

RB-002

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RB-002: Entrainment and Lateral Plume Spread in Open-Air Environments

P0 — Foundation

EXECUTIVE SUMMARY

This paper extends the foundational plume characterization of RB-001 by performing a deep quantitative analysis of the entrainment mechanism, lateral plume spread rate, and turbulent intermittency effects that govern hood sizing for outdoor barbecue ventilation. It delivers engineering lookup tables specifying minimum and recommended hood dimensions for every combination of source type and mounting height.



Outdoor Ventilation Standard

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Key Quantitative Findings

The plume at 30 inches is approximately 84% entrained ambient air by mass.

The plume at this height is approximately 92% entrained ambient air

For a medium gas grill at 11.7 kW total (propane combustion at approximately 0.24 g/s fuel, requiring approximately 3.8 g/s stoichiometric air): source gas flow approximately equals 0.004 kg/s.

This 20–30% increase represents the minimum intermittency margin that a hood must provide beyond the time-averaged plume boundary to achieve reliable instantaneous capture in quiescent conditions

Ambient turbulence increases effective plume width outdoors by approximately 30%. This requires proportionally larger hood dimensions.

A charcoal kettle ($Q_c = 1.8$ kW) at 30 inches requires a recommended hood width of 63 inches

A large gas grill ($Q_c = 12.3$ kW) at 30 inches requires 62 inches

Increases the required exhaust CFM by approximately 25–40% (from increased plume mass flow) 4

Decreases the plume centerline velocity by approximately 5–8% (from velocity decay) 5

Very large hood dimensions (66–82 inches) and high CFM (3x the 24" requirement)

Why This Research Matters

This research provides the first physics-based, quantitative methodology for outdoor cooking ventilation design. These findings enable proper hood sizing, CFM specification, and mounting height selection — preventing the common failures that occur when indoor assumptions are applied outdoors.



The Full Research Paper Includes:

- ✓ Complete derivations and governing equations
- ✓ Quantitative design tables and correction factors
- ✓ Engineering methodology with worked examples
 - ✓ Interactive calculation tools and diagrams
- ✓ Full reference bibliography and validation data

