
RWDI

Reducing Stack Height – Understanding the Formation of Rooftop Re-circulation Regions

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Introduction

- The fundamental goal of stack design is to prevent contaminated exhaust from entering building air intake systems
- High volume flow and high exit velocity are common methods used to increase stack-to-intake dispersion
- This allows exhaust to escape roof top re-circulation zones, without significant increases in stack height

Introduction

- For specialty type exhaust stacks, low volume flow is often unavoidable
- Tall stacks may then be necessary to achieve the required dispersion

Introduction

- The re-circulation region that forms over the roof of tall rectangular buildings can be very large - *greater than 20 feet in many cases*
- It often engulfs the entire area of the roof
- This requires a combination of tall stacks, high flow rates and high exit velocity
- All of these scenarios can result in high energy costs

Presentation Outline

- Brief overview of how re-circulation regions are formed
- Discuss the concept of effective stack height as it relates to re-circulation regions
- Apply the concept of effective stack height to tall rectangular buildings using wind tunnel data to show that stack location can be optimized to increase exhaust dispersion
- Discuss the advantages for potential energy cost savings

Presentation Outline

and time permitting, discuss…

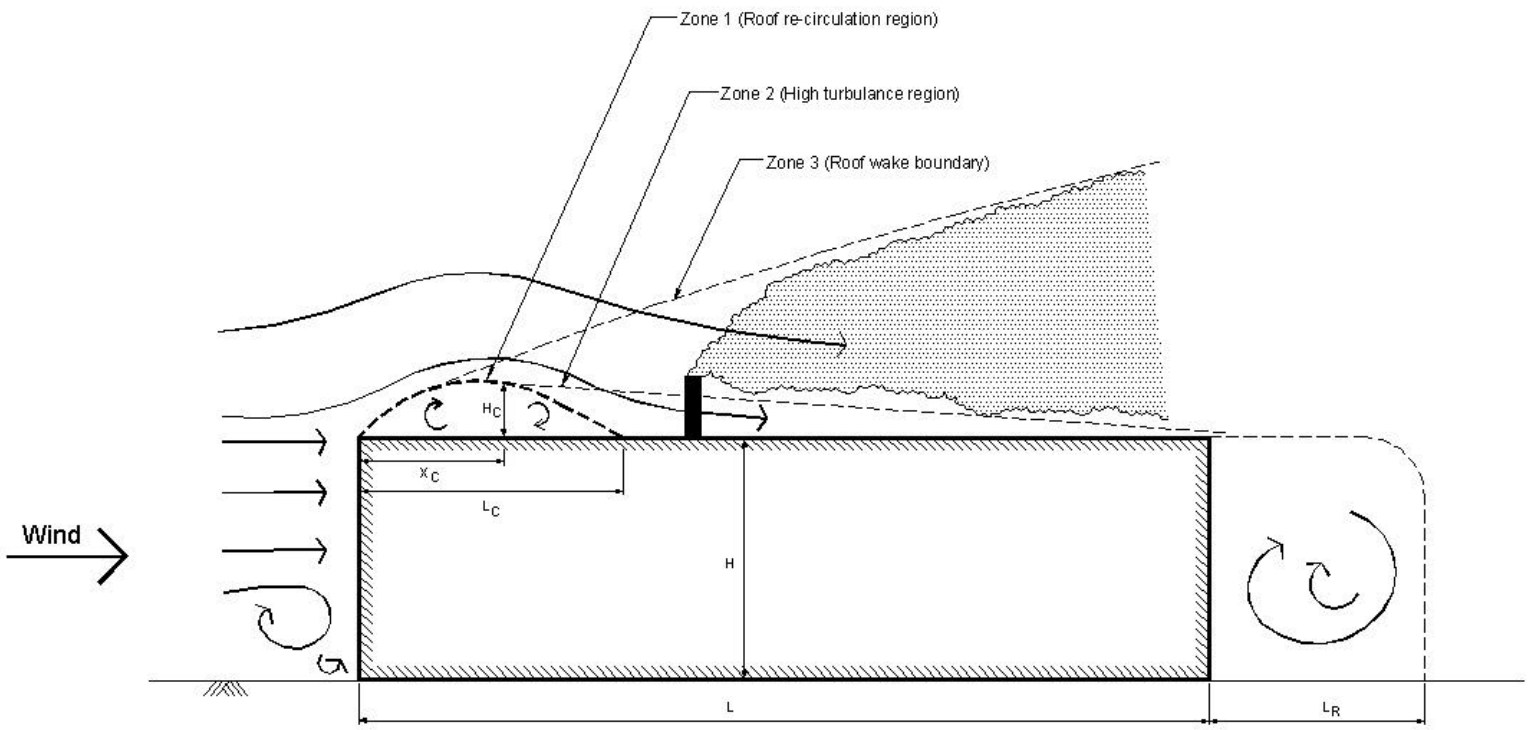
- Optimal air intake locations
- Impact of screen walls on re-circulation regions and exhaust dilution

Re-circulation Regions

Overview

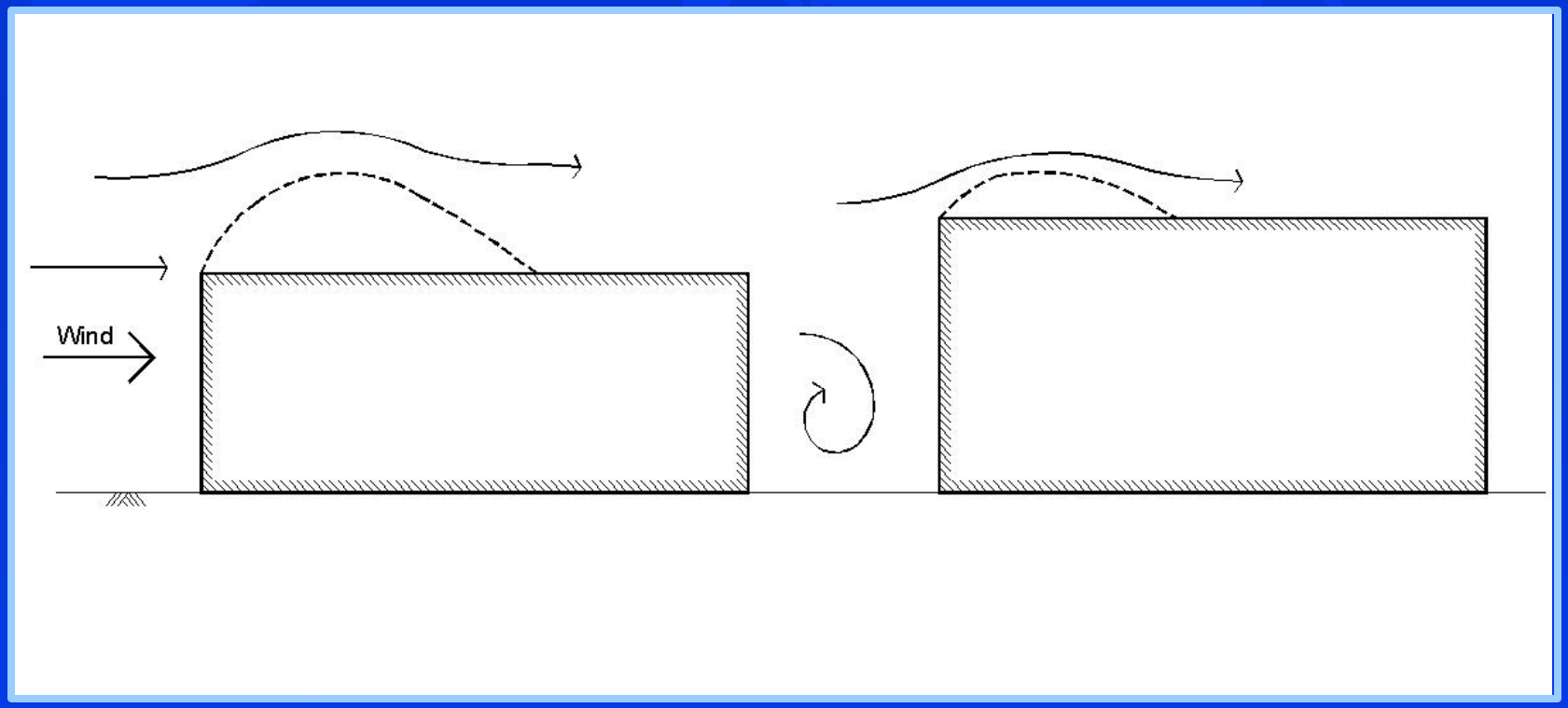
- American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) provides guidance on stack design
- Prevent re-entrainment of contaminated air into building air intakes
- Discharge the exhaust at a height that is above the re-circulation region or “bubble” that forms over the roof

Re-circulation Regions

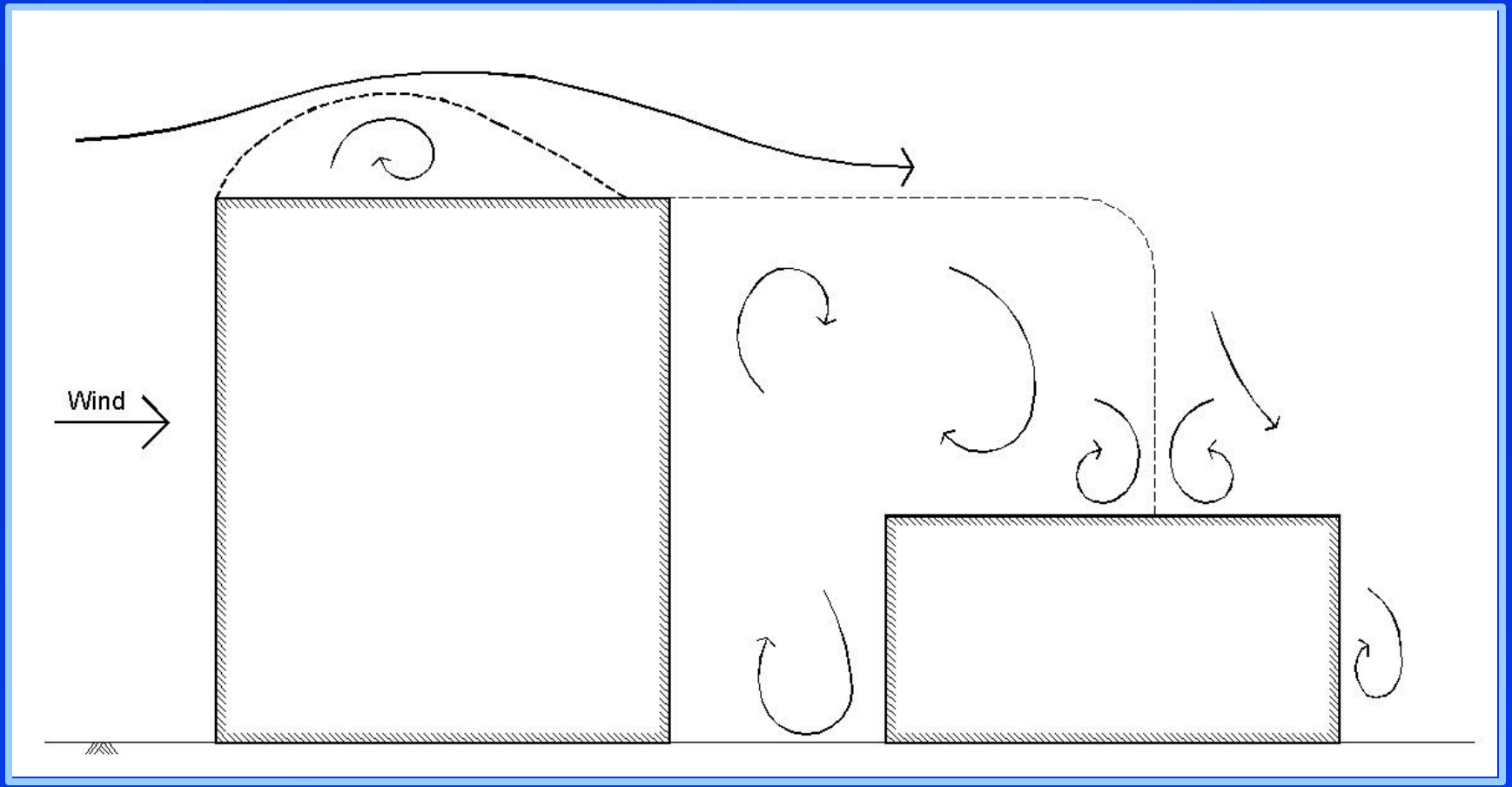


RECREATED FROM ASHRAE (1999) APPLICATIONS

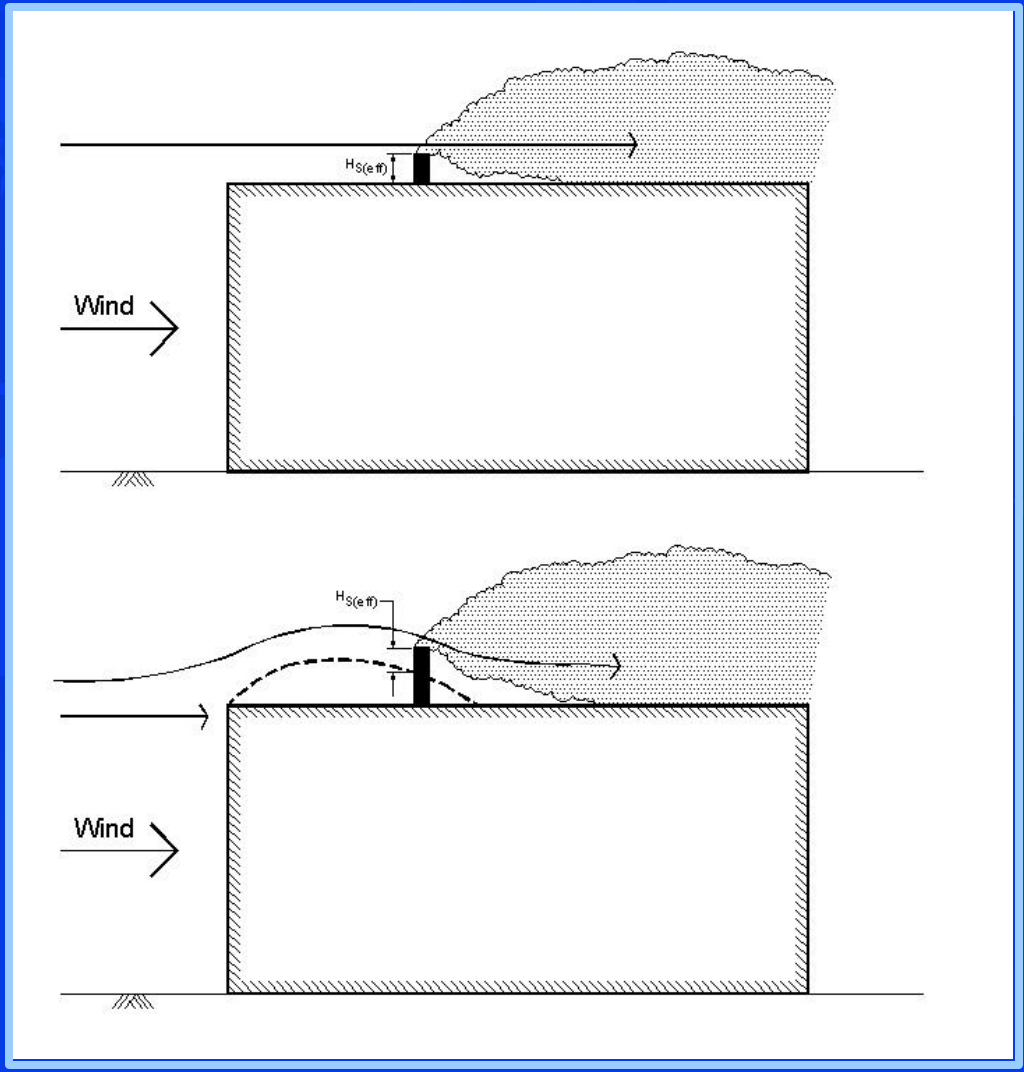
Upwind Building Effects



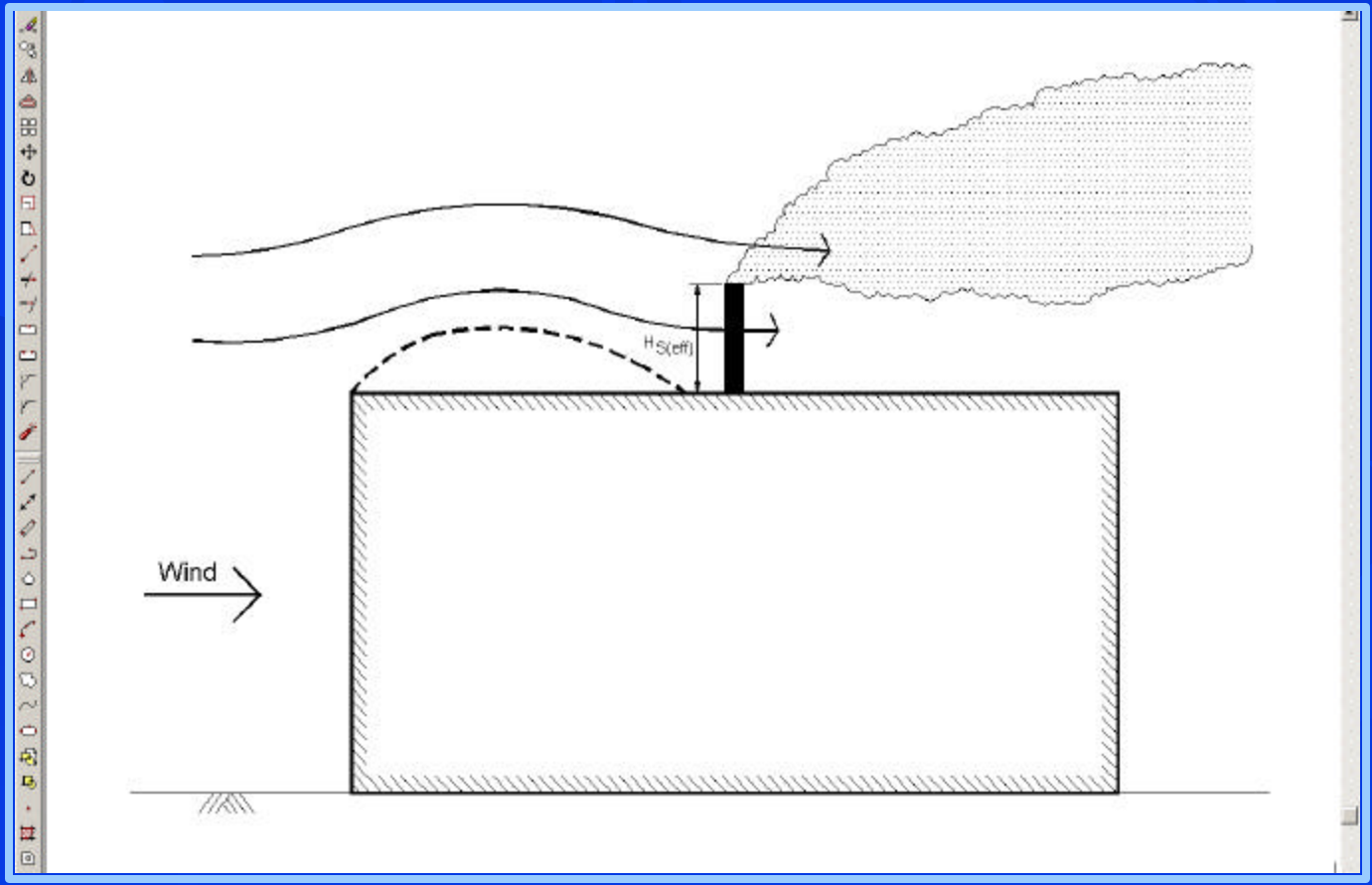
Taller Upwind Building



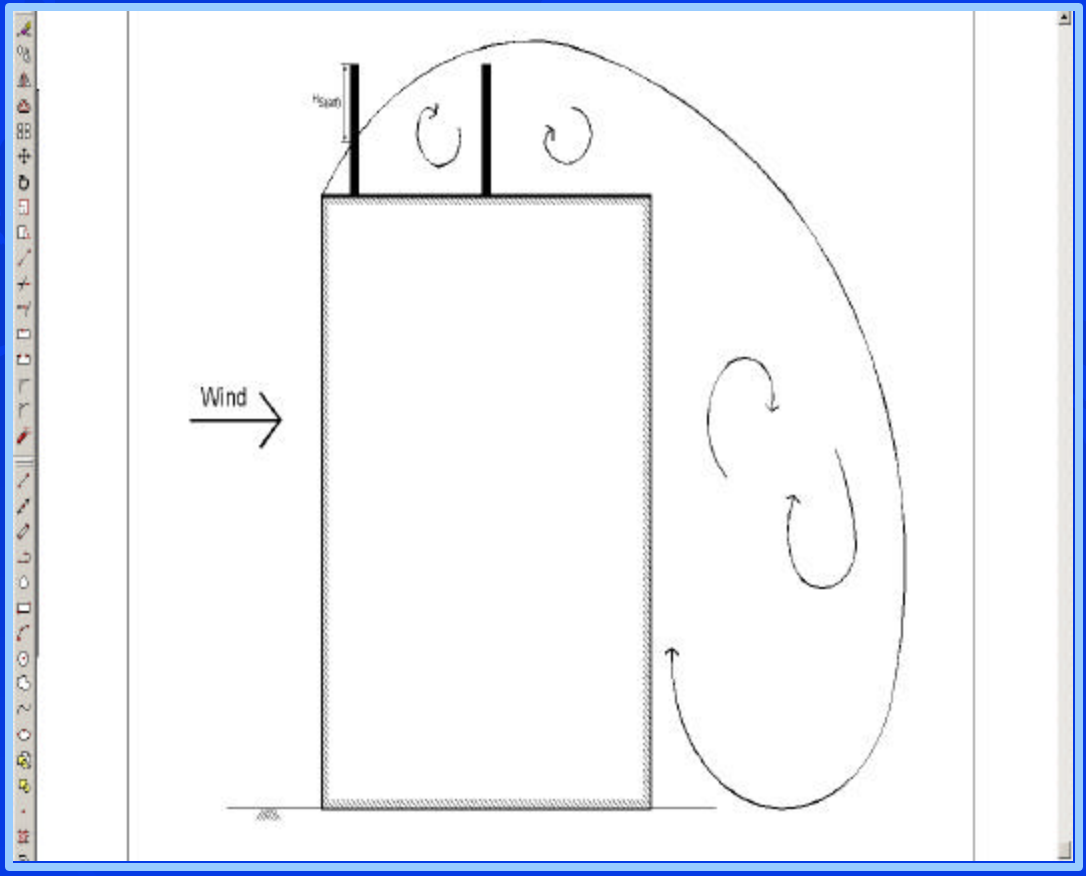
Effective Stack Height



Short Squat Buildings



Tall Rectangular Buildings



Wind Tunnel Program

Designed to demonstrate that:

- A set-back penthouse on a tall rectangular building results in a smaller and more streamlined re-circulation bubble
- A stack located on the upwind side of the bubble has more effective stack height
- Both effects provide increased exhaust dilution at rooftop receptors

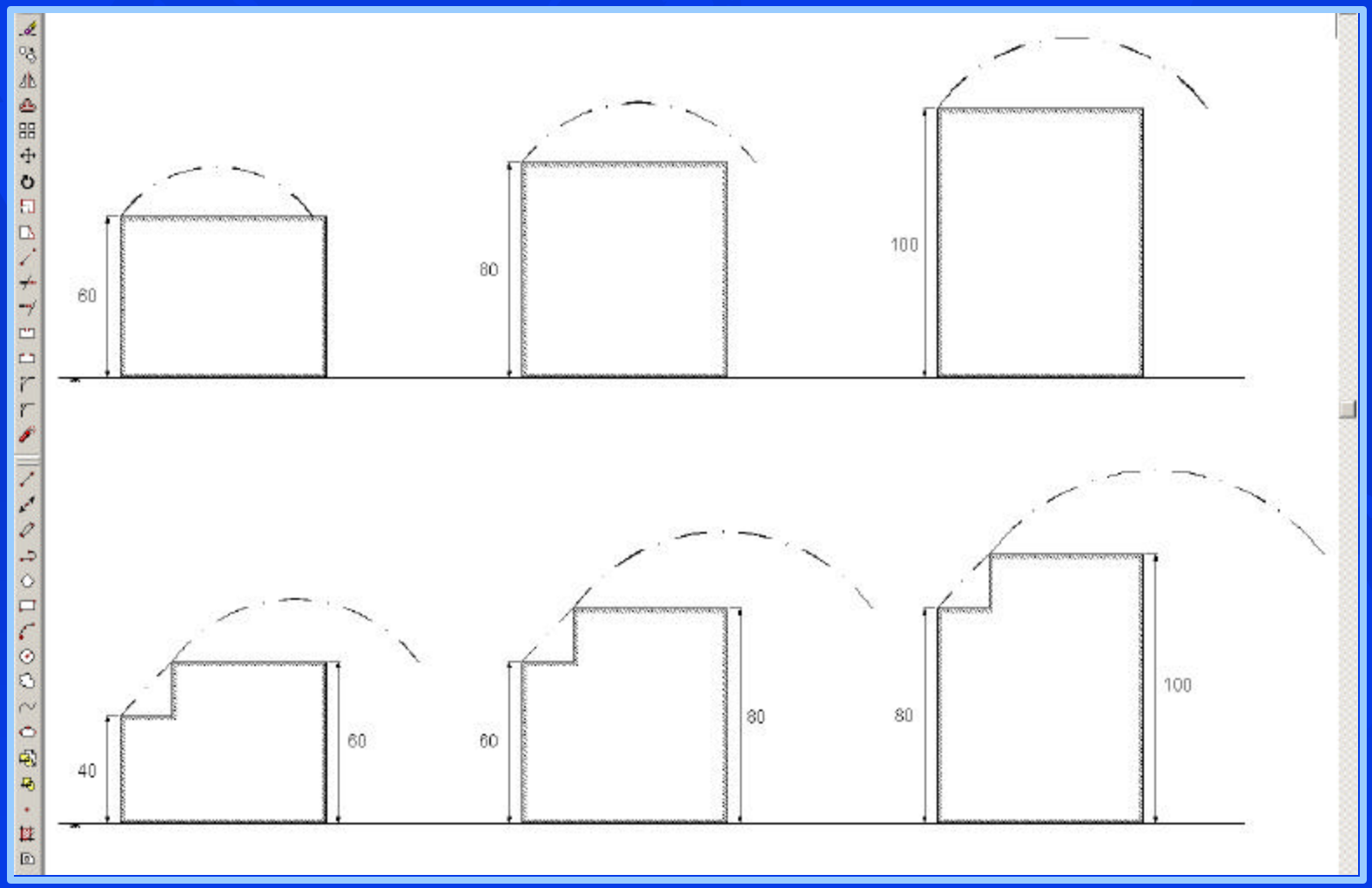
Test Parameters

- Two stack locations (A and B)
- Full scale stack heights 10, 15, 20 and 25 feet above roof
- Full scale building heights 60, 80 and 100 feet
- Full scale building footprint 160 feet by 80 feet

Test Parameters

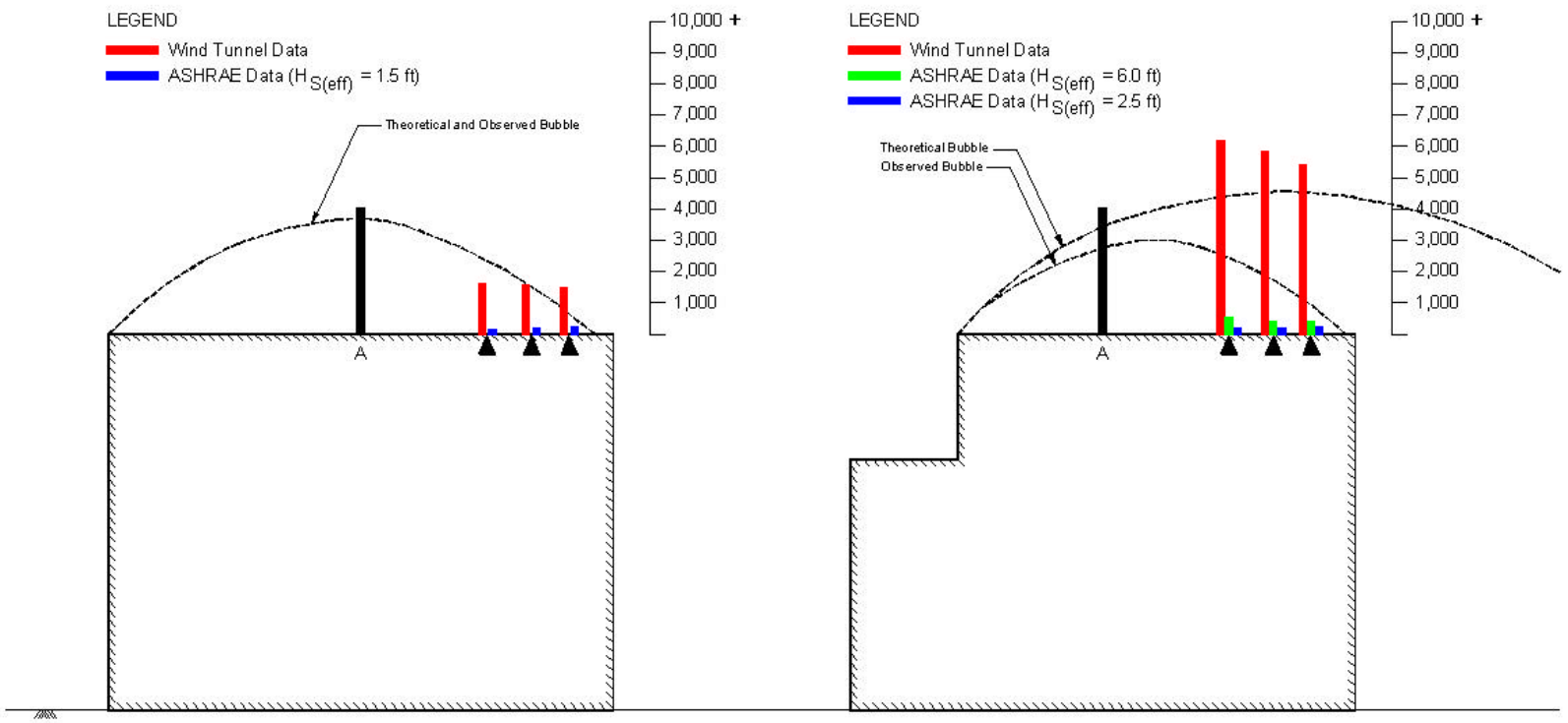
- Non-buoyant plume, low volume flow rate (1,300 cfm) and high exit velocity (3,000 fpm)
- Full plume bend over was achieved
- Seven rooftop receptors and one down wind side wall receptor

Summary of Building Configurations



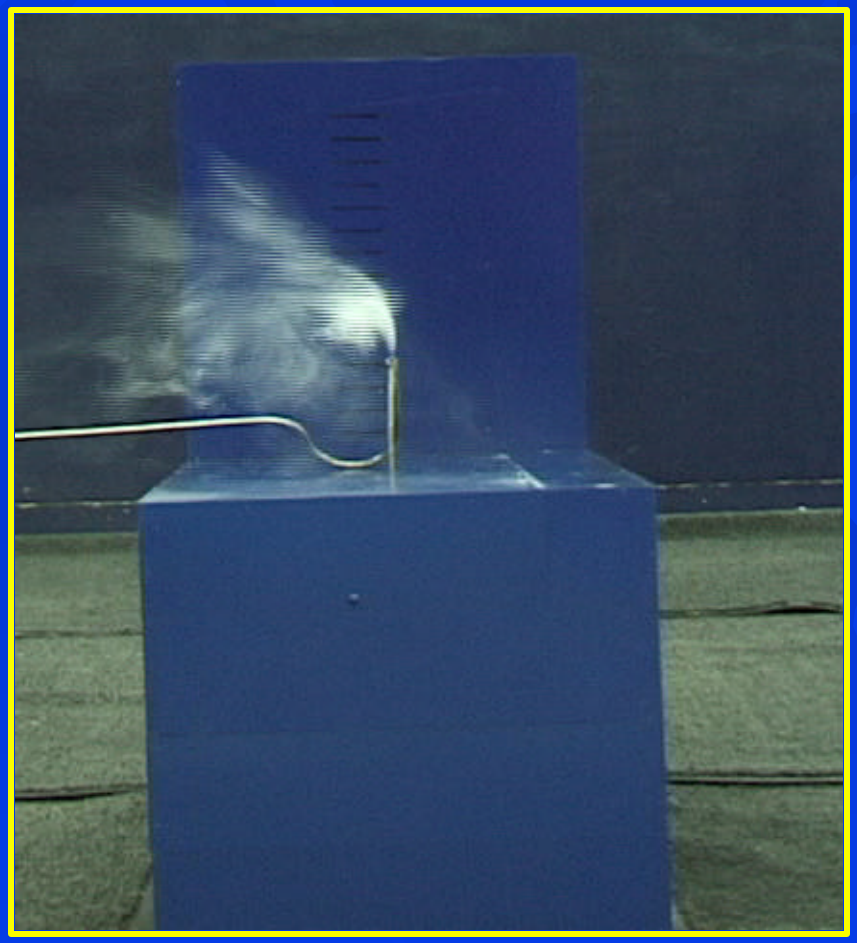
Study Buildings

Effects of Roof Step

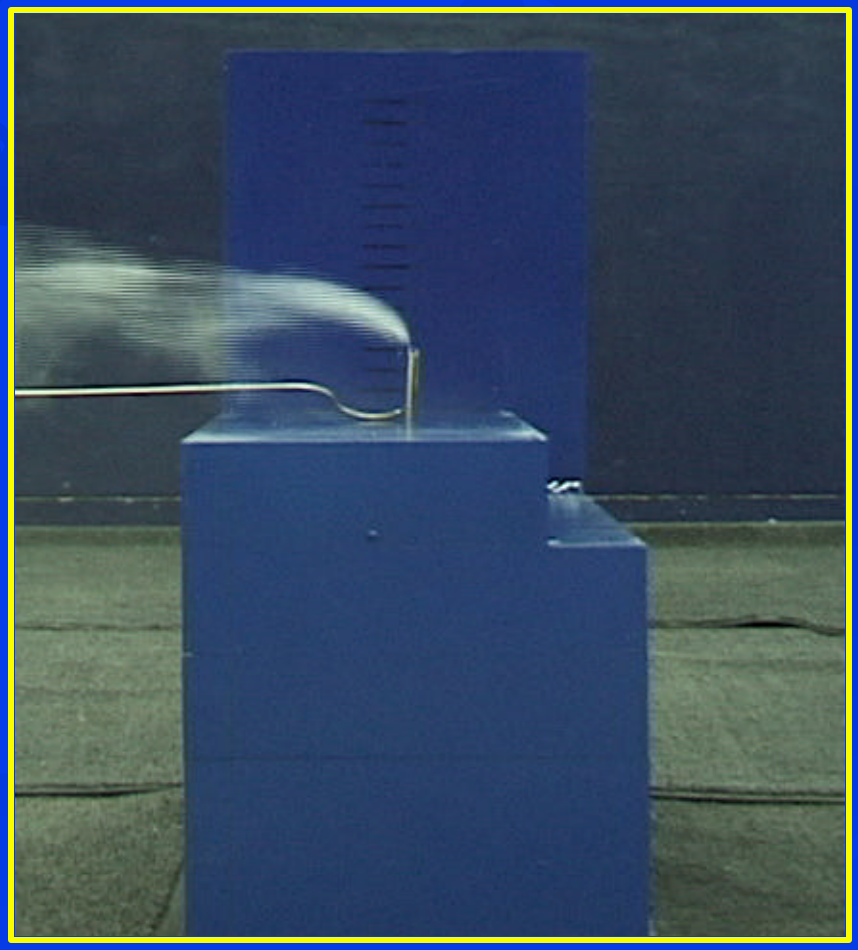


Stack A – 15 foot

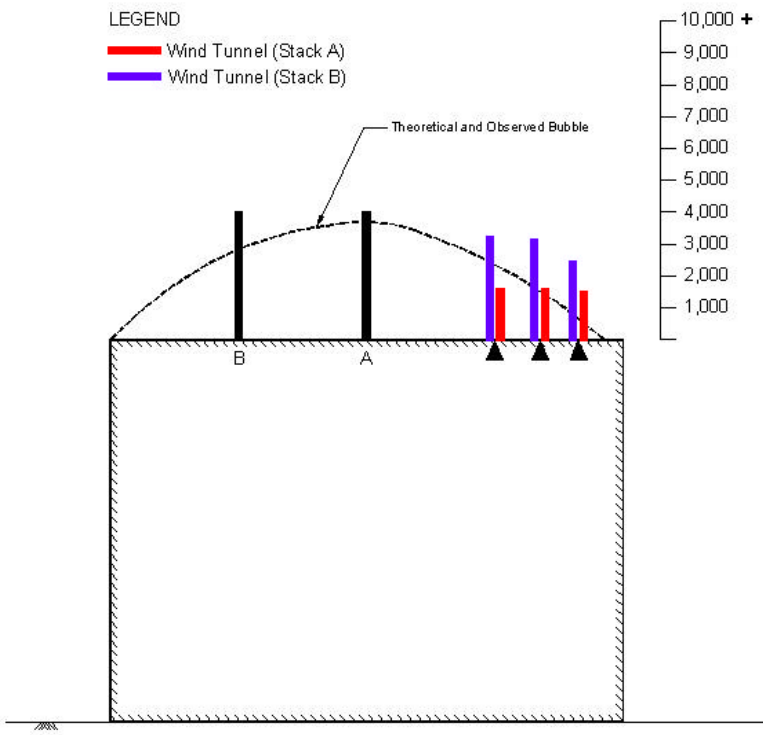
Block Roof

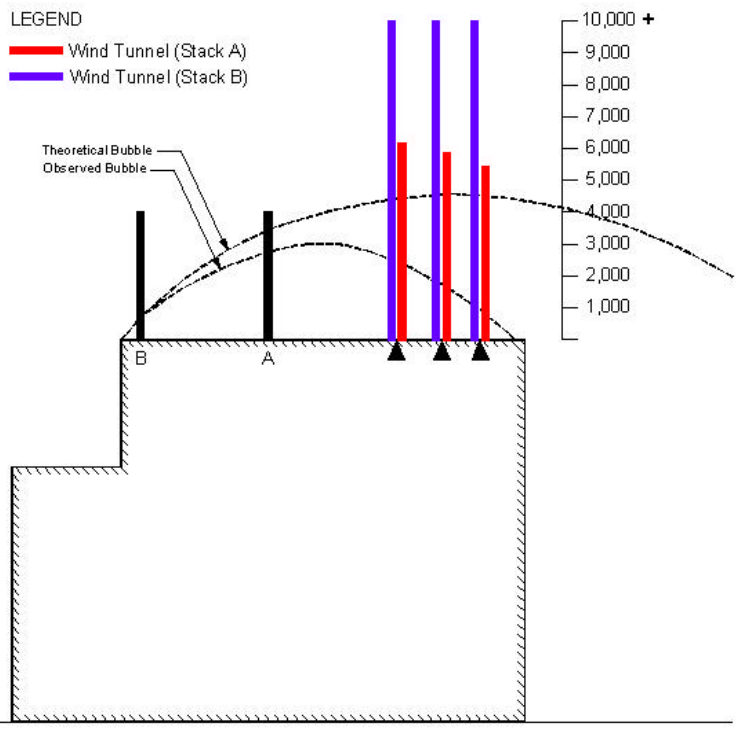


Stepped Roof



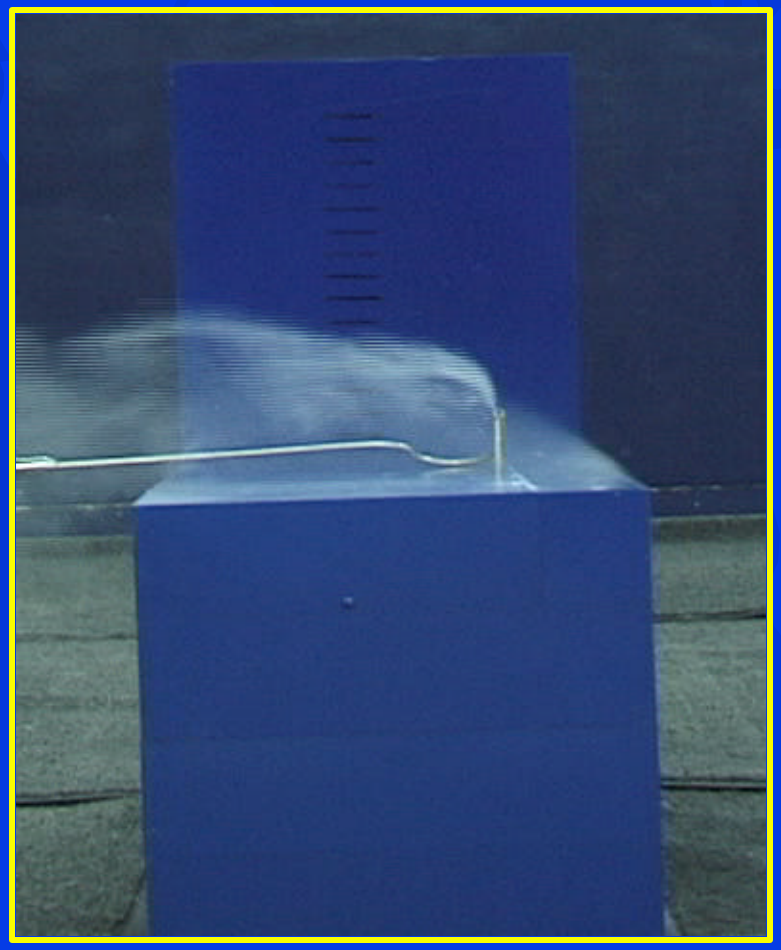
Effects of Stack Location



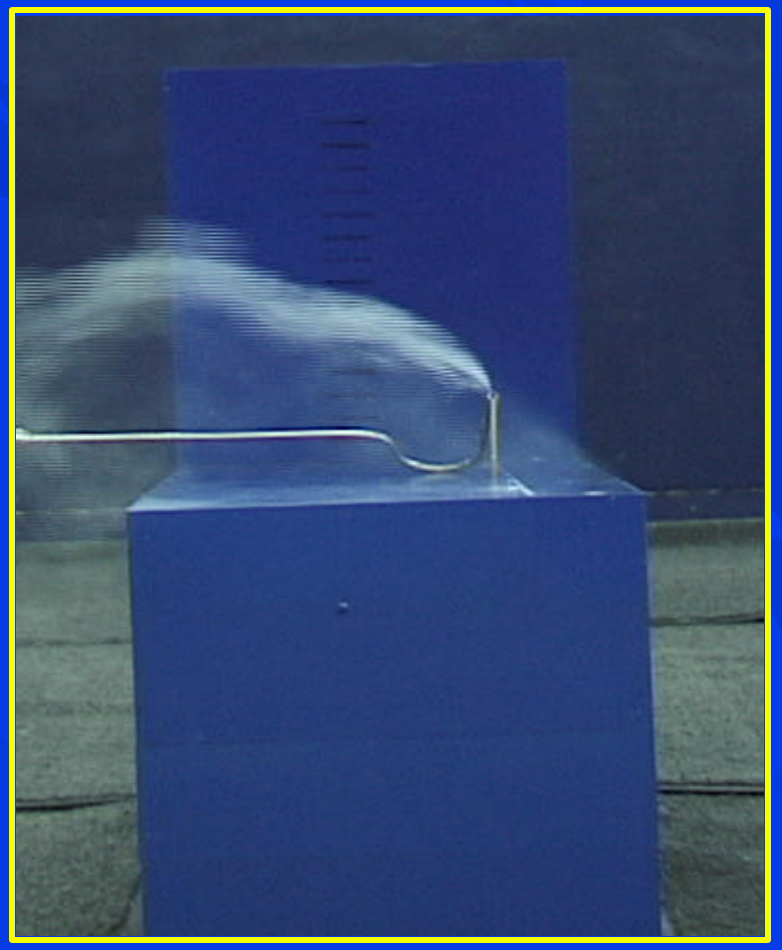


Stack B – Block Roof

10 foot stack

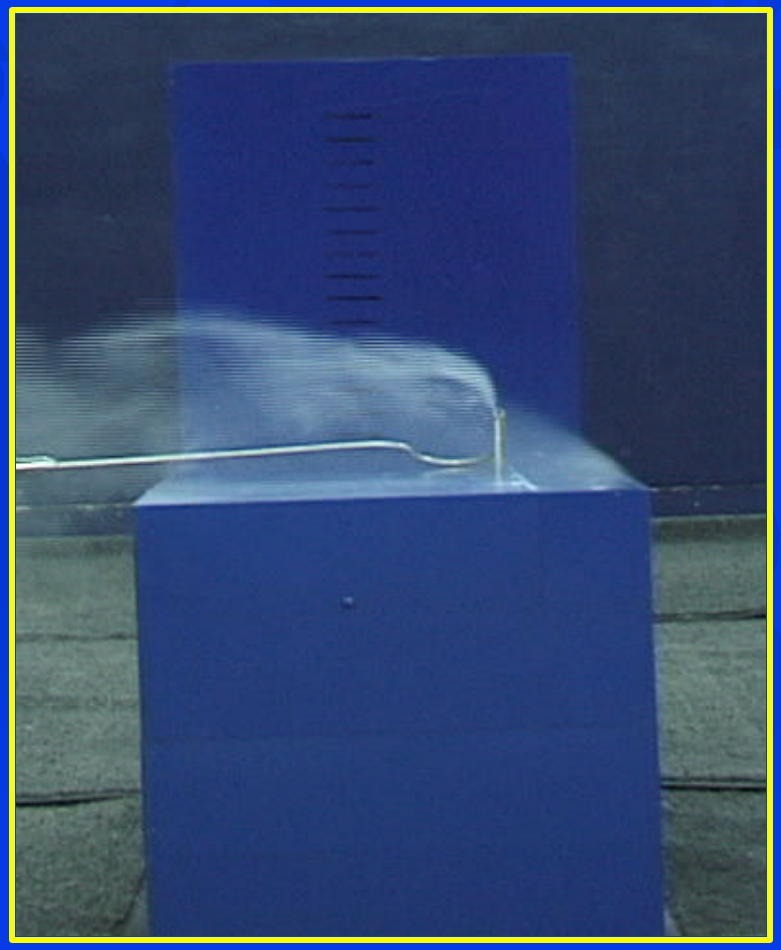


15 foot stack

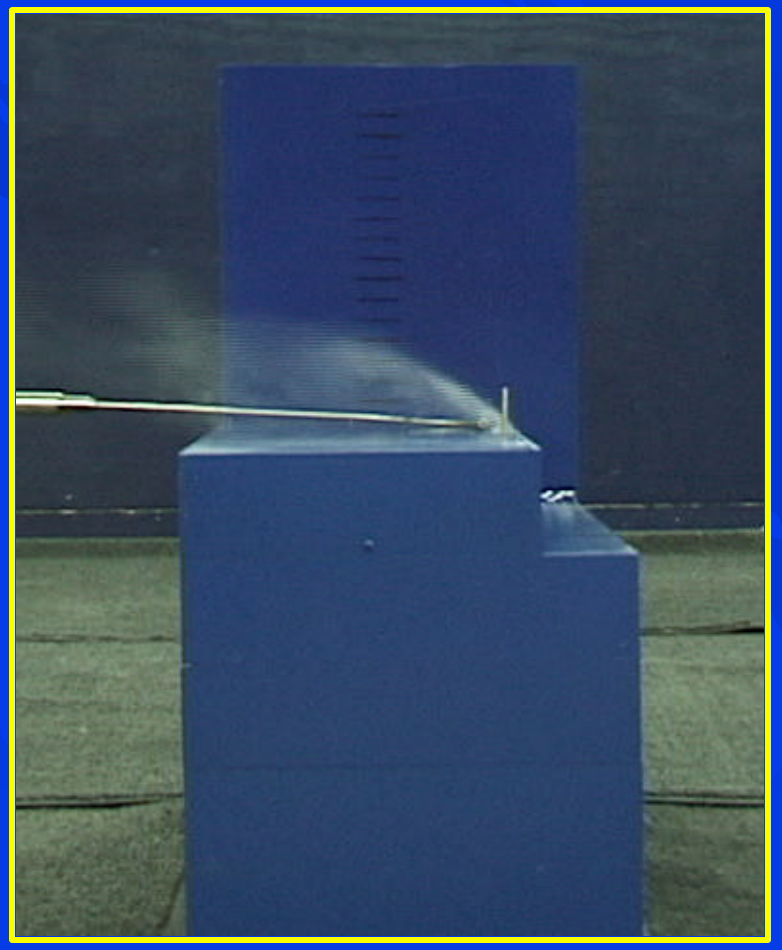


Stack B

10 foot stack block roof

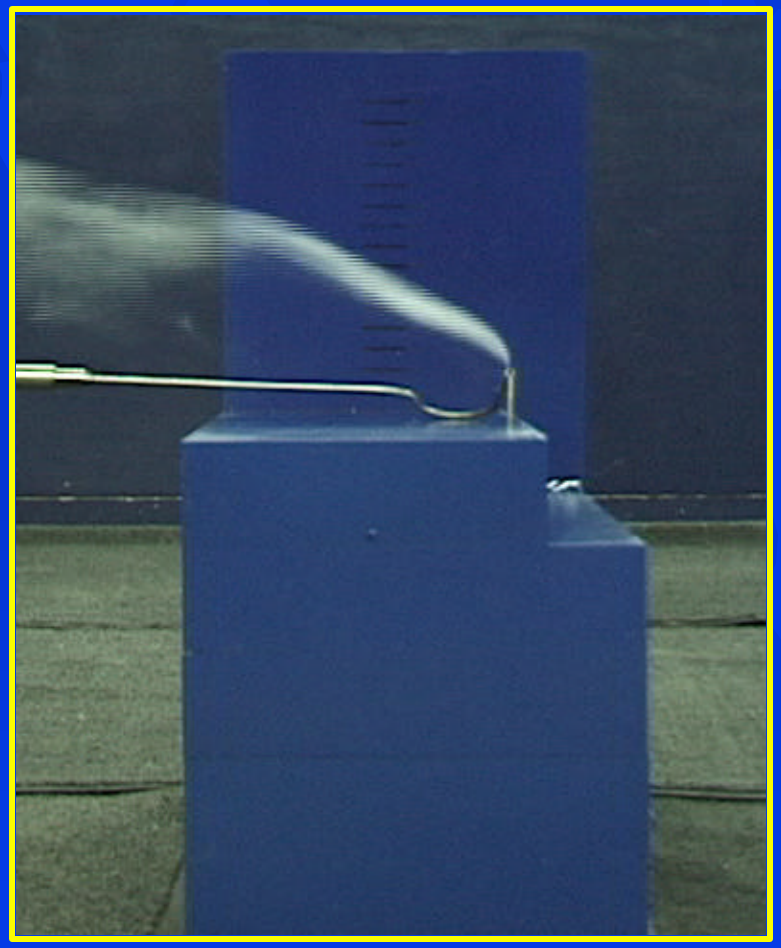


10 foot stack stepped roof

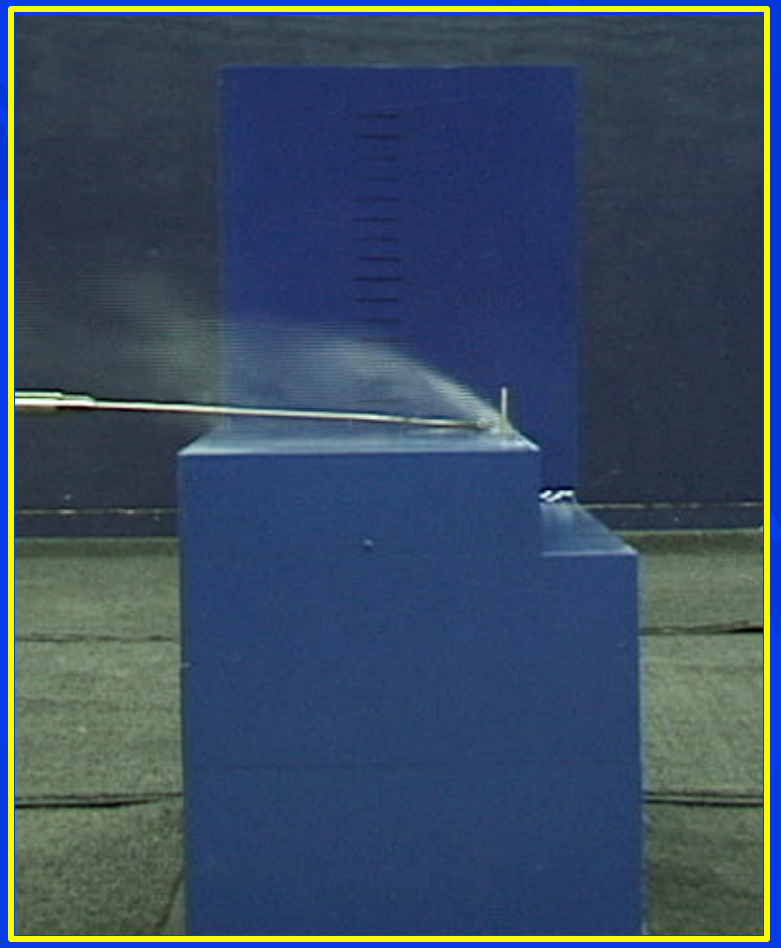


Stack B – Stepped Roof

Stack Plume



Re-circulation boundary



Discussion

- If a stack can be located so that you don't need:
  - Significant additional height
  - The provision of induced air
  - Increased exit velocity
- Then the system can be designed to provide more operational efficiency, such as reduced design requirements for exhaust fans
- This can lead to operational savings

Conclusions

- Exhaust stacks can be moved up stream of the re-circulation bubble to increase effective stack height and dilutions
- Stepped back roof helps to reduce bubble height, providing increased effective stack height
- Bubble is also shifted downwind from the stacks also increasing effective stack height
- Increasing effective stack height provides operational flexability

Summary of the Results

Taller stacks required for screen wall in all cases

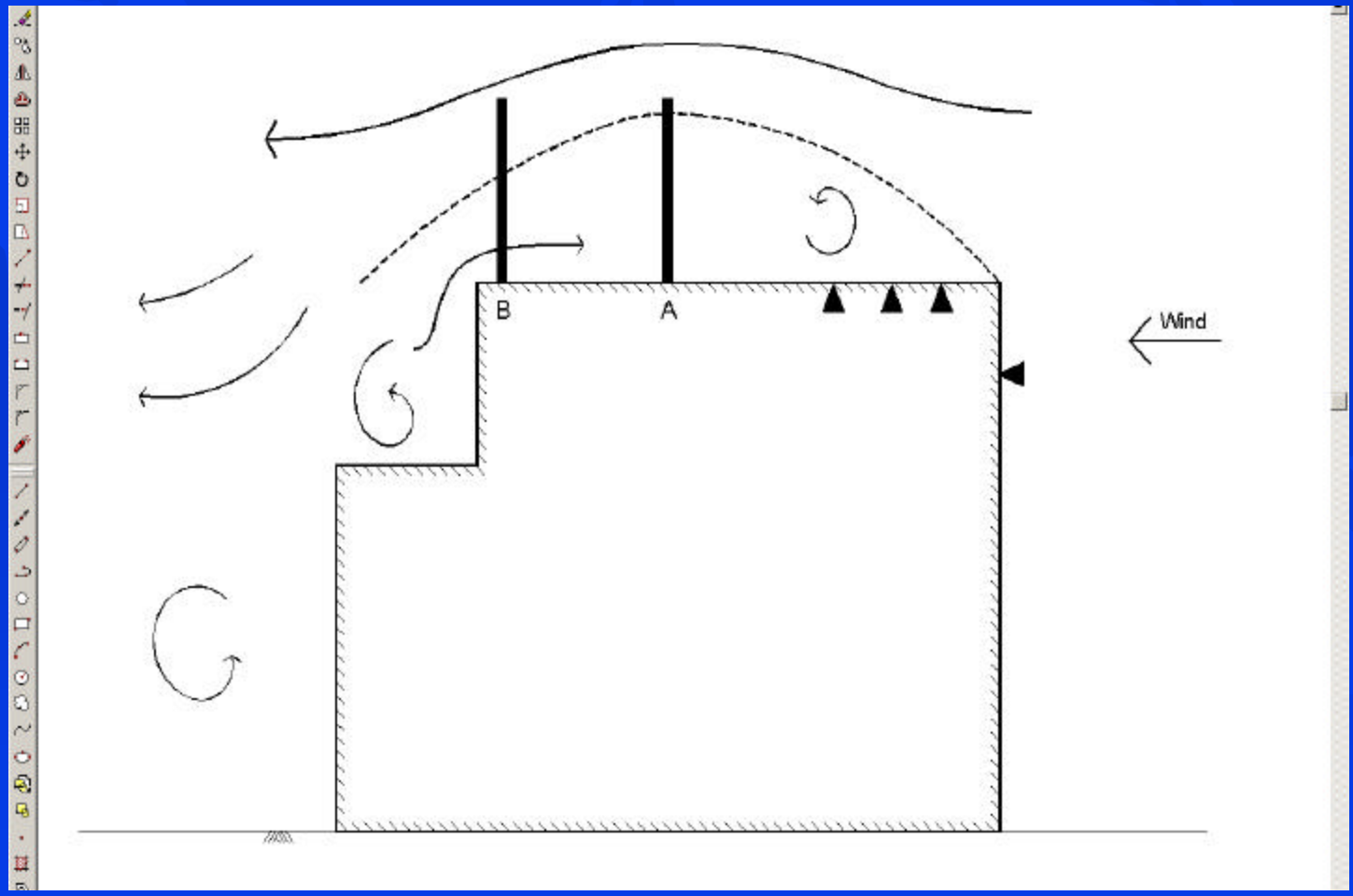
Location B is better than location A in all cases

Set-back roof is better than no set-back roof in all cases

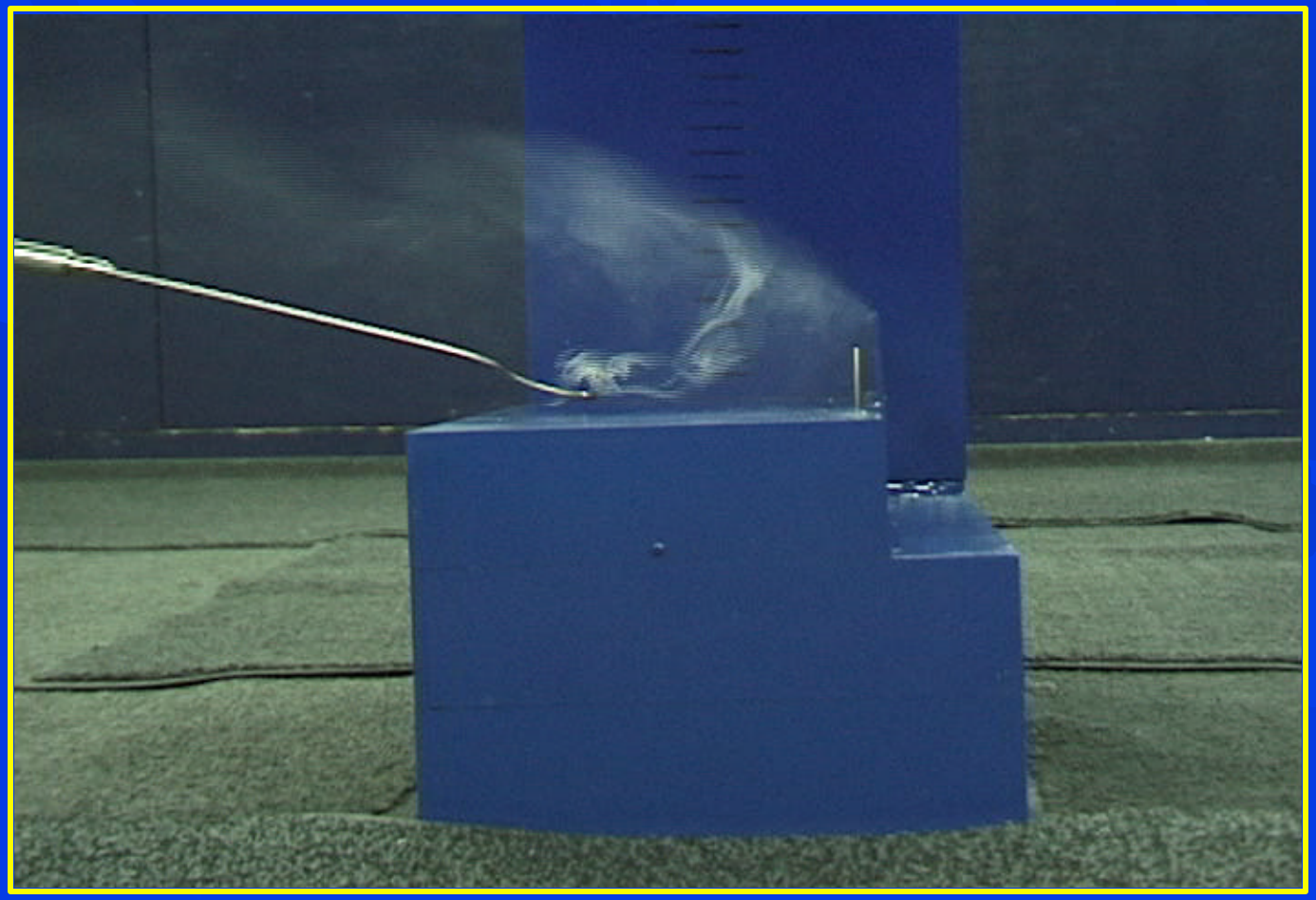
LEGEND

Exhaust Dilution
< 1000
1000 - 5000
> 5000

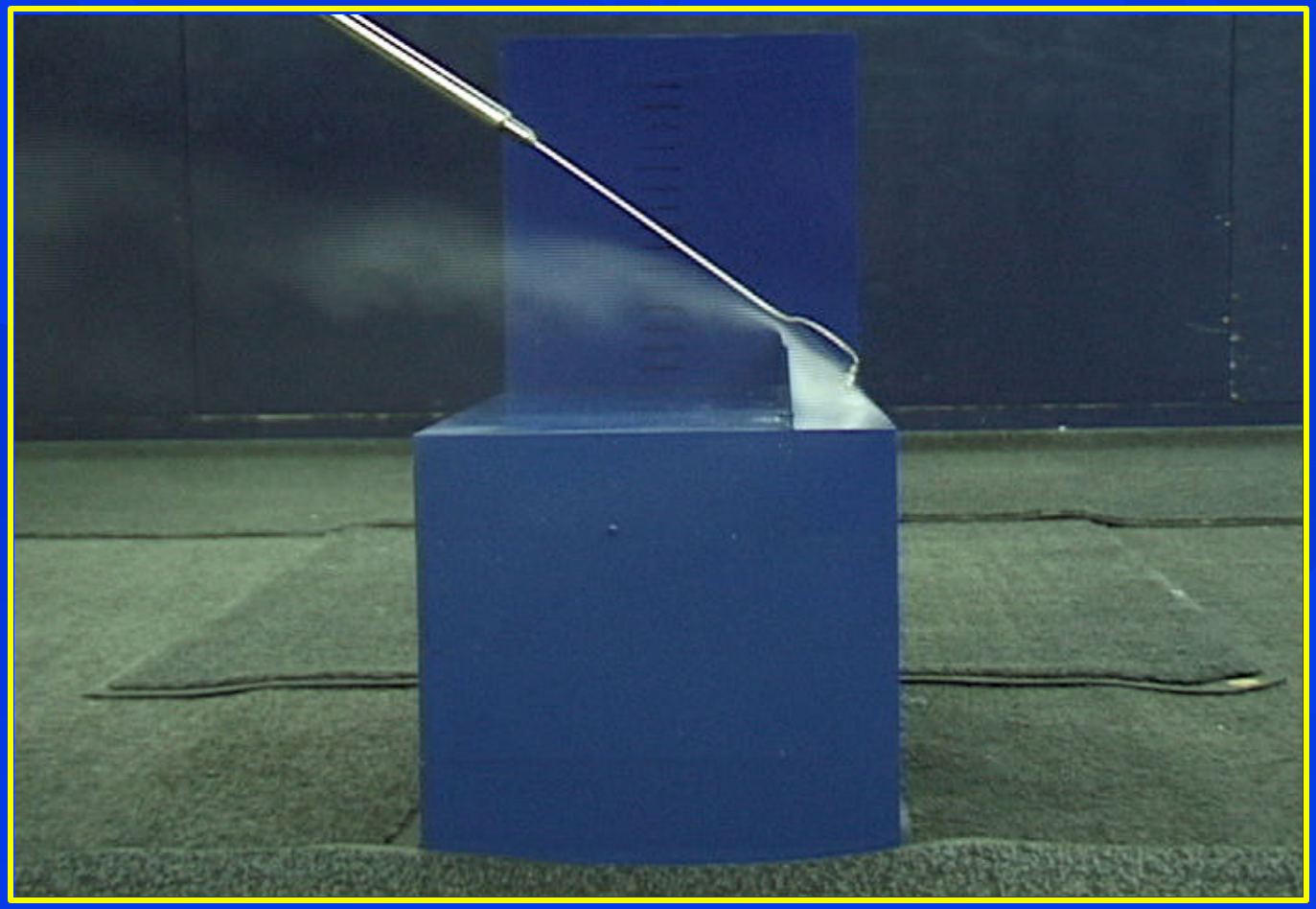
Intake Locations



Still from video



Still from video



Questions……..