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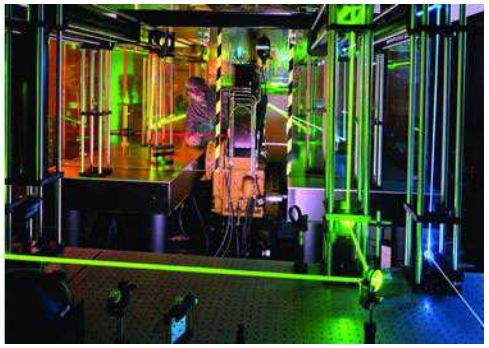


First Principles Modeling of Aerosol Release from Vessel Ruptures & Detonations: The Source Term

Fred Gelbard and Alexander L. Brown

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Background & Motivation

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- Radioactive liquid solutions are present throughout a reprocessing facility, and accidents have been reported of tanks destroyed by such solutions detonating.

- The solutions may be aerosolized by self-detonations or simple plumbing leaks or ruptures.

- Currently, best guess of the aerosolized mass and respirable fraction from DOE-Handbook-3010-94, but data unavailable for our applications.

- The “source term” i.e. the releases radioactive aerosol mass and the particle size distribution are needed as input to assess transport and consequences of a release.

Objectives

- Provide a first-principles model from mechanical failure and pressurized liquid release, to aerosol formation by spraying and splattering.
- Simulate initiating events: (1) explosive detonations in a tank, and (2) plumbing cracks and spray formation.
- Provide a set of correlation for the source term for codes such as MELCOR.
  - Aerosolized particle size distribution, mass concentration, deposited mass, and liquid remaining in vessel

Demonstration Movie

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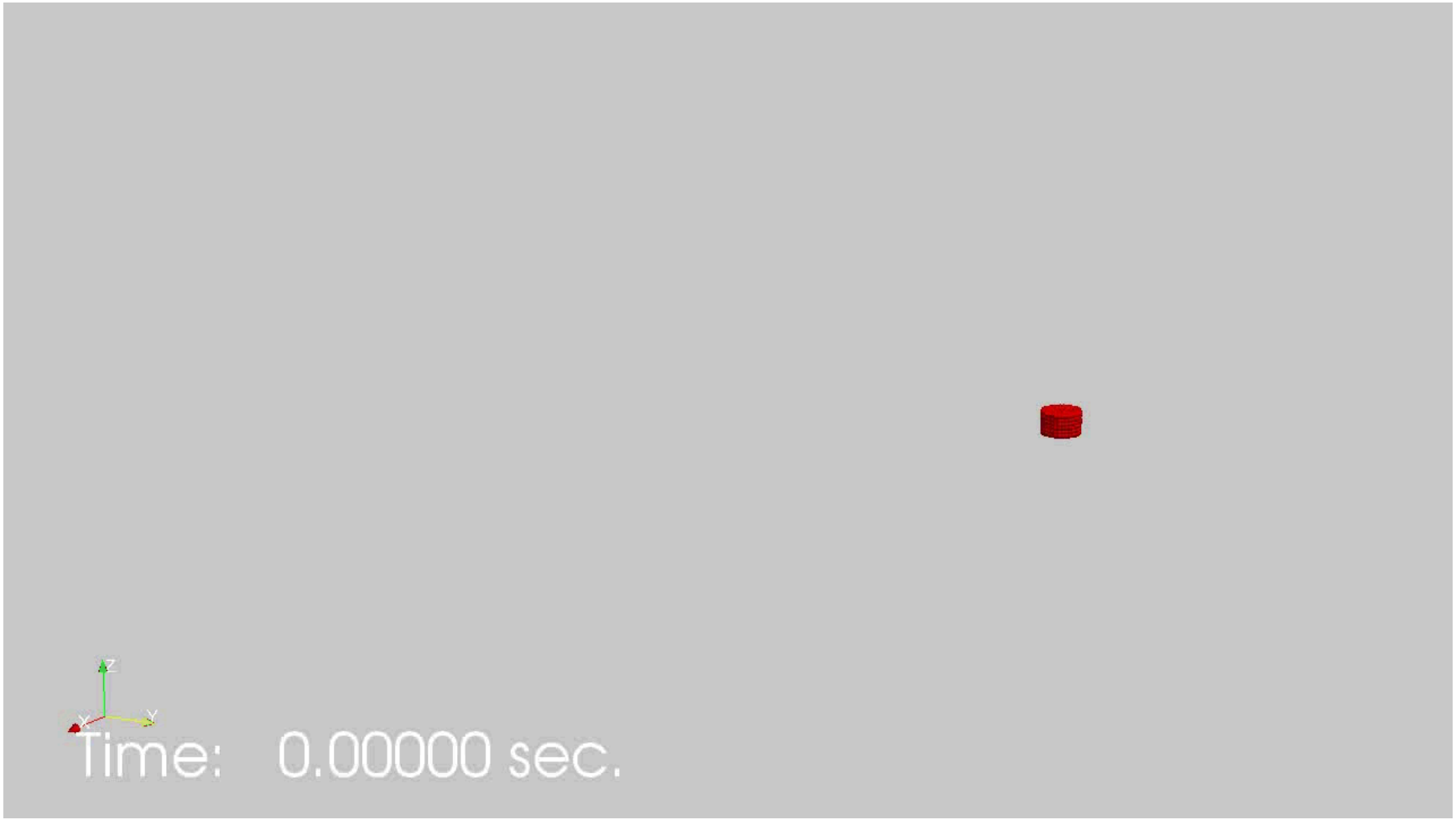
- Right circular cylindrical tank, 4 feet 2 inch diameter and height, 0.1 inch steel wall thickness
- Explosive liquid placed at bottom of tank and detonated at time zero.
- Fluid modeled (for now) as water.
- Tank is anchored to the floor but for convenience, walls, ceiling, and other structures are not included in simulation. (Will be added in the future.)
- ~100,000 particles to represent fluid in tank.

show the movie

Movie



Practical Computational Aspects

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- All codes are internal to SNL and do not require purchasing a license for use.
- Typically use hundreds of thousands of particles to represent liquid.
- Computational time for a simulation: 4 to 20 processor-days. The code is therefore best executed on a parallel machine (e.g. RedSky at SNL).
  - 1 processor: minimum of ~4 days of computing.
  - 64 processors: ~2-3 hours of computing.
  - No additional charge to use RedSky, but many user for the thousands of processors on the machine.

Next Steps

- Incorporate appropriate chemical explosive energy and density for reprocessing tanks.
- Incorporate actual solution physical properties: density, viscosity, and surface tension.
- Refine tank geometry and materials model based on tank design and room floor plan.
- Refine liquid model: increase number of particles from 100,000 to about 500,000.
- Compare calculation results with limited observations from reported accidents.