

Quantification of Aerosol Release by Concrete Scarifying Operations

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Context and objective

Concrete structures in nuclear facilities contain radioactivity mainly due to activation by the neutron flux undertaken continuously and by direct contact in case of spill with contaminated liquids. Prior to dismantling operations the radioactive concrete thickness has to be removed over several millimeters, so that the resulting waste meets the criterion of Very Low Level Waste (VLLW). Concrete clean up involves mechanical aggression of the layer containing the radioactivity by various techniques: abrasive blasting, scarifying, hammering, etc.

The presented work investigates aerosol release during scarifying operations on a concrete slab at industrial scale.

Material and Methods

The study was performed in a closed inflatable containment tent of 73 m³ volume and 26 m² floor surface.

A concrete slab of 2500 mm (L), 2100 mm (W) and 200 mm (H), was specifically poured.

The scarifying operations were completed, using an industrial milling machine (Blastrac BMP-265E) of 175 kg equipped with milling cutters rotating at 1500 rpm at 5.5 kW, handled by an operator on one-way rides along the concrete slab.

The machine is coupled with a vacuum dust containment system (BDC138- HLP), functioning at 2.45 m³/min flowrate and placed outside of the tent.

The emitted aerosol during concrete scarifying was collected by five high-volume samplers (HVS-TSP) working each at 1.13 m³/min flowrate with HEPA (High Efficiency Particulate Air) filters.



Aerosol collected on a TSP- HVS HEPA filter



Dust collected by the vacuum collecting bag



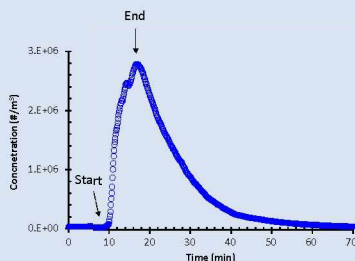
Heavy gravels pile scrubbed on the concrete slab



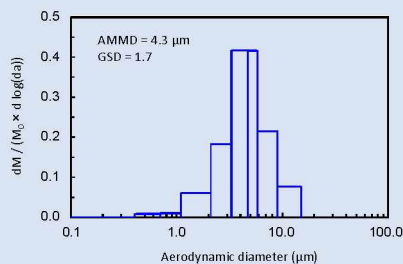
Lost volume measurement of the concrete slab

Results

Dust concentration using OPC Grimm 1.109



Particle mass size distribution using Andersen Cascade Impactor



Mass of aerosol and concrete rubble produced during a milling trial

Mass of aerosol (g)		Mass of concrete rubble (kg)		Volume crushed of the concrete slab (kg)	
HVS 1	1.23 (g)	Inside the vacuum bag	8.87 (kg)	Thickness	1.33 (cm)
HVS 2	1.20 (g)	Onto the slab	5.58 (kg)	Length	26.5 (cm)
HVS 3	1.29 (g)	Under the access ramp	2.72 (kg)	Width	225 (cm)
HVS 4	0.78 (g)	-	-	Volume	7930 (cm³)
HVS 5	1.58 (g)	-	-	Density	2.21 (g/cm³)
Total	6.09 (g)	17.17kg		17.53 kg	

The milling operation is accompanied by the production of significant amount of aerosol, even though the dust production is mitigated with a vacuum system.

Airborne particles produced during the milling operation are in the respirable and thoracic conventional size fraction ranges.

The collected mass of aerosol is in the order magnitude of one gram per filter.

The mass of scarified concrete assessed either with weighing of the concrete debris and rubble or lost volume calculation of the concrete slab is quite consistent with a mass of several kg for each trail and around 5% difference for the three trails.

About half of the scarified mass is collected in the vacuum bag.

Aerosol Release Fraction (ARF)

Trial	# Rides	Blank (g)	Airborne particles (g)	Mass of rubble (kg)	ARF
1	7	0.015	6.90	16.87	3.61 X 10 ⁻⁴
2	9	0.029	5.15	14.57	3.54 X 10 ⁻⁴
3	7	0.015	3.17	15.03	2.11 X 10 ⁻⁴
mean			5.07	15.49	3.09 X 10 ⁻⁴
COV			37%	8%	27%

$$ARF^* (-) = \frac{\text{mass of collected aerosol (kg)}}{\text{mass of concrete rubble (kg)}}$$

* Particle loss by Sedimentation inside the containment tent is not currently considered

Conclusions

The mean ARF value is 3.09 x 10⁻⁴ with a COV of 27% that shows a quite good repeatability of the measurements for this kind of experiment at a full scale.

The vacuum dust containment system combined to the concrete milling operation reduces significantly the dust generation but does not suppress entirely the aerosol release in the surrounding atmosphere.

In absence of the vacuum containment, in the hypothesis that all the dust collected in vacuum bag was airborne, the ARF should have been in the order of magnitude of 10⁻¹; which would mean that 10 % of the scarified concrete mass become airborne during the milling operations.

These results could help to design ventilation systems for such operation and adapted protective clothing for operator in order to manage occupational exposure in normal operating condition