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Reference: **Product Certification Statement**
Rooftop Mounted Mechanical Equipment
Westinghouse Outdoor HVAC Unit (Group 4)
Model Nos.: **WHS30SZA21S; WHS36SZA21S**
WHP24SZA21S

Based on the manufacturers cut sheets for the referenced rooftop equipment, I have performed a wind load analysis to determine compliance with wind load criteria set forth by 2017 Florida Building Code Mechanical Section 301.15, Florida Building Code Building Chapter 16 and ASCE 7-10. Analysis results demonstrate that the equipment without retrofit is structurally adequate to withstand wind loads at the specified mounting heights for Exposure Categories identified in Table 1. This wind certification includes anchorage of equipment with 5/16" diameter anchors at the four base mount locations. Anchor material strength shall meet or exceed ASTM A307 requirements. Specifications for anchor attachment to host structure and certification for structural adequacy of host support structure is not included and is to be determined by others. For analysis results, refer to Summary of Results at the end of the structures report associated with this certification.

TABLE 1

Design Wind Speed	Max Mounting Height Above Natural Grade (ft)		Kz
	Exposure C	Exposure D	
120	500	500	2.79
130	500	500	2.37
140	500	500	2.05
150	500	350	1.78
160	275	175	1.57
170	160	85	1.39
175	120	60	1.31
180	90	45	1.24
186	65	30	1.16
190	55	22	1.11
200	35	Ground Mount Only	1.00

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8/17/2020

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WIND LOAD ANALYSIS AND STRUCTURAL CALCULATIONS

FOR

WIND CERTIFICATION

OF

ROOFTOP MECHANICAL EQUIPMENT

WESTINGHOUSE OUTDOOR HVAC UNIT (GROUP 4)

MODEL NOS:
WHS30SZA21S; WHS36SZA21S
WHP24SZA21S

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AUGUST 2020

Wind Load Analysis for Rooftop Mounted Equipment
Equipment:
Westinghouse 2.0 - 3.0 Ton Chassis
Model Nos: WHS30SZA21S; WHS36SZA21S WHP24SZA21S

Approximate Weight of Unit (wt_{unit}): $wt_{unit} := 128 \cdot lbf$

Length of Unit (L_e): $L_e := 34.8 \cdot in$

Width of Unit (W_e): $W_e := 14.4 \cdot in$

Height of Unit (H_e): $H_e := 31.3 \cdot in$

Mount Hole spacing Along Length (MH_L): $MH_L := 26.1 \cdot in$

Mount Hole spacing Along Width (MH_W): $MH_W := 15.4 \cdot in$

Corner Weight at Point A (Rdl_A): $Rdl_A := \frac{wt_{unit}}{4}$ $Rdl_A = 32 \cdot lbf$

Corner Weight at Point B (Rdl_B): $Rdl_B := \frac{wt_{unit}}{4}$ $Rdl_B = 32 \cdot lbf$

Corner Weight at Point C (Rdl_C): $Rdl_C := \frac{wt_{unit}}{4}$ $Rdl_C = 32 \cdot lbf$

Corner Weight at Point D (Rdl_D): $Rdl_D := \frac{wt_{unit}}{4}$ $Rdl_D = 32 \cdot lbf$

Material Data:

Ultimate Tensile Strength of Cold Formed Sheet Metal Casing in Contact with Screw Head ($Fu1_{cas}$): $Fu1_{case} := 45 \cdot ksi$

Ultimate Tensile Strength of Cold Formed Sheet Metal Casing Not in Contact with Screw Head ($Fu2_{cas}$): $Fu2_{case} := 45 \cdot ksi$

Ultimate Strength of Metal Fasteners (Fu_{fas}): $Fu_{fas} := 50 \cdot ksi$

Yield Strength of Metal Casing (Fy) $F_y := 30 \cdot ksi$

Calculate Wind Load (Per ASCE 7-10)

Building Risk Category (B_{Risk}): $Bldg_{Risk} := \text{"IV"}$

Design Wind Speed (V): $V := 186$ mph

Mounting Height above Grade (H): $H := 30 \cdot ft$

$ExpCat := \text{"D"}$

Velocity pressure exposure coefficient at height from ground to Centroid of Equipment (K_z): $K_z := 1.16$

Topographic Factor (K_{zt}): $K_{zt} := 1.0$

Directionality Factor From Table 6-4 (Similar Structures) (K_d): $K_d := 0.90$

Ultimate Design Velocity Pressure Evaluated at height z of the Centroid of the Effective Area (q_{zULT}):

$q_{zULT} := 0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2 \cdot psf$ $\quad q_{zULT} = 92.5 \cdot psf$

Allowable Design Velocity Pressure Evaluated at height z of the Centroid of the Effective Area (q_z):

$q_z := q_{zULT} \cdot 0.6$ $\quad q_z = 55.5 \cdot psf$

Lateral Pressure Coefficent $\quad GCf_{lat} := 1.9$

Uplift Pressure Coefficent $\quad GCf_{upl} := 1.5$

Lateral Wind Pressure (p_{lat}): $p_{lat} := q_z \cdot GCf_{lat}$ $\quad p_{lat} = 105.4 \cdot psf$

Uplift Wind Pressure (p_{upl}): $p_{upl} := q_z \cdot GCf_{upl}$ $\quad p_{upl} = 83.2 \cdot psf$

Projected Area Normal to Wind (A_n): $A_n := L_e \cdot H_e$ $\quad A_n = 7.6 \cdot ft^2$

Projected Area Parallel to Wind (A_p): $A_p := L_e \cdot W_e$ $\quad A_p = 3.5 \cdot ft^2$

Calculate the Wind Load Reactions at Unit to Curb (Refer to Figure I)

$F_h := p_{lat} \cdot A_n$ $F_h = 0.8 \cdot kip$

$F_{up} := p_{upl} \cdot A_p$ $F_{up} = 0.3 \cdot kip$

$Rwl_A := \frac{F_h \cdot \frac{H_e}{2}}{2 \cdot MH_W} - \frac{F_{up}}{4}$ $Rwl_A = 0.3 \cdot kip$ **(Downward)**

$Rwl_B := \frac{F_h \cdot \frac{H_e}{2}}{2 \cdot MH_W} - \frac{F_{up}}{4}$ $Rwl_B = 0.3 \cdot kip$ **(Downward)**

$Rwl_C := \frac{F_h \cdot \frac{H_e}{2}}{2 \cdot MH_W} + \frac{F_{up}}{4}$ $Rwl_C = 0.5 \cdot kip$ **(Upward)**

$Rwl_D := \frac{F_h \cdot \frac{H_e}{2}}{2 \cdot MH_W} + \frac{F_{up}}{4}$ $Rwl_D = 0.5 \cdot kip$ **(Upward)**

Calculate Combined Reactions at each Anchorage Location (Dead + Wind x FSstab):

Vertical Reactions:

$Rtot_A := Rdl_A + Rwl_A$ $Rtot_A = 0.4 \cdot kip$

$Rtot_B := Rdl_B + Rwl_B$ $Rtot_B = 0.4 \cdot kip$

$Rtot_C := Rdl_C - Rwl_C$ $Rtot_C = -0.4 \cdot kip$

$Rtot_D := Rdl_D - Rwl_D$ $Rtot_D = -0.4 \cdot kip$

Horizontal Reactions:

$R_{hor} := \frac{F_h}{4}$ $R_{hor} = 0.2 \cdot kip$

Therefore, with the assumption of 4 anchor points (1 at each corner of the unit); each anchorage to curb and corresponding building support components must be designed to withstand the Uplift Reaction of $Rtot_C = -0.4 \cdot kip$ and a Horizontal Shear Reaction of $R_{hor} = 0.2 \cdot kip$.

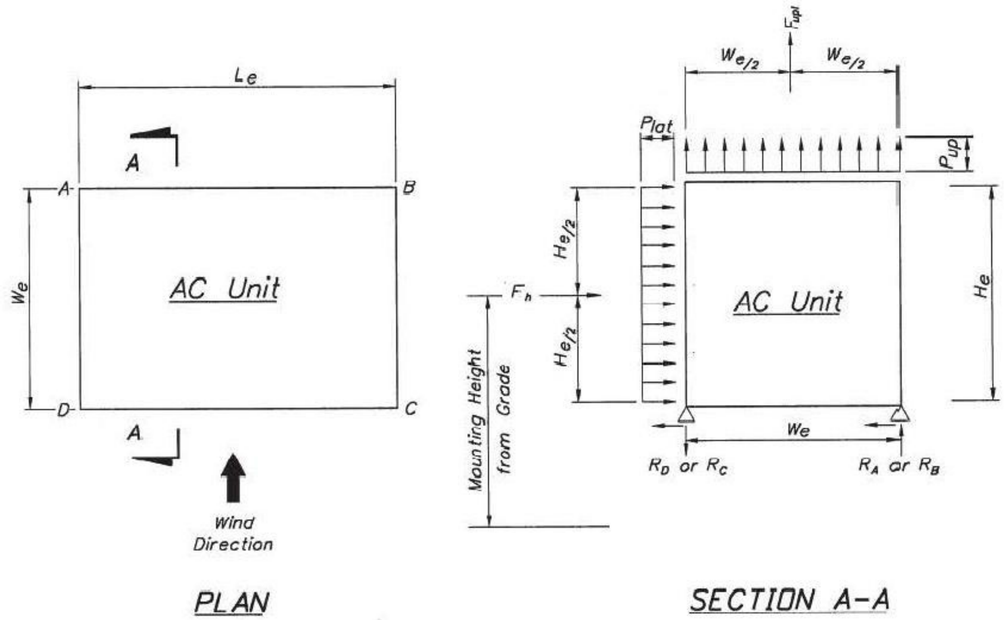
Le
A
A
B
We
AC Unit
D
C
A
Wind
Direction
PLAN
F_{upl}
We/2
We/2
Plat
Pup
He/2
He/2
Fh
Mounting Height
from Grade
AC Unit
He
We
R_D or R_C
R_A or R_B
SECTION A-A

FIGURE I

Calculate No. of Fasteners Req'd for Panel No. 1

Attachment Data:

Nominal Screw Diameter (Φ_{screw}): $\phi_{screw} := 0.157 \cdot in$

Thread Series, threads per in (unc): $unc := 14$

Affective Shear Stress Area of Screw (A_v):

$$A_v := \frac{\pi}{4} \cdot \left(\frac{\phi_{screw}}{in} - \frac{1.2269}{unc} \right)^2 \cdot in^2 \qquad A_v = 0.0038 \cdot in^2$$

Thickness of Metal Casing in Contact with Screw Head (t1): $t1 := 0.0276 \cdot in$

Thickness of Metal Casing Not in Contact with Screw Head (t2): $t2 := 0.0276 \cdot in$

Casing Thickness Ratio (rc): $rc := \frac{t2}{t1}$ $rc = 1$

Panel Length (L_{pan}): $L_{pan} := L_e = 34.8 \cdot in$

Panel Width (W_{pan}): $W_{pan} := W_e = 14.4 \cdot in$

Calculate Nominal Shear per Fastener Based on Bearing for rc <= 1.0 (Pns_{case}):

$$Pns1 := 4.2 \cdot \sqrt{t1^3 \cdot \phi_{screw}} \cdot Fu1_{case} \qquad Pns1 = 0.343 \cdot kip$$

$$Pns2 := 2.7 \cdot t1 \cdot \phi_{screw} \cdot Fu1_{case} \qquad Pns2 = 0.526 \cdot kip$$

$$Pns3 := 2.7 \cdot t2 \cdot \phi_{screw} \cdot Fu2_{case} \qquad Pns2 = 0.526 \cdot kip$$

$$Pns_{case} := if(Pns1 \le Pns2, if(Pns1 \le Pns3, Pns1, Pns3), if(Pns2 \le Pns3, Pns2, Pns3))$$

$$Pns_{case} = 0.343 \cdot kip$$

Calculate Nominal Shear per Fastener Based on Shear Capacity of Screw (Pns_{screw}):

$$Pns_{screw} := Fu_{fas} \cdot A_v \qquad Pns_{screw} = 0.189 \cdot kip$$

Calculate Allowable Shear per Fastener (Pas):

$$\Omega_{brg} := 3.0 \qquad Pas1 := \frac{Pns_{case}}{\Omega_{brg}} \qquad Pas1 = 0.114 \cdot kip$$

$$\Omega_{screw} := \frac{\sqrt{3}}{0.40} \qquad Pas2 := \frac{Pns_{screw}}{\Omega_{screw}} \qquad Pas2 = 0.044 \cdot kip$$

$$Pas := if(Pas1 \le Pas2, Pas1, Pas2) \qquad Pas = 0.044 \cdot kip$$

Calculate Total Uplift on Panel (F_{upl}):

$$F_{upl} := p_{upl} \cdot L_{pan} \cdot W_{pan} \qquad F_{upl} = 0.3 \cdot kip$$

Calculate Total No. of Screws Required (No_{screws}):

$$No_{screws1} := ceil\left(\frac{F_{upl}}{Pas}\right) \qquad No_{screws1} = 7$$

Calculate No. of Fasteners Req'd for Panel No. 2

Attachment Data:

Nominal Screw Diameter (Φ_{screw}): $\phi_{screw} := 0.157 \cdot in$

Dia of Hex Head: $\phi_{head} := 0.32 \cdot in$

Thread Series, threads per in (unc): $unc := 14$

Affective Tensile Stress Area of Screw (A_t):

$$A_t := \frac{\pi}{4} \cdot \left(\frac{\phi_{screw}}{in} - \frac{0.9743}{unc} \right)^2 \cdot in^2 \qquad A_t = 0.006 \cdot in^2$$

Thickness of Metal Casing in Contact with Screw Head (t1): $t1 := 0.0276 \cdot in$

Thickness of Metal Casing Not in Contact with Screw Head (t2): $t2 := 0.0276 \cdot in$

Casing Thickness Ratio (rc): $rc := \frac{t2}{t1}$ $\qquad rc = 1$

Panel Length (L_{pan}): $L_{pan} := H_e = 31.3 \cdot in$

Panel Width (W_{pan}): $W_{pan} := W_e = 14.4 \cdot in$

Calculate Nominal Tension or Pullout per Fastener Based on Bearing (Pnt_{case}):

$Pnt1 := 0.85 \cdot t2 \cdot \phi_{screw} \cdot Fu2_{case}$ $\qquad Pnt1 = 0.166 \cdot kip$

$Pnt2 := 1.5 \cdot t1 \cdot \phi_{head} \cdot Fu1_{case}$ $\qquad Pnt2 = 0.596 \cdot kip$

$Pnt_{case} := if(Pnt1 \le Pnt2, Pnt1, Pnt2)$ $\qquad Pnt_{case} = 0.166 \cdot kip$

Calculate Nominal Tensile or Pullout per Fastener Based on Tensile Capacity of Screw (Pnt_{screw}):

$Pnt_{screw} := Fu_{fas} \cdot A_t$ $\qquad Pnt_{screw} = 0.300 \cdot kip$

Calculate Allowable Pullout per Fastener (Pat):

$\Omega_{brg} := 3.0$ $\qquad Pat1 := \frac{Pnt_{case}}{\Omega_{brg}}$ $\qquad Pat1 = 0.055 \cdot kip$

$\Omega_{screw} := \frac{1}{0.40}$ $\qquad Pat2 := \frac{Pnt_{screw}}{\Omega_{screw}}$ $\qquad Pat2 = 0.120 \cdot kip$

$Pat := if(Pat1 \le Pat2, Pat1, Pat2)$ $\qquad Pat = 0.055 \cdot kip$

Calculate Total Horizontal Force on Panel (F_{horiz}):

$F_{horiz} := p_{lat} \cdot L_{pan} \cdot W_{pan}$ $\qquad F_{horiz} = 0.330 \cdot kip$

Calculate Total No. of Screws Required (No_{screws}):

$No_{screws2} := ceil\left(\frac{F_{horiz}}{Pat}\right)$ $\qquad No_{screws2} = 6$

Calculate No. of Fasteners Req'd for Panel No. 3

Attachment Data:

Nominal Screw Diameter (Φ_{screw}): $\phi_{screw} := 0.157 \cdot in$

Dia of Hex Head: $\phi_{head} := 0.32 \cdot in$

Thread Series, threads per in (unc): $unc := 14$

Affective Tensile Stress Area of Screw (A_t):

$$A_t := \frac{\pi}{4} \cdot \left(\frac{\phi_{screw}}{in} - \frac{0.9743}{unc} \right)^2 \cdot in^2 \qquad A_t = 0.006 \cdot in^2$$

Thickness of Metal Casing in Contact with Screw Head (t1): $t1 := 0.0276 \cdot in$

Thickness of Metal Casing Not in Contact with Screw Head (t2): $t2 := 0.0276 \cdot in$

Casing Thickness Ratio (rc): $rc := \frac{t2}{t1}$ $\qquad rc = 1$

Panel Length (L_{pan}): $L_{pan} := L_e = 34.8 \cdot in$

Panel Width (W_{pan}): $W_{pan} := H_e = 31.3 \cdot in$

Calculate Nominal Tension or Pullout per Fastener Based on Bearing (Pnt_{case}):

$Pnt1 := 0.85 \cdot t2 \cdot \phi_{screw} \cdot Fu2_{case}$ $\qquad Pnt1 = 0.166 \cdot kip$

$Pnt2 := 1.5 \cdot t1 \cdot \phi_{head} \cdot Fu1_{case}$ $\qquad Pnt2 = 0.596 \cdot kip$

$Pnt_{case} := if(Pnt1 \le Pnt2, Pnt1, Pnt2)$ $\qquad Pnt_{case} = 0.166 \cdot kip$

Calculate Nominal Tensile or Pullout per Fastener Based on Tensile Capacity of Screw (Pnt_{screw}):

$Pnt_{screw} := Fu_{fas} \cdot A_t$ $\qquad Pnt_{screw} = 0.300 \cdot kip$

Calculate Allowable Pullout per Fastener (Pat):

$\Omega_{brg} := 3.0$ $\qquad Pat1 := \frac{Pnt_{case}}{\Omega_{brg}}$ $\qquad Pat1 = 0.055 \cdot kip$

$\Omega_{screw} := \frac{1}{0.40}$ $\qquad Pat2 := \frac{Pnt_{screw}}{\Omega_{screw}}$ $\qquad Pat2 = 0.120 \cdot kip$

$Pat := if(Pat1 \le Pat2, Pat1, Pat2)$ $\qquad Pat = 0.055 \cdot kip$

Calculate Total Horizontal Force on Panel (F_{horiz}):

$\%open := 50\%$

$F_{horiz} := p_{lat} \cdot L_{pan} \cdot W_{pan} \cdot (1 - \%open)$ $\qquad F_{horiz} = 0.399 \cdot kip$

Calculate Total No. of Screws Required (No_{screws}):

$$No_{screws3} := ceil\left(\frac{F_{horiz}}{Pat} \right) \qquad No_{screws3} = 8$$

Check Adequacy of Base Plate and Anchorage Hardware

Attachment Data:

Nominal Bolt Diameter (Φ_{bolt}): $\phi_{bolt} := 0.3125 \cdot in$

Affective Bolt Area (A_{eff}):

$$A_{eff} := \frac{\pi}{4} \cdot \left(\frac{\phi_{bolt}}{in}\right)^2 \cdot in^2 \qquad A_{eff} = 0.077 \cdot in^2$$

BoltMaterial := "ASTM A307 or Greater"

Allowable Tensile Strength (F_t): $F_t := 20 \cdot ksi$

Allowable Shear Strength (F_v): $F_v := 9.9 \cdot ksi$

Bolt Shear Capacity (V_{all}): $V_{all} := A_{eff} \cdot F_v = 0.8 \cdot kip$

Bolt Tension Capacity (T_{all}): $T_{all} := A_{eff} \cdot F_t = 1.5 \cdot kip$

Check Bolt Adequacy with Wind Perpendicular to Long Side

Number of Bolts Provided to resist Tension ($NoBolts_{provdtens}$): $NoBolts_{provtens} := 2$

$$t_{bolt} := \frac{\left|2Rtot_C\right|}{NoBolts_{provtens}} \qquad t_{bolt} = 0.4 \cdot kip$$

Number of Bolts Provided to resist Shear ($NoBolts_{provdshear}$): $NoBolts_{provshear} := 4$

$$v_{bolt} := \frac{2 \cdot R_{hor}}{NoBolts_{provshear}} \qquad v_{bolt} = 0.1 \cdot kip$$

$$CSR_{bolt} := \frac{t_{bolt}}{T_{all}} + \frac{v_{bolt}}{V_{all}} \qquad CSR_{bolt} = 0.422$$

$Check_{bolt} := if\left(CSR_{bolt} \le 1.0, \text{"OK"}, \text{"NG"}\right)$ $\qquad Check_{bolt} = \text{"OK"}$

Check Base Plate

Width of Base Plate: $b_{bp} := 2.0 \cdot in$

Thickness of Base Plate: $t_{bp} := 0.047 \cdot in$

Moment Arm: $arm := 1.5in$

Calculate Effective Section Properties of Base Plate (Unit - Inches)														
b	t	hflange	I1	I2	d1	d2	A1	A2	ybar	y1	y2	Itotal	Stotal	Atotal
2	0.047	0.66	1.73E-05	0.000902	0.6365	0.3065	0.094	0.0288	0.631	0.029	0.631	0.042611	0.06753	0.122811

Area: $Ax := 0.128811 \cdot in^2$

Section Modulus: $Sx := 0.06753 \cdot in^3$

Bending Stress: $f_b := \frac{t_{bolt} \cdot arm}{Sx} = 9.9 \cdot ksi$

Shear Stress: $f_v := \frac{t_{bolt}}{Ax} = 3.5 \cdot ksi$

Allowable Bending Stress $F_b := 0.6 \cdot F_y = 18000\ psi$

Allowable Shear Stress $F_v := 0.4 \cdot F_y = 12000\ psi$

$$CSR_{bp} := \frac{f_b}{F_b} + \left(\frac{f_v}{F_v}\right)^2 = 0.6$$

$CheckBasePlate := if(CSR_{bp} \le 1.0, "OK", "NG") = "OK"$

Summary of Results:

$BuildingRisk := Bldg_{Risk} = "IV"$

$DesignWindSpeed := V \cdot mph = 186 \cdot mph$

$ExposureCategory := ExpCat = "D"$

$MountingHeight := H = 30 \cdot ft$

Number of Panel Fasteners Provided By Manufacturer:

Panel No. 1: $No_{screws.std1} := 8$

Panel No. 2: $No_{screws.std2} := 10$

Panel No. 3: $No_{screws.std3} := 10$

Number of Panel Fasteners Required By Analysis:

Panel No. 1: $No_{screws1} = 7$

Panel No. 2: $No_{screws2} = 6$

Panel No. 3: $No_{screws3} = 8$

Panel Fastening Check:

$check_{panel1} := if(No_{screws.std1} \ge No_{screws1}, "OK", "NG") = "OK"$

$check_{panel2} := if(No_{screws.std2} \ge No_{screws2}, "OK", "NG") = "OK"$

$check_{panel3} := if(No_{screws.std3} \ge No_{screws3}, "OK", "NG") = "OK"$

Equipment Tie Down to Support By Others:

BoltMaterial = "ASTM A307 or Greater"

$TieDownBoltDia := \phi_{bolt} = 0.3125 \cdot in$

$CSR_{bolt} = 0.4$

$CSR_{bp} = 0.6$