



Krško NPP Slovenia Spent fuel dry storage project

Rotterdam, ISOE Symposium 2024

Daniel Novak, Jan Jamnik Srpčič



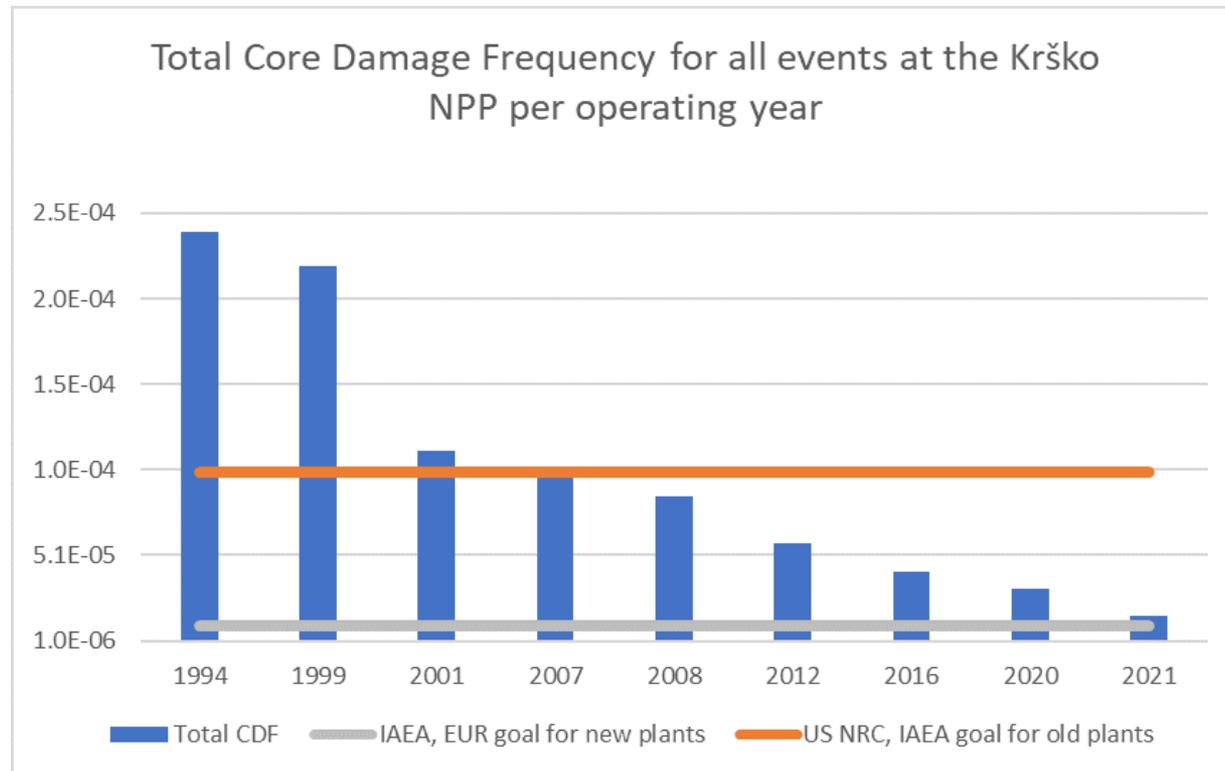
www.nek.si

Spent Fuel Dry Storage Project – part of Krško Safety Upgrade Program



Upgrade is based on modern standards of nuclear industry after events in Fukushima (2011) and is based on state and European law. **NPP Krško recognized benefits of safety upgrade early and started the program prior to the 2011 events!**

New safety upgrades allow NEK long-term operation and make safety of the plant comparable to new plants!





- Dry Storage of Spent Fuel (SF) was already foreseen in the Slovenian National Program on Handling of Nuclear Waste & Spent Fuel
- Following the events in 2011 safety aspects of the power plant were reassessed:
 - Further extension of Wet Storage (re-racking) is not a viable option
 - Dry Storage further increases the safety of SF storage and lowers the amount of SF in Wet Storage
 - Dry Storage construction should begin in 2020's as part of the current nuclear facility



Timeline

- Building construction: 02/2021 – 10/2022
- Dry runs and testing: 10/2022 – 02/2023
- Fuel movement (1st campaign - 16 casks): 03/2023 – 08/2023
- Fuel movement (2nd campaign - 16 casks): 2028 – 2029

- Up to 2 more campaigns are foreseen in the future
- The final number and time of campaigns will be determined based on the SFP availability and plant requirements

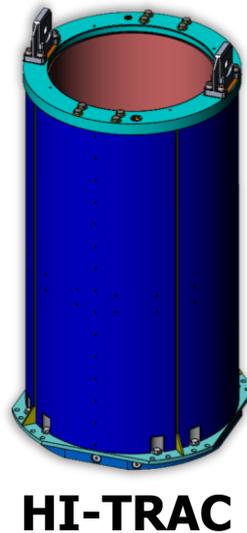
The Basic Concept

Based on NRC regulations 10-CFR-72 (SF Dry Storage) and 10-CFR-71 (SF Transport):

- Provides safety of storage in normal, abnormal and postulated accident conditions
- Maintains subcriticality
- Removal of residual heat
- Providing radiation protection
- Maintaining containment over the lifetime of storage facility
- Enables retrievability of spent fuel



Dry storage technology



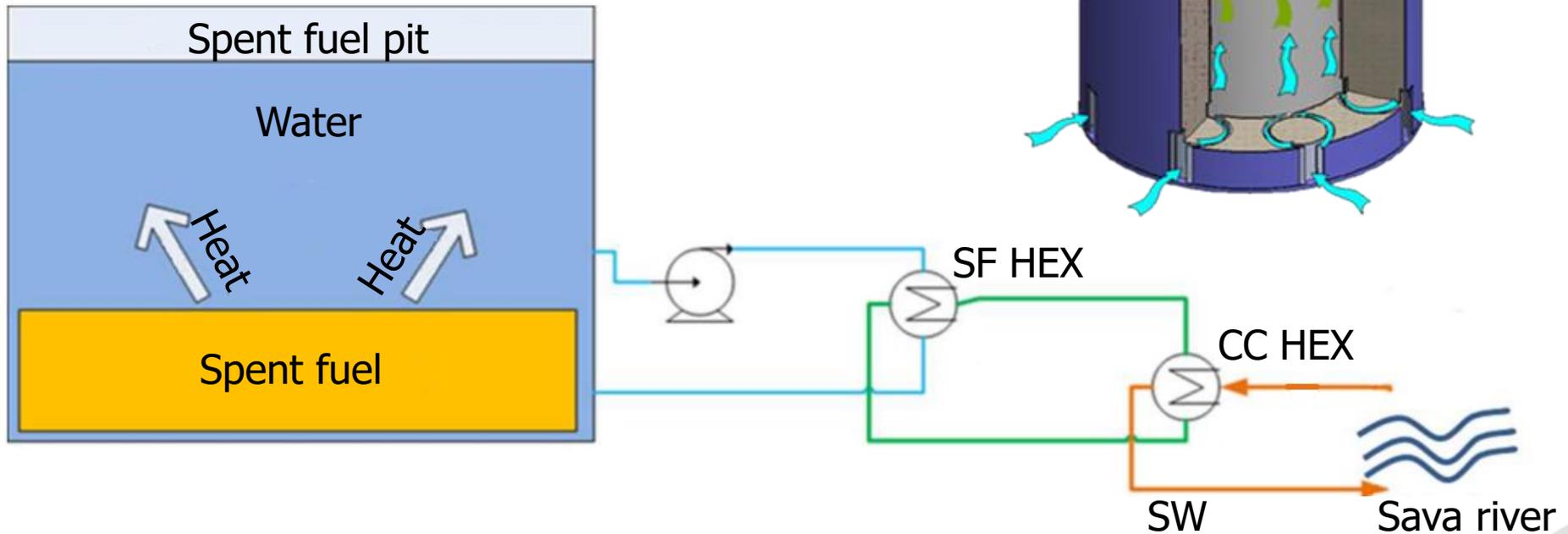
Dry storage

How dry storage increases safety?



Storage of spent fuel in spent fuel pit requires **active** components for cooling.

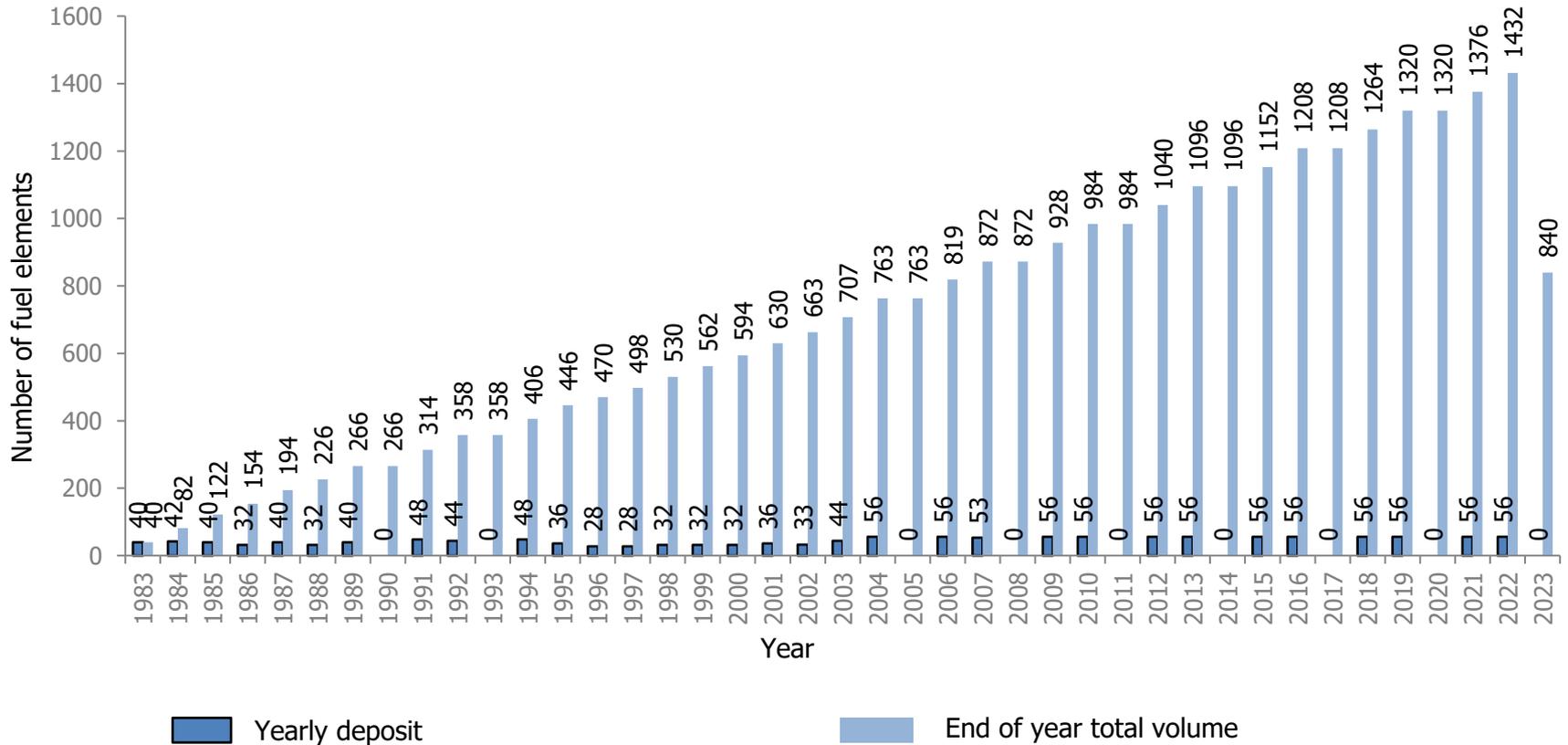
Dry storage design allows canisters containing fuel to be cooled **passively** with ambient air!



Spent Fuel Management



Total No. of Spent Fuel Elements in the SFP per year

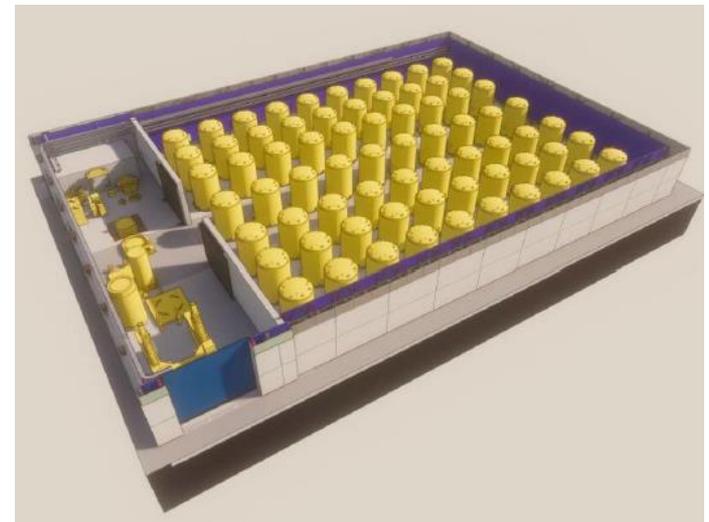


At the end of 2023, **840** spent fuel elements from 32 fuel cycles were stored in the spent fuel pool. In 2023, **592** spent fuel elements in 16 **casks** were moved from the spent fuel pool to the **Spent Fuel Dry Storage**.

Dry storage building



- **HI STORM casks can be stored outdoors!**
- Additional NEK requirement for dry storage building - following EU practices
- **The safety of storage is still solely provided by the storage cask**
- Decreases dose to surrounding (regulatory limit is 0.2 mSv/year on the site fence from all NPP sources)
- The DSB acts as soft additional environmental protection and is minimizing aging effect of the cask from environmental conditions
- Reduces dose during operation (biological shield between storage and transfer area)
- Increases safety



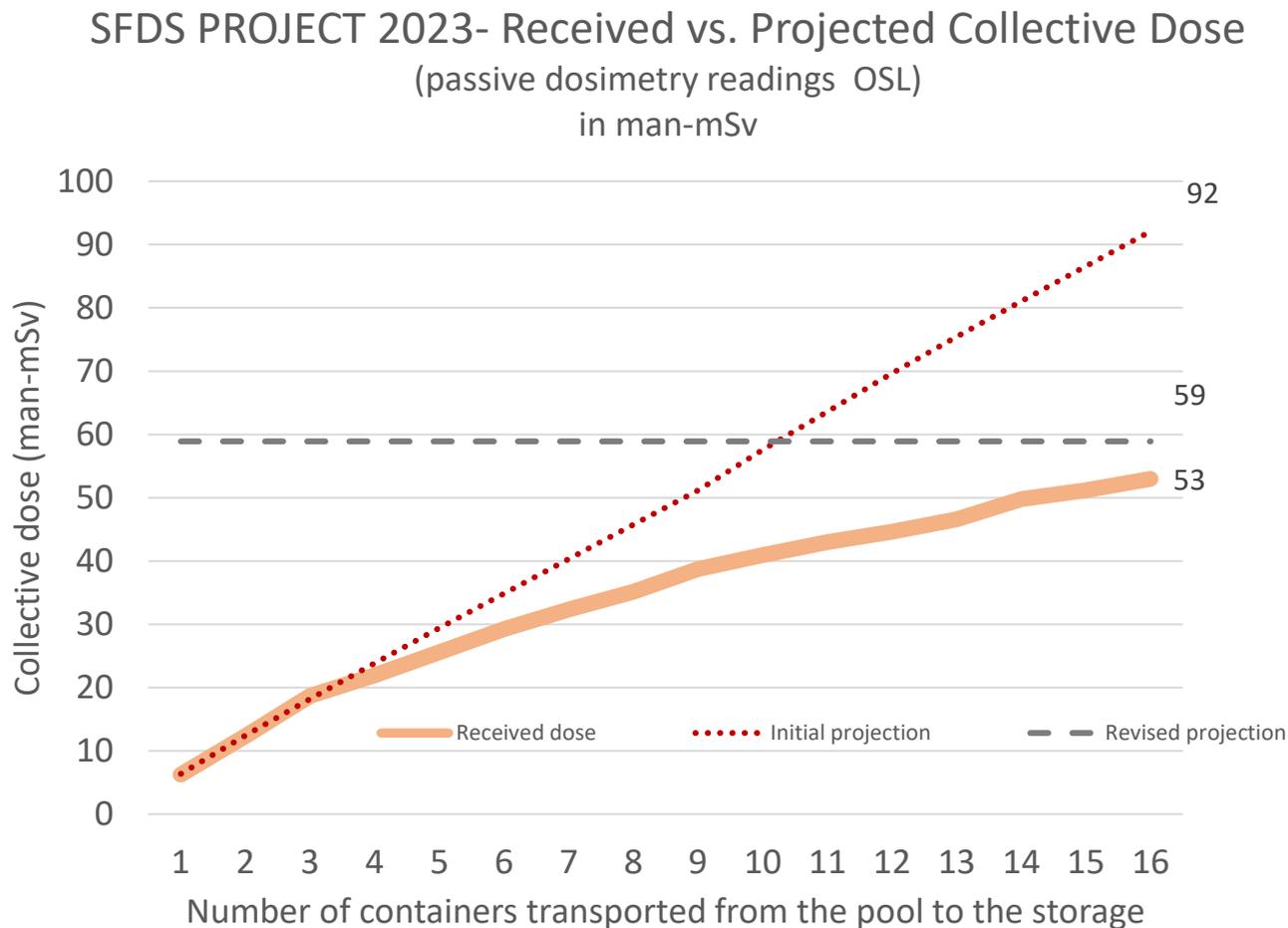


Spent Fuel Dry Storage Project - Preparation

- Written procedure for conducting radiological control during the transfer of spent fuel
- ALARA plan
- Prior first cask loading an actual full 4-stage dry run was performed to check crew prepadness and to verify that all stage-critical tasks or equipment is good to go. Based on the dry run results final updates to the procedures were made.



Krško SFDS Project



Collective dose is 50% of planned dose!



Group doses and highest personal doses

	Collective dose [person.mSv]	Highest dose [mSv]	Number of people
H-Holtec	15.26	2.69	19
H-Welders	7.44	1.78	5
H- Numpis	8.09	2.45	5
H-Other	7.24	2.84	4
Total	38.03		33
Radiation protection	Collective dose [person.mSv]	Highest dose [mSv]	Number of people
RP staff, Nutronic	6.37	1.39	23
Decontamination	Collective dose [person.mSv]	Highest dose [mSv]	Number of people
KM, Kostak	6.2	1.14	10
Total:	51		66

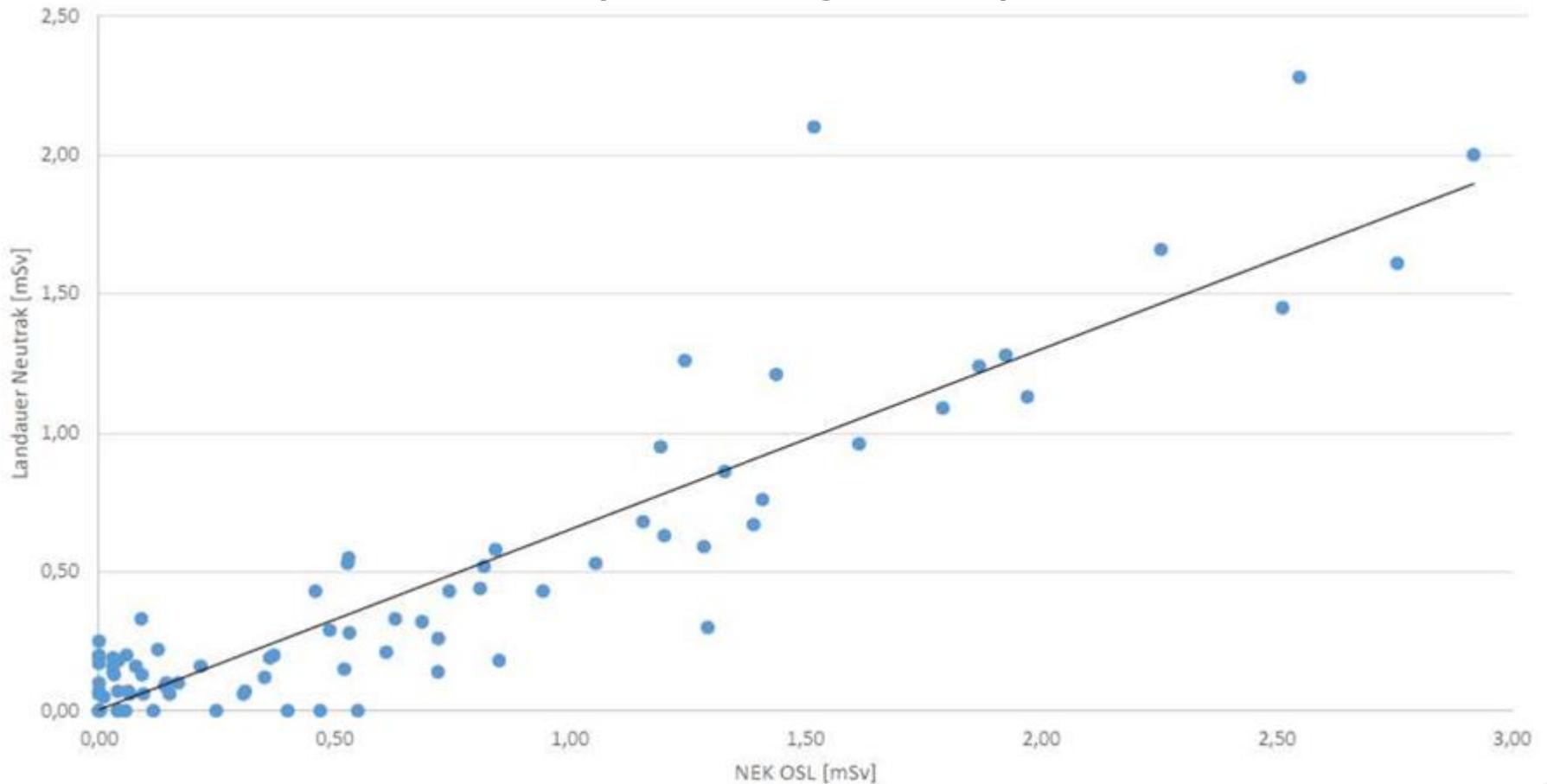
Expected dose for welders was 1.5 mSv and that is also their average dose.

The expected highest doses for decontaminators were 4 mSv.

Personal dose readings from the project



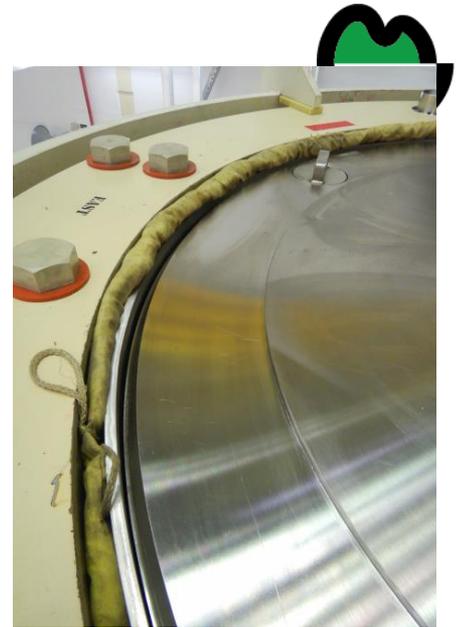
NEK OSL – NEUTRAK Landauer dose comparison
Combined dose from gamma and neutron irradiation
(March – August 2023)



Spent Fuel Dry Storage Project

Shielding

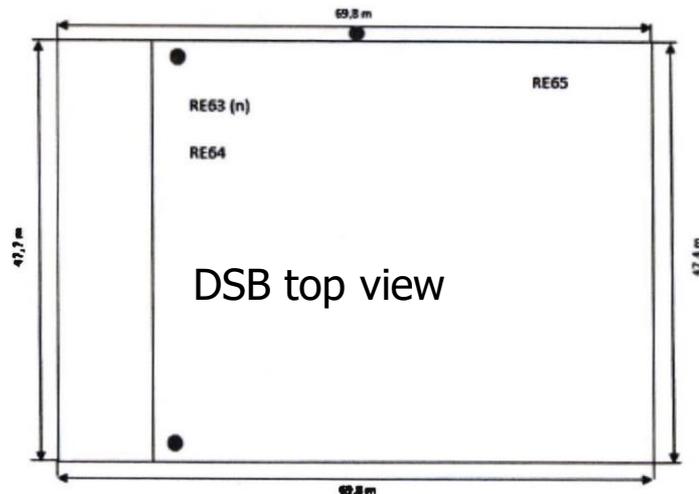
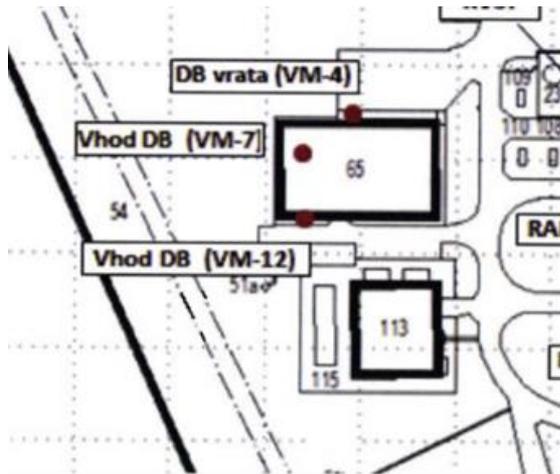
- „Snake“ shield for annulus region between HI-TRAC and MPC
Removed during welding
- 20 heat resistant lead blankets
Shielding during welding
Shielding during cleats installation/removal
- Segmental shield
Shielding during FHD operation
- Lead blankets between HI-TRAC and FHD skid
After 10th cask added neutron shields





DSB dosimeters

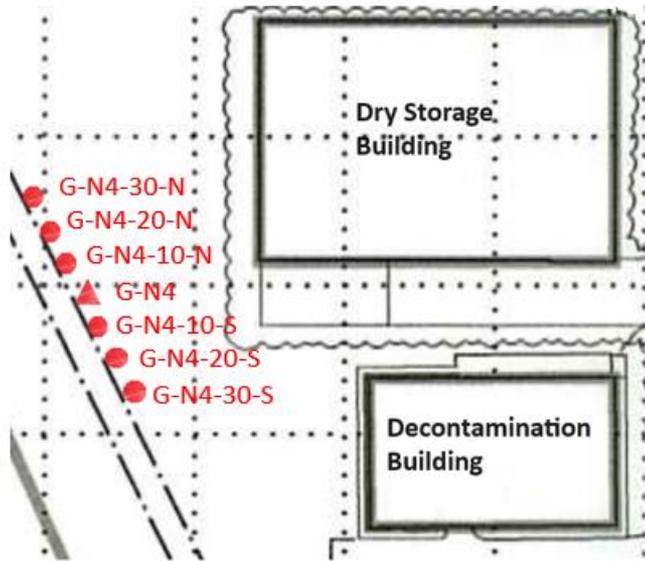
- 2 dosimeters are on the outside of the north wall of the DSB (at 2 m and 5 m)
- 6 dosimeters are on the wall inside the DSB. On two locations (at 6 m, 10 m and 14 m)



Period:	July – December 2023		
Dosimeter label NEUTRAK (LANDAUER)	Location	gamma dose [mSv]	Neutrons Hp(10) [mSv]
2779030	DSB-1-NW 6m	0,55	M
2779031	DSB-2-NW 10m	0,07	M
2779032	DSB-3-NW 14m	0,22	0,12
2779033	DSB-1-SW 6m	0,07	M
2779034	DSB-1-SW 10m	M	M
2779035	DSB-1-SW 14m	M	M
2779036	DSB-1-N 2m	M	M
2779037	DSB-1-N 5m	M	M
	<u>Average dose</u>	0,23	0,12

M – below detection limit

NPP Krsko fence additional dosimeters due to SDFS



Period:	July – December 2021		
<u>Dosimeter label</u> TLD (JSI)	<u>Location</u>	<u>gamma dose</u> [mSv]	<u>Neutrons</u> Hp(10) [mSv]
TLD 1	G-N4-30-S	0,302	M
TLD 2	G-N4-20-S	0,308	M
TLD 3	G-N4-10-S	0,298	M
TLD 4	G-N4	0,296	M
TLD 5	G-N4-30-N	0,304	M
TLD 6	G-N4-20-N	0,303	M
TLD 7	G-N4-10-N	0,308	M
	<u>Average dose</u>	0,303	M

Period:	July – December 2023		
<u>Dosimeter label</u> TLD (JSI)	<u>Location</u>	<u>gamma dose</u> [mSv]	<u>Neutrons</u> Hp(10) [mSv]
TLD 1	G-N4-30-S	0,308	M
TLD 2	G-N4-20-S	0,309	M
TLD 3	G-N4-10-S	0,299	M
TLD 4	G-N4	0,299	M
TLD 5	G-N4-30-N	0,291	M
TLD 6	G-N4-20-N	0,301	M
TLD 7	G-N4-10-N	0,293	M
	<u>Average dose</u>	0,300	M

M – below detection limit



Thank you for
your attention!



www.nek.si