KOHLER.

Designing Enclosures for *Hurricane Ratings* and the *Florida Building Code*

AUTHOR
JACOB VANDERLOOP
Senior Design Project Engineer
Kohler Power Systems

Kohler Co.
Kohler Energy Division

INTRODUCTION

During a severe weather event, a standby power system enclosure must be capable of enduring a variety of weather elements with the risk of losing essential power to critical needs facilities such as shelters, hospitals, and emergency response resources. In the state of Florida, a standby power system may experience some of the most severe weather conditions in the United States during a hurricane event.

According to the National Oceanic and Atmospheric Administration (NOAA) some of the most severe hurricanes are capable of winds over 180 mph. Therefore, the state of Florida has developed standardized test protocols and regulations when designing and determining the survivability of structures, such as critical power system enclosures, during a hurricane weather event. These test protocols can be found in the Florida Building Code (FBC) and focus on the enclosure's ability to withstand wind load, rain intrusion, and wind-borne debris impact. It is important to consider the requirements for each of these factors when designing a power system enclosure so that the power system remains fully functional at its most critical moments

This white paper will review these critical design factors for power system enclosures in the state of Florida, and compliance requirements to meet hurricane ratings and the FBC.

FLORIDA BUILDING CODE (FBC)

The FBC is a set of regulations and standards that govern construction and building practices in the state of Florida. The FBC was established in 2002 by the state of Florida as a single state building code that is enforced by all local governments and is designed to ensure that buildings and structures in Florida are safe and resilient to hurricanes and other natural disasters.

The FBC categorizes structures based on their occupancy risk. Per section 1604.5 of the FBC, there are four occupancy risk categories that are used to classify buildings and structures based on their intended use and the potential risks associated with those uses. These categories help ensure that buildings and structures are constructed in a way that aligns with their intended purpose and requirements. Each building and structure shall be assigned a risk category in accordance with table 1604.5 of the FBC.

The occupancy risk categories vary slightly based on their intended purpose. For example, essential facilities such as nursing homes or hospitals are classified as risk category IV. These risk categories apply to the entire state of Florida regardless of location. Chapter 4 of the FBC also outlines special detailed requirements and guidelines for specific structures based on occupancy and use. It is important to review this chapter when determining specific structure requirements in the state of Florida.

HIGH-VELOCITY HURRICANE ZONES

The FBC includes regulations that pertain to standby power system enclosures. These regulations are intended to ensure that power system enclosures are constructed and installed securely, particularly in high-velocity hurricane zones (HVHZ) of the state.

Per FBC, Broward and Miami-Dade counties are designated as high-velocity hurricane zones and witness some of the most severe conditions during a hurricane event. HVHZ have the highest rated requirements for critical power systems and their enclosures per FBC.

To validate structural integrity, standby power system enclosures must comply with strict regulations and testing protocols for wind load, rain load, and impact from wind-borne debris. These requirements and regulations help protect the standby power system during adverse weather events to ensure that it operates as intended during power outages.

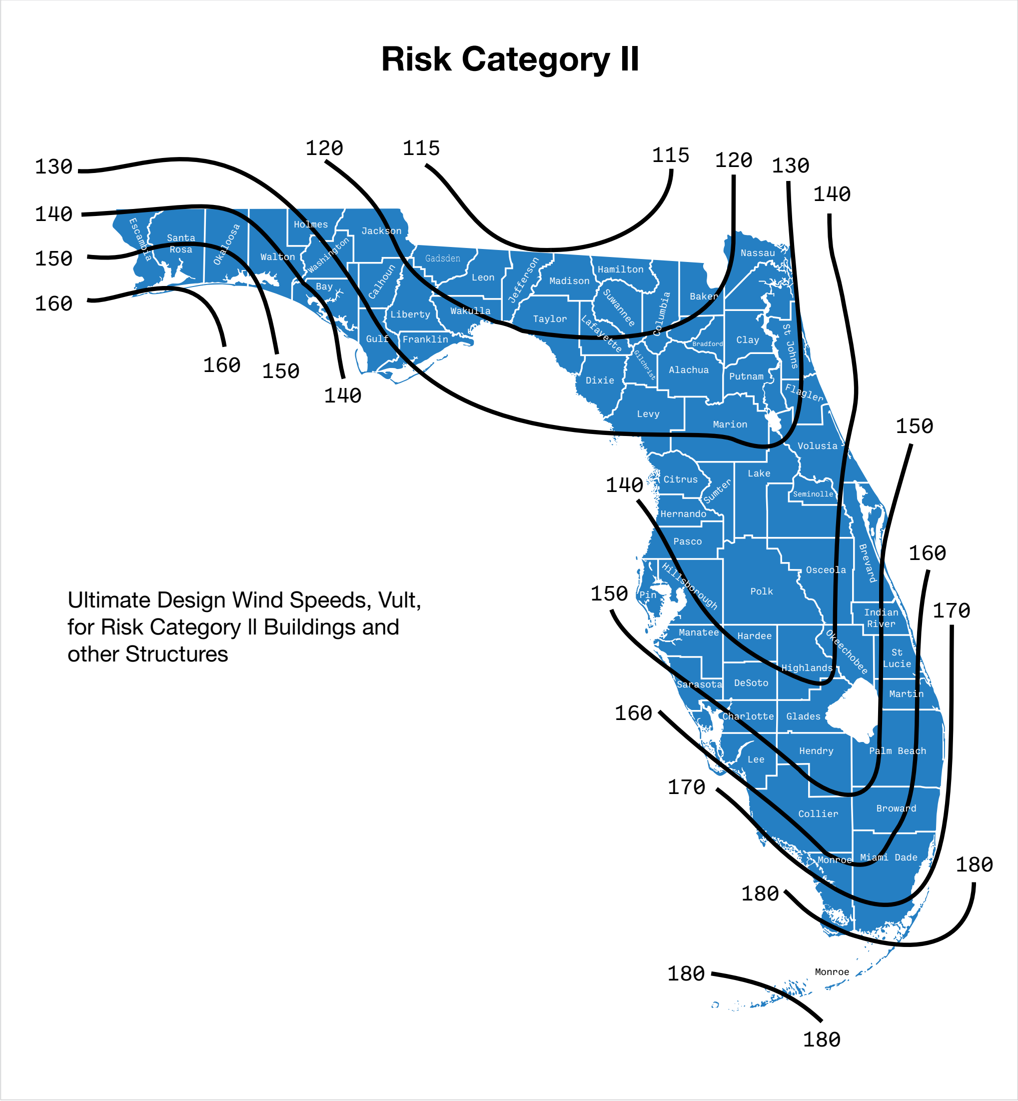
RISK CATEGORIES

Section 1620 of the FBC identifies wind load requirements for structures in HVHZ. This FBC section requires that all buildings and structures be designed and constructed to meet ASCE 7-10 based on their risk category I, II, III, and IV. The risk category is determined based on the use or occupancy of buildings and structures. Refer to ACSE 7-10, Table 1.5-1 for more details.

RISK CATEGORIES-CONT.

A standby power system is usually considered Risk Categories II or III and IV. Figure 1 illustrates the basic wind speeds in the state of Florida for Risk Categories II.

Figure 1



RISK CATEGORIES (CONT.)

Figures 2, and 3 illustrate the basic wind speeds in the state of Florida for Risk Categories III and IV, respectively.

Figure 2

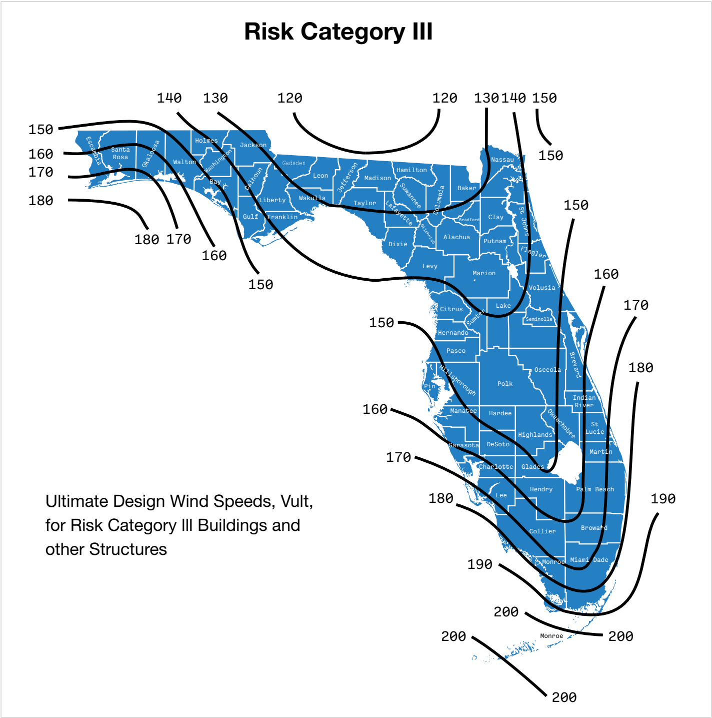
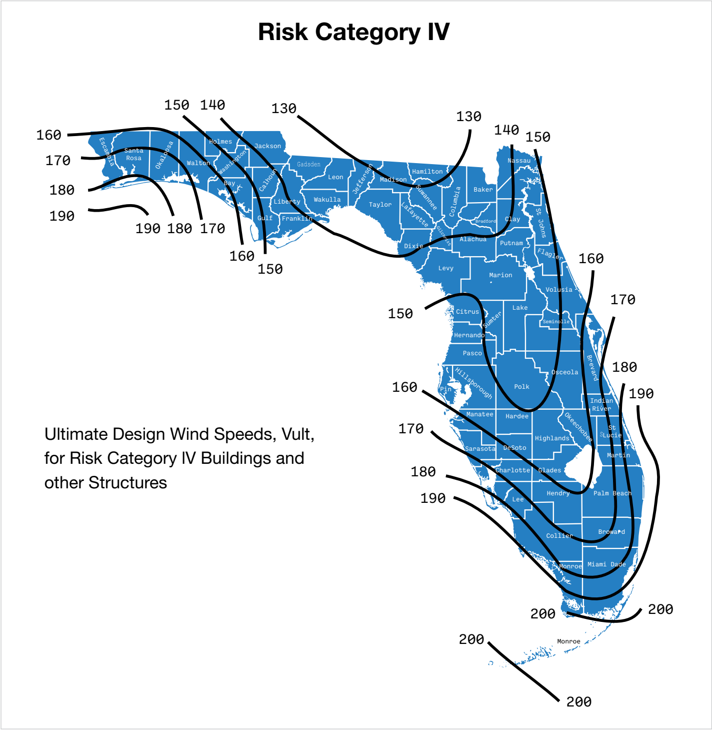


Figure 3



DESIGN METHODS

Computational methods such as wind load simulations are an acceptable way to simulate wind load on a desired structure to determine if the structure is acceptable for the region. Section 1620.2 of the FBC outlines wind velocities for structures based on their risk category in a HVHZ. Section 1620.2 also requires that buildings and structures shall be designed and constructed to meet the requirements of Chapters 26 through 31 of ASCE 7.

Once a risk category for a structure is determined, these wind velocities can be used in structural calculations and simulations to aid in designing a power systems enclosure.

See the worst-case wind loads for two counties in Florida shown in Figure 4.

Figure 4

Section 1620.2 of the Florida Building Code

1620.2

Wind velocity (3-second gust) used in structural calculations shall be as follows:

Miami-Dade County

Risk Category I Buildings and Structures: 165 mph
Risk Category II Buildings and Structures: 175 mph
Risk Category III Buildings and Structures: 186 mph
Risk Category IV Buildings and Structures: 195 mph

Broward County

Risk Category I Buildings and Structures: 156 mph
Risk Category II Buildings and Structures: 170 mph
Risk Category III Buildings and Structures: 180 mph
Risk Category IV Buildings and Structures: 185 mph

INTERNATIONAL BUILDING CODE

The International Building Code (IBC) also addresses wind load design requirements for buildings and components such as power systems enclosures. To further understand IBC requirements and design parameters for wind load, please refer to Kohler's "Understanding IBC Wind Load Requirements for Generating Systems" white paper.

RAINWATER MANAGEMENT

Infiltration from rainwater can be detrimental to a standby power system. While providing adequate air ventilation is important to prevent the power system from overheating, it is equally critical to ensure that rainwater cannot also enter through the intake ventilation of the enclosure. Therefore, the enclosure's wind-driven rain louvers are designed to prevent rainwater ingression through the power system's intake ventilation while maintaining an adequate amount of cooling air to run efficiently.

UL 2200 sets standards for ensuring the safety and functionality of standby power systems by providing test protocols and validation for a power system enclosure. This testing is used to validate that the enclosure can withstand rainwater ingression. It is important to note that this testing does not factor in wind load. The UL testing protocols and requirements for rainwater ingress for outdoor standby power systems can be found in Section 103 of UL 2200.

LOUVER DESIGNS

Kohler implements a vertical high-velocity rain louver design to meetUL 2200 high-velocity wind-driven rain and rain ingress standards. Kohler validates each enclosure to meet UL 2200 and conducts a more stringent rain test to simulate high-velocity rain considering AMCA 550 and/or AMCA 500-L standards to effectively prevent rain ingress to the enclosure while maintaining an adequate amount of airflow to the power system. Computational fluid dynamics (CFD) simulations are used to determine correct sizing and to verify that the power system has enough airflow for the engine's intake, while maintaining proper cooling performance for both the engine and alternator.

SIMULATION METHODS

Figure 5 demonstrates the airflow through a high-velocity rain louver using CFD simulation. As shown in the figure, air enters the louver at a maximum velocity of 6.5 m/s (1,250 ft/min). Air can be seen simultaneously accelerating and turning once entering the louver. The air can make the curve of the louver while the water particles cannot. These water particles are then trapped by the C-shape profile.

Figure 5

Simulation of Airflow Through a Rain Louver

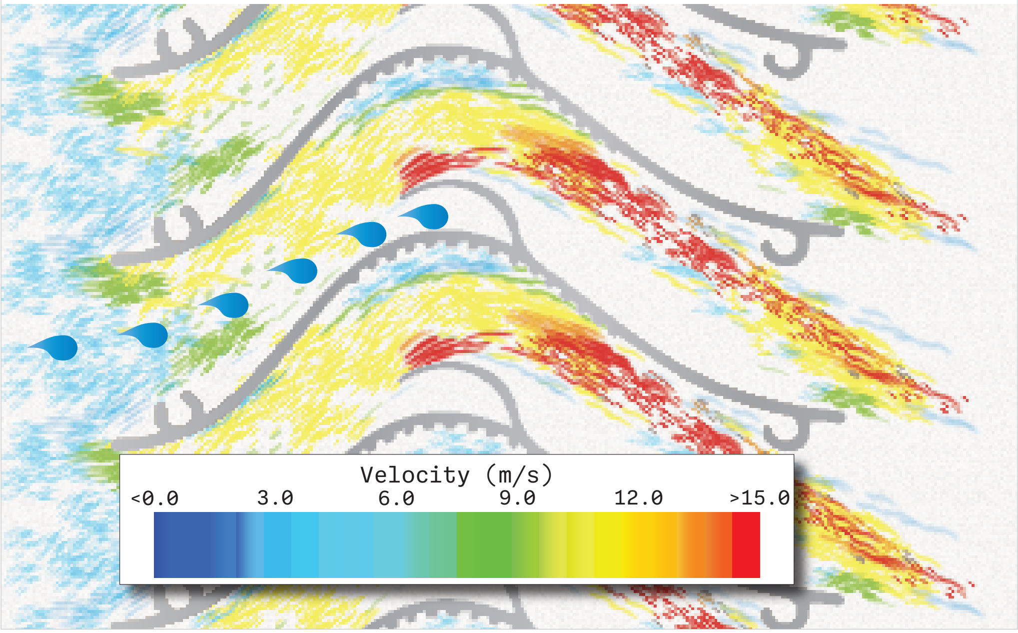
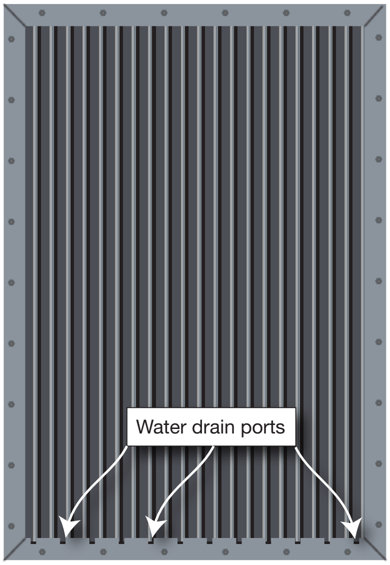


Figure 6

Rain Water Drain Port Locations



Gravity assists in draining water out the bottom of the louver through the drain ports shown in Figure 6. The airflow then can be seen accelerating and continuing through the louvers and into the power system enclosure.

It is important to note that air restriction is an important factor when sizing a rain louver and to verify that the power system receives an adequate amount of airflow to remain functional.

MISSILE IMPACT TESTING

In a state prone to hurricanes such as Florida, wind-borne debris can become extremely detrimental to all types of buildings and structures. Therefore, missile impact testing for standby power system enclosures in the state of Florida is a critical component to ensure the structural integrity and safety of the enclosure.

The Florida Building Code (FBC) identifies critical needs facilities that require critical systems, such as a standby power system. These standby power systems are required to be protected from debris impact by a housing or enclosure that complies with the impact protection standards per Section 1626 of FBC. In this section of the FBC, it outlines missile impact testing, which is to be conducted per testing protocols TAS 201 and TAS 203. This testing is intended to assess how well an enclosure can withstand the impact of wind-borne debris during a high wind hurricane event.

TESTING METHODS

Missile impact testing involves launching simulated missiles, such as wooden two-by-fours, at high speeds towards the enclosure. This test is used to assess the enclosure's ability to resist penetration and structural damage from wind-borne debris.

The following testing requirements are outlined in section 1626.2 through 1626.4 of FBC.

- This testing shall be conducted on at least three fully assembled enclosure units.
- The large missile shall be comprised of a piece of timber having nominal dimensions of two inches by four inches weighing nine pounds (4.1 kg).
- The large missile shall impact the surface of each test specimen at a speed of 50 feet per second (15.2 m/s) and 80 feet per second (24.38 m/s) for Risk Category IV (essential facility building or structures).
- Each test specimen shall receive two impacts at each specified location.

It is important to note that Risk Category IV structures, such as essential facilities buildings or structures, require missile impact testing to be completed at 80 feet per second (24.38 m/s) per 1626.2.4 of FBC. `Table 1` below from the Division of Emergency Management 2018, compares the level of protection D and E based on the difference in missile velocity 50 ft/sec (15.2 m/s) vs. 80 ft/sec (24.38 m/s) respectively.

`Table 1`

Division of Emergency Management 2018

Table K-1. Wind-Borne Debris Impact Criteria Comparisons for Vertical Surfaces

Level of Protection, Vertical Surface	Hurricane Design Wind Speed, MPH (3-sec gust)	Missile Weight, LB	Missile Velocity, MPH	Missile Velocity, FT/Sec	Energy, FT-LB	Momentum, LB-Sec
Enhanced-D[2]	68[1]	9	34	50	349	14
Enhanced-E[2]	110	9	55	80	910	22

PASS/FAIL CRITERIA

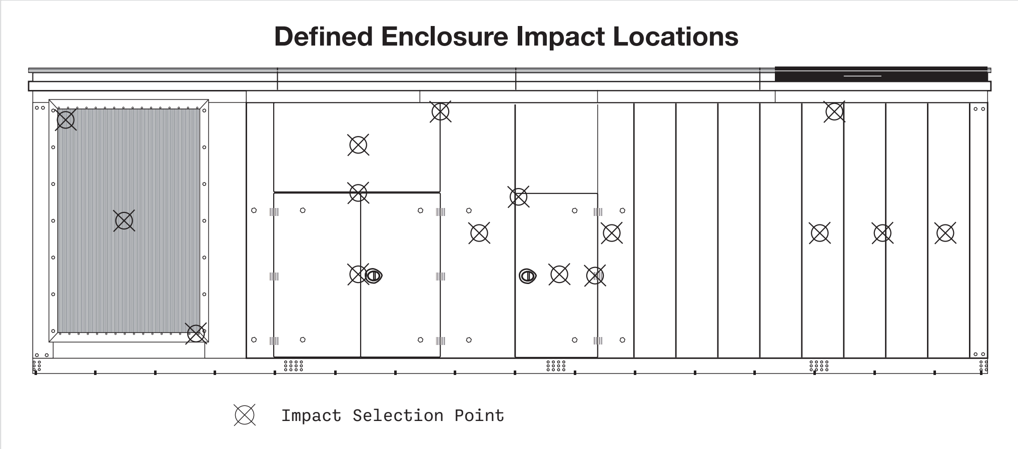
Standby power system enclosures that pass missile impact testing may receive certification indicating compliance with the FBC requirements. This certification will help building inspectors verify compliance during the permitting and inspection process. The following pass/fail criteria listed is required for an enclosure to meet the FBC certification.

- No panel or fastener disengagement (FBC 5.1.3).
- No opening larger than 3.0" in diameter.
- No projectile penetration into enclosure.
- Access doors must be functional (open and close) after impact.

CERTIFICATION BODIES

Missile impact testing must be completed by a certified testing facility and approved per FBC regulations. The locations of the impacts must be agreed upon by both the testing facility and enclosure supplier. These impact locations must be on all sides of the enclosure and outlined on a hit map like Figure 7.

Figure 7



SIMULATION METHODS

Computational simulation and analysis, such as finite element analysis (FEA), can be a critical tool in aiding in the design process of a power system enclosure. Impact simulations are used to determine potential failure points and locations prior to missile impact testing.

Having the ability to simulate impact testing allows for the opportunity to revise the enclosure design prior to build and testing. An example of the simulations used for missile impact testing can be seen in Figure 8. This figure demonstrates the accuracy of the FEA simulations and highlights potential failure points of the enclosure design.

Figure 9 demonstrates and compares impact testing simulations vs. the results seen during missile impact testing. It can be seen in the simulation in Figure 8 that the access door becomes concaved when impacted by the simulated missile. Similar results can be observed during actual missile impact testing in Figure 9 when impacted at the same location—this time with designed bracing to pass the test.

It is important to note, an enclosure cannot be certified only using impact simulations. Actual missile testing is required for an enclosure to be certified under the Florida Building Code (FCB).

Figure 8

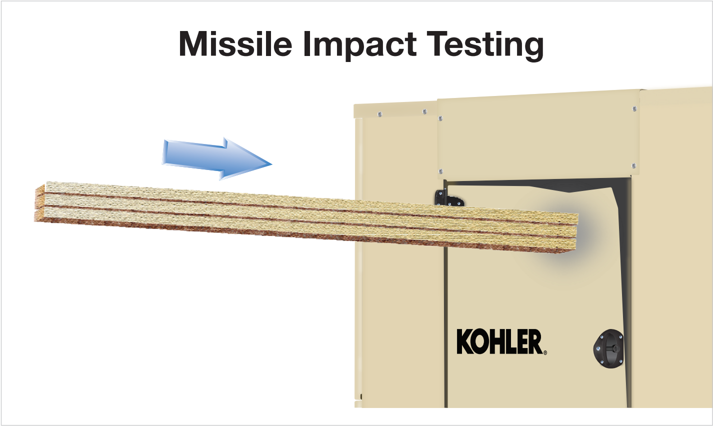


Figure 9

SUMMARY

Wind load, rain ingress, and wind-borne debris impact are critical factors when designing a power system enclosure to be used in the state of Florida.

It is important to consider and follow the regulations set forth by the FBC for a power system enclosure to be certified and compliant with state regulations. However, once the enclosure design is certified, it can be manufactured at higher volumes without further certification. In addition, it is important to follow all installation requirements set forth by the FBC to ensure the performance of the standby power system enclosure.

KOHLER ADVANTAGES

Kohler designs UL 2200-listed aluminum enclosures with 3.175 mm (.125") thick walls to handle hurricane winds and certifies those designs from the factory which means lower delivery and submittal lead times.

Many other generator manufacturers rely on third-party enclosure packagers who do not list the generator and enclosure package to UL 2200 which can lead to additional costs for field evaluation/site certification. End customer as-built drawings are immediately available for download from Kohler, including weights, dimensions, and load lead stub-up areas with no risk of a certification delay caused by a one-off enclosure design.

If you have questions about hurricane ratings or purchasing a certified generator and enclosure package, please contact a Kohler distributor near you for assistance.

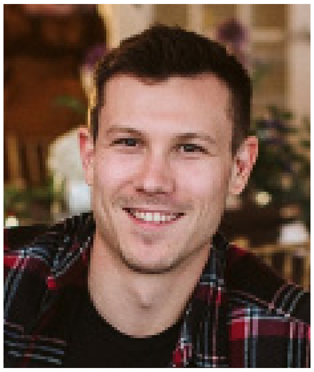
ADDITIONAL REFERENCES

FBC risk category

https://codes.iccsafe.org/s/FBC2017/chapter-16-structural-design/FBC2017-Ch16-Sec1604.5

Understanding IBC Wind Load Requirements for Power Generation Systems:

https://kohlerpower.com/en/generators/industrial/brochures-literature



ABOUT THE AUTHOR

Jacob Vanderloop is a Senior Design Project Engineer with Kohler Co. He holds a bachelor of science degree in mechanical engineering from UW-Platteville. Jacob joined Kohler in 2022 as part of the Industrial Solutions Engineering Team.

ABOUT KOHLER ENERGY

Kohler Energy, a global leader in energy resilience solutions, brings bold design and powerful impact to the energy systems that sustain people and communities everywhere around the world. It is an integral part of Kohler Co., with solutions across home energy, industrial energy systems, and powertrain technologies. With more than a century of industry leadership, Kohler Energy leverages the strength of its portfolio of businesses—Power Systems, Kohler Generators, Kohler Uninterruptible Power, Clarke Energy, Heila Technologies, Curtis Instruments, and Kohler Engines.

Kohler Energy builds resilience and goes beyond functional, individual recovery to create better lives and communities. For more details, please visit KohlerEnergy.com.

For more information, contact your Kohler source of supply or call toll-free in the U.S. and Canada 800-544-2444.

KohlerEnergy.com

KOHLER®

PRINTED IN U.S.A. WF528081 G26-53 KPS 142 12/23