



# Krško NPP Slovenia 2023 Projects



Rotterdam, ISOE Symposium 2024

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# Krško Plant DATA



## Krško NPP – Owners are utilities from Slovenia and Croatia

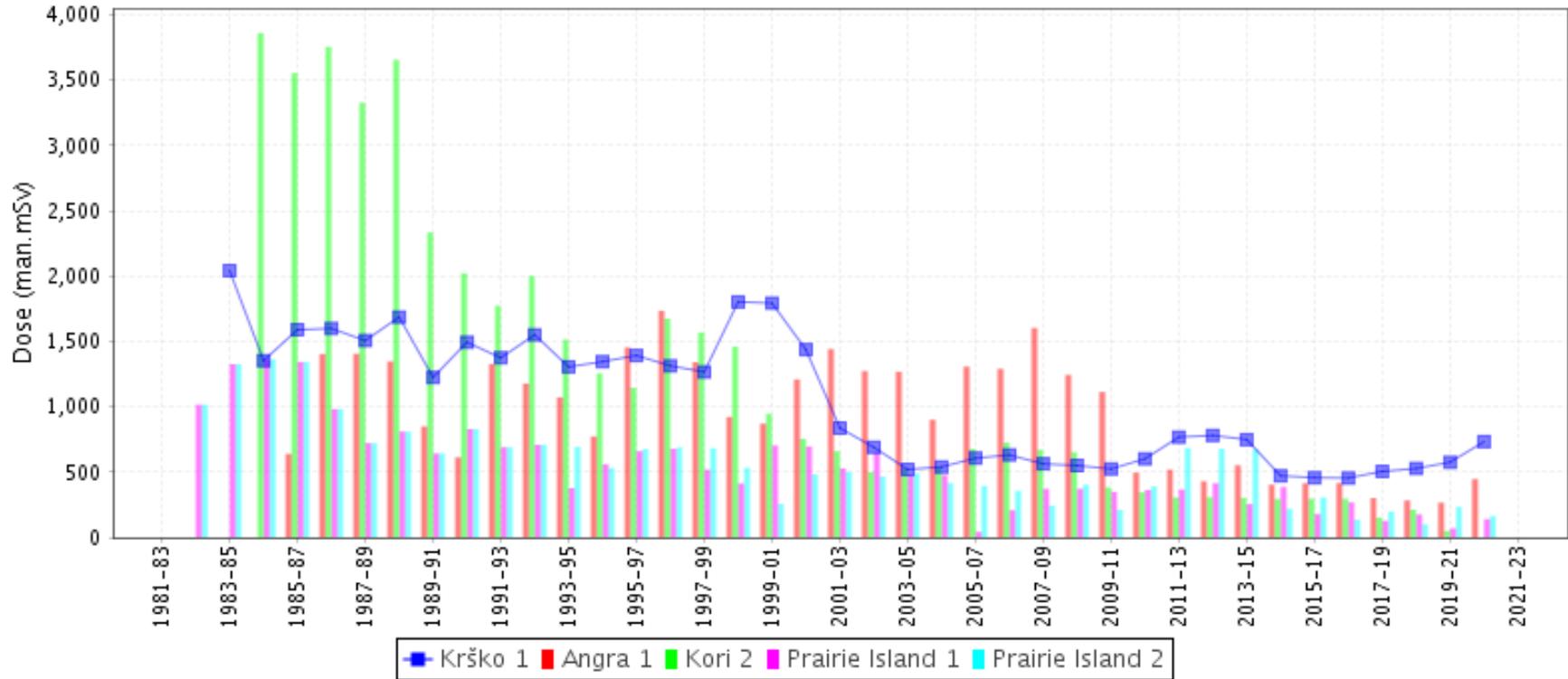
- Pressurized water reactor, 2 loops, Westinghouse
- Commercial operation since **1983**
- Electrical output : 727 MWe (Gross) – 696 MWe (net)
- Operating licence for 60 years (with 10y Periodic Safety Review)



# CRE

## 3-Year rolling average compared with sister plants in operation

3-Year rolling average collective dose per reactor for Krško 1 compared with other units in its sister unit group



#U-23

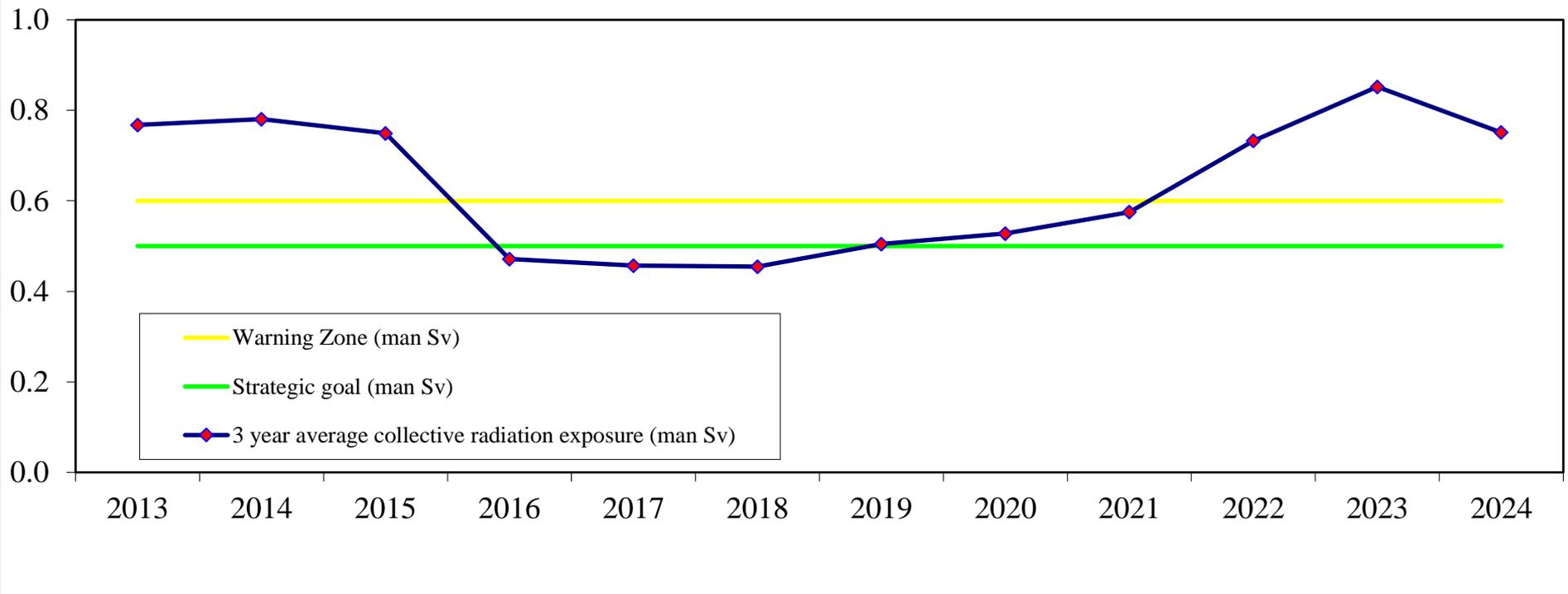
Source: ISOE

- 1982 – 2019  
→ problems with old SGs  
FW modif. and  
SG pluggings
- 2000  
→ SG  
replacement
- 2013 - 2015  
→ RTD bypass  
removal  
and baffle jetting  
(fuel failures)
- 2022  
→ MSIP

# CRE INDICATOR (3 year rolling average 2011-2022) 18 months fuel cycle



*Collective radiation exposure - 3 year rolling average*



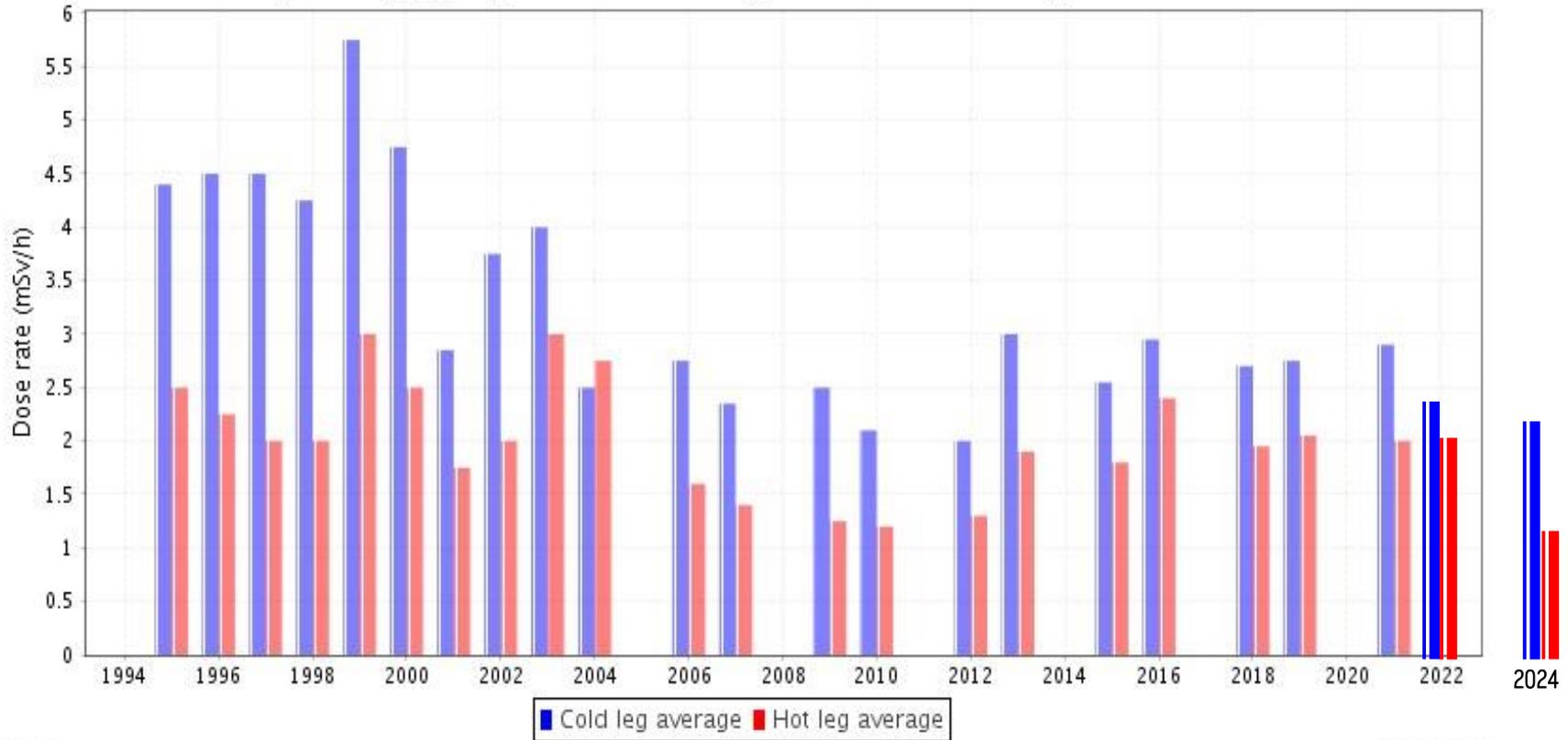
# Modifications and Improvements during 2012 - 2022



- 2012- Replacement of reactor vessel head** with new gamma shield and neutron shields in reactor cavity
- 2013 – RTD bypass removal after** some baffle jetting induced fuel rod damages - fuel failures due to cladding fretting in the upper core baffle region, and installation of stairs to the reactor cavity.  
Alpha monitoring program was in place (presented at Bern ISOE Symposium)
- 2015 – Up-flow conversion** (the modification to prevent fuel failures)
- 2016 – 2017** Construction of Waste Manipulation Building to improve working conditions and water management (BRHUT #3). **Radwaste handling**
- 2018** - Installation of pressurizer valves
- 2019 - PRZ by-pass valves** completed in outage 2019. Installation and radiography on **new alternate cooling systems components** (ASI, ARHR, CNT).  
RadWaste processing and handling.
- 2022 –** Treatment of the connections of reactor coolant piping to the reactor vessel i.e. **Mechanical Stress Improvement Process.**  
(MSIP is a mechanical process *for reducing residual tensile stresses in bimetal welds*). **5**



PWR primary piping cold and hot legs dose rates averages for Krško 1



#U-26

Source: ISOE

2000- SG replacement

2012- RVH replacement

2013- RTD bypass removal

# Krško NPP Safety Up-grade Program



## **Phase 1 (2013):**

- Passive containment filter-vent system (PCFV) and
- Hydrogen recombiners;

## **Phase 2 (2019-21):**

- Emergency control room with a new technical support centre
- Alternative spent fuel pool cooling and spray system
- PCFV effluent monitor
- New shelter building (operative support centre)

## **Phase 3 – completed in 2022:**

- Bunkered building with safety injection pump and borated water tank
- Auxiliary feed water pump with condensate storage tank and alternative RHR pump
- Spent Fuel Dry Storage (SFDS) Building at the plant location

# Spent Fuel Dry Storage (SFDS) Project



**NEK-HOLTEC Campaign March 27. – August 18. 2023**

**The first 16 casks have been stored in the SFDS Building**

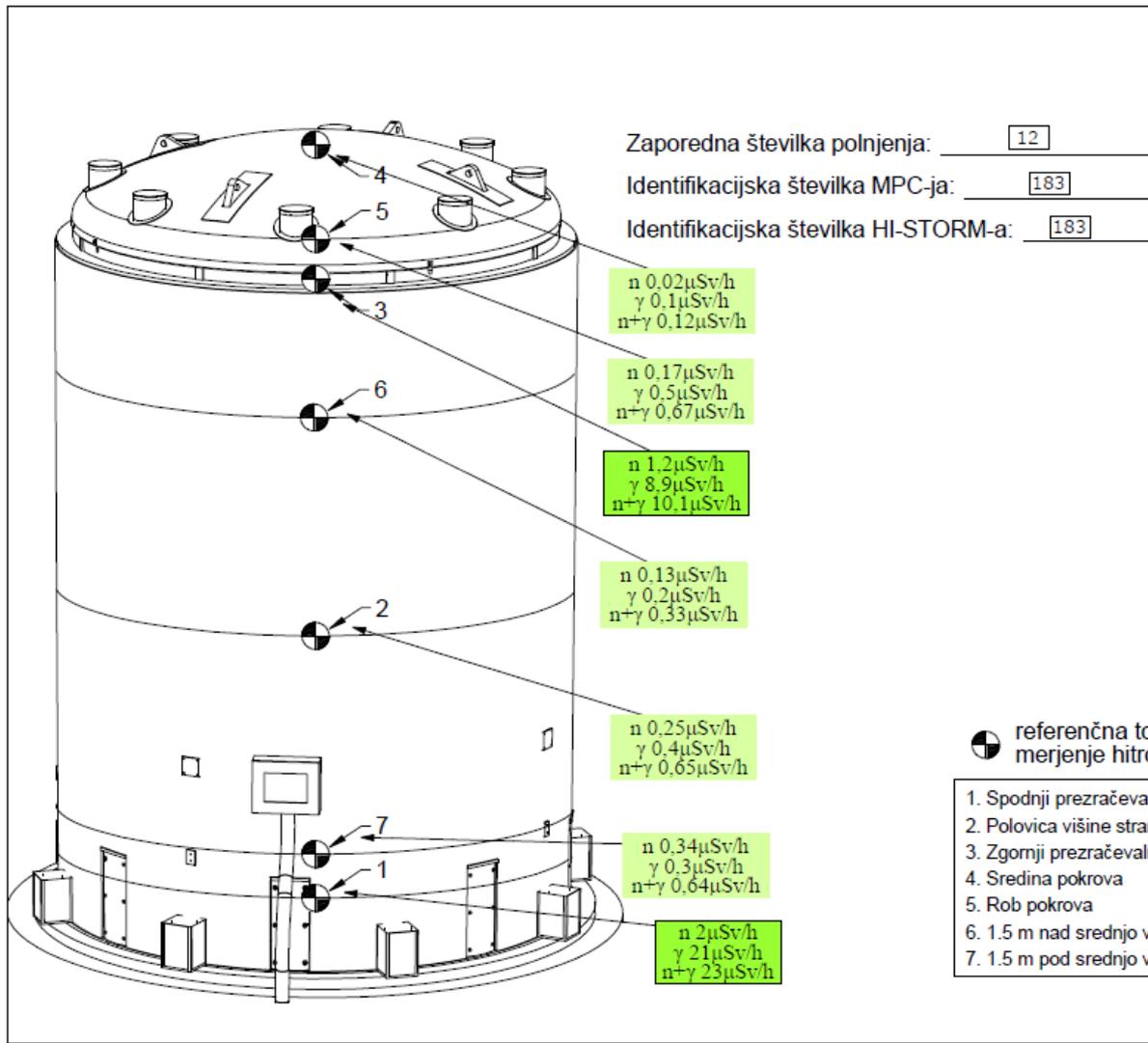
# HI-STORM (Holtec)

No. 12

## Dose rate Survey REPORT

Nuklearna elektrarna Krško / Krško NPP  
RADIOLOŠKI NADZOR - MERITVE  
RADIATION MONITORING AND CONTROL - SURVEY

Map name: DSB 100.55 002 , STORAGE AREA

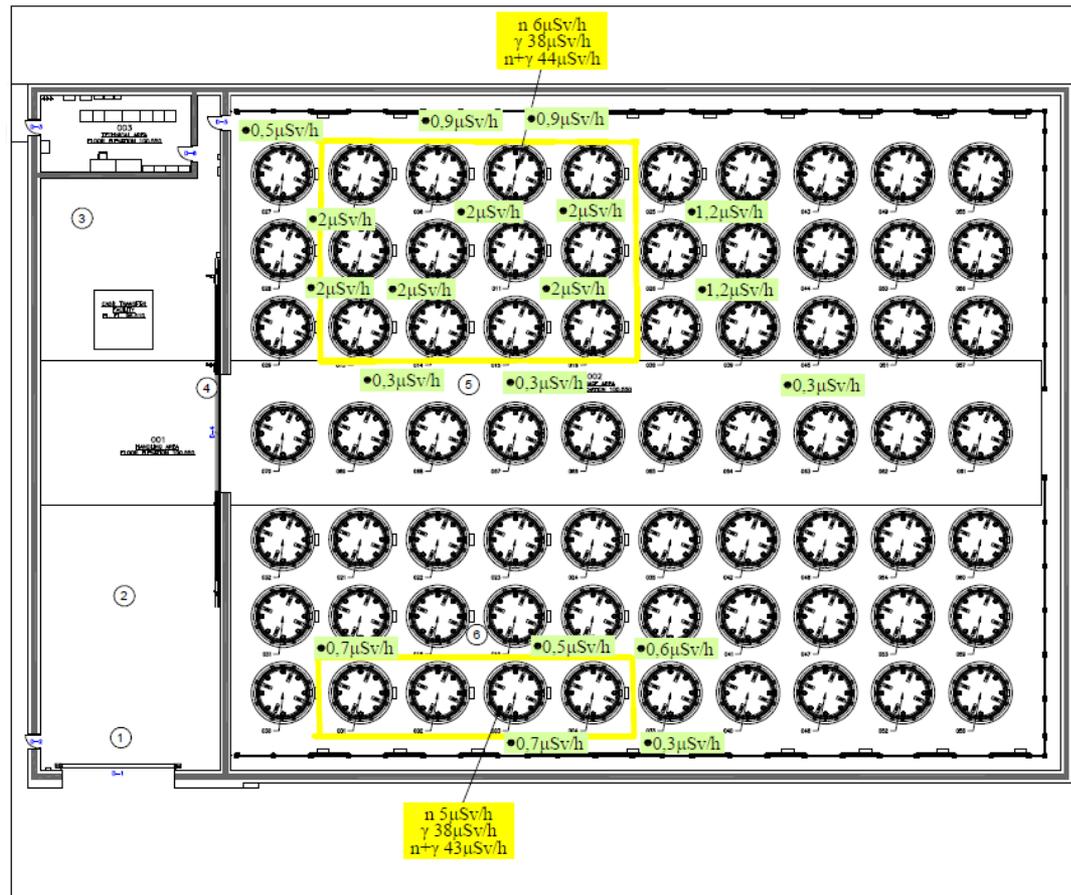


# SFDS 2023

# Survey REPORT

## Nuklearna elektrarna Krško / Krško NPP RADIOLOŠKI NADZOR - MERITVE RADIATION MONITORING AND CONTROL - SURVEY

Map name: DSB 100.55 000 , DSB\_100.55



BRIS KONTAMINACIJE Bq/100 cm <sup>2</sup>	
1	0 βy tla 0 α airta
2	0 βy tla 0 α airta
3	0 βy tla 0 α airta
4	0 βy tla 0 α airta
5	0 βy tla 0 α airta
6	0 βy tla 0 α airta

BRIS VELIKEGA PODROČJA Bq/100 cm <sup>2</sup>	

DIREKTNA MERITEV KONTAMINACIJE Bq/100 cm <sup>2</sup>	

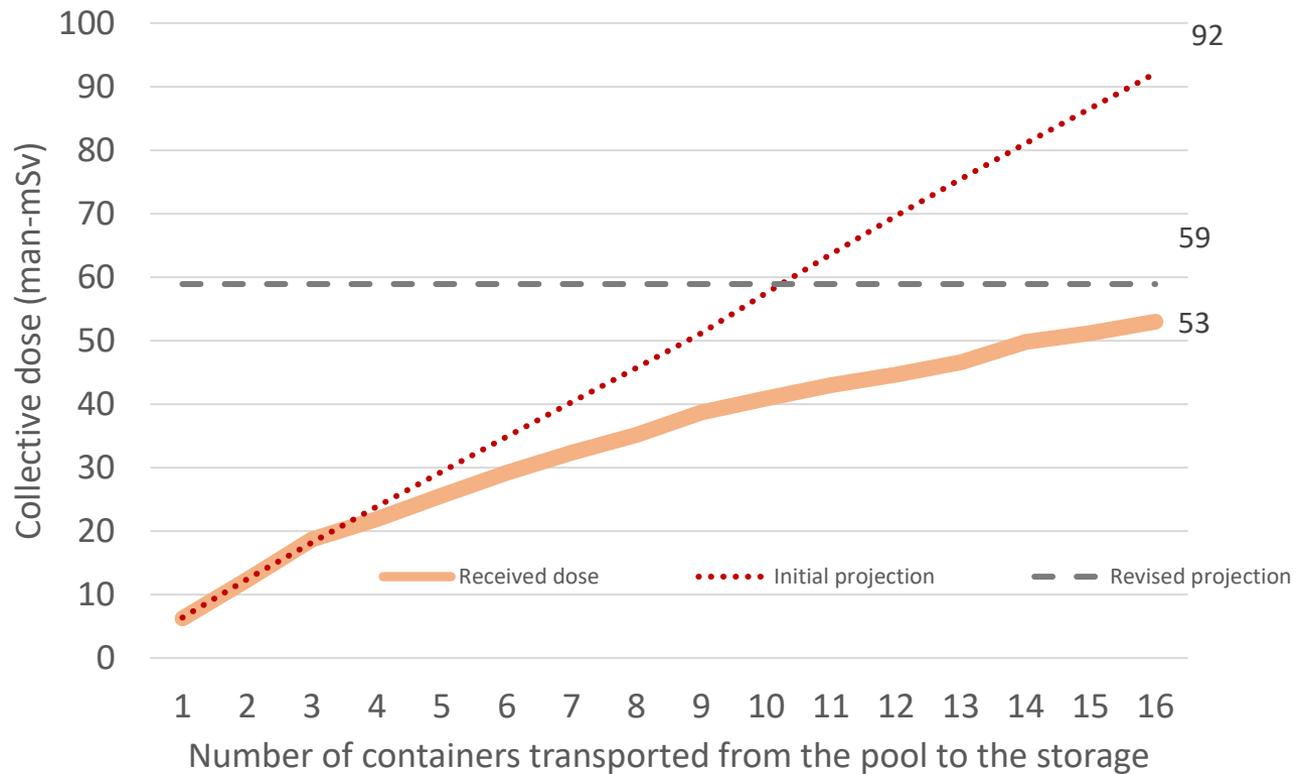
VZOREC ZRAKA Bq/m <sup>3</sup>	

Komentar:  
Vrata D-1 in D-2 so zaklenjeni.  
Zapisana je največja hitrost  
caskov v posameznem obdobju.

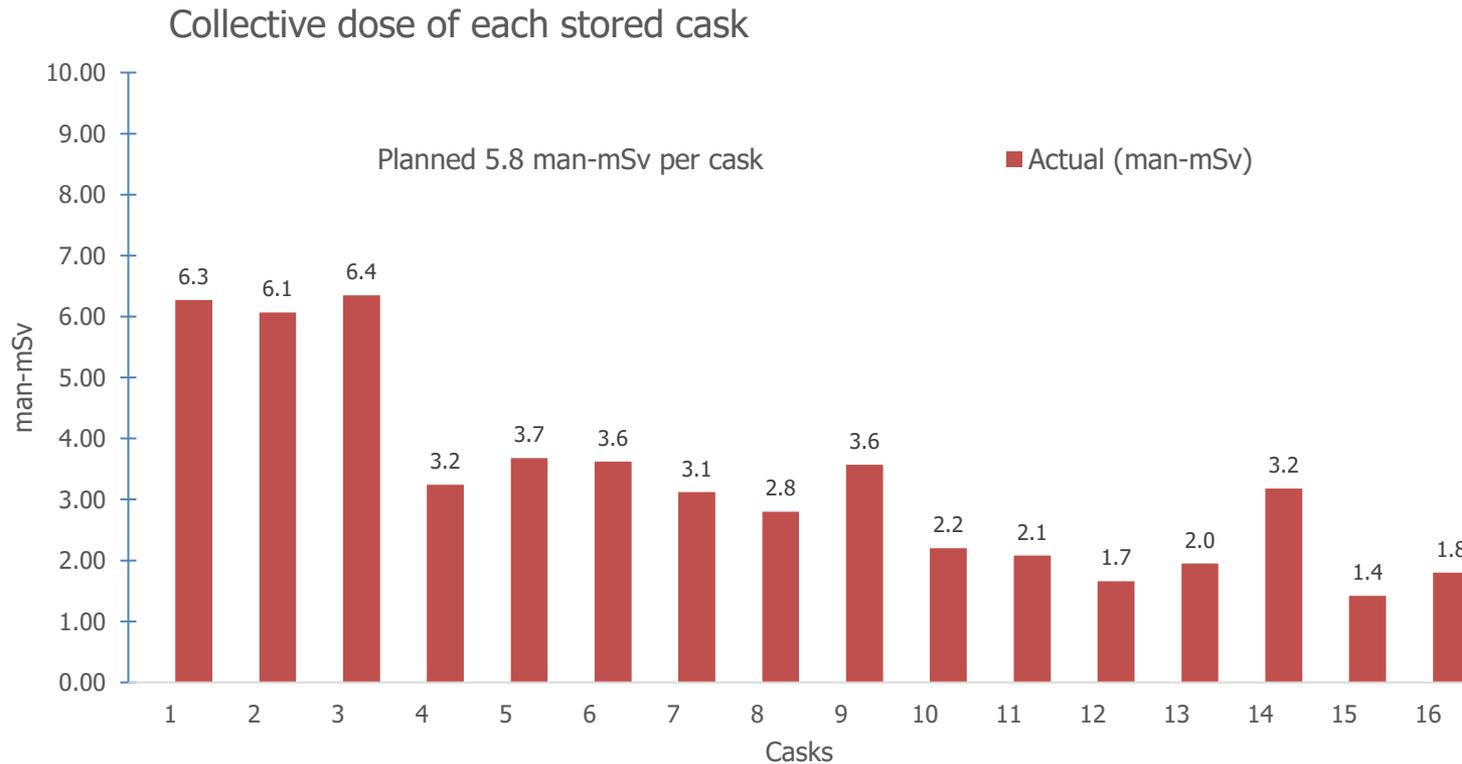
- <0.025 mSv/h      ● y hitrost doze      ● <400 Bq/100cm<sup>2</sup>
- 0.025 - 1.0 mSv/h      ● Gamma dose rate      ● 400 - 4000 Bq/100cm<sup>2</sup>
- >1.0 mSv/h      ● n nevtroni      ● >4000 Bq/100cm<sup>2</sup>
- β beta      ● (1/10 za alfa)
- ① Bris kontaminacije      A Bris velikega področja
- Smear contamination      Large area smear
- a Direktna meritev      1 Vzorec zraka
- Direct contamination      Air sample
- measurement      Vroča točka
- \* Stalna meritev



SFDS PROJECT 2023- Received vs. Projected Collective Dose  
(passive dosimetry readings OSL)  
in man-mSv



# First Spent Fuel Dry Storage Campaign





## Information Exchange and International Contacts

- Sizewell ALARA Presentation, ALARA Report and Expert Consultation (ISOE Membership) Sizewell Experts
- Holtec – Angra Visit to Observe and Consult on Dry Storage Activities (Project Management)
- Landauer - Neutron and Gama Dosimetry Services (in paralell to NEK's)
- Nutronic Support in RP manpower
- Webinar on Cook-Braidwood SFDS Lessons Learned (NATC ISOE for Krško staff)

## Supervision

Continous Supervision of Independent Experts Managed by the Regulator

# FORCED OUTAGE 2023 (October-November)



## Event Description 5.10.2023

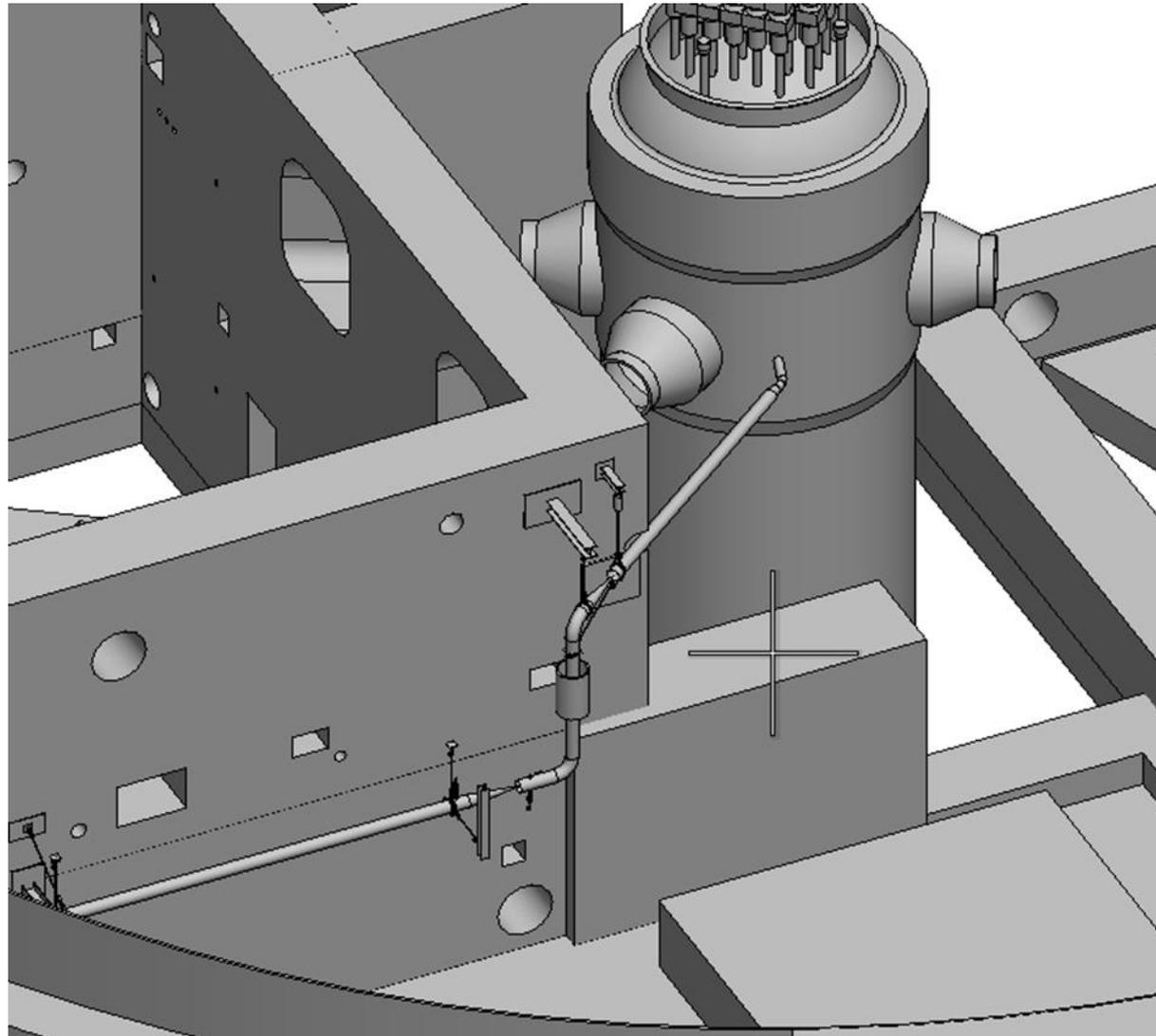
### Reactor Coolant Leakage 27 l/h

- Containment particulate monitor 70 Bq/m<sup>3</sup> (RM-11)
- Iodine and Xenon radionuclides in the first gamma spectrometry of the air sample
- Additional air filter analysis shows also traces of corrosion product and the others:

Mn-54, Co-58, Fe-59, Co-60, Mo-99, Br-82, Cs-134, Cs-137

- Containment quick inspection
- Reactor shutdown and cooldown

# Safety Injection (SI) pipe



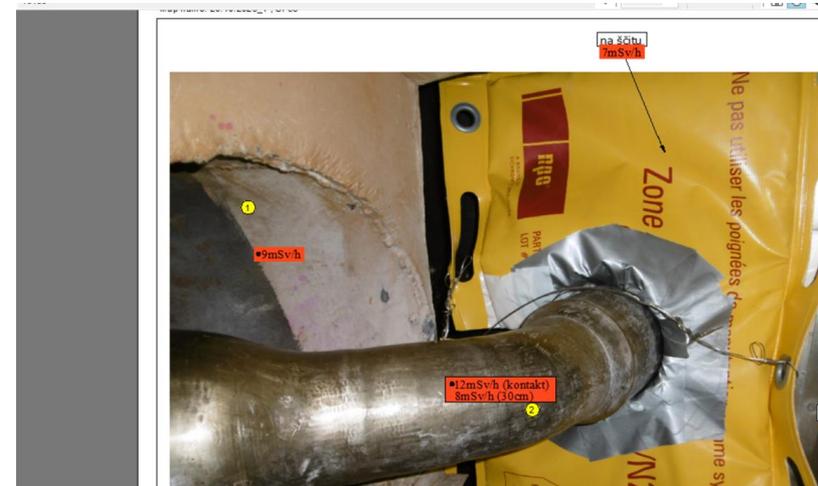


# Safety Injection Line

Leakage location



dose rates 3,5 mSv/h  
to 12 mSv/h



# Safety Injection Line Repair

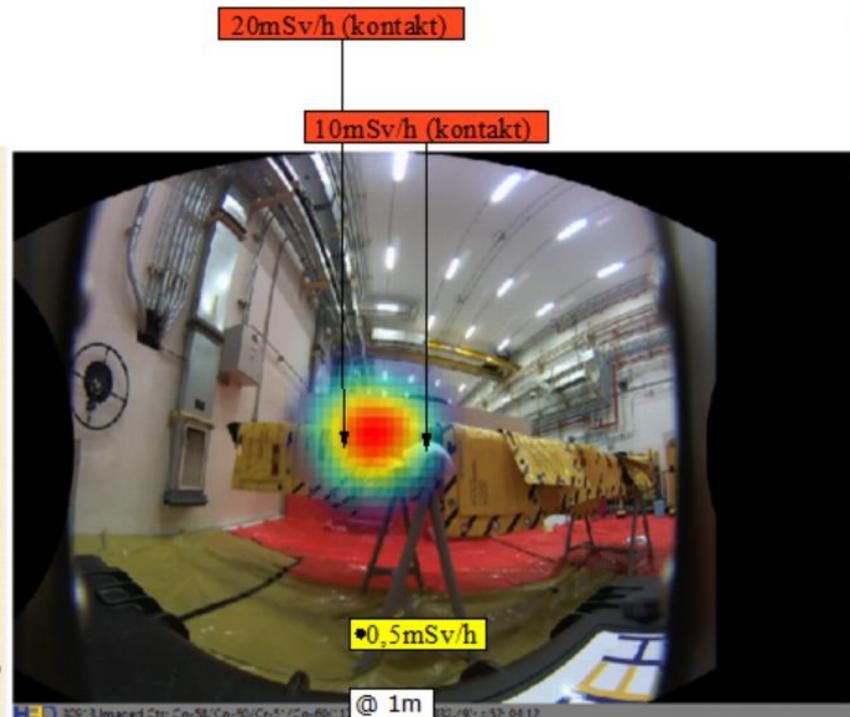
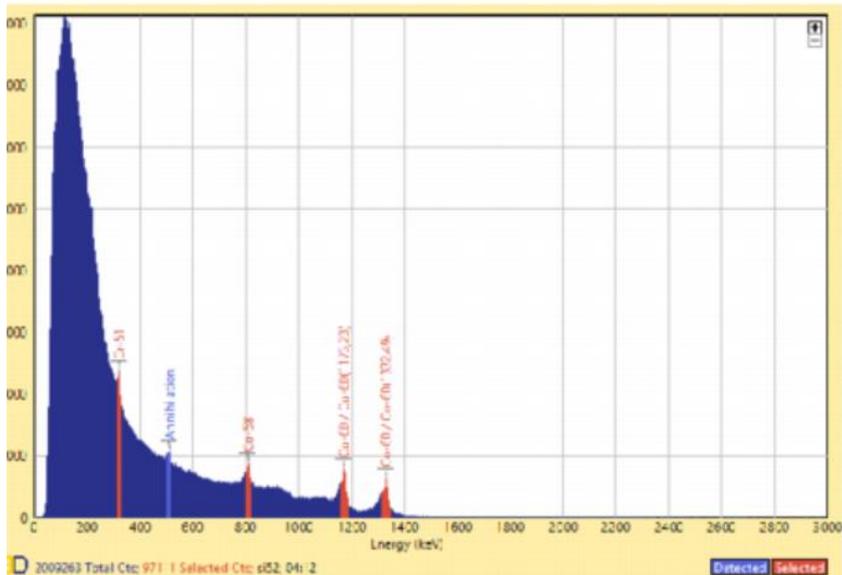


BRIS KONTAMINACIJE Bq/100 cm <sup>2</sup>		N	Sheet Proper
6	300 βγ cev znotri 0 α R <sub>alfa</sub> =0,00%	S	Object Properties
4	220 βγ stena stopniš 0 α R <sub>alfa</sub> =0,00%	D	
5	70 βγ strop 0 α R <sub>alfa</sub> =0,00%	M	
1	60 βγ cev 0 α R <sub>alfa</sub> =0,00%	M	Views
2	50 βγ stena 0 α R <sub>alfa</sub> =0,00%	S	
3	50 βγ pločevina 0 α R <sub>alfa</sub> =0,00%	K	
BRIS VELIKEGA PODROČJA Bq/100 cm <sup>2</sup>		M	Cross Sections
		S	
		K	
DIREKTNA MERITEV KONT. Bq/100 cm <sup>2</sup>		N	Layers
		I	
		V	
VZOREC ZRAKA Bq/m <sup>3</sup>		P	Text Data
		O	
			Grid Data

# SHIELDED PIPE



## Qualitative Analysis with Gamma Camera: Cr-51, Co-58 and Co-60 activation products



BRIS VELIKE Bq/1
DIREKTNA M Bq/1
VZORE B

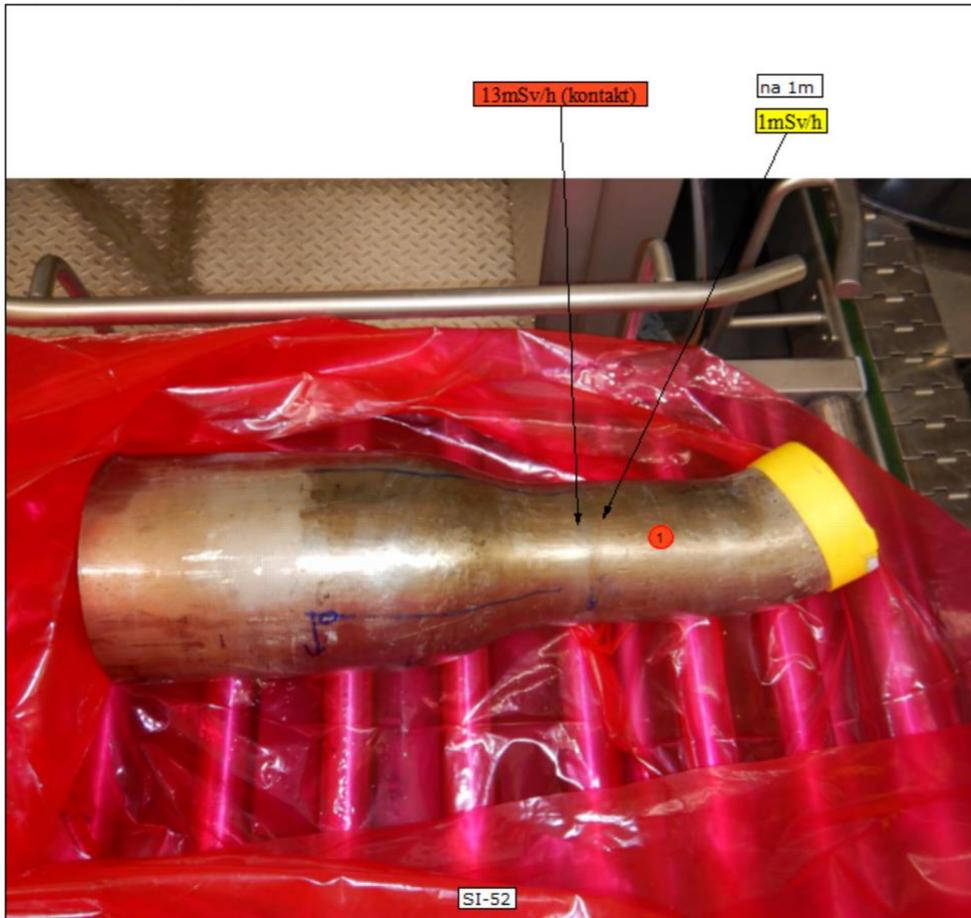
# Shipment for metallurgical analysis



## Nuklearna elektrarna Krško / Krško NPP RADIOLOŠKI NADZOR - MERITVE RADIATION MONITORING AND CONTROL - SURVEY

Map name: DEL SI CEVI\_1, WMB100

Survey #: 113311



BRIS KONTAMINACIJE Bq/100 cm <sup>2</sup>		NADZOR: 113311 Stran: 1 od 1 Datum: 08.11.2023 Moč Rx: 0% Razlog: Izredni
1	10 k βy notranjost 8 α R <sub>alfa</sub> =0,08%	
BRIS VELIKEGA PODROČJA Bq/100 cm <sup>2</sup>		MECL:
DIREKTNA MERITEV KONT. Bq/100 cm <sup>2</sup>		
VZOREC ZRAKA Bq/m <sup>3</sup>		Mer: RADEYE G-10 S/N: 33048 Kal.do: 07.03.2024 Mer: RADEYE GX S/N: 11734 Kal.do: 24.12.2023 Mer: RADEYE SX S/N: 51715 Kal.do: 05.02.2024 Mer: RAM ION S/N: 2198-022 Kal.do: 03.04.2024  Nadzor opravil: Maja Kozole Misha Romih  Pregledal: Marjan Pavlin  Odobril: Marjan Pavlin
Komentar: SI-52 28,4 kg		

- <0.025 mSv/h      ● γ hitrost doze      ● <400 Bq/100cm<sup>2</sup>
- 0.025 - 1.0 mSv/h      ● Gamma dose rate      ● 400 - 4000 Bq/100cm<sup>2</sup>
- >1.0 mSv/h      ● n nevtroni      ● >4000 Bq/100cm<sup>2</sup>
- β beta      ● (1/10 za alfa)
- 1 Bris kontaminacije      A Bris velikega področja
- 1 Smear contamination      A Large area smear
- a Direktna meritev kontaminacije      ■ Vzorec zraka
- a Direct contamination measurement      ■ Air sample
- \* Stalna merilna točka (Measurement point)      ■ Vroča točka (Hot spot)

**Preliminary findings**



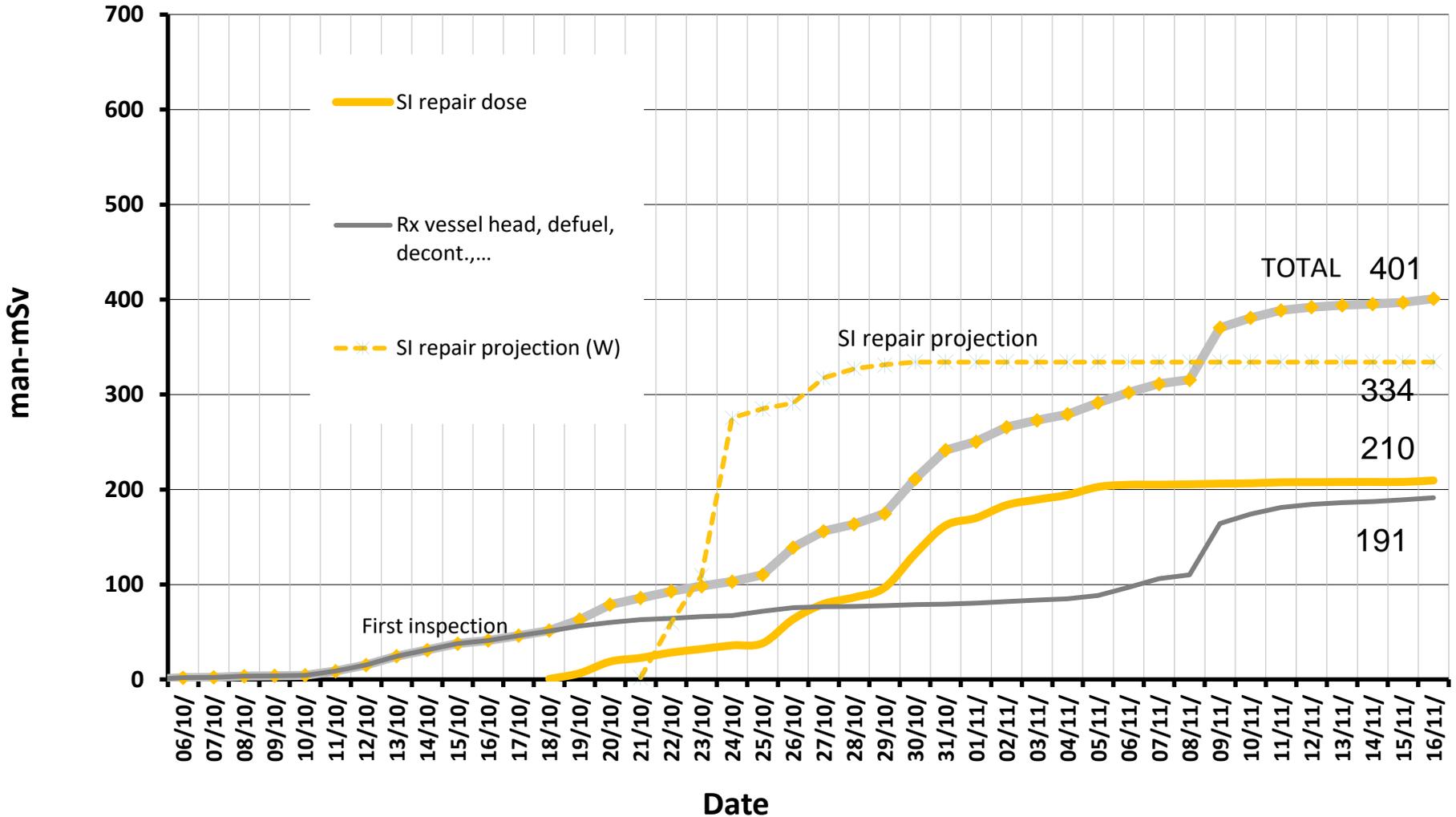
**Corrosion fatigue?**

# SI pipeline repair project



## FORCED OUTAGE 2023 COLLECTIVE DOSES

(man-mSv)





## Information Exchange and International Contacts

- Doel NPP - Lessons Learned (ISOE Membership)
- Contractor - Westinghouse (initial ALARA plan)

## Supervision

Continuous Supervision of the Experts Managed by the Regulator