



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

*P. M. Whaley, G. R. Kline,  
E. J. Artnak*

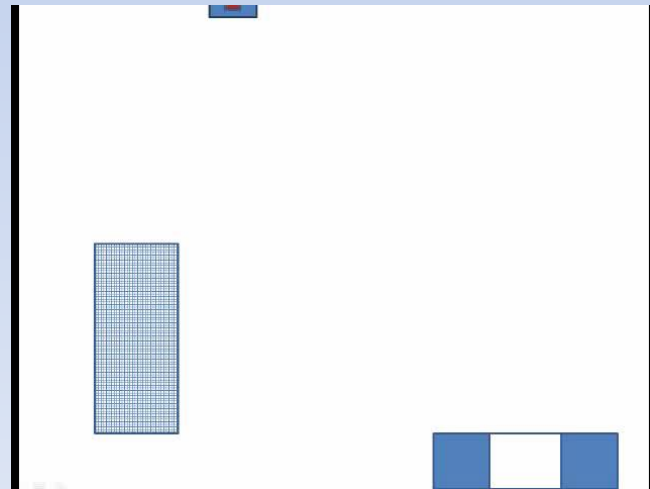
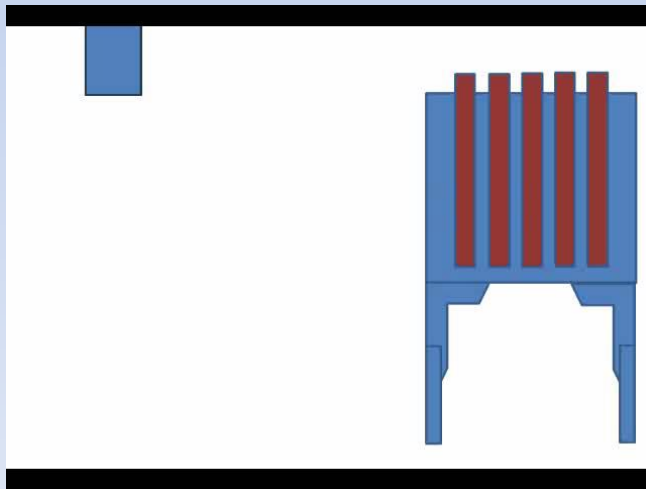
# INTRODUCTION

- 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



# Department of Defense 6<sup>th</sup> Civil Support Team



Accumulated Dose  
for 8/20/15

#2 – 662.86 uR/hr

#15 - 239.31 uR/hr

#14 - 25.69 uR/hr

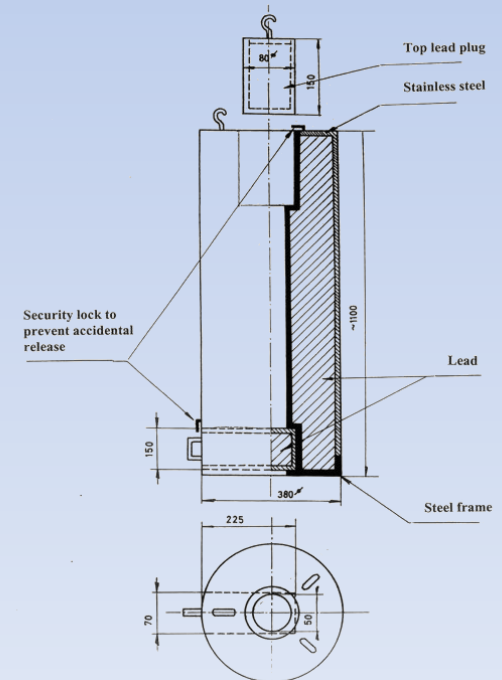


8/20/2015 12:37	2356
8/20/2015 12:38	2469
8/20/2015 12:38	3703
8/20/2015 12:38	6004
8/20/2015 12:38	8000
8/20/2015 12:38	8000
8/20/2015 12:38	5906
8/20/2015 12:38	3083
8/20/2015 12:39	2201

**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

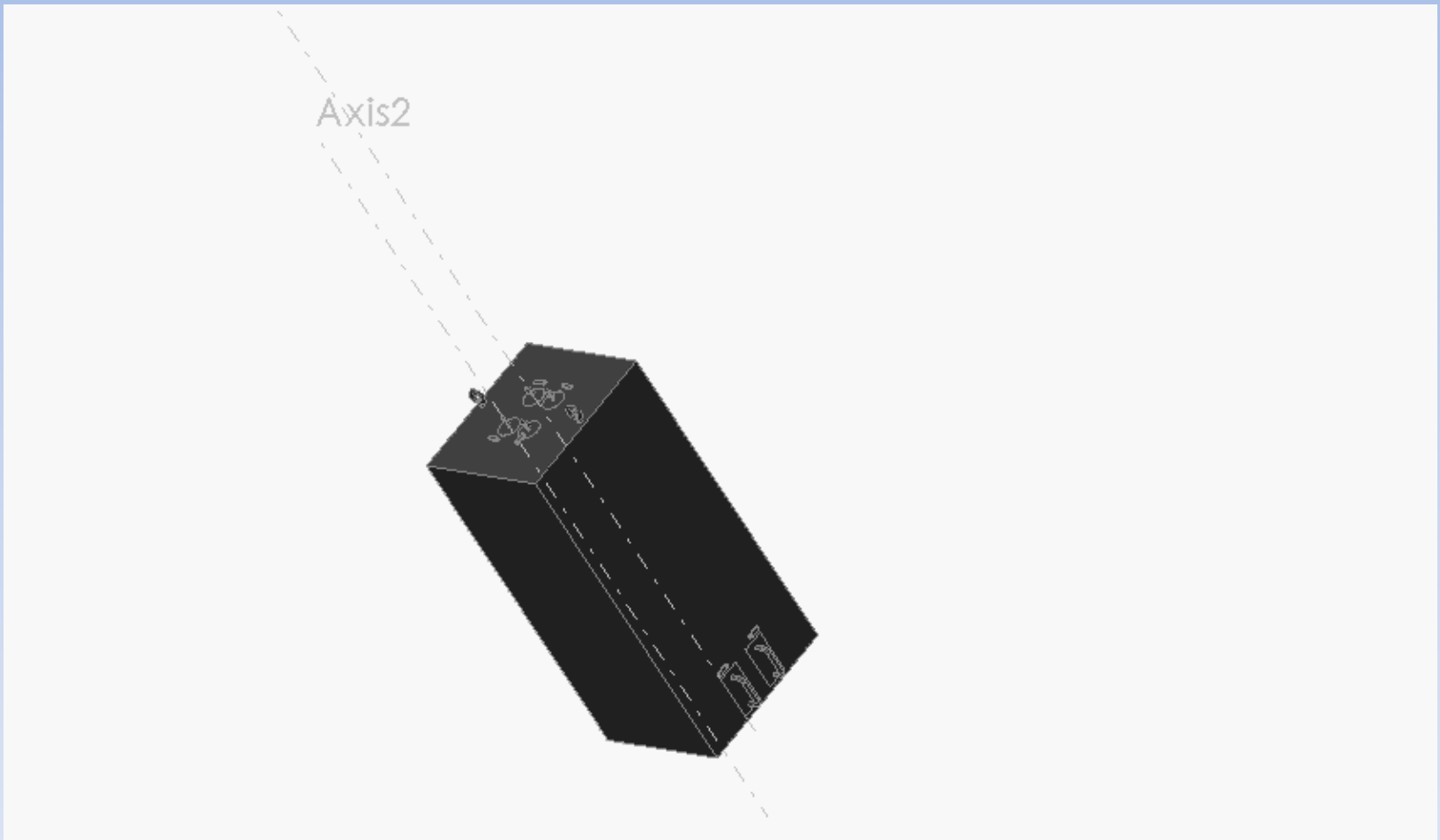
- Specify design considerations/strategy
- Identify potential for vendor support
  - Cost estimate
  - Timeline
- Evaluate shielding material
- Purchase
  - Cask structure
  - Cask hardware
  - Shielding material
- Assemble cask and shielding



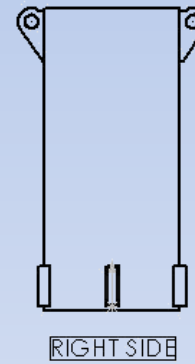
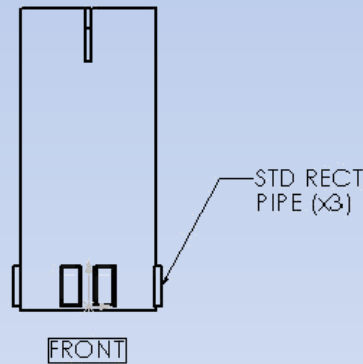
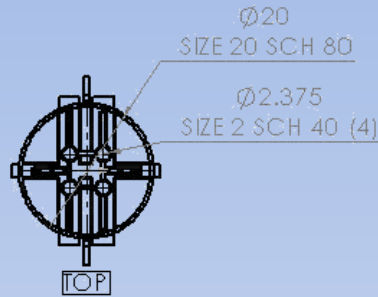
# Design Considerations

- 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



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		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	TITLE: DESIGN 7, CASK, FUEL MOVEMENT, 3 VIEW	
		DIMENSIONS ARE IN INCHES TO LEAST FIBER: FRACTIONAL 1/4 DECIMAL .025		DRAWN	G. KLINE		8/4/2015
		INTERPRET GEOMETRIC TOLERANCING PER: AS10		CHECKED	J. ARTNAK		8/6/2015
		MATERIAL: CARBON STEEL		ENG APPR.			
		FINISH: OIL BASED EPOXY		MFG APPR.			
		DO NOT SCALE DRAWING		Q.A.			
				COMMENTS:			
NEXT ASSY	USED ON			SIZE DWG. NO.		REV	
APPLICATION				<b>A</b> <b>CASK 7</b>		<b>2</b>	
				SCALE: 1:20 WEIGHT: 577LBS SHEET 3 OF 8			

5

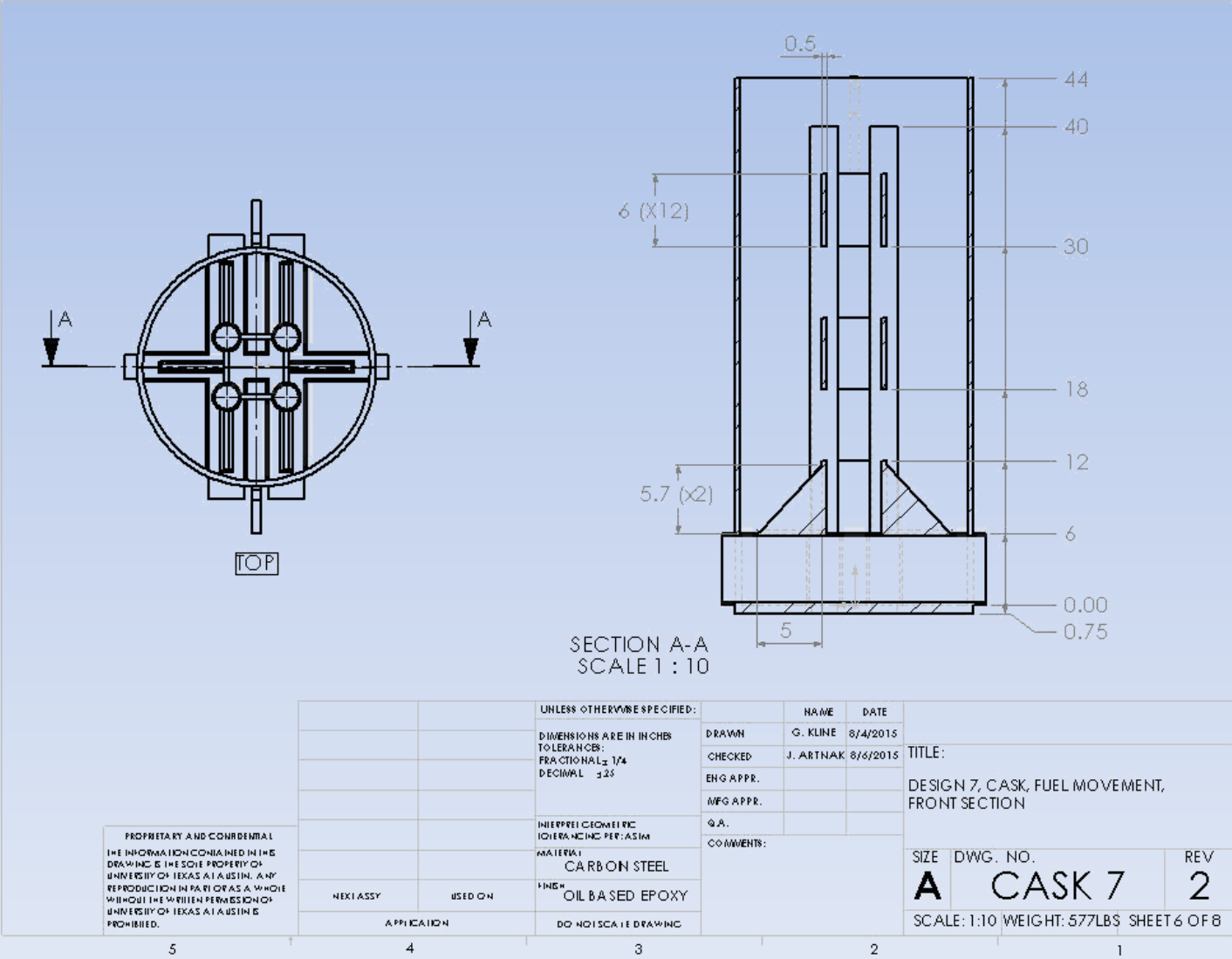
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# Final Design Wireframe View



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		DIMENSIONS ARE IN INCHES		DRAWN	G. KLINE 8/4/2015	
		TOLERANCES: FRACTIONAL $\pm 1/4$		CHECKED	J. ARTNAK 8/6/2015	
		DECIMAL $\pm .025$		ENG APPR.		
		INTERPRETATION: TOLERANCES PER: AS10		MFG APPR.		SIZE DWG. NO. REV <b>A</b> CASK 7 2
		MATERIAL: CARBON STEEL		Q.A.		
		FINISH: OIL BASED EPOXY		COMMENTS:		
NEXT ASSY	USED ON	DO NOT SCALE DRAWING		SCALE: 1:10 WEIGHT: 577LBS		SHEET 6 OF 8

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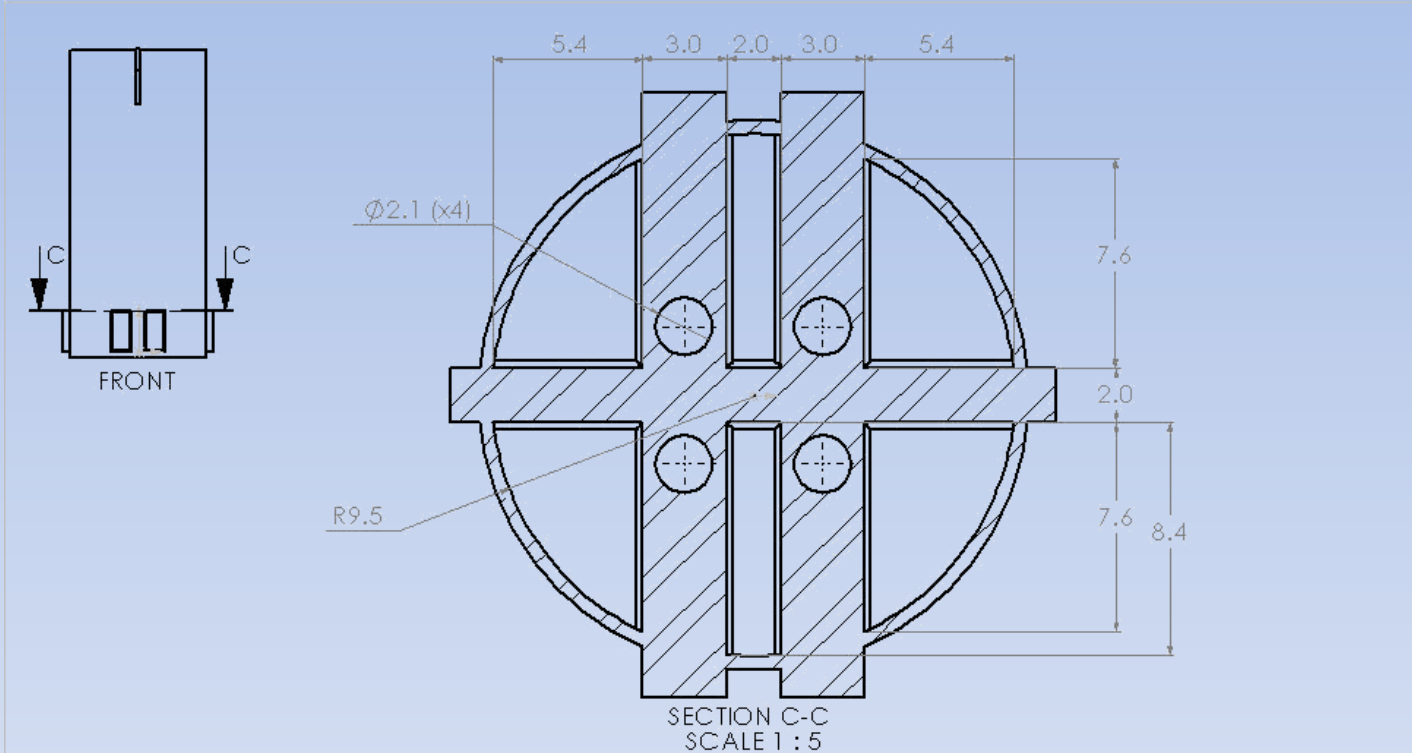
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1

# Final Design Drawer Detail



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		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± 1/4 DECIMAL ± .025		DRAWN	G. KLINE 8/4/2015	
				CHECKED	J. ARTNAK 8/6/2015	
				ENG APPR.		
				MFG APPR.		SIZE DWG. NO. REV <b>A</b> <b>CASK 7</b> <b>2</b>
				Q.A.		
				COMMENTS:		
		MATERIAL CARBON STEEL				SCALE: 1:20 WEIGHT: 577LBS SHEET 8 OF 8
		FINISH OIL BASED EPOXY				
		DO NOT SCALE DRAWING				
5	4	3	2			1

# Isometric, Exterior View



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APPLICATION

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES  
 TOLERANCES:  
 FRACTIONAL ±.04  
 DECIMAL ±.02

HEAT TREATING  
 IDENTIFICATION REF. AS SHOWN

MATERIAL:  
 CARBON STEEL  
 FINISH:  
 OIL BASED EPOXY

ISO 401 SCALE DRAWING

NAME DATE

DRAWN G. KLINE 8/4/2015

CHECKED J. ARTHUR 8/16/2015

ENG APPR.

MFG APPR.

Q.A.

COMMENTS:

TITLE:

DESIGN 7, CASK, FUEL MOVEMENT

SIZE DWG. NO.

**A** **CASK 7**

REV

**2**

SCALE: 1:10 WEIGHT: 577LBS SHEET 1 OF 8

5

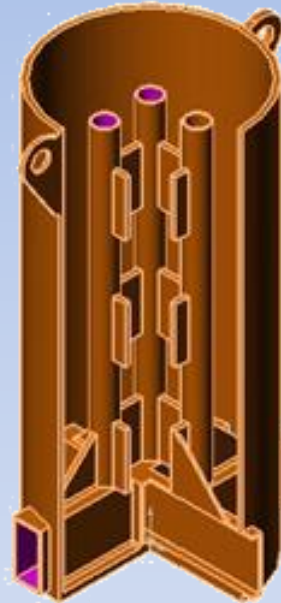
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# Isometric Cut View



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DIMENSIONS ARE IN INCHES  
 TOLERANCES  
 FINISHES  
 SURFACES

REFERENCE TO OTHER DRAWINGS

MATERIALS

CARBON STEEL

OIL BASED EPOXY

DO NOT SCALE DRAWING

NAME DATE

DRAWN G. KLINE 8/4/2015

CHECKED J. ARTMAN 8/11/2015

ENGR APPR.

AWG APPR.

QA

COMMENTS:

TITLE:  
 DESIGN 7, CASK FUEL MOVEMENT  
 ISO-SECTION

SIZE DWG. NO.

**A CASK 7**

REV

**2**

SCALE: 1:10 WEIGHT: 577LBS SHEET 2 OF 8

5

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# FABRICATION

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





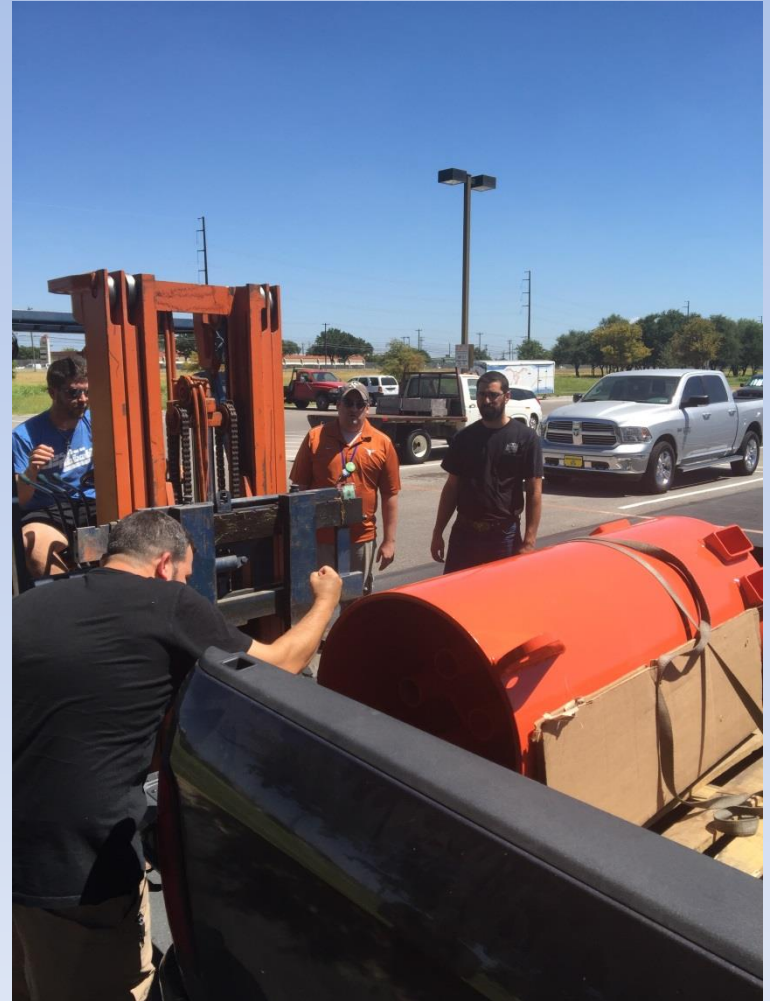
# Internal Structure



# Shell



# Completion and Delivery

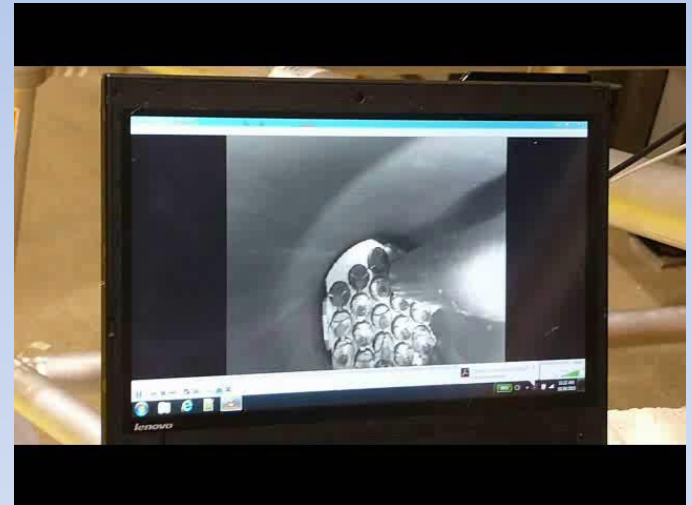


# Receipt



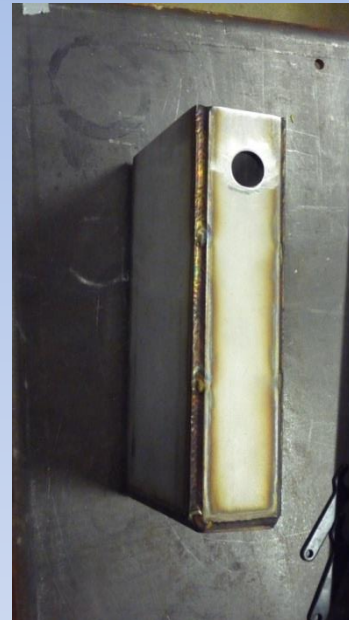
# HOLD POINT: CAPABILITY TEST

- 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



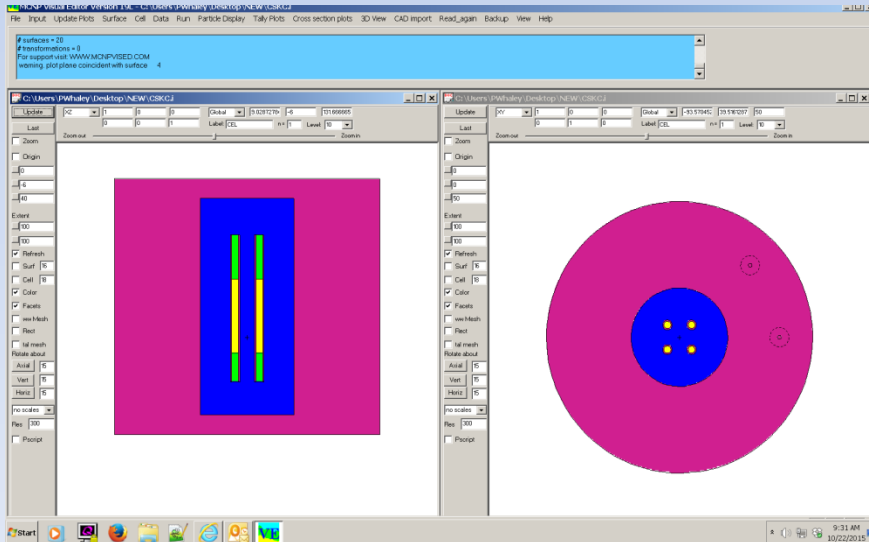
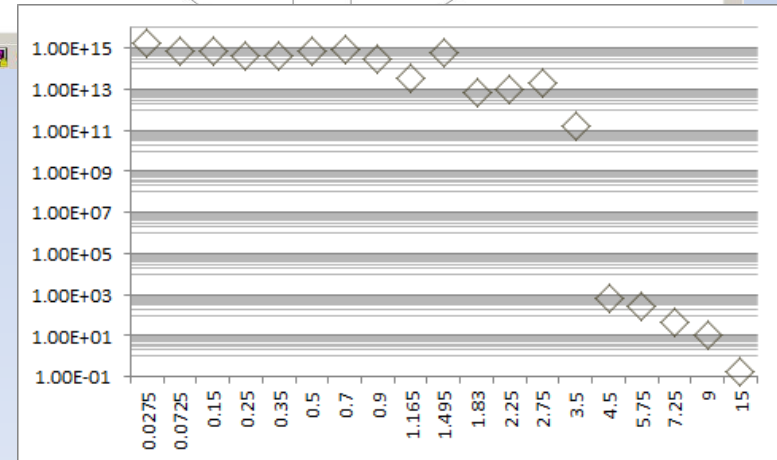
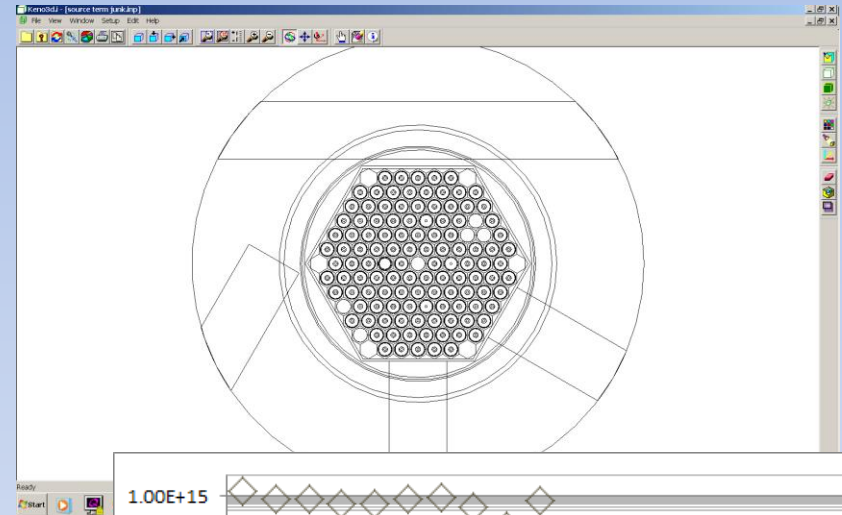


# SHIELDING MATERIAL

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

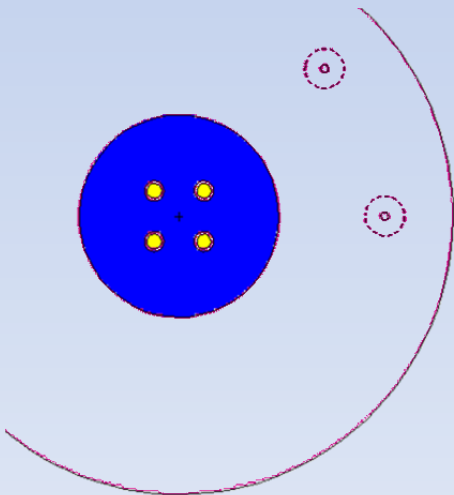
# Calculations

- 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

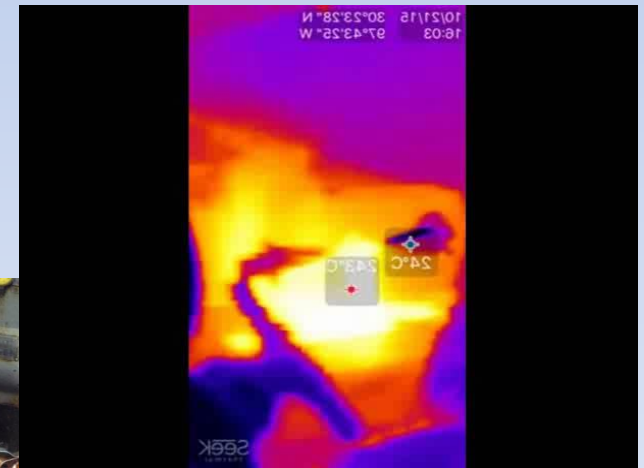
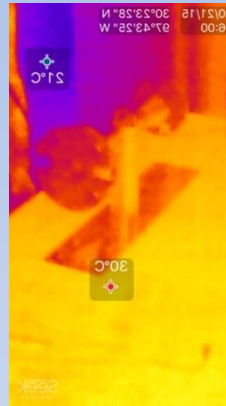
# Shielding Configurations

- 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

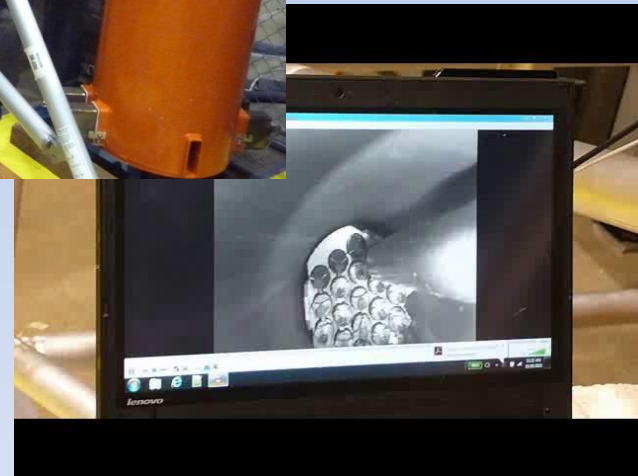
- Drawer & top plug shells
  - Not closed volumes
  - Difficult to stabilize
  - Melted in place
- Lead
  - Melt temp 327 °C
  - Boiling point 1750 °C
  - Temp < 500 °C
- Heat deformation



# 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 <sup>1</sup>
SIDE 2	56	25 <sup>2</sup>
BOTTOM	0.07	19

NOTE 1: Average at 0°, 90°, 180°, 270°

NOTE 2: Average at 45°, 135°, 225°, 315°



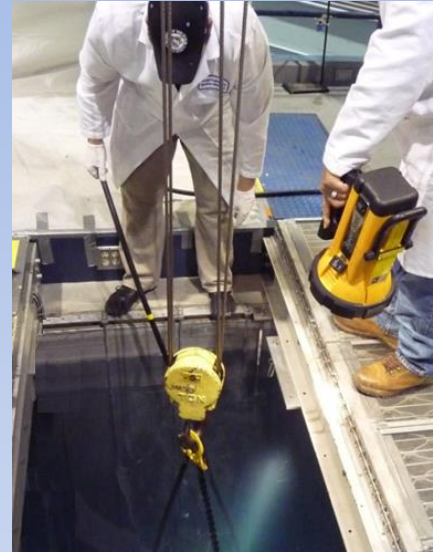
# Department of Defense 6<sup>th</sup> Civil Support Team

- Exterior Cumulative Dose during Refueling  
*background*

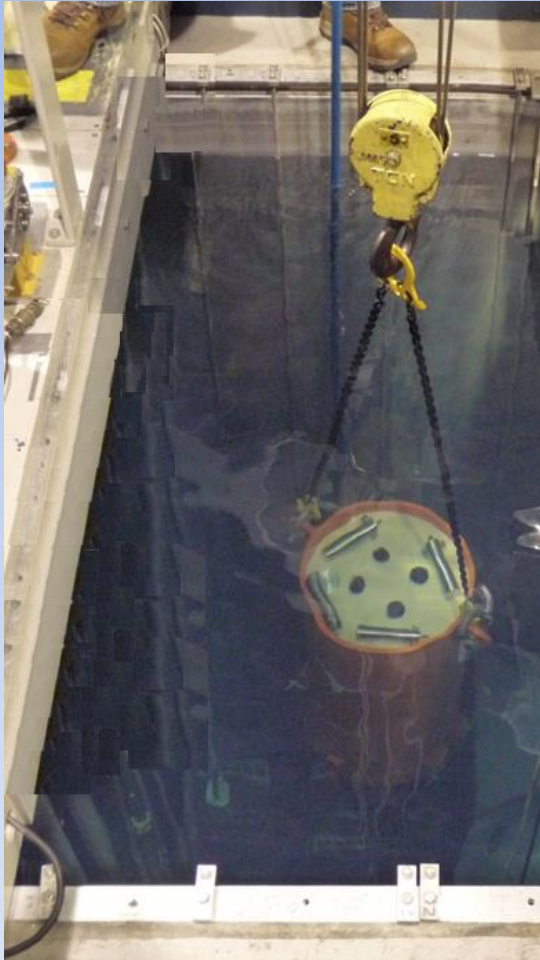
# Movement to Poolside



# Into the Pool



# In the Pool



# Conclusions & Lessons Learned

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