Pool Scrubbing system for aerosol removal: focus on bubble characteristics and modeling

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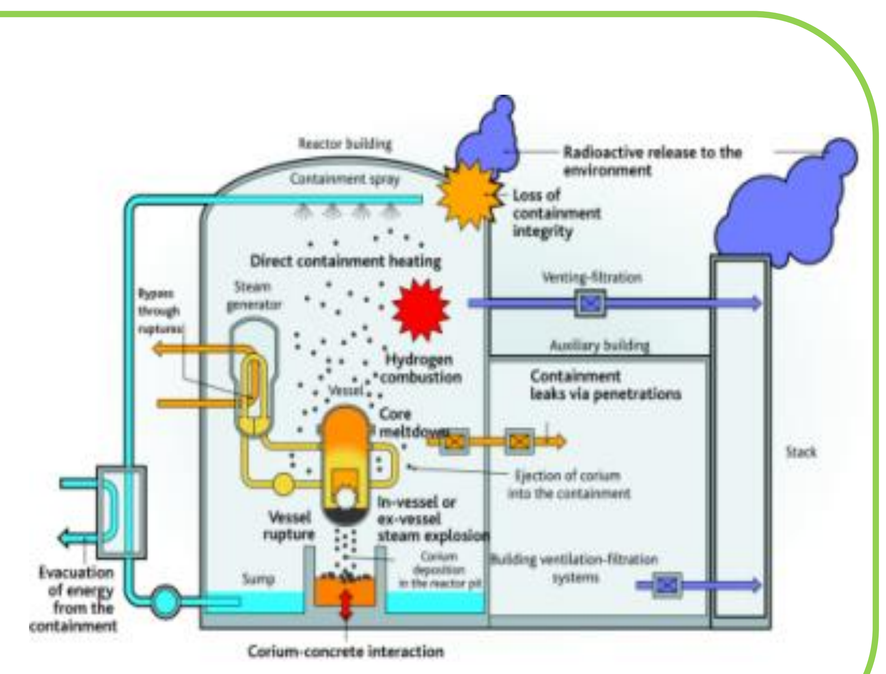
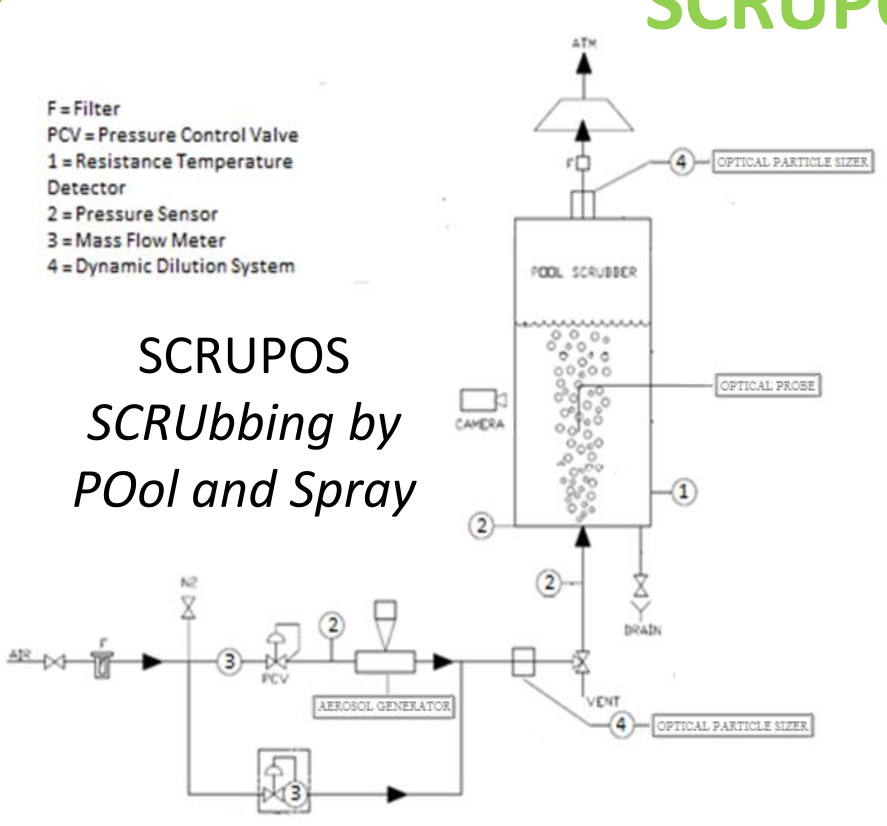
PASSAM Project

The PASSAM - *Passive and Active Systems on Severe Accident source term Mitigation project* (7th FP project, 2013 – 201) is mainly of an R&D experimental nature, aiming at studying phenomena that, under severe accident conditions, might have the potential for reducing radioactive atmospheric releases to the environment. RSE is involved in experimental and modeling activity on pool scrubbing. Decontamination depends on hydrodynamics of bubbles in particular on **bubble size** (bubble classes distribution), **bubble shape** and **bubble velocity**



SCRUPOS Facility



SCRUPOS
SCRUbbing by POol and Spray

Instrumentation

Photo camera:
- Bubble size
- Bubble shape

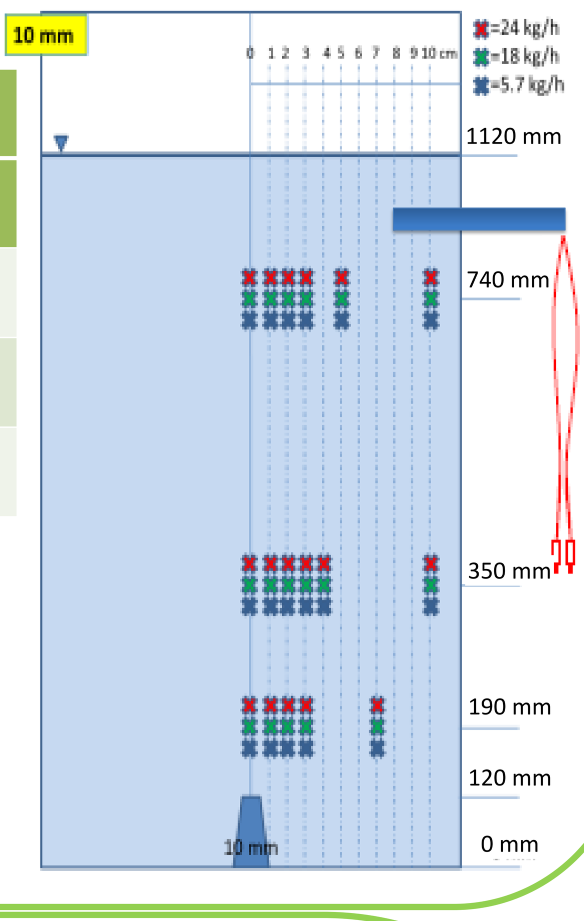
Optical Probe:
- Void Fraction
- Bubble velocity
- Bubble size distribution

Tank dimension: 1x0.5X1.5 m

Test Matrix

Test Matrix	
Orifice Diameter	Gas Mass Flow Rate
10 mm	6-18-24 Kg/h
20 mm	18-24 Kg/h
50 mm	24 Kg/h

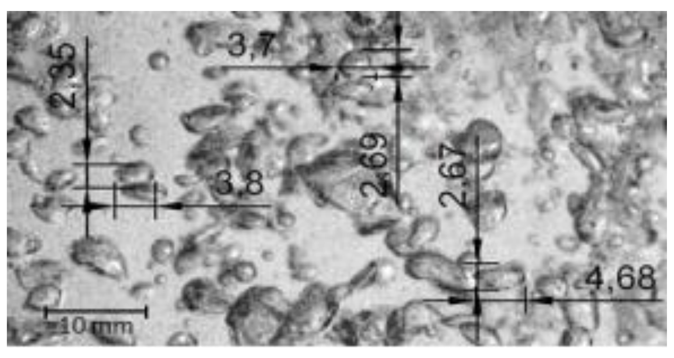
- Pool, depth 1 m
- Gas at room temperature



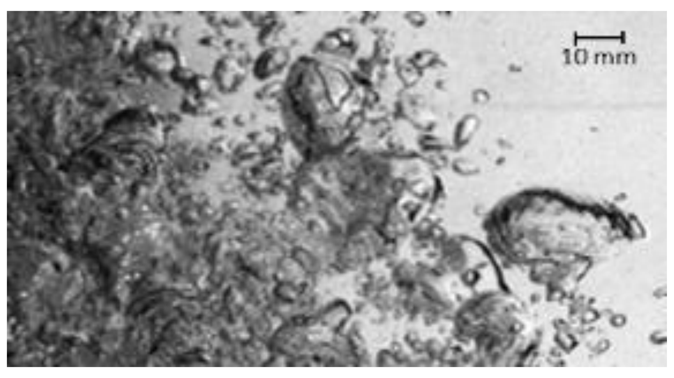
Experimental Data

Bubble Size & Shape

Φ =2.5 mm

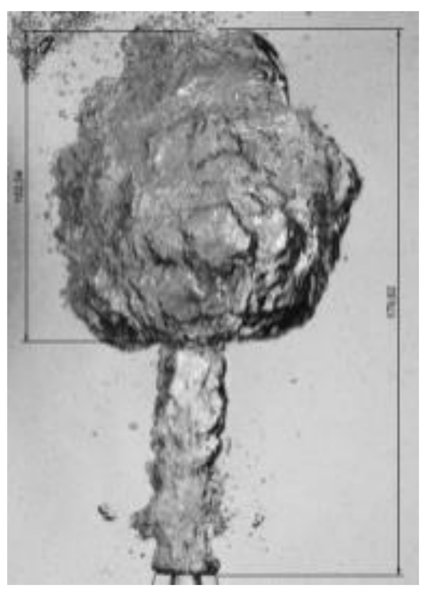


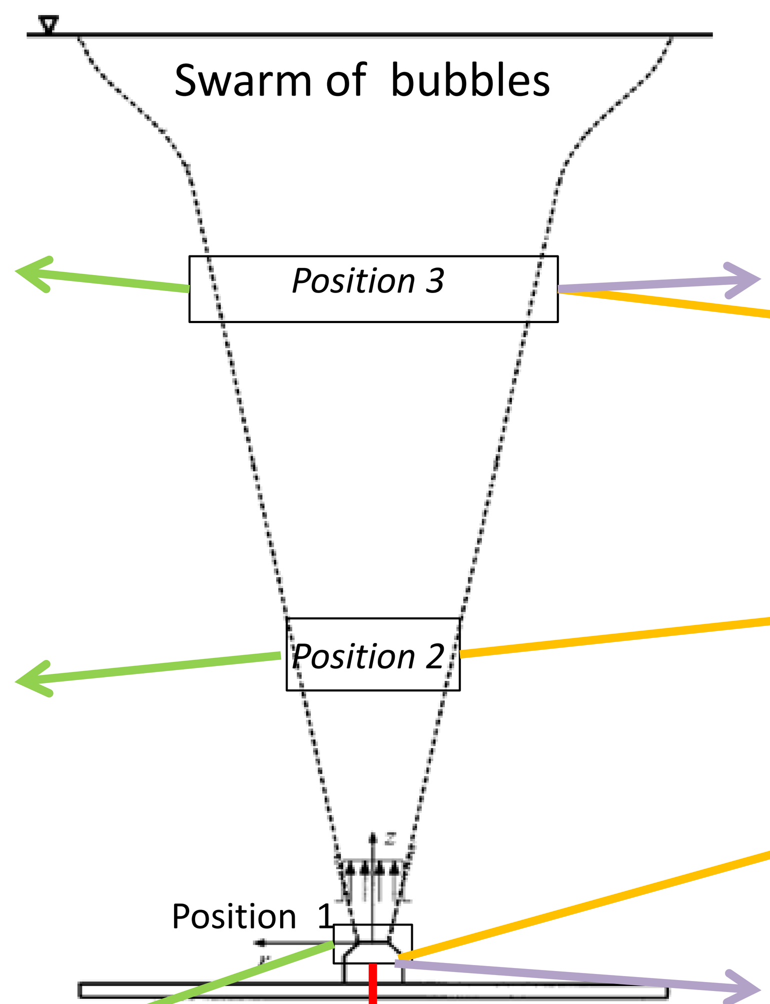
Φ =7.8 mm



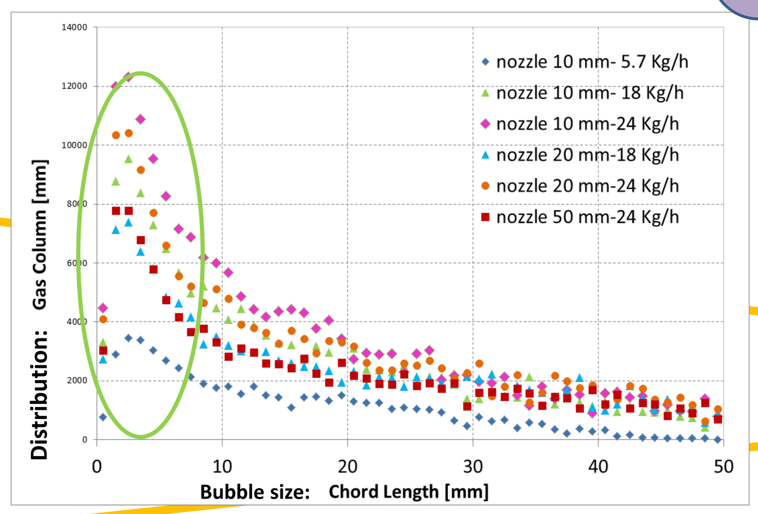
Φ =91 mm

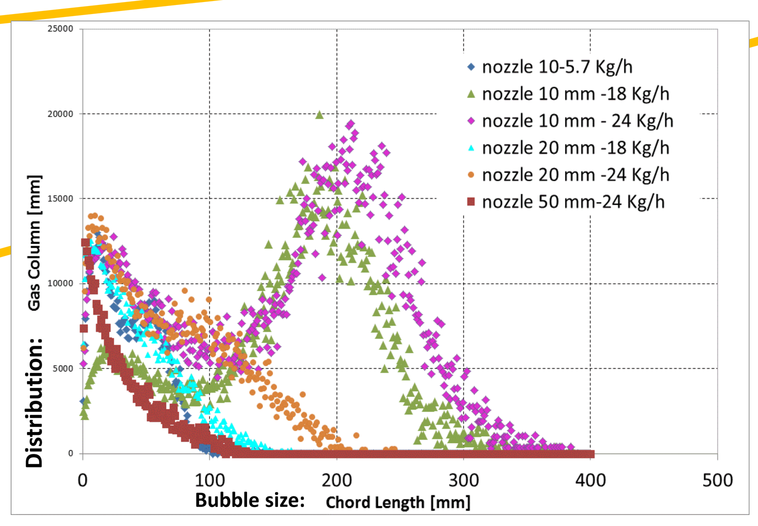
Test:
10 mm orifice
18 kg/h



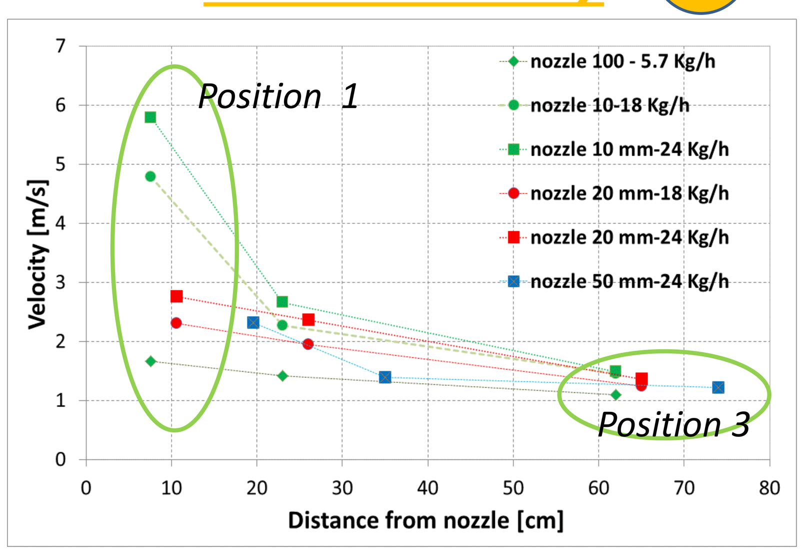


Bubble Size Distribution





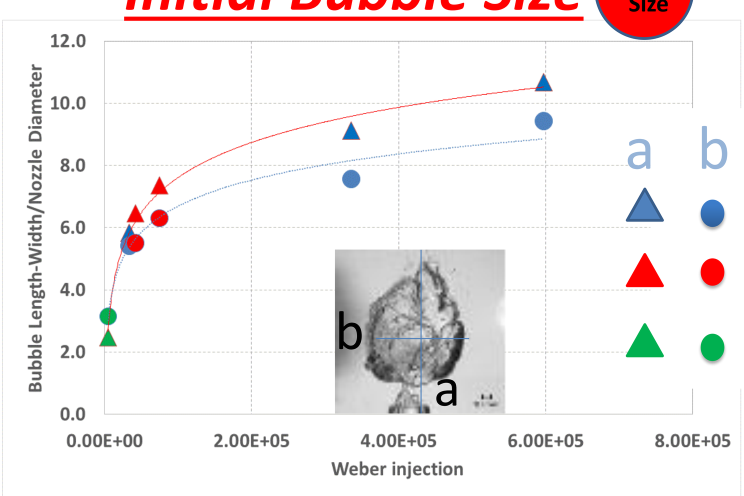
Bubble Velocity



Initial Bubbble Size ∝ We$_{inj}$
(*Weber number at injection*)

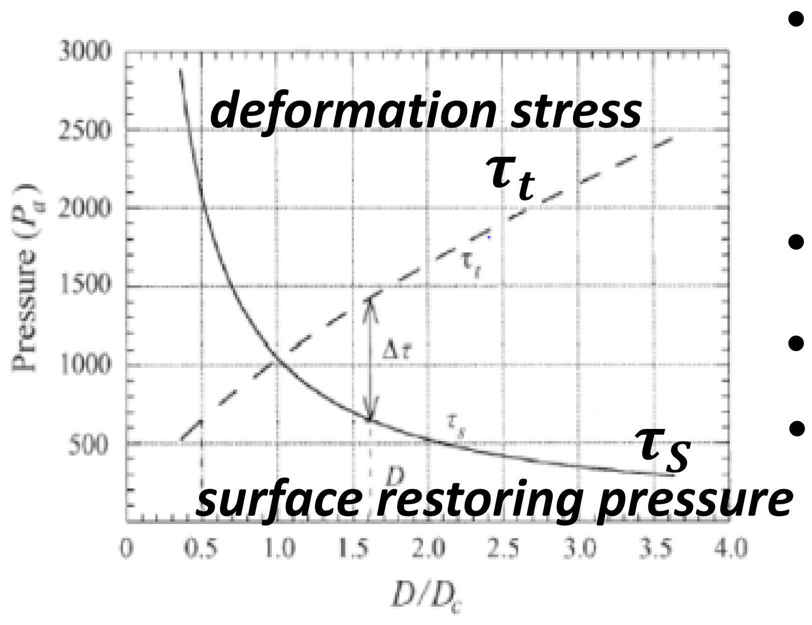
Initial Bubble velocity and size depend on:
- Mass flow rate
- Orifice diameter

Initial Bubble Size



Final bubble velocity and diameter are the same for different:
- Mass flow rate
- Orifice diameter

Theory



Bubble breaking when:

- $\tau_t(D_{bubble}) > \tau_s(D_{bubble})$

$$\frac{\rho\,\delta u^2(D_{bubble})\,D_{bubble}}{\sigma} \geq 12$$

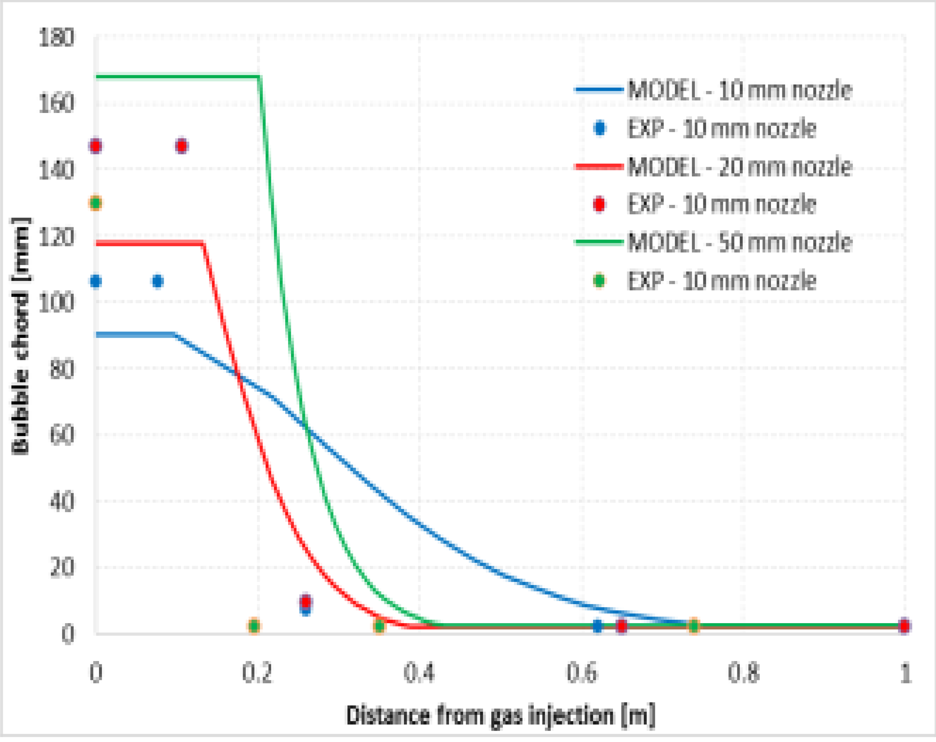
- $\delta\,u \propto \varepsilon$
- Stability $D_c \propto \varepsilon$
- Breaking Rate $\frac{1}{t_b} \propto \tau_t - \tau_s$

D_c *critical diameter*
t_b *bubble break up time*
ε *rate of dissipation of turbulent kinetic energy*
δu *velocity fluctuation in the liquid between two points at distance D*

Bubble Model

Hypothesis

- Experimental data:
  $D_{first\ bubble}$ $V_{bubble}(z)$ D_c
- $D_c \longrightarrow \varepsilon \longrightarrow t_b$
- **t_b is constant**
- No coalescence
- Monodispersed Bubble
- Bubble breaks create two equal bubbles



Future developments

Hydrodynamics tests:
- Sea water (salinity: 1 - 30 g/l)
- Surfactant

Decontamination tests:
Aerosol SiO_2, Size: 0.5- 1 - 2.5 μm
Concentration: 1-5 g/m^3

Model:
- Coalescence
- Polidispersed Bubble
- Dependence of ε from test conditions

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