



# Siempelkamp

Nukleartechnik

## Recycling of Metallic Residues with NORM Contamination by Melting

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Siempelkamp

Nukleartechnik

# Agenda

- Siempelkamp Group
- Recycling Business
- GERTA Plant
- Waste Management
- Lessons Learned
- Radiation Protection
- Summary

# Siempelkamp Group

## Siempelkamp Group Figures 2011 (Mio. €)

Order intake: 327.4  
Turnover: 705.7  
Employees: 3,305

## Nuclear Technology Figures 2011 (Mio. €)

Order intake: 121.6  
Turnover: 107.0  
Employees: 600



**Machinery**



**Foundry**



**Nuclear**



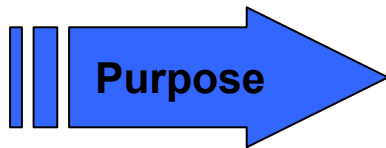
**Recycling**

# Siempelkamp Recycling Business



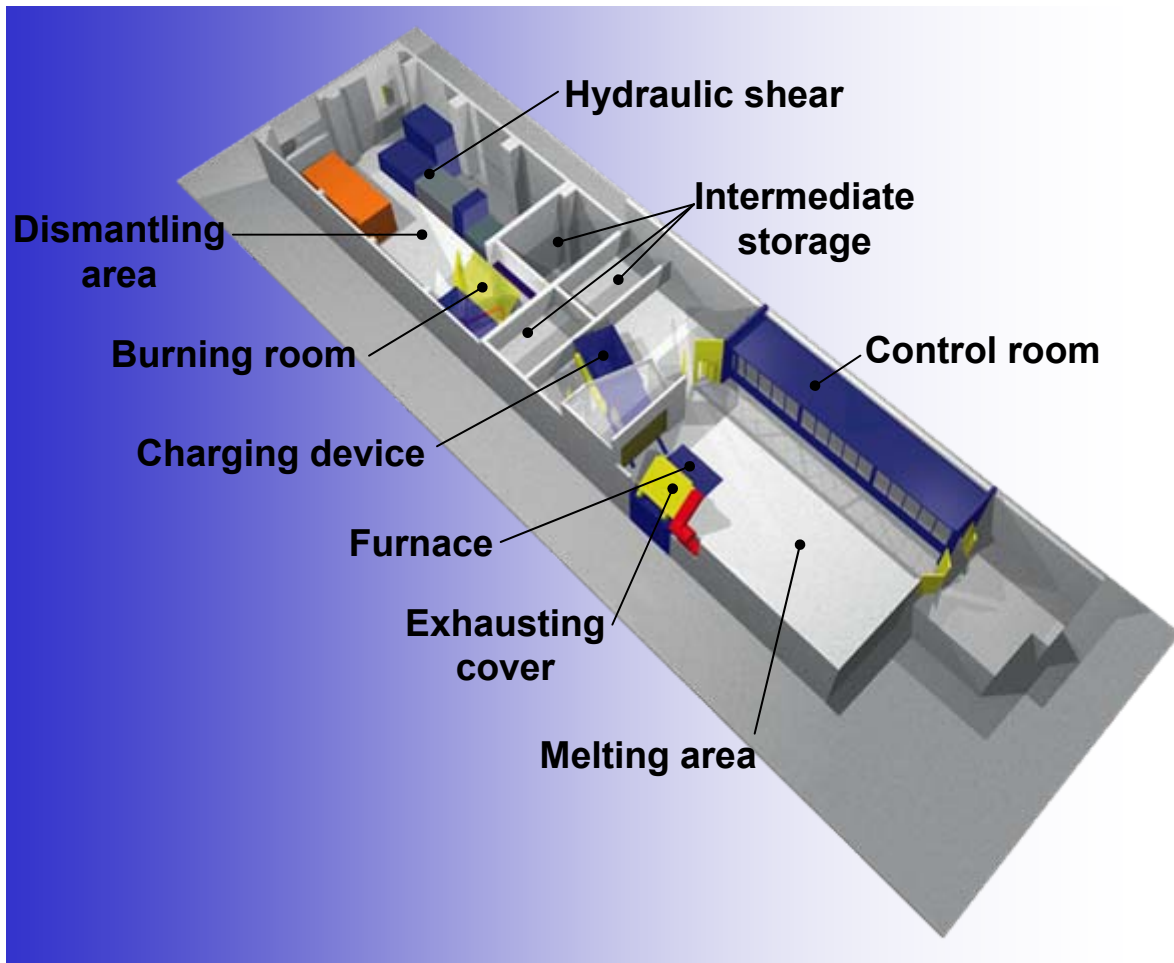
- start of operation in 1989
- melting plant approved according to § 7 of the German Radiation Protection Ordinance for the treatment of radioactive materials
- annual capacity: 4,000 Mg
- artificial radioactive material

- start of operation in 1998
- melting plant licensed according to BImSchG (German federal immission control act)
- annual capacity: 2,000 Mg
- NORM, Hg, Asbestos, PCB, PCDD/F



**Recycling, decontamination, secure inclusion of remaining activity**

# Design Parameters



**GERTA**  
Grosstechnische Einrichtung  
zum Recyclieren Toxischer Abfälle

- designed for melting steel scrap of all qualities
- accredited waste management company
- capacity 2,000 Mg/year

# Clients



- **Petrochemical**  
Exploration and production of oil and gas
- **Chlorine**  
Chlorine gas production using the mercury process
- **Tungsten**  
Manufacture of welding electrodes and filaments
- **Fertilizer**  
Production of phosphorous fertilizer
- **Pigment / Paper**  
Production of aggregates for building materials and colors

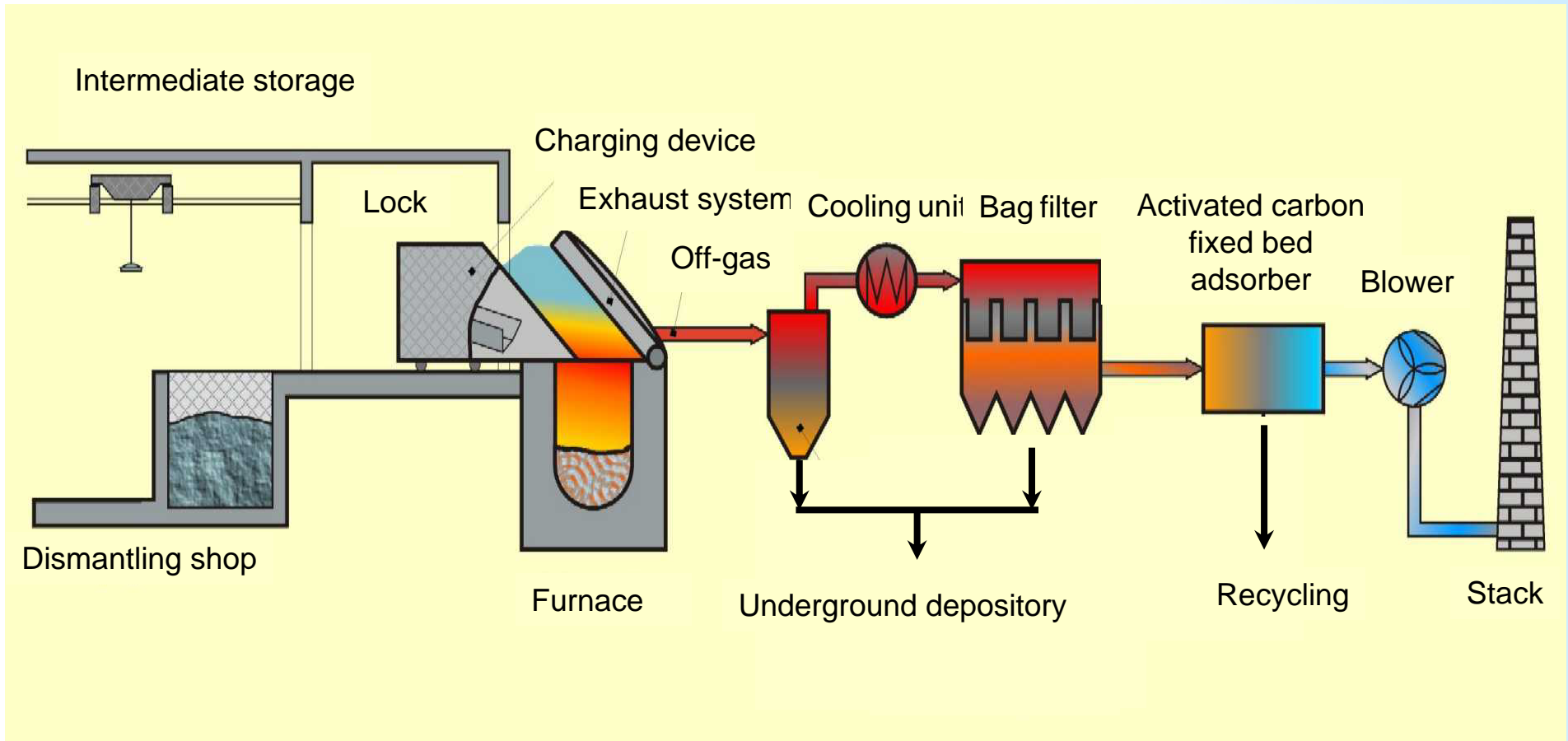
# Acceptance Criteria

- **Metal > 95 weight %**
- **NORM individual check (1 mSv/y)**
- **Mercury < 1 weight %**
- **Organics < 5 weight %**
- **Asbestos < 0,1 weight %**
- **PCB < 50 mg/kg  $\Sigma$**
- **PCDD/F < 10.000 ng/kg**



Waste Code Number	Kind of Waste: Designation according to AVV (* hazardous wastes)	Restrictions	Activity according to EfbV
05 07 01*	mercury containing sludges, here only mercury containing tubes and components The acceptance of sludges is specifically prohibited.	<b>Limitation:</b> Hg-share < 1 %  asbestos share < 0,1 %	<b>Storage, treatment and recycling</b>
06 04 04	mercury containing wastes		
06 04 99	wastes a. n. g.		
06 07 01*	asbestos containing wastes from electrolysis		
06 13 04*	wastes from asbestos processing		
15 01 04	packagings of metal		
15 01 10*	packagings containing residues of hazardous materials or being polluted by hazardous materials		
16 02 09*	transformers and condensors, containing PCB		
16 02 12*	used equipment containing free asbestos		
17 04 05	iron and steel		
17 04 07	mixed metals		
17 04 09*	metal wastes, being polluted by hazardous materials		
19 12 02	iron metals		
19 12 03	non-iron metals		

# Layout

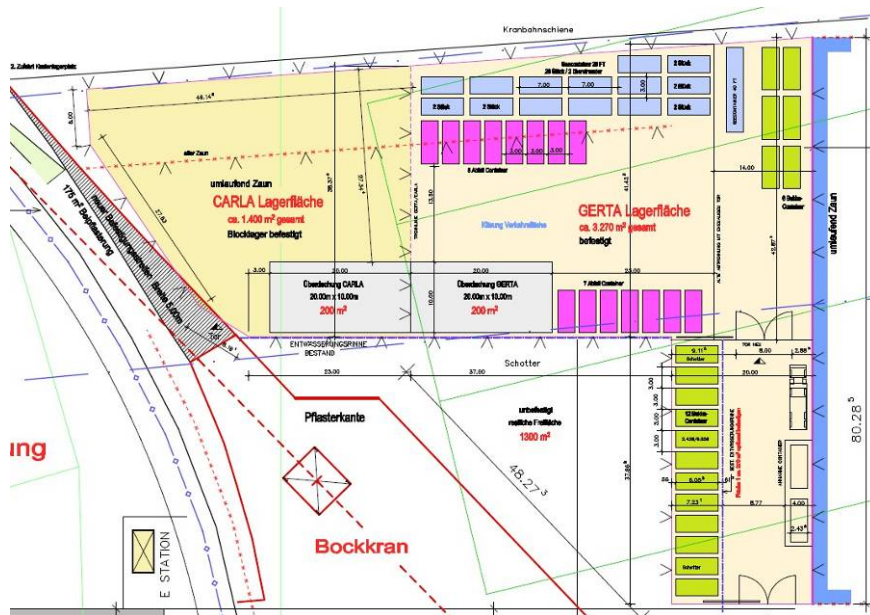




# Technical Data

## Storage Capacity

**500 Mg** outside on sealed areas  
**200 Mg** inside in 3 bunkers  
contamination specific



## Dismantling

**thermal:** 75 KW  
up to 100 mm  
separately exhausted

**mechanical:** 650 Mg  
800 mm width

# Technical Data

## Furnace

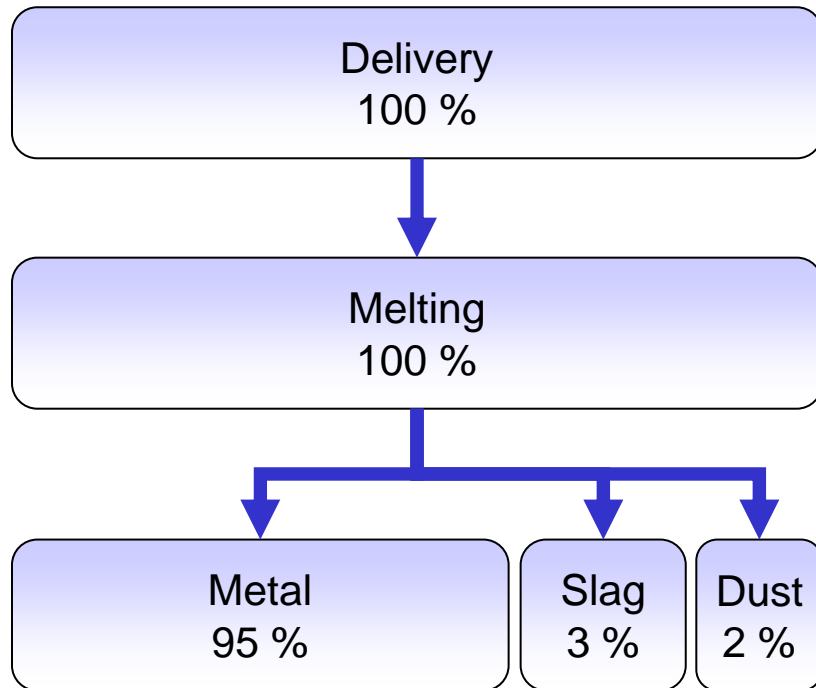
- 8 Mg capacity
- induction furnace
- 1,350°C - 1,550°C
- charging device
- exhaust system



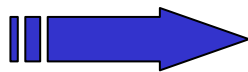
## Off-Gas Processing

- cyclone
- air cooler
- fabric filter
- fixed bed absorber
- 28,500 m<sup>3</sup>/h in two systems

# Material / Nuclide Distribution



<b>Nuclides</b>	<b>Melt</b>	<b>Slag</b>	<b>Dust</b>
<b>U-238, U-235</b>	1 %	98 %	1 %
<b>Th-232, Th-234</b>	< 1 %	> 98 %	1 %
<b>Ra-226, Ra-228</b>	-	98 %	2 %
<b>Pb-210</b>	-	7 %	93 %
<b>Po-210</b>	-	2 %	98 %



Concentration of radionuclides in the waste streams

# Metal Reuse



- metal ingots of one ton each
- free of contamination
- for reuse in steel works

# Slag Disposal

Radiological expert opinion in 2002 (Thierfeld, S., Wörlen, S.)

## Input:

- **Scrap input (1000 Mg/y total):**
  - 775 Mg/y from oil and gas industry
  - 75 Mg/y from fertilizer industry
  - 75 Mg/y from paper industry
  - 75 Mg/y tungsten material
- **Slags from melting NORM**
  - maximum 100 Mg/y
- **Slag Disposal**
  - continuous discharge for recycling
  - maximum 8 Mg per batch
  - mixing ratio at least 1 : 4
- **Recycling Method**
  - recycling to road construction material on landfill sites

## Output:

<b>Nuclide</b>	<b>Specific activity [Bq/g]</b>	<b>annual activity [10<sup>9</sup> Bq]</b>
U-238sec	21	8.4
Th-232sec	15	6
Ra-226+	25	10
Pb-210++	40	16

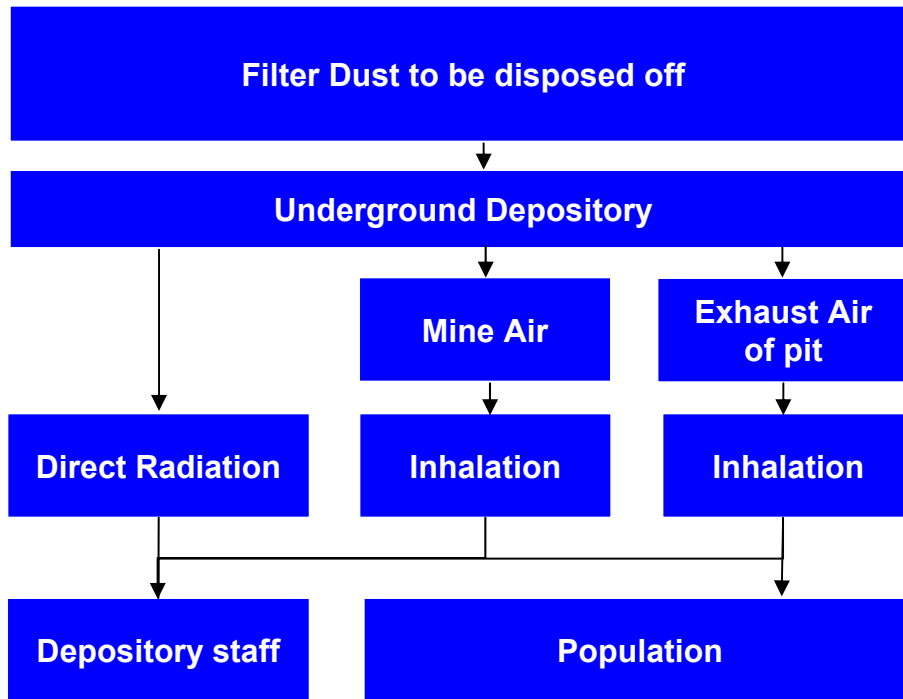


In compliance with the above stated values, the 1 mSv/y criterion is given for slag recycling

# Filter Dust Disposal

## Radiological expert opinion in 2000 (Urban, M.)

### Input:



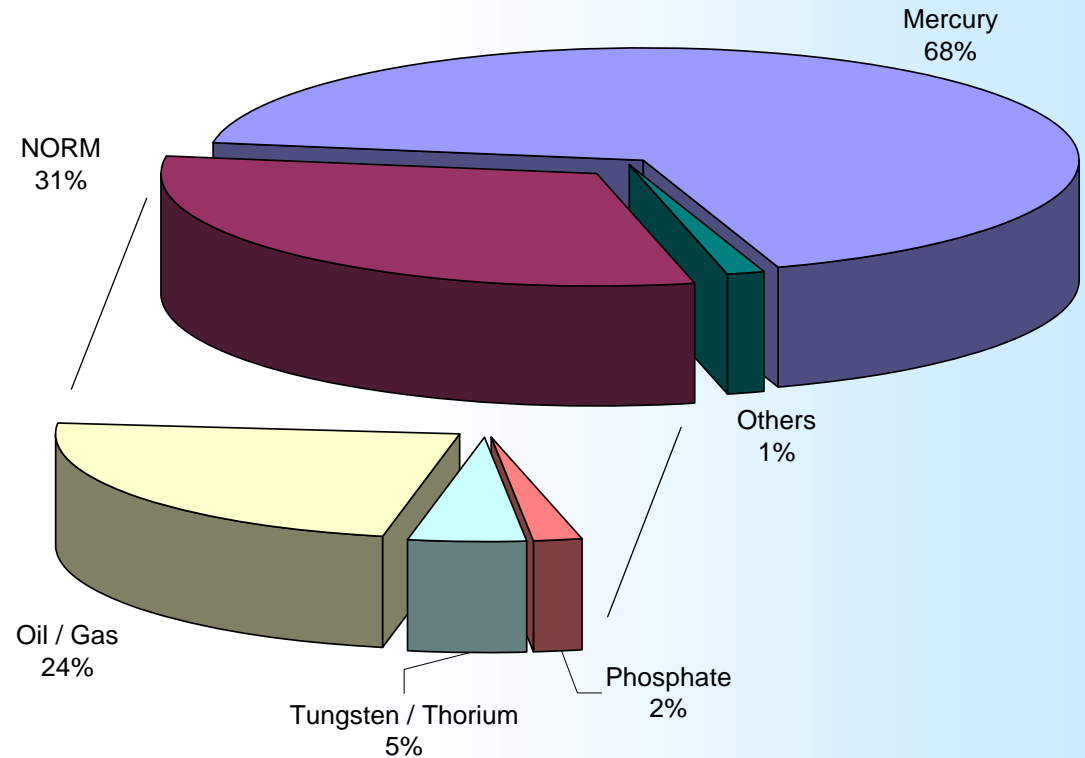
- Dumping of 2 x 160 pcs. 200 l drums per year
- Containing mercury and NORM

### Output:

- Maximum 100 Mg per year
- max. 70 Bq/g in total (relating to U-238sec, Th-232sec, Ra-226+ und Pb-210++)
- Exposure to staff << 10  $\mu$ Sv/y due to direct radiation and inhalation
- Unintended exposure to staff due to damaged drum < 10  $\mu$ Sv by ingestion
- Geological Radon concentration inside the cavern: 70 – 150 Bq/m<sup>3</sup>,
- Increase of Radon concentration inside the cavern due to disposal of 25 Mg/y only 1 Bq/m<sup>3</sup> (within natural deviation)

# Experiences (quantitative)

- Recycling of 20,000 Mg in 14 years
- 6,200 Mg of NORM
- 18,500 Mg clean steel returned
- 1,000 Mg of slag successfully recycled
- 600 Mg of filter dust disposed



# Experiences (radiological)

	Oil / Gas	Tungsten/Thorium	Phosphate	Paper
Amount	~ 4,800 Mg	~ 800 Mg	~ 400 Mg	~ 200 Mg
Contamination	NORM Mercury	NORM	NORM	NORM
NORM decay chain	Ra-226++	Th-232sec	U-238sec U-235+ Th-232sec	Ra-226++
Specific activity of adherences	Up to 250 Bq/g Ø 10 Bq/g	Up to 65 Bq/g Ø 12 Bq/g	Up to 130 Bq/g Ø 60 Bq/g	Up to 250 Bq/g Ø 3,5 Bq/g

- **no remaining activity in the metals**
- **complex geometries easily decontaminated**
- **safe inclusion of activity in an eluate permanent matrix**
- **reliable and tolerant of variable NORM characteristics**
- **high recycling quota, up to 95 %**



# Radiation Protection

## Investigation of the SNT GERTA process due to the requirements of § 97 of the German Radiation Protection Directive

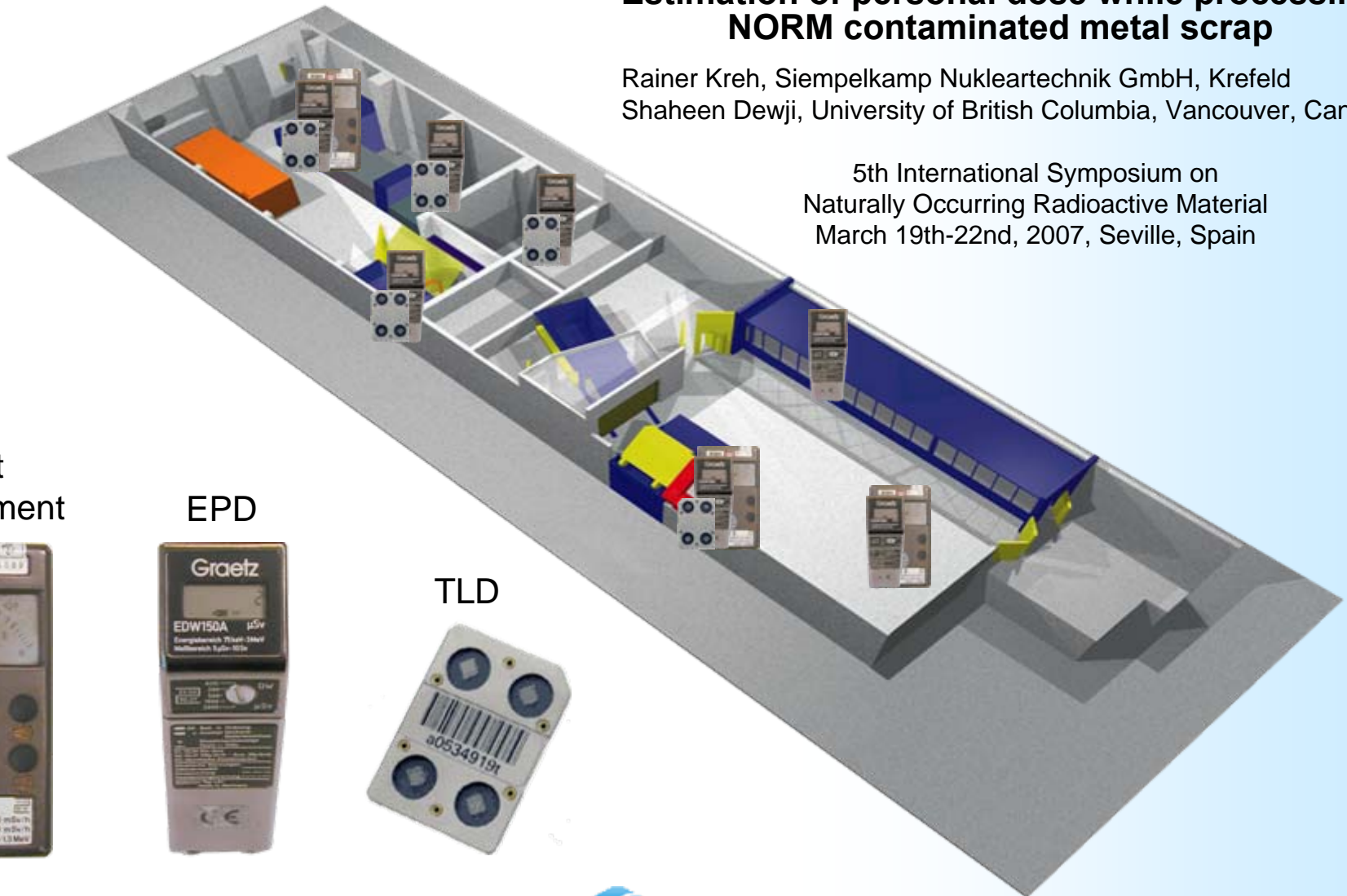
- How much is the dose for the workers in GERTA while processing NORM contaminated metal scrap ?
- Is the dose probably more than 1 mSv per year?
- To ascertain, if this limit is exceeded, a lot of various dose measurements were necessary.
- Data were recorded during three measurement campaigns involving dismantling and melting of NORM material from oil- and gas production industry and tungsten industry

# Dose Measurements

## Estimation of personal dose while processing NORM contaminated metal scrap

Rainer Kreh, Siempelkamp Nukleartechnik GmbH, Krefeld  
Shaheen Dewji, University of British Columbia, Vancouver, Canada

5th International Symposium on  
Naturally Occurring Radioactive Material  
March 19th-22nd, 2007, Seville, Spain



Direct  
measurement



EPD

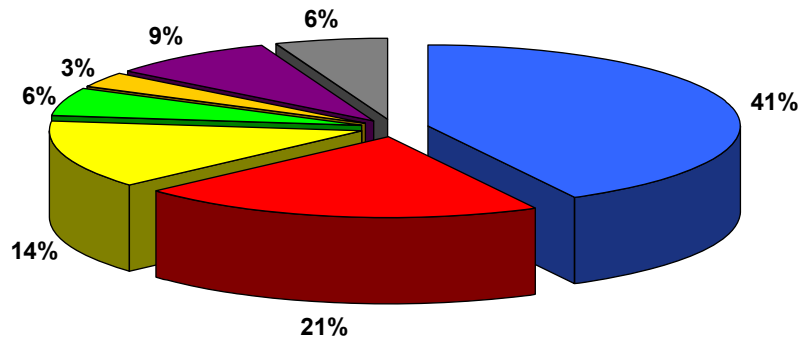


TLD



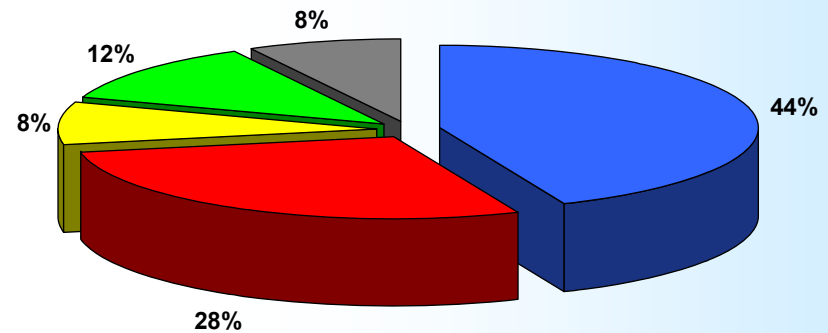
# Time Statistics

Part of the daily worktime  
In the melting area



- Melting hall 3,43 hrs
- Furnace control 1,72 hrs
- Pouring and slag removal 1,11 hrs
- Exhausting system 0,46 hrs
- Internal transports 0,23 hrs
- Outdoor 0,71 hrs
- Sundries 0,47 hrs

Part of the daily worktime  
in the dismantling area



- Dismantling hall, shear 3,48 hrs
- Thermal cutting room 2,26 hrs
- Internal transports 0,68 hrs
- Outdoor 0,96 hrs
- Sundries 0,61 hrs

# Annual Dose Calculation

## Calculated annual dose rates for the main working areas

(related to a ratio of NORM and non-NORM contaminated material of 1:1)

Method	Cutting [mSv/y]	Melting [mSv/y]	calculated annual Dose [mSv/y]
personal EPD	0.04	0.10	0.14
workplace EPD	0.03	0.26	0.29
TLD	0.07	0.21	0.28

- PPE not considered
- Incorporation dose not relevant
- Excretion analytics showed values below detection limits
- Currently stationary thermo luminescence dosimeter at work place, monthly evaluation.

# Summary

## No Harm to Workers, Public and Environment

- more than 20,000 Mg of contaminated material recycled
- more than 6,200 Mg of NORM Scrap
- safe inclusion of activity in an eluate permanent matrix
- process reliable and tolerant of variable NORM characteristics
- process completely compliant to the 1 mSv/y criterion
- intensive working place studies and monitoring
- limited acceptance amounts
- limited disposal amounts
- fixed activity budget
- reviewed waste management for secondary wastes



# Thank you for your Attention!

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