Technical Meeting on Lessons Learned from the Russian Research Reactor Fuel Return (RRRFR) Programme

Da-Nang City, Vietnam ***18-20 June 2014***

EQUIPMENT DESIGNING AND SAFETY ANALYSIS FOR PREPARATION OF LIQUID SNF OF IIN-3M RR FOR SHIPMENT

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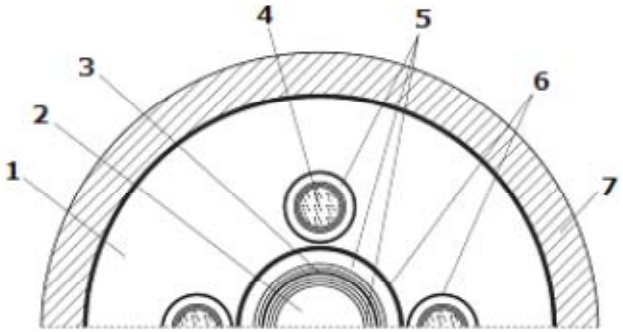
IIN-3M Reactor at Foton JSC

- SNF chemical formula: $UO_2SO_4 + H_2O$ (aqueous uranyl sulphate solution)
- SNF quantity: ~ 22.4 l (in reactor); 1.3 l (in temporary storage canisters)

Top view of INN-3M reactor
from above-reactor room



1 – nuclear fuel;
2 – central experimental channel;
3 – booster rod;
4 – control rod;
5 – shrouds;
6 – liner;
7 – vessel

INN-3M core cross section

Removal Concept Issues Considered in 2012 and Their Status in 2014

- **Experience in Handling Liquid SNF**

  Russia has no experience in transportation and reprocessing of liquid SNF from solution reactors, since these facilities are either in operation, or their fuel has been discharged and stored on the sites.

- **Legal Framework for SNF Removal to Russia**

  A Gov-to-Gov agreement was signed to ship the SNF to Russia; ratification procedures are under way; the SNF Shipment Unified Project materials are being developed.

- **Feasibility of Receiving Liquid SNF at Mayak PA**

  A procedure and safety justification of the LSNF receipt and reprocessing have been prepared; an application for modifications to the license conditions have been submitted, since the fuel solution is non-standard for the reprocessing plant.

- **Selection of Packaging and Transport Mode**

  A multimodal shipment was chosen, i.e. in the SKODA VPVR/M cask by road, then in TUK-145/C by air and road.

- **Shipment Safety Analysis (Nuclear, Radiation, Fire and Explosion Safety)**

  Safety justification was prepared and Russian certificates of approval were obtained for the design and shipment of SKODA VPVR/M and TUK-145/C.

- **Development of Conceptual Procedure for LSNF Discharge into a Canister**

  Sosny R&D Company developed equipment preliminary designs; the fuel discharge equipment has been fabricated and is ready for operation on FOTON site; the equipment for loading into the packaging and receipt at Mayak PA is being fabricated.

Russian Technical Support

Fuel Characterization

- Report on SNF characterization procedure was approved
- Draft characterization report is being prepared

RF Package Design and Shipment License

- Nuclear Safety Analysis Report for TUK-145/C is approved
- Certificate RUS/3197/B(U)F-96T for TUK-145/C is approved

Permits for transportation of the package

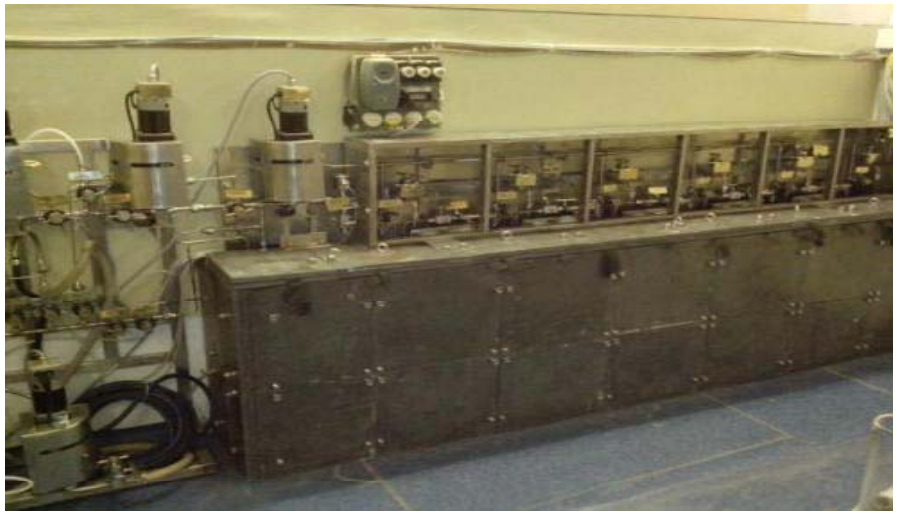
- Technical specifications for delivery are approved
- Special Requirements to Air Shipment are approved

RF VPVR/M Package Design and Shipment License

- Nuclear Safety Assessment Report for SKODA VPVR/M is approved
- Certificate RUS/3205/B(U)F-96T for SKODA VPVR/M is approved

Assembling of the TUK-145/C package and Air Shipment

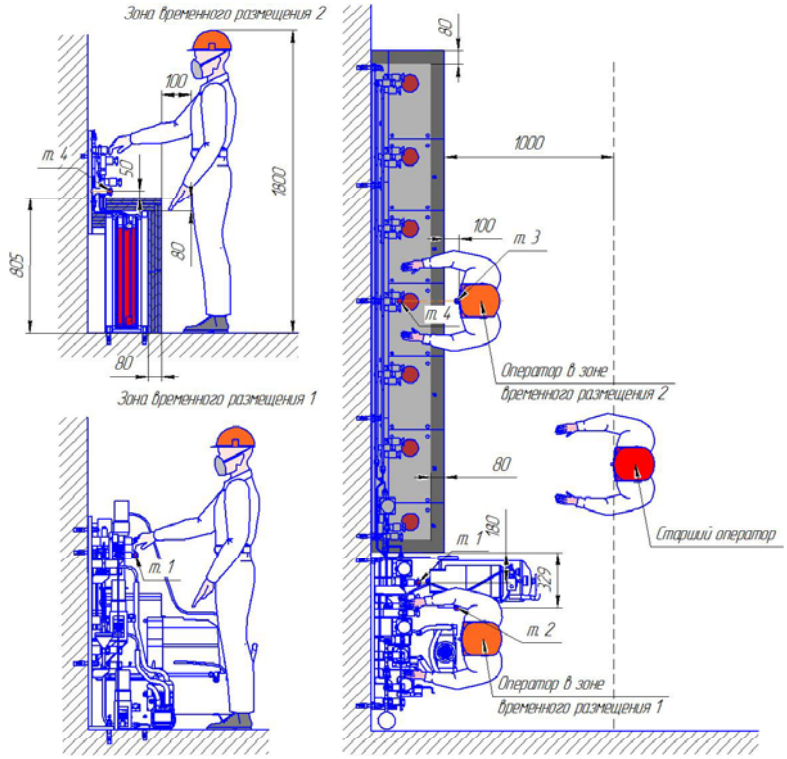
Discharge and Interim Storage Equipment

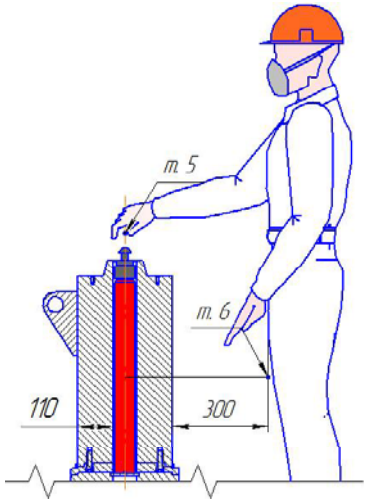


Radiation Safety Analysis

Doses of gamma radiation at work places

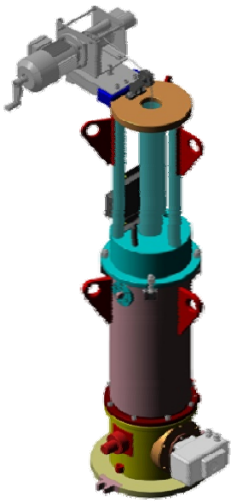
- In loading of the liquid spent fuel in transport canisters

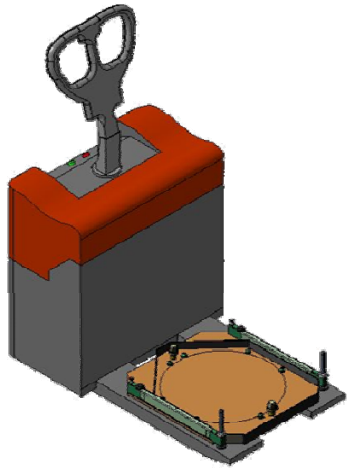


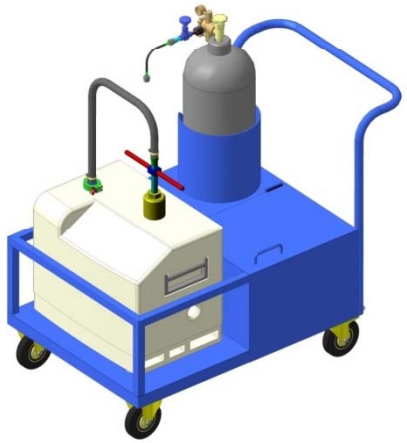


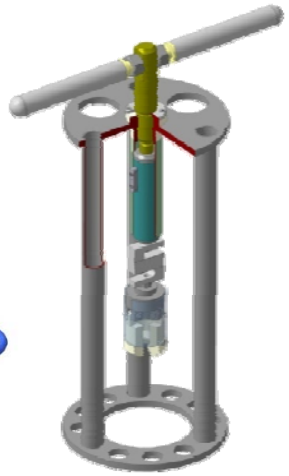
- point 1 – 1.76 μSv/h
- point 2 – 1.18 μSv/h
- point 3 – 2.31 μSv/h
- point 4 – 4.82 μSv/h
- point 5 – 462 μSv/h
- point 6 – 11.1 μSv/h

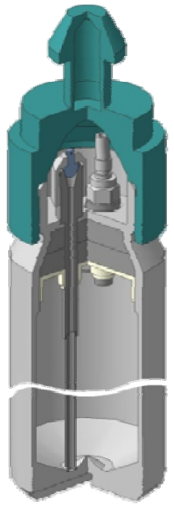
Design of Equipment for LSNF Discharge into Canisters

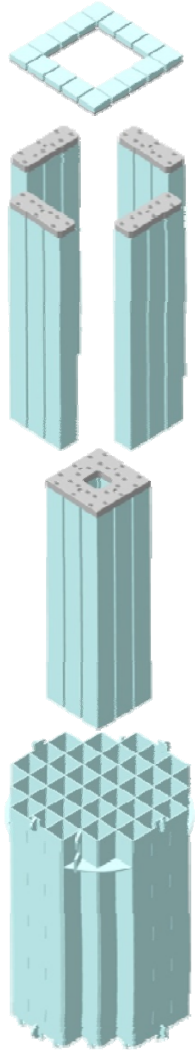


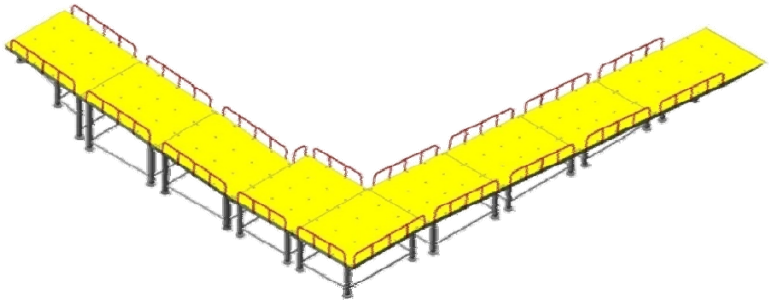




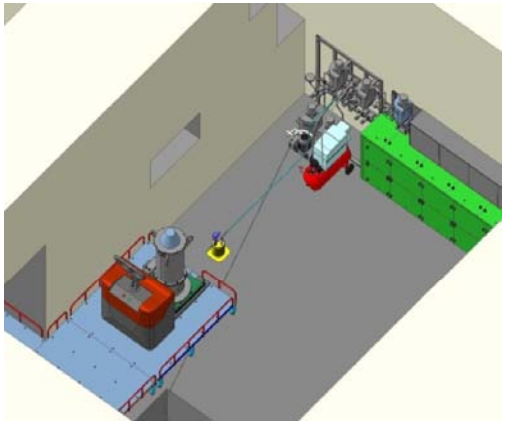


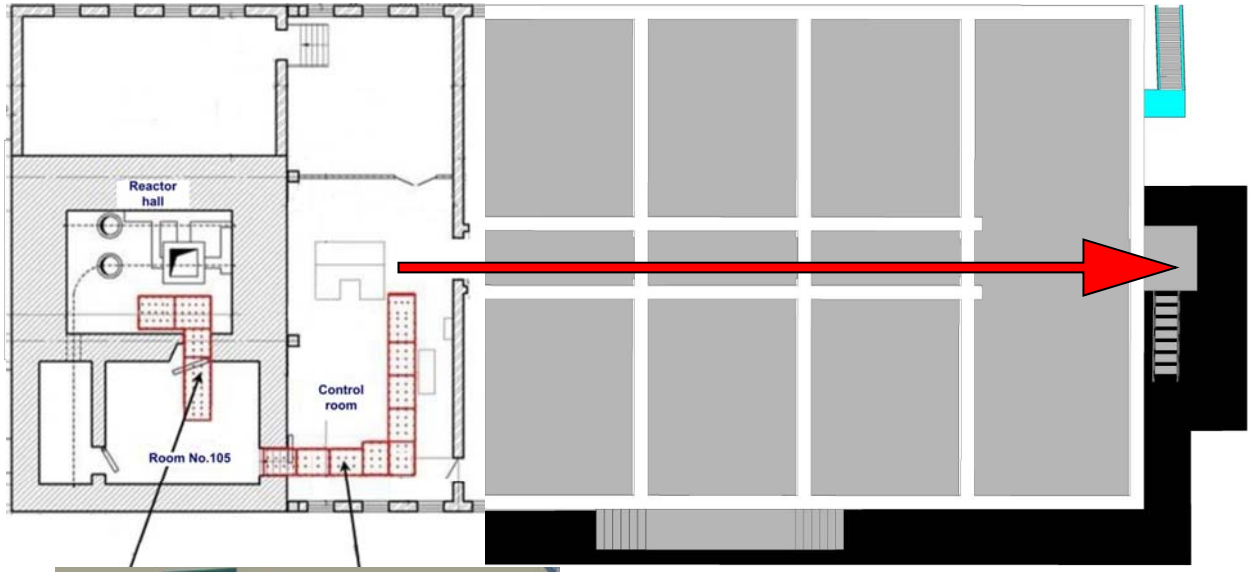


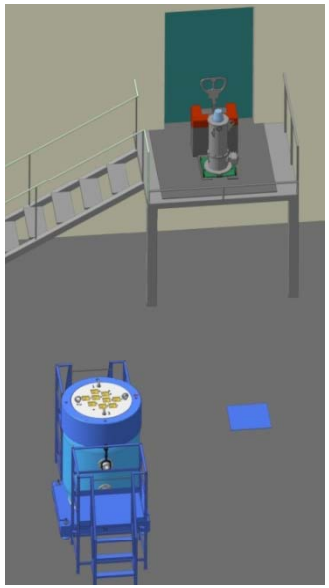


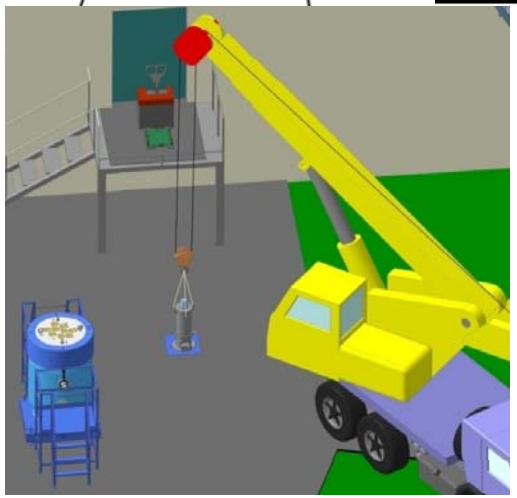


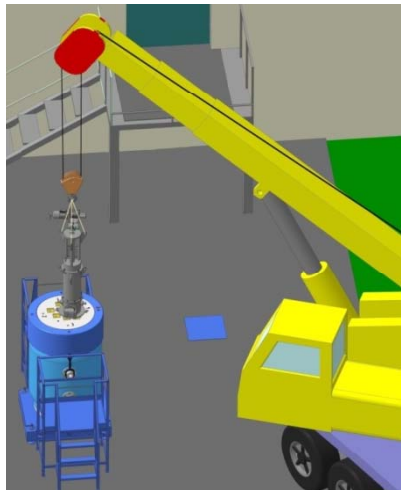
Procedure for Loading the LSNF canisters into Basket of SKODA VPVR/M and TUK-145/C Packaging









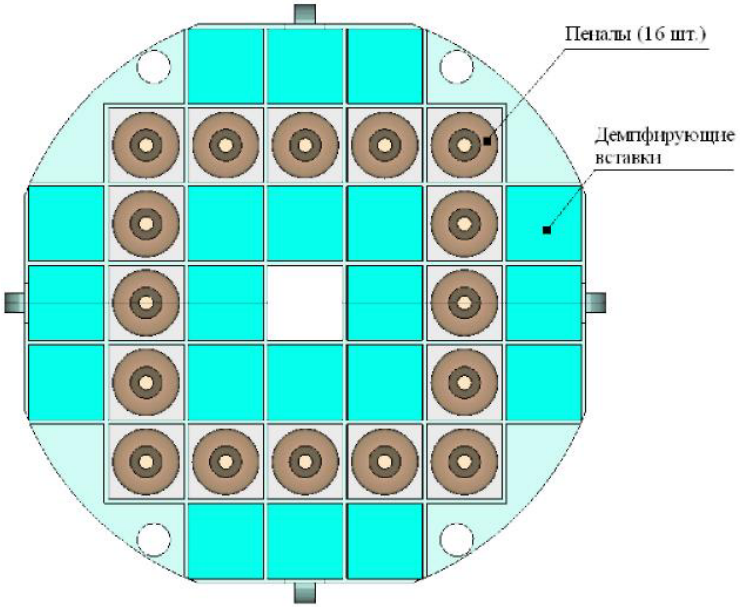


Nuclear Safety Analysis

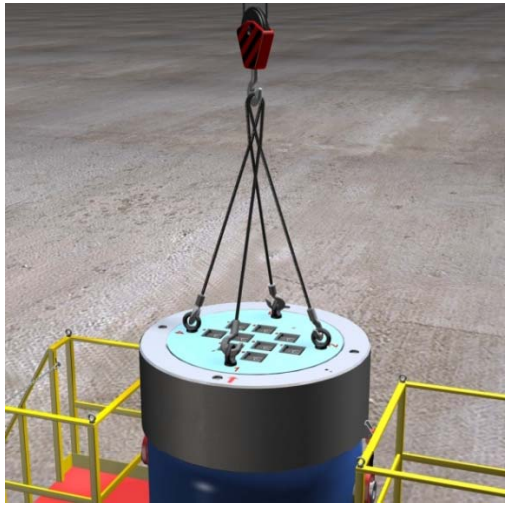
Nuclear safety of SKODA VPVR/M cask

Operation mode	Calculated value of Keff	Admissible value
Normal operation	0.444	0.95
Abnormal operation	0.501	0.98

Safe arrangement of canisters containing the liquid spent fuel in SKODA VPVR/M cask is approved with the nuclear safety assessment report No. 13-152 issued by the IPPE Nuclear and Radiation Safety Department.



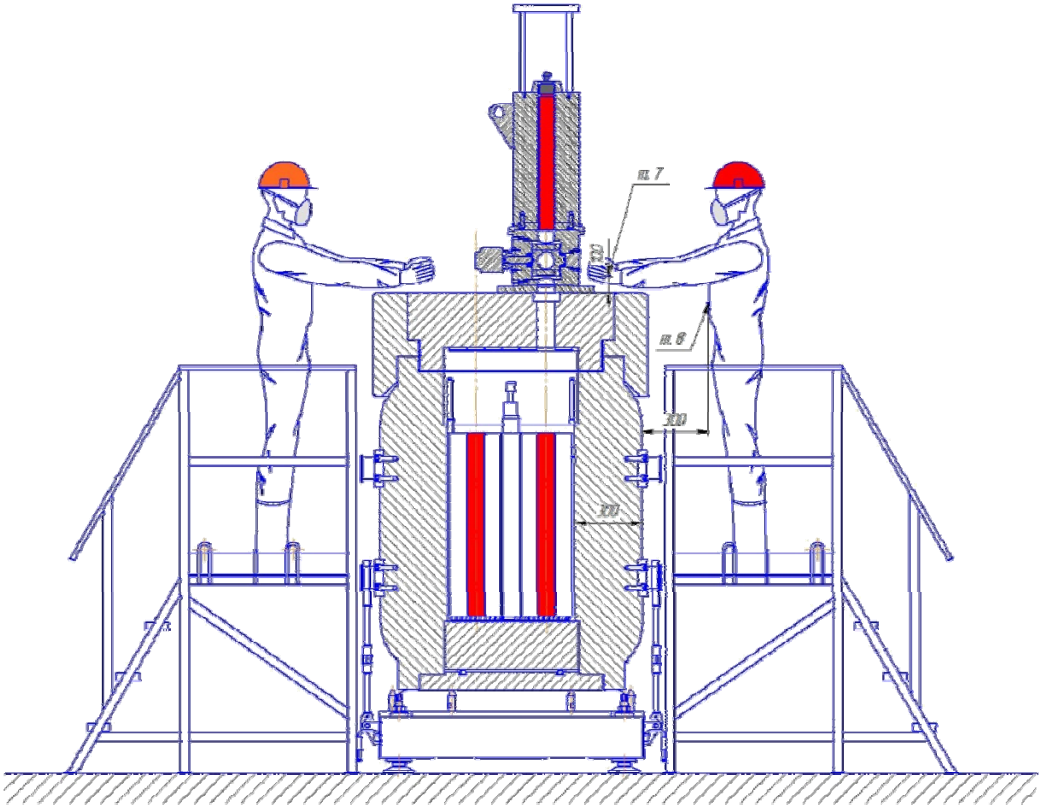
Equipment Fabricated for Removal from Vietnam Will Be Used at Foton



Radiation Safety Analysis

Doses of gamma radiation at work places

- In loading of the transport canisters into SKODA VPVR/M cask



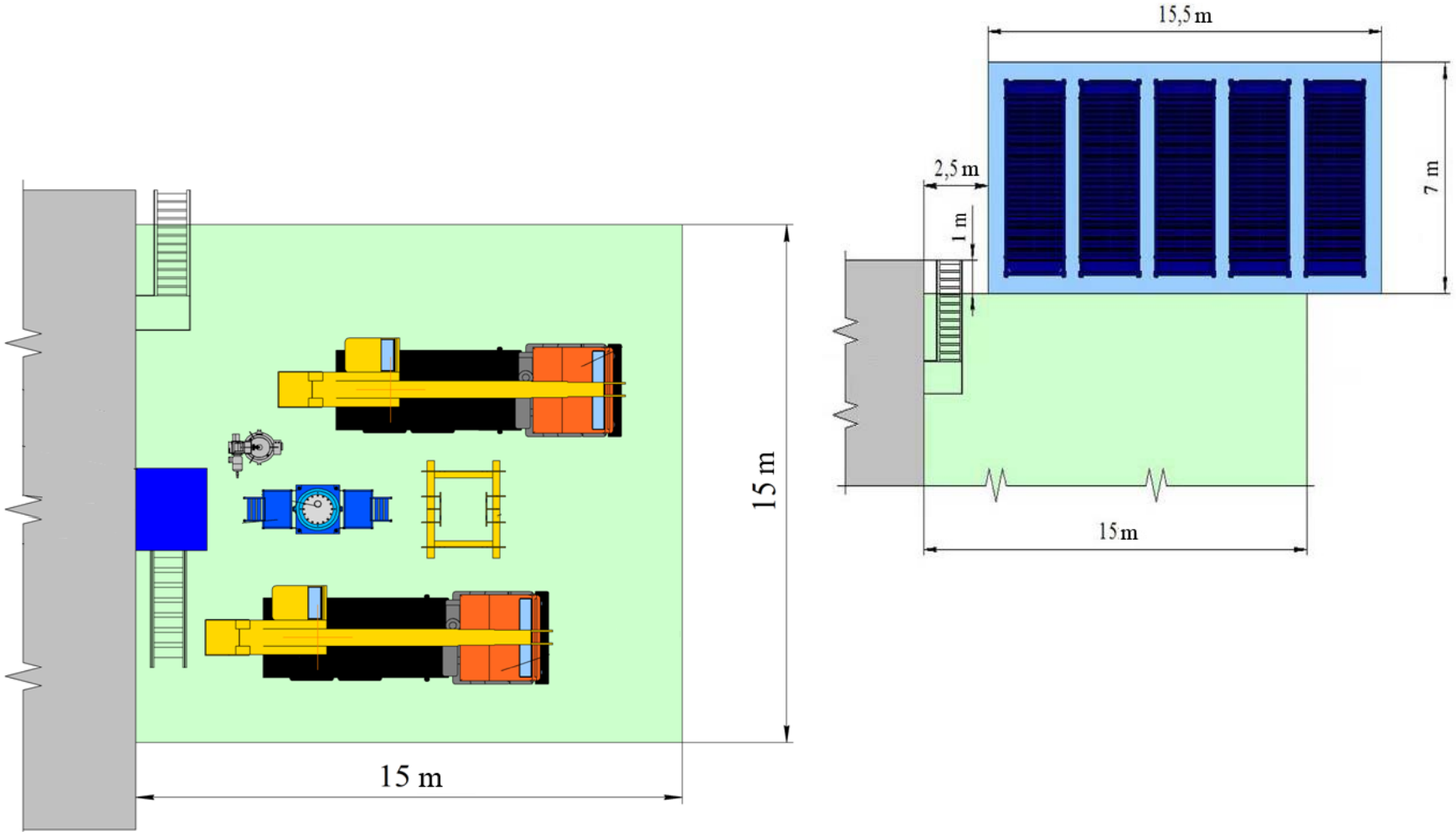
- point 7 – 21.2 μSv/h
- point 8 – 6.7 μSv/h

Radiation Safety Analysis

Personnel exposure (calculated)

Position	Hand exposure, mSv	Maximum hand exposure, mSv	Body exposure, mSv	Maximum hand exposure, mSv	Duration, h
Operator	6.82	500	1.02	20	78.08
Senior operator	1.23		0.95		78.08

Adaptation of Foton Site for Loading SKODA VPVR / M



Safety Analysis

List of accidents

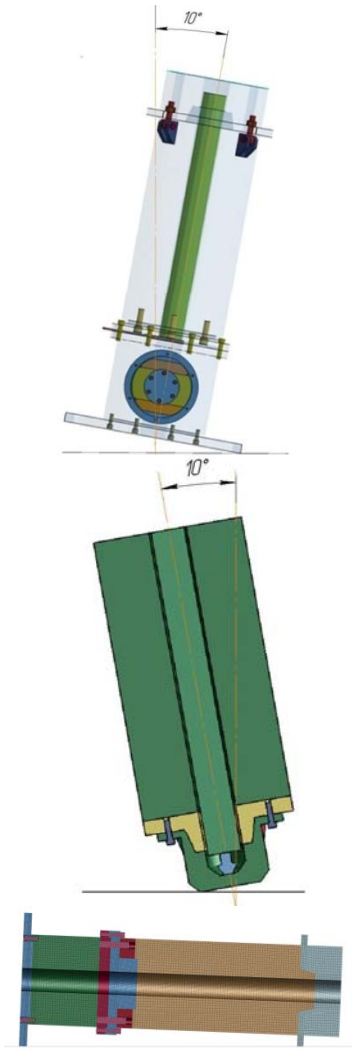
- loss of the integrity of equipment containing the liquid spent fuel;
- drop of the transfer cask with the canister containing the liquid spent fuel;
- drop of the canister containing the liquid spent fuel during its loading into the cask;
- failure of the lifting equipment;
- loss of the power supply of equipment;
- maximum credible earthquake - a beyond design accident.

Safety Analysis (example)

Drop of the transfer cask

- *Initial events*: Defect of structural materials of slinging equipment, human error.
- *Accident scenario:* Drop of the cask on a solid target from a height of 2 m. Options:
- drop on the lower flange;
- drop on the temporary lid;
- side drop.

- *Results of the analysis*:
- biological shielding suffers no damage;
- the bolts maintain their integrity;
- engineering cavities and holes of the gate remain unchanged in their shape;
- the canister maintains its containment, and retrievability.



Transport Plan for Shipping Liquid SNF from Uzbekistan to Russia

The route includes road and air sections:

- from Foton site to the airport of Tashkent - by road in SKODA VPVR/M,
- from Tashkent to Koltsovo airport, Yekaterinburg - by air in TUK-145/C,
- from Koltsovo airport to Mayak site - by road in TUK-145/C.

Uranium Extraction Technology

Development of the receipt, interim storage and reprocessing technology at Mayak PA

- Develop a transport and handling procedure on LSNF receipt, interim storage and reprocessing at Mayak PA
- Optimize of extraction parameters of U separation process
- Develop measures compensating the effect of corrosive solution on the equipment
- Specify parameters of waste produced during LSNF reprocessing and develop procedure on its handling

Development of equipment for Mayak

- Identify requirements and develop concept design of equipment for LSNF receipt, transportation, handling and feed to dissolver
- Develop preliminary design of equipment for LSNF receipt, transportation, handling and feed to dissolver. Calculate equipment strength and seismic resistance
- Develop specifications and final drawings of equipment for LSNF receipt, transportation, handling and feed to dissolver

Modifications to license

- Perform calculations justifying fire and explosion safety of LSNF interim storage and reprocessing
- Perform calculations justifying radiation safety of handling LSNF at Mayak PA
- Perform calculations and issue expert assessments of nuclear safety of LSNF interim storage and reprocessing at Mayak PA
- Analyze design and beyond design accidents, perform calculations of accident consequences
- Develop SAR
- Obtain the Sanitary-Epidemiological Conclusion Certificate on Technical Design
- Develop modifications to QAP and operational procedures
- Provide technical support of review of Mayak PA documents by the expert authority of Rostechnadzor
- Prepare modifications to license

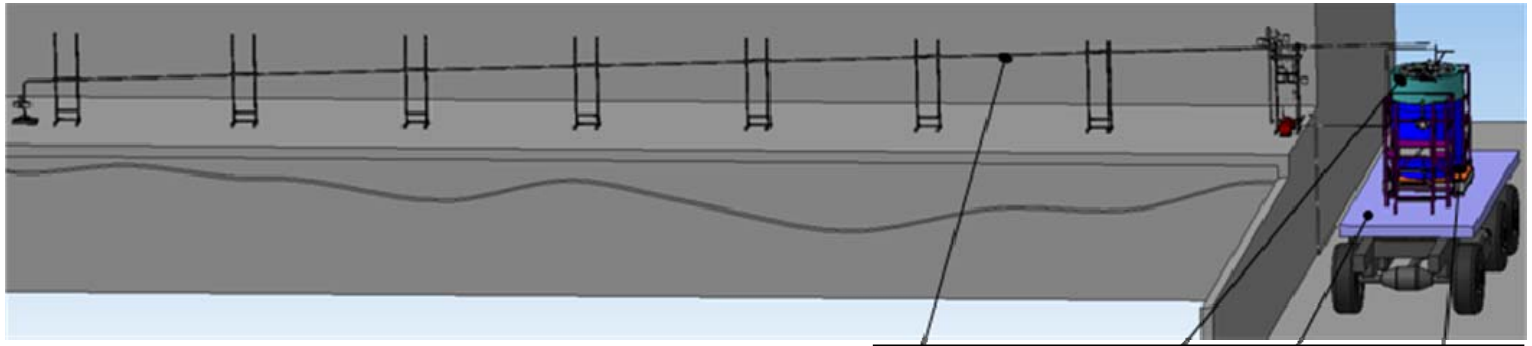
Fabrication of equipment

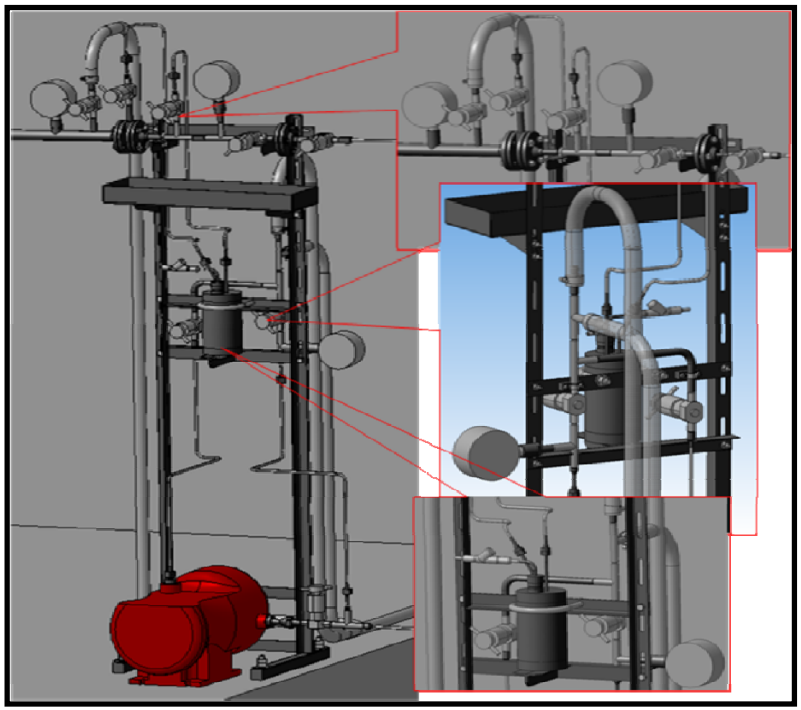
- Fabricate, procure and deliver basic and support equipment for analytical complex
- Fabricate, procure and deliver equipment for receipt, interim storage and handling LSNF at Mayak PA

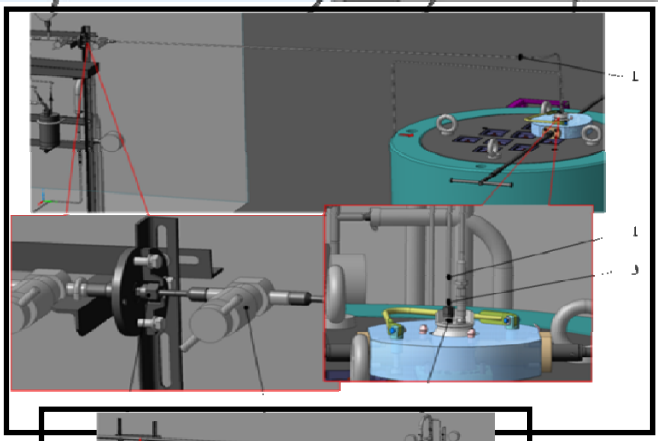
Equipment Commissioning

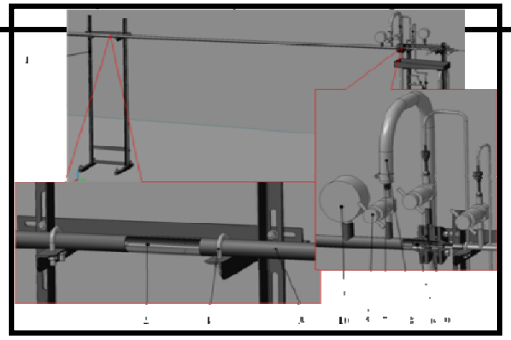
- Install and commission equipment for the LSNF receipt module and analytical complex
- Develop personnel training programs
- Conduct personnel training
- Perform equipment tests

Adaptation of Mayak PA for Unloading Liquid SNF from Canisters









Conclusions (1 / 2)

Main results:

- The equipment for the LSNF discharge from the reactor and interim storage is ready for operation. The personnel is prepared.
- Russian shipment permits (Certificates, Technical Specification, Special Requirements for Air Shipment) are available.
- Preliminary designs were developed and safety was justified for all the equipment for the LSNF discharge, interim storage, loading into canisters and packaging, unloading and reprocessing at Mayak PA.

Conclusions (2 / 2)

Organization of LSNF removal from Uzbekistan requires:

- Discharge the LSNF from the reactor into interim storage canisters and complete the LSNF inspection.
- Obtain approval of modifications to Mayak's license conditions for reprocessing the FOTON IIN-3M reactor LSNF.
- Fabrication and delivery of equipment loading the LSNF into TUK-145/C.
- The LSNF shipment is possible after the Gov-to-Gov agreement is ratified and a positive state ecological assessment of the Unified Project is obtained.

The experience gained from the removal of the LSNF can be used for shipments of the fuel from Russian solution reactors.

Thank you for attention!