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COOLING

Specifying Air Handling Units

to Endure High Wind Events

How engineers and HVAC contractors can determine which AHUs will stand up to the potential damage caused by a hurricane, tornado or other catastrophic high wind event.

News coverage of hurricanes, tornados and other high wind events typically focus on building structural damage images; however, few reports show what wind speeds upwards of 200 mph can do to outdoor HVAC air handler (AHU) cabinets.

Tree limbs, 2x4s from wind-destroyed building structures, and satellite dishes are just a few of the potential projectiles that slam into AHUs during high wind events. Furthermore, extreme winds create inherent frame and cabinet wall pressure stress.

AT A GLANCE

- Florida's Miami-Dade County product approval is the Gold Standard of building codes for AHUs.
- Nortek Air Solutions™ holds the top three spots of Miami-Dade County's High Velocity Hurricane Zone (HVHZ) rating compliances for AHU cabinets.
- Nortek Air Solutions' WF-2 AHU (227-PSF/301mph) is the highest rated cabinet in the industry and more than doubles the strength of any other HVAC brand on Miami Dade County HVHZ list.
- Nortek Air Solutions has two other (ITF) models that are rated second and third on the Miami Dade County HVHZ list at (135 PSF/230 mph and 110 PSF/216 mph).

by Terry Leatham and Lee Magill — Nortek Air Solutions

Consequently, AHUs with cabinets not designed for catastrophic storms don't fare well.

The terms "high wind" or "strong wind" conjure thoughts of occasional winds reaching 30-60 mph. Although these winds are indeed high, they are not considered "high velocity." High velocity winds produce so much force they transform objects into fast-moving projectiles that can cause considerable impact damage.

One person that's "seen it all" in terms of what high winds can do to AHUs is Chris Cioffi, Commercial Lines Engineer, Insurance Institute for Business & Home Safety (IBHS), Tampa, Fla., an independent, nonprofit, scientific research and communications organization supported solely by property insurers and reinsurers. Cioffi's post-Hurricane Michael inspections included a damaged supermarket's multiple ton (weight, not refrigeration) HVAC rooftop system that had been completely blown from the 30-foot-high roof, resulting in a pile of mangled metal on the ground.





Post-hurricane rooftop HVAC cabinets with decimated frames and damaged or missing panels. (Photos: FEMA)

Hurricane and Tornado High Wind Zones

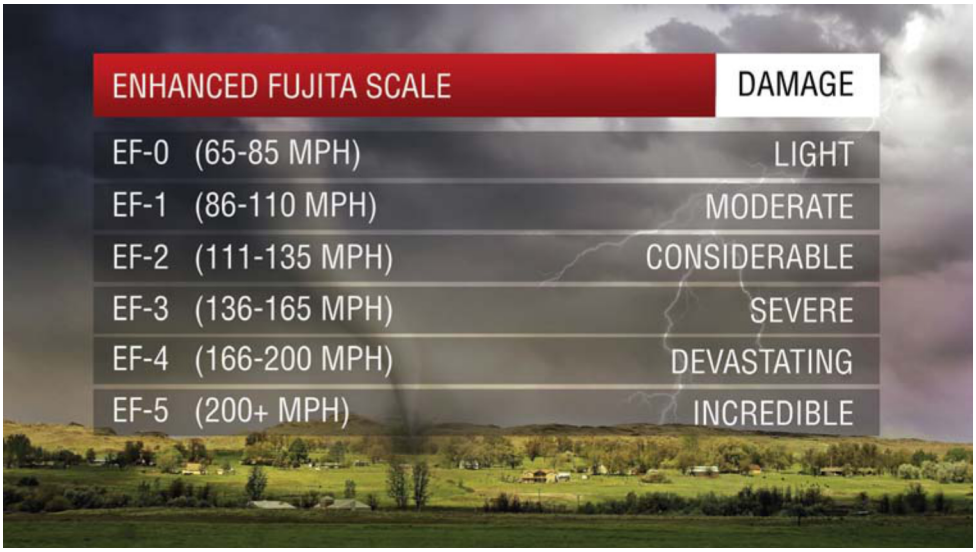
So that their specific AHUs don't experience the same fate, consulting engineers are concerned with all high wind events, including both hurricanes and tornados. One major difference between the two storm types is AHU wind stress from tornados typically lasts less than a minute, whereas hurricane winds can last days. Withstanding long periods of high winds is an important AHU design parameter.

Hurricane zones aren't just in Florida. AHUs in temperate zones also need cabinets designed for high winds. U.S. hurricanes can make landfall in Florida and then travel along the eastern seaboard as far north as New York, New Jersey, and even Maine.

Hurricanes are rated in five categories ranging up to wind speeds surpassing 155 mph.

Category	Wind Speed (mph)	Damage at Landfill	Storm Surge (feet)
1	74 - 95	Minimal	4 - 5
2	96 - 110	Moderate	6 - 8
3	111 - 130	Extensive	9 - 12
4	131 - 155	Extreme	13 - 18
5	> 155	Catastropic	19+

Likewise, tornados are also divided into categories by the Enhanced Fujita Scale with wind speeds surpassing 200 mph for an EF-5 storm.



(Tornado illustration Source: Weather.com)

Why AHUs Must Survive Catastrophic Weather Events

Recovery from hurricane and tornado devastation can take months or even years. For example, Hurricane Katrina reached a Category 5 rating in 2005 (recorded maximum winds sustained at 175 mph), resulting in $125-billion in damage and more than 1,800 fatalities. New Orleans was hit the hardest; however, Katrina affected areas from the Bahamas to Eastern Canada. Recovery/rebuilding efforts in these areas are still ongoing in 2020. When recovery efforts get underway, it's important to maintain critical infrastructure operations, such as medical and communications facilities. Therefore, HVAC air management AHUs must also remain operable. An AHU can only survive a hurricane or tornado encounter through carefully planned design.





Hurricane Katrina was a Category 5 storm causing $125-billion in damage and more than 1,800 fatalities.

Miami-Dade County Approved

Miami-Dade County (MDC) has a set of building standards specifically designed around high wind conditions.

After 1992's Hurricane Andrew decimated the Sunshine State's coastal areas, Florida set out to standardize its building codes so that structures fare better during a hurricane[1]. MDC went beyond the Florida Building Code's (FBC) already stringent requirements and is now known as the gold standard for hurricane ratings. MDC surpassed the following codes:

- FBC-TAS 201-94
  - "Impact Test Procedures"
- FBC-TAS 202-94 (Structural Only)
  - "Criteria for Testing Impact and Non-Impact Resistant Building Envelope Components using Uniform Static Air Pressure"
- FBC-TAS 203-94
  - "Criteria for Testing Products Subjected to Cyclic Pressure Loading"
- ASTM E8
  - "Tensile Strength of Metallic Materials"
- ASTM E72-10
  - "Standard Test Methods of Conducting Strength Tests of Panels of Building Construction"

AHUs must be designed to comply with the MDC's HVHZ standards and meet the requirements through several methods, including testing, calculations, quality assurance and material certifications:

- Large missile impact
- Cyclic wind pressure testing
- Uniform static air pressure testing

MDC standards have been adopted by many counties in high wind zones elsewhere in Florida, as well as other states that recognize their superiority and "don't want to reinvent the wheel." This trend will continue to challenge engineers to stay abreast of what brands and models comply with MDC requirements.

Consequently, AHUs must meet the requirements through several methods, including testing, calculations, quality assurance and material certifications. Applicable rules and regulations governing the use of construction materials are comprehensively considered in the composition of each AHU:

- Base
- Floors
- Panels
- Access Doors
- Handles
- Framework
- Latches
- Hinges

If an AHU can pass MDC testing, then it is a safe assumption that the AHU can survive any high wind zone found across the U.S. because MDC standards far surpass all other North American building codes.

Miami-Dade County's Best-in-Class AHUs Certified for HVHZ

Nortek Air Solutions (NAS) set a goal of designing the best hurricane-rated AHUs in the HVAC industry. This consists of heavy gauge metal exterior panels and interior liners, and a structural integral or welded framework with a fully-welded structural unit base. There are approximately 20 AHU cabinet designs from a variety of brands carrying MDC HVHZ certifications. NAS assumes the top three spots of cabinet designs with one Welded Frame (WF-2) and two Integrated Thermal Break Frame (ITF) industrial/ commercial models. designs with two Welded Frame (WF-2) and two Integrated Thermal Break Frame (ITF) commercial/industrial models.

APPLICANT	CONSTRUCTION	PSF	EXPIRATION
Nortek Air Solutions Inc. (WF-2)	**Foam-Filled Steel or Stainless Steel**	**227-PSF (301-MPH)**	**November 19, 2025**
Nortek Air Solutions Inc. (ITF)	**Foam or fiberglass-filled galvanized steel or stainless steel**	**135-PSF (230-MPH)**	**April 25, 2024**
Nortek Air Solutions Inc. (ITF)	**Foam-Filled Aluminum**	**120-PSF (216-MPH)**	**April 25, 2024**
Haakon Industries (Canada) Ltd.	Steel	110-PSF (207-MPH)	August 27, 2025
Seasons-4 Inc.	Steel	100-PSF (197-MPH)	December 24, 2024
Greenheck Fan Corp.	Steel	96.5-PSF (193-MPH)	February 14, 2024
ClimateCraft Inc.	Steel	95-PSF (192-MPH)	August 29, 2024
Johnson Controls Inc.	Steel	80-PSF (176-MPH)	December 26, 2023
Daikin Applied	Composite	75-PSF (171-MPH)	April 17, 2023
Air Enterprises	Composite	65-PSF (159-MPH)	October 5, 2022
Ring Power Corp. -dba Phoenix Products	Aluminum	60-PSF (153-MPH)	September 22, 2021
Trane U.S. Inc.	Steel	55-PSF (146-MPH)	November 21, 2023

Nortek Air Solutions has the three best hurricane-rated AHU cabinets in the HVAC industry, according to Miami-Dade Country.

Understanding PSF and its Relationship to MPH

MDC certifies AHUs in terms of wall pressure rating (pounds per square foot (PSF)). When specifying, it is important to note that mph is more of a general reference point and isn't directly correlated to PSF. Instead, building importance or "risk factor" and the elevation of the equipment must both be factored into the final equation. These factors are normally available from the structural engineer. Furthermore, rated PSF is at design pressure, which is 67-percent of overload pressure.

The Best Hurricane-Rated AHU Cabinets

The top-rated model, which far surpasses the rest of the industry, is the WF-2 with four-inch, foam-insulated walls available under the Nortek Air Solutions Temtrol™ and Nortek Air Solutions Governair™ brands. MDC certified it in 2020 (NOA No. 20-0630.02) for 227-PSF, which can be calculated in wind speed as 301 mph. After NAS' former WF-2 110-PSF (201 mph) unit passed MDC's HVHZ certification, NAS engineering set out to design a welded-frame cabinet that would far surpass every AHU on the market, which resulted in the aforementioned 227-PSF unit[2]. Incidentally, that same unit design was pushed to its limit, or maximum PSF, because NAS engineers felt they had designed a cabinet that hadn't shown its maximum test potential. The WF-2 was tested up to a 340-PSF (369 mph) maximum result. However, for MDC compliance purposes, the final result is rated at 67-percent (safety factor) of the maximum for a listed design pressure of 227-PSF, which far surpasses any competitor.



A completed WF-2 cabinet for a Nortek Air Solutions Temtrol brand AHU.

The second (135-PSF/230 mph) and third (110-PSF/216 mph) hurricane-rated units on the MDC's High Velocity Hurricane Zone (HVHZ) list are ITF cabinets (NOA No. 19-0227.05).

All other manufactured brands (except for one competitor at 110-PSF) fall below 110 and the majority lie in the range of 55- to 80-PSF (146 to 176 mph)[3].



A completed ITF cabinet for a Nortek Air Solutions Temtrol brand AHU.

How to Choose

NAS provides multiple options in cabinet construction and ratings that allow the engineer and building owner to select the proper equipment for each project. Options to consider include insulation thickness (3 or 4-inch), insulation material (foam or fiberglass) and required PSF rating (110, 135 or 227) for a project. The WF-2 (227 PSF) has a welded upper steel frame and 4-inch foam panel construction. The ITF has a mechanically-fastened, upper steel frame with 3-inch foam (135 PSF) or 3-inch fiberglass (110 PSF) panel construction. It's important to select the rooftop equipment based on jobsite requirements. All three models exceed industry standards and are considered exceptional products.



A welded frame versus a screwed frame will exhibit the most strength against high velocity winds.

All models perform similarly regarding testing for missile impact, uniform static air pressure and fatigue loading. However, the WF-2 has higher performance statistics for wind loading and a racking test, which is another wind force test applied laterally to the wall. The WF-2 welded-frame construction, which potentially withstands higher wind pressures and internal forces, offers engineers more customization and strength than the ITF. For example, a project specified in Alaska was a customized vertical unit with 6x6-inch corner posts and a unit height of a four-story building that could withstand both high wind forces and seismic loads.

MDC testing standards cover the entire AHU installation, from the curb and fasteners to the AHU itself. However, AHU manufacturers are responsible for only the structural design and MDC compliance of the unit. The entire AHU installation design is the responsibility of the architect or engineer on record. Recommendations for curbs, curb materials, fastener locations and strength, height of the curb/unit combination, ductwork configurations and gauge, piping and connections to the AHU, and other parameters in designing an HVHZ AHU installation can be found in the International Building Code (IBC), American Standards of Testing and Materials (ASTM) and the American Institute of Steel Construction (AISC).

Besides compliance with MDC, the WF-2 and ITF cabinet designs were also subjected to rigorous in-house factory laboratory testing during research and development for performance, strength and durability. This assures the specifier receives unit performance specifications promised by the manufacturer.

Importance of Understanding Wind Velocity Acting on a Surface

When wind traveling at any mph encounters a surface, the interaction between the wind and the surface is known as a "wind load." Wind load is the actual force of the wind on the structure. There are three different types of wind loads: uplift load, shear load and lateral load.

When these wind loads interact with the surface of an AHU, the resultant force is a PSF condition. The MDC minimum is 110 PSF (207 mph). That is the amount of force that the wind is exerting upon the surface of the AHU; not to be confused with positive and negative air pressures. The PSF measurement is the physical attribute of the wind that is trying to move the AHU.



Spray foam in AHU cabinet floors add high R-Value efficiencies as well as “oil canning” prevention.

What is Tested

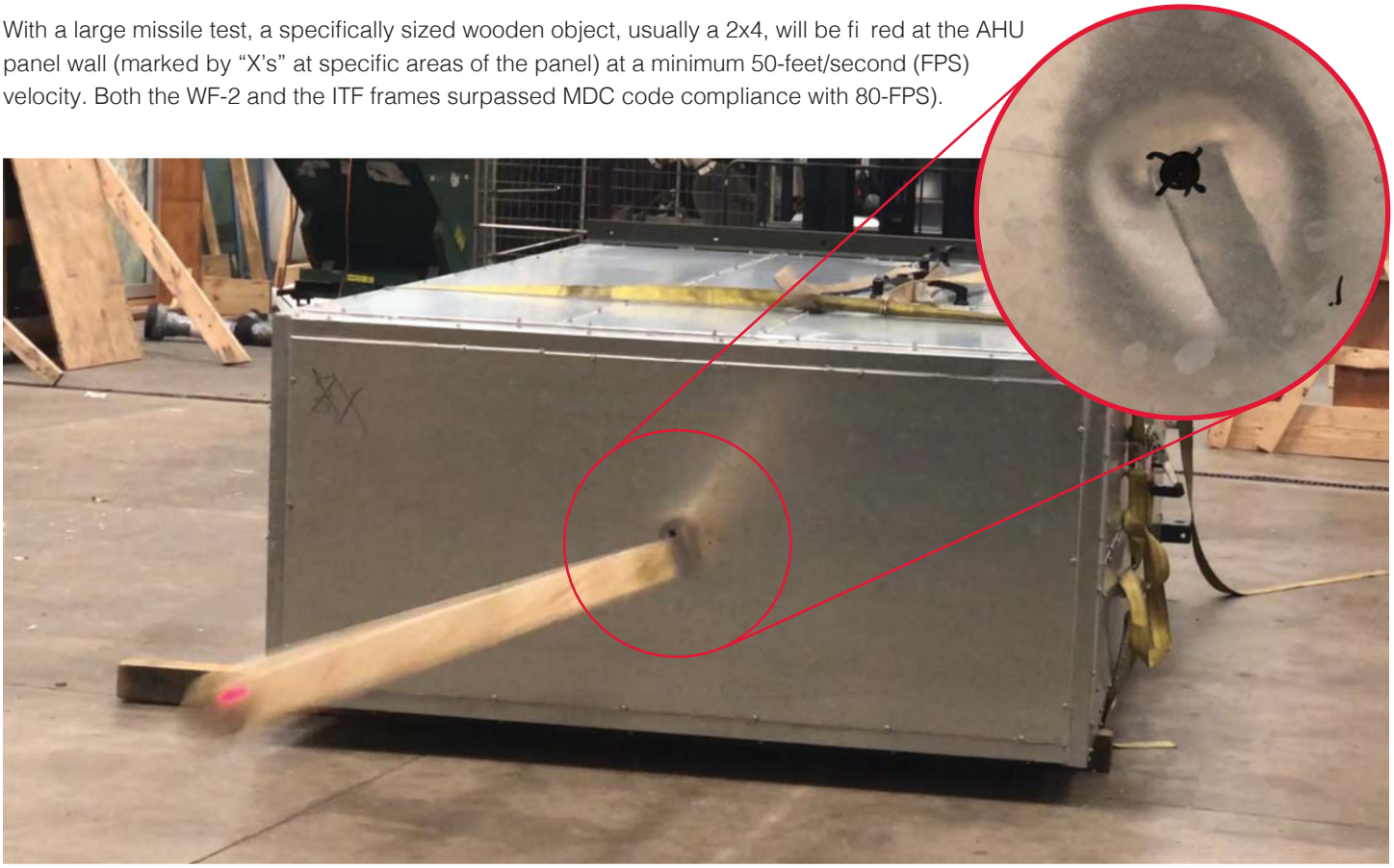
MDC AHU testing standards outline several responsibilities of the AHU manufacturer. Besides the prescribed 110-PSF rating, NAS also goes well beyond many other MDC requirements below in parentheses:

- All structural steel member joints are continuously welded.
- Primed and painted unit base. (1,500 to 5,000 salt hour coatings available for longer cabinet life cycles).
- An internal floor member spacing of 24” maximum to prevent oil canning (internal foam insulation also prevents oil canning).
- AHU roof and wall tubular frame spacing is typically 24”with a maximum of 30”wide.
- Thermal and acoustic properties of the spray foam insulation meet an R-value for the WF-2 and ITF of 26.8 and 20.1, respectively.
- Standard inner liner is solid 20-gauge steel, stainless steel or aluminum, and can be used in any combination as required throughout the AHU cabinet.

Missile Testing

The main criteria behind missile testing are the impact resistance properties of an AHU. Testing entails launching a specifically sized object at a fixed speed to simulate hurricane wind debris and how the construction of the AHU withstands it.

With a large missile test, a specifically sized wooden object, usually a 2x4, will be fi red at the AHU panel wall (marked by “X’s” at specific areas of the panel) at a minimum 50-feet/second (FPS) velocity. Both the WF-2 and the ITF frames surpassed MDC code compliance with 80-FPS).



A wooden 2x4 is launched with a minimum 50-feet/second (FPS) velocity into a WF-2 cabinet during MDC hurricane-rating tests.

Missile Testing continued

The panel wall must survive three direct impacts without the cabinet wall breaking to pass the large missile test. The exterior liner can be breached according to MDC testing allowances; however, the inner liner must not be penetrated. Even at 80-FPS, the outer liner was not penetrated by missile impact tests.



Hurricane winds propel projectiles of all shapes and sizes, therefore only properly designed and constructed AHUs can withstand repeated impacts. Resistance to impacts also maintains the internal sealing of the AHU, resulting in no air or water infiltration.

During the missile testing, the lab will test a bottom corner, an upper corner, doors, door latches and random spots.

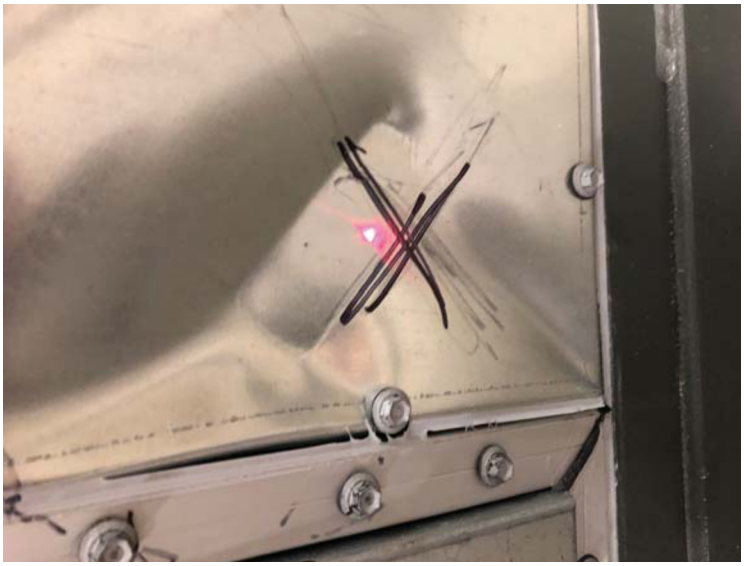




Illustration: Missile testing also includes bottom corner (left), top corner (right) and some random positions to ensure structural integrity throughout the entire cabinet.

Cyclic Wind Pressure and Uniform Static Air Pressure Testing

AHUs also encounter varying wind speeds, which can cause what is known as fatigue loading. Fatigue testing consists of exposing AHUs to these varying PSF conditions by cycling pressure on the cabinet. Cyclic wind pressure testing consists of different wind speeds that create variable air pressures applied to the AHU. Pressure is applied for several seconds as it cycles from positive to negative. To simulate potential fatigue conditions an AHU experiences during high wind events, testing includes 600 cycles at 50-percent, 70 cycles at 60-percent and 1 cycle at 130-percent of the design pressure. Not only does this fatigue apply to the cabinet walls, but it also applies to the external-facing components of the AHU, such as door handles and latches.

Properly constructed AHUs will withstand impacts and withstand fatigue conditions. Maintaining this integrity ensures proper operational conditions of the AHU under extreme wind conditions.

Uniform Static Air Pressure Testing

Uniform static air pressure testing, as the name implies, is the application of a uniform pressure load. Both positive and negative pressures are applied to determine the maximum amount of uniform wind pressure the AHU can withstand. AHUs that can pass this test provide the building owner with assurance the AHU will remain operable in high wind conditions.



Door handles and latches are the highest quality possible and are subjected to the same pressure testing as the entire cabinet.

Site Inspections by Consulting Engineers and Maintenance

Unfortunately, a consulting engineer can specify an AHU cabinet that meets the most stringent building codes; however, the unit may not remain operable after a catastrophic weather encounter if it was poorly installed or maintained. That's why the IBHS's Cioffi recommends engineering fi rms visit sites they've designed after installation, if possible. A site visit after a catastrophic weather event can also lend a wealth of information as to if the unit tipped over, curb was breached, access panels blew off and other post-storm revelations.

"One of the most common damages I see are units separated from their curbs," said Cioffi, who previously specified rooftop HVAC systems for commercial buildings while at TLC Engineering Solutions, Tampa, before joining the IBHS. "That could be due to improper curbs, non-compliant fasteners, or it could also indicate that a lack of maintenance allowed the fasteners to corrode over time. Maintenance departments should check rooftop units every season to detect early corrosion, or if access panels are unlocked, have loose screws or missing screws."



Periodic corrosion maintenance of fasteners that hold the AHU to the curb is as critical as specifying an AHU manufactured specifically for high wind zones. (Photo: IBHS).

Conclusion

While MDC is considered the Gold Standard of HVHZ rooftop AHU design, engineers should use the criteria to choose equipment even though it might not be a hurricane zone project. High winds, especially tornados, are possible in nearly every state. Specifying an AHU with a high PSF rating will give the engineer peace of mind and offer the best possible reliability for a building owner if a catastrophic wind event occurs. While the building's infrastructure may have damage, the interior temperature and humidity environment will still be operable due to the built-in protection that surpasses local building codes.

Or, another way of looking at it: The WF-2 foam panel AHU cabinet boasts a 227-PSF (301 mph) HVHZ rating that's the best-in-class, according to the nation's most stringent AHU building code. No other manufacturer's best product can survive what the WF-2 has withstood in laboratory tests.

About Nortek Air Solutions: Nortek Air Solutions is the largest manufacturer of Miami-Dade County (MDC)-certified custom HVAC air handling equipment in North America. With a notice of acceptance (NOA) received from MDC for its WF-2 and Integrated Thermal Break Framing (ITF) system air handling unit product models, Nortek Air Solutions has the four top performing air handling units on the market specifically designed for high velocity hurricane zone (HVHZ) conditions, as compared to other competitors. Nortek's WF-2 and ITF and both the Best-in-Class and carry the highest MDC top two wall pressure ratings of 227-PSF (301-MPH) and 135-PSF (230-MPH), respectively. Nortek also commands the third and fourth ranking on the MDC ratings with another ITF at 120-PSF (216-MPH) and another WF-2 at 110-PSF (201-MPH) thereby exemplifying Nortek Air Solutions' industry-leading capabilities in providing high wind tolerant air handling units.

REFERENCES:

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2) https://www.miamidade.gov/building/pc-result_app.asp?fldNOA=&Classification=1%2CHigh+velocity+hurricane+zone%2C1&AdvancedSearch=Go&applicantlist=101918&categorylist=0&subcategorylist=0&materiallist=0&impactlist=0&fldMDPP=0.00&fldMDPN=0.00

3) https://www.miamidade.gov/building/pc-result_app.asp?fldNOA=&Classification=1%2CHigh+velocity+hurricane+zone%2C1&AdvancedSearch=Go&applicantlist=0&categorylist=8&subcategorylist=82&materiallist=0&impactlist=0&fldMDPP=0.00&fldMDPN=0.00

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BIO: *Terry Leatham is Principal Mechanical Engineer at Nortek Air Solutions, Oklahoma City, Oklahoma. He joined NAS' Governair® brand in 1998 and currently works with NAS-Listed product for International Building Code (IBC), Office of Statewide Health, Planning & Development (OSHPD—div. Seismic Conditions) and Notice of Acceptance (NOA—div. of hurricanes) Miami-Dade County. Leatham earned an Electronic Engineering Technology degree from Brigham Young University and has more than 30 years HVAC industry experience with companies, such as Carrier and ClimateMaster. He also taught HVAC design/application courses for sales and application engineers at Carrier's Syracuse, N.Y. facility. He can be reached at terry.leatham@nortek.com.*

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