

RB-006

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RB-006: Wind Interaction and Cross-Flow Effects

P1 — Core

EXECUTIVE SUMMARY

This paper is the most practically important analysis in the Outdoor Ventilation Standard for real-world outdoor installations. It extends the still-air plume characterization of RB-001 and the CFM analysis of RB-003 into the wind-exposed environment that defines outdoor cooking. Using Briggs bent-plume trajectory equations, Froude number analysis, and wind momentum ratio formulations, it quantifies lateral plume deflection at every combination of source type, mounting height, and wind speed from 0 to 15 mph. It identifies the critical wind speeds at which standard hoods lose reliable capture, quantifies the CFM and geometric compensation required, and delivers a four-tier wind exposure classification system with specific design recommendations per class.

THE CHALLENGE

Outdoor cooking installations operate in a fundamentally different aerodynamic environment than indoor kitchens. Indoor hoods benefit from enclosure walls that block lateral airflow, ceiling surfaces that redirect escaped plume gas, and room pressurization that assists recirculation toward the exhaust. Outdoors, the **Buoyant Cooking Plume** rises into an atmosphere that is rarely still. Even on nominally calm days, thermal convection and terrain effects produce air movement of 1 to 3 mph at cooking-surface height. In moderately exposed locations (open patios, rooftop terraces, beachfront installations), sustained winds of 5 to 10 mph are routine. In exposed locations (hilltops, open fields, coastal sites), 10 to 15 mph winds occur frequently.



Outdoor Ventilation Standard

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Key Quantitative Findings

Using the plume velocities from RB-001 Table 3.5 (1.0 to 2.8 m/s at 18 inches; 1.0 to 2.1 m/s at 48 inches), the CVP onset wind speed is:

At 30 inches: $U_w_{CVP} = 0.5 * 1.0 \text{ to } 0.5 * 2.4 = 0.5 \text{ to } 1.2 \text{ m/s (1.1 to 2.7 mph)}$

At 30 inches: $U_w_{disruption} = 3.0 * 1.0 \text{ to } 3.0 * 2.4 = 3.0 \text{ to } 7.3 \text{ m/s (6.7 to 16.3 mph)}$

The practical implication is that a site with a mean wind speed of 5 mph experiences instantaneous gusts of 8.5 mph ($G = 1.7$) or 10 mph ($G = 2.0$)

Source types (8 representative types from RB-001): Gas Small ($Q_c = 5.1 \text{ kW}$, $z_0 = -0.30 \text{ m}$), Gas Medium ($Q_c = 8.2 \text{ kW}$, $z_0 = -0.37 \text{ m}$), Gas Large ($Q_c = 12.3 \text{ kW}$, $z_0 = -0.41 \text{ m}$), Gas High-Output ($Q_c = 16.4 \text{ kW}$, $z_0 = -0.44 \text{ m}$), Charcoal Kettle ($Q_c = 1.8 \text{ kW}$, $z_0 = -0.47 \text{ m}$), Wood-Fired ($Q_c = 7.6 \text{ kW}$, $z_0 = -0.36 \text{ m}$), Pellet Smoker Low ($Q_c = 1.5 \text{ kW}$, $z_0 = -0.38 \text{ m}$), Pellet Smoker High ($Q_c = 5.7 \text{ kW}$, $z_0 = -0.30 \text{ m}$).

Mounting heights: 18" (0.46 m), 24" (0.61 m), 30" (0.76 m), 36" (0.91 m), 48" (1.22 m).

Wind speeds: 0, 2, 5, 8, 10, 15 mph (0, 0.89, 2.24, 3.58, 4.47, 6.71 m/s).

All mounting heights 18" to 36" are viable

48" mounting acceptable for low-output sources only

Hood sizing per RB-002 plus additional 4" overhang on windward side (or all sides if prevailing wind direction varies)

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