Research Reactor Decommissioning Demonstration Project (R^2D^2P)

Workshop on ‘’Dismantling of the higher active parts of a research reactor’’

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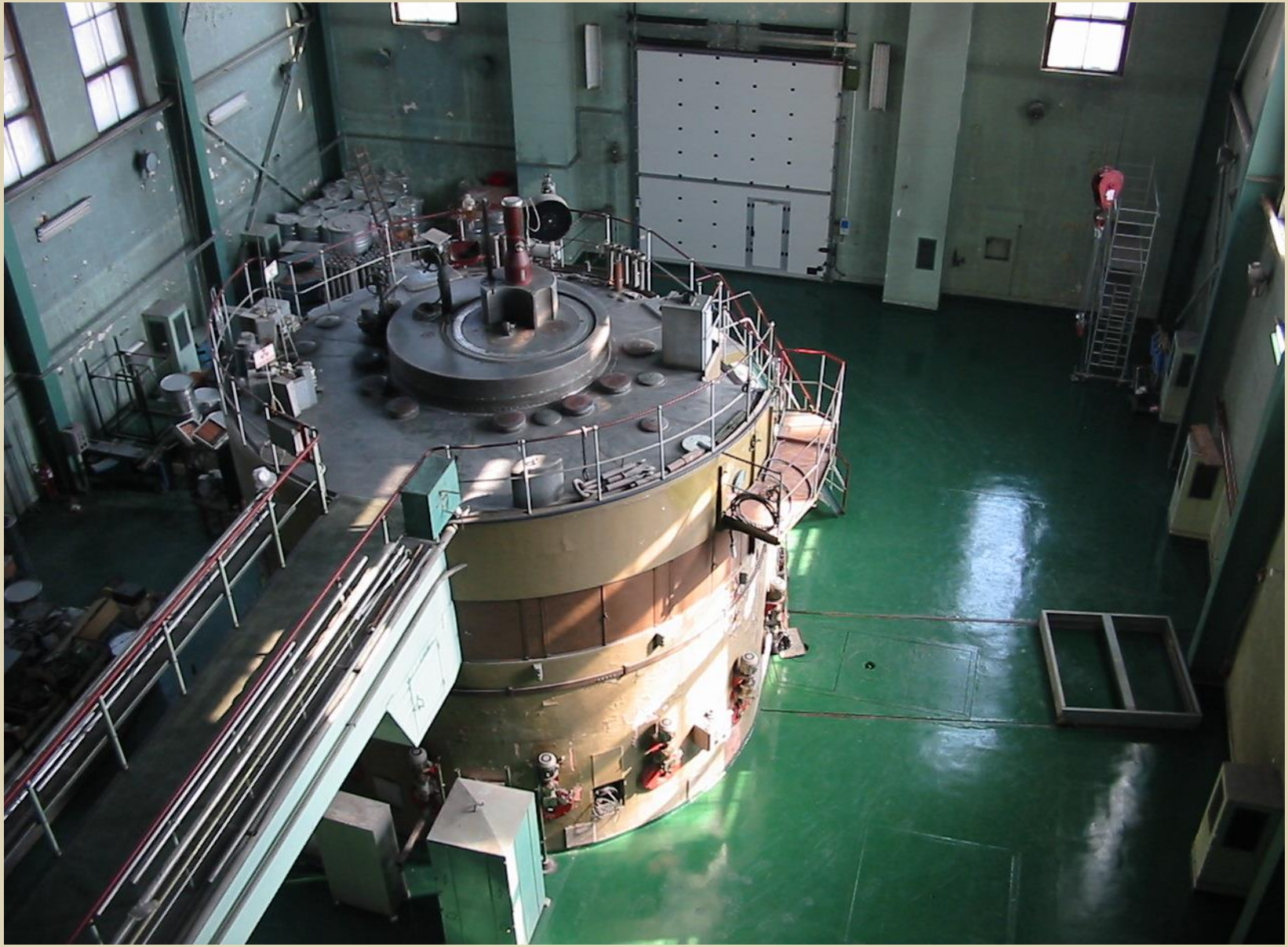
REACTOR BLOCK

DISMANTLING CONCEPTS



1. DECOMMISSIONIG CONCEPTS

- The decommissioning of the facility can be done with different technical assumption.
- One major aspect is the environmental protection and the ALARA principle concerning the operators.
- Following this directive the work packages of decommissioning steps has been developed covering the main aspects of safety provisions.
- The decisions regarding dismantling can differ in two basic concepts:

- Concept 1 – Dismantling approach from inside outwards starting from top remotely operated; after removal of inner part of the reactor, included activated zones, further dismantling will be continued manually as it is described in concept 1.

- Concept 2 – Dismantling approach from outside inwards starting from top manually operated

2. Common consideration for both concepts

- 2.1. Initial status before starting dismantling
  - Core basket is emptied totally
  - Reactor vessel is emptied
  - Reactor vessel is continuously dry air vented
  - Power supply and I&C systems are disconnected
  - Experimental channels are emptied by additional procedures
  - Reactor lids and plugs are removed.

- 2.2. All other decommissioning steps regarding the further plant facilities and installations like the dismantling of primary circuit, core / absorber rods, ionizing chambers, drive assembly, core components, other internal components, thermal column, cooling pond, de-aerator, hot cells, technological ventilation, active drainage and ancillary buildings are executed in the same manner in both of the two concepts.

2.3. Preparatory Measures

• Installation of a dry size reduction area consisting of a base tray, disassembly tent with a separate exhaust and disassembly tools, e.g. mechanical cutting tools (band saw), tube milling, tools for plasma cutting and the common separating tools.
• Provide handling equipment for reactor components with high dose output (shielding socket, if using a remotely controlled reactor building crane: contamination protection).
• Provide equipment for concrete cutting (diamond saw, hydraulic excavator [Remote Operated Vehicle ROV] with rock chisel, shear, hydraulic expanding cylinder, drills, hand-operated dismantling tools, etc.).
• Provide a core drilling unit to extract embedded parts like radiation channels and disc cutter unit with diamond embedment for cutting pipes or steel plates like liner.
• Provide exhaustion aggregate (mobile filter units) sucking air directly from operating source.
• Provide a supporting scaffold to be mounted inside the biological shielding; supporting scaffold adjustable to working height.
• Provide a supporting scaffold to be mounted outside reactor block allowing work performance on different levels outside the biological shield.
• Provide an enclosure to cover internal space of reactor biological shielding equipped with auxiliary systems like light, exhaust air opening, power supply opening etc.
• Others: screw drivers, dust cleaners, tools in general.

CONCEPT 1

DISMANTLING APPROACH FROM THE INSIDE OUTWARDS

- This concept will be realized in activated zones based on characterization survey which shows high dose rate. In this case the dismantling approach from inside outwards will be realized remotely of the internal zones starting from top of the reactor.

- After dismantling the activated parts from inside of the reactor the remaining reactor biological shielding will be dismantled from outside manually.

Dismantling Concept I/O (page 1)

- Opening of the reactor vessel (RV) closure head and dismantling in dry size reduction area.
- Lifting out control rod guide thimbles, vertical irradiation channels, decay channels, cover plate and core basket (Handling with shielding socket, alternatively handled with overhead crane); dismantling in wet dismantling area; packaging into transport box using a shielding socket; alternatively by using overhead crane remotely controlled.
- Dismantling of servo motors for driving the rods and mobile fission chambers, cables at the top of the reactor.
- Lifting the reactor tank and dismantling in dry size reduction area; dismantling: preliminary work is done manually, cutting work is done semi-automatically and packaging is done manually.
- Dismantling of the remaining biological shield components which are not cast

Dismantling Concept I/O (page 2)

- Mounting of supporting scaffold inside the biological shielding with the help of remotely controlled reactor building crane
- Positioning of ROV equipped with adequate tools like rock chisel, shovel, hydraulic expanding cylinder
- Starting on top of biological shielding by demolishing the concrete around the backside of cast iron rings including the vertical irradiation channels closest to the core, removal of debris with a shovel and filling in transport containers, container transfer to dismantling in dry size reduction area by using the overhead crane remotely controlled; repetition of work until reaching the level of liner skirt.
- Pick up excavated cast iron rings by overhead crane and transfer to dry size reduction area for further manual dismantling and packing (preliminary work is done manually, cutting work automatically if necessary, packaging is done manually); repetition of work until reaching the level of liner skirt.
- Cutting of excavated irradiation channels remotely by the disc cutter unit and transferring to the dry size reduction area for further manual dismantling.

Dismantling Concept I/O (page 3)

- Removal of liner skirt until not activated level by loosening the concrete on the backside with the ROV, cutting the liner into pieces with the help of the disc cutter unit and transfer to the dry size reduction area for further manual dismantling
- Before reaching the activated zone, positioning of enclosure (plastic tent) above reactor biological shielding and connecting it to the auxiliary system like light, ventilation, power supply of remote operated units etc.
- Continuing the remote dismantling process by the ROV using proved tools for removal of:
  - lower part of activated liner skirt
  - activated cast iron rings
  - activated vertical irradiation channels
- The dismantling will be carried out in the same manner as described before.
- Dismantling of horizontal irradiation channels by using the core drilling unit; excavated channels will be pulled inside, pre cut and transferred to the dry size reduction area for further treatment.

Dismantling Concept I/O (page 4)

After removal of the activated embedded parts and concrete layer of the internal biological shielding the manual dismantling starts with:

- Dismantling of the inactive outer concrete by cutting of the biological shield in blocks (diamond saw technology, hydraulic expanding if no other embedded parts exist).
- Dismantling of activated concrete with hydraulic excavator with rock chisel. Contaminated and activated backfill parts were sealed before, are cut off after concrete was removed, and are then dismantled and packed in the dry size reduction area (preliminary work is done manually, cutting work automatically if necessary, packaging is done manually).
- Dismantling of the inactive outer concrete by cutting of the biological shield in the area of backfill parts using hand-operated dismantling equipment, if necessary, by use of a hydraulic excavator with rock chisel (contaminated backfill parts are sealed before, are cut off after concrete was removed, and are then dismantled and packed in the dry size reduction area (preliminary work is done manually, cutting work automatically if necessary, packaging is done manually)). The concrete parts are packed in transport boxes and are transferred to free released station for free release, if possible.

Dismantling Concept I/O (page 5)

- The thermal shielding is uncovered by removing the ambient concrete. The uncovered cast steel rings are transported to the dry size reduction area by using the overhead crane and are dismantled there. The horizontal jet pipes and the reactor base plate are handled accordingly. In individual cases a preliminary dismantling may be necessary.
- Tubes and channels which are embedded in the reactor base plate are dismantled in the same way as the reactor backfill parts.
- Dismantling of remaining structures
- Cleaning of the area

CONCEPT 2

DISMANTLING APPROACH FROM THE OUTSIDE INWARDS

This concept will be realized based on characterization survey which shows low dose rate in activated zones. In this case the dismantling approach from outside inwards will be realized starting from top of the reactor. The different working steps will be executed manually considering safety aspects.

Dismantling Concept O/I (page 1)

- Removal of RV rotating lid and dismantling in dry size reduction area.
- Lifting control rod guide thimbles, vertical irradiation channels, decay channels, cover plate and core basket (Handling with shielding socket, alternatively handled remotely with overhead crane); dismantling in wet dismantling area; packaging into transport box using a shielding socket; alternatively by using overhead crane remotely controlled.
- Dismantling of servo motors for driving the rods and mobile fission chambers, cables at the top of the reactor.
- Lifting reactor tank and dismantling in dry size reduction area;
  dismantling: preliminary work is done manually, cutting work is done automatically and packaging is done manually.
- Dismantling of remaining biological shield components which are not cast
- Dismantling of the inactive outer concrete coating of the biological shield in blocks (diamond saw technology, hydraulic expanding if no other embedded parts exist

Dismantling Concept O/I (page 2)

- Pick up excavated cast iron rings by overhead crane and transfer to dry size reduction area for further manual dismantling and packing (preliminary work is done manually, cutting work automatically if necessary, packaging is done manually); repetition of work until reaching the level of liner skirt accordingly. In individual cases a preliminary dismantling may be necessary.
- Dismantling of the inactive outer concrete coating of the biological shield in the area of backfill parts using hand-operated dismantling equipment, if necessary, by use of a hydraulic excavator with rock chisel (contaminated backfill parts which are sealed before, are cut off after concrete was removed, and are then dismantled and packed in the dry size reduction area (preliminary work is done manually, cutting work automatically if necessary, packaging is done manually)). The concrete parts are packed in transport boxes and transferred to free released station for free release, if possible.
- The thermal shielding is uncovered by removing the ambient concrete. The uncovered cast steel rings are transported to the dry size reduction area by using the overhead crane and are dismantled there. The horizontal jet pipes and the reactor base plate are handled accordingly. In individual cases a preliminary dismantling may be necessary.

Dismantling Concept O/I (page 3)

- Continuing (partly parallel to the steps before) the remote dismantling process using proved tools for removal of:
  - liner skirt
  - activated cast iron rings
  - activated vertical irradiation channels
- Dismantling of activated concrete with hydraulic excavator with rock chisel. Contaminated backfill parts are sealed before, are cut off after concrete was removed, and are then dismantled and packed in the dry size reduction area (preliminary work is done manually, cutting work automatically if necessary, packaging is done manually).
- Tubes and channels which are cast in concrete in the reactor base plate / are dismantled in the same way as the reactor backfill parts.
- Dismantling of remaining structures
- Cleaning of the area

No	Measure	Tools	Material	Mass	Spec. Data	Duration		Team	Dose Rate	Collective dose
						critical path	parallel			
	Dismantling Approach from inside outwards									
	Preparatory Measures									working time = 6h
I.1	Installation of dry size reduction area	Hack saw tube milling tools for plasma cutting common separating tools				10 d		6	1 µSv/h	369 µSv
	Dismantling									
II.1	Removal of RV rotating lid			x		1 d		4	5 µSv/h	123 µSv
	Lifting									
II.2	- control rod guide thimbles					1 d		4	20 µSv/h	492 µSv
II.3	- vertical irradiation channels					2 d		4	20 µSv/h	985 µSv
II.4	- decay channels					2 d		4	20 µSv/h	985 µSv
II.5	- cover plate					1 d		4	20 µSv/h	492 µSv
II.6	- core basket					1 d		4	20 µSv/h	492 µSv
IV.8	- shielding socket									

IV.9	Dismantling of rotating lid in dry dismantling area	transport box shielding socket remotely controlled overhead crane		44.500 kg	400 kg/Mh		28 d	4	20 µSv/h	13.692 µSv
IV.10	Lifting reactor tank	reactor building crane				1 d		6	50 µSv/h	1.846 µSv
IV.11	Dismantling reactor tank	dry size reduction area					5 d	4	50 µSv/h	6.154 µSv
	Dismantling of upper biological shield components			2.000 kg	20 kg/Mh	2 d		6	10 µSv/h	
IV.12	- control rod drives			incl.						
IV.13	- e-supply			incl.						
IV.14	- entrance RV head			incl.						
IV.15	- drives of horizontal jet pipe lock			incl.						
IV.16	Mounting of supporting scaffold inside the biological shielding	remotely controlled reactor building crane				5 d		6	20 µSv/h	3.692 µSv
IV.17	Positioning of ROV	rock chisel ROV shovel hydraulic expanding cylinder				2 d		6	10 µSv/h	738 µSv
IV.18	Demolishing of concrete on biological shielding around the backside of cast iron rings including the vertical irradiation channels (A)	shovel transport container remotely controlled overhead crane	concrete	68.800 kg	125 kg/h	69 d		6	2 µSv/h	5.081 µSv
IV.19	Pick up excavated cast iron rings	overhead crane	cast iron	6 pieces	4 h/piece	3 d		4	10 µSv/h	738 µSv

IV.20	Cutting of excavated irradiation channels	disc cutter unit	steel				20 d	4	10 µSv/h	4.923 µSv
IV.21	Removal of liner skirt until not activated level is reached	ROV disc cutter unit	steel	600 kg	20 kg/Mh	8 d		4	10 µSv/h	1.969 µSv
IV.22	Positioning of enclosure above reactor biological shielding	plastic tent				5 d		6	5 µSv/h	923 µSv
IV.23	Removal of lower part of activated liner skirt	ROV		600 kg	20 kg/Mh	8 d		4	20 µSv/h	3.938 µSv
IV.24	Removal of activated cast iron rings					5 d		4	20 µSv/h	2.462 µSv
IV.25	Removal of activated vertical irradiation channels	ROV		6 pieces	4 h/piece			4	20 µSv/h	0 µSv
IV.26	Dismantling of horizontal irradiation channels	core drilling unit		9 pieces				4	20 µSv/h	0 µSv
IV.27	Dismantling of the inactive outer concrete cutting of the biological shield in blocks (B)	diamond saw technology		274.560 kg	500 kg/h	69 d		6	2 µSv/h	5.095 µSv
IV.28	Dismantling of the inactive outer concrete cutting of the biological shield in the area of backfill parts (D)	hand-operated dismantling equipment hydraulic excavator with rock chisel		11.130 kg	125 kg/h	11 d		6	2 µSv/h	812 µSv
IV.29	Dismantling of activated concrete (C)	hydraulic excavator with rock chisel		84.378 kg	125 kg/h	84 d		6	10 µSv/h	31.015 µSv
IV.30	Removing of ambient concrete (E)	hydraulic excavator with rock chisel		555.660 kg	500 kg/h	139 d		6	2 µSv/h	10.265 µSv
IV.31	Transport of uncovered cast steel rings	overhead crane		11 pieces	4 h/piece	11 d		4	20 µSv/h	5.415 µSv

IV.32	Dismantle tubes and channels	hydraulic excavator with rock chisel		11 pieces	4 h/piece		10 d	4	20 µSv/h	4.923 µSv
IV.33	Demolishing of remaining parts	hydraulic excavator with rock chisel				10 d		6	5 µSv/h	1.846 µSv
IV.34	Cleaning activities					20 d		6	1 µSv/h	738 µSv
	Intervention	10%								10.983 µSv
	Summary					**460 d**	**63 d**			121 mSv

No	Measure	Tools	Material	Mass	Spec. Data	Duration		Team	Dose Rate	Collective dose
						critical path	parallel			
	Dismantling approach from the outside inwards									
	Preparatory Measures									
III.1	Installation of a dry size reduction area	Hack saw tube milling tools for plasma cutting common separating tools				10 d		6	1 µSv/h	369 µSv
	Dismantling									
IV.1	Removal of RV rotating lid					1 d		4	5 µSv/h	123 µSv
	Lifting	remote handling with overhead crane								
IV.2	- control rod guide thimbles					1 d		4	20 µSv/h	492 µSv
IV.3	- vertical irradiation channels					2 d		4	20 µSv/h	985 µSv
IV.4	- decay channels					2 d		4	20 µSv/h	985 µSv
IV.5	- cover plate					1 d		4	20 µSv/h	492 µSv
IV.6	- core basket					1 d		4	20 µSv/h	492 µSv

IV.7	- shielding socket									
IV.8	Dismantling of rotating lid in dry dismantling area	transport box shielding socket remotely controlled overhead crane		44.500 kg	400 kg/Mh		28 d	4	20 µSv/h	13.692 µSv
IV.9	Lifting reactor tank	reactor building crane				1 d		6	50 µSv/h	1.846 µSv
IV.10	Dismantling reactor tank	dry size reduction area					5 d	4	50 µSv/h	6.154 µSv
IV.11	Dismantling of upper biological shield components			2.000 kg	20 kg/Mh	2 d		6	10 µSv/h	769 µSv
IV.12	- control rod drives			incl.						
IV.13	- e-supply			incl.						
IV.14	- entrance RV rotating lids			incl.						
IV.15	- drives of horizontal jet pipe lock			incl.						
IV.16	Dismantling of the inactive outer concrete cutting of the biological shield (A + B)	diamond saw technology		343.360 kg	750 kg/h	57 d		4	2	2.806 µSv
IV.19	Pick up excavated cast iron rings	overhead crane	cast iron	6 pieces	4 h/piece	3 d		4	10 µSv/h	738 µSv
IV.17	Dismantling of the inactive outer concrete cutting of the biological shield in the area of backfill parts (D)	hydraulic excavator with rock chisel		11.130 kg	125 kg/h	11 d		6	2 µSv/h	812 µSv
IV.19	Removing of ambient concrete (E)	wire saw overhead crane		555.660 kg	750 kg/h	93 d		6	2 µSv/h	6.868 µSv

IV.18	Dismantling of activated concrete (C)	hydraulic excavator with rock chisel		84.378 kg	125 kg/h	84 d		6	10 µSv/h	31.015 µSv
IV.21	Dismantling of liner skirt	ROV disc cutter unit	steel	1.200 kg	20 kg/Mh	15 d		4	10 µSv/h	3.692 µSv
IV.24	Removal of activated cast iron rings					5 d		4	20 µSv/h	2.462 µSv
IV.20	Dismantling of tubes and channels	hydraulic excavator with rock chisel		11 pieces	4 h/piece		10 d	4	20 µSv/h	4.923 µSv
IV.21	Demolishing of remaining parts	hydraulic excavator with rock chisel				10 d		6	5 µSv/h	1.846 µSv
IV.22	Cleaning activities					20 d		6	1 µSv/h	738 µSv
	Intervention	10%								8.304 µSv
	Summary					**339 d**	**43 d**			103 mSv

COMPARISON OF COSTS

Criteria	Concept 1 From inside outwards	Concept 2 From outside inwards
Investment costs		
Equipment for dismantling and disassembly	++	+
Transport equipment	o	o
Transport container		
Dismantling period and personnel costs	++	o
Costs of operation	+	o
Expenditure licensing process	+	o
Required modification of civil structure before starting dismantling activities	o	o
Fire Protection	o	o

Organzation on site – personnel organization	o	o
Waste water path	o	o
Disposal of remote handling devices and equipment	+	o
Decommissioning of remote handling equipment, auxiliary devices and their further appolicability	+	o
Electrical energy consumption	+	o

Remark: Radiation protection aspects were not assessed by financial means.

LEGEND:
o…basic costs
+…higher costs than basic
++…much higher costs than basic

DURATION ESTIMATION AND DOSES FOR THE PERSONAL

CONCEPT 1 Dismantling Approach from inside outwards

DURATION : 460 DAYS
COLLECTIVE DOSES: 121 mSv

CONCEPT 2 Dismantling Approach from outwards inside

DURATION : 339 DAYS
COLLECTIVE DOSES: 103 mSv

THANK YOU