Valuation of the Sodium Fire Models in the CONTAIN-LMR/1B-Mod.1 Code Against the ABCOVE Experiments
Churl Yoon*(cyoon@kaeri.re.kr), Sang June Ahn and Seok Hun Kang
Korea Atomic Energy Research Institute

Purpose and Ultimate Goal
Purposes : To validate the sodium fire models in the CONATIN-LMR/1B code against the ABCOVE experiments, and
To compare the results with the MELCOR results without using the sodium fire models.
Ultimate Goal : Demonstration of the CONTAIN-LMR/1B code's capability to estimate transient P and T inside the containment during postulated accident conditions, as a design tool for the SFR(Sodium-cooled Fast Reactor) containment

Sodium Spray Fire Model
Phenomenological model used in NACOM code :
- Spray burning rate
  \[ m_t(t) = \int_0^t m_i(D_d, t', t) V_d(D_d, t', t) dD_d dN \]
  \( m_t \) = sodium droplet burning rate
  \( D_d \) = droplet diameter
  \( V_d \) = droplet velocity
  \( dN = \) number of droplets in
  \( D_d \) = volume of droplets
  \( D_d = \) volume mean diameter
- Calculation begins by partitioning the injected sodium spray source among 11 discrete droplet-size classes
  \[ \frac{dN}{dD_d} = \left( \frac{3.915}{B} \right)^2 \frac{D_d^2}{D_d^2} \exp \left[ -\frac{3.915}{B} \right] \]
- Now, \( dN \) can be derived from the sodium leak rate and drop size distribution
  \[ dN = \frac{6m_t(t')}{\pi D_d^3} \frac{dD_d}{dt} dD_d dN \]
- Important user input parameters
  - Mass mean droplet diameter
  - Fall height and terminal velocity
  - Relative proportions of Na2O and Na2O2 in the reaction products

Sodium Pool Fire Model
Chemical reaction model used in SOFIRE II code :
- Sodium burning rate is proportional to oxygen concentration at the sodium pool surface, to which oxygen in the atmosphere diffuse.
- Diffusion coefficient for oxygen-nitrogen mixtures
  \[ D_{O_2+O_3} = 6.4315 \times 10^{-9} \frac{T_{1827}}{P} \]
  \( T \) = gas (film) temperature [K]
  \( P \) = pressure [atm]
  \( m_0 \) = mass of sodium burned
  \( t \) = burning time
  \( \beta \) = gas expansion coefficient
  \( S \) = stoichiometric combustion ratio
- Gas transport coefficient, \( H_G \)
  \[ H_G = \frac{1}{\beta} \left( \frac{A_p}{A_s} \right) \frac{1}{\frac{t}{T_{SS}} - \frac{t}{T_{DS}}} \]
- Default Assumptions in the CONTAIN-LMR/1B :
  - All the produced peroxide(Na2O2) is aerosolized.
  - All the produced monoxide(Na2O) enter the pool.

Validation against ABCOVE AB5
Single-species aerosol test by spraying sodium into air
- Containment System Test Facility(CSTF): 852 m² carbon steel vessel
- Sodium spray starts from 13s to 885s.

Validation against ABCOVE AB6
NaI aerosol release test in the presence of a sodium spray fire
- Spraying 205kg of sodium into the CSTF over a period of 4780s (from 620s to 5400s).
- Oxygen conc. was maintained relatively constant.

Validation against ABCOVE AB7
A small sodium pool fire following sodium leakage from a line at 10-m elevation.
- Leakage from a sodium spray line was stopped 20s after.
- Leaked sodium formed a pool and burned as a pool fire.

* Corresponding author