ALARA in Practice
Reactor internal parts repair at the Temelín NPP

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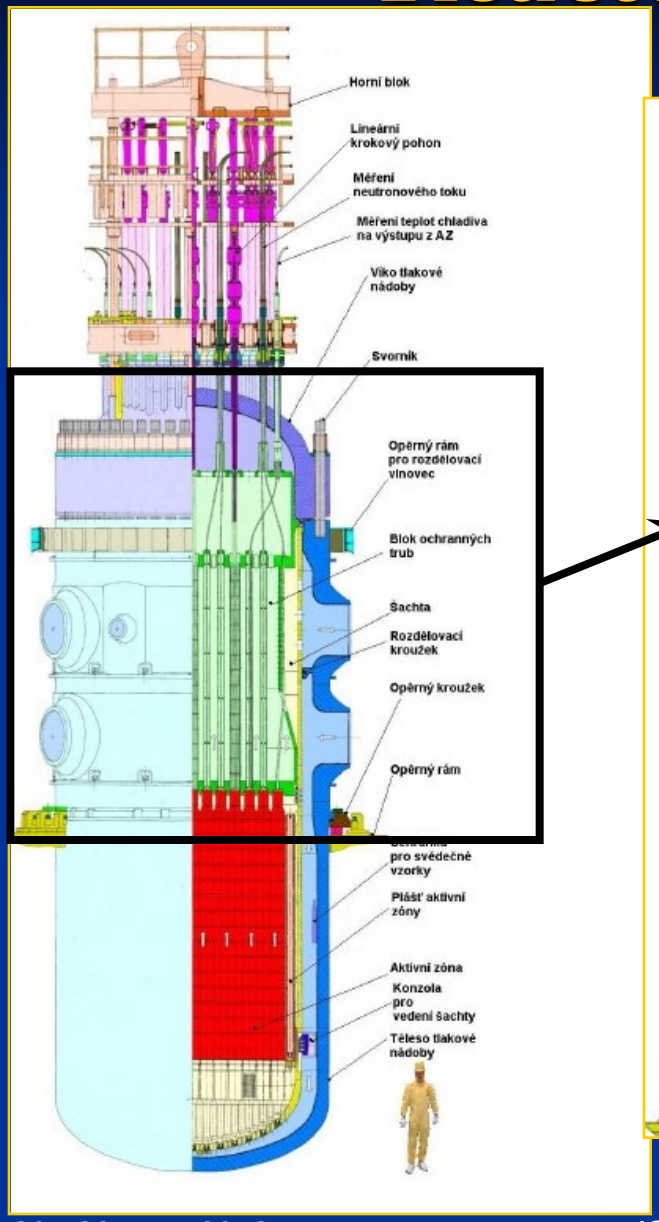
ALARA in practice

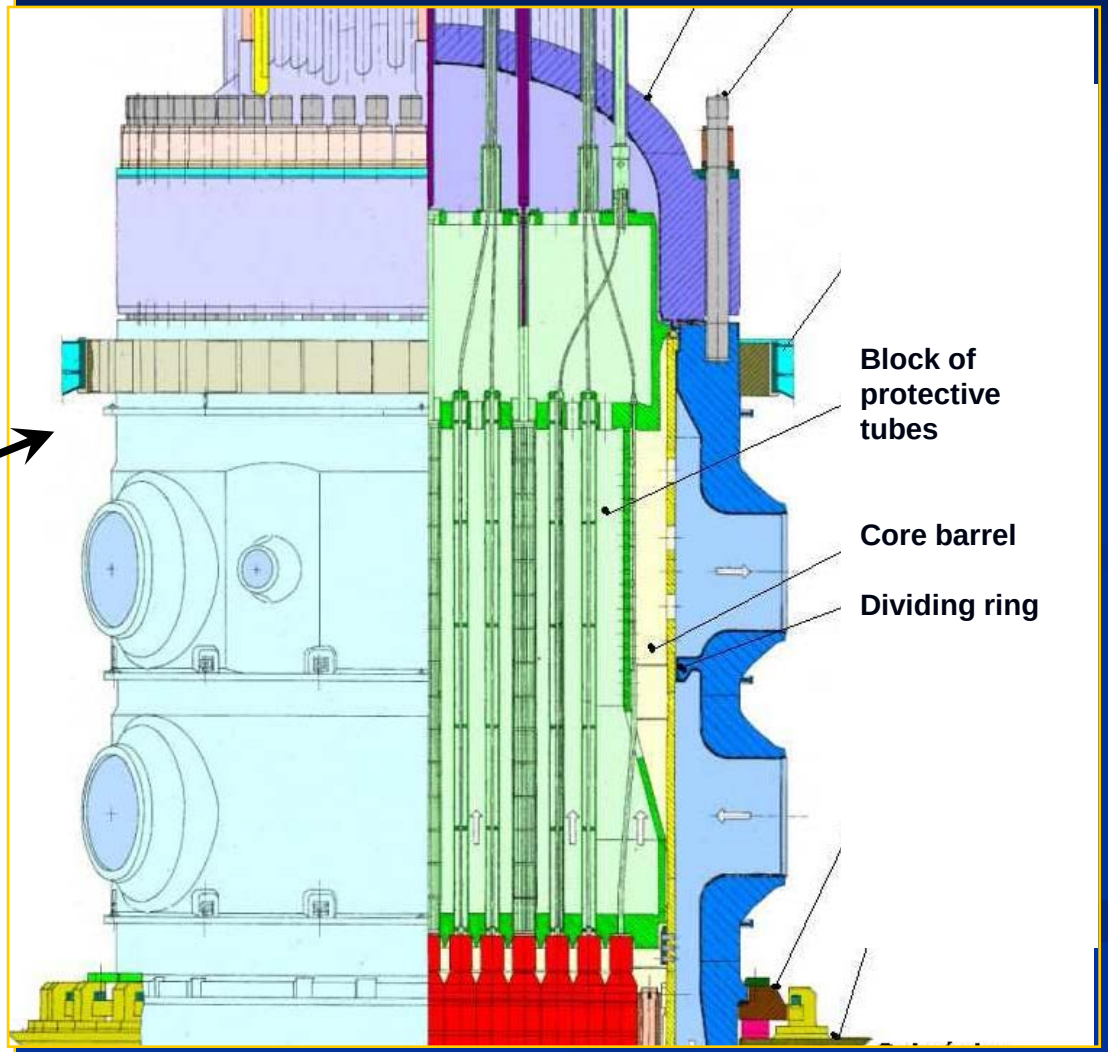
- cause of situation
- situation
- caused activities
- dose optimization
- results

Situation and its cause

- Temelín NPP, Unit 2 refuelling outage 2011
- damage of the reactor inner parts:
  - block of protective tubes – bottom plate surface
  - core barrel – inner and outer surface
  - reactor vessel dividing ring – inner surface
- cause: mutual seizing with foreign objects (stainless steel pin, nut)
- damage: scratches, grooves, pressure marks

Reactor cross section





Transport cavity, inspection wells

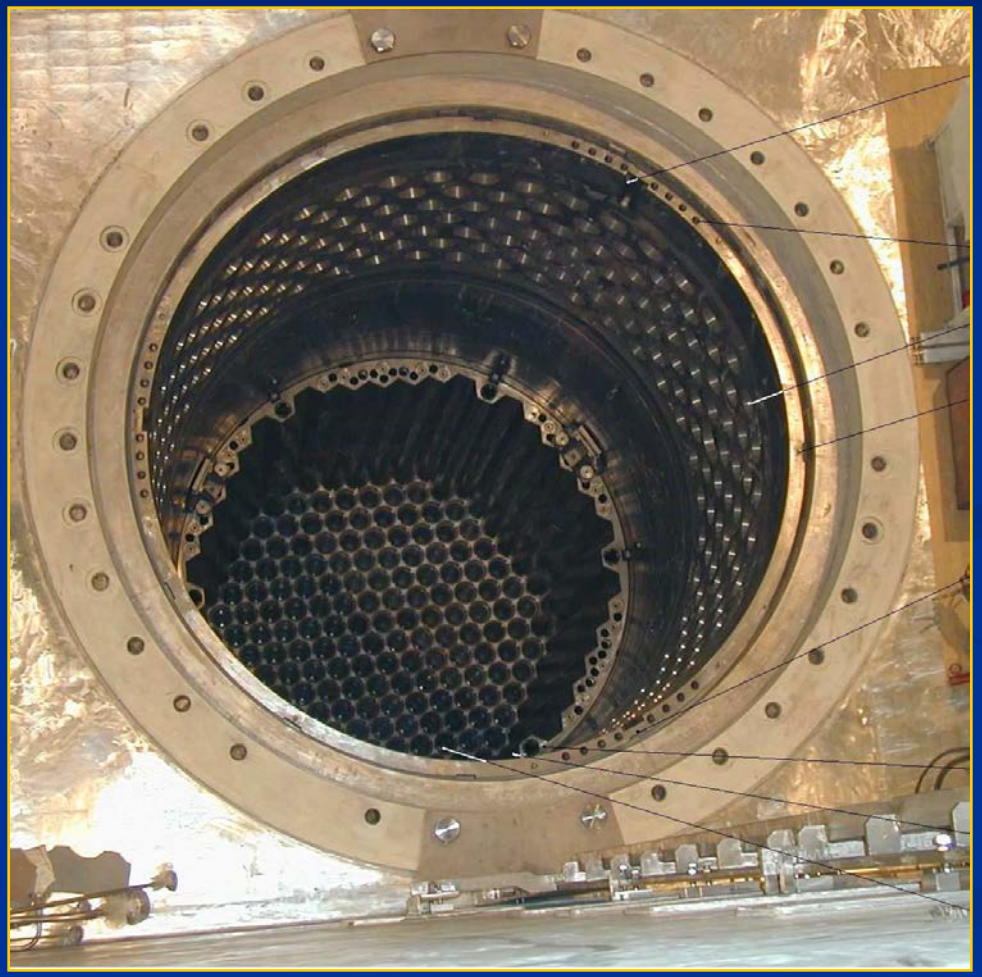
Starting point for repairs

- foreign objects removed
- block of protective tubes in inspection well
- fuel removed
- core barrel in inspection well
- reactor and both inspection wells filled with water
- surface damage – well known position, remote identification, imprints of scratches
- unknown radiation situation

Works to do

- grinding, burnishing of scratches
- non destructive testing, taking of check imprints
- imprints analyses at the ŠKODA material testing laboratories
- calculations and simulations

Core barrel



General scenario – preparation

- careful radiation situation analysis
- detailed procedures description – chronology of activities, hazards, dosimetry, alarms, …
- documentation – R-order, RP ensuring program
- repair drill, test run, monitoring functional test
- pre-job briefing

General scenario – repair execution

- general exposure reduction principles: time, distance, shielding
- RP supervision and support
- occupational safety

General scenario – after works

- removing of protective clothing and protective tools
- contamination check
- decontamination of equipment
- evaluation of executed works
- dose assessment
- post-job debriefing

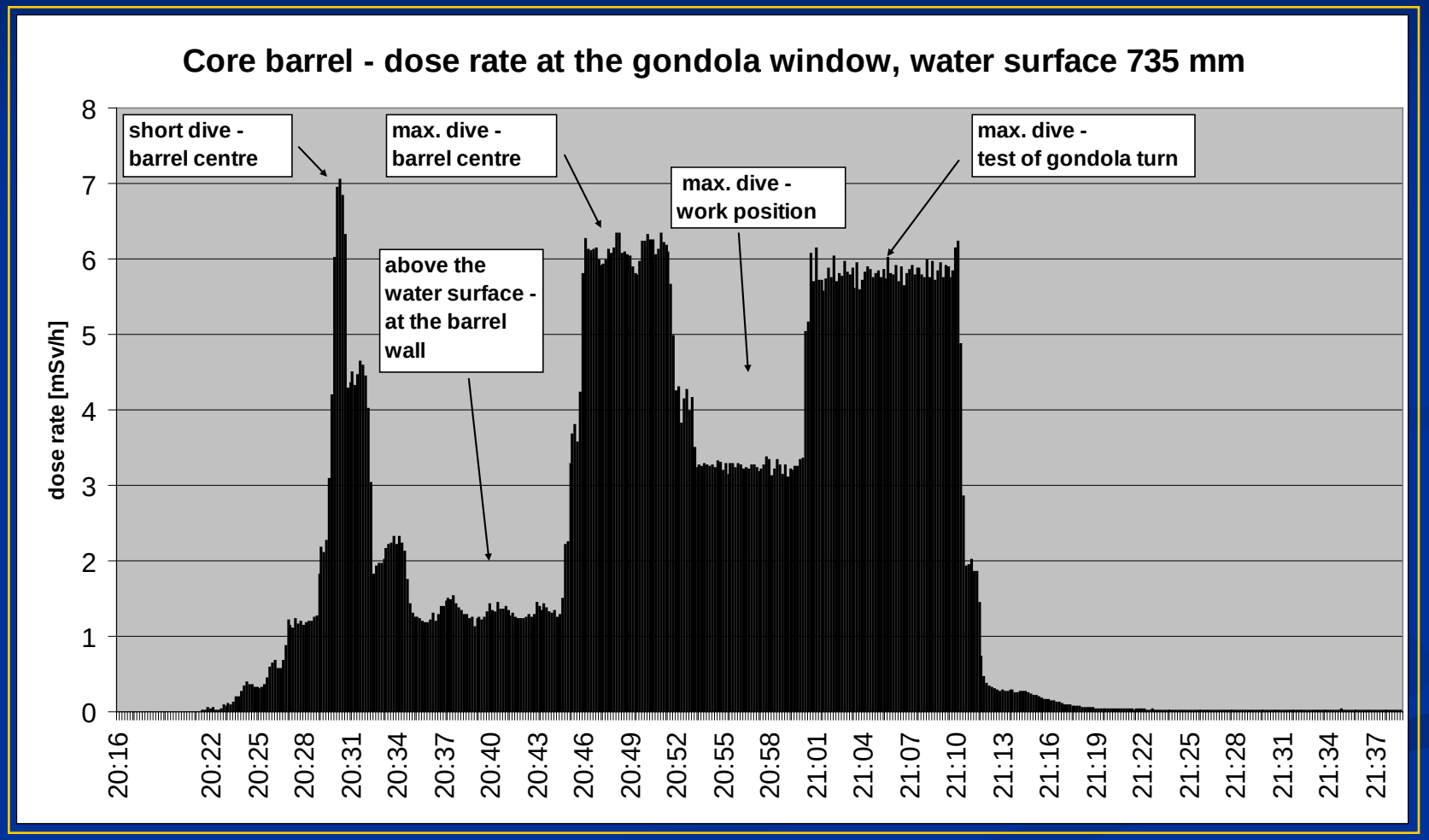
Core barrel repair preparation – inner surface

- lead shielded hanging cage (the gondola)
- optimization of the gondola trajectory
- precise tuning of the water level in the well
- careful work preparation – manual works
- unoccupied gondola test run with on-line remote radiation monitoring in the gondola

Core barrel repair preparation – inner surface

- the gondola
- mass 7360 kg
- max. load 300 kg
- lead shielding 5 cm / 10 cm bottom
- additional shielding - Radshield plate

Core barrel repair preparation – inner surface



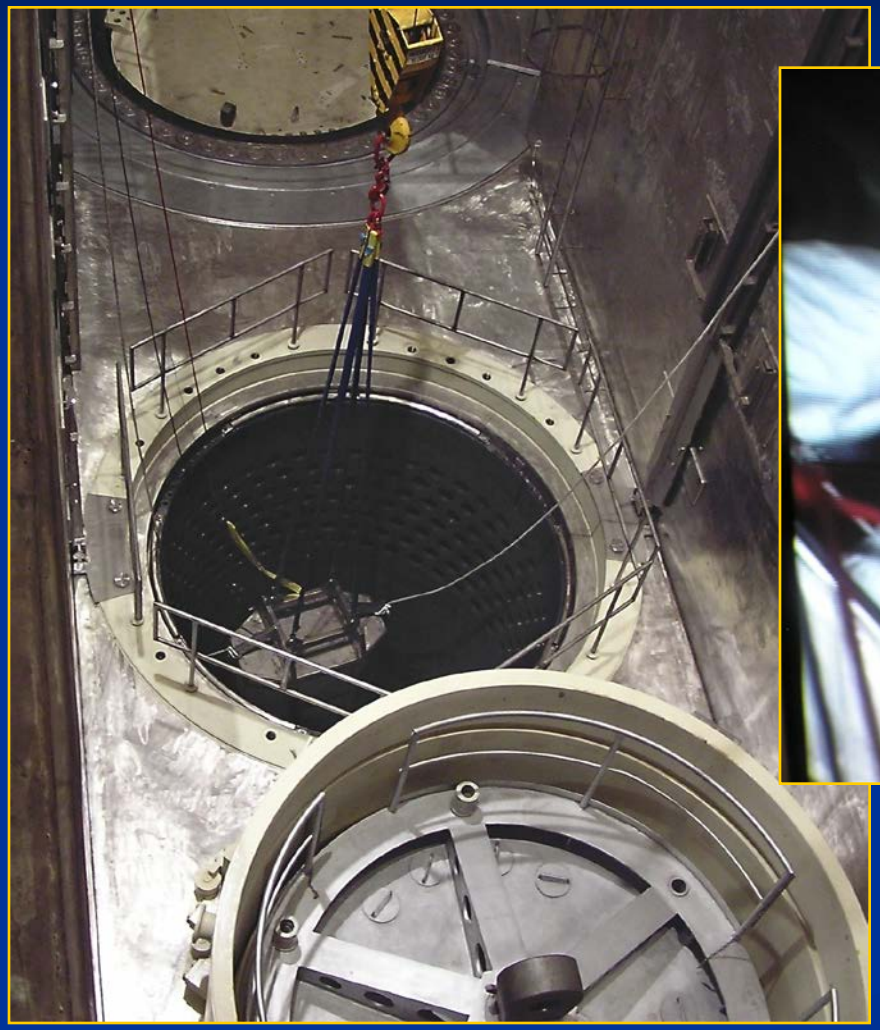
Core barrel repair – planned doses

Activity	Time (min)	Max. dose (mSv)	Number of workers	KED (mSv)
Gondola lowering	10	0,250	6	1,50
Repairs	50	4,000	2	8,00
Gondola pulling up	10	0,250	6	1,50
Gondola relocation	5	0,500	6	3,00
Visual test	2	0,250	2	0,50
Penetration test – app.	15	1,375	2	2,75
Penetration test – eval.	15	1,375	2	2,75
Total	107	$IED_{max} = 5$	2 + 2	20,00

Core barrel repair – inner surface
Repair execution

- work time reduction – experienced workers
- shielding – the gondola, Radishield
- distance – gondola as close as possible to wall
- work combination: 2 persons (repairer, tester)
- workers on the gondola bottom during transportation, optimized gondola trajectory
- occupational safety – emergency extrication, communication, remote dose rate monitoring

Core barrel repair – inner surface



Core barrel repair – inner surface
Obtained doses

Activity	Time (min)	Plan. IED (mSv)	Plan. KED (mSv)	Number of workers	IED_{max} (mSv)	KED (mSv)
Repairs incl. transports (all persons)	260	5,0	10,0	9	0,920	1,908
NDT incl. transports (all persons)	240	5,0	10,0	4	1,015	2,218
Total	7:30 – 18:40	5,0	20,0	13	1,015	4,126

Core barrel repair – outer surface

- preparation – dose rate monitoring during core barrel drawing up from the inspection well
- works: manual burnishing of scratches from the transport cavity bottom
- NDT, check imprints

Core barrel repair – outer surface

Core barrel repair – outer surface
Obtained doses

Activity	Time (min)	Plan. IED (mSv)	Plan. KED (mSv)	Number of workers	IED_{max} (mSv)	KED (mSv)
Repairs incl. support	60	2,0	5,0	6	0,048	0,189
NDT	30	0,5	1,0	3	0,117	0,194
Total	8:35 – 9:40	2,0	6,0	9	0,117	0,383

Reactor vessel dividing ring – inner surface

- similar to the core barrel inner surface repair
- works: manual burnishing of scratches from the gondola
- NDT, check imprints

Reactor vessel dividing ring – inner surface

RV dividing ring – inner surface
Obtained doses

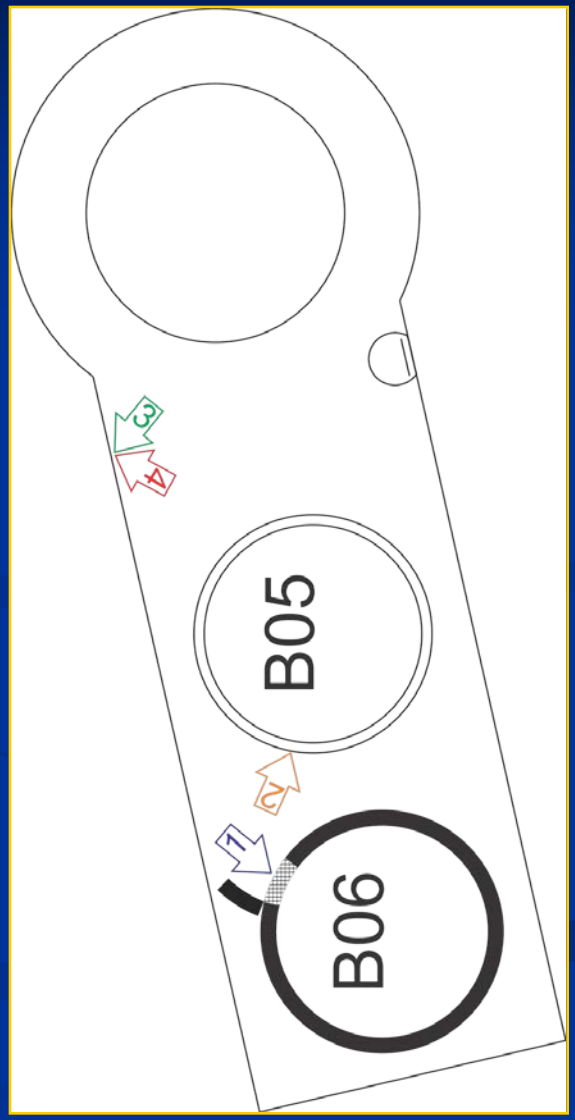
Activity	Time (min)	Plan. IED (mSv)	Plan. KED (mSv)	Number of workers	IED_{max} (mSv)	KED (mSv)
Repairs incl. transports	70	5,0	8,0	2 / 1	0,094	0,094
NDT	70	5,0	8,0	2 / 1	0,108	0,108
Repairs – support	80	5,0	4,0	5	0,009	0,050
Total	13:40 – 15:00	5,0	20,0	7	0,108	0,252

Block of protective tubes

- severe radiation situation – remote monitoring
- works: remote milling and burnishing of scratches at the bottom plate surface

Block of protective tubes

- dose rate measurement
- 4 top of the ladder
  45 mSv/h
- 3 mid of the ladder
  87 mSv/h
- 2 core barrel well (150 cm)
  236 mSv/h
- 1 supporting ring window
  244 mSv/h (max 2682 mSv/h)



Block of protective tubes

- schematic view of remote repair assembly

Block of protective tubes
Obtained doses

Activity	Time (min)	Plan. IED (mSv)	Plan. KED (mSv)	Number of workers	IED_{max} (mSv)	KED (mSv)
Repairs incl. support	480	2,0	8,0	7	0,046	0,134
Indirect NDT	480	1,0	2,0	4	0,004	0,004
Total	1:45 – 10:00	2,0	10,0	11	0,046	0,138

Overview of results

Repair of:	Repair KED (mSv)	Total KED (mSv)
Core barrel	4,5	8,2
RV dividing ring	0,3	3,2
Block of protective tubes	0,1	3,8
Other activities		0,9
Total	4,9	16,1

Total = incl. supporting activities

Thank you for your attention