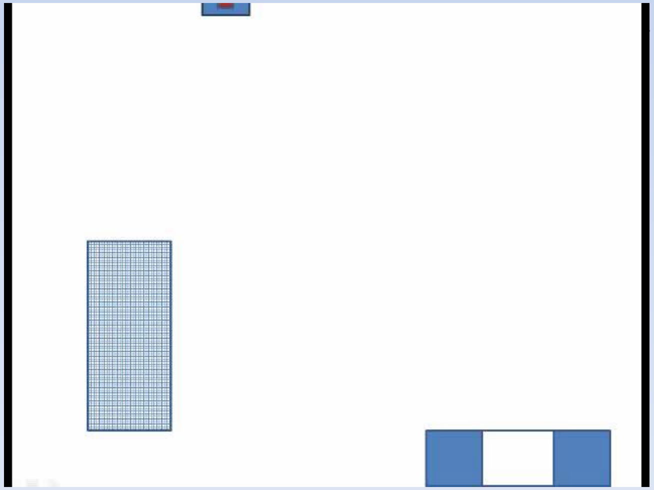
INTRODUCTION

- A 3-element transfer cask fabricated for BMI shipping cask at initial UT TRIGA core load
- Subsequently used as the facility fuel transfer cask
- Workable, but vulnerable

Three-Element Basket Operations

- Rigging interference (loading/unloading)
  - Chain lowered & shifted for fuel tool access
  - Potential instability (swing or tip) during lift operations
- Lifting fuel in air to storage





Resource Intensive

- 3 (minimum) pool side
- 2 on scaffolding
- 1 at storage well
- 2 fuel tools

Vulnerabilities

- Inadequate Shielding
  - No top shielding
  - Minimal side shielding
  - Everyone in bay shelters
- Operations from scaffolding
  - Increase distance from source
  - Still significant exposure
  - Stability & fall protection
- Cask to storage
  - Rigging operations close to cask
  - Scaffolding exposure

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Accumulated Dose for 8/20/15

#2 – 662.86 uR/hr

#15 - 239.31 uR/hr

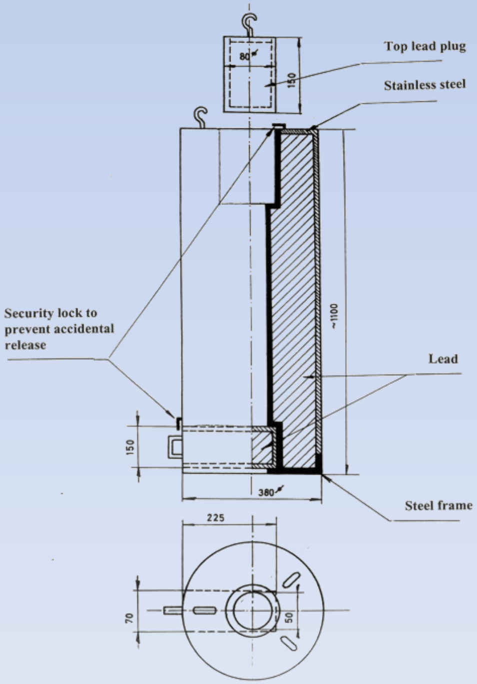
#14 - 25.69 uR/hr

8/20/2015 12:37	2356
8/20/2015 12:38	2469
8/20/2015 12:38	3703
8/20/2015 12:38	6004
8/20/2015 12:38	8000
8/20/2015 12:38	8000
8/20/2015 12:38	5906
8/20/2015 12:38	3083
8/20/2015 12:39	2201

Sample of Doses During Defueling (3 element cask)

PROPOSAL FOR IMPROVEMENT

- After seeing the process it was decided to see if we could fit into the bellows repair timeline acquisition of a more suitable cask with:
  - Rigging clearance for the fuel handling tool
  - Bottom access (loading/unloading)
  - Better shielding
- Reduce resource requirements
  - Scaffolding
  - Need for 2 fuel handling tools



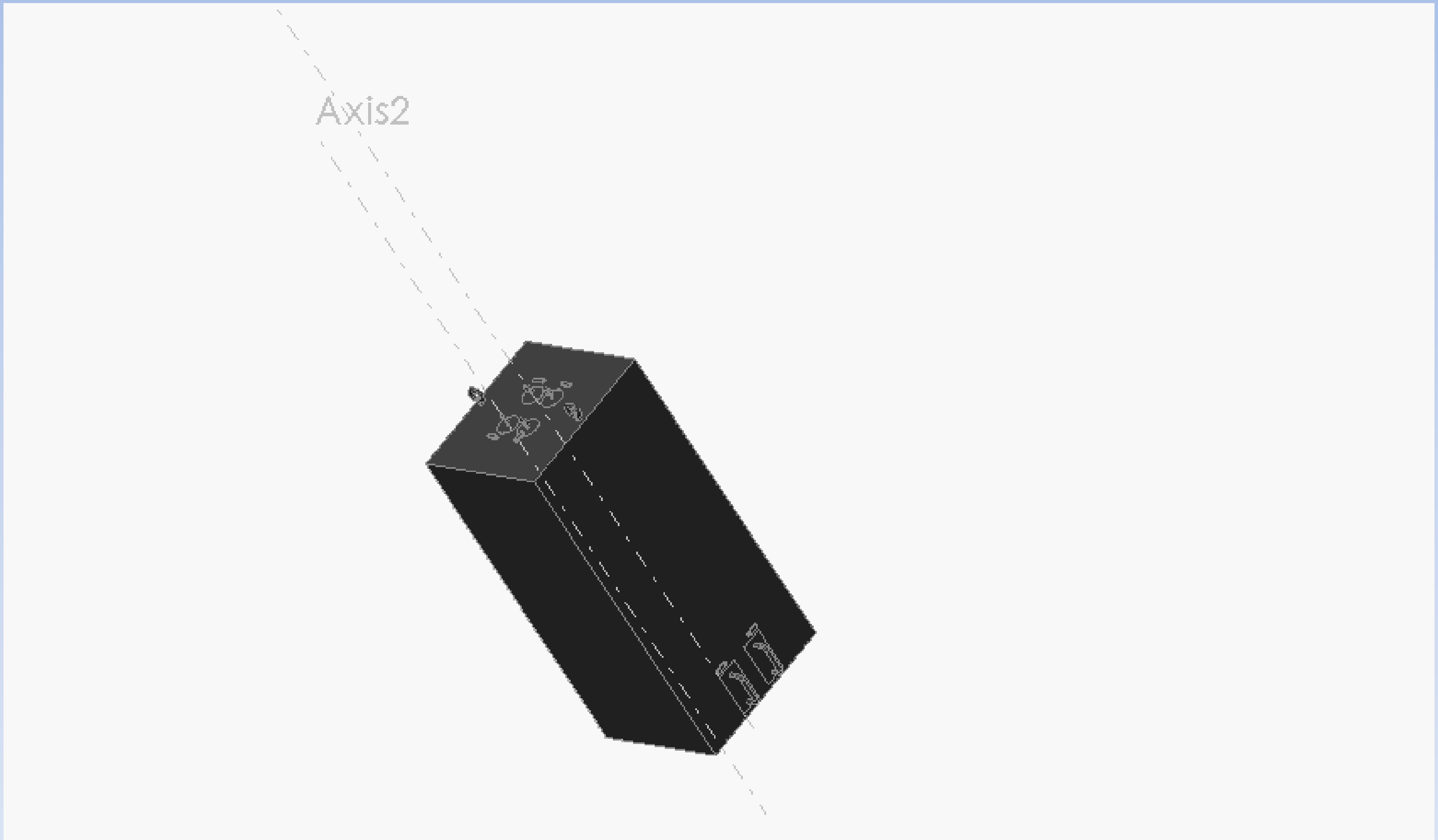
Development Process

- Specify design considerations/strategy
- Identify potential for vendor support
  - Cost estimate
  - Timeline
- Evaluate shielding material
- Purchase
  - Cask structure
  - Cask hardware
  - Shielding material
- Assemble cask and shielding

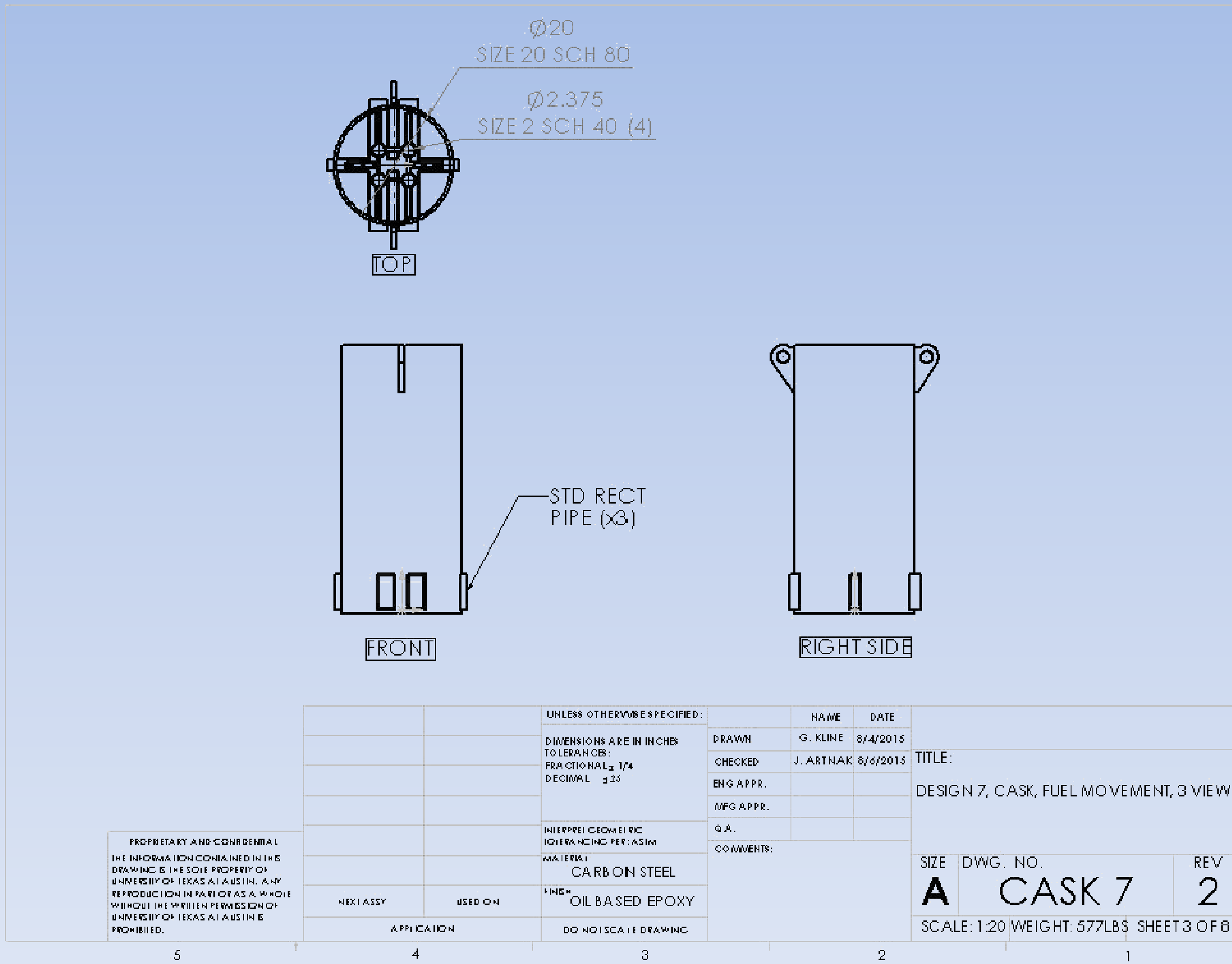
Design Considerations

- Fabrication from off-the-shelf components
  - Constrain cost
  - Minimize manufacturing time
- Weight limited to pallet jack capacity
- Assembly/installation process timeline

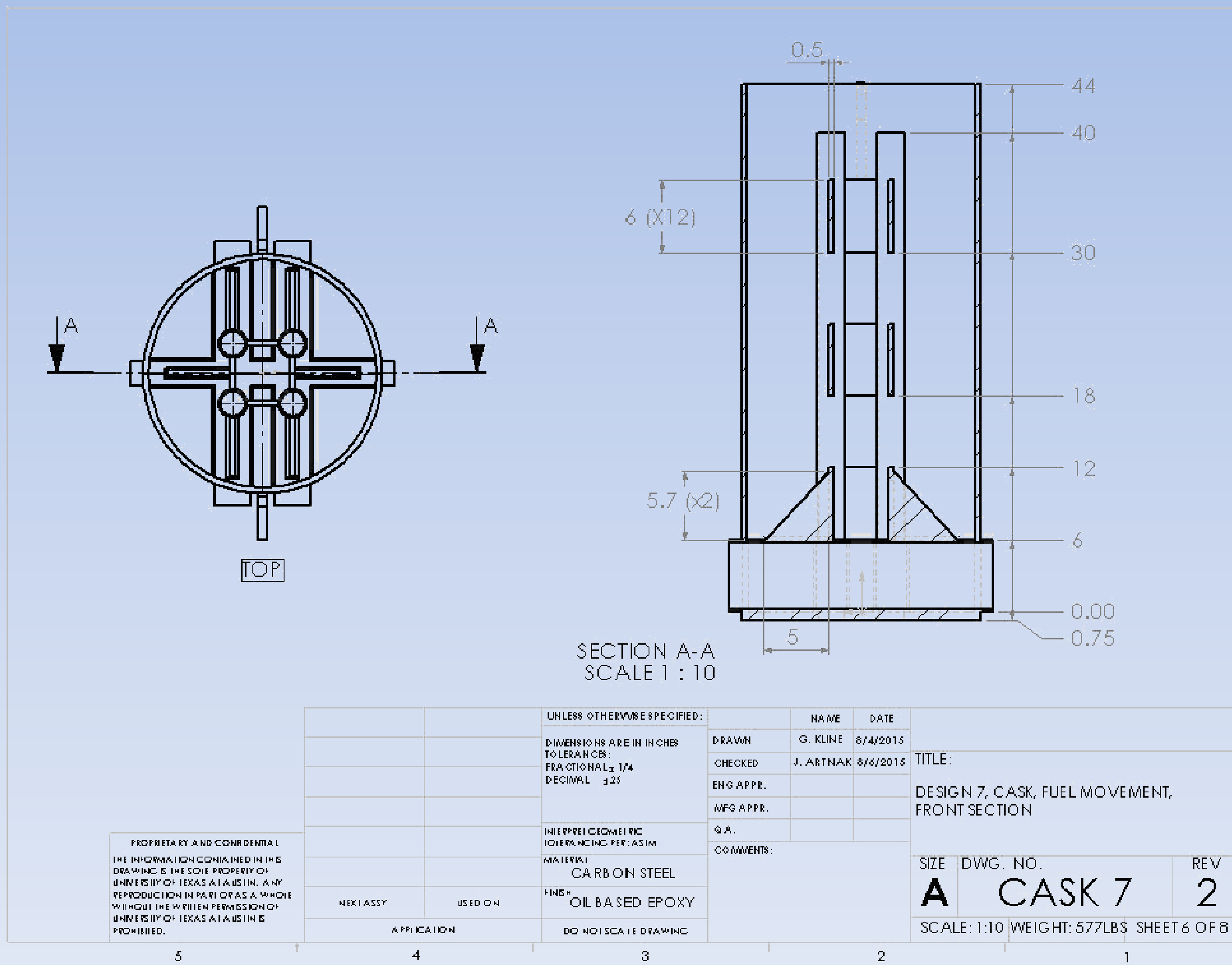
Conceptual Design



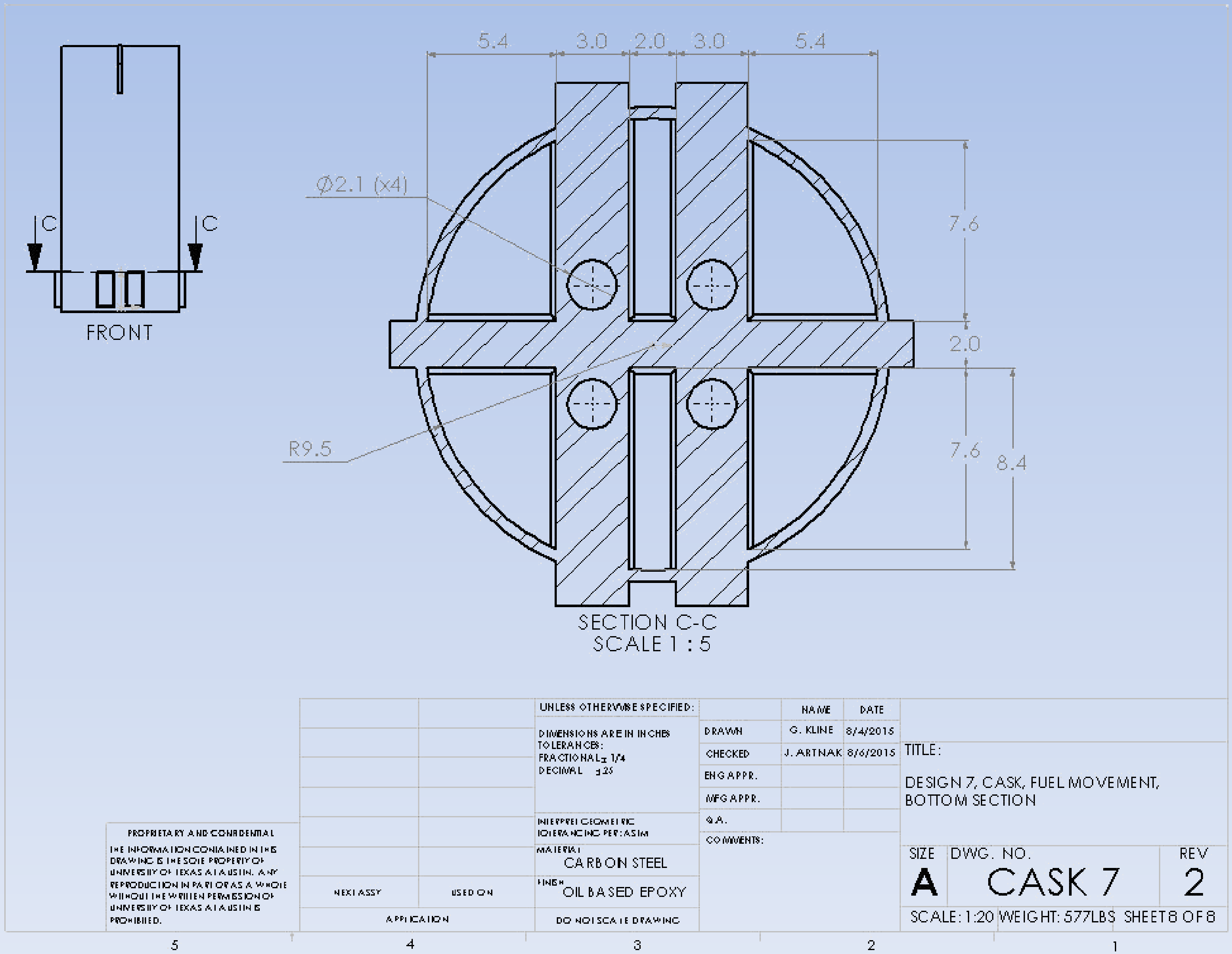
Final Design



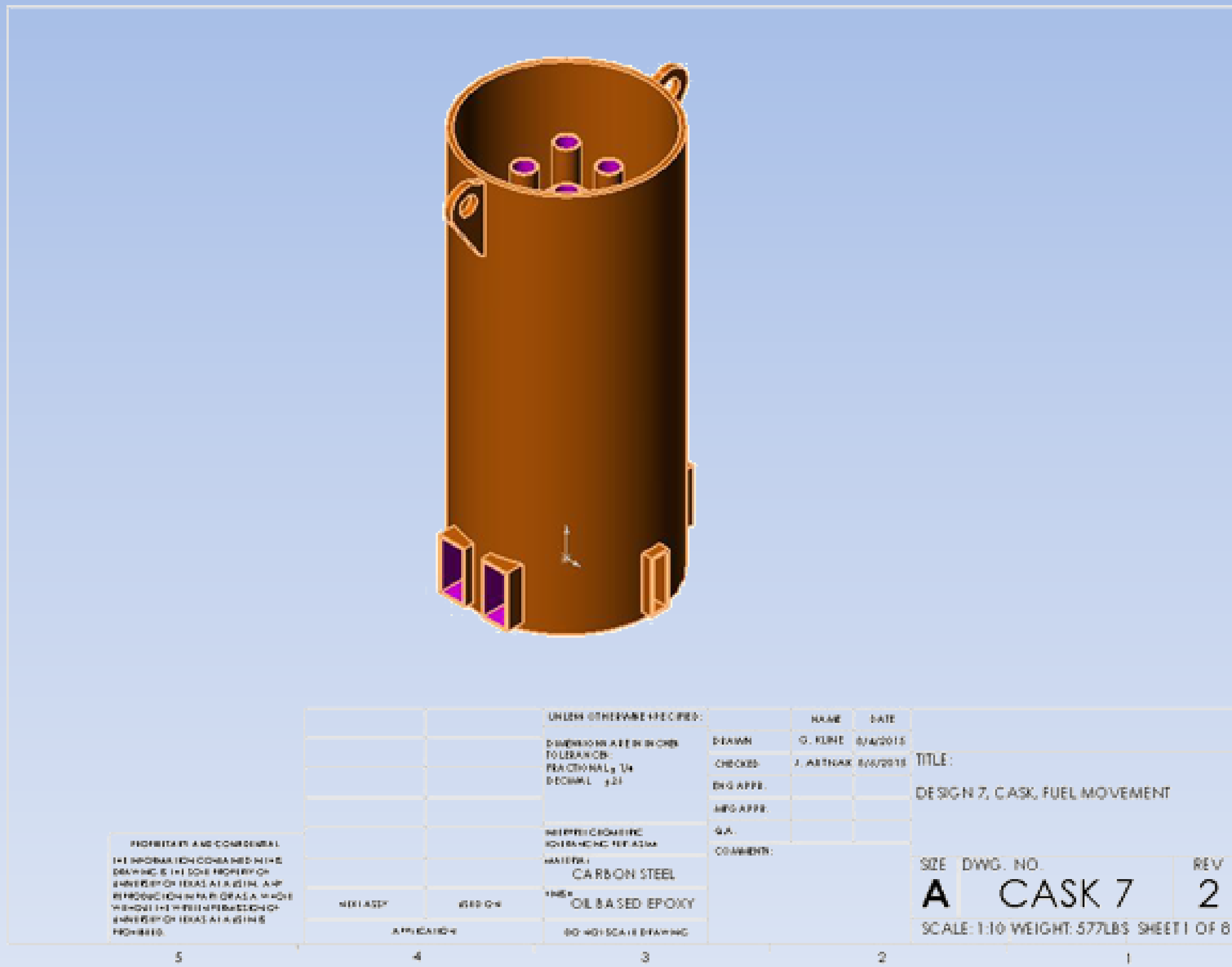
Final Design Wireframe View



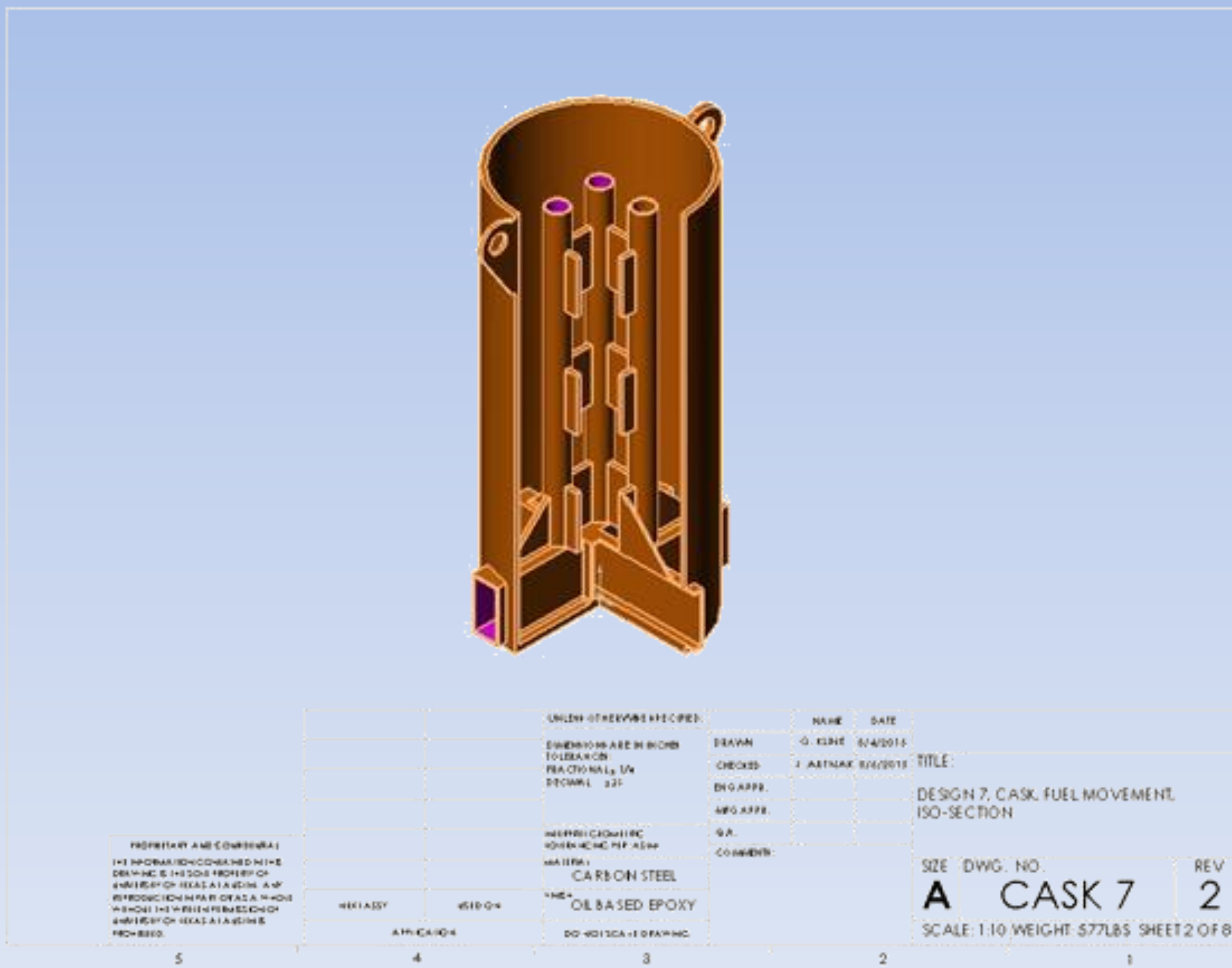
Final Design Drawer Detail



Isometric, Exterior View



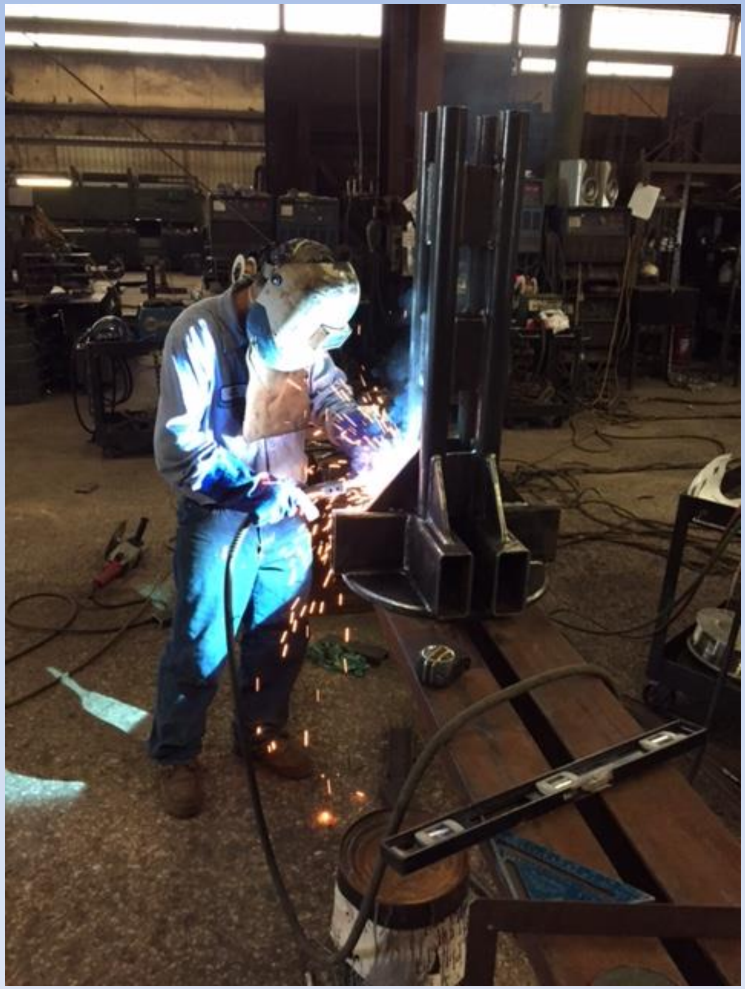
Isometric Cut View



FABRICATION

- Approximately 1 week delivery
- Acceptable cost estimate
- Iteration with the shop:
  - Assure acceptable safety factors
  - Improve fabrication

Internal Structure



Shell

Completion and Delivery

Receipt

HOLD POINT: CAPABILITY TEST

- General sanity check, prior to shielding load
- Provide staff opportunity to develop & test

FINAL HARDWARE DEVELOPMENT

- Drawers
  - Beveled hole
  - Fuel end fitting
- Top plug
- Stainless steel liners
- Self centering guide

Drawer Installation

- Surface smoothness was not specified Fabrication/welding warped surface
- Drawer openings required work



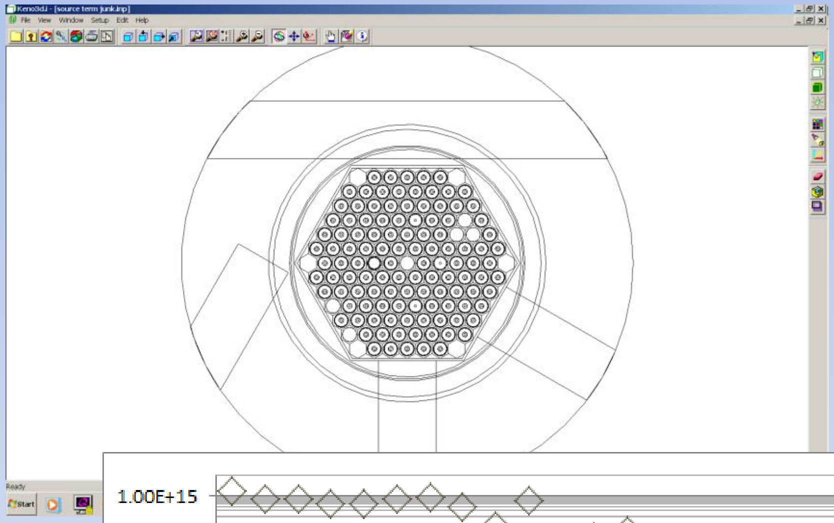

Drawer Action

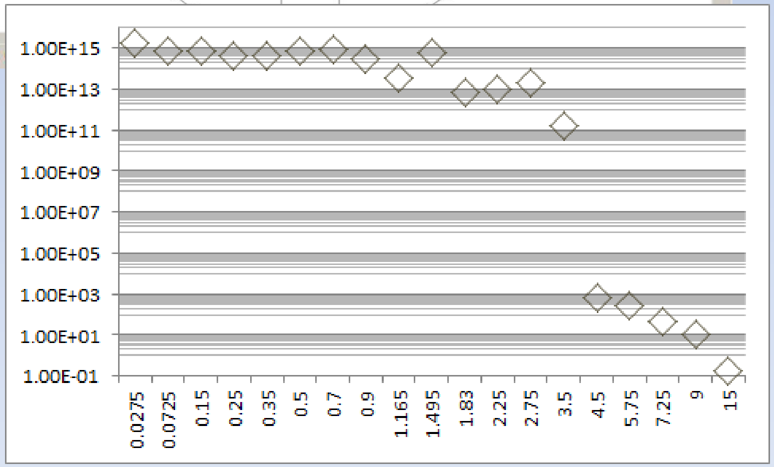
SHIELDING MATERIAL

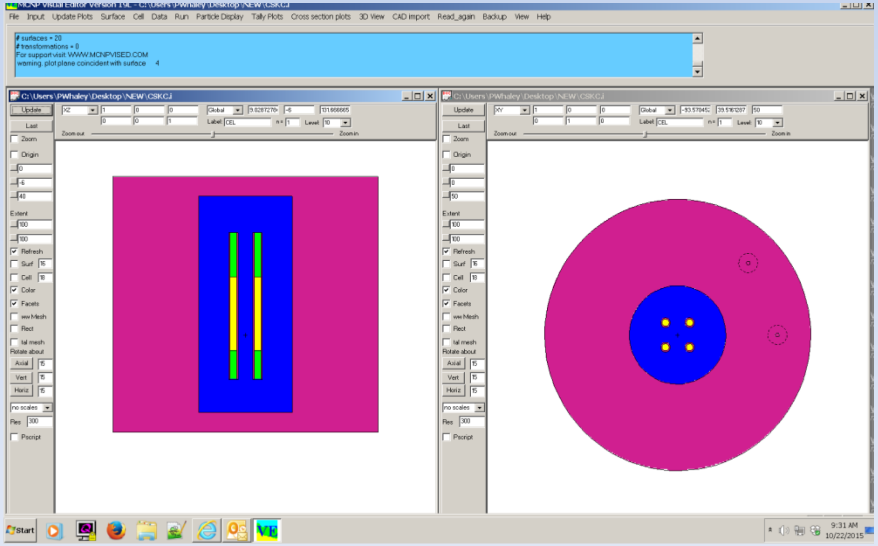
- Options
  - Cast in place lead
  - Lead Shot
  - Steel shot (rejected)
  - High density concrete (nuclear vendor)
- Comparisons
  - Shielding effectiveness
  - Cost
  - Weight
  - Installation process

Calculations

- SCALE (KENO/ORIGEN) source term (25%, 7 d)
- MCNP for shielding
  - High density concrete
  - Lead
  - Lead shot (70% density)

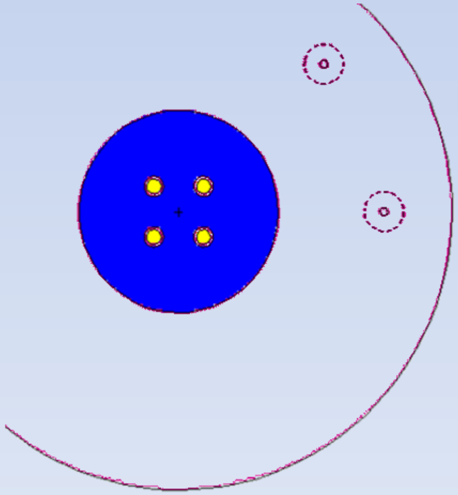






Calculated Dose Rates
(mrem/h)

	CONCRETE	LEAD	LEAD SHOT
Top Surface	2	<1	~1
Bottom Surface	2.3	<1	~1
Side Surface	449	32	50
1 ft. (Area tally)	239/336	23/34	35/50
1 ft. (Surface tally)	244/314	23/39	35/60



- Lead Shot ~70% of lead
- Upper & lower surfaces simplified
- Processing for shot simple

Shielding Configurations

- Bulk shielding
  - Lead shot (reclaimed lead)
  - Sealed and stabilized polymer

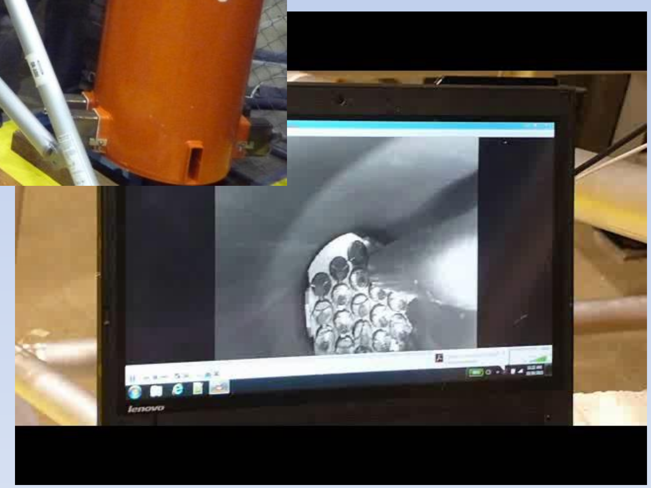
- Total weight less than 4500 lbs (~3600 lbs)
- Top plug & drawer manufactured separately
  - Financing consideration
  - Stainless steel

Drawer & Plug Shielding

- Drawer & top plug shells
  - Not closed volumes
  - Difficult to stabilize
  - Melted in place
- Lead
  - Melt temp 327 °C
  - Boiling point 1750 °C
  - Temp < 500 °C
- Heat deformation

Sealing

Video Guidance: Very Difficult



Utilization Dose Rates (mrem/h)

- MCNP Calculations
  - 70% nominal lead density
  - 6” from side surface*
  - Top & Bottom (oversimplified) Contact
- Measured 6” dose rates
- Surface dose rates
  - Maximum 135 mrem/h
  - Minimum 3.6 mrem/h

FOUR-ELEMENT DOSE RATES		
POSITION	CALC	MEAS
TOP	0.38	4
SIDE 1	78	38[1]
SIDE 2	56	25[2]
BOTTOM	0.07	19

NOTE 1: Average at 0°, 90°, 180°, 270°
NOTE 2: Average at 45°, 135°, 225°, 315°

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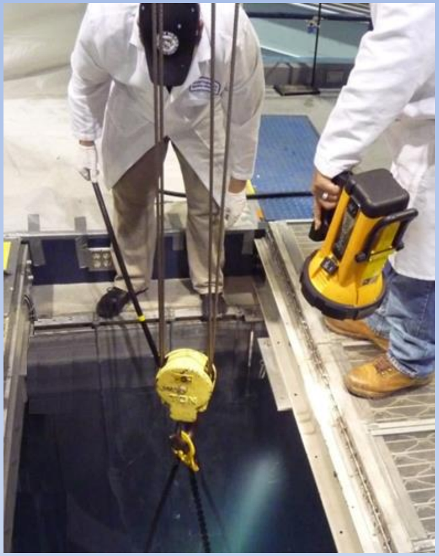
- Exterior Cumulative Dose during Refueling

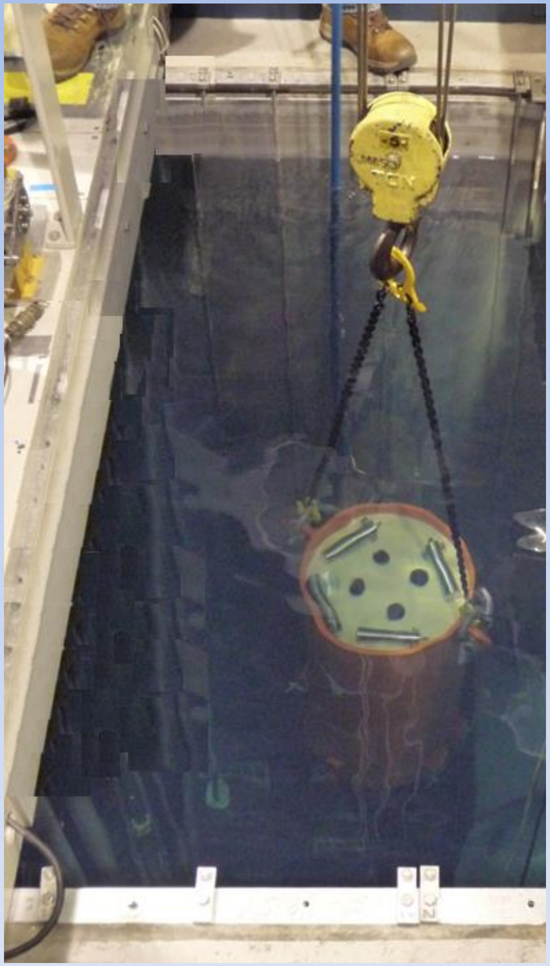
background

Movement to Poolside

Into the Pool



In the Pool



Conclusions & Lessons Learned

COMPARISON FUEL TRANSFER TO STORAGE AND CORE RELOAD			
	Units	BTB[1]	BOT-C[2]
Radiation Protection			
Total exposure	mrem	669	186
Maximally exposed worker	mrem	219	72
Dose rates (cask surface)	mrem/h	Est 500K	3.6-135
Dose Rates (bay)	mrem/h	35 (@ 20’)	4-40 (@ 6”)
Max Dose Rate (outside)	mrem/h	8.7	Bkg
Process			
Required Staffing	Persons	7	2
Required fuel tools	No.	2	1
Time per element	Minutes	8.3 (3 ele.)	<2.5 (4 ele.)

[1] BMI Transfer Cask/Basket

[2] Bevo Orange Transfer Cask

Total Cost

- Cask shell $3500 (10% UT Discount)
- Protective finish $2000
- Drawer and plug shells $1500
- Lead $4975
- Misc. $1200

CONCLUSIONS & LESSONS LEARNED

- Quick fabrication by design
  - Simple construction
  - Standard pipe dimensions
  - Interaction with fabricator
    - Lots of feedback and discussion
    - Updated design based on fabrication requirements
- Safer, faster, better fuel handling process

LESSONS LEADRNED: WHAT WE'D DO DIFFERENTLY

- Drawer fabrication by same shop as cask
- Solid stainless steel plugs and drawers
- Cask wells/storage spaces:
  - Stainless steel
  - Seamless
  - Optimized pitch

EXTENSION: SURPRISES

- 50.59 Review
  - The Safety Analysis Report does not contain any information or reference to fuel handling hardware
    - Transfer mechanism
    - Fuel tool
    - Process
  - Facility procedures do not reference fuel handling hardware

LESSONS LEARNED/ISSUES

- Bottom drawers
- Cask well/storage spaces
- Drains
- Finish

Drawer Issues

- A design revision
  - removed a drawer stop
  - not identified in review
  - required compensation
- Drawer fit
  - Internal cask surface warp
  - Melting lead warped drawer surfaces

Cask Well Issues

- Well tubing seams had to be ground.
- Need for liners was an afterthought
- Stainless steel liners difficult to expand (muffler tools)

Drain Issues

- Stainless steel liners
  - Terminated above the polymer seal
  - Drains had to be cut
- No drawer drains

    May be installed later

Finish Issues

- Applied immediately following fabrication
- Drawers fabricated separately and later
- Machining the cask so drawers fit damaged finish and required rework

Long Term Lead Shot Settling

- Lead shot may settle
- Polymer seal may dimple
- Fix:
  - Add shot
  - Replace seal