Insurance Institute for Business & Home Safety®

EXECUTIVE SUMMARY

*Where building science leads to real-world solutions.*

# Wind Loads on Small Roof-Mounted Air-Conditioning Units

*IBHS conducted a detailed investigation into the wind loads of roof-mounted equipment (RME) under numerous configurations. This investigation examined the effects that unit porosity, location and elevation had on wind loads, using custom-designed force balances specifically designed by IBHS for this study. Full details of both the experiments and results can be found in the full technical report: "Wind Loads on Small Roof-Mounted Air-Conditioning Units" (IBHS – RC01 – 2013). Some of the study's main findings and conclusions are outlined here.*

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- Wind loading coefficients in ASCE7-10 (2010) are adequate to envelope wind loads obtained from all RME configurations in the study, with the exception of goosenecks, and at certain locations where the RME is substantially elevated above the roof surface.
- The type of venting style or fin style does not appear to have a large effect on wind loads. Modeling RME – as a solid rectangle – generated higher uplift forces, while all other forces and moments appeared unchanged. This suggests that model scale wind tunnels, which typically model RME as a solid rectangle, may overestimate uplift forces on vented condenser units.
- Increasing elevation of the RME above the roof surface increases wind loads for locations on the roof and the range of elevations tested in the study. It is hypothesized that this increase is the result of RME experiencing higher wind speeds in the separated shear layer that exists in close proximity to the roof surface. Wind loads can be expected to reach some maximum at a certain ratio between the height above the roof and building height. It has been shown that the increase of force coefficients with elevation above the roof is less at locations closer to the interior of the roof, as compared to locations close to the roof edge. As a result, codification applying different force coefficients and limits to equipment height, h, above the roof based on roof zones (e.g. corner, edge and interior zones) is likely a more appropriate approach than universally increasing force coefficients found in section 29.5.1 of ASCE7-10 (2010).
- Results suggest, on average, the measured overturning moments are equal to what would be expected if lateral forces are applied at the center of the projected area of the unit in a vertical plane perpendicular to wind direction. ASCE7-10 (2010) does not explicitly state where force coefficients should be applied for calculating overturning moments on RME. Based on the results, language should be added to the ASCE7-10 (2010) stating that the wind loads be applied at the geometric center of the RME.
- For gooseneck units, the projected area varies significantly based on wind angle. For these high aspect ratio units with an asymmetric geometry, results suggest that projected area may not be the appropriate area for normalization of applied forces. However, a significantly more detailed study on these types of units would be required to confirm this conclusion.
- A significant reduction in wind loads on RME was observed for units downstream of a cluster of units. The reduction has been found to be as high as 70 percent for the downwind unit. However, upwind units did not experience a significant reduction in loads. The magnitude of reductions in loads for shielded units appear consistent with previous results from Erwin, et al. (2011). With such a substantial decrease in wind loads due to shielding effects, a more detailed investigation appears warranted regarding shielding schemes using screens and barriers surrounding a unit or a cluster of units.

Despite detailed study, there are several areas where further research onto wind loads on RME is required. Some of these unanswered questions only became apparent during analysis of current test results. Aspects of wind loads on RME which deserve further study include the following:

- Large load reductions were observed due to shielding effects from surrounding RME elements. The substantial reduction in wind loads observed from this shielding call for a more comprehensive investigation to quantify shielding effects from screens and barriers.
- Wind loads on goosenecks were found to be substantially higher than for other RME elements. Goosenecks used in the study were quite tall, being nearly 40 percent of the overall building height. A rigorous investigation into wind loads on goosenecks is warranted to confirm high wind loading coefficients observed in the study. In addition, a more detail study of RME with high aspect ratios and asymmetric geometries is required to determine if the projected area perpendicular to the wind direction is the correct normalization area.
- These experiments measured forces on RME units near the upwind roof edges where highest loads are expected. This means that units were located upstream of the flow reattachment point. Wind loads on RME in the interior region of the roof, downstream of the flow reattachment point, deserves further study.
- Parapets along roof edges are common. Since the investigation did not examine the effect of parapets, this should be examined in future investigations.