

Unit Reactions from Wind Explained*

*NOTE: The following explanations are not to be considered as signed and sealed engineering. No certifications are offered or implied herein. The following explanations may not be applicable to all scenarios. Results shall be verified by a registered Professional Engineer. Contact this office for assistance with your evaluation needs.

Introduction

This article is intended for use in tandem with the "Unit Reactions from Wind" guide included in Technical Evaluation Reports (TER's). To request a quote for a mechanical equipment evaluation or to view TER's available for purchase, see here: <https://www.engineeringexpress.com/mechanical-equipment/>

For more information about TER's in general, see here: <https://www.engineeringexpress.com/wiki-search/?search=ter>

For mechanical equipment, the unit reactions (including gravity, lateral, uplift, and tension forces) may be derived by using the "Unit Reactions from Wind" guide explained below. This guide is intended for use by the Engineer of Record or other design professional in designing host structures for mechanical equipment.

Is your host structure a concrete pad? If so, see if these ready-made design aid calculators suit your application:

<https://www.engineeringexpress.com/product/diversitech-concrete-pad-selector/>

<https://www.engineeringexpress.com/product/solid-concrete-equipment-pad-uplift-calculator/>

Is your host structure a Miami Tech aluminum roof stand? If so, see if these ready-made design aid calculators suit your application:

<https://www.engineeringexpress.com/product/miami-tech-ast-standard-duty-design-tool/>

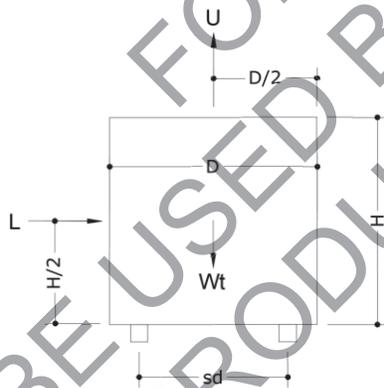
<https://www.engineeringexpress.com/product/miami-tech-as14-heavy-duty-stand-design-tool/>

For designing other host structures for mechanical equipment, see the guide explanation and examples as follows:

Guide Explanation

UNIT REACTIONS FROM WIND GUIDE

This guide is intended for use by a qualified design professional. Design parameters shall abide all specifications and limitations stated in the respective product evaluation. The design professional shall consider all forces, including seismic and snow loads, per governing building code. Unit reactions obtained from this guide shall be verified by a registered Professional Engineer. Sample calculations are provided below.



Design Parameters:

- Lateral Wind Pressure, P_{lat}
- Unit Height, H
- Unit Width, W
- Support Spacing across Depth, sd
- Uplift Wind Pressure, P_{up}
- Unit Depth, D
- Unit Weight, Wt
- Support Spacing across Width, sw

Unit Reaction Equations:

Long Side (Width x Height):

- Sliding Force, $L = P_{lat} \times W \times H$
- Uplift Force, $U = P_{up} \times W \times D$
- Total Tension per Long Side = $(L \times H/2 + U \times sd/2 - Wt \times 0.6 \times sd/2) / sd$

Short Side (Depth x Height):

- Sliding Force, $L = P_{lat} \times D \times H$
- Uplift Force, $U = P_{up} \times W \times D$
- Total Tension per Short Side = $(L \times H/2 + U \times sw/2 - Wt \times 0.6 \times sw/2) / sw$

Guide Directive, Explained:

This guide serves to provide the worst-case reactions that a mechanical unit experiences in response to wind loading from a direction of interest. For more explanation on the methodology and design assumptions employed, please see the following information.

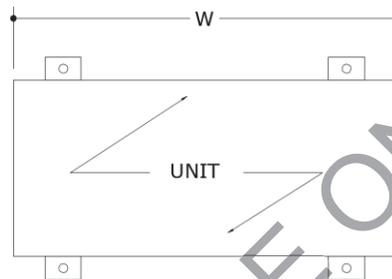
Design Parameters, Explained:

- Lateral and Uplift wind pressures, P_{lat} and P_{up} , shall be calculated by a qualified design professional in accordance with the applicable codes and standards. Contact this office for an evaluation to determine the wind pressures specific to the unit in question. For more information on calculating wind pressures, see here: <https://www.engineeringexpress.com/wiki/wind-speed-vs-wind-pressure-explained/>

- Unit dimensions (height H , width W , depth D , and unit net weight Wt) are values obtained either through measurement of the unit in question or via manufacturer-listed specifications. To ensure worst-case reactions are obtained, it is suggested to use the greatest height, width, and depth dimensions and lightest unit net weight possible for each unit. Width is defined as the longest horizontal unit dimension and depth as the shortest horizontal unit dimension.

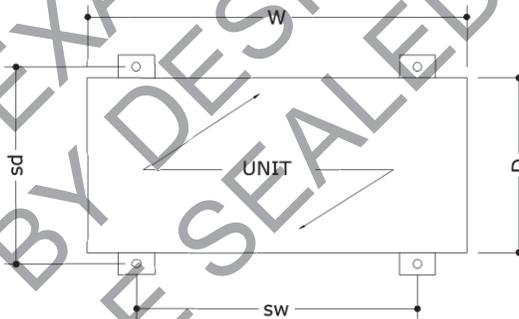
- Support spacing is dependent on the unit anchoring system and host structure configuration employed. Let's take a look at a few examples:

○ **Example 1: Anchors on Long Sides (width x height) only**

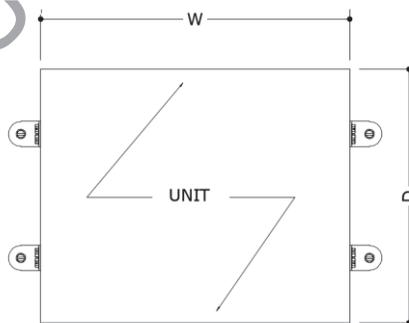


The above unit configuration is typical for Mini-Split units. The typical anchoring points are the four circled locations above. These can be unit integrated feet or tie-down clips. What would the support spacing across the unit width and depth be?

Answer:

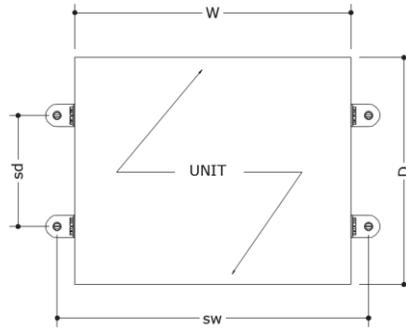


○ **Example 2: Anchors on Short Sides (depth x height) only**

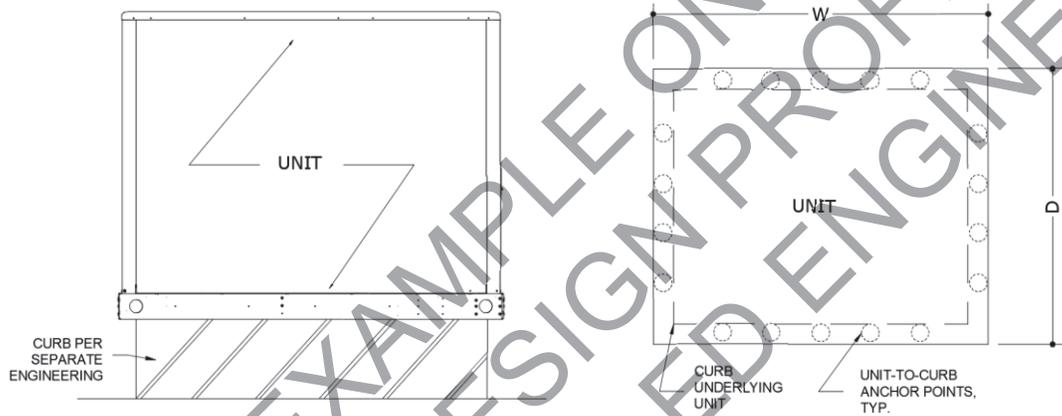


The above unit configuration is less common. It may occur if there are spatial limitations or other constraints when installed in the field. What would the support spacing across the unit width and depth be?

Answer:

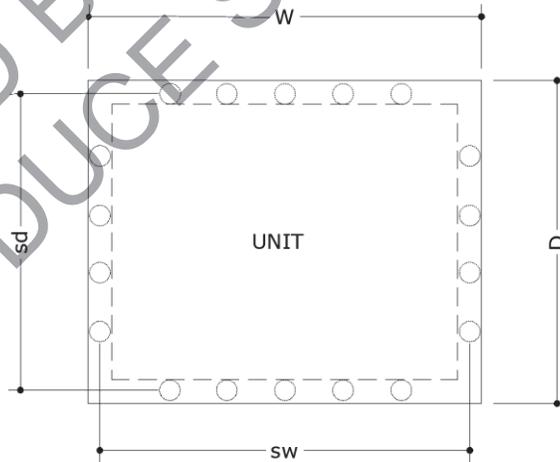


- **Example 3: Unit mounted to curb (Anchors on all sides)**



When curbs are employed, the anchor attachment typically involves using thru-bolts to attach the unit base to the curb. Attachment points are circled on the above right diagram. What would the support spacing across the unit width and depth be?

Answer:



Does your mechanical unit have a tie-down configuration different than the examples given? Contact this office for a consultation or evaluation.

Unit Reaction Equations, Explained:

- The worst-case lateral (sliding, or shear) force is taken as the total wind force acting on the projected area of the unit side of interest. Porosity from louvers, fans, or other apertures is not considered. Frictional effects are not considered. This lateral force is equivalent to the sliding, or shear force the unit experiences.

- The worst-case uplift force is taken as total wind force acting on the projected area of the unit top/roof. Porosity from louvers, fans, or other apertures is not considered.

- The worst-case gravity force is taken as the unit net weight, W_t , multiplied by 0.6.

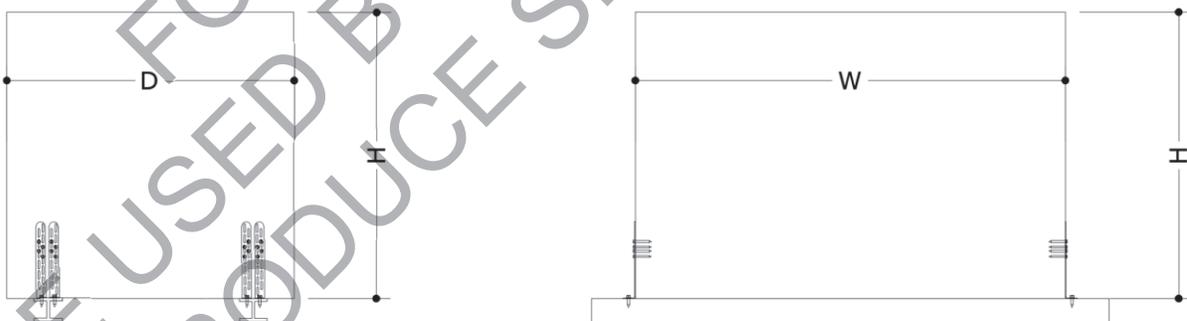
- The 0.6 reduction factor comes from Florida Building Code 7th Ed., Section 1605.3: Load combinations using allowable stress design (ASD). The governing load combination is Equation 16-15: $0.6D + 0.6W + H$. For the purposes of this guide:
 - D = dead load = unit net weight, W_t .
 - W = wind pressure. The 0.6 reduction factor is assumed to already have been accounted for so long as the lateral and uplift wind pressures were calculated in accordance with allowable stress design methodology.
 - H = Load due to lateral earth pressures, ground water pressure, or pressure of bulk materials, is assumed to be zero.
 - All other factors (flood loads, rain loads, snow loads, etc.) are assumed to be zero.
- The tightening of tie-down cables or straps may increase the downward force the unit experiences. However, because higher downward force results in less tension / shear and may vary in the field, this office chooses to ignore this supplemental downward force. If you are designing the supporting host structure where gravity forces are a potential failure mode, the supplemental downward force from tie-down cables or straps should be considered.

- The worst-case tension force is derived from a sum of moments, in which the pivot point is the support opposite from the unit face receiving the lateral wind load, divided by the support spacing perpendicular to the face area receiving the lateral wind load. (see examples A and B below).

- The gravity force is concentrated into a point load acting on the center of mass, which is treated as equal to the unit centroid. The unit centroid is considered as the geometric center of the unit (half of the height and half of the depth/width).
- The uplift force is concentrated into a point load acting on the unit centroid.
- The lateral (sliding, or shear) force is concentrated into a point load acting on the unit centroid.

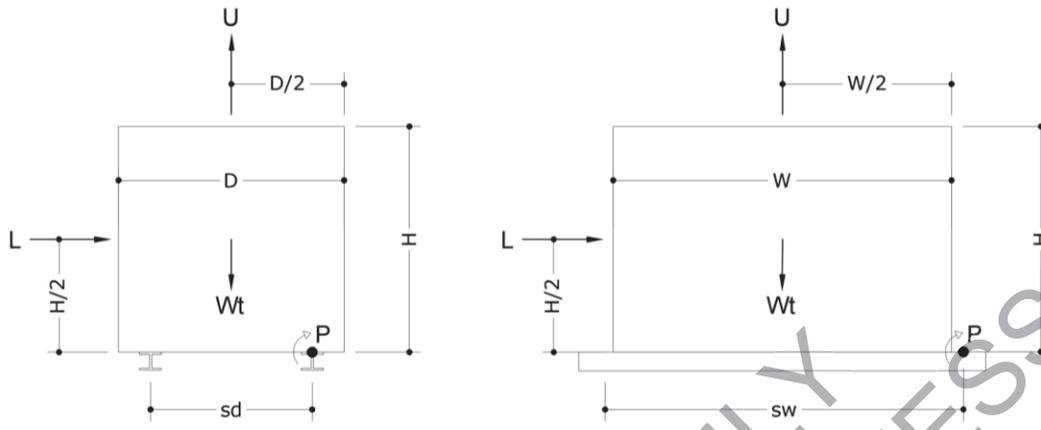
Unit Reactions Examples:

Example A: A (4' W x 2' D x 3' H), 300 lb net weight mechanical unit is tied down to roof stand rails by using (4) tie-down clips per side, (2) per rail, = (8) total. The ASD wind pressures are 100 psf lateral and 79 psf uplift. Roof stand rails are spaced 20" apart. Tie-down clip anchors are placed on-center on the 2" square tie-down clip leg. There is 1" spacing between neighboring tie-down clips. Side views are shown below. What are the reactions for this unit?



~ See Next Page for Example A Answer ~

Answer:



Example A: Design Parameters:

Lateral Wind Pressure, $P_{lat} = 100$ psf
 Unit Height, $H = 36$ in
 Unit Width, $W = 48$ in
 Support Spacing across Depth,
 $sd = (\text{Roof Stand Rail Spacing}) = 20$ in

Uplift Wind Pressure, $P_{up} = 79$ psf
 Unit Depth, $D = 24$ in
 Unit Weight, $Wt = 300.0$ lb
 Support Spacing across Width,
 $sw = 50$ in

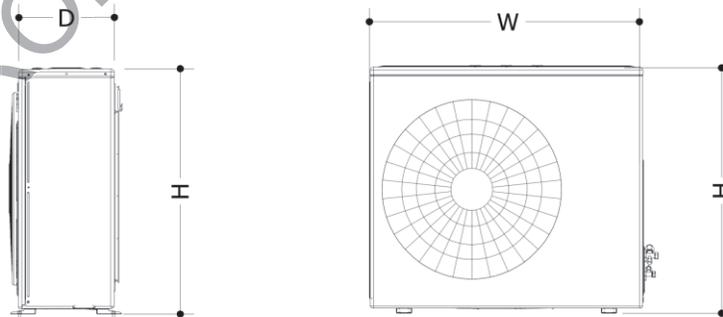
Example A1: Unit Reactions, Long Side (Width x Height)

1. Sliding Force, $L = P_{lat} \times W \times H$
 $= 1200$ lb
2. Uplift Force, $U = P_{up} \times W \times D$
 $= 632$ lb
3. Total Tension per Long Side = $(L \times H/2 + U \times sd/2 - Wt \times 0.6 \times sd/2) / sd$
 $= 1306$ lb

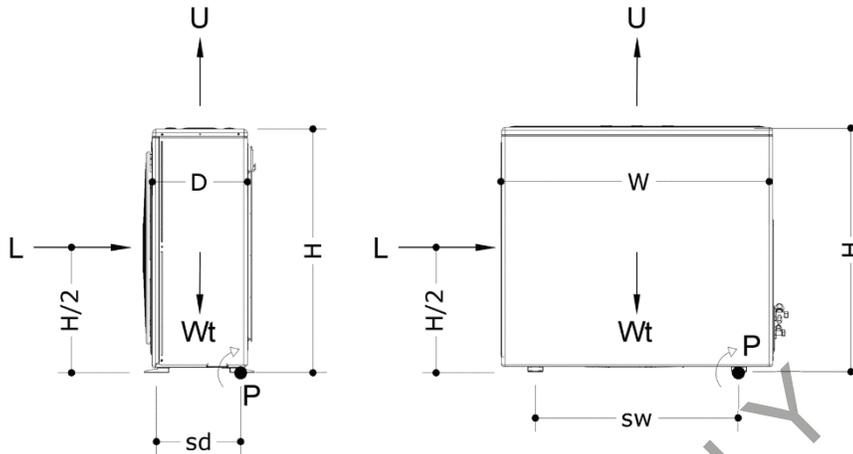
Example A2: Unit Reactions, Short Side (Depth x Height)

1. Sliding Force, $L = P_{lat} \times D \times H$
 $= 600$ lb
2. Uplift Force, $U = P_{up} \times D \times W$
 $= 632$ lb
3. Total Tension per Short Side = $(L \times H/2 + U \times sw/2 - Wt \times 0.6 \times sw/2) / sw$
 $= 442$ lb

Example B: A (22" W x 12" D x 31" H), 67 lb net weight mechanical unit is tied down to roof stand rails by using the (4) unit integrated feet, (1) anchor per foot. The mounting hole locations on the unit integrated feet have 18" spacing across width and 13" across depth. The ASD wind pressures are 60 psf lateral and 48 psf uplift. Side views are shown below. What are the reactions for this unit?



Answer:



Example B: Design Parameters:

Lateral Wind Pressure, $P_{lat} = 60$ psf
 Unit Height, $H = 31$ in
 Unit Width, $W = 22$ in
 Support Spacing across Depth, $sd = 13$ in

Uplift Wind Pressure, $P_{up} = 48$ psf
 Unit Depth, $D = 12$ in
 Unit Weight, $Wt = 67.0$ lb
 Support Spacing across Width, $sw = 18$ in

Example B1: Unit Reactions, Long Side (Width x Height)

1. Sliding Force, $L = P_{lat} \times W \times H$
 $= 284$ lb
2. Uplift Force, $U = P_{up} \times W \times D$
 $= 88$ lb
3. Total Tension per Long Side = $(L \times H/2 + U \times sd/2 - Wt \times 0.6 \times sd/2) / sd$
 $= 363$ lb

Example B2: Unit Reactions, Short Side (Depth x Height)

1. Sliding Force, $L = P_{lat} \times D \times H$
 $= 155$ lb
2. Uplift Force, $U = P_{up} \times D \times W$
 $= 88$ lb
3. Total Tension per Short Side = $(L \times H/2 + U \times sw/2 - Wt \times 0.6 \times sw/2) / sw$
 $= 157$ lb