Unplanned Exposure During Diving in the Spent Fuel Pool

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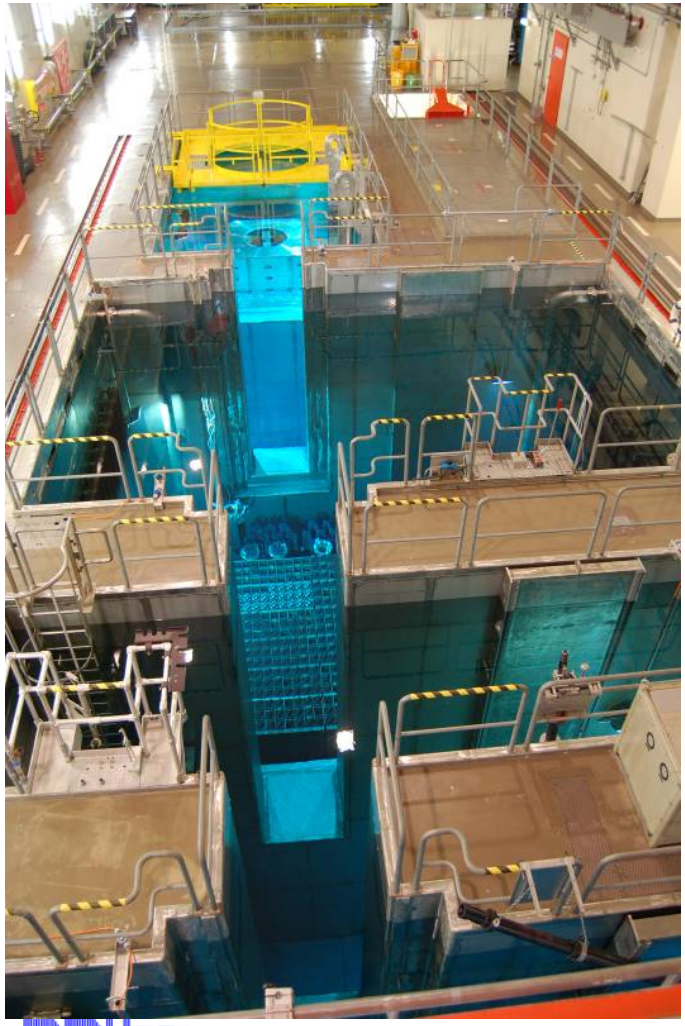
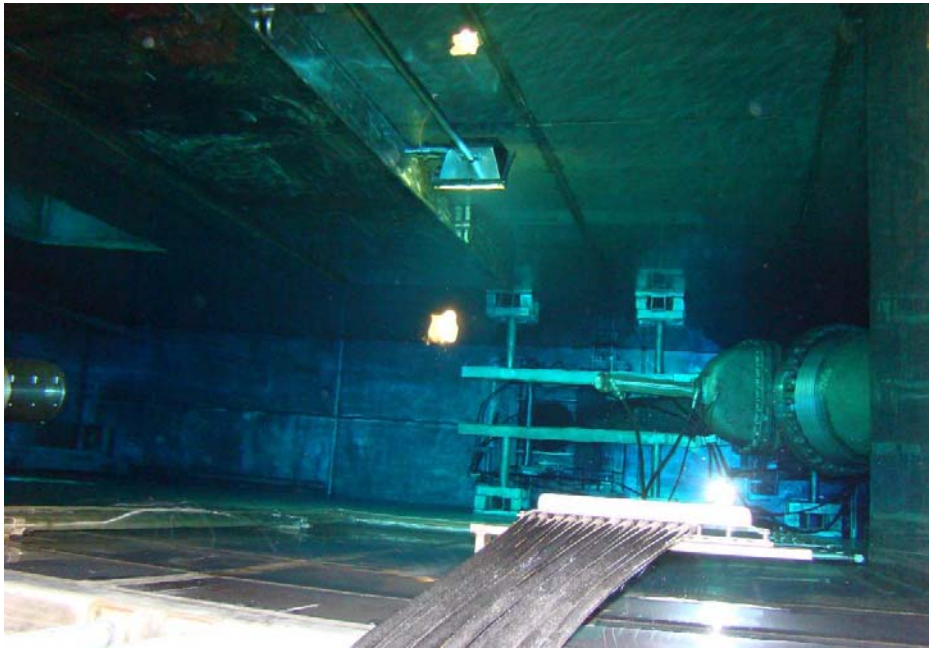
Diving in the Spent Fuel Pool

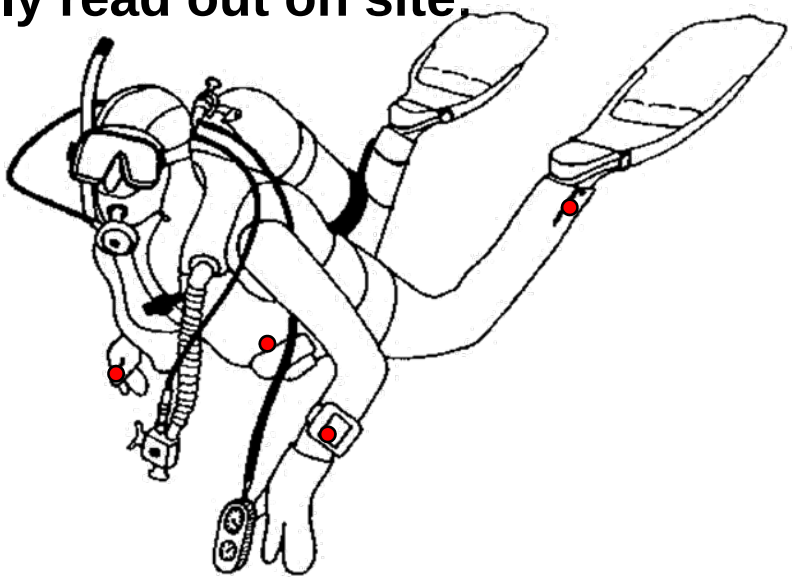




Kernkraftwerk Leibstadt

August 31st 2010, during RFO26

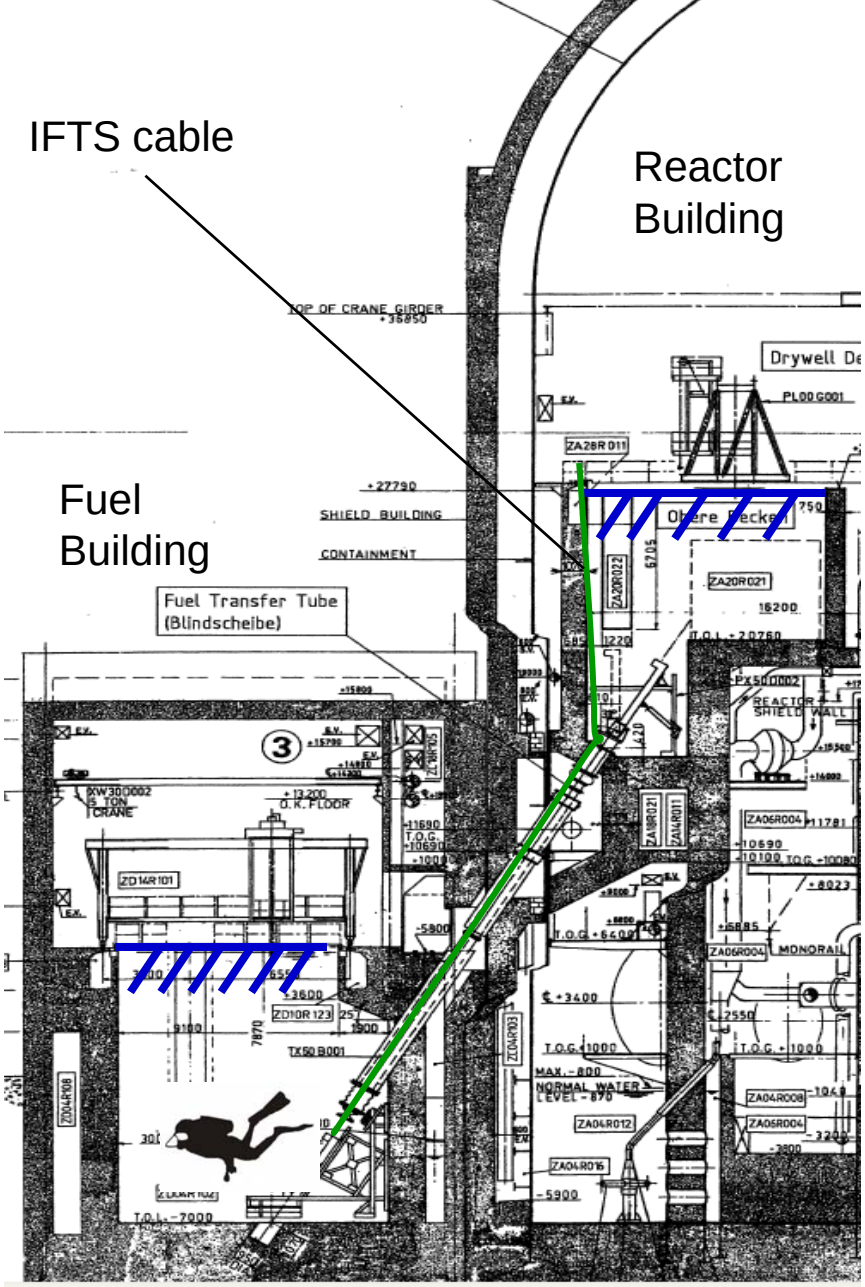
- **When a diver left the spent fuel pool, his electronic dosimeter was alarming. The display showed 40,1 mSv.**
- **The divers TLDs were immediately read out on site:**
  - Whole body: 19 mSv
  - Right finger: 1123 mSv
  - Left hand: 306 mSv
  - Left foot: 11 mSv



- **The dose limit for hands (500 mSv/a) was exceeded**
- **The situation concerning the whole body (dose limit: 20 mSv/a) was questionable (2 different readings, TLD and EPD)**

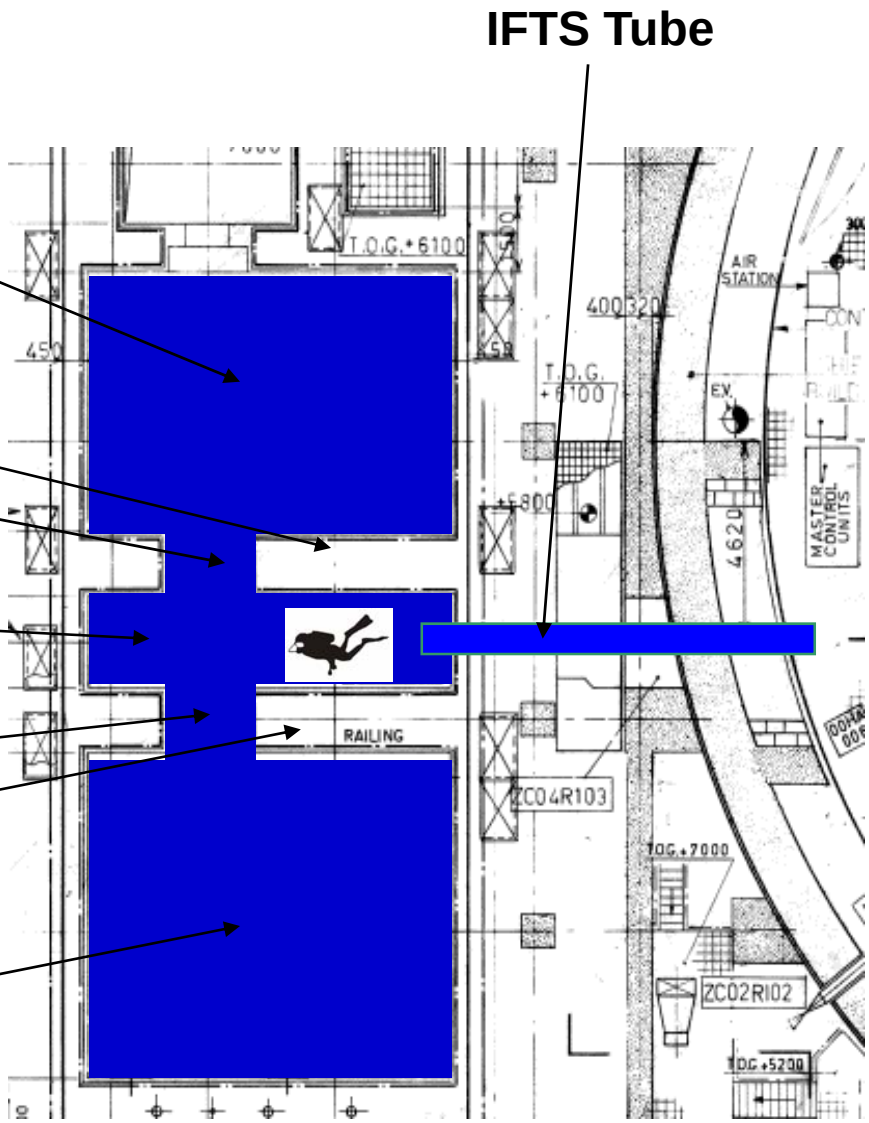
The Job

- **The Inclined Fuel Transfer System (IFTS) moves fuel and reactor internals from the Reactor Building to the Fuel Building and vice versa**
- **Planned maintenance: Replacement of cables on IFTS**
- **The same job has been performed safely by a diver in the past**
- **Decided to do it with the diver again**



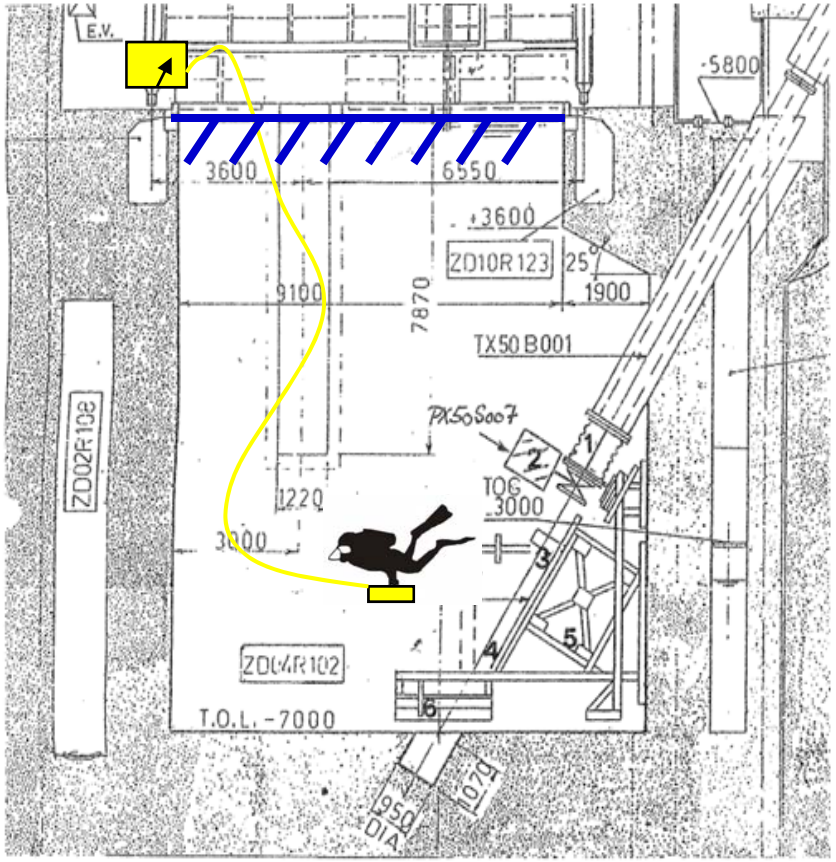
The Layout

- Spent Fuel Pool „East“
- Wall
- Gate
- Transfer Pool
- Gate
- Wall
- Spent Fuel Pool „West“



The Survey (before start of cable exchange)

- **Dose rate survey with submerged probe performed by diver at place of work (locations 1 – 6)**
- **Reading outside water at RP post**
- **Reading at locations 1 – 6 within expectations: no danger**



DL-Messungen Transfer PX50 / ZD1 BE-Lager:

Messung mit: Mitteldosissonde „Thermo FH40G-X" ***Serie-Nr.:*** 10836-001

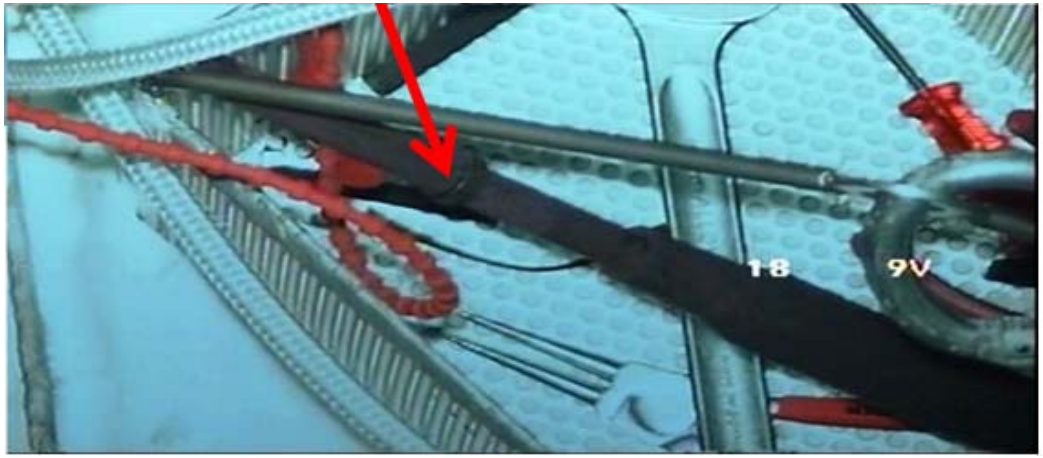
Datum	Messpunkt	$DL_{Kontakt}$ (mSv/h)	$DL_{Abstand\ 50\ cm}$ (mSv/h)	Bemerkung
26.08.2010 Messungen mit Rohr	1	2.0	0.055	
	2	3.2	0.030	
	3	0.7	0.120	
	4	1.5	0.020	
	5	Keine Messung		Kein vorgesehener Arbeitsbereich
	6	13.0	0.030	
30.08.2010 Messungen ohne Rohr	1	DI-Messungen im Arbeitsbereich seitlich vom Rohr: 0.3 bis 0.6 mSv/h		
	2			
	3			
	4			
	5	Keine Messung		
	6	Keine Messung		

The Briefing

- **The fuel pool gates were left open to allow cool water to flow in (heat stress protection for the diver)**
- **The diver was briefed not to pass the gates because of spent fuel on the other side: high risk**
- **The diver was not briefed not to touch anything unidentified**
- **The diver was not briefed to strictly stay inside the surveyed area of the transfer pool**
- **The diver was briefed for requirements specific to diving (air supply, communication rules etc.)**

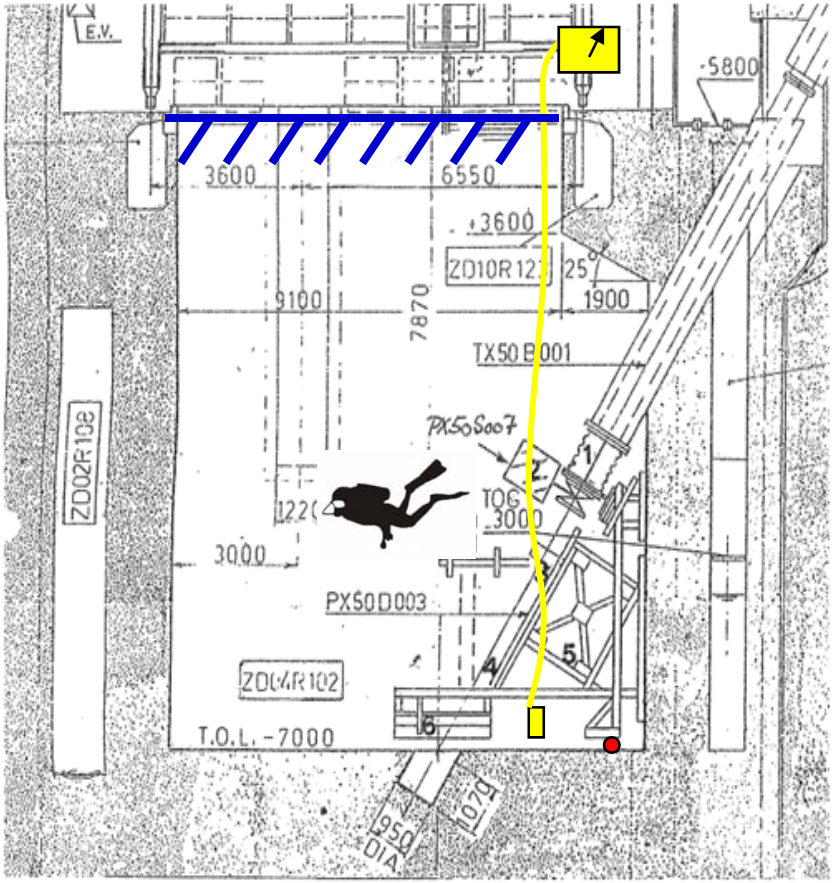
What happened?

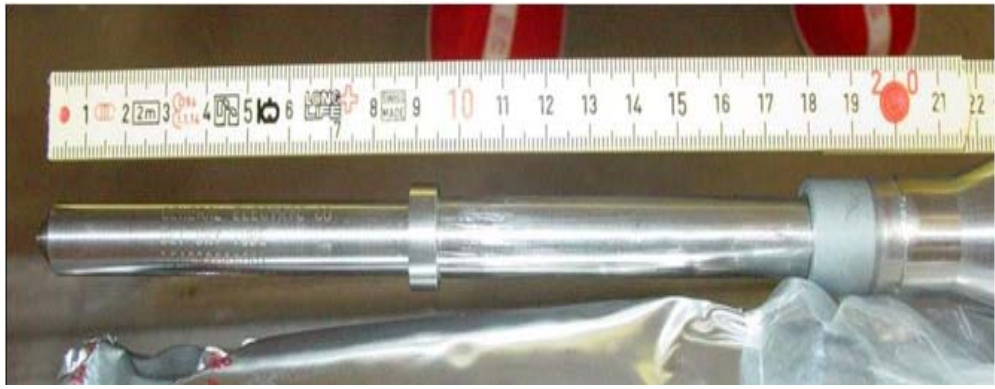
- The diver spotted an unidentified object during an interruption of the task
- Asked the diving supervisor what to do
- Was told to put it in his tool basket
- While lifting of the basket the Area Radiation Monitor alarmed, with the basket still submerged. Teletector reading at pool railing was elevated
- Basket lowered again
- Diver leaves pool



The Object

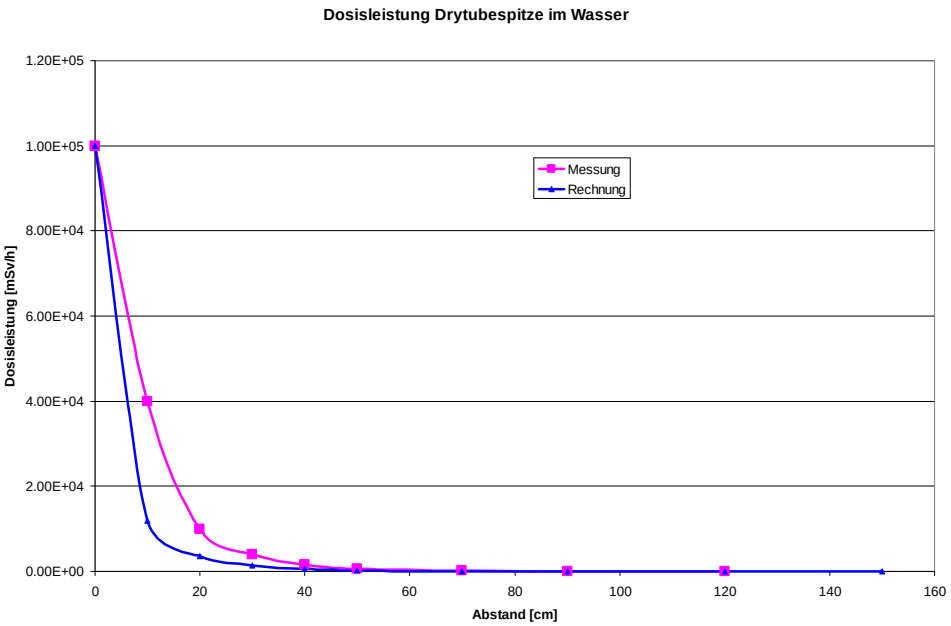
- **Dose rate reading in excess of 100 Sv/h (10‘000 R/h) contact**
- **Identified as top part of Dry Tube (= housing of neutron monitors in the reactor core). Highly activated by neutron flux**
- **Found in a remote part of pool**
- **Not accessible to submerged probe from outside pool due to geometry**





The Shielding

- **Water shielding is very effective**
- **No dose rate in a distance > 1.4 meters of drytube**
- **Source is hard to localize by dose rate surveys**
- **Extremly high dose rates if source is brought close to parts of body**
- **Dose rate change is very fast**

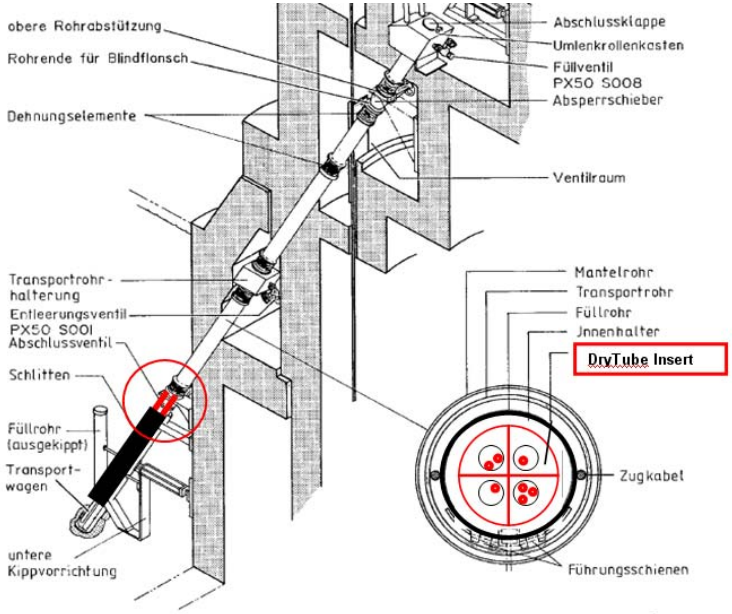


The Diver

- **Had no signs of acute radiation syndrome**
- **Was put under medical examination**
- **Was closed out from radiation work**
- **Was offered psychological assistance**
- **Had a personal talk with the plant manager, who expressed his regrets for the incident**
- **Received radiation-biological basics by senior expert of regulator**
- **Should not expect any longtime consequences**

How did the Drytube get there?

- Drytubes were removed and cut in pieces in the reactor cavity during RFO2006
- Some pieces were slightly longer than drytube insert for IFTS
- During tilting operation of the IFTS cask, the top part of a drytube was probably sheared off
- Drytube top part was on bottom of spent fuel pool since 2006



Shortcomings

- The loss of highly radioactive material was not noticed
- The missing part of the drytube was not detected
- The EPD alarm was not heard because of air bubble noise
- There was no remote radiation survey during diving
- There was no written order (to remove the drytube),
- therefore RP was not involved in the drytube removal
- The hazard of foreign material was not assessed
- The procedure for maintenance tasks generally requires clean up of the work area

Corrective action as of end december 2010

- **Drytubes will be moved in a closed container (done)**
- **A procedure for collection of loose material in pools shall be put in place (was missing before)**
- **The audible alarm of the divers EPD will be brought on his headset**
- **Teledosimetry will be installed on the divers body**
- **A procedure to track the loss of hazardous material shall be developed**
- **Pre-job-briefing improvements**

The regulators findings

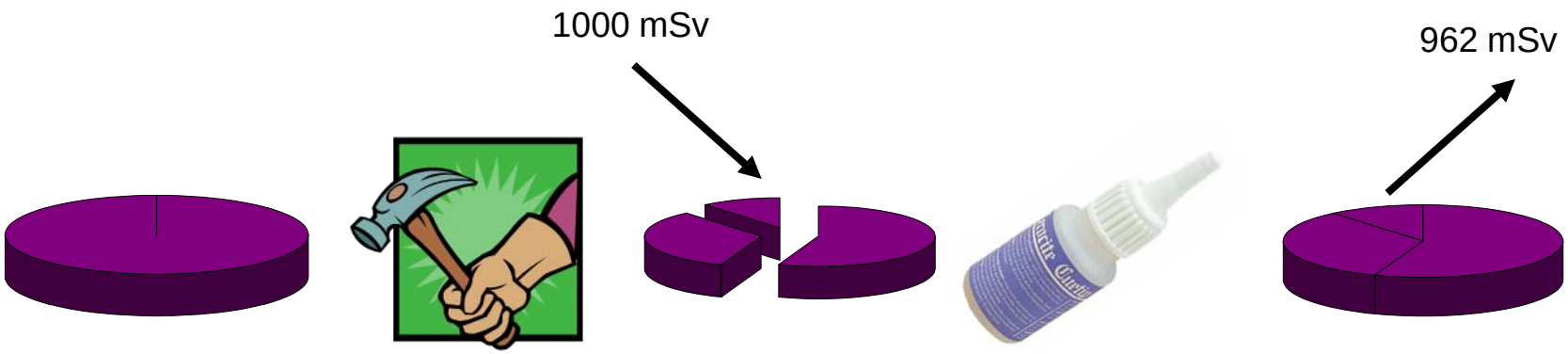
The regulator assessed by calculations

- the whole body dose: 28 mSv (2.8 rem)
- the hand dose: 7500 mSv (750 rem)

- **The event was rated INES 2 „exposure of a worker in excess of the statutory annual limits“**
- **The issue will not be dealt with a court of law**
- **The drytubes activity was assessed to be 1.8 TBq (50 Ci)**
- **The divers video monitor must be observed by an RP Tech**
- **Unknown objects to be handled only with a tool**
- **Dose rate survey in an extended area also by handheld submersible instrument**

Side effect: the broken TLD

- **The divers TLD at the finger was broken due to mechanical loads during use**
- **The broken TLD was repaired with instant glue and processed „normally“**
- **This process was validated:**



Questions?