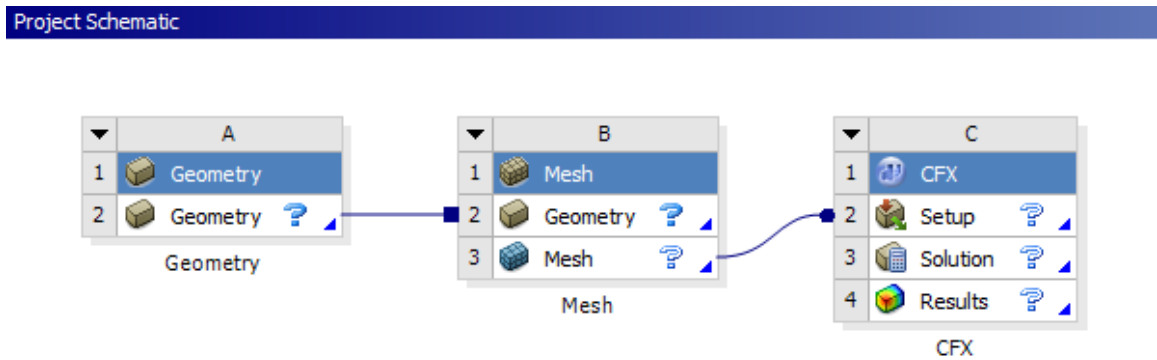


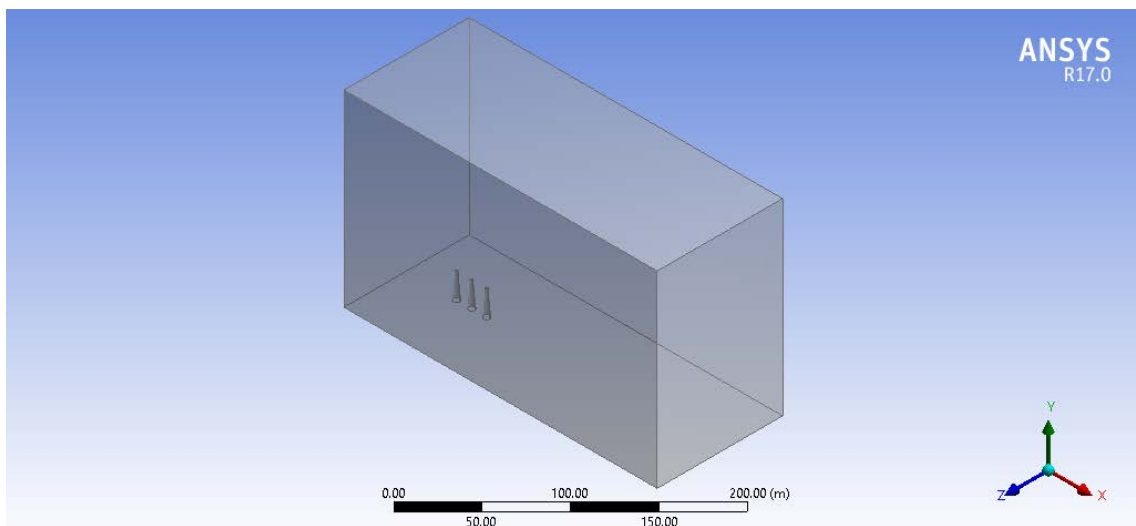
LAMPIRAN

Project Schematic ANSYS WORKBENCH :



Geometry :

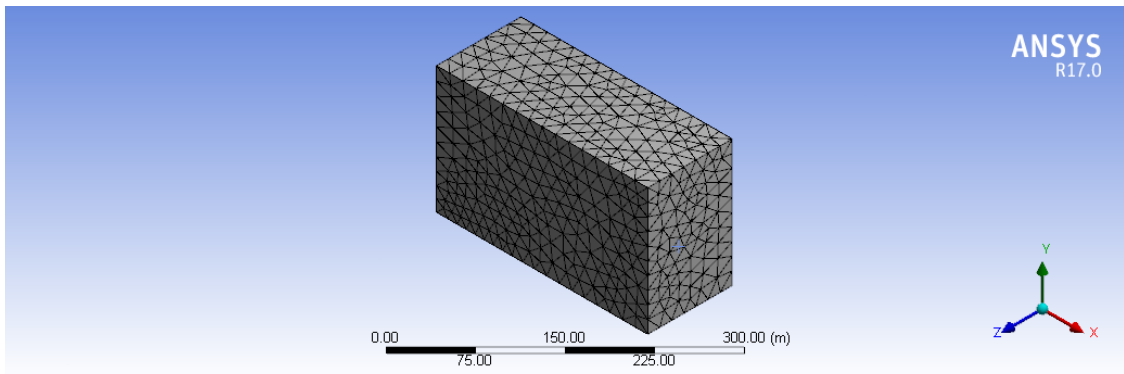
X = 250 m ; Y = 150 m ; Z = 100 m



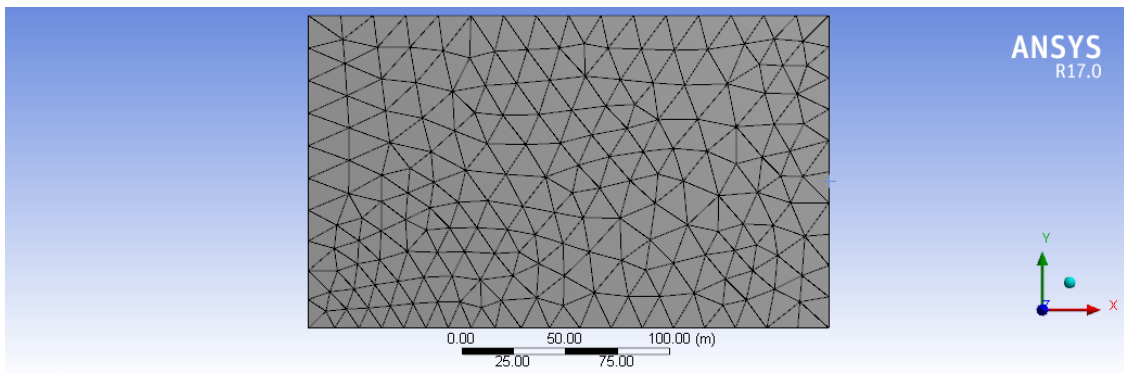
Mesh :

Details of "Mesh"	
[-] Display	
Display Style	Body Color
[-] Defaults	
Physics Preference	CFD
Solver Preference	CFX
<input type="checkbox"/> Relevance	0
Shape Checking	CFD
Element Midside Nodes	Dropped
+ Sizing	
+ Inflation	
+ Advanced	
+ Statistics	

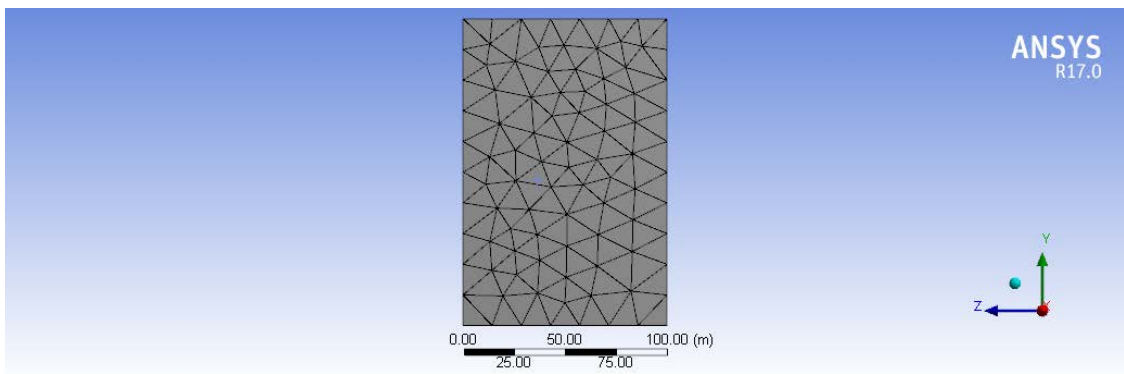
Tampak Isometri



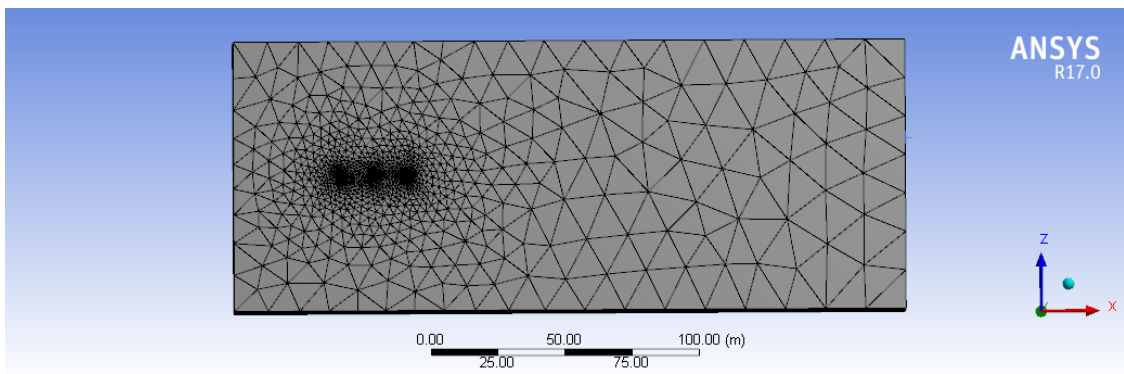
Tampak Samping (Z)



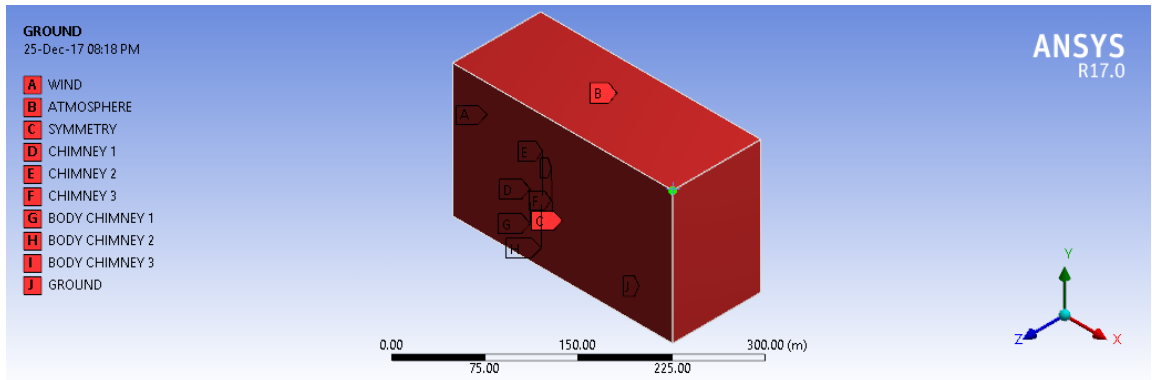
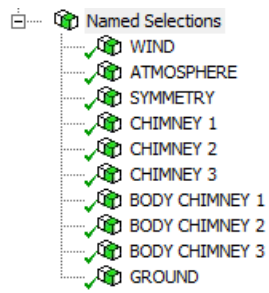
Tampak Depan (X)



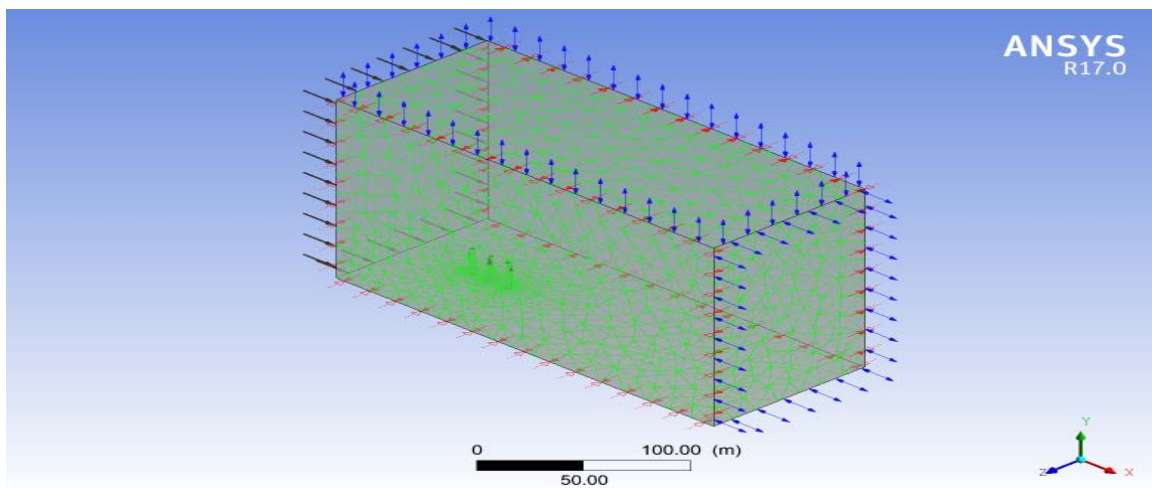
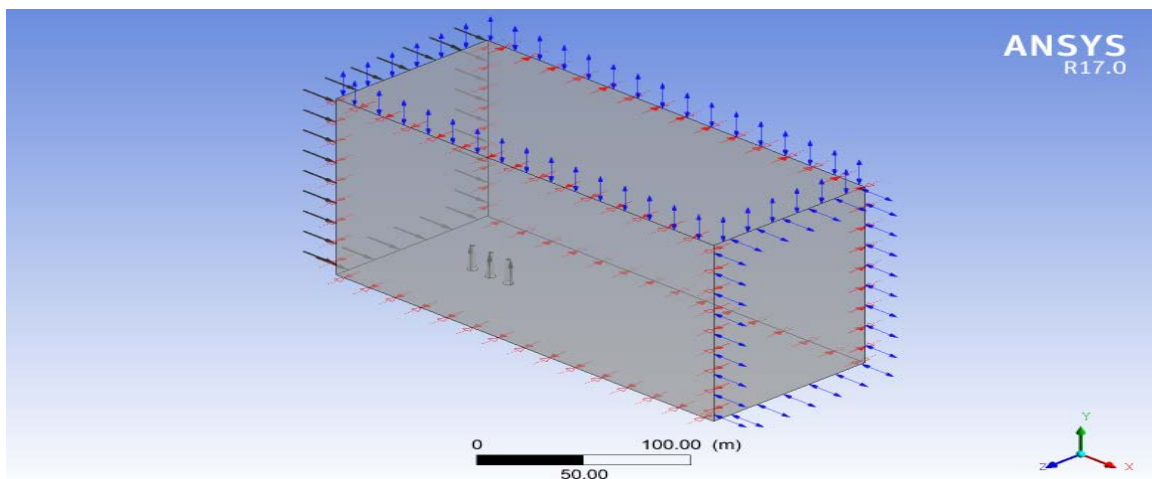
Tampak Atas (Y)



Name Selections :



Setup :



Analysis Type :

Details of **Analysis Type** in **Flow Analysis 1**

Basic Settings

ANSYS MultiField Coupling

Option

Analysis Type

Option

Time Duration

Option

Total Time

Time Steps

Option

Timesteps

Initial Time

Option

Time

Material :

Details of **SMOKE**

Basic Settings **Mixture Properties**

Option

Material Group ...

Materials List ...

Material Description +

Thermodynamic State +

Coordinate Frame +

Solution Unit :

Details of **Solution Units** in **Flow Analysis 1**

Basic Settings

Mass Units ...

Length Units ...

Time Units

Temperature Units

Angle Units +

Angle Units

Solid Angle Units +

Solid Angle Units

Default Domain – Basic Settings :

Details of **Default Domain** in **Flow Analysis 1**

Basic Settings Fluid Models Fluid Specific Models Fluid Pair Models Initialization

Location and Type

Location: B31

Domain Type: Fluid Domain

Coordinate Frame: Coord 0

Fluid and Particle Definitions...

AIR IDEAL GAS

SMOKE

AIR IDEAL GAS

Option: Material Library

Material: Air Ideal Gas

Morphology: Continuous Fluid

Minimum Volume Fraction

SMOKE

Option: Material Library

Material: SMOKE

Morphology: Dispersed Fluid

Mean Diameter: 1 [m]

Minimum Volume Fraction

Maximum Packing

Domain Models

Pressure

Reference Pressure: 1 [atm]

Buoyancy Model

Option: Buoyant

Gravity X Dirn.: 0 [m s⁻²]

Gravity Y Dirn.: -9.81 [m s⁻²]

Gravity Z Dirn.: 0 [m s⁻²]

Buoy. Ref. Density: 1.2 [kg m⁻³]

Ref. Location: Automatic

Domain Motion

Option: Stationary

Mesh Deformation

Option: None

Default Domain – Fluid Models :

Details of **Default Domain** in **Flow Analysis 1**

Basic Settings Fluid Models Fluid Specific Models Fluid Pair Models Initialization

Multiphase [-]

Homogeneous Model

Free Surface Model [-]

Option None

Heat Transfer [-]

Homogeneous Model

Option Total Energy

Incl. Viscous Work Term

Turbulence [-]

Homogeneous Model

Option Fluid Dependent ...

Combustion [-]

Option None

Thermal Radiation [-]

Option None

Electromagnetic Model [+]

Default Domain – Fluid Specific Models :

Details of **Default Domain** in **Flow Analysis 1**

Basic Settings Fluid Models Fluid Specific Models Fluid Pair Models Initialization

Fluid [-]

AIR IDEAL GAS
SMOKE

AIR IDEAL GAS

Fluid Buoyancy Model [-]

Option Density Difference

Turbulence [-]

Option k-Epsilon ...

Wall Function Scalable

High Speed (compressible) Wall Heat Transfer Model

Turbulent Flux Closure for Heat Transfer [+]

Advanced Turbulence Control [+]

Buoyancy Turbulence [-]

Option None

Default Domain – Fluid Pair Models :

Details of **Default Domain** in **Flow Analysis 1**

Basic Settings Fluid Models Fluid Specific Models **Fluid Pair Models** Initialization

Fluid Pair

AIR IDEAL GAS | SMOKE

Surface Tension Coefficient

Interphase Transfer

Option Particle Model

Minimum Volume Fraction for Area Density

Momentum Transfer

Drag Force

Option Schiller Naumann

Non-drag forces

Lift Force - None

Virtual Mass Force - None

Wall Lubrication Force

Turbulent Dispersion Force

Turbulence Transfer

Option None

Mass Transfer

Option None

Heat Transfer

Option Ranz Marshall

Initialization – Global Setting :

Details of **Global Initialization** in **Flow Analysis 1**

Global Settings Fluid Settings

Coordinate Frame

Initial Conditions

Static Pressure

Option Automatic with Value

Relative Pressure 1 [atm]

Initialization – Fluid Setting (Air Ideal Gas) :

Details of **Global Initialization** in **Flow Analysis 1**

Global Settings Fluid Settings

Fluid Specific Initialization

AIR IDEAL GAS
SMOKE

AIR IDEAL GAS

Initial Conditions

Velocity Type Cartesian

Cartesian Velocity Components

Option Automatic with Value

U 1 [m s⁻¹]

V 0 [m s⁻¹]

W 0 [m s⁻¹]

Temperature

Option Automatic with Value

Temperature 301 [K]

Turbulence

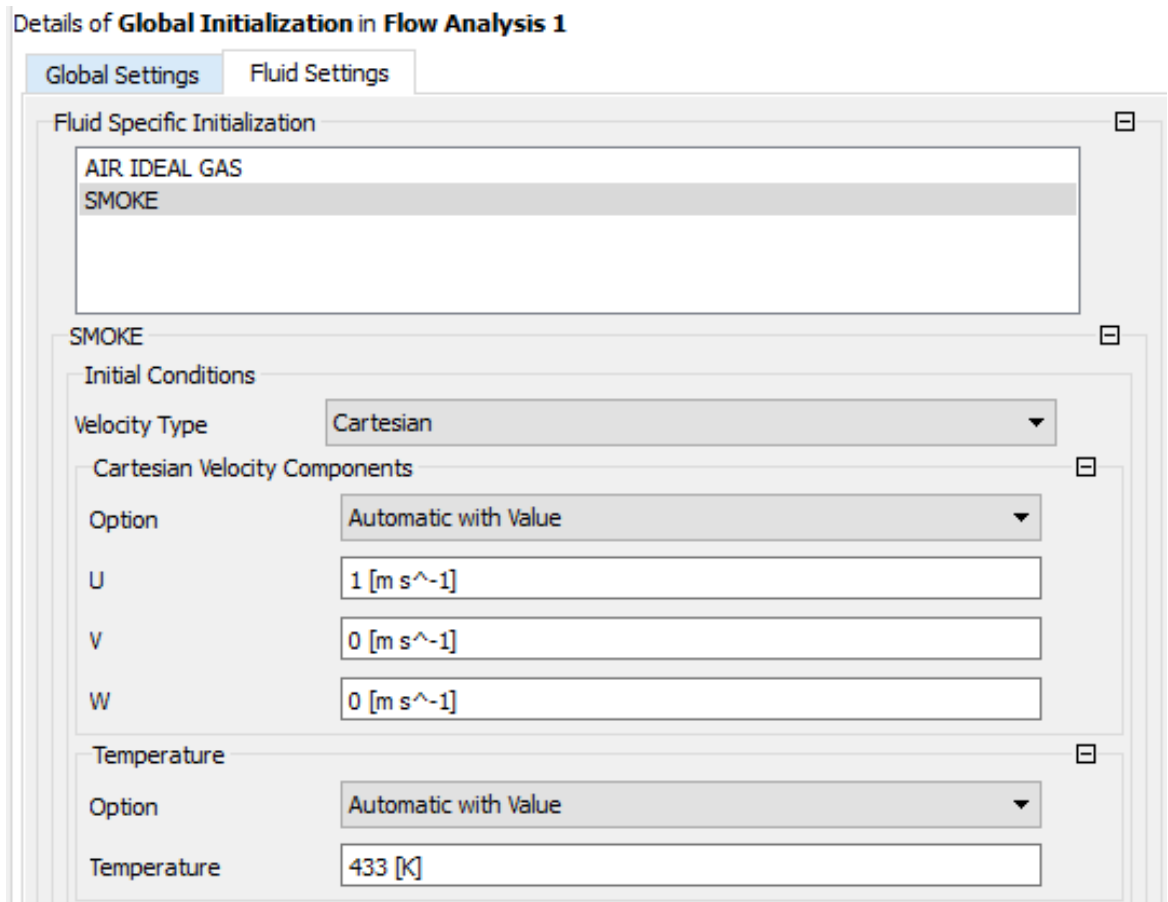
Option Low (Intensity = 1%)

Volume Fraction

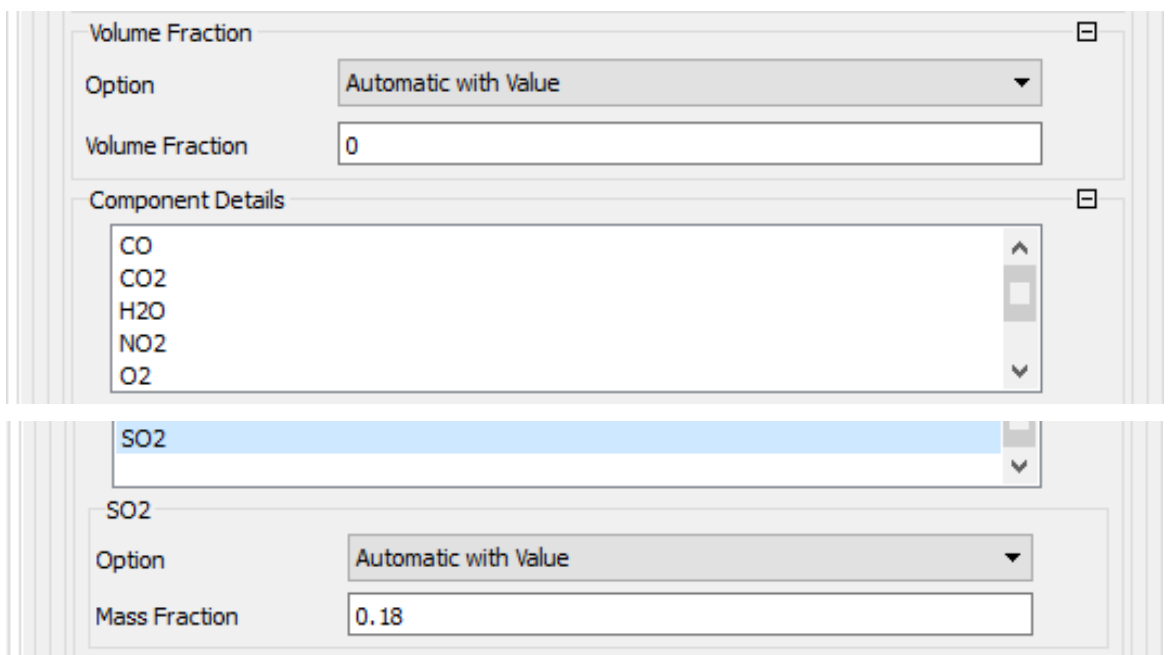
Option Automatic with Value

Volume Fraction 1

Initialization – Fluid Setting (Smoke) :



Value Mass Fraction : CO = 0 ; CO₂ = 0 ; H₂O = 0 ; NO₂ = 0.32 ; O₂ = 0.22 ; NO₂ = 0.18



Boundary – Default Domain Default

Basic Settings :

Details of **Default Domain Default** in **Default Domain** in **Flow Analysis 1**

Basic Settings	Boundary Details	Sources
Boundary Type	Wall	
Location	F32.31,F36.31,F38.31,F40.31	
<input type="checkbox"/> Coordinate Frame		

Boundary Details :

Details of **Default Domain Default** in **Default Domain** in **Flow Analysis 1**

Basic Settings	Boundary Details	Sources
Mass And Momentum		
Option	No Slip Wall	
<input type="checkbox"/> Wall Velocity		
Wall Roughness		
Option	Smooth Wall	
Heat Transfer		
Option	Adiabatic	
Wall Contact Model		
Option	Use Volume Fraction	

Boundary – Atmosphere

Basic Settings :

Details of **ATMOSPHERE** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Boundary Type: Opening

Location: ATMOSPHERE

Coordinate Frame

Boundary Details :

Details of **ATMOSPHERE** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Flow Regime: Subsonic

Mass And Momentum: Opening Pres. and Dirn

Relative Pressure: 1 [atm]

Flow Direction: Normal to Boundary Condition

Loss Coefficient

Turbulence: Low (Intensity = 1%)

Heat Transfer: Opening Temperature

Opening Temperature: 301 [K]

Fluid Details :

Details of **ATMOSPHERE** in **Default Domain** in **Flow Analysis 1**

Basic Settings | **Boundary Details** | Fluid Values | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE

AIR IDEAL GAS

Volume Fraction

Option: Value

Volume Fraction: 1

Details of **ATMOSPHERE** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | **Fluid Values** | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE

SMOKE

Volume Fraction

Option: Value

Volume Fraction: 0

Boundary – Wind

Basic Settings :

Details of **WIND** in **Default Domain** in **Flow Analysis 1**

Basic Settings	Boundary Details	Fluid Values	Sources	Plot Options
Boundary Type	Inlet			
Location	WIND			...
<input type="checkbox"/> Coordinate Frame	+			

Boundary Details :

Details of **WIND** in **Default Domain** in **Flow Analysis 1**

Basic Settings	Boundary Details	Fluid Values	Sources	Plot Options
Flow Regime	Option: Subsonic			
Mass And Momentum	Option: Normal Speed Normal Speed: 1.6 [m s ⁻¹]			
Turbulence	Option: Low (Intensity = 1%)			
Heat Transfer	Option: Static Temperature Static Temperature: 301 [K]			

Fluid Details :

Details of **WIND** in **Default Domain** in **Flow Analysis 1**

Basic Settings | **Boundary Details** | Fluid Values | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE

AIR IDEAL GAS

Volume Fraction

Option: Value

Volume Fraction: 1

Details of **WIND** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | **Fluid Values** | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE

SMOKE

Volume Fraction

Option: Value

Volume Fraction: 0

Boundary - Symmetry :

Basic Settings :

Details of **SYMMETRY** in **Default Domain** in **Flow Analysis 1**

Basic Settings

Boundary Type: Symmetry

Location: SYMMETRY

Boundary – Chimney 1

Basic Settings :

Details of **CHIMNEY 1** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Boundary Type: Inlet

Location: CHIMNEY 1

Coordinate Frame

Boundary Details :

Details of **CHIMNEY 1** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Flow Regime: Subsonic

Mass And Momentum: Normal Speed

Normal Speed: 10 [m s⁻¹]

Turbulence: Medium (Intensity = 5%)

Heat Transfer: Static Temperature

Static Temperature: 433 [K]

Fluid Details :

Details of **CHIMNEY 1** in **Default Domain** in **Flow Analysis 1**

Basic Settings | **Boundary Details** | Fluid Values | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE

AIR IDEAL GAS

Volume Fraction

Option: Value

Volume Fraction: 0

Details of **CHIMNEY 1** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | **Fluid Values** | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE**

SMOKE

Volume Fraction

Option: Value

Volume Fraction: 1

Boundary – Chimney 2

Basic Settings :

Details of **CHIMNEY 2** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Boundary Type: Inlet

Location: CHIMNEY 2

Coordinate Frame

Boundary Details :

Details of **CHIMNEY 2** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Flow Regime: Subsonic

Mass And Momentum: Normal Speed

Normal Speed: 20 [m s⁻¹]

Turbulence: Medium (Intensity = 5%)

Heat Transfer: Static Temperature

Static Temperature: 433 [K]

Fluid Details :

Details of **CHIMNEY 2** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE**

AIR IDEAL GAS

Volume Fraction

Option: Value

Volume Fraction: 0

Details of **CHIMNEY 2** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE**

SMOKE

Volume Fraction

Option: Value

Volume Fraction: 1

Boundary – Chimney 3

Basic Settings :

Details of **CHIMNEY 3** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Boundary Type: Inlet

Location: CHIMNEY 3

Coordinate Frame

Boundary Details :

Details of **CHIMNEY 3** in **Default Domain** in **Flow Analysis 1**

Basic Settings | Boundary Details | Fluid Values | Sources | Plot Options

Flow Regime: Subsonic

Mass And Momentum: Normal Speed

Normal Speed: 30 [m s⁻¹]

Turbulence: Medium (Intensity = 5%)

Heat Transfer: Static Temperature

Static Temperature: 433 [K]

Fluid Details :

Details of **CHIMNEY 3** in **Default Domain** in **Flow Analysis 1**

Basic Settings | **Boundary Details** | Fluid Values | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE

AIR IDEAL GAS

Volume Fraction

Option: Value

Volume Fraction: 0

Details of **CHIMNEY 3** in **Default Domain** in **Flow Analysis 1**

Basic Settings | **Boundary Details** | Fluid Values | Sources | Plot Options

Boundary Conditions

- AIR IDEAL GAS
- SMOKE**

SMOKE

Volume Fraction

Option: Value

Volume Fraction: 1

Output Control :

Details of **Output Control** in **Flow Analysis 1**

Results Backup Trn Results Trn Stats Monitor Export

Transient Results

Transient Results 1

Option Standard

File Compression Default

Output Equation Residuals

Extra Output Variables List

Output Frequency

Option Every Timestep

Solver Control :

Details of **Solver Control** in **Flow Analysis 1**

Basic Settings Equation Class Settings Advanced Options

Advection Scheme

Option High Resolution

Transient Scheme

Option Second Order Backward Euler

Timestep Initialization

Option Automatic

Lower Courant Number

Upper Courant Number

Turbulence Numerics

Option First Order

Convergence Control

Min. Coeff. Loops 1

Max. Coeff. Loops 10

Fluid Timescale Control

Timescale Control Coefficient Loops

Convergence Criteria

Residual Type RMS

Residual Target 1.E-4

Conservation Target

Elapsed Wall Clock Time Control

Interrupt Control

CONVERSION FACTORS*

Length:

$$1 \text{ ft} = 0.3048 \text{ m} = 12 \text{ in.} = \text{mile}/5280 = \text{nautical mile}/6076 \\ = \text{km}/3281$$

$$1 \text{ m} = 3.281 \text{ ft} = 39.37 \text{ in.} = \text{km}/1000 = 100 \text{ cm} = 1000 \text{ mm} \\ = 10^6 \text{ microns} = 10^6 \mu\text{m} = 10^9 \text{ nm} = 10^{10} \text{ \AA}$$

Mass:

$$1 \text{ lbm} = 0.45359 \text{ kg} = \text{short ton}/2000 = \text{long ton}/2240 = 16 \text{ oz (av.)} \\ = 14.58 \text{ oz (troy)} = \text{metric ton (tonne)}/2204.63 = 7000 \text{ grains} \\ = \text{slug}/32.2$$

$$1 \text{ kg} = 2.2046 \text{ lbm} = 1000 \text{ g} = (\text{metric ton or tonne or Mg})/1000$$

Force:

$$1 \text{ lbf} = 4.4482 \text{ N} = 32.2 \text{ lbm} \cdot \text{ft}/\text{s}^2 = 32.2 \text{ poundal} = 0.4536 \text{ kgf}$$

$$1 \text{ N} = \text{kg} \cdot \text{m}/\text{s}^2 = 10^5 \text{ dyne} = \text{kgf}/9.81 = 0.2248 \text{ lbf}$$

Volume:

$$1 \text{ ft}^3 = 0.02831 \text{ m}^3 = 28.31 \text{ liters} = 7.48 \text{ U.S. gallons} \\ = 6.23 \text{ Imperial gallons} = \text{acre-ft}/43\,560$$

$$1 \text{ U.S. gallon} = 231 \text{ in.}^3 = \text{barrel (petroleum)}/42 = 4 \text{ U.S. quarts} \\ = 8 \text{ U.S. pints} = 3.785 \text{ liters} = 0.003785 \text{ m}^3$$

$$1 \text{ m}^3 = 1000 \text{ liters} = 35.29 \text{ ft}^3$$

Energy:

$$1 \text{ Btu} = 1055 \text{ J} = 1.055 \text{ kw} \cdot \text{s} = 2.93 \times 10^{-4} \text{ kwh} = 252 \text{ cal} \\ = 777.97 \text{ ft} \cdot \text{lbf} = 3.93 \times 10^{-4} \text{ hp} \cdot \text{h}$$

$$1 \text{ J} = \text{N} \cdot \text{m} = \text{W} \cdot \text{s} = \text{volt} \cdot \text{coulomb} = 9.48 \times 10^{-4} \text{ Btu} \\ = 0.239 \text{ cal} = 10^7 \text{ erg} = 6.24 \times 10^{18} \text{ electron volts}$$

*These values are mostly rounded. There are several definitions for some of these quantities, e.g., the Btu and the calorie; these definitions differ from each other by up to 0.2 percent. For the most accurate values see the *ASTM Metric Practice Guide*, ASTM Pub. E 380-93, Philadelphia, 1993.

Power:

$$1 \text{ hp} = 550 \text{ ft} \cdot \text{lb}/\text{s} = 33\,000 \text{ ft} \cdot \text{lb}/\text{min} = 2545 \text{ Btu}/\text{h} = 0.746 \text{ kW}$$

$$1 \text{ W} = \text{J}/\text{s} = \text{N} \cdot \text{m}/\text{s} = \text{volt} \cdot \text{ampere} = 1.34 \times 10^{-3} \text{ hp} = 0.239 \text{ cal}/\text{s} \\ = 9.49 \times 10^{-4} \text{ Btu}/\text{s}$$

Pressure:

$$1 \text{ atm} = 101.3 \text{ kPa} = 1.013 \text{ bar} = 14.696 \text{ lb}/\text{in.}^2 = 33.89 \text{ ft of water} \\ = 29.92 \text{ inches of mercury} = 1.033 \text{ kg}/\text{cm}^2 = 10.33 \text{ m of water} \\ = 760 \text{ mm of mercury} = 760 \text{ torr}$$

$$1 \text{ psi} = \text{atm}/14.696 = 6.89 \text{ kPa} = 0.0689 \text{ bar} = 27.7 \text{ in. H}_2\text{O} = 51.7 \text{ torr}$$

$$1 \text{ Pa} = \text{N}/\text{m}^2 = \text{kg}/\text{m} \cdot \text{s}^2 = 10^{-5} \text{ bar} = 1.450 \times 10^{-4} \text{ lb}/\text{in.}^2 \\ = 0.0075 \text{ torr} = 0.0040 \text{ in. H}_2\text{O}$$

$$1 \text{ bar} = 10^5 \text{ Pa} = 0.987 \text{ atm} = 14.5 \text{ psia}$$

Psia, psig:

Psia means pounds per square inch, absolute. Psig means pounds per square inch, gauge, i.e., above or below the local atmospheric pressure.

Viscosity:

$$1 \text{ cp} = 0.01 \text{ poise} = 0.01 \text{ g}/\text{cm} \cdot \text{s} = 0.001 \text{ kg}/\text{m} \cdot \text{s} = 0.001 \text{ Pa} \cdot \text{s} \\ = 6.72 \times 10^{-4} \text{ lbm}/\text{ft} \cdot \text{s} = 2.42 \text{ lbm}/\text{ft} \cdot \text{h} = 2.09 \times 10^{-5} \text{ lbf} \cdot \text{s}/\text{ft}^2 \\ = 0.01 \text{ dyne} \cdot \text{s}/\text{cm}^2$$

Kinematic viscosity:

$$1 \text{ cs} = 0.01 \text{ stoke} = 0.01 \text{ cm}^2/\text{s} = 10^{-6} \text{ m}^2/\text{s} = 1 \text{ cp}/(\text{g}/\text{cm}^3) \\ = 1.08 \times 10^{-5} \text{ ft}^2/\text{s} = \text{cp}/(62.4 \text{ lbm}/\text{ft}^3)$$

Temperature:

$$\text{K} = ^\circ\text{C} + 273.15 = ^\circ\text{R}/1.8 \approx ^\circ\text{C} + 273 \quad ^\circ\text{C} = (^\circ\text{F} - 32)/1.8$$

$$^\circ\text{R} = ^\circ\text{F} + 459.67 = 1.8 \text{ K} \approx ^\circ\text{F} + 460 \quad ^\circ\text{F} = 1.8^\circ\text{C} + 32$$

Concentration (ppm):

In the air pollution literature and in this book, ppm applied to a gas always means parts per million by volume or by mol. These are identical for an ideal gas, and practically identical for most gases of air pollution interest at 1 atm pressure. Ppm applied to a liquid or solid means parts per million by mass.

For perfect gases at 1 atm and 25°C, 1 ppm = (40.87 · molecular weight) $\mu\text{g}/\text{m}^3$