The application of a Positive Displacement Ventilation Protocol in an industrial precious metal refining facility.

Society for Mining, Metallurgy & Exploration

Annual Meeting

February 25, 2013

William D. Mele, CIEC

Senior Engineer

Chemistry&Industrial Hygiene

Wheat Ridge, Colorado

Learning Objectives

1. Recognize the difference between turbulent flow and laminar flow airstreams
2. Understand the function of make-up air temperature, thermal plumes and velocity in developing Piston Flow
3. Appreciate the role of commissioning in system functioning and operation.

Definitions

- Ventilation
- Local Exhaust Ventilation
- General Dilution Ventilation
- Turbulent Flow
- Laminar Flow
- Thermal Displacement Ventilation

Definitions

- Ventilation The process of supplying fresh air to an enclosed space in order to refresh, remove, or replace the existing atmosphere.

- Local exhaust ventilation is designed to capture an emitted contaminant at or near its source, before the contaminant has a chance to disperse into the workplace air.

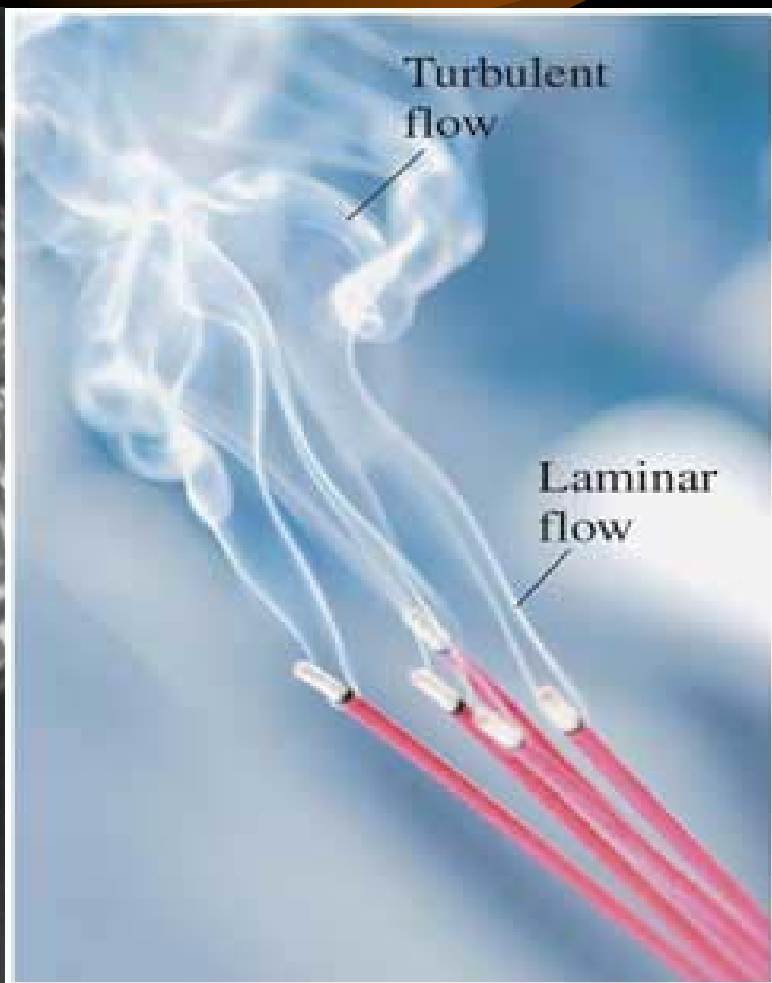
- General dilution ventilation allows the contaminant to be emitted into the workplace air and then dilutes the concentration of the contaminant to an acceptable level (e.g. below the PEL). Dilution systems are often used to control evaporated liquids.

Turbulent Flow:

A fluid motion in which velocity, pressure, and other flow quantities fluctuate irregularly in time and space

Laminar flow:

Sometimes known as streamline flow, occurs when a fluid flows in parallel layers, with no disruption between the layers



Thermal Displacement Ventilation

A distribution strategy whereby conditioned ventilation air is supplied at the floor level, at lower temperature, and low velocity, gradually filling the space from the bottom up. Warmer contaminated air is displaced in a laminar flow fashion, on thermal plumes, to the upper regions of the space above a stratification level of uniform temperature.

Design Criteria

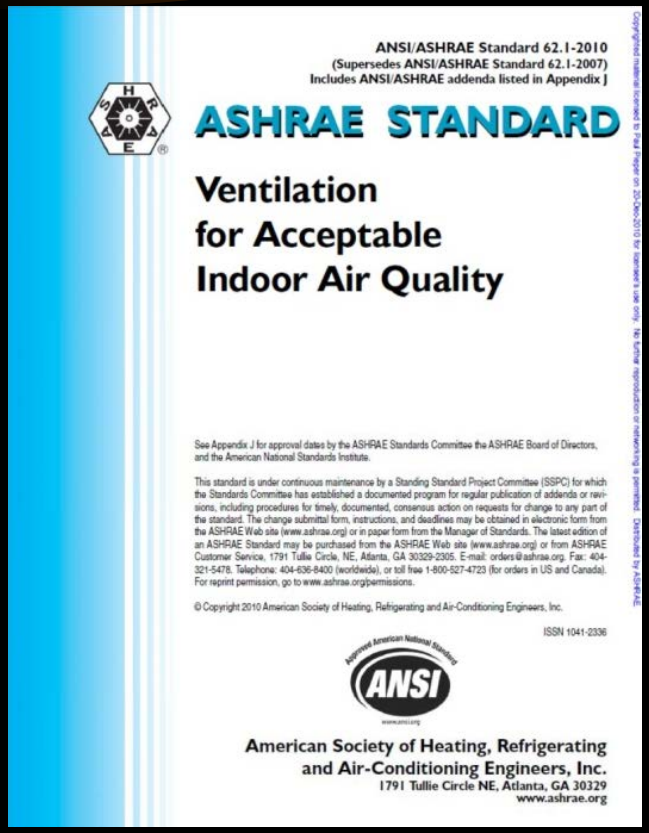
V= 40-50 fpm

$\Delta T = 4\text{-}10^{0}$ F

H= ≥ 9 ft.

E_z = 1.2 for Low Velocity Displacement Ventilation (ASHRAE 62.1)

E_z = Zone Air Distribution effectiveness



The Process

- Metal is recovered from cyanide solution through electrowinning process (125-130^0 F)
  - Screen wash causes aerosolization
- Cake is pressed in filter unit and dried in oven (350^0 F)
- Loaded into melting furnace generating dust
- Furnace melting emits fumes (2100-2200^0 F)
- Crucible slagging emits fumes (~200^0 F)
- Furnace tilting for bar pouring emits fumes

The Problem

- High contaminant levels requires respirators
- Large high bay space
- Multiple contaminant sources
- Inadequate/impractical local exhaust
- Limited exhaust/make-up air availability
- Contaminant transfer to adjoining spaces

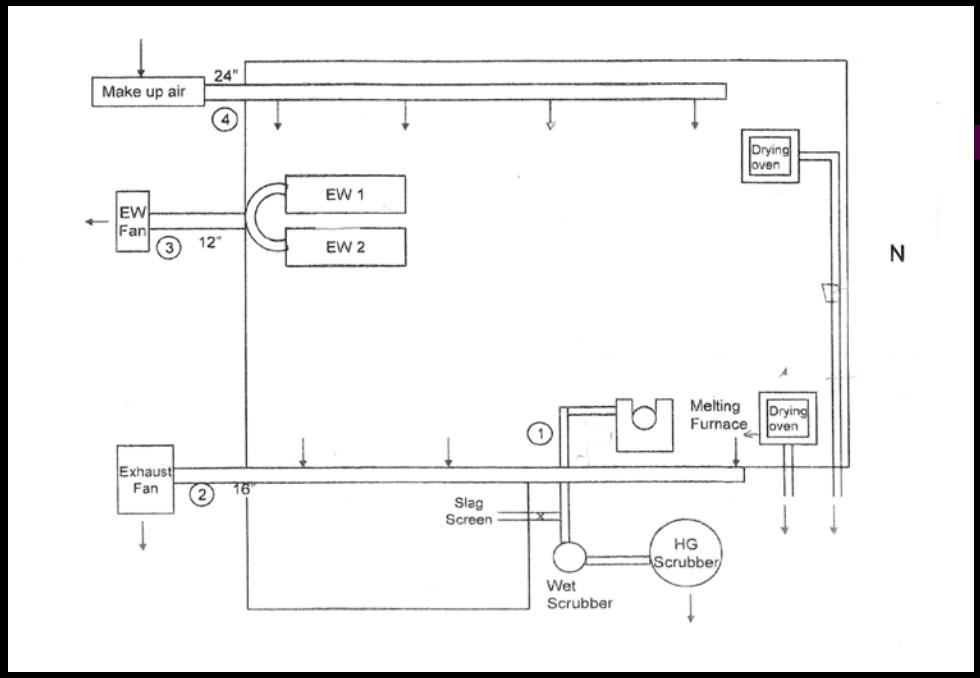
Contaminant Levels

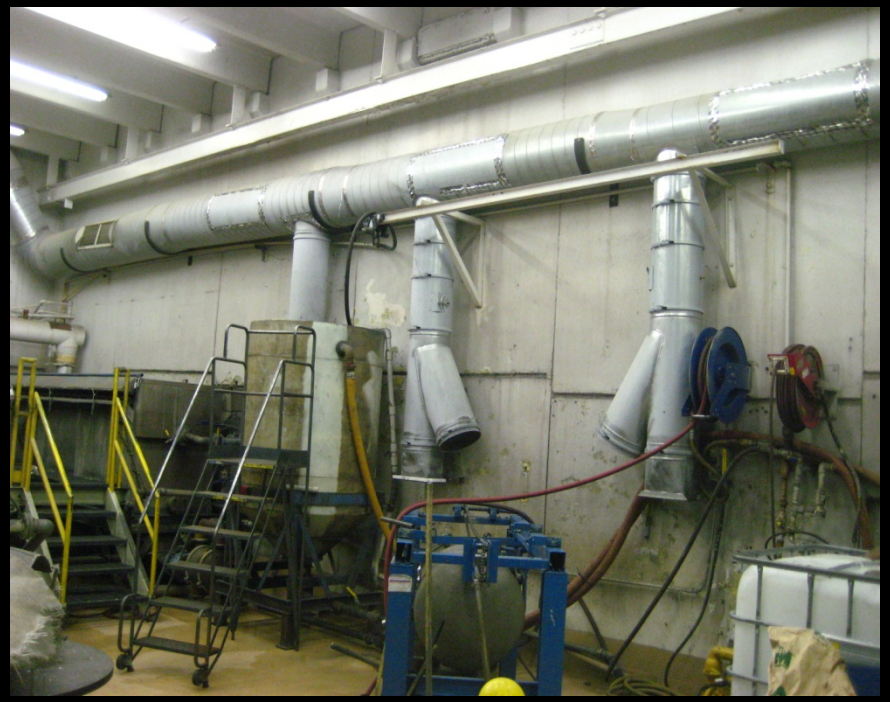
- Point sources
- Personal samples
- Area samples
  - Various height levels

Pre-existing condition

- Local exhaust at melting furnace and electro-winning cells
- General dilution exhaust
  - High velocity down discharge MUA along west wall
  - Turbulent flow
  - Exhaust air high along east wall and high bay ceiling
  - Primarily cross flow arrangement
  - 18 ACH
- Poor room pressure control

Original Refinery Floorplan

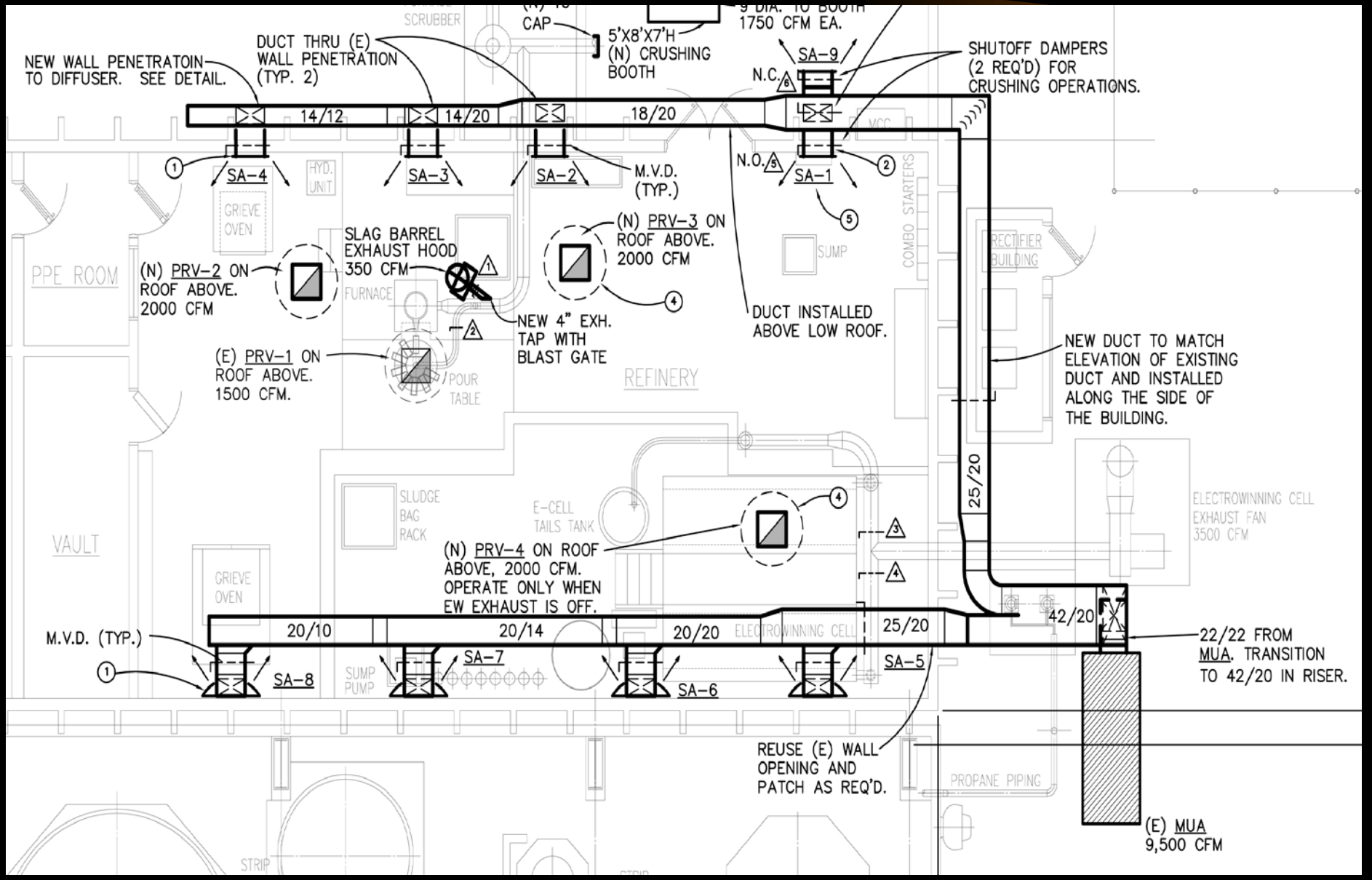




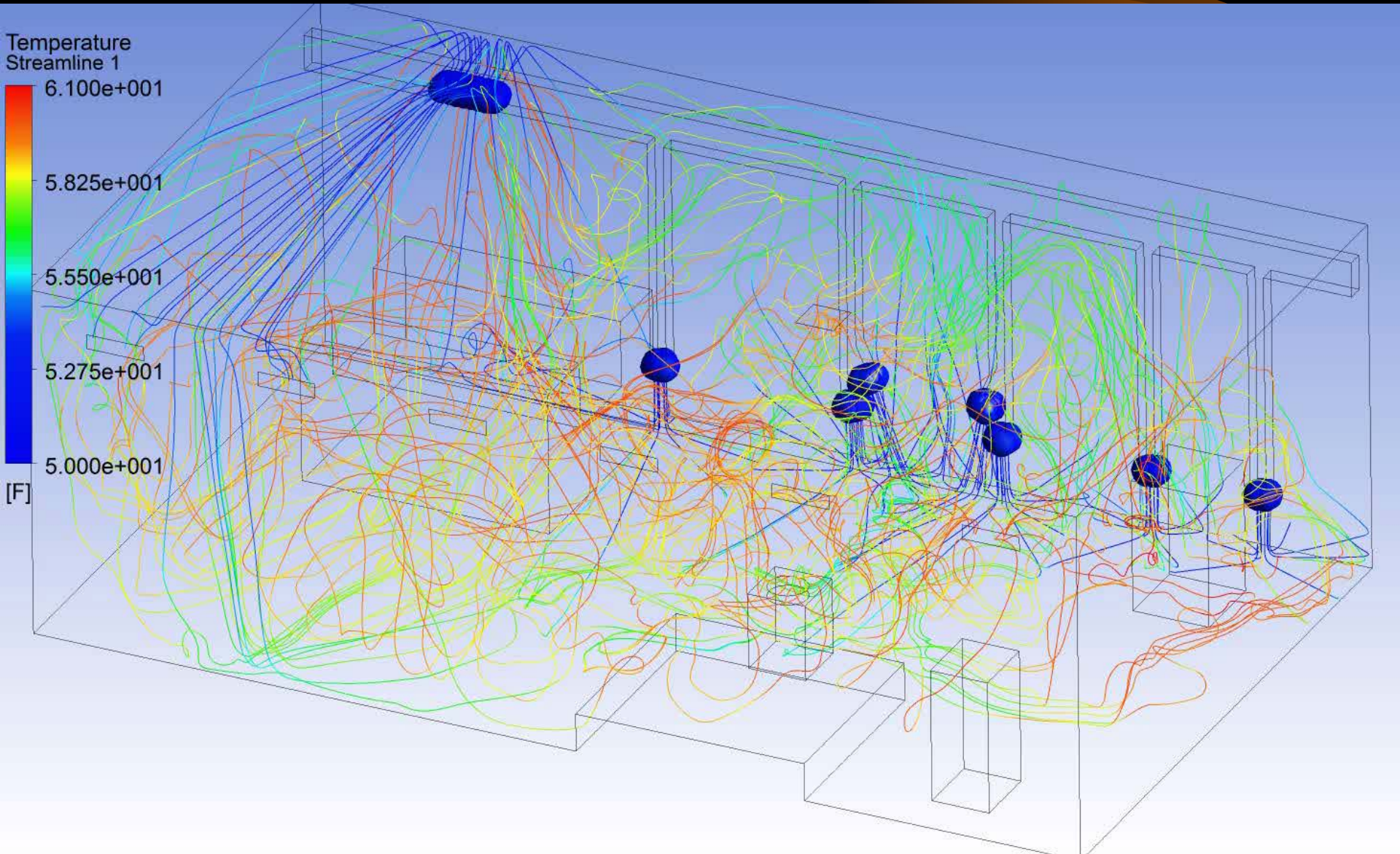
Displacement Ventilation

- Make-up air delivered at the floor along both east and west walls through low velocity diffusers
- Low velocity, lower temperature (set 10 degrees)
- Local furnace and electrowinning exhaust
- Add high bay (ceiling) exhaust utilizing thermal plumes
- Balanced supply and exhaust for slight negative room pressure

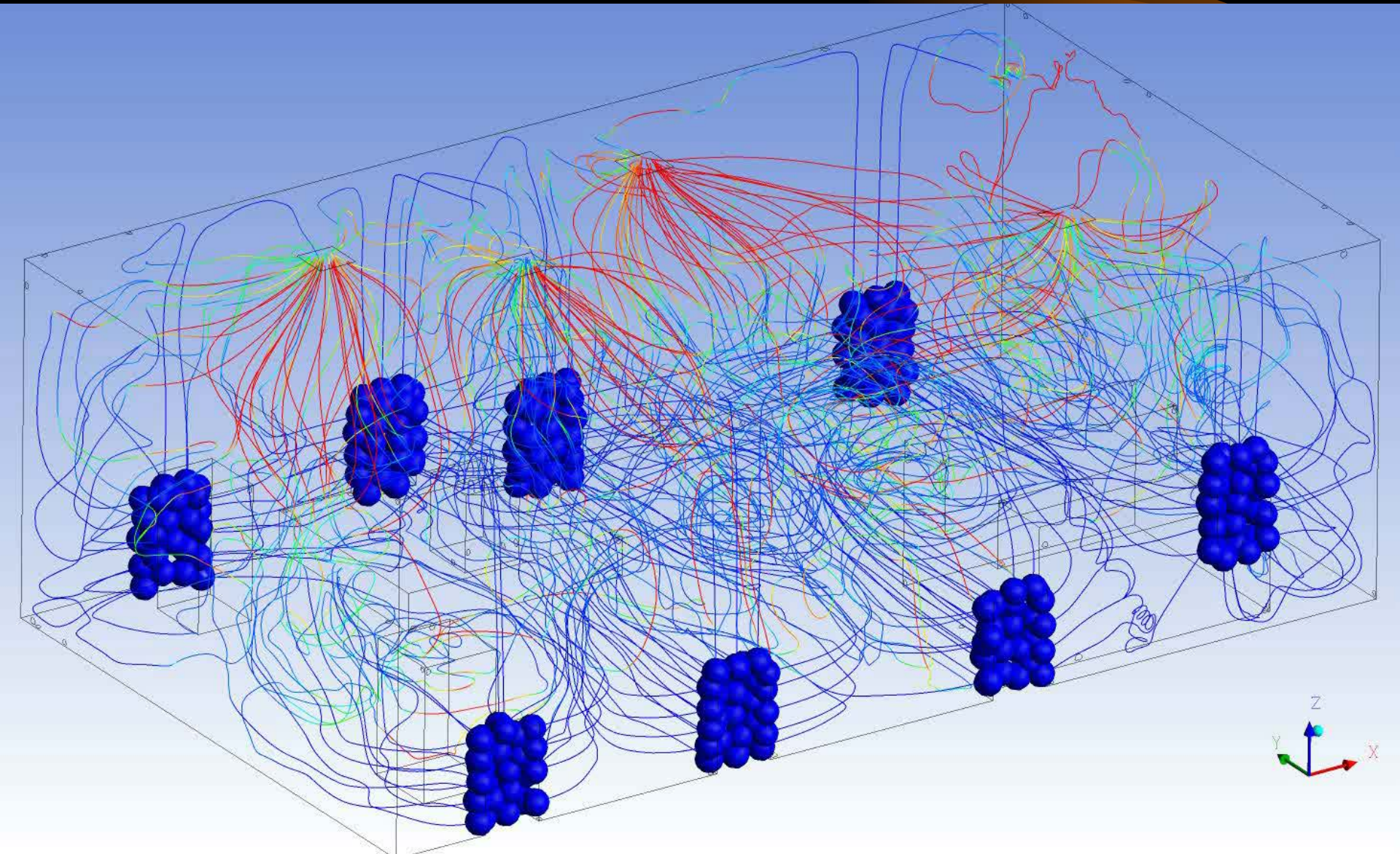
New Refinery Floorplan



CFD Model Dilution Ventilation



CFD Model Displacement Ventilation



Displacement Ventilation CFD

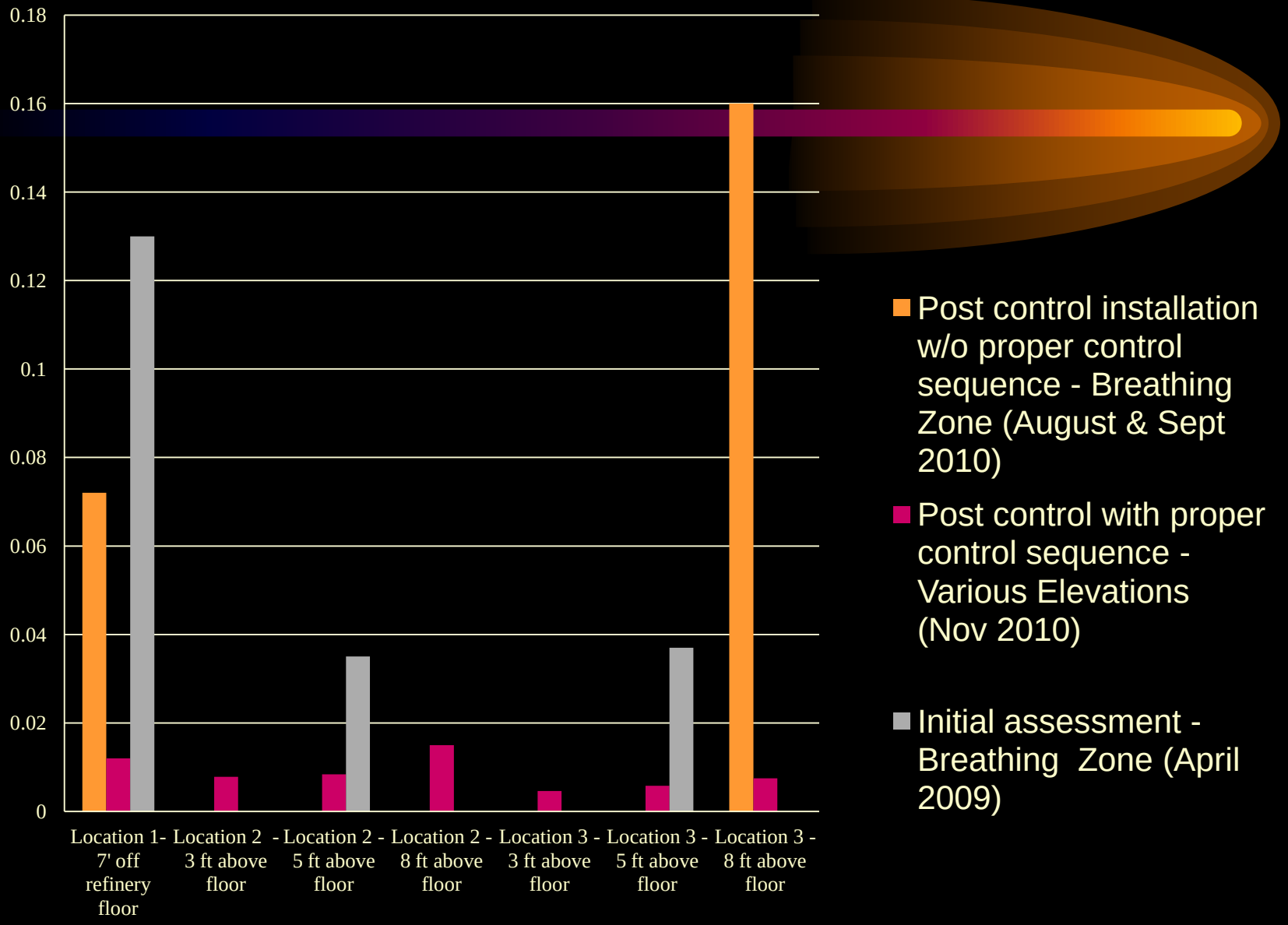
- Temperature dependent
  - Various temperatures
  - 10 degrees F optimal
  - Utilize thermal plumes
- Velocity dependent
  - Various velocities
  - 40-50 fpm optimal

Results

- Dust/fume concentration
- Area Samples
- Elevation gradient

Area Sample Results for Silver, mg/m^3

PEL = 0.01mg/m^3



Lessons Learned

- Turbulent flow (mixing) requires high volumes of air for adequate dilution
- Laminar (piston) flow maintains concentration gradients dependent upon temperature and velocity
- Thermal plumes drive contaminants upward above the stratification level
- Systems must be commissioned and maintained

Acknowledgements

- Cynthia Ellwood, PhD, CIH
- Cassidy Strode
- Daniel Hall, PE