RB-004

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RB-004: Why Indoor Ventilation Assumptions Fail Outdoors

P1 — Core

EXECUTIVE SUMMARY

This paper audits the major indoor kitchen ventilation standards and identifies six categories of enclosure-dependent assumptions that fail in outdoor installations. For each lost mechanism, a quantitative performance penalty is estimated. The combined effect of removing walls, ceiling, pressurization, controlled makeup air, wind shielding, and enclosed dilution volume requires outdoor hoods to be 1.4-1.7x wider and to exhaust 1.7-2.5x the CFM of equivalent indoor installations. Indoor CFM ratings, hood sizes, and manufacturer claims based on indoor testing are systematically misleading for outdoor use.

THE CHALLENGE

The fundamental problem is one of implicit assumptions. ASHRAE 154, IMC Chapter 5, and UL 710 do not explicitly state "this standard applies only indoors." They do not enumerate the environmental conditions they assume. They simply specify performance requirements — exhaust rates, hood dimensions, face velocities, capture efficiency test procedures — that were developed and validated in enclosed test rooms. The enclosure is treated as a given, not as a variable. When a manufacturer or designer applies these specifications to an outdoor installation, every enclosure-dependent mechanism is silently lost, and the resulting system is systematically underspecified.

Outdoor Ventilation Standard

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Key Quantitative Findings

F_wind = 1.3 for light variable breeze (0-3 mph, typical outdoor residential)

F_wind = 1.6 for sustained directional wind (3-7 mph, exposed installation)

A hood rated at 85% capture efficiency per UL 710 may achieve only 50-65% first-pass capture in an outdoor environment, depending on wind conditions and installation geometry.

4 | Exhaust rate tables | Quiescent indoor air; ceiling jet recovery | CFM is 1.7-2.5x too low for outdoor use | | ASHRAE 154 Sec

RB-002 Section 3.9 established that the effective outdoor capture diameter (with turbulence and wind margins) is 1.3-1.4x the indoor capture diameter

Removing the wall and all outdoor margins increases the required hood depth by approximately 40-60%.

For hood width (the side-to-side dimension), indoor side walls — when present — provide 10-20% width reduction

To achieve the same 90% total capture efficiency outdoors (first-pass only) as the indoor 90% (first-pass + recirculation), the outdoor hood must increase its first-pass capture from 70% to 90%

RB-003 Table 3.4a showed that achieving v_edge = 0.15-0.30 m/s (30-60 fpm) at the hood perimeter requires an exhaust flow approximately 1.5-2.0x the bare plume mass flow rate

The incremental CFM penalty attributable specifically to pressure loss is approximately 10-20% of the total outdoor CFM 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