Reducing the Exhaust Velocity for High Volume Flow Laboratory Exhausts

A Case Study for the U.C. Davis Robert Mondavi Institute for Wine and Food Sciences

Presented at Labs for the 21st Century

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By

Brad Cochran

Cermak Peterka Petersen, Inc. (CPP)

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OUTLINE

- Applicable Exit Velocity Standards/Guidelines
- Issues Associated with Reducing the Exit Velocity
- Stack-Tip-Downwash
- Rain Infiltration
- Case Study – UC Davis RMI
- Exhaust Parameters Evaluated
- Dispersion Modeling Results
- Energy/Cost Issues

Applicable Exit Velocity Standards/Guidelines

- 3000 fpm – *ANSI/AIHA Standard for Laboratory Ventilation, Z9.5-2003.*
- 1500 to 2000 fpm – *ASHRAE Handbook-HVAC Applications, 2003.*

Issues Associated with Reduced Exit Velocity Exhaust Stacks

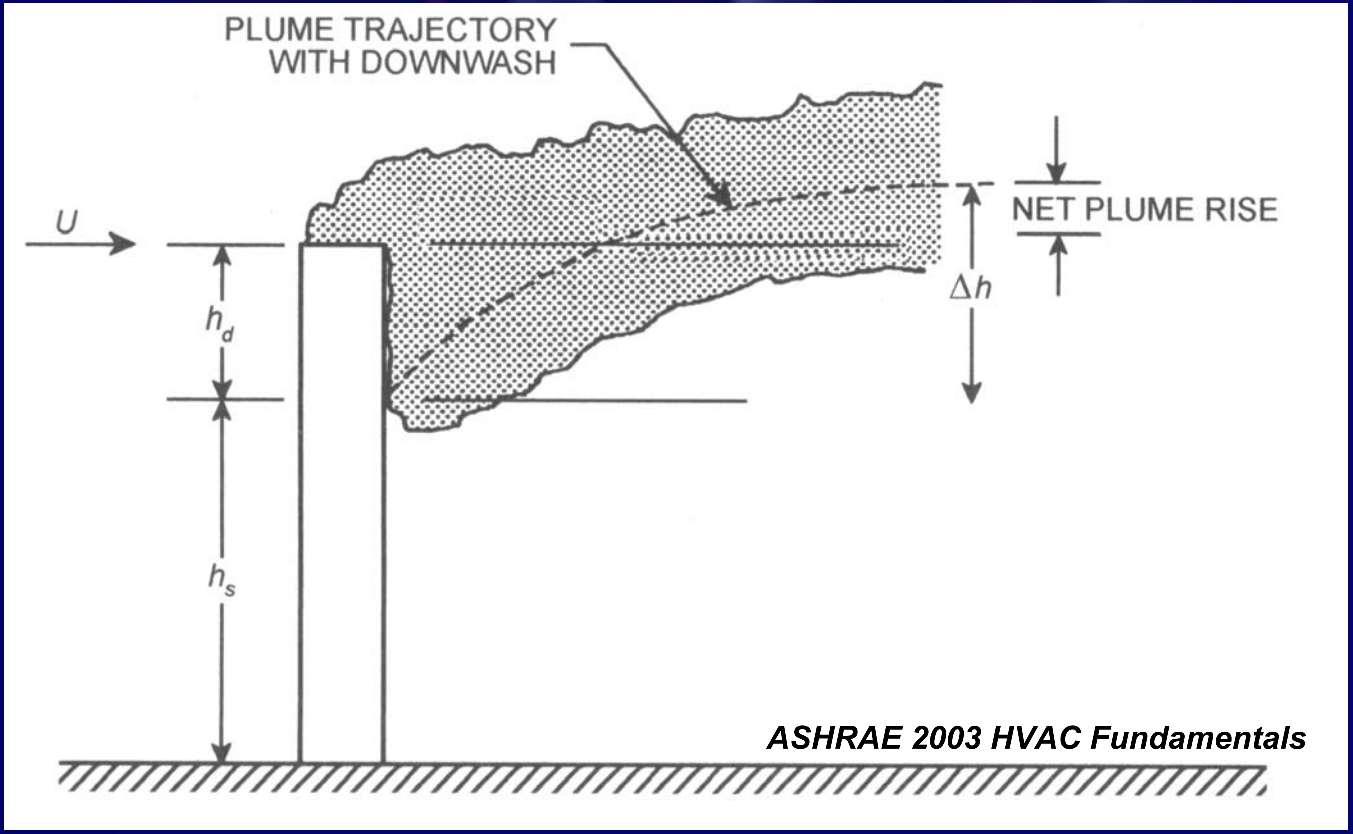
Pros:

- Smaller Fan and/or Motor Requirements
- Lower Energy Consumption
- Reduced Noise and Vibration

Cons:

- Stack-Tip-Downwash
  - Decreased Plume Rise
  - Increase Downwind Concentrations
  - Need for Greater Stack Heights
- Potential Rain Infiltration

Stack-Tip-Downwash



Stack-Tip-Downwash

Ratio of Exit Velocity/Approach Wind Speed Required to Avoid Stack-Tip-Downwash

Subcritical Reynolds Number:

- *Ratio of 1.5 for Re < 2 x10^5.*

  (12 in dia. stack, 20 mph wind, 2000 cfm)

Supercritical Reynolds Number:

- *Ratio of 1.1 for Re > 4 x10^5.*

  (24 in dia. stack, 20 mph wind, 10,000 cfm)

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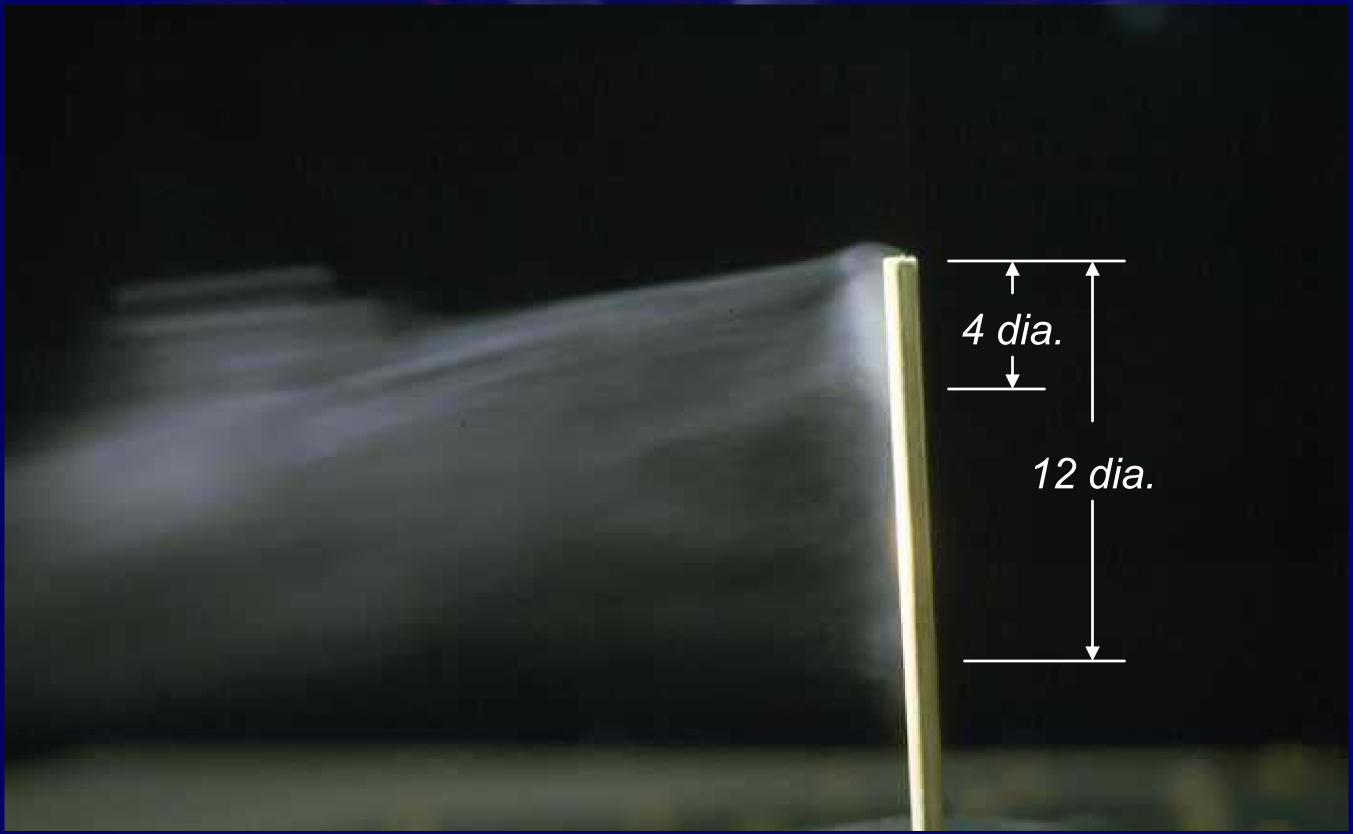
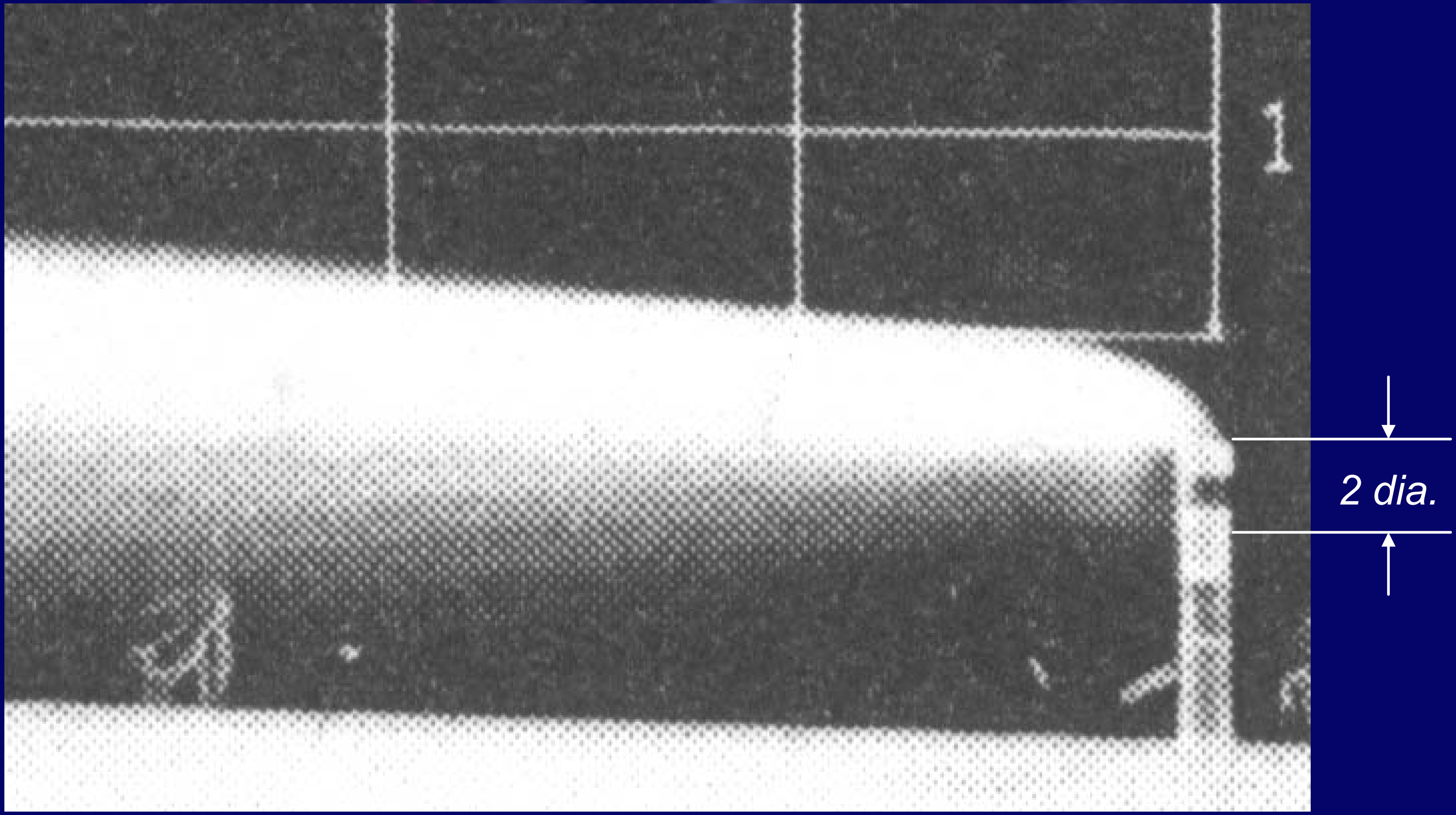
Stack-Tip-Downwash from a low Re exhaust stack



Stack-Tip-Downwash from a high Re exhaust stack



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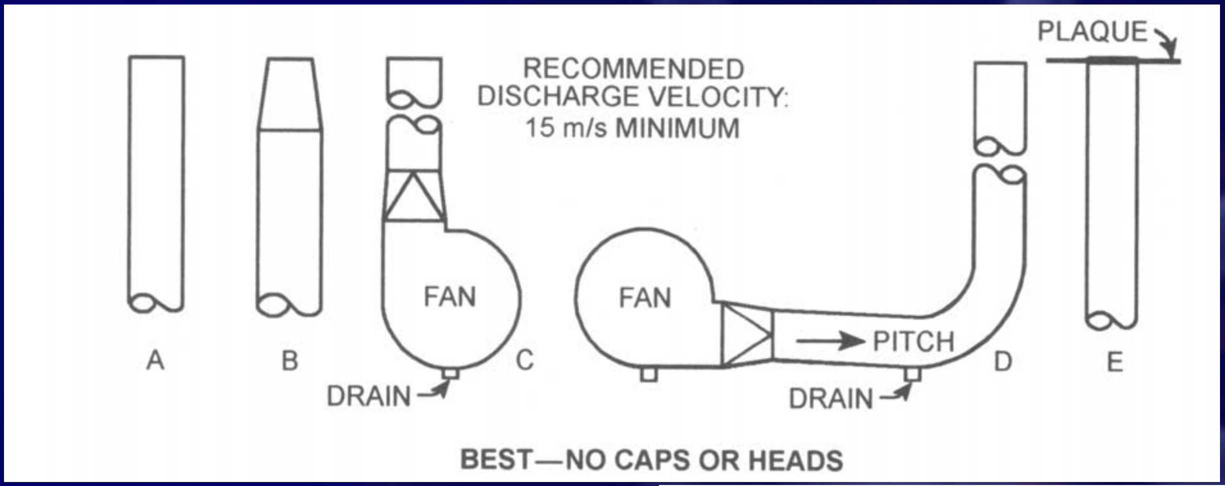
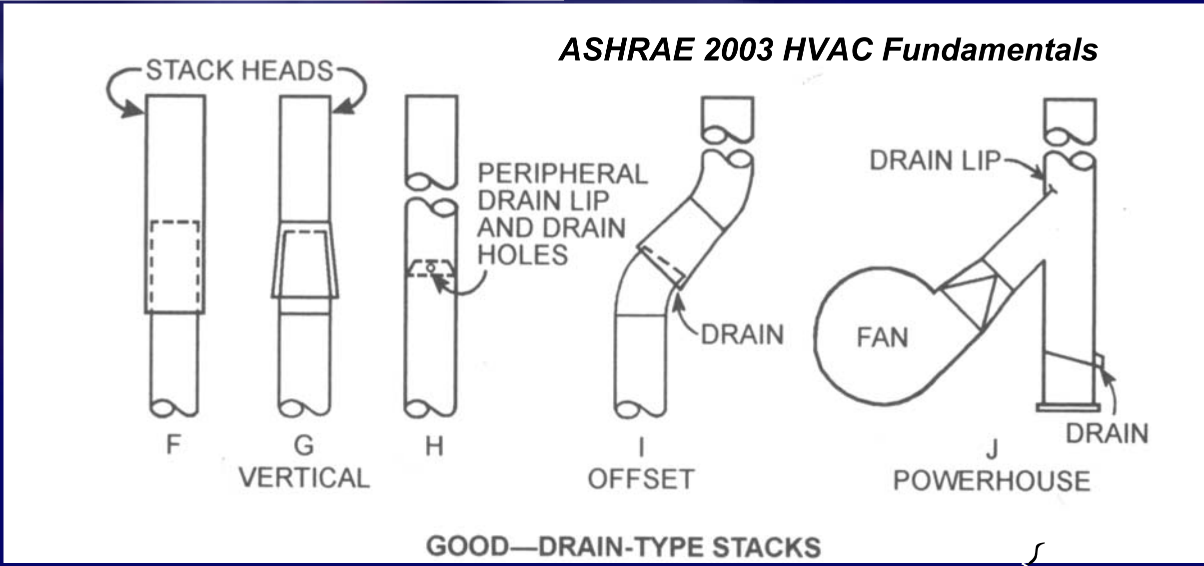
Rain Infiltration

(Manifolded stacks typically already have some rain protection designed in to accommodate redundant stacks)





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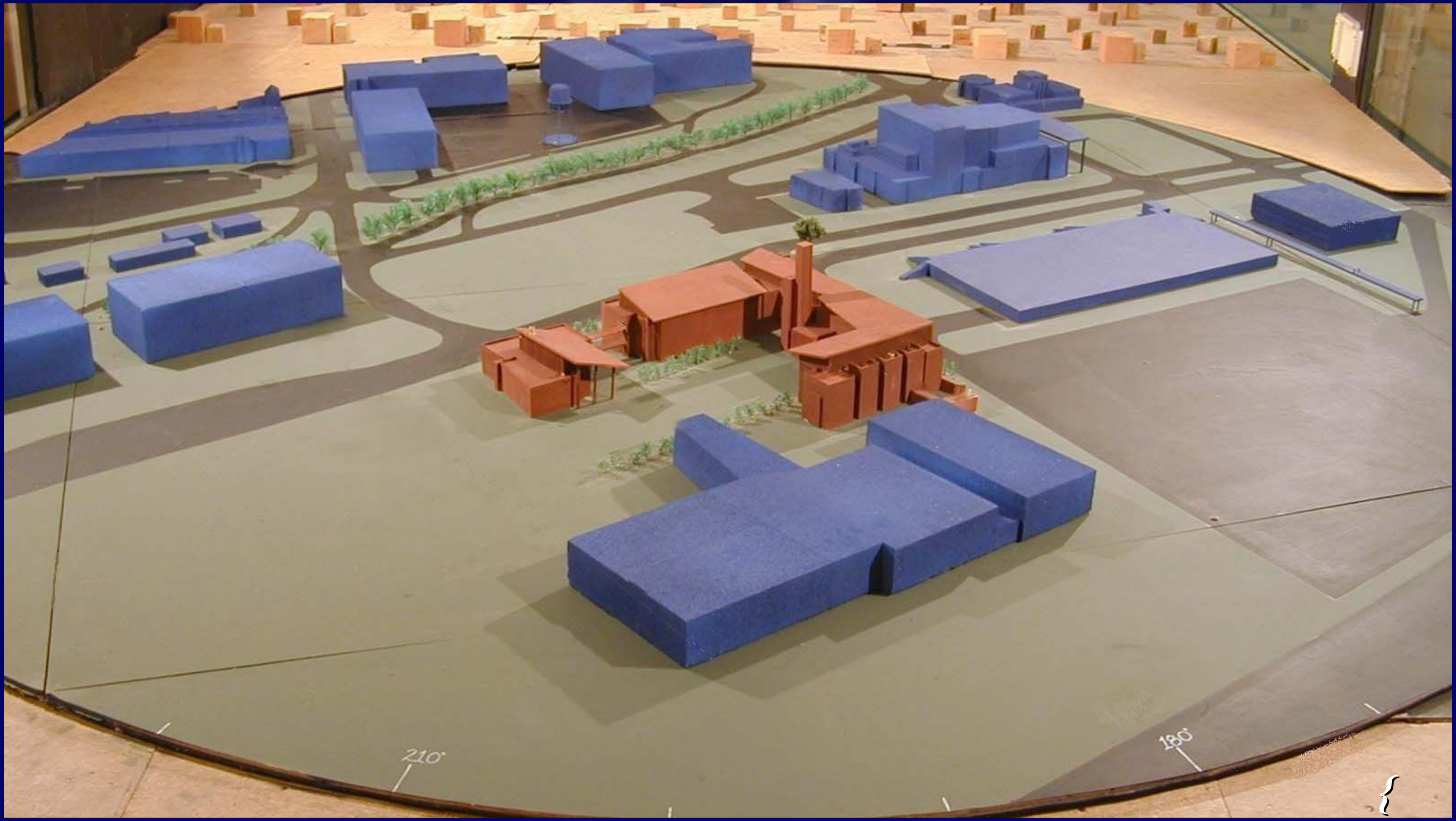

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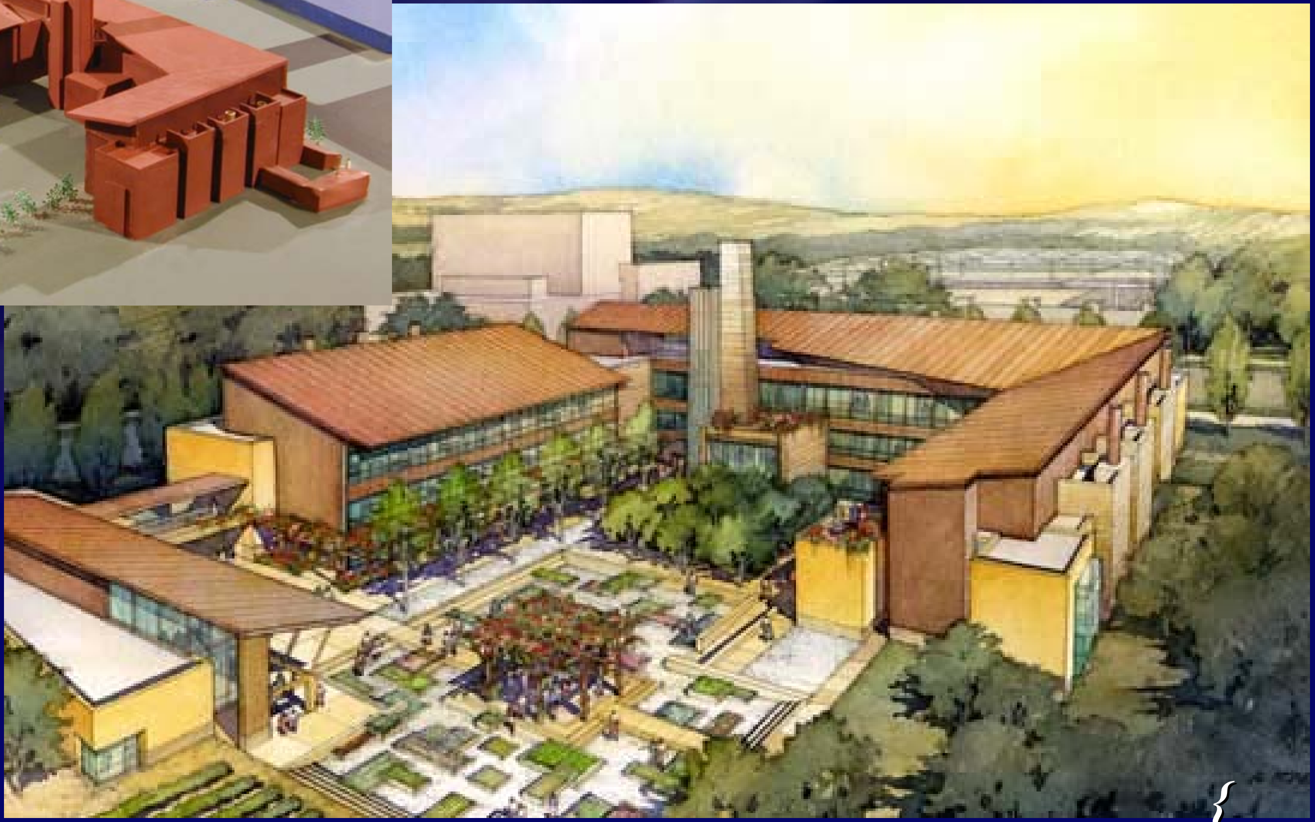

Exhaust Parameters

Stack Diameter	Height Above Base (ft)	Volume Flow Rate (cfm)	Exit Velocity (fpm)
50 Inch	15.0	40,000	3,000
54 Inch	15.0	40,000	2,500
60 Inch	15.0	40,000	2,000

Fan Operating Parameters

(40,000 cfm Volume Flow Rate)

Exit Velocity (fpm)	Static Pressure (in WG)	Fan Motor Horse Power (BHp)	Sound Power Level Inlet LwA	Sound Power Level Outlet LwA	Per Stack ----- Annual Energy ----- Consumption (kW- Hr)	Consumption ($)	Savings ($)
2,000	3.0	26.0	87	89	169,900	$ 16,990	(-)
2,500	3.2	27.2	87	90	177,700	$ 17,770	$ 780
3,000	3.4	28.6	88	90	187,000	$ 18,700	$ 1,710

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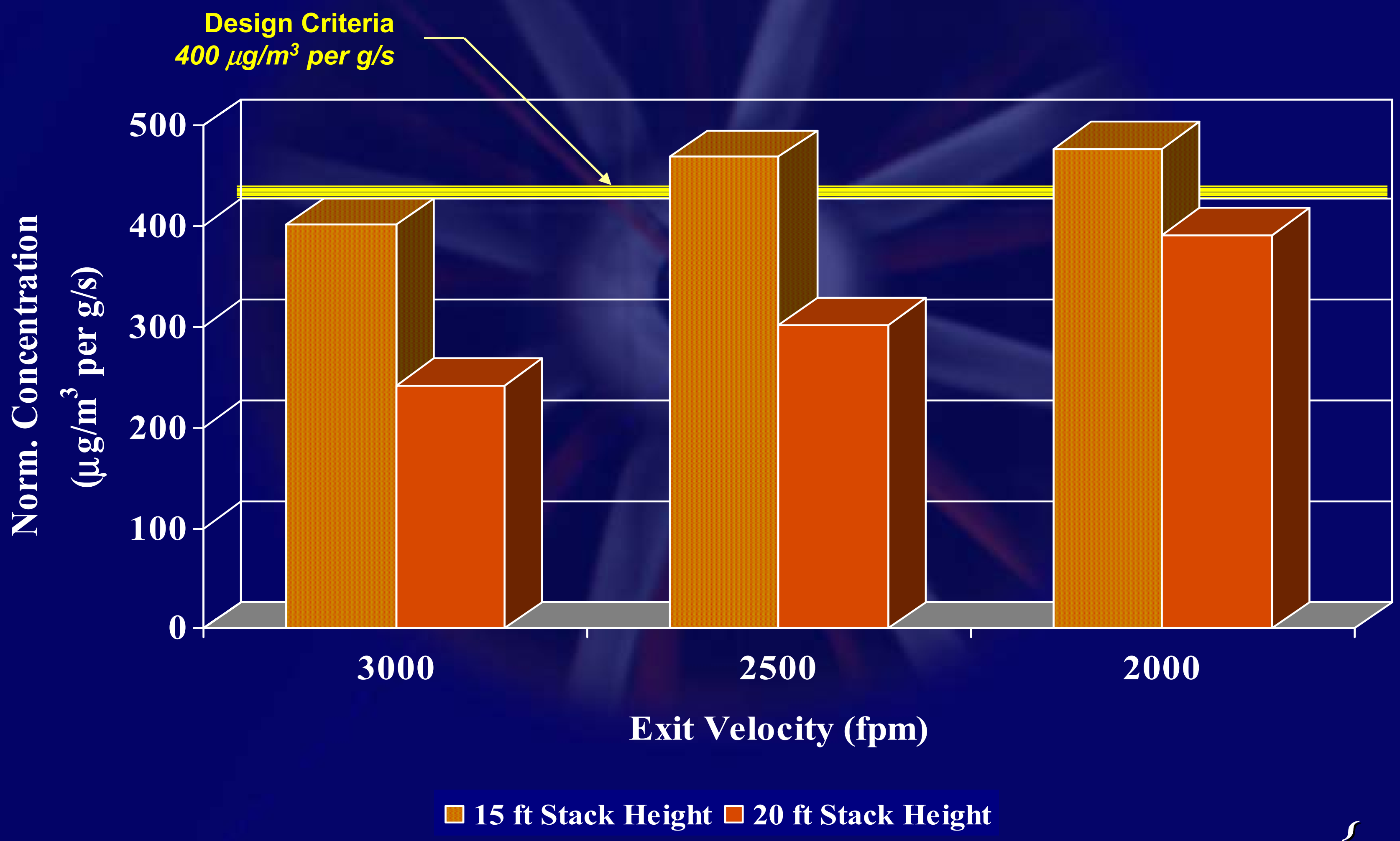
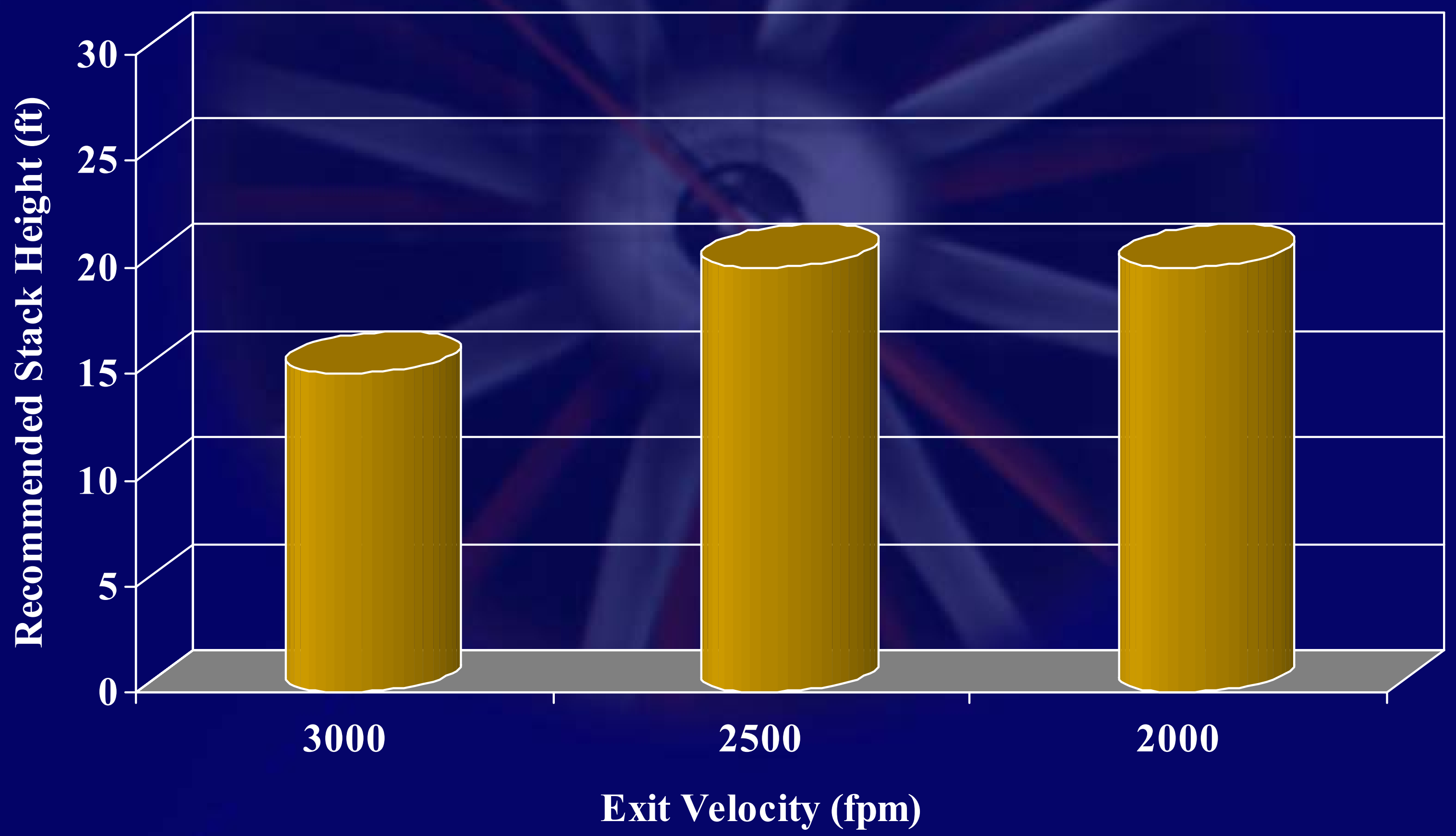
Maximum Measured Concentration vs. Exhaust Stack Exit Velocity



Recommended Stack Height vs. Exhaust Stack Exit Velocity



Summary

Reducing the Exit Velocity from 3000 fpm to 2000 fpm:

- *Increased the recommended stack height from 15 ft to 20 ft above the local roof*
- *Reduced the fan horsepower from 28.6 BHp To 26.0 BHp*
- *Saved 17,100 kW-Hr / Yr per fan in energy consumption*
- *Saved ~$10,260 in annual energy costs for 12 exhaust stacks*
- *Reduced both the inlet and outlet sound power levels.*

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Extending a typical air quality assessment to include an evaluation of the designed exit velocity provides the design team with the opportunity to optimize equipment costs and energy consumption while maintaining a stack design that fits within their design concepts.