INL/CON-24-80065-Revision-0

HEU Removal from MNSR Reactors

August 2024

Igor Bolshinsky, Wendell D Hintze

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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National Nuclear Security Administration

MATERIAL MANAGEMENT AND MINIMIZATION
CONVERT, REMOVE, DISPOSE

Office of Nuclear Material Removal and Elimination

HEU Removal from MNSR Reactors

Technical Meeting
on HEU/LEU Conversion, Operation and Utilization of
MNSR and SLOWPOKE Research Reactors

28-30 August 2024, IAEA Vienna, Austria

Igor Bolshinsky, INL

Wendell Hintze, INL

M3's Office of Nuclear Material Removal and Elimination: Less is More

MNSR reactor spent HEU core removal

- The Chinese-built Miniature Neutron Source Reactor (MNSR) is low-power (~30KW) neutron source used primarily for neutron activation analysis, education, and training.
- Four MNSR reactors were built in China and five outside of China (Ghana, Nigeria, Syria, Pakistan, and Iran).
- There reactors have cores consisting of about 1.1 kg of HEU.
- In 2006, IAEA established a Collaboration Research Project to coordinate activities in the conversion of the MNSR reactors to LEU fuel.
- Upon the successful conversion of MNSR, the irradiated HEU cores should be returned to China for permanent disposition and new LEU cores delivered from China to reactor operators.

ŠKODA cask fleet

- In 2004, the IAEA and Czech government **jointly procured 16 VPVR/M type**, high-capacity and dual-purpose transport containers:
  - Designed and manufactured by the ŠKODA JS a.s., Czech Republic
  - By transferring the ownership of the containers to the UJV Řež, Czech Republic
- **This container fleet, which has B(U) and "S" type licenses (for 50 years storage)**, became a standard transport container type for Russian-origin fuel returns

VPVR/M cask placing into an ISO 20^{ft} container

ŠKODA VPVR-M cask

Material and Dimensions

- Cask body: cast iron
- Internal basket: boronated steel
- Outer dimensions: ∅1200mm x 1505 mm
- Weight: 12390 kg (loaded weight)

Radioactive content

- Total activity: max. 3.93 10^{15} Bq
- Residual heat power/FA: max. 37.7 W
- Total residual heat power: 450 W

License

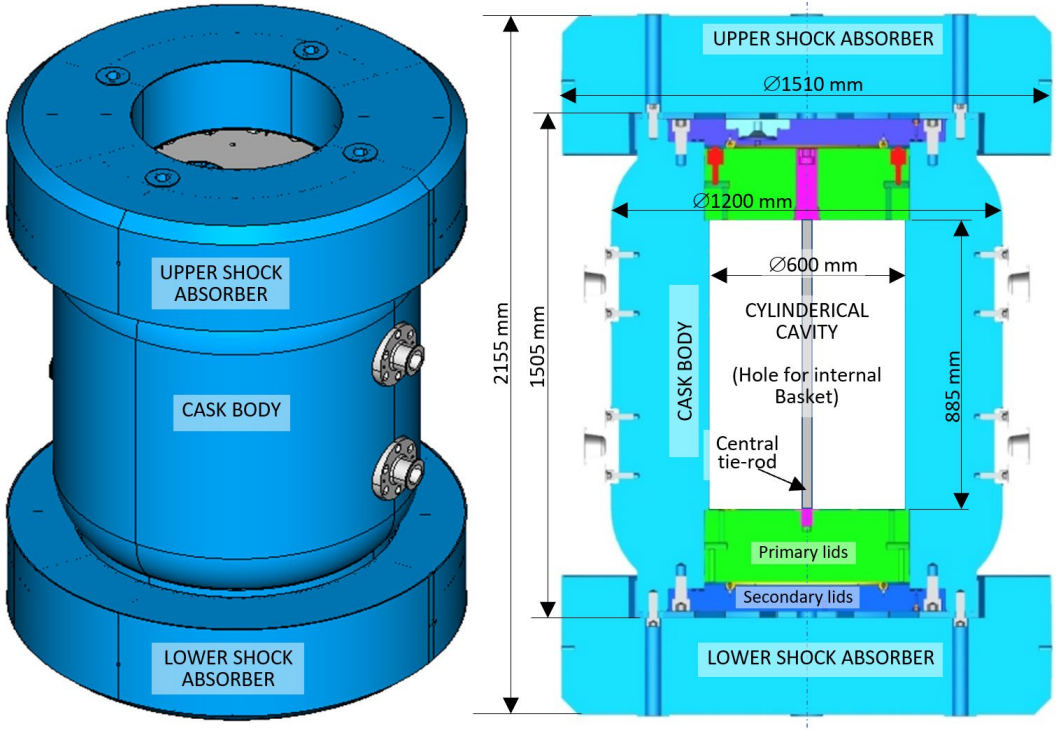
- B(U) type for transport and “S”-type for storage
- Licensed FAs: EK-10, S-36, VVR-M, VVR-M2, VVR-M5, VVR-M7, VVR-(S)M, IRT-2M,IRT-3M, IRT-4M, TVR-S
- Number of FAs in the cask: max. 36
- Weight of ^{235}U/FA: max. 500 g

Packaging operation

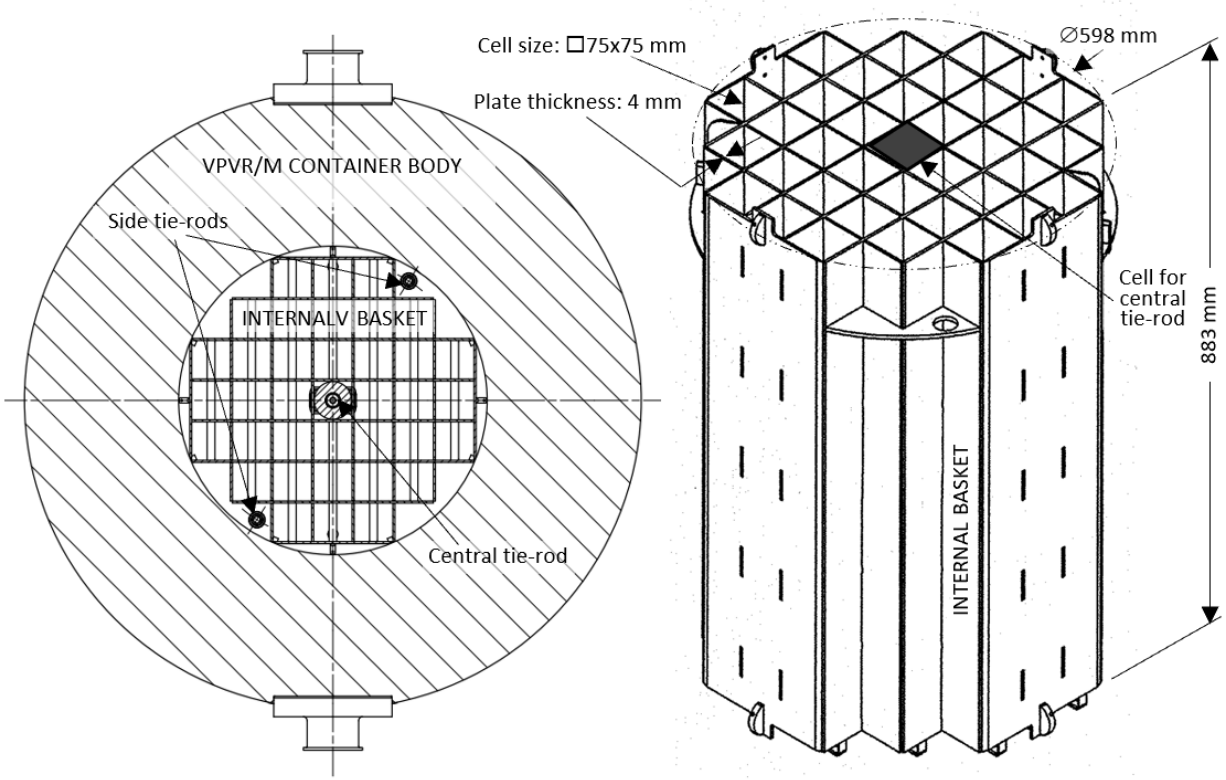
- Cask can be loaded from the bottom or top

ŠKODA VPVR/M Cask with shock absorbers

ŠKODA VPVR-M cask overview – cask body



ŠKODA VPVR-M cask overview – Internal Basket

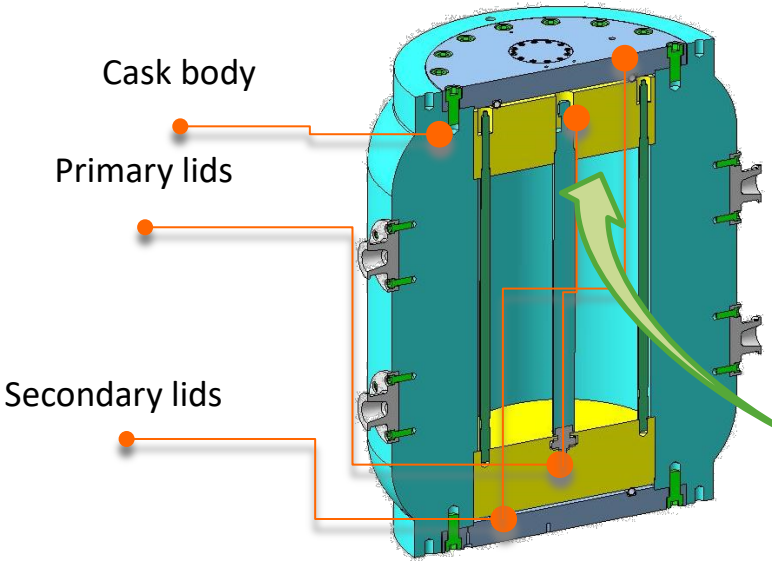


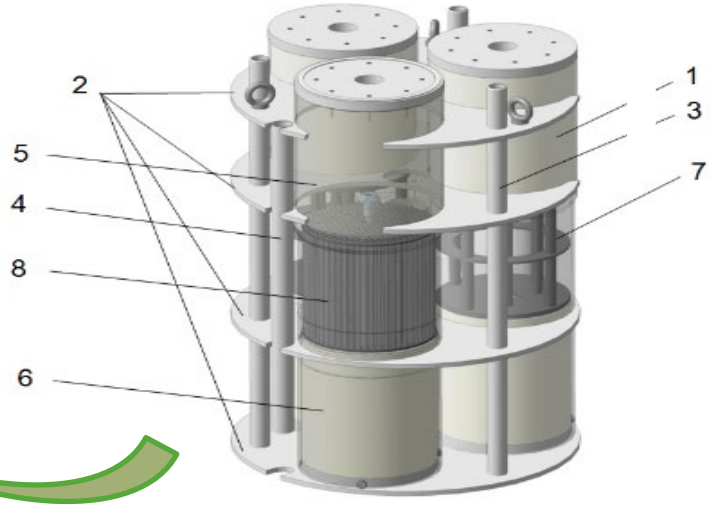
Transportation of ŠKODA Cask

ŠKODA VPVR-M inside ISO container

Transportation ISO container

ŠKODA - MNSR Transportation Cask

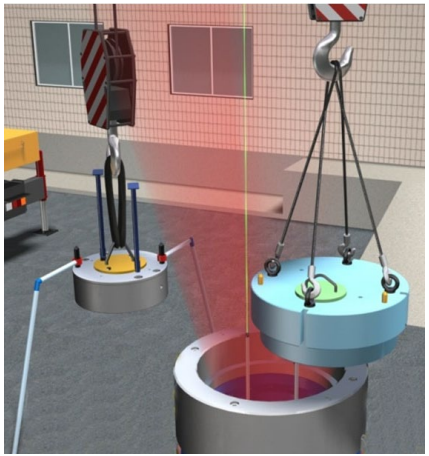


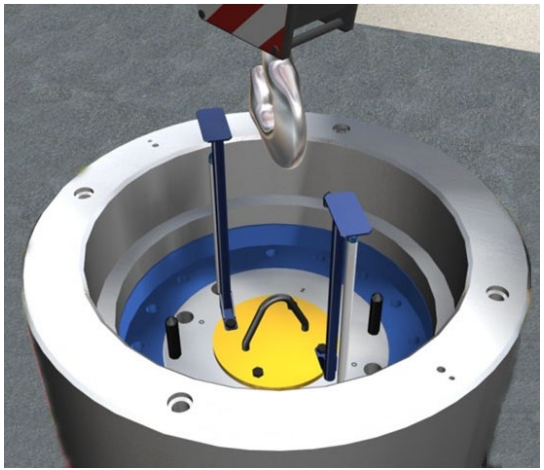


MNSR basket

1 – Tube	2 – Plates
3 – Post	4 – Guide tube
5 – Upper shock absorber	6 – Lower shock absorber
7 – Housing for fuel pins	8 – MNSR core

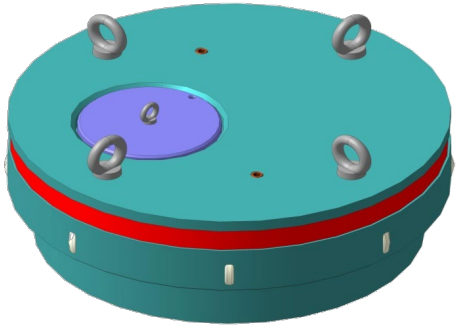
ŠKODA cask preparation for core loading





- ✓ **Remove the upper primary lid of the inner cask with the crane.**
- ✓ **Install the interface ring and adapter**
- ✓ **Remove the upper damper (plug) over the basket cell.**
- ✓ **Bring the transfer cask with MNSR core and install it on the adapter.**

Interface Ring and Adaptor



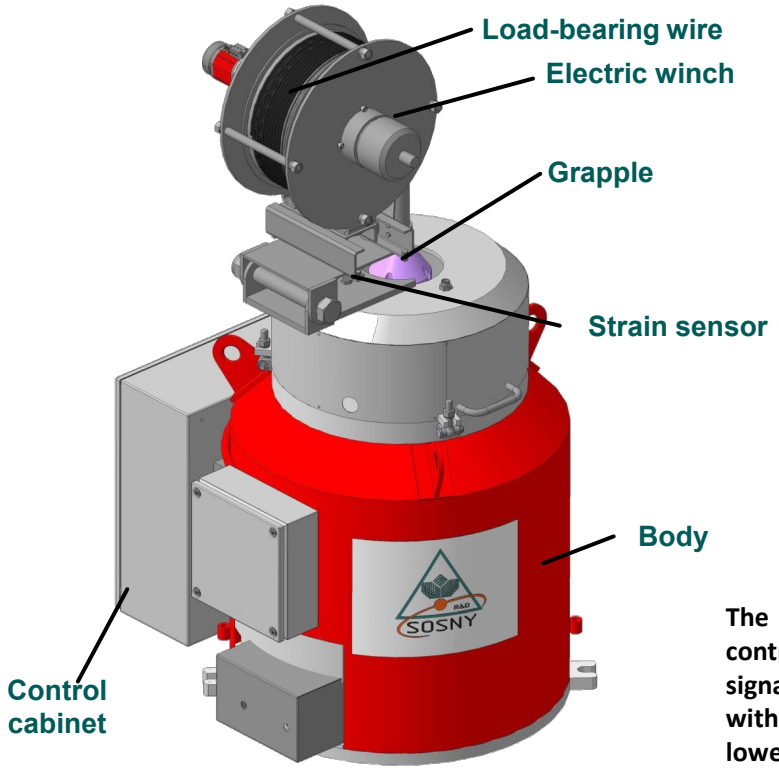
Adaptor is intended:

• to align the transfer cask against the basket cell of the SKODA MNSR cask when unloading the core from the transfer cask;
• to protect the personnel from ionizing radiation during core reloading from the transfer cask into the SKODA MNSR cask basket.

Specifications:

Material - steel 20.

Overall dimensions, mm:
- diameter ……. 950;
- height ……. 350;
- Mass, kg …… 1450;



Specifications:

Winch hoisting capacity, kg	120
Overall dimensions, mm:	
- diameter.....	775
- height.....	1750
- wall thickness	250
Mass, kg	2950
Grapple velocity (high/low), m/s	0.01/0.04
Power	220V, 50 Hz
Input power, max., kW	1
Max. grapple stroke, m.....	6

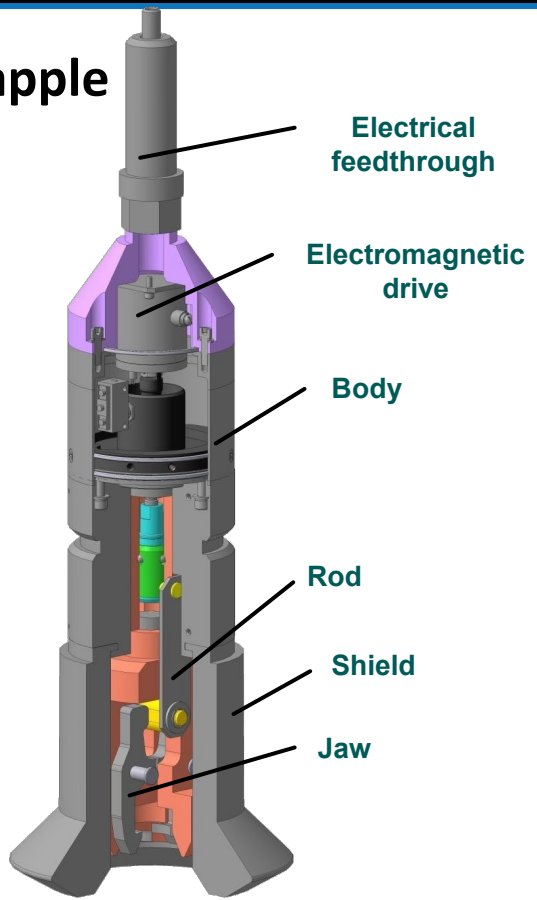
Body material - Steel 20.

Inner lining material of body and slide valve - corrosion-resistant steel.

The grapple is moved by the electric winch with redundant manual control and the load-bearing wire that will transmit a control electric signal to the grapple electromagnetic drive. Winch motor is equipped with electromagnetic brakes to prevent the spontaneous grapple lowering.

Interim Transfer Cask (ITC) (general view)

ITC Grapple

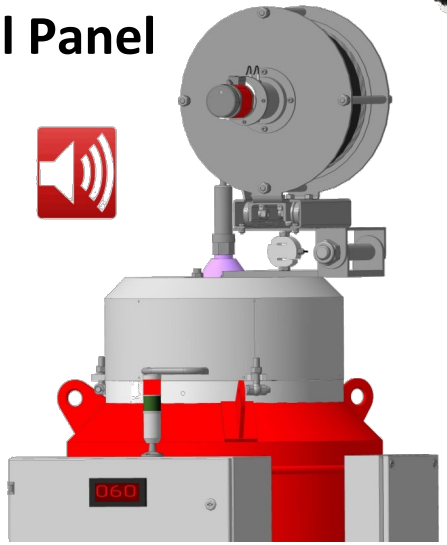


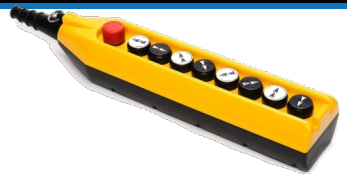
The grapple with an electromagnetic drive is used to pull the core into transfer cask.
When the electromagnet power is off, the grapple is in CLOSE position.

The load-bearing elements of the grapple have been analyzed to confirm its mechanical strength.

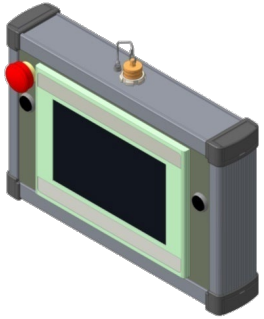
The main structural material for the grapple is corrosion resistant steel

ITC Control Panel

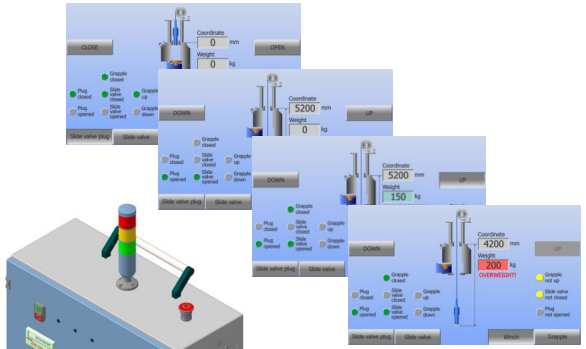


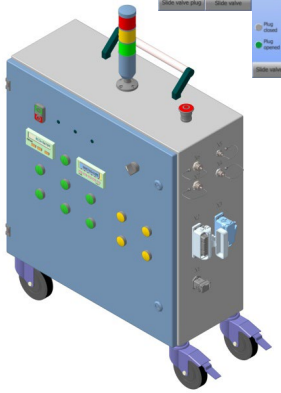


Pendant control 1



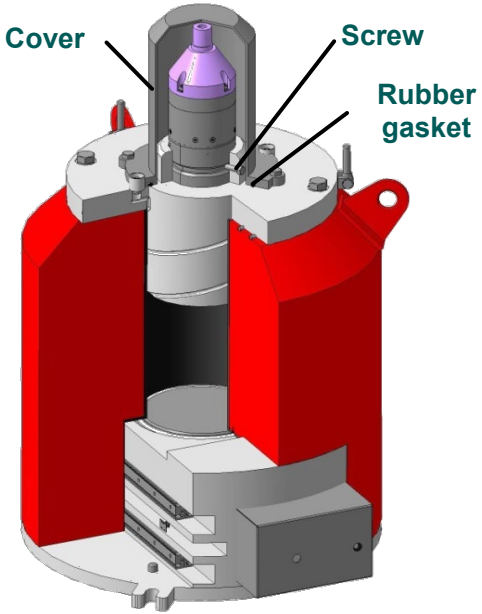
Control panel 2

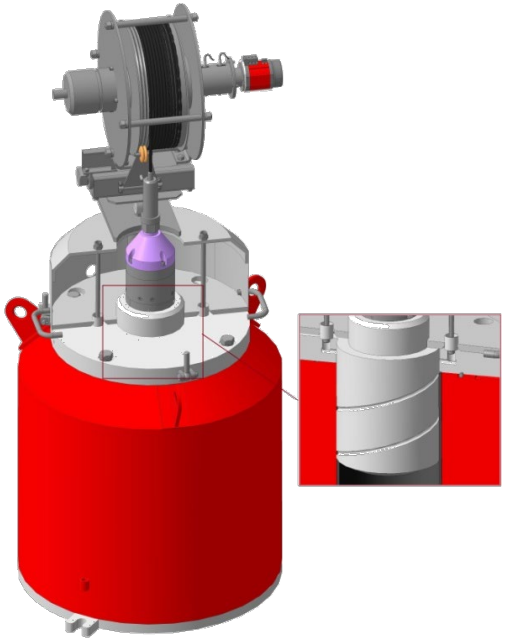




The winch rope adjustment device is used to coil a load-bearing wire on a drum at a right angle. A strain sensor is used to monitor the loading experienced by the load-bearing wire. The loading on the wire, current grapple coordinate, and active lockouts are displayed on the control cabinet front panel and on the touch screen of control panel 2. In case of overload, the power of the electric winch motor is switched off, and simultaneously, the light and acoustic alarm will be activated. The winch is equipped with limit switches for its uppermost and lowermost positions.

Temporary Storage in Interim Transfer Cask

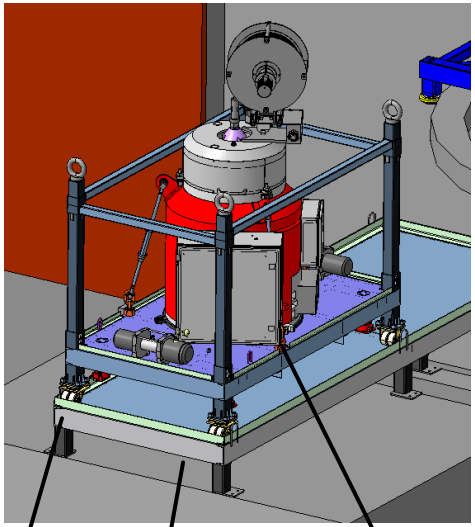




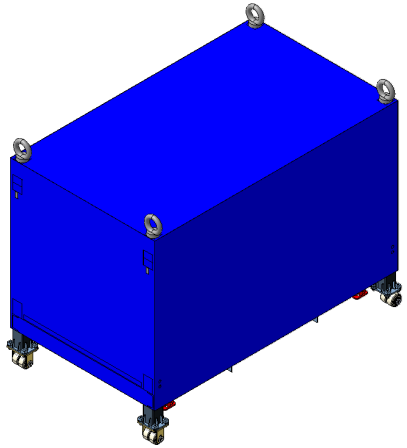
If temporary storage of the core in the transfer cask is required, the empty grapple will be fixed with a stopper, the winch will be removed, and the cover will be put on to seal the inner cask space with a rubber gasket.

To dry the core in ITC, the channels to connect the system for blowing hot air above the pool after the core loading into transfer cask are drilled into the upper part of the transfer cask.

Interim Transfer Cask Dolly



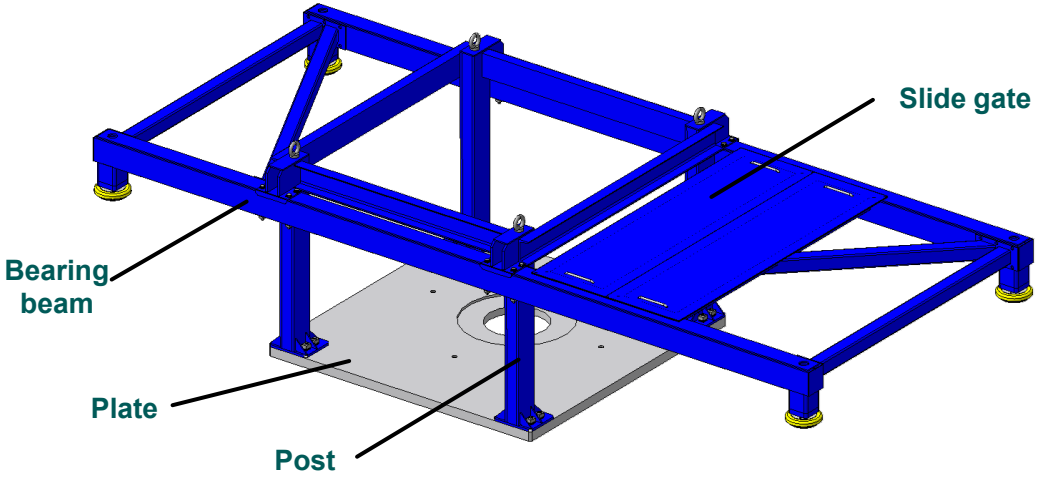
Purpose: The dolly is intended to transport and store the transfer cask. To prevent spontaneous moving, the dolly wheels are equipped with mechanical locks. A ramp installed in front of the transport entrance will allow the dolly to enter the reactor hall freely. When transported, the dolly is covered with rubberized fabric.



Specifications:

Capacity, kg	3000;
Overall dimensions, mm:	
- length	1860;
- width	1080;
- height	1366;

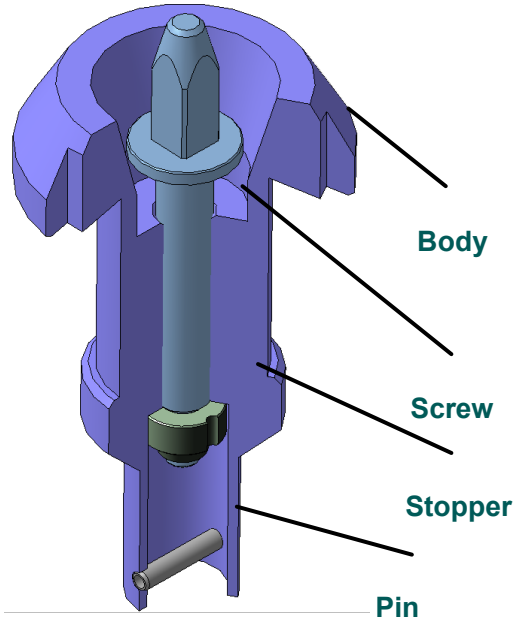
Frame to Install Transfer Cask above Reactor Vessel



The frame is intended:

- **to install the transfer cask above the reactor pool for core loading;**
- **to align the transfer cask with the reactor vessel;**
- **to protect the personnel from ionizing radiation during loading of the MNSR core into transfer cask.**

Adaptor Pintle



Purpose: The adaptor pintle is installed on the MNSR core to function as an adaptor between the core and the transfer cask grapple.

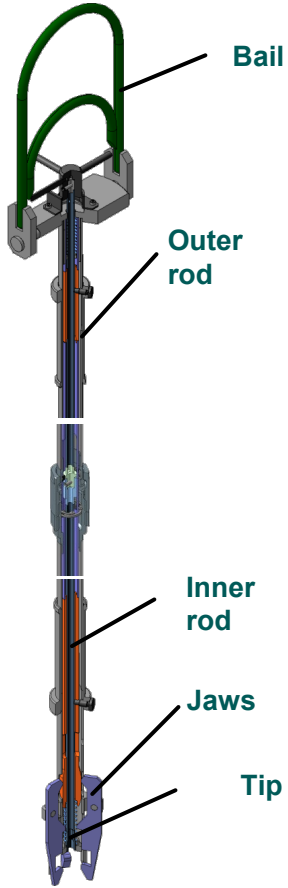
Specifications:

The material is corrosion-resistant steel.

Overall dimensions, mm:

- **diameter ……. 47;**
- **height ……..... 97;**

Mass, kg ……. 0.3;



Adaptor Pintle Grapple

Purpose: Adaptor pintle grapple is intended to install the adaptor pintle on the MNSR core after withdrawal of the core from the pool.

Specifications:

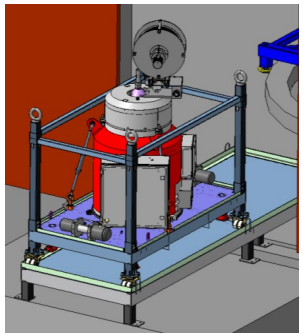
The material is corrosion-resistant steel.

Overall dimensions, mm:

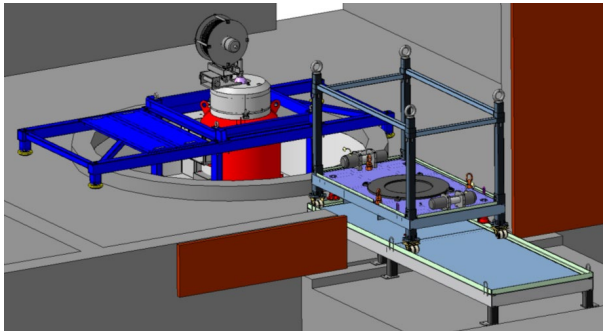
- **diameter ……. 74;**
- **height ……. 5404;**

Mass, kg …….. 19.5;

Interim Transfer Cask Installation Over Reactor Vessel



The dolly with the transfer cask is put on the metal platform.



The dolly is pulled into the reactor hall with a winch. The transfer cask is installed on the frame above the reactor vessel with a crane.

Interim Transfer Cask (dry-run)

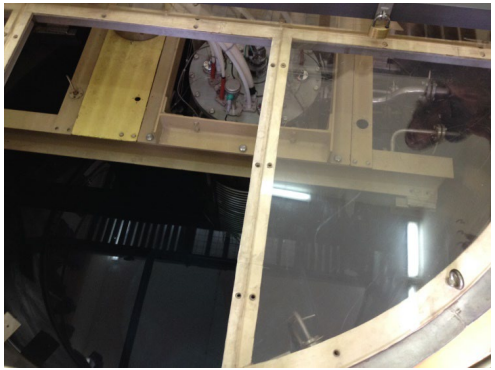
Transfer cask at the UJV facility

Installation of transfer cask on top of a SKODA cask

Modified SKODA basket with the MNSR core model

GHARR-1 reactor spent HEU core removal

- The Ghana Research Reactor-1 (GHARR-1) was the first reactor sending the irradiated HEU core back to China
- The SKODA spent fuel transportation cask with the modified basket was used for HEU transportation by road.
- The specially designed transfer cask was used to load and offload the SKODA cask.
- HEU was shipped to China by air using TUK-145/C cask.



TUK-145/C-MNSR Delivered to Ghana

✓ **Delivery of TUK-145/C-MNSR cask to the site using a truck with a semi-trailer.**

HEU Core Removal in Ghana

- In August 2016, the HEU core was removed from the Ghana MNSR.
- The irradiated core was stored for 2 months in a transfer cask.
- In October 2016, the irradiated core was reloaded from the transfer cask into SKODA and sealed by IAEA

Installation of the transfer cask above the MNSR pool

Moving transfer cask with HEU core into storage facility

Preparation for HEU core reloading from transfer cask into SKODA cask

HEU Core Removal from Ghana

- In August 2017, the new LEU core was delivered to Ghana.
- On August 26, 2017, the TUK-145/C-MNSR was loaded onto the special trailer and moved to the Accra international airport.
- On August 27, 2017, the AN-124 cargo plane with irradiated HEU core left Ghana.
- After two stops in Morocco and Russia, the cargo plane landed at the Shijiazhuang airport in China and HEU was delivered to CIAE on August 29, 2017.

TUK-145 is ready to move to Accra airport

TUK-145 is leaving Shijiazhuang airport

TUK-145 is arriving to CIAE

HEU Core Removal from Ghana

- Upon arrival to CIAE, HEU was reloaded into the “red” transfer cask.
- In December 2017, the HEU was discharged from the transfer cask and stored at the spent fuel pool at CIAE.

International team after HEU was discharged from TUK-145

Transfer cask with HEU core

International MNSR Training Facility

- International MNSR Training Facility was built in Ghana for training MNSR operators to remove the irradiated HEU core and to load it into the SKODA transportation cask.
- Four training sessions were conducted in preparation for the Nigeria MNSR core removal.

International Training Facility in Ghana

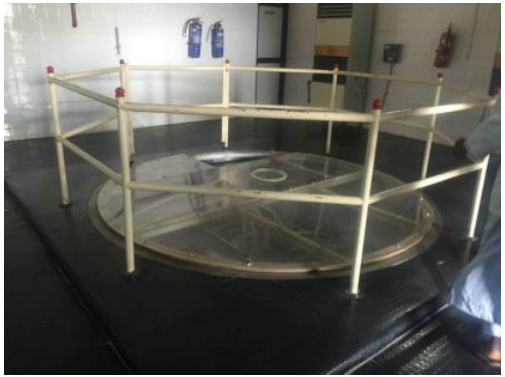
Training of the Nigerian Specialists

NIRR-1 Reactor Spent HEU Core Removal

- The Nigeria Research Reactor-1 (NIRR-1) was the second reactor that sent its irradiated HEU core back to China.

- Technology developed for removal of the HEU core from Ghana was used
  - SKODA - MNSR cask
  - Transfer cask
  - Air shipment using AN-124 cargo plane

Outer and inner gates
ramp without a horizontal platform near the gate



Reactor pool mounting on the floor

HEU Removal from Nigeria

- Four ISO containers with special equipment and the TUK-145/C-MNSR transportation cask were delivered from Ghana to Kaduna airport at 3:00 am on October 23.

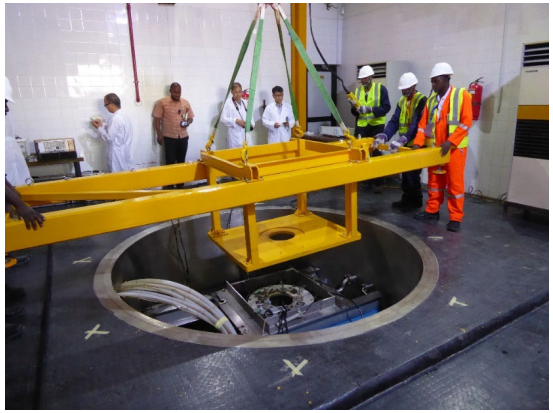
- By 6:00 am all equipment was delivered to the CERT facility in Zaria.

Offloading of TUK-145/C-MNSR cask

Offloading of ISO containers

HEU Removal from Nigeria

- By 6:00 pm the HEU core was removed from the reactor and packaged into the SKODA cask.
- By 10:00 pm the TUK-145/C-MNSR cask was sealed by the IAEA inspector.



Equipment installation over the reactor pool

Transfer cask installation

Transfer cask with HEU inside

HEU Removal from Nigeria

- On December 6, 2018, the HEU core was delivered to China.
- In March 2019, the HEU core was discharged from the TUK-145/C-MNSR cask and stored at the spent fuel pool at CIAE.
- In April-May 2019, all 4 ISO containers and TUK-145/C-MNSR were returned to Ghana.

THANK YOU!