CODES:

FLORIDA BUILDING CODE 2014, 5TH EDITION
ASCE STANDARD 7-2010
MIAMI DADE WIND SPEED = 186 MPH

WIND DESIGN REQUIREMENTS:

ULTIMATE DESIGN WIND SPEED, Vult (3 sec. gust)	186 mph
NOMINAL DESIGN WIND SPEED, Vasd	144 mph
RISK CATEGORY	IV
HEIGHT TO CENTROID	200 FT
EXPOSURE CATEGORY	D
ENCLOSURE CATEGORY	N/A
EFFECTIVE WIND AREA	N/A
INTERNAL PRESSURE COEFFICIENT GCPi	N/A
DIRECTIONALITY FACTOR Kd	0.90
TOPOGRAPHIC FACTOR Kzt	1.00
GUST EFFECT FACTOR	N/A

WIND LOAD METHOD:

VELOCITY PRESSURE:
based on ASCE 7-10, Eq. 29.3-1
$qz = 0.00256\ Kz\ Kzt\ Kd\ V^2$ psf
Kz = 1.61
V = Vult
qz = 128.3 psf

WIND PRESSURES:
based on ASCE 7-10 Eq. 29.5.1 & FBC 1620.6
F = qh GCf Af psf Eq 29.5-2
GCf = 3.10 FOR LATERAL FORCES
GCf = 1.50 FOR VERTICAL FORCES

LOAD COMBINATIONS:

POSITIVE VERTICAL FORCE:	1.0*D + 0.6*W [FBC 1605.3.1 EQ. 16-12]
SLIDING & ANCHOR PULLOUT:	0.6*D + 0.6*W [FBC 1605.3.1 EQ. 16-15]
OVERTURNING:	0.67*D + 0.78*W [FBC 1605.3.2 EQ. 16-18]

GENERAL NOTES:

1. THIS ENGINEERING REPORT DOCUMENTS THE ANALYSIS OF AC EQUIPMENT MOUNTED ON A ROOF STAND AND THE ASSOCIATED ANCHORING SYSTEMS TO RESIST DEAD WEIGHT AND WIND LOAD FORCES.
2. THE ANALYSIS CONFORMS TO THE REQUIREMENTS OF THE FLORIDA BUILDING CODE 2014 AND ASCE 7-2010, FOR USE WITHIN & OUTSIDE HVHZ.
3. THE AC UNIT IS MOUNTED ON A METAL STAND WHICH IS SECURED TO THE ROOF.
4. ANCHORS USED TO FASTEN THE UNIT TO THE ROOF STAND ARE A307 OR HIGHER STRENGTH STEEL BOLTS.
5. THE ROOF STAND IS DESIGNED AND VERIFIED BY STRUCTURAL ANALYSIS BY THIS ENGINEER.
6. ALTERNATE ROOF STAND DESIGNS (E.G. ALUMINUM) THAT ARE DESIGNED TO RESIST THE ABOVE WIND LOADS MAY BE USED AT THE CONTRACTOR'S OPTION. FOR ALTERNATE ROOF STAND DESIGNS, PROVIDE DETAILS AND CALCULATIONS SIMILAR TO THIS SHEET AND DETAILED CALCULATIONS ON DRAWING 2, STAMPED BY A PROFESSIONAL ENGINEER REGISTERED IN THE STATE OF FLORIDA.
7. THE CONTRACTOR IS RESPONSIBLE FOR SAFETY, INSTALLATION, AND SPECIAL INSPECTIONS & TESTS PER FBC CHAPTER 17.

CALCULATIONS: SEE DETAILED CALCULATIONS ON DRAWING 2.

WIND LATERAL AND VERTICAL FORCES:

1. THE WIND LOAD ACTING NORMAL TO THE LARGE VERTICAL SIDE OF THE AC UNIT IS USED FOR WORST CASE SHEAR.
2. THE WIND LOAD ACTING ON THE TOP OF THE UNIT UPWARD AND THE HORIZONTAL WIND LOAD IS USED TO CALCULATE UPLIFT AND MOMENT.
3. THESE FORCES MUST BE RESISTED BY THE SHEAR AND TENSILE STRENGTHS OF THE ANCHORS HOLDING THE UNIT TO THE SUPPORT BAR AND ALSO THE ANCHORS HOLDING THE SUPPORT BAR TO THE ROOF STAND. THE ROOF STAND INTERNAL STRESSES ARE VERIFIED BY THIS ENGINEER TO BE WITHIN THE ALLOWABLE STRENGTHS OF ITS ELEMENTS AND CONNECTIONS.

SUPPORT BAR STRENGTH:

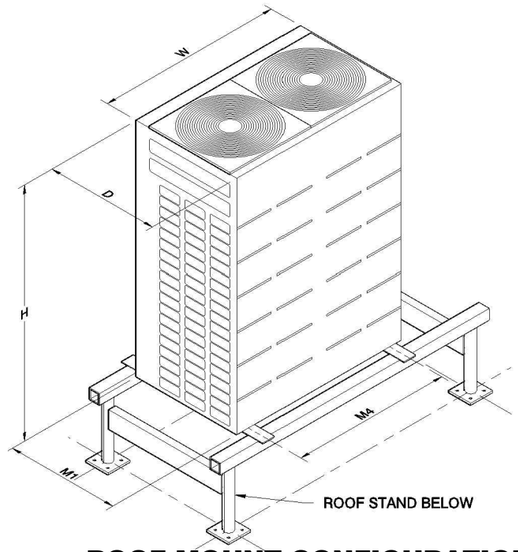
4. THE MOMENT AND SHEAR MUST BE TRANSFERRED FROM THE AC UNIT TO THE ROOF STAND BY A SUPPORT BAR AS THE AC UNIT DEPTH CAN BE UNEQUAL TO THE ROOF STAND DEPTH.
5. MAX MOMENT AND SHEAR TO THE SUPPORT BAR DETERMINE SELECTION OF THE SUPPORT BAR.

ROOF STAND STRENGTH:

6. CRITICAL LIMITS ARE THE POST LEGS AND WELD STRENGTH TO THE BASE, CROSS BRACE TO POST CONNECTION, AND RAILING TO POST CONNECTION.

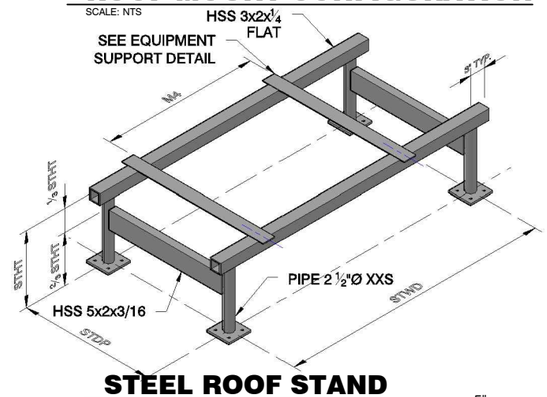
ENCLOSURE FASTENERS:

7. THE METAL SHELL FASTENERS MUST RESIST THE NEGATIVE WIND PRESSURES CAUSING TENSILE STRESS IN THE SCREWS AND PULL-OVER EFFECTS OF THE SHEET METAL.



ROOF-MOUNT CONFIGURATION

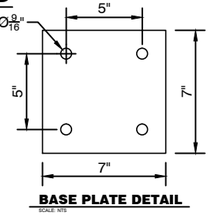
SCALE: NTS



STEEL ROOF STAND

SCALE: NTS

ROOF STAND STRENGTH LIMITS		
LIMIT TYPE	AMOUNT	UNITS
MAX SHEAR AT POST BASE	1.40	KIP
MAX PULLOUT AT POST BASE	4.22	KIP
MAX MOMENT AT POST BASE	26.76	KIP*IN
MAX MOMENT AT CROSS BRACE	27.842	KIP*IN



BASE PLATE DETAIL

SCALE: NTS

ROOF STAND NOTES:

1. ROOF STAND IS DESIGNED AND VERIFIED FOR THE FORCES DESCRIBED IN THIS DOCUMENT AS SUMMARIZED IN THE ENGINEERING CALCULATIONS INCLUDED.
2. STHT = STAND HEIGHT = MIN 18", MAX 30".
3. STWD = STAND POST SPACING = 54" MIN, 66" MAX.
4. STDP = STAND DEPTH = 40" MIN, 48" MAX.
5. EQUIPMENT SUPPORT AND FASTENERS TO STAND TOP RAIL ARE DEFINED IN SEPARATE DETAIL.
6. AC UNIT MUST BE CENTERED ON SUPPORT.
7. 1/2" BASE PLATE IS ANCHORED TO CONCRETE SLAB W/ ½" Ø ADHESIVE ANCHORS (HILTI HIT-HY 200+HAS) WITH MIN. 4 ½" EMBED. OF GALV HAS RODS IN CONCRETE. ANCHOR GROUP CAPACITY COMBINED TENSION = 4220 LBS, SHEAR = 1400 LBS, AND MOMENT 26760 IN*LBS.
8. IF NO ROOF SLAB, BASE PLATES SHALL BE ANCHORED TO STEEL ROOF FRAMING (DESIGNED BY OTHERS FOR THESE LOADS) WITH 1/2"Ø A307 BOLTS.

STEEL FABRICATION NOTES:

- ALL MATERIAL IS STEEL WITH MIN Fy = 35 KSI.
- ALL JOINTS SHALL BE WELDED CONTINUOUS ALL AROUND W/ 3/16" FILLET.

OTHER NOTES:

- EQUIPMENT SUPPORT IS NOT PART OF ROOF STAND.
- MIN NUMBER OF POSTS IS 4 PER CONDENSER. FOR MULTIPLE CONDENSERS, USE ONE STAND PER CONDENSER.
- 1"± NON-METALLIC NON-SHRINK GROUT MAY BE USED UNDER THE BASE PLATES.

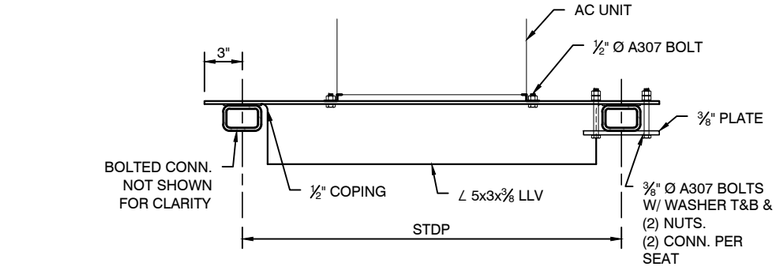
ENGINEERING CONFORMANCE ANALYSIS:

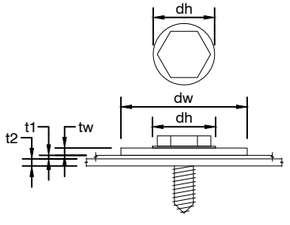
THE TABLE BELOW SHOWS DIMENSIONS, MIN STAND DEPTH, AND SHELL ENCLOSURE SCREWS FOR SOME MODELS OF LG ELECTRONICS USA HVAC OUTDOOR EQUIPMENT THAT MEET THE FOLLOWING ANALYSIS:

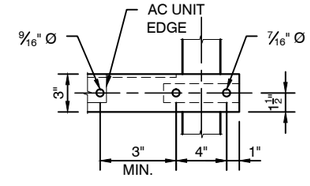
- ROOF STAND STRENGTH: POST AND CROSS-BRACE STRENGTH TO RESIST UNIT WEIGHT AND WIND LOAD LATERAL AND VERTICAL SURFACES
- STAND POST ANCHORS: PULLOUT AND SHEAR DUE TO OVERTURNING AND SLIDING FORCE IS WITHIN REQUIREMENTS
- EQUIPMENT METAL COVER FASTENERS: MIN NUMBER AND SIZE

	CONDENSER DIMENSIONS						ROOF STAND	SHELL SCREWS	DESIGN CHECK W/ NOM/REQ'D >= 1.00 = OK: STAND STRENGTH			
MODEL #	W	D	H	M1	M4	Wt	DIMS: STDP MIN (IN)	ON LONG SIDE, QTY. & SIZE	ANCHOR SHEAR	UPLIFT	BRACE MOMENT	METAL SHELL
ARUB096BTE4 ARUB096DTE4 ARUN096BTE4 ARUN096DTE4 ARUN121BTE4 ARUN121DTE4 ARUB121BTE4 ARUB121DTE4 ARUB096BTE5 ARUB096DTE5 ARUB121BTE5 ARUB121DTE5	48.81	29.94	66.13	29.06	43.38	563	40	32, #10	0.96	0.98	0.96	0.98
ARUN122BTE4 ARUN122DTE4 ARUB122BTE4 ARUB122DTE4 ARUB122BTE5 ARUB122DTE5	48.81	29.94	66.13	29.06	43.38	661	40	32, #10	0.96	0.98	0.96	0.98
ARUN144BTE4 ARUN144DTE4 ARUB144BTE4 ARUB144DTE4 ARUN168BTE4 ARUN168DTE4 ARUB168BTE4 ARUB168DTE4 ARUB144BTE5 ARUB144DTE5 ARUB168BTE5 ARUB168DTE5 ARUB192BTE5 ARUB192DTE5	48.81	29.94	66.13	29.06	43.38	628	40	32, #10	0.96	0.98	0.96	0.98
ARUN145BTE4 ARUN145DTE4 ARUB145BTE4 ARUB145DTE4 ARUN169BTE4 ARUN169DTE4 ARUB169BTE4 ARUB169DTE4 ARUB216BTE5 ARUB216DTE5	48.81	29.94	66.13	29.06	43.38	660	40	32, #10	0.96	0.98	0.96	0.98

NOTE: STAND DIMENSIONS ARE MINIMUMS. STAND SHALL BE BUILT TO SUPPORT ONE CONDENSER UNIT AS OUTLINED IN THE LG ELECTRONICS USA INSTALLATION MANUAL.







EQUIPMENT SUPPORT DETAIL

SCALE: NTS

ENCLOSURE FASTENERS		
DESCRIPTION	SIZE	UNITS
SCREW SIZE (d)	#10	
INTEGRAL WASHER SIZE (dw)	0.50	IN
THICKNESS OF SHEET METAL (t1)	0.043	IN
MIN. THICKNESS OF FRAME (t2)	0.07	IN
DEPTH OF PENETRATION	0.25	IN
SCREW YIELD STRENGTH	55	KSI
ALLOWABLE TENSILE STRENGTH/SCREW	321	LBS
ALLOWABLE PULLOVER STRENGTH/SCREW	371	LBS
ALLOWABLE PULL-OUT STRENGTH/SCREW	170	LBS

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DRAWING TITLE: 48-30-R-128 INFORMATION & DIAGRAMS

PROJECT TITLE: LG ELECTRONICS USA HVAC OUTDOOR CONDENSING UNIT ROOF MOUNT CONFIGURATION

REVISIONS

NO.	DATE	BY	DESCRIPTION

SCALE	DATE
NTS	11/02/16
DRAWN BY	PROJECT MGR
JDP	PCP
PROJECT NO.	FLAT FILE
160387	

DRAWING NO.
48-30-R-128

SHEET 1 OF 2

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ENGINEERING CALCULATION DETAIL SHEET

Outdoor Condensor Units on Roof Stand - Suitability Verification
Designed by: Paul C. Perrin, PE, SE

SINCE THIS DESIGN IS BASED ON WIND PRESSURE, qz, THIS DESIGN IS ALSO SUITABLE FOR THE FOLLOWING CASES:

- MIAMI DADE WIND SPEED = 186 MPH, RISK CATEGORY IV, EXPOSURE CATEGORY C, HEIGHT UP TO 320 FT.
- MIAMI DADE WIND SPEED = 186 MPH, RISK CATEGORY II, EXPOSURE CATEGORY D, HEIGHT UP TO 398 FT.
- BROWARD WIND SPEED = 180 MPH, RISK CATEGORY IV, EXPOSURE CATEGORY D, HEIGHT UP TO 289 FT.

DESIGN METHODOLOGY: ASD

OBJECTIVE:
Determine Wind Load on AC unit mounted on roof stand using ASCE 7 (2010), Section 29.5. Confirm stability, roof stand strength, anchor configuration and strength, and equipment envelope fastening.

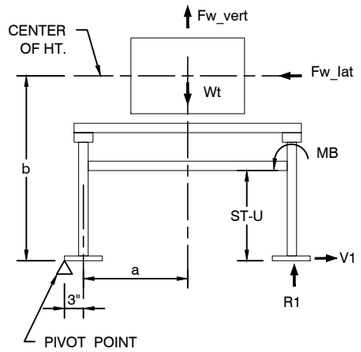
WIND LOAD: (See also "Wind Design Requirements" on Drawing 1)

Vult = 186 mph (FBC 2014 1620.2) for Miami-Dade, Risk Category IV

From "29.3 Velocity Pressure"
qz = 0.00256*Kz*Kzt*Kd*V2 = 128.3 psf (Eq. 29.3-1)
From "29.5 Design Wind Loads - Other Structures"
F = qz(GCr)Af (Eq. 29.5-1)

Fvertical = 128.3 psf * (1.50) * Af = 192.5 psf x Area (ft^2)
Flateral = 128.3 psf * (3.10) * Af = 397.8 psf x Area (ft^2)

Example AC Unit:
Use LSU090HEV1 in Table w/ dims (W, D, H, Wt) = (48.81", 29.94", 66.13", 563 lbs)



WIND LOAD FORCES:

Top Area = 29.94" * 48.81" / (144 in^2/ft^2) = 10.15 sf
Fw vertical (Fw_vert) = 192.5 psf * 10.15 sf = 1954 lbs (unfactored)

Long side Area = 48.81" * 66.13" / (144 in^2/ft^2) = 22.42 sf
Fw lateral (Fw_lat) = 397.8 psf * 22.42 sf = 8917 lbs (unfactored)

LOAD COMBINATIONS:

0.67D + 0.78W for overturning FBC 1605.3.2 Eq. 16-18
0.6D + 0.6W for sliding and anchors FBC 1605.3.1 Eq. 16-15

CALCULATE REACTION FORCES ON ROOF STAND:

Shear V1 = 0.6 * Fw_lat / 4 posts = 0.6 * 8917 #/ 4 = 1338 lbs
Pull-up R1 = [0.6 * Fw_lat * b + (0.6 * Fw_vert - 0.6 * Wt) * (a+3")] / (2 * a+3")/ 2 posts
= [0.6*8917 #*(30"+66.13"/2)+(0.6*1954#-0.6*563#)*(40"/2+3")]/(40"+3")/2
= 4.147 kips
Moment MB = V1 * ST-U = 1338# * 20" = 26.752 kip*in

NOMINAL STRENGTH OF ROOF STAND:

All limits are based on posts at min. depth of 40", max. height of 30", and max. spacing of 66".
Limits: Shear at base, Uplift at one post, Moment on frame
Given:

1. (4) anchors per base with allowable max pull-up of 4220 lbs, allowable max shear of 1400 lbs and allowable max moment of 26.760 kip*in per anchor group, (1/2"diameter adhesive anchor with 4.5" embedment in min 3000 psi concrete).
2. All welds 3/16" fillet. All materials steel with min Fy = 35 ksi.

Posts are 2.5" Ø extra extra strong pipe.

Cross brace is HSS 5 x 2 x 3/16

Limits per post:
Max shear = min(pipe shear, anchor shear)
= min(0.6 * 35 ksi * 1.61 * in^2 / 1.67, 1.400 kips)
= 1.400 kips
Max uplift at one post = anchor pull-up capacity = 4220 lbs = 4.220 kips
Max moment at brace = min (brace flexural strength, weld strength, post flexural strength)
= min (46 ksi* 2.60 in^3/1.67, 2.78 kip/in * 2" * 5",35 ksi*1.94 in^3/1.67)
= min (71.6 kip*in, 27.8 kip*in, 40.7 kip*in)
=27.8 kip*in

THE CALCULATIONS ON THE DRAWING ARE REPRESENTATIVE OF THE FOLLOWING LG ELECTRONICS OUTDOOR CONDENSING UNITS:

ARUB096BTE4	ARUN145DTE4
ARUB096DTE4	ARUB145BTE4
ARUN096BTE4	ARUB145DTE4
ARUN096DTE4	ARUN169BTE4
ARUN121BTE4	ARUN169DTE4
ARUN121DTE4	ARUB169BTE4
ARUB121BTE4	ARUB169DTE4
ARUB121DTE4	ARUB096BTE5
ARUN122BTE4	ARUB096DTE5
ARUN122DTE4	ARUB121BTE5
ARUB122BTE4	ARUB121DTE5
ARUB122DTE4	ARUB122BTE5
ARUN144BTE4	ARUB122DTE5
ARUN144DTE4	ARUB144BTE5
ARUB144BTE4	ARUB144DTE5
ARUB144DTE4	ARUB168BTE5
ARUN168BTE4	ARUB168DTE5
ARUN168DTE4	ARUB192BTE5
ARUB168BTE4	ARUB192DTE5
ARUB168DTE4	ARUB216BTE5
ARUN145BTE4	ARUB216DTE5

DESIGN METHODOLOGY: ASD

VERIFY ANCHOR SHEAR RESISTANCE TO SLIDING:
Use Load Combination FBC 1605.3.1 Eq. 16-15
0.6D + 0.6W = 0.6 * Fw_lat = 0.6 * 8917# = 5350 lbs
Shear per post = 5350# / 4 = 1338 lbs
Fsliding nominal = 1.400 kips
Since 1.400 kips > 1.338 kips
Resistance to Sliding Checks OK.

CHECK OVERTURNING ANCHOR PULLOUT/UPLIFT RESISTANCE:
Use Load Combination FBC 1605.3.1 Eq. 16-15
0.6D + 0.6W
On one post
Pull-up R1 = 4.147 kips
Max uplift at one post = 4.220 kips
Since 4.220 kips > 4.147 kips
Anchor Resistance to Overturning Checks OK.

CHECK BRACE RESISTANCE TO MOMENT:
Use worst case on one post
Moment at brace MB = 26.752 kip-in per post
Max moment at brace = 27.8 kip-in
Since 27.8 kip-in > 26.752 kip-in
Moment at Stand Brace Checks OK.

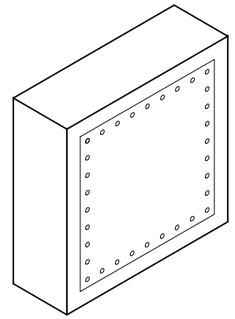
CHECK SHEET METAL ENVELOPE FASTENER RESISTANCE:
Analysis based on AISI S100-2007 "Cold Formed Steel Structural Members" Section E4:Screw Connections
Use Load Combination FBC 1605.3.1 Eq. 16-15
0.6D + 0.6W
On long side worst case
0.60 * Fw_lat = 0.60 * 8917# = 5350 lbs

Resistance to the metal shell pull-off is the minimum of the tensile strength of the screw and the pull-over strength of the sheet metal.

Inputs:
#10 screw, d = 0.19" with integral 0.5"-diameter washer
Thickness of metal shell, t1 = 0.043" (18 gauge)
Depth of penetration of screw into frame, tc = 0.25"
Strength of screw, Fu1 = 55 ksi

Based on the above data:
Allowable tensile of the screw, Pts/Ω = 321 lbs per screw (where Ω = 3.0)
Allowable Pull-out strength, Pnot/Ω = 170 lbs per screw
Allowable Pull-over strength, Pnov/Ω = 371 lbs per screw
Therefore the min number of screws per long side = 5350# / 170#/screw = 31.47 screws
Rounds up to min 32 screws per side, use 32 screws for symmetry.

Anchor Resistance to Metal Enclosure Pull-Off Checks OK.



VERIFY STRENGTH OF SUPPORT BARS AND CONNECTIONS:
Use Load Combination
0.67 D + 0.78 W
Max uplift on one side of AC Unit at mounting anchors:
F_M1 = (0.78*Fw_lat*H/2)/(2*M1)+(0.78*Fw_vert-0.67*Wt)/4 =
F_M1 = (0.78*8.92 kips*66.13 in/2)/(2*29.06 in)+(0.78*1.95 kips-0.67*0.563 kips)/4
F_M1 = 4.244 kips
Allowable tensile capacity of bolt = 4.42 kips > 4.244 kips
Bolt Resistance at Mounting Anchor Checks OK
Max uplift on one side of AC Unit at side support HSS:
F_STDP = (0.78*Fw_lat*H/2)/(2*STDP)+(0.78*Fw_vert-0.67*Wt)/4 =
F_STDP = (0.78*8.92 kips*66.13 in/2)/(2*48 in)+(0.78*1.95 kips-0.67*0.563 kips)/4
F_STDP = 2.682 kips
Allowable tensile capacity of 2 bolts = 2*2.49 kips=4.97 kips > 2.682 kips
Bolt Resistance at Side Supports Checks OK
Max moment in Support Angle:
F_M1*(STDP-M1)/2 = 4.244 kips*(48 in-29.06in)/2 = 40.188 kip-in
Sx*Fy/Ω = 2.22 in^3 *36 ksi/1.67 = 47.856 kip-in > 40.188 kip-in
Support Angle Flexural Capacity Checks OK
Max moment in Side HSS:
F_STDP*(STWD-M4)/2 = 2.682 kips*(66 in-48.38 in)/2 = 23.631 kip-in
Sy*Fy/Ω = 1.11 in^3 *46 ksi/1.67 = 30.575 kip-in > 23.631 kip-in
Side HSS Flexural Capacity Checks OK

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DRAWING TITLE: 48-30-R-128 CALCULATIONS
PROJECT TITLE: LG ELECTRONICS USA HVAC OUTDOOR CONDENSING UNIT ROOF MOUNT CONFIGURATION

REVISIONS

NO.	DATE	BY	DESCRIPTION

SCALE	DATE
NTS	11/02/16
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DRAWING NO.
48-30-R-128

SHEET 2 OF 2

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