PRACTICAL EXERCISE

Demolition of the Biological Shielding

Group C:

Brazil, Indonesia, Irak, Malaysia, Vietnam

R^2D^2P: Workshop on Safety Assessment for Decommissioning
Risoe, Denmark, 4- 8 October 2010

Summary

- Description of the Facility;
- Identification of Potential Hazards;
- Selection of the Cutting Technology;
- Demolition Strategy and Cutting Sequence;
- Removal and Transfer of RW to Storage Facility;
- Dose Evaluation due to Airbone Inhalation: WC, WA, PC, PA.

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Description of the Facility

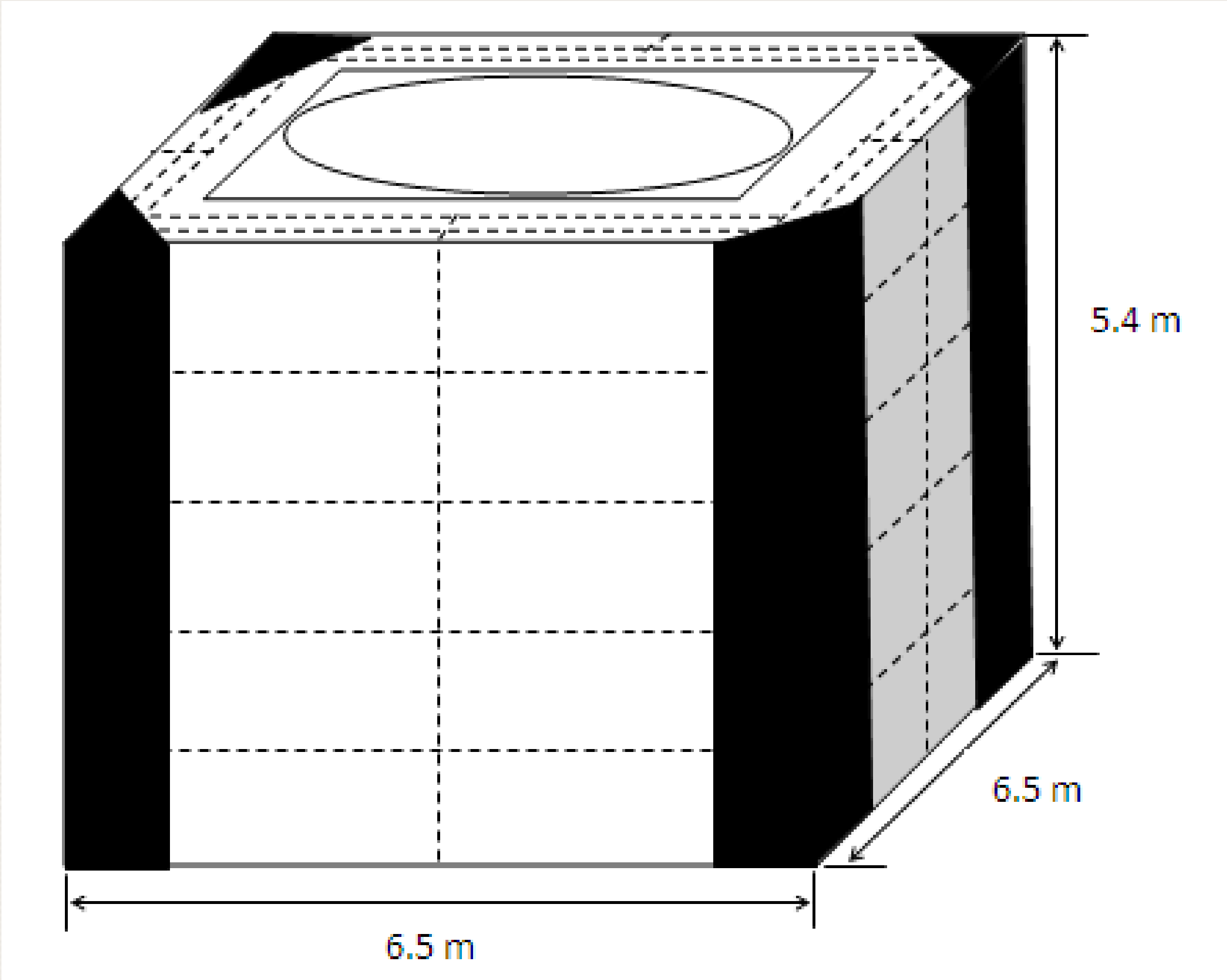
•The biological shield surrounds the reactor and serves to reduce the dose rate during operation of the reactor. The reactor block is characterised as follows in [DAN 06]:

•The reactor block, neglecting the top part, which is primarily steel, has the shape of a box with a length of about 6.5 m and a height of about 5.4 m. The volume of the block is about 230 m^3.

•The volume of the steel tank with the thermal shield, the graphite reflector, the reactor tank and the reactor lid is about 30 m^3, and the volume of the steel ball concrete ring and the shielding plates around the horizontal experimental tubes is about 11 m^3.

•The remaining volume consists mostly of barite concrete and amounts to about 190 m^3. However, this volume includes the vestibule boxes at the outer ends of the horizontal tubes and the tubing in the reactor block. With a density of the barite concrete of about 3.4 g/cm^3, the amount of barite concrete is estimated to about 650 Mg.

Description of the Facility



Hazard!!

HAZARDS	RELEVANCY FOR PLANNED WORK
Radiological hazards	
Direct radiation sources	YES (IMPORTANT)
Radioactive material, incl. form: (solid, liquid, gaseous)	YES (SOLID)
Criticality	NO
Other radioactive sources (smoke detectors, lightning rods)	NO
Fire/explosion hazards	
Oxygen	NO
Sodium	NO
Explosive substances	NO
Flammable gases (e.g. oxyacetylene, propane gas), liquids, dust	NO
Combustible / inflammable materials	NO
Compressed gases	NO
Hydrogen generation	NO
Overheating or fire, caused by e.g. portable heaters,overload of electrical circuits, application of cutting techniques	YES (IMPORTANT)

HAZARDS	RELEVANCY FOR PLANNED WORK
Electrical hazards	
High voltages	YES
Power overload and shortcuts, power failures	YES
Inadequately disconnected circuits / prevention against inadvertent connection	YES
Non-Ionizing Radiation Hazards	
Non-Ionizing Radiation Sources, incl. lasers	NO
Electromagnetic radiation (e.g. microwaves)	NO
High Intensity Magnetic Fields	NO
Chemical/toxic hazards	
Chemotoxic material	NO
Spills	NO
Chemicals (aggressive chemicals)	NO
Accidental mixing / combination of chemicals (e.g. in sewage systems, in decontamination work etc.)	NO
Asbestos and other hazardous materials, like lead or beryllium	NO
Pesticide use	NO
Biohazards	NO

HAZARDS	RELEVANCY FOR PLANNED WORK
Physical hazards	
Kinetic energy (vibration)	YES
Potential energy (springs, Wigner energy in graphite)	NO
Degraded or degrading structures, systems and components	YES
Steam	NO
Temperature extremes (high temperatures, hot surfaces, cryogenics)	YES
High pressure (pressurized systems, compressed air)	NO
Working environment hazards	
Working at heights (e.g. ladders, scaffolding, man baskets)	YES (IMPORTANT)
Excavations, formation of underground cavities (subsidence) from rain, waste degradation etc.	NO
Vehicle traffic	
Heavy lifts, material handling, heavy equipment, manual lifting, overhead hazards, falling objects, cranes	YES (IMPORTANT)
Inadequate illumination	YES (IMPORTANT)
Inadequate ventilation	YES (IMPORTANT)
Noise (high noise areas and tools)	YES (IMPORTANT)
Dust	YES (IMPORTANT)

HAZARDS	RELEVANCY FOR PLANNED WORK
External hazards / initiating events	
Ambient temperature extremes	NO
Airplane crash	NO
Storm and adverse weather conditions	NO
Earthquakes	YES (UNLIKELY)
Other hazards	
Degraded / corroded barriers, ageing of materials	NO
Unknown or unmarked materials	NO
Spills	NO

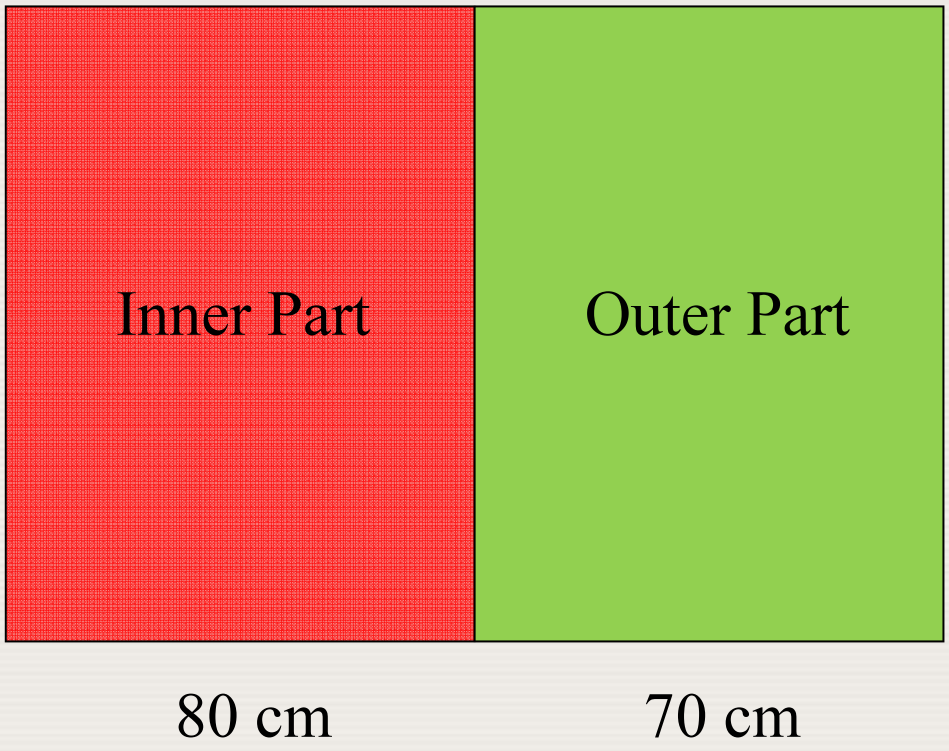
Comparison of Cutting Techniques

Techniques	Advantages	Disadvantages
Brokk	- Less expensive (if machine procurement not required) - Fire hazard unlikely - Faster (without considering the preparation time to allow the Brokk to operate, waste removal works)	- Higher dust generated - More probability for industrial accident to happen - As the machine crush the concrete, it will crush the inner piping inside the bio shield and produce pieces of activated waste
Diamond wire (dry)	- Lower dust generated than the Brokk - Easier to handle the pieces of the waste - Lower probability for accident - Using diamond wire saw allow us to cut the concrete and inner piping inside the bio shield and properly manage the waste	- Expensive - Fire hazard - Slower compare to Brokk techniques

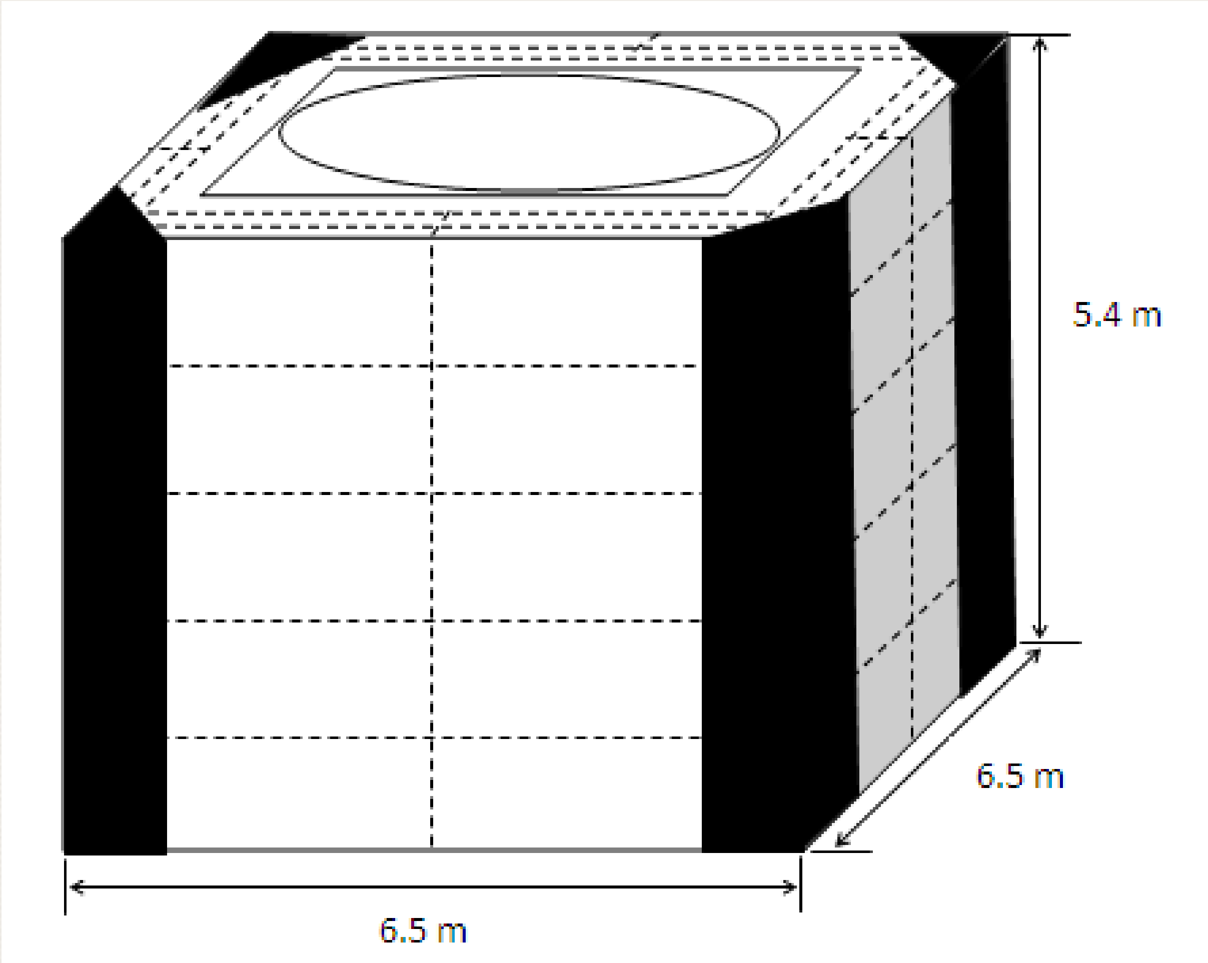
- Recommended technique is Dry Diamond Wire technique while the Brokk is been put in standby mode if the iron ball inside unable to be cut.

Demolition Strategy

- Removal of the non-activated part of the bioshield prior to the demolition of the activated one.



Cutting Sequence



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Assumptions and Calculations

10 min for drilling + 10 min for positioning

Cutting velocity = 5 m^2/h

Assumptions and Calculations

- 12 pieces of 1.4m x 1.4m x 1.8m / 2 (1.8 m^3 or 6 t):
- Total volume= 21.6 m^3
- Total mass= 72 t
- Total cutting surface= 33 m^2 (4.5 m^2/piece)
- Estimated time*: 16 h (1 h 20 min/piece)
- * 10 min for drilling + 10 min for positioning + 1 h for cutting
- 2 workers: 20 min (total 4 h)
- 1 worker: 1 h (total 12 h)

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Assumptions and Calculations

- 80 pieces of 2.2m x 1.1m x 0.35m (0.85 m^3 or 2.9 t):
- Total volume= 68 m^3
- Total mass= 232 t
- total cutting surface= 288 m^2 (3.6 m^2/piece)
- Estimated time*: 107 h (1 h 20 min/piece)
- * 10 min for drilling + 10 min for positioning + 1 h for cutting
- 2 workers: 20 min/piece (total 27h)
- 1 worker: 1 h/piece (total 80 h)

Assumptions and Calculations

Assumptions for the dose estimations:

- The dose due to the removal of the outer part of the bioshield can be neglected;
- The calculations were considered the same for the activated part;
- The maximum value of the dose rate (0.1 mSv/h) obtained at various samples from boreholes was used to estimate the exposure dose due to the removal of the activated concrete.

Dose Estimates

- 1 Worker (cutting machine operator): 9.2 mSv
- 2 Workers: 3.1 mSv/worker
- Collective Dose: 15.4 mSv

Work Package 2: Lifting and Transporting

- **Planned Work Steps;**

  a) Attached the block to the crane. (anchor or sting)

  b) Transfer the block using the crane into the transfer truck

  c) Move the block to the interim storage immediately

  Assumptions

  •Time for attaching and transferring (site – truck) of a concrete block is 10 minutes

  • Truck capacity: 1 block (2.2 m x 1 m x 1 m)

  • Transfer truck speed: 5 km/h

  • Distance from RR building to interim storage: 1 km, thus the time needed from Reactor building to the interim storage is 0.2 h, (12 minutes).Time for unloading a block from the trucks is 18 minutes.

  • Total = 40 minutes!

Work Package 2: Lifting and Transporting

Dose Estimates – Workers (2)

- Normal Operation:

(2) Lifting and transporting:

- The maximum number of concrete pieces approximately 100.
- The exposure dose for a worker will be 100 pieces x 40 minutes (2/3 hr) x 0.1 mSv/hr.

  = 6.7 mSv for 100 pieces of concrete.
- Due to high exposure dose, safety measures must be established to reduce the dose received by the worker to acceptable limit.
  - Increasing number of workers
  - Installing lead shield on the back of driver seat
  - Limiting working time of the workers

Identification of Incident/Accident

- **During lifting and transporting:**

  a) Fall of cut block during lifting the block (to the truck)

  b) Crane problem / stuck

  c) Power lost

  d) Fall of cut block as the truck moves

  e) Trouble on vehicle/engine

  f) Vehicle crash

Screening of Incident/Accident

Hazard	Possibility	Consequences
Fall of concrete block during removal	Highly possible	Airborne and ground contamination, may fall on people working on the ground, shockwave damage may be affecting other system
Crane problem /stuck	Possible	The concrete pieces will hung up for unplanned time and exposing the workers to more radiation
Power lost	Unlikely	The crane ,lighting system, ventilation system will stop
Fall of cut block as the truck moves	Unlikely	Airborne and ground contamination, especially for the public
Trouble on vehicle/engine	Unlikely	The driver will be exposed more as the trip takes more time than planned.
Vehicle crash	Possible	Airborne and ground contamination, as well as direct personnel exposure

Preventing Incident/Accident

Hazard	Possibility	Safety precaution
Fall of concrete block during removal	Highly possible	Ensure that nobody is on the ground during the work
Crane problem /stuck	Possible	There crane must be stopped and checked periodically
Power lost	Unlikely	Put power generator on stand by mode especially for lighting purpose
Fall of cut block as the truck moves	Unlikely	Forklift and lifting equipments must be put on standby mode
Trouble on vehicle/engine	Unlikely	Prepare more than one vehicle
Vehicle crash	Possible	Forklift and lifting equipment must be put on standby mode

Fall of concrete block during removal

- Scenario – Human error lead to the incident
- Assumption
  - 1 mm of the concrete block that fall apart exposed to the atmosphere
  - It takes 1 hour to mitigate the incident.
  - Inhalation rate = 8400 m3/yr
  - For conservative estimation, the block that contain the highest contamination, fall down.
  - Due to ventilation system of the hall, the contamination is assumed to be homogeneous in all part the reactor building. (9000 m3)
- Formula
  - Inhalation dose = airborne activity concentration x dose conversion factor x inhalation rate x time of exposure
  - Airborne activity concentration = activity concentration of concrete block x density of the block x surface area of concrete block x thickness of the concrete block exposed to the atmosphere / volume of the reactor hall

Fall of concrete block during removal

Radionuclide	Maximum Activity Bq/g	Inhalation Dose Conversion Factor (Sv/Bq)	Inhalation Dose (µSv)
Ba 133	400	2.11 x 10e-9	0.6
Eu 152	300	2 x 10 e-10	0.04
Eu 154	25	5.3 x 10e-8	0.65
Co-60	700	3.1 x 10 e-8	15.456
TOTAL DOSE			17

Dose evaluation due to:

Airborne / Inhalation

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Airborne / Inhalation

General information

Dust Rate: **DR = 150 kg/h**
(generated by cutting activities)

Air Exchange Rate: **ER = 20000 m^3/h**
(air flux on the air exchange system)

Dust Physical/Mechanical Behavior:
- Suspendable Fraction **SF= 1%**
- Respirable Fraction **RF= 10%**

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General information

By summing the maximum concentration (Bq/g) of all significant radionuclides (Co60, Eu133, Eu 152, Ba 133 from core samples) multiplied by its respective conversion factors:

Total Dose due to all radionuclide on the dust:

RD = 4.16×10^{-5} Sv/g

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Airborne / Inhalation

Workers by chronic exposure

WCDD: Efficiency of the Dust collecting device: **99%**
WCME: Mask Efficiency: **90%**
SF: Suspendable Fraction: **1%**
RF: Respirable Fraction**: 10%**

<u>Reduction Factor</u> due to protective systems and physical/mechanical behavior of the dust:

$$\mathbf{WC = (1\text{-}WCDD)x(1\text{-}WCME)x(SF\ x\ RF) = 1x10^{-6}}$$

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Airborne / Inhalation

Workers by chronic exposure

Breathing Rate considering hard working activities: **BR=1.5 m^3/h**

WCIR: worker inhalation rate: (DR x ER x WC) x BR = **1.1×10^{-8} g/h**

Dose due to all radionuclide on the dust:
RD = **4.16×10^{-5} Sv/g**

Dose Rates due to chronic exposure to the workers:

DRWC = WCIR x RD = 4.7×10^{-7} μSv/h

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Workers by Accidental exposure

No dust collecting device and no mask

WADD = WAME = 0%

Reduction Factor is only due to physical/mechanical behavior of the dust

WA = (1-WCDD)x(1-WCME)x(SFxRF) = $1x10^{-3}$

Breathing Rate for hard working activities: **BR=1.5 m^3/h**

WAIR: worker inhalation rate: (DR x ER x WC) x BR = **$1.1x10^{-5}$ g/h**

Dose Rates due to accidental exposure to the workers:

DRWA = WAIR x RD = 4.7x10-4 μSv/h

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Public by chronic exposure

PCDD: Efficiency of the Dust collecting device: **99%**

PCFE: HEPA Filter Efficiency: **99%**

Reduction Factor due to protective systems and physical/mechanical behavior of the dust

PC = (1-PCDD)x(1-PCME)x(SF x RF) = 1×10^{-7}

Breathing Rate considering normal breathing conditions: **BR=1 m^3/h**

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Public by chronic exposure

Stack –> Mass Diffusion Mechanism
(**Safety Series 19**, Fig. 7, Table 1)

PCDC :Dust Concentration (at 1km) = 25% x $4x10^{-5}$(m)/wind speed (5.8 m/s) x Dust Discharge Discharge (g/s)

PCIR: public (adult) inhalation rate: PCDC x PC x BR = **$4.4x10^{-14}$ g/h**

Dose Rates due to chronic exposure to the public:

PRPC = PCIR x RD = $1.8x10^{-12}$ μSv/h

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Airborne / Inhalation

Public by Accidental exposure

<u>no dust collecting device and no HEPA filter</u>

PADD: Efficiency of the Dust collecting device: **0%**

PAFE: HEPA Filter Efficiency: **0%**

Reduction Factor due to protective systems and physical/mechanical behavior of the dust
PA = (1-PADD)x(1-PAME)x(SF x RF) = $1x10^{-3}$

Breathing Rate considering normal breathing conditions: **BR = 1 m^3/h**

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Airborne / Inhalation

Public by Accidental exposure

Stack –> Mass Diffusion Mechanism
(**Safety Series 19**, Fig. 7, Table 1)

PADC :Dust Concentration (at 1km) = **100%** x $4x10^{-5}$(m)/wind speed (5.8 m/s) x Dust Discharge Discharge (g/s)

PAIR: public (adult) inhalation rate: PCDC x PC x BR = **$1.7x10^{-9}$g/h**

Dose Rates due to chronic exposure to the public:

PRPA = PAIR x RD = $7.2x10^{-8}$ µSv/h

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Airborne / Inhalation

Estimated Dose due Activated Dust Inhalation

Scenarios	Max. Dose Rate (μSv/h)
Workers / Chronic	4.7E-07
Workers / Accident	4.7E-04
Public / Chronic	1.8E-12
Public / Accident	7.2E-08

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THANK YOU FOR YOUR ATTENTION

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