3. FDS Configuration and Simulation Setup

3.1 Fire Dynamics Simulator Overview

Fire Dynamics Simulator (FDS) is a large-eddy simulation (LES) code developed by NIST for modeling fire-driven fluid flow. The model numerically solves a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport.

3.2 Computational Domain and Mesh

Mesh Resolution Criteria:

- **D*/δx ratio:** The characteristic fire diameter (D*) to cell size (δx) ratio should typically be between 4 and 16 for adequate plume resolution
- **Characteristic fire diameter:** $D^* = (\dot{Q}/\rho_\infty c_p T_\infty \sqrt{g})^{2/5}$
- **Cell aspect ratio:** Grid cells should have aspect ratios close to 1:1:1 in critical regions

3.3 Simulation Parameters

Numerical Methods:

- **Turbulence model:** Large Eddy Simulation (LES) with Deardorff subgrid-scale model
- **Radiation solver:** Finite volume method with gray gas assumption
- **Time integration:** Second-order accurate explicit Runge-Kutta scheme
- **Pressure solver:** Fast Fourier Transform (FFT)-based direct solver

3.4 Output Quantities

The simulation generates Plot3D format output files containing three-dimensional field data for the following quantities at regular time intervals:

- **Temperature (°C):** Gas phase temperature field
- **Visibility (m):** Calculated from smoke extinction coefficient
- **CO_2 Volume Fraction:** Carbon dioxide concentration
- **CO Concentration (ppm):** Carbon monoxide concentration