

# **SUSTAINABILITY AND SMOKE CONTROL**

**DR. JOHN H. KLOTE, PE**

**CIBSE, LONDON UK**

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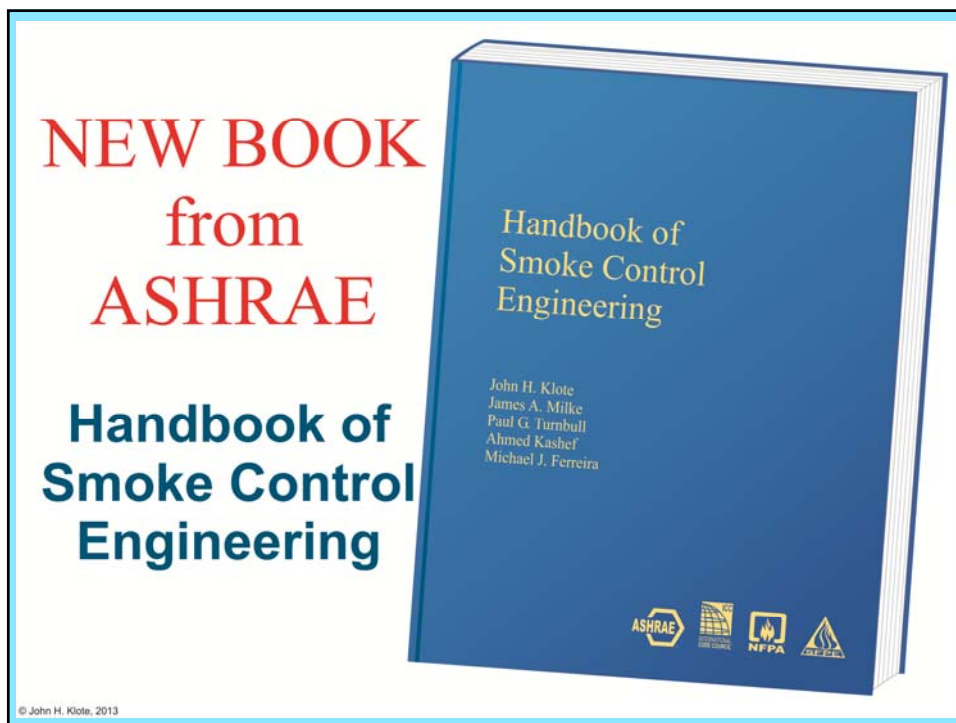
## **Sustainability & Smoke Control**

- Fire Protection & Smoke Control Systems – Sustainable
  - During Fire: Minimize Damage to Materials
  - During Fire: Minimize Impact on Environment
- The focus of this talk is sustainable smoke control systems that can be used in place of code mandated systems.

Note: In this talk, the term “atrium” is used in a generic sense to mean any large volume space (atrium, enclosed shopping mall, sports arena, airplane hangar, etc.).

## Sustainability & Smoke Control

- Sustainable Smoke Control Systems Limited Only by Ingenuity, Creativity, and Knowledge of the Design Team
- Essential: Alternate Systems Provide at Least Equivalent Protection
- Many Sources of Smoke Control Information
  - New ASHRAE Publication “Handbook of Smoke Control Engineering”



## **Topics in New Smoke Control Book**

- Design Weather Data
- Flow of Air and Smoke
- Egress Analysis
- Design Fires
- Human Exposure to Smoke
- Automatic Controls
- Pressurized Stairwells
- Pressurized Elevators
- Zoned Smoke Control
- Atrium Smoke Control

## **Topics (Continued)**

- Fire and Smoke Control in Transport Tunnels
- Computer Analysis (CONTAM, CFAST & CFD)
- Full Scale Fire Testing
- Commissioning & Periodic Testing
- Appendix: Derivation of Equations

## Smoke Control Systems

- Conventional System: Goal is to keep smoke away from occupants during evacuation.
  - There is always some amount of smoke that comes into contact with occupants.
  - The intent is that smoke contact is slight.
- Tenability System: Goal is to maintain a tenable environment during evacuation.
  - A tenable environment is one in which smoke and heat are limited such that exposure is not life threatening.
  - Systems are analyzed to provide confidence that a tenable environment is maintained.

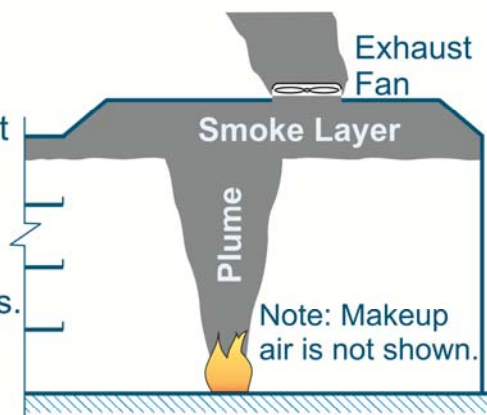
## Analysis of Tenability Systems

- Smoke Transport Calculations
  - CFD Modeling (Atria)
  - Network Modeling (Large Buildings)
- Tenability Calculations
  - Toxic Gases
  - Heat
  - Thermal Radiation
  - Reduced Visibility
- Evacuation Calculations
  - Evacuation time = pre-movement + movement time

## Atrium Smoke Exhaust

### Smoke Exhaust - Common Approach to Atrium Smoke Control

- Needs Large Exhaust Fans ( $45 \text{ m}^3/\text{s}$  or more)
- Sustainable system can eliminate the fans.



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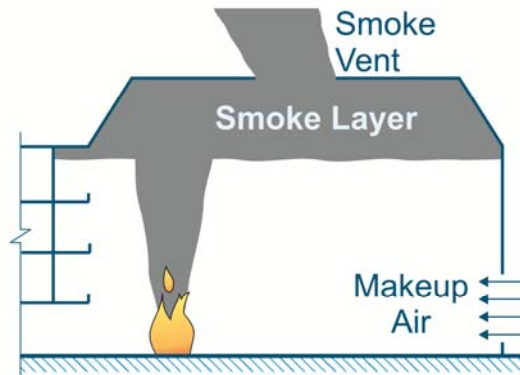
## Natural Smoke Venting

- Alternative to Atrium Smoke Exhaust (Natural Venting Used more in UK than US)
- Smoke Vented through Opening(s) in Ceiling
- Makeup Air from Opening(s) in Wall(s)
- Eliminate Fans
- Only Equipment: Automatic Vents & Controls
- Saves Some Power during Weekly Self-Tests

## Natural Smoke Venting

### Common Approach to Sustainable Atrium Smoke Control

- Eliminate Fans
- Only Equipment
  - Automatic Vents
  - Controls
- Saves Power during Weekly Self-Tests
- Calculation by Algebraic Equations Feasible

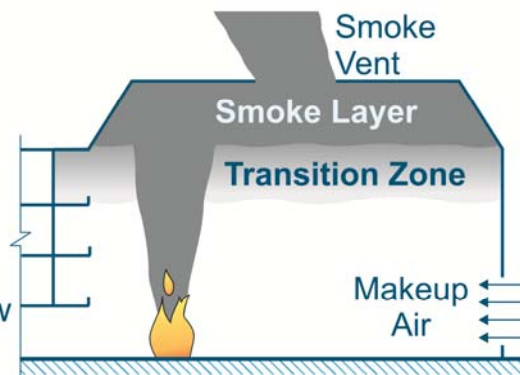


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## Natural Smoke Venting

### CFD & Tenability Approach

- CFD Simulates Transition Zone & Helps with Tenability Calculations.
- CFD Simulation can Include Wind & Transient Smoke Flow



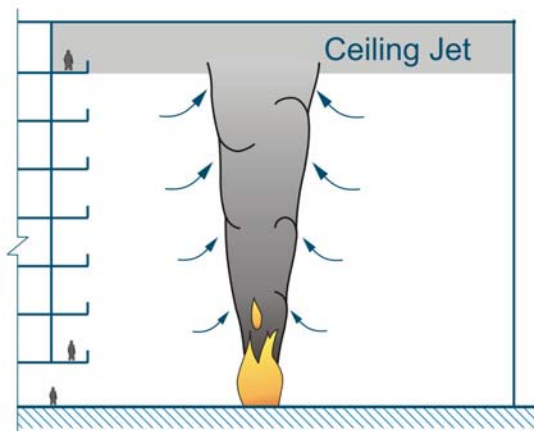
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## Smoke Filling

- Alternative to Atrium Smoke Exhaust (Smoke Filling Used more in UK than US)
- Applicable for Very Large and High Atria
- Smoke Diluted in Large Volume (Plume Mechanics)
- Eliminates All Smoke Control Equipment
- CFD & Tenability Analysis Recommended

## Atrium Smoke Filling

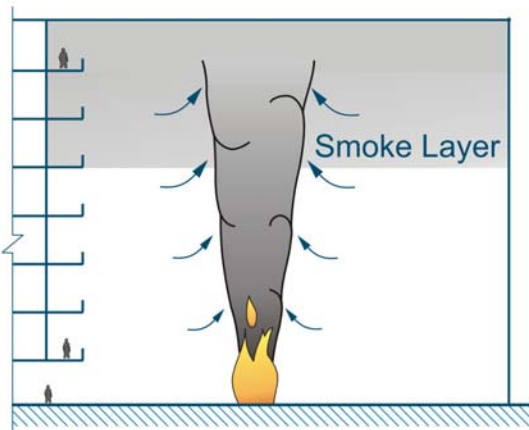
- Arrows indicate air (or smoke) that is entrained into the plume.
- Smoke filling eliminates the need for any smoke control equipment including fans, ductwork, and controls.



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## Atrium Smoke Filling

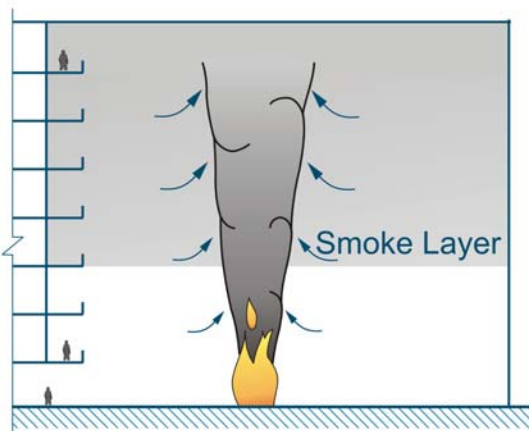
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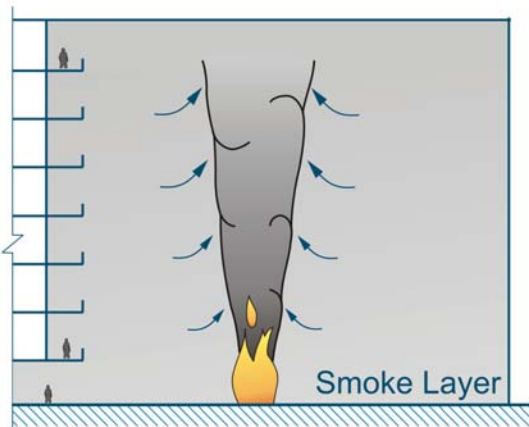


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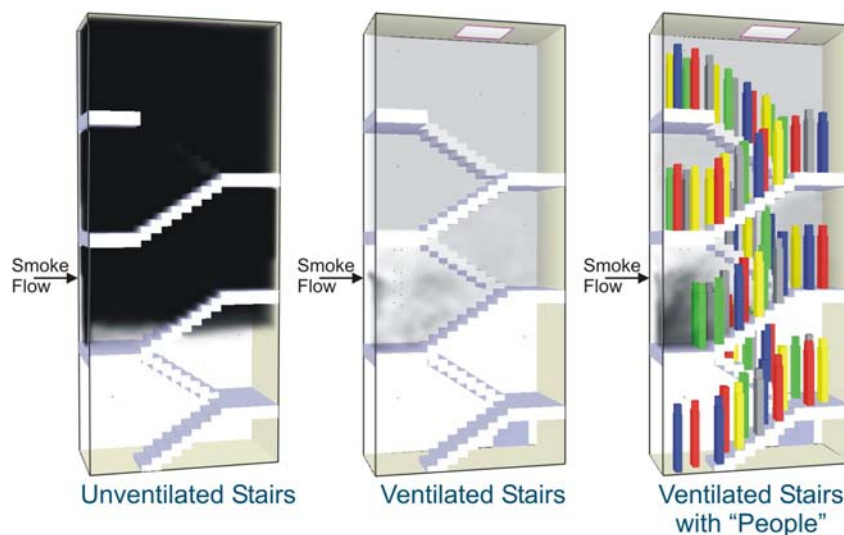
## Pressurization Systems

- Pressurization systems are conventional because they are intended to keep smoke away from occupants during evacuation.
- Sustainable Systems
  - Reduce Fan Size: Tighten Construction & Door Leakage
  - Change to a Tenability System (Ventilation System or Passive System)
- Reevaluated Old Ideas?
  - Purged Vestibules, Smoke Shafts, Exterior Wall Vents, etc.

## Stairwell Ventilation

- Example of Using Ventilation (Ferreira & Cutonilli 2008; Klote 2011)
- Concept: Ventilation Air Supplied to Stairs to Dilute Smoke & Maintain Tenable Conditions
  - $\Delta P$  Not Intended
  - Some Smoke Leakage
- Design: Balance between Ventilation & Smoke Leakage
- Ventilation Promising for Tall Stairwells

## CFD Analysis of Stairwell Ventilation



## Summary

- Sustainable smoke control systems can be used in place of code mandated systems.
- Smoke control systems can be classified as (1) conventional systems and (2) tenability systems.
- Tenability systems are particularly useful as sustainable smoke control systems.
- Examples of sustainable systems: (1) Atrium Venting, (2) Atrium Filling, and (3) Stairwell Ventilation.

**Questions?**

**John H. Klote**