SAND2008-1011P

MOX Fresh Fuel Package Testing

KOPEC/KNFC Meeting

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February 18, 2008

Sandia National Laboratories

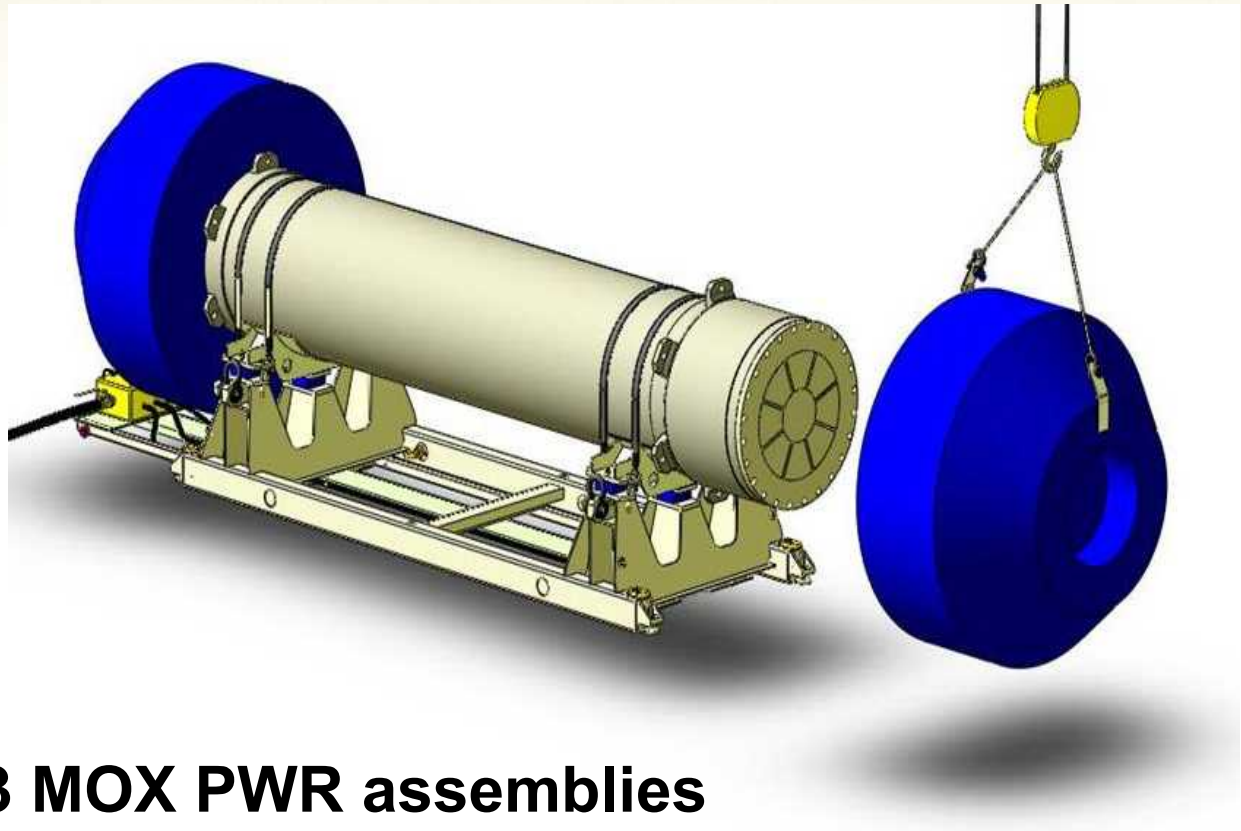
Albuquerque, NM

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Introduction

- The United States plans to destroy surplus weapons grade plutonium by burning it in commercial power reactors.
- The plutonium will be made into MOX fuel assemblies at the MOX Fuel Fabrication Facility (MFFF), a DOE facility.
- Transport from the MFFF to the commercial reactors will be in a Type B package carried in a SafeGuards Trailer (SGT).
- Sandia performed the certification tests on this Type B package in the fall of 2003.

The MOX Fresh Fuel Package



- **Holds 3 MOX PWR assemblies**
- **Loaded weight, including skid is about 16,000 pounds (mass ≈ 7300 kg)**

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Certification Tests

- **Test Series Number 1 (dummy mass inside package)**
  - **9-meter impact in a side-on orientation with package chilled to -29°C**
  - **Puncture test on edge of closure impact limiter with package axis 15° from vertical**
  - **Puncture test on center of closure impact limiter with package axis 25° from vertical**
- **Test Series Number 2 (real strong-back with one prototypical FA)**
  - **9-meter drop in a C.G.-over-corner orientation with the lid down and the package chilled to -29°C**
  - **Puncture test in the same orientation impacting the damaged area**
- **Test Series Number 3 (real strong-back with 3 dummy FA)**
  - **9-meter slapdown drop with closure lid primary**
  - **9-meter slapdown drop with closure lid secondary**
  - **Puncture at package center with package horizontal**
  - **Puncture near package center with package 30° from horizontal**

Conduct of Tests

- **Real-time view of tests**

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Conduct of Tests

- **High-Speed video of tests**

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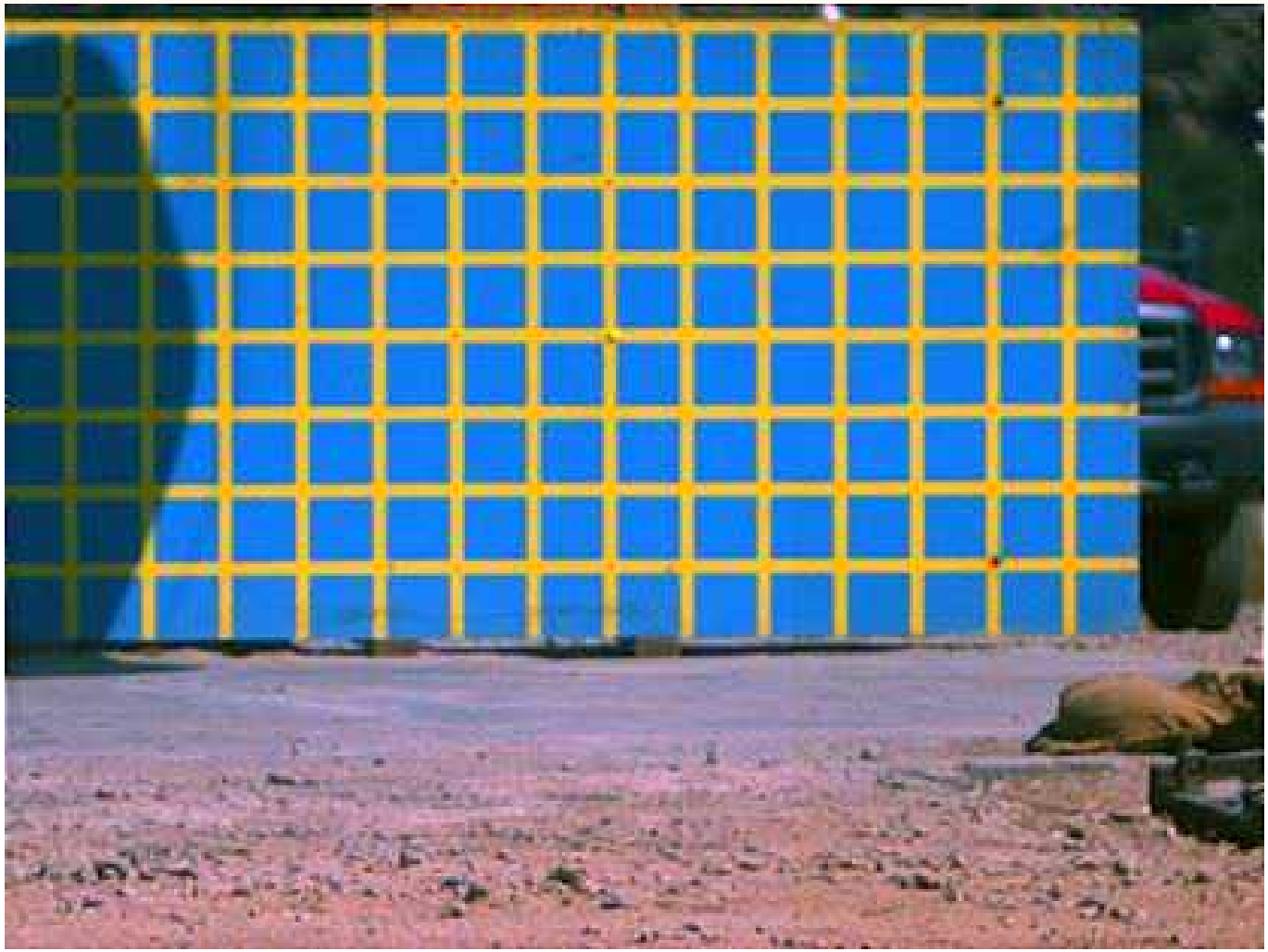
CG-Over-Corner Drop Test

- **This test puts maximum load on the lid and lid bolts.**
- **It also puts maximum bending stress in the prototypical fuel assembly.**



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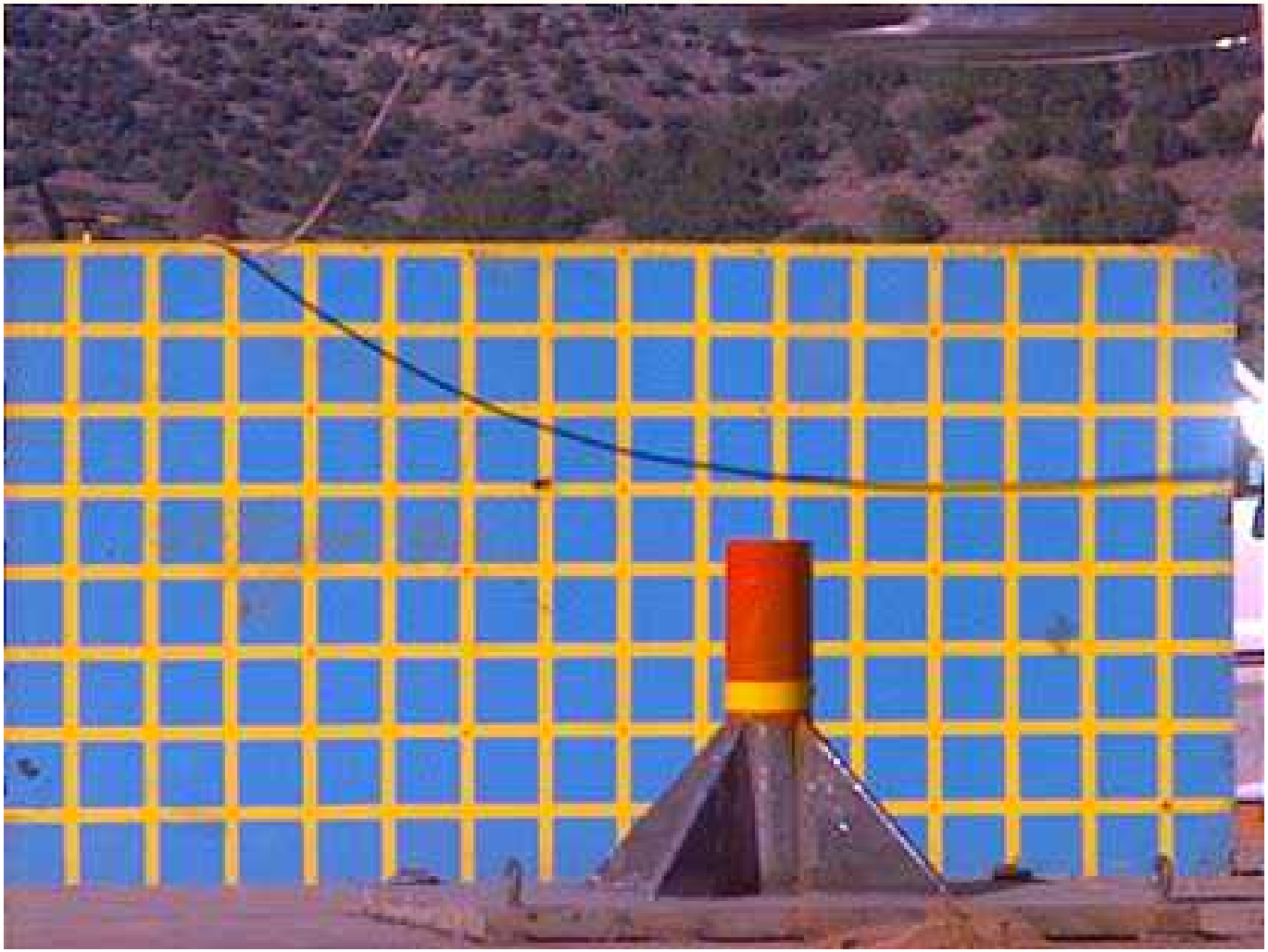
CG-Over-Corner Puncture Test

- **This test accumulated damage in the same area that was damaged from the 9-meter drop test.**



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Slapdown Drop with Closure End Down

- **This test puts maximum bending moment in the cask body and strong-back.**

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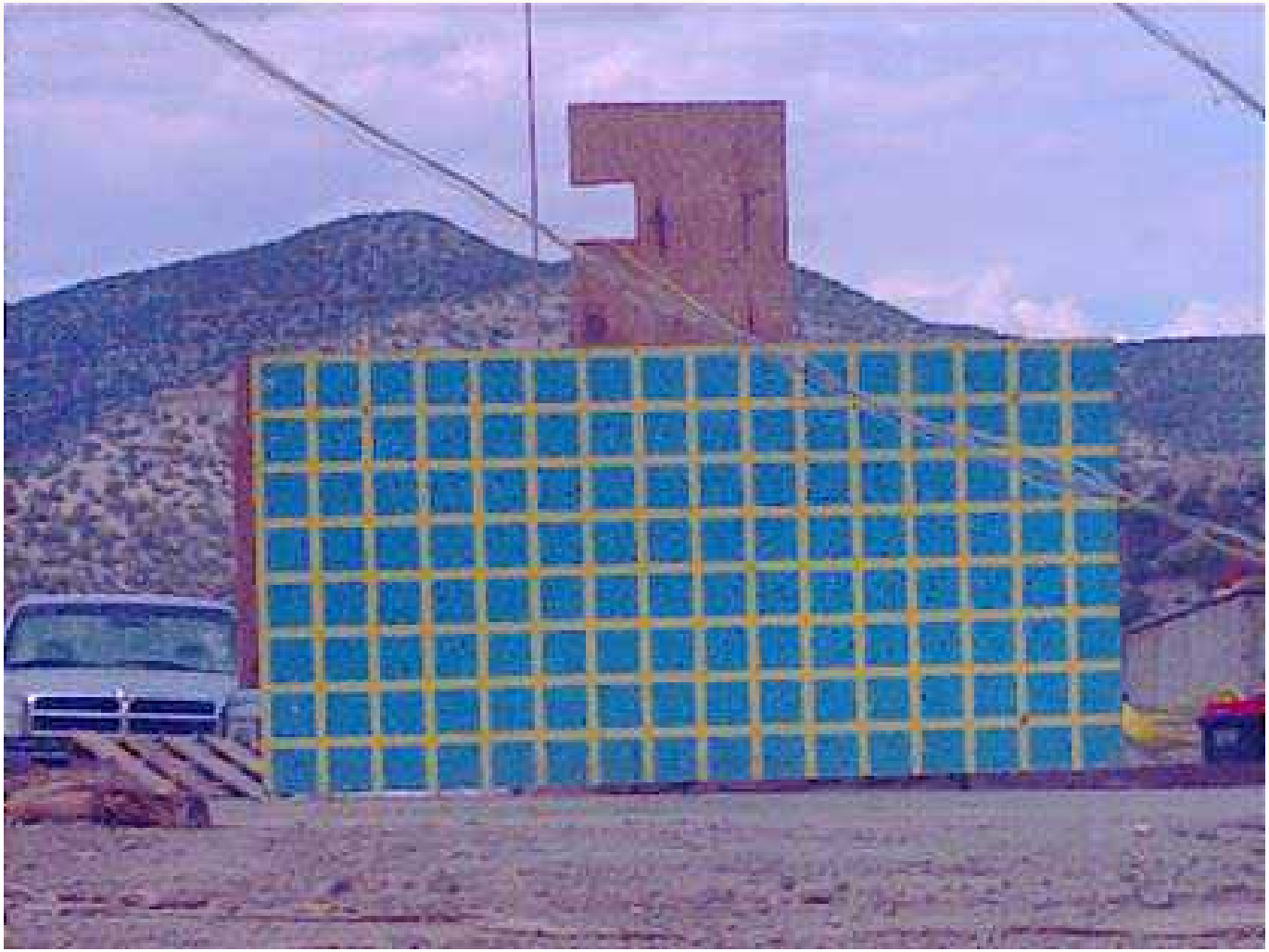
Slapdown Drop with Closure End Up

- This test puts maximum acceleration to the closure lid.
- It also puts maximum bending to the strong-back in a different azimuthal position.



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Puncture with Cask Horizontal

- **This test puts maximum puncture force on the side of the cask.**

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Puncture with Cask at 30° from Horizontal

- **This test is the most likely to tear through the cask wall.**
- **It concentrates the drop energy onto a very small area.**

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Damage to Cask from Tests

- **The next series of slides will show some of the damage that resulted from the tests.**

Tearing the Impact Limiter Weld

- **Exposing the foam of the impact limiter.**
- **This can cause problems during the fire test.**
- **They redesigned the corner joint to avoid this problem.**

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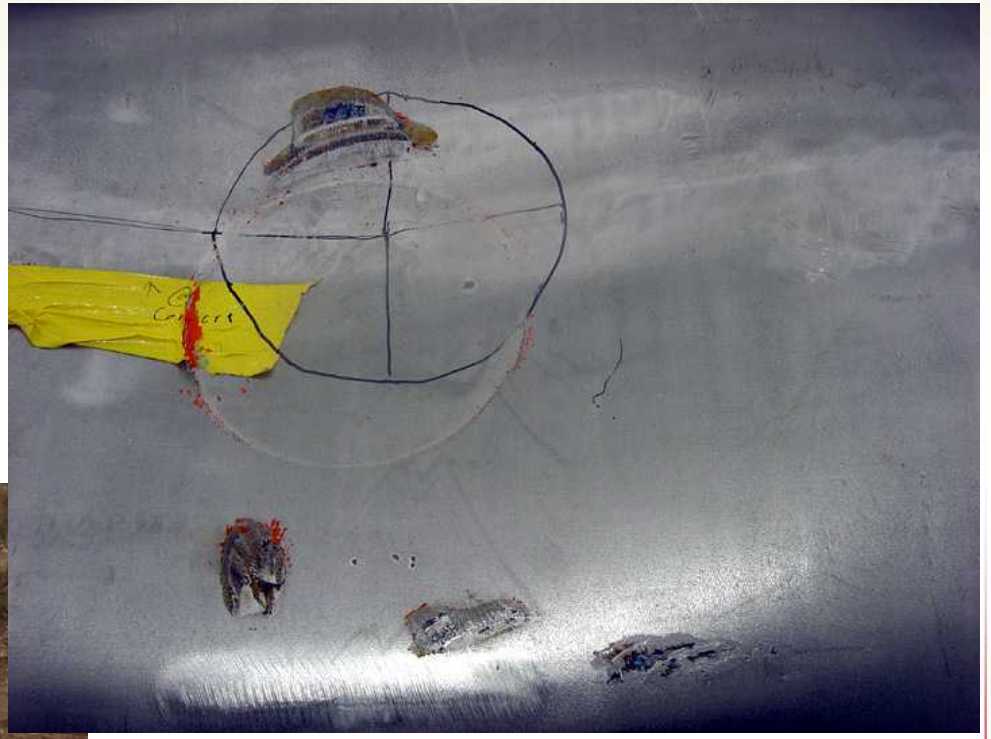
Dent from Horizontal Puncture

- **This was expected and does not cause a problem.**



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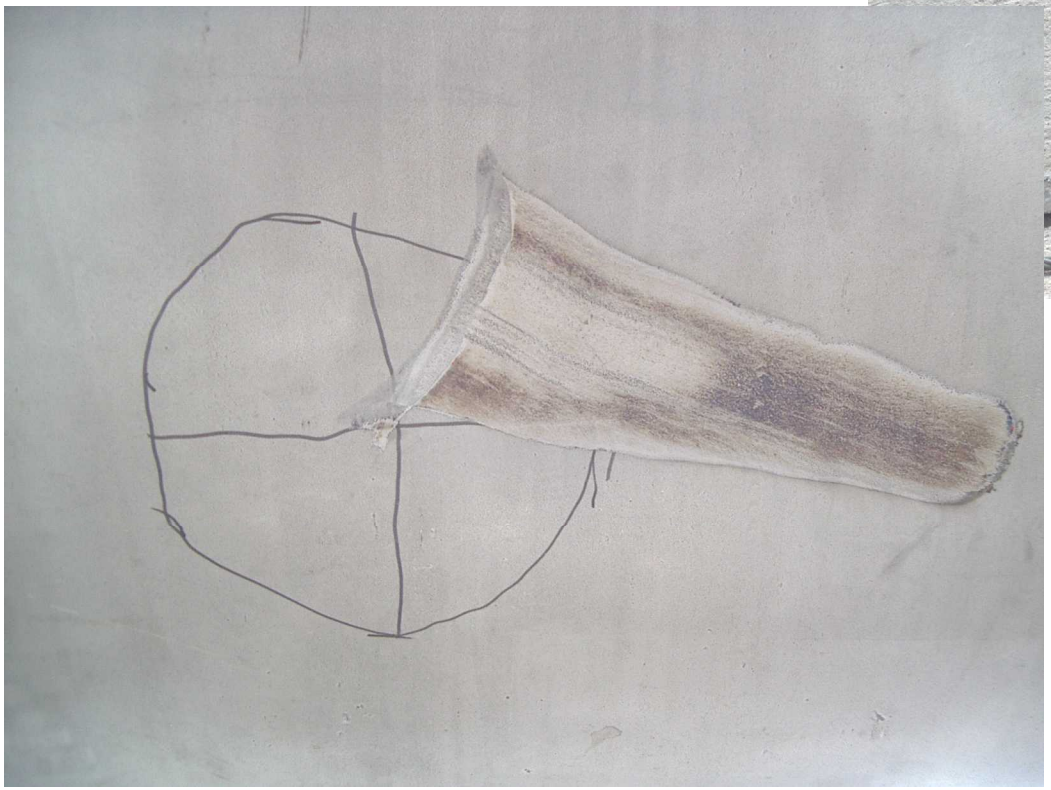
Dent from 30° Puncture

- **The sliding of the cask on the puncture probe can be clearly seen.**



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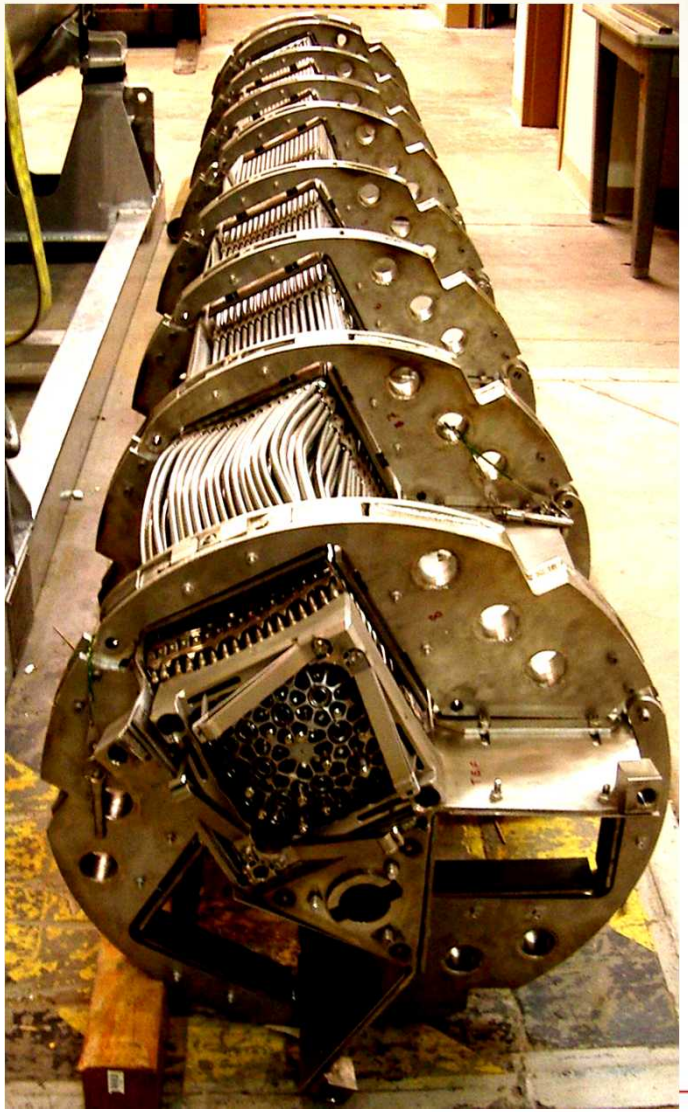
Damage to the Prototypical Fuel Assembly

- **The buckling of the fuel rods could cause an increase in nuclear reactivity.**
- **A design change was implemented to prevent this behavior.**



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Demonstration of Handling the MFFP

- **The MFFP is very different from other fresh-fuel packages.**
- **Operators at both the MOX Fuel Fabrication Facility and the mission reactors needed training in how load and unload the package and prepare it for shipment in the SGT.**

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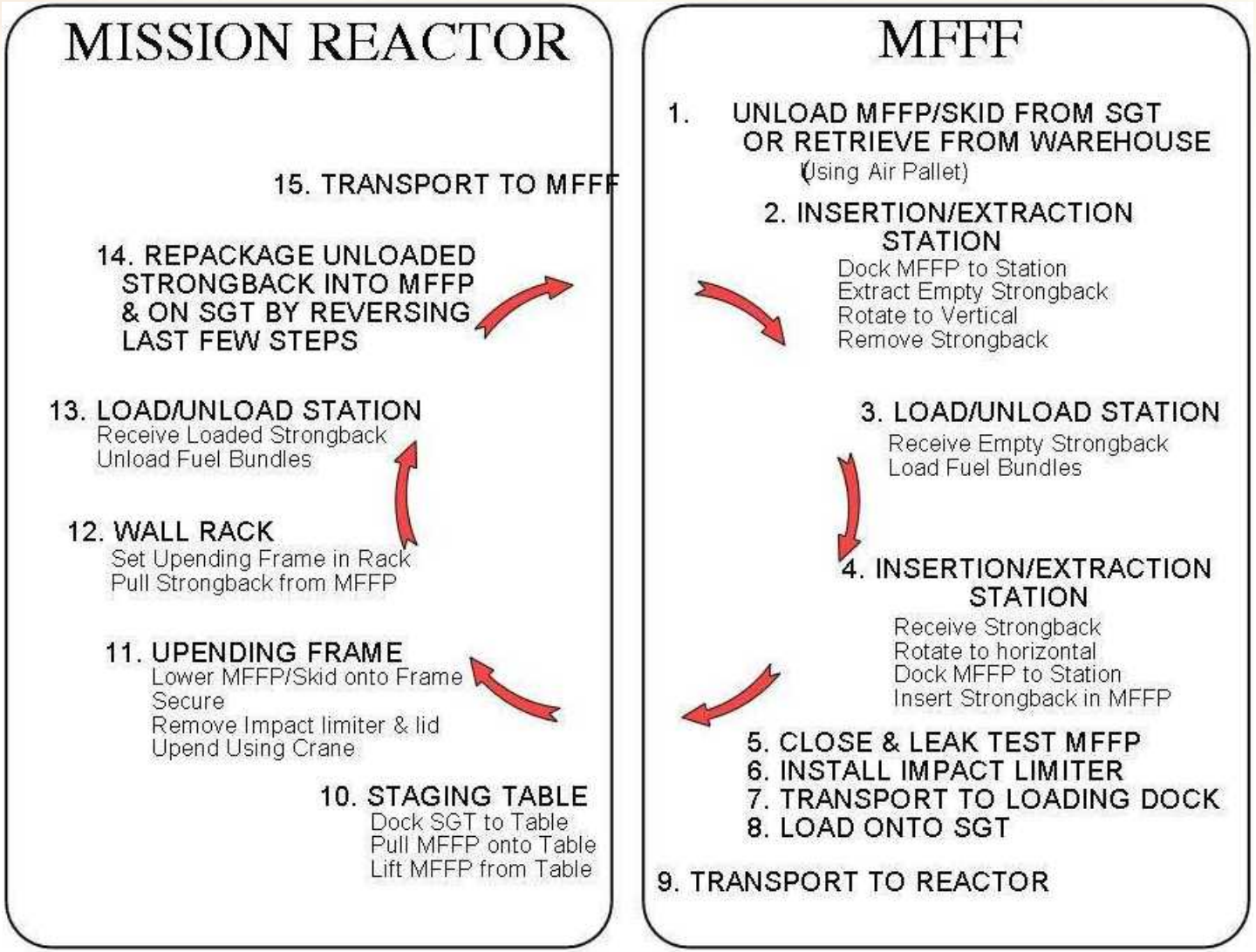

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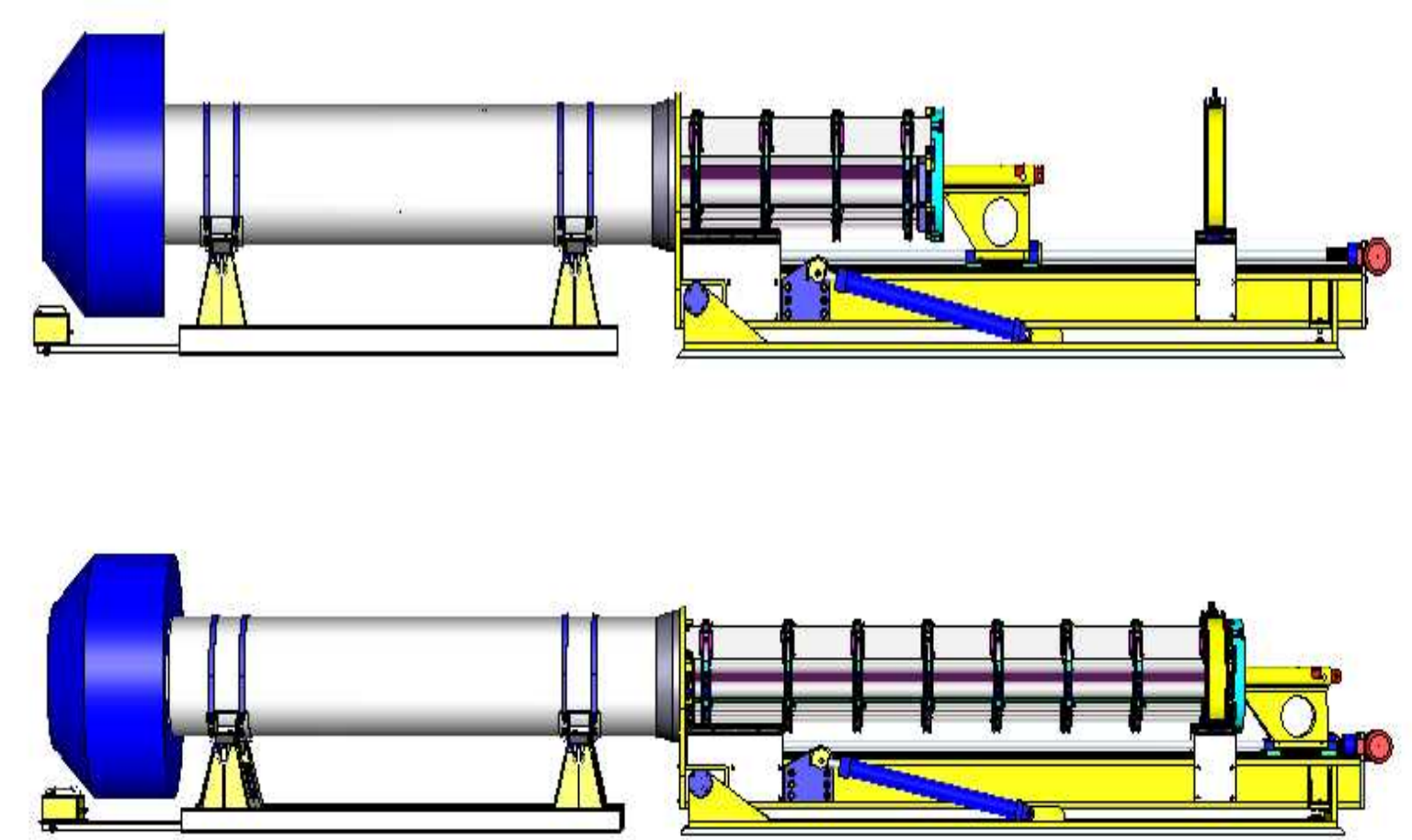
At the MOX Fuel Fabrication Facility

Extraction of Strong-back from MFFP



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Strong-back extraction

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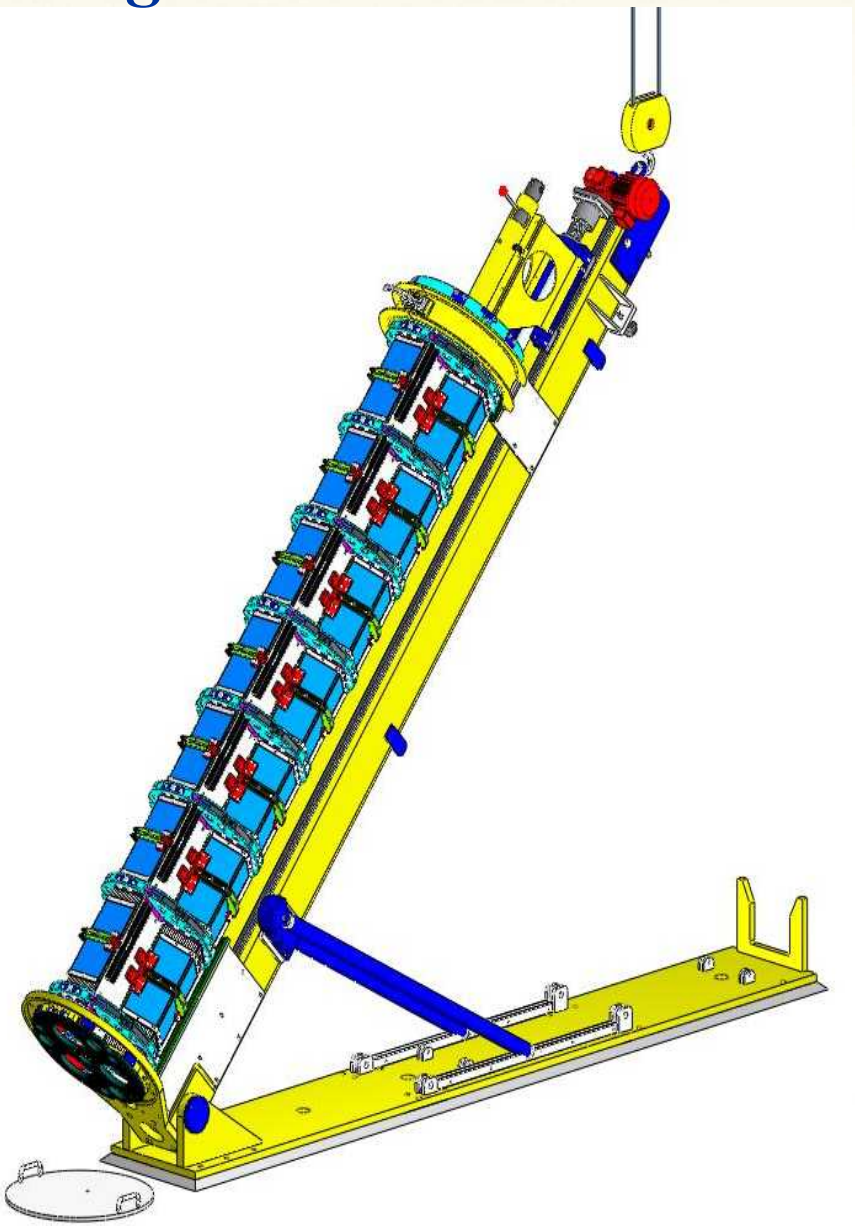
Raising Insertion/Extraction Station and Strong-back to Vertical



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Up-ending the Insertion/Extraction Station

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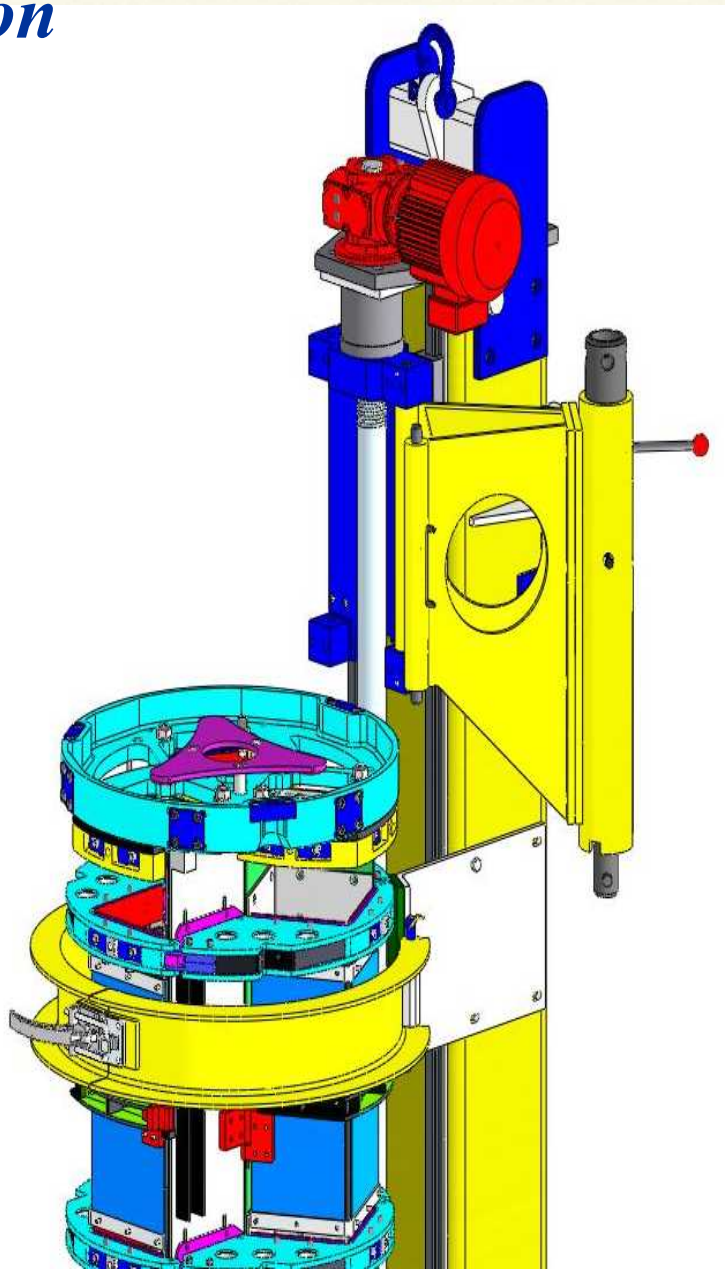
Remove Strong-Back from Insertion/Extraction Station



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Attaching the Crane to the Strong-back

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Removal of the Strong-back

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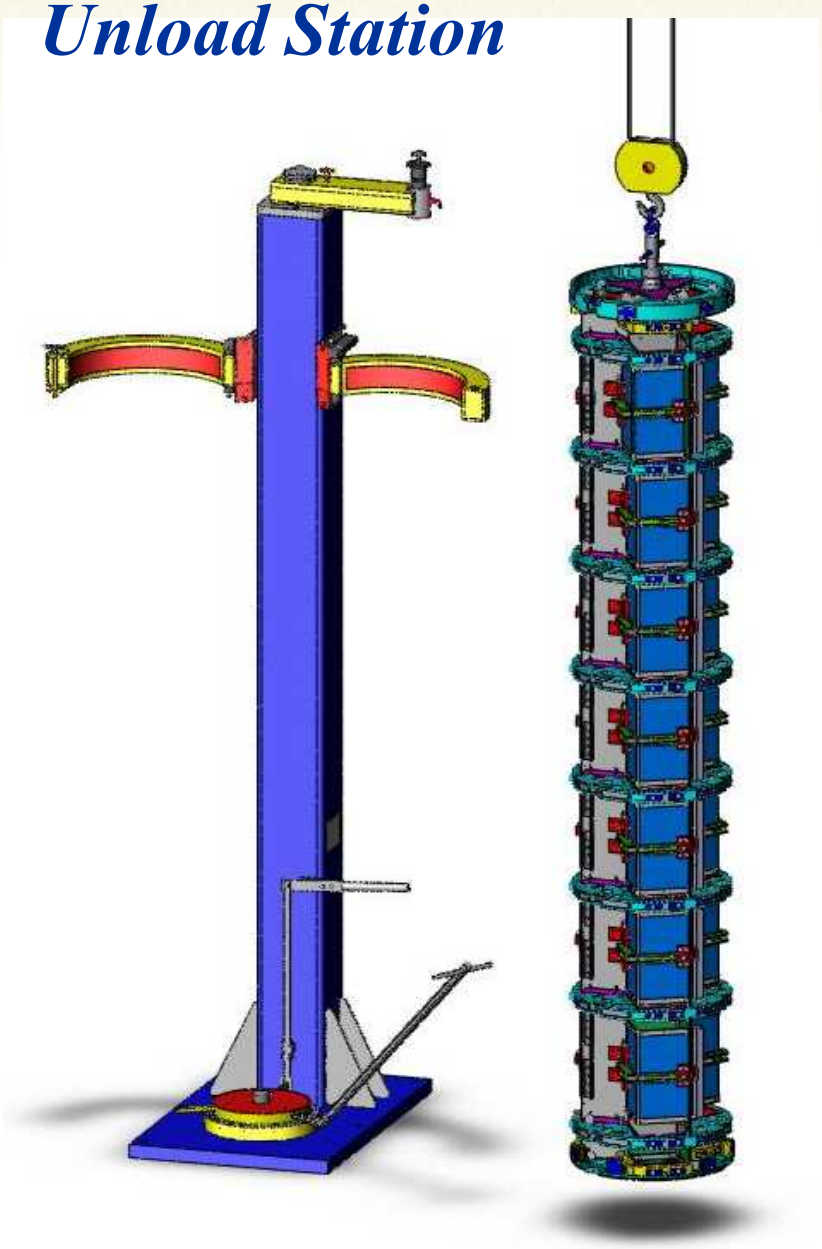
Transport the Strongback to the Load / Unload Station



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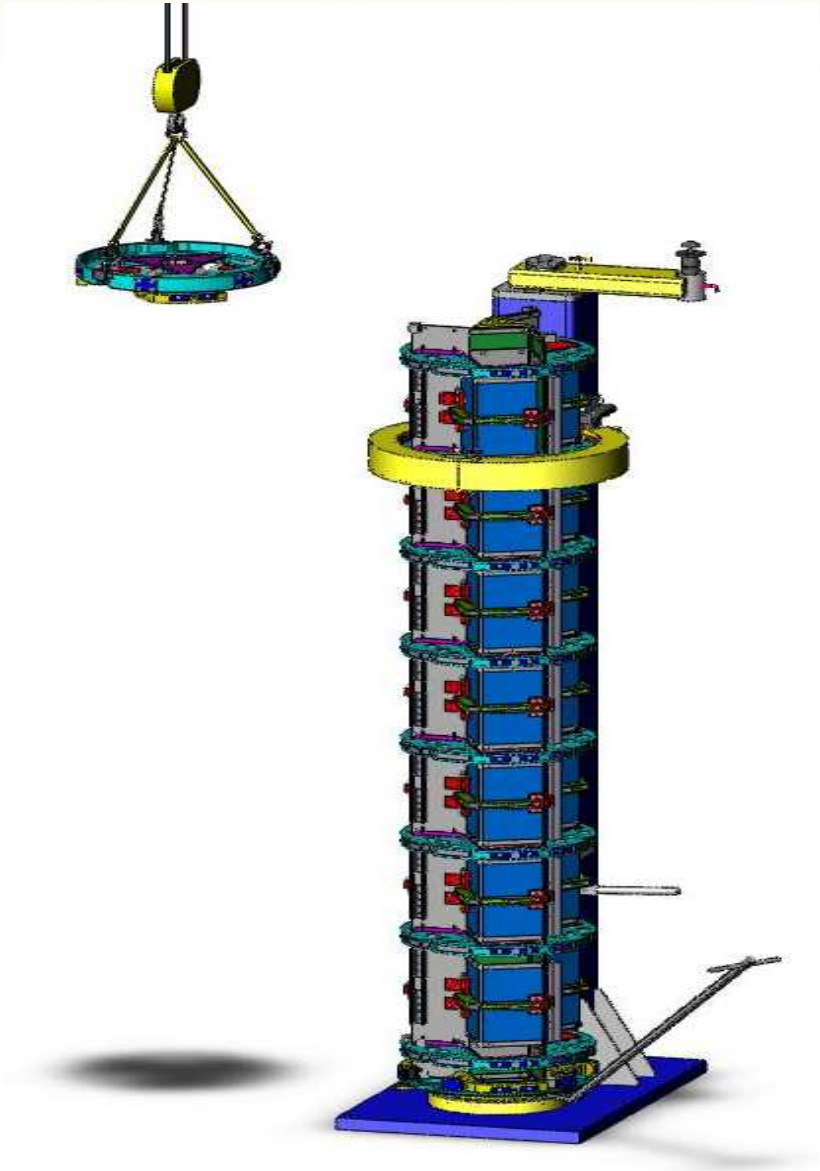
Strong-back in Load/Unload Station, Top Plate Removed



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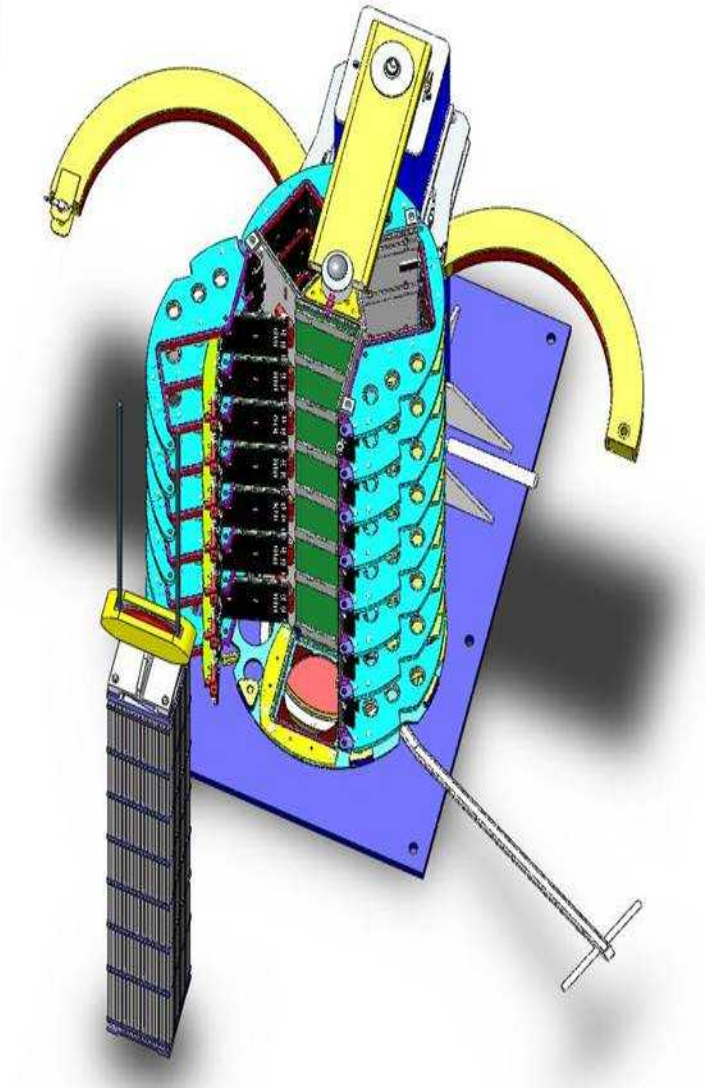
Loading of Fuel Assemblies into Strong-back



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Loading a Dummy Fuel Assembly

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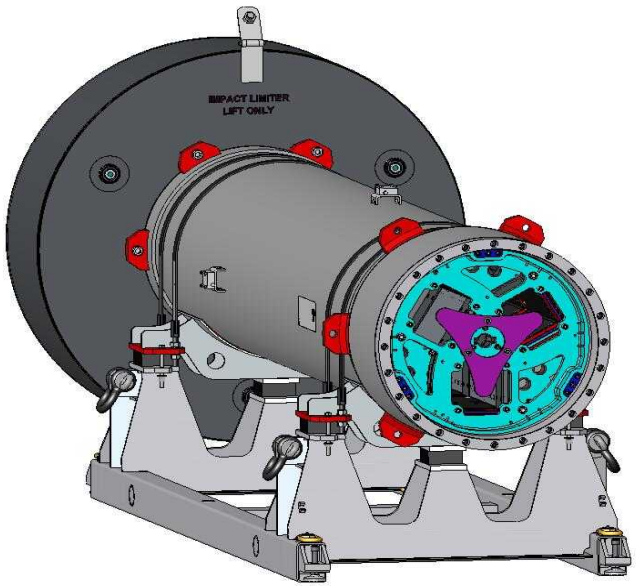
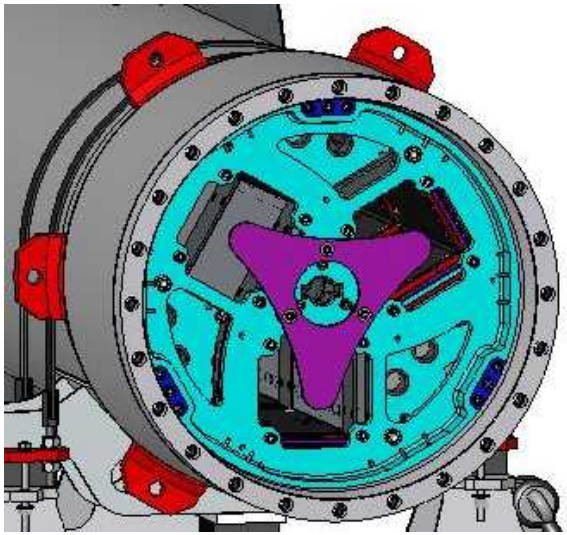
MFFP with Correctly Oriented Strong-back





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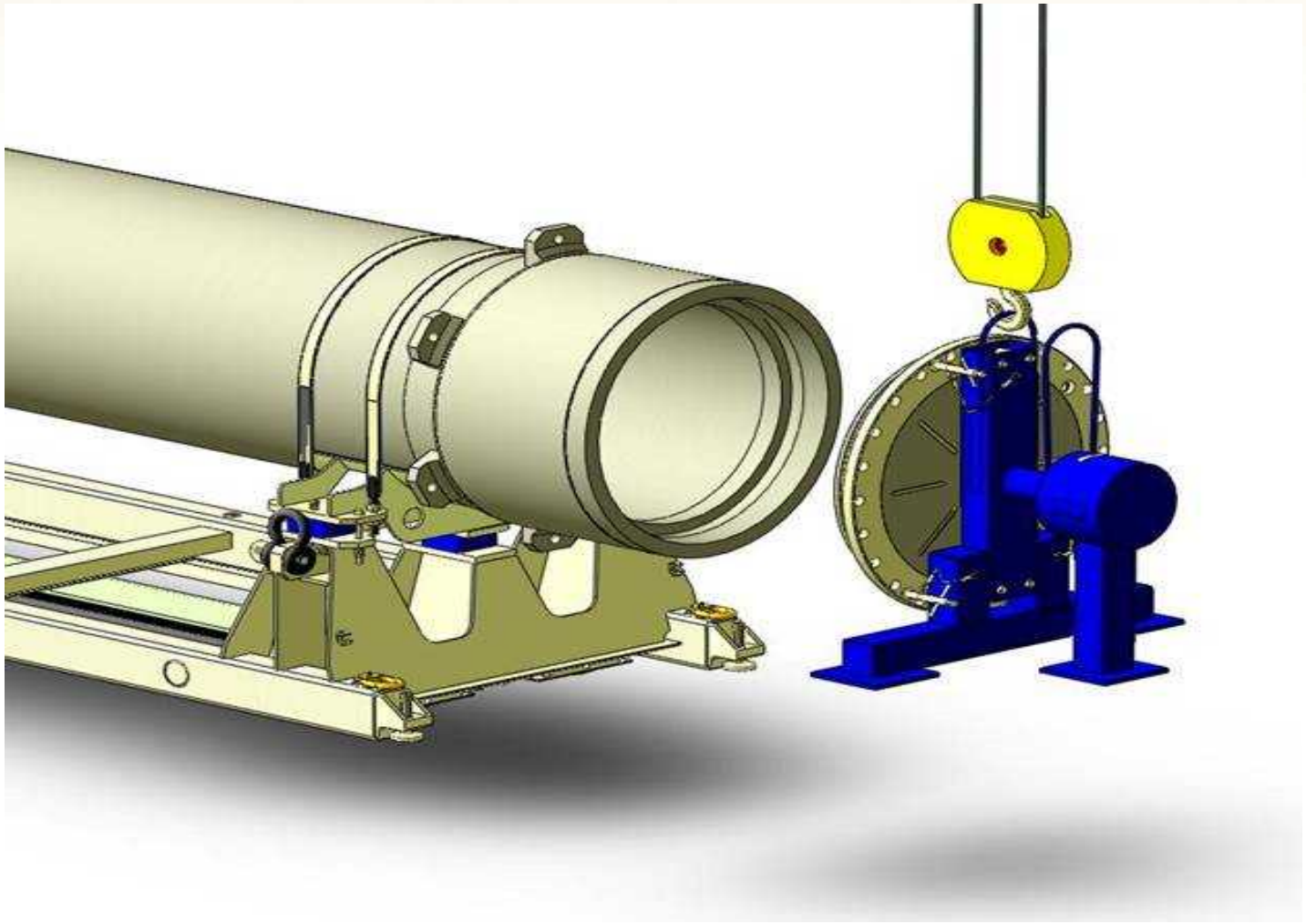
Attachment of the Closure Lid



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Last Steps at the MFFF

- **Install closure end impact limiter**
- **Load MFFP into the SGT**
- **Transport to the mission reactor**

At the Mission Reactor

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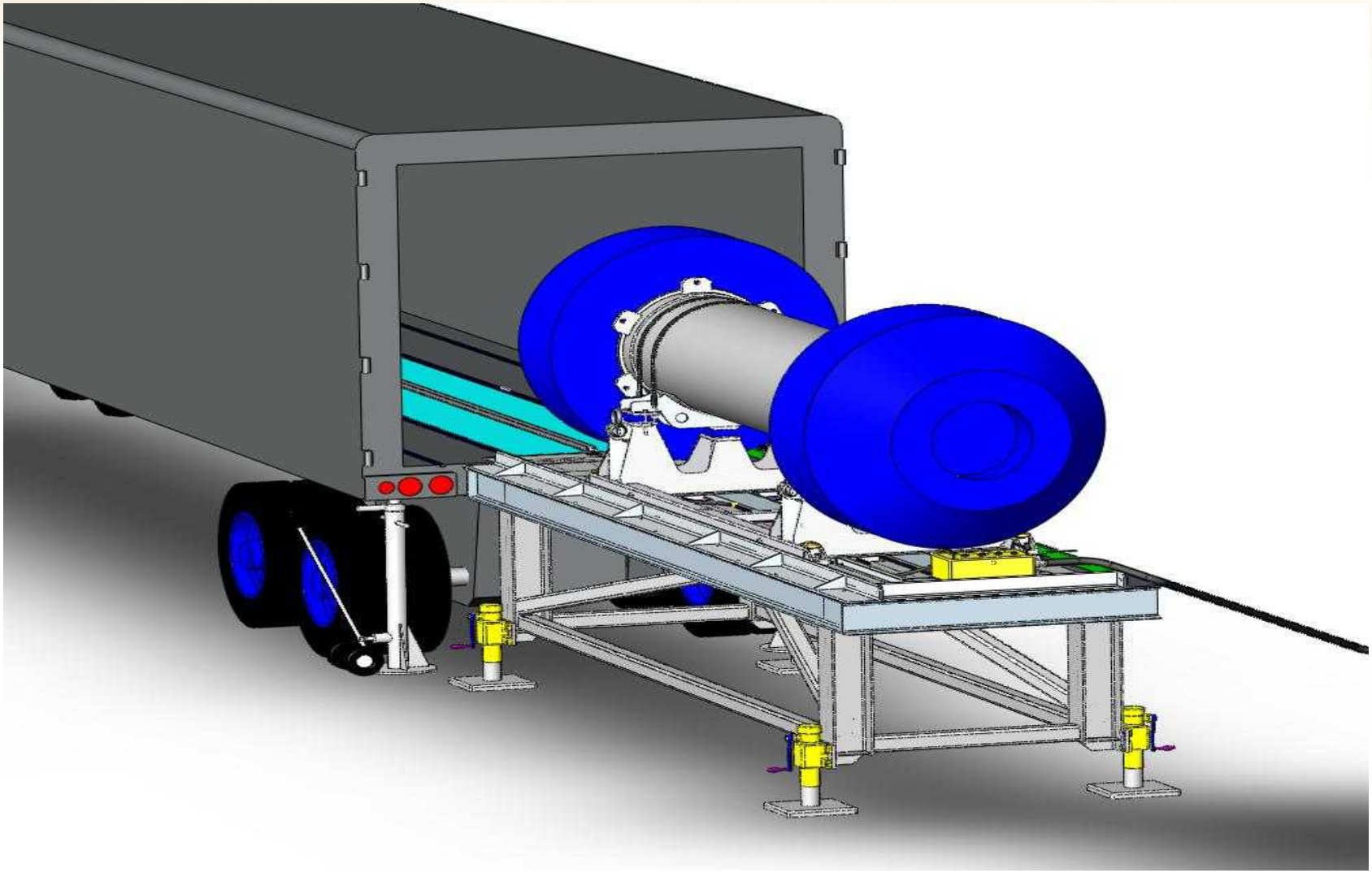
Unload MFFP/Skid from SGT using Air Pallet



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Moving the MFFP from the SGT to the Staging Table

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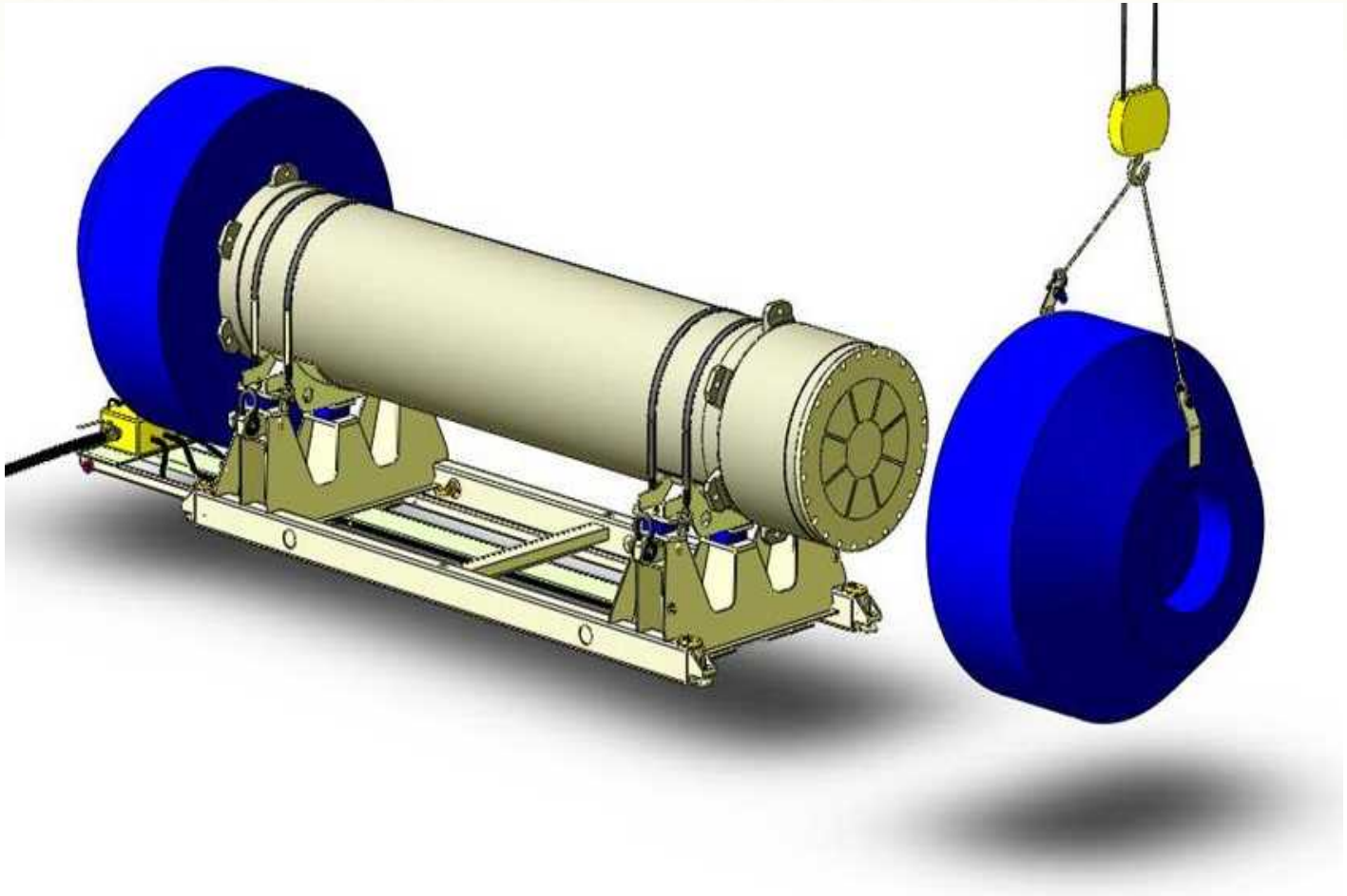
Removing the Impact Limiter



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Removing the Impact Limiter

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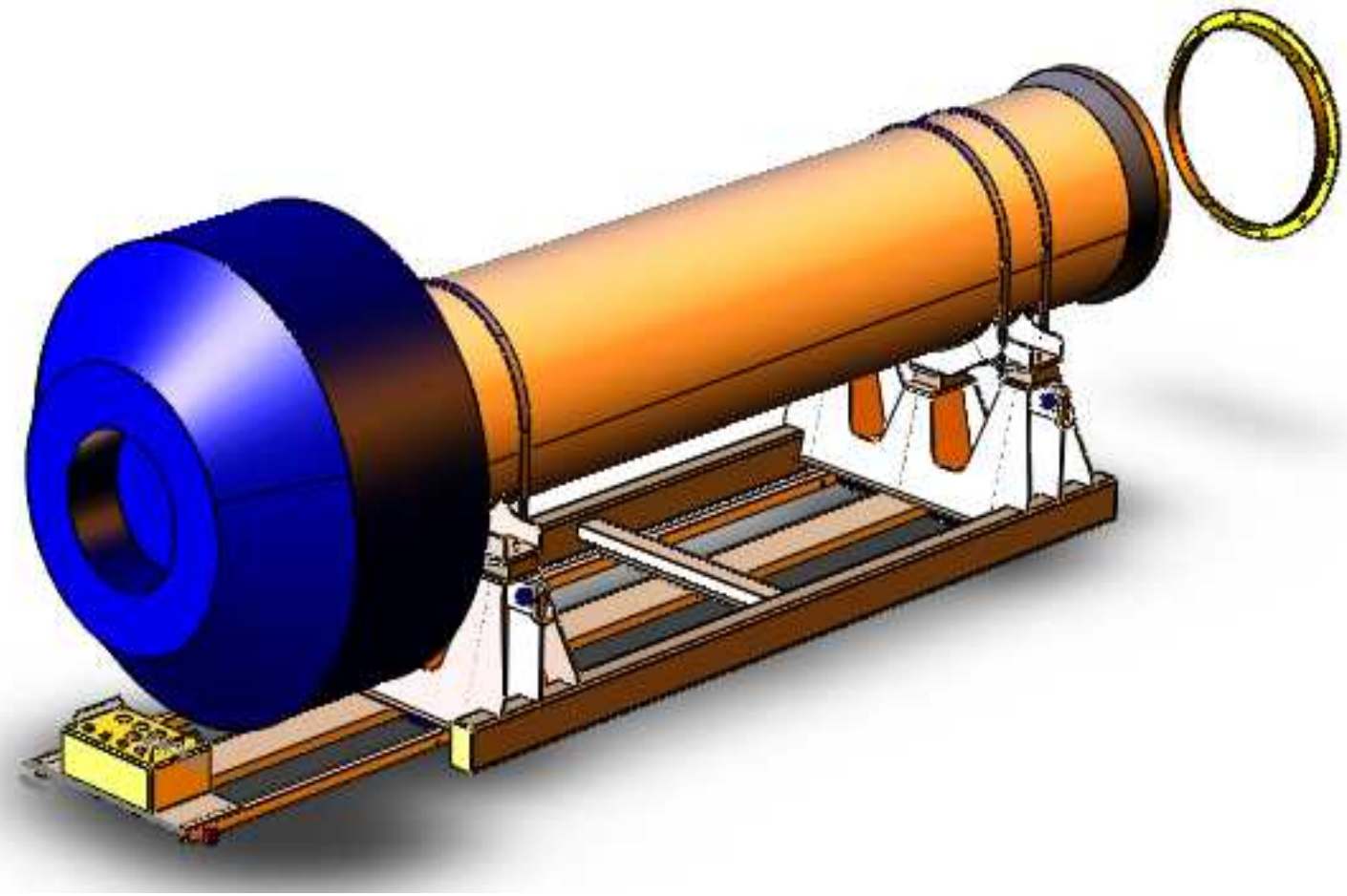
MFFP Cask with Sealing Surface Protector after Lid Removed



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Loading and Unloading at the Mission Reactor

- **At the mission reactor the removal of the strong-back from the MFFP is done with a crane in the vertical position.**
- **The MFFP is secured against tipping with a bracing frame.**
- **The fuel is unloaded from the strong-back by reversing the steps for loading it at the MFFF.**

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Lessons Learned from the Demonstration

- Showed where there is a problem with tolerances
- Needs for chamfers or rounding of corners
- Need better guides for locating strong-back
- Replace some bolts with ball-lock pins
- Up-ending frame should have a feature to eliminate snap-through (we used the large wood block for this)
- Some locks are difficult to operate in a vertical position
- Operation of the air pallet (rollers, quick disconnects)
- Should have passive feature for up-ending and down-ending the insertion/extraction station