CASA DEL SOL
Team Orange County

PROJECT MANUAL

U.S. DEPARTMENT OF ENERGY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ORANGE COUNTY GREAT PARK

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

CASA DEL SOL

Team Orange County

•Making a Sustainable Future•
•Feel Like Home•

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2015

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CONSTRUCTION DOCUMENTATION PROJECT MANUAL
08/17/2015

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01_ INTRODUCTION

DEAR FRIEND,

THE U.S. DEPARTMENT OF ENERGY'S SOLAR DECATHLON CHALLENGES UNIVERSITIES TO CREATE SOLAR POWERED HOUSES THAT ARE COST-EFFECTIVE, ENERGY-EFFICIENT AND ATTRACTIVE. IT IS ONE OF THE MOST PREEMINENT AND EXCLUSIVE INTERNATIONAL DESIGN COMPETITIONS IN THE WORLD HOSTED AT THE GREAT PARK IN IRVINE, CA.

TEAMING UP FOR THEIR FIRST U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON, STUDENTS FROM THE UNIVERSITY OF CALIFORNIA, IRVINE, CHAPMAN UNIVERSITY, IRVINE VALLEY COLLEGE, AND SADDLEBACK COLLEGE ARE BUILDING CASA DEL SOL; A SOLAR-POWERED, ZERO NET ENERGY, AND MULTIGENERATIONAL HOME IDEAL FOR SOUTHERN CALIFORNIA. COMPRISED OF A RESEARCH INSTITUTION, A PRIVATE UNIVERSITY, AND TWO COMMUNITY COLLEGES, TEAM ORANGE COUNTY INCORPORATES A BROAD RANGE OF PERSPECTIVES AND EDUCATIONAL BACKGROUNDS WITH WIDESPREAD ACADEMIC AND PROFESSIONAL SUPPORT ACROSS ORANGE COUNTY.

CASA DEL SOL'S USE OF COST-EFFECTIVE, CLEAN TECHNOLOGY WILL SERVE AS A CATALYST FOR THE FUTURE OF THE ORANGE COUNTY HOUSING INDUSTRY. BUT IN ORDER FOR US TO SUCCEED, WE NEED YOUR SUPPORT. YOU WILL HAVE MULTIPLE OPPORTUNITIES FOR ENGAGEMENT WITH THE NEXT GENERATION OF INNOVATORS WHO ARE MAKING A SUSTAINABLE FUTURE FEEL LIKE HOME.

THROUGHOUT THE COURSE OF THE SOLAR DECATHLON COMPETITION:

• 70K ATTENDED IN 2013; 100K+ EXPECTED IN 2015.

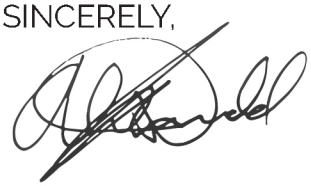
• PUBLIC RECOGNITION: WEBSITE, CONSTRUCTION SITE AT IVC (JEFFREY AND IRVINE), T-SHIRTS, COMPETITION SITE, AND DOCUMENTARY.

• FORM PERSONAL RELATIONSHIPS WITH TEAM OC STUDENTS; 100+ LEADERS OF NEXT GENERATION CLEANTECH SPANNING FOUR OC CAMPUSES.

• PUBLICITY, ON A GLOBAL SCALE, TO BE GENERATED BY OUR COMMUNITY EFFORT.

AS YOU KNOW, THE GIFT OF YOUR TIME GOES WELL BEYOND OUR IMMEDIATE ARCHITECTURAL DESIGN CRITIQUE. YOUR SUPPORT HELPS TO RETAIN STUDENTS WITHIN STEM EDUCATION RELATED FIELDS, AND PREPARE THE NEXT GENERATION OF LEADERS WITHIN CLEAN-TECH. FOR MORE INFORMATION ON TEAM OC, PLEASE SEE: TEAMOC2015.COM. THANK YOU FOR YOUR TIME AND WE LOOK FORWARD TO WORKING WITH YOU.

SINCERELY,



ALEX MCDONALD
TEAM ORANGE COUNTY PROJECT MANAGER

CASA DEL SOL
Team Orange County

4 Petal Design

Team Orange County is not only the home team in this year's competition, but also the only team in Southern California. Comprised of a hundred students across four schools, Team OC is the largest team the Solar Decathlon has ever seen. We engage a public research institution (UC Irvine), a private school (Chapman), and two community colleges (IVC and Saddleback). Inspired by the California state flower, the golden poppy, our home – Casa Del Sol – embraces four petal design principals:

1. **Passive Solar** embraces the sun and prevailing winds
2. **Disruptive Innovation** pushes the limits of energy and design
3. **SoCal Market Appeal** inspires indoor/outdoor, multigenerational living
4. **Drought Resilience** landscape that beautifies as it sustains

Passive Solar

The California State flower opens and closes as it adjusts to the light of the sun, a method emulated by Casa Del Sol in order to promote the indoor-outdoor California lifestyle. Pivot panels connect our outdoor living room to our surrounding neighborhood, and accordion kitchen windows open to a spacious deck for outdoor dining. As we are in the northern hemisphere, the sun hangs in the southern sky. To protect residents from the sun and moderate solar heat gain, southern shading elements have been placed over windows and living spaces as seen in the tensile structure above. Unsheltered windows on the western side of our home open to cool, prevailing ocean winds. Automated windows serve to naturally ventilate living spaces. A brise soleil is built up on the eastern side to protect occupants against warm, violent Santa Ana winds, which often strike in October; we shall see the brise soleil on the other side of the detached studio.

Disruptive Innovation

Team Orange County's Casa Del Sol is an innovative, solar powered, net zero energy building. Smart grid ready, our home utilizes a bidirectional inverter to make use of both AC grid power, and DC power generated from solar panels. Our innovative inverter is able to directly use DC power from solar panels to charge our electric vehicle. A sub wet-bulb evaporative chiller and heat pump both chill water that runs in our home's ceilings to provide air conditioning. To increase efficiency, the heat pump rejects its waste heat into our hot water tank. Additionally, the heat pump can provide ducted heating and cooling when needed. Solar thermal collectors not only heat our hot water, but also help to provide heat for our dryer. Appropriate building materials have been selected to promote good indoor air quality, low carbon footprints, and environmental sustainability-all of which is produced within socially just manufacturing facilities. PEX piping has been used over that of PVC to promote use of cleaner building materials.

SoCal Market Appeal

A contemporary take on Southern California's historic modern architecture, our home meets the growing needs of multigenerational households. The incorporation of the studio serves to address life-style changes as we look to house elderly parents, children returning home, to be used as an office, guesthouse, or acts as a possible rental. Despite our country's slowing population birth rate, the urban population of Southern California is expected to continue to grow. Our studio responds to the need for increased housing stock by promoting multigenerational living and neighborhood walkability while still preserving residential character. In addition to meeting multigenerational demands, Casa Del Sol is also competitively priced with Orange County's real estate market.

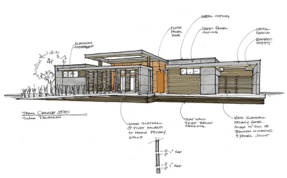
Drought Resilience

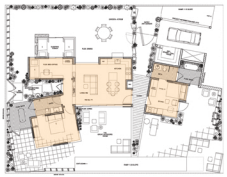
Like the poppy, Casa Del Sol is drought resistant. This notion of water resilience is more relevant than ever as Southern California faces increasingly dry conditions. In SoCal residential housing, landscaping uses the most water. To mitigate this demand, Casa Del Sol recycles its wastewater and uses rainwater catchment to water a garden filled with drought resistant plantings. The back porch is host to an edible garden that complements the outdoor dining experience.

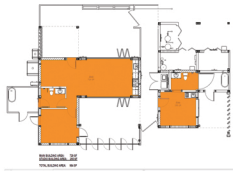
Team Orange County's home addresses ecological concerns, and helps meet the need for affordable housing in Southern California. Our modern design makes a sustainable future feel like home.

02_ SUMMARY OF CHANGES

CASA DEL SOL
Team Orange County







02_Summary of Changes

[08/17/15] Revision

The Project Manual has been updated from the previous issue. Revisions include:

- **Architecture**

  Updated solar design layout and stanchions. Additional detailing was added for breezeway and ramps. Roof penetration diagram added. Framing scope diagram updated. Parapets added to exterior canopy. Downspouts and scuppers now shown, which connect to the rainwater catchment system. Exterior bathtubs removed and converted to surf showers with grey water catchment.

- **Landscape Architecture**

  Total number of planters was reduced to include only those on the South side of the house. 36" big box tree was removed from plant list. Vertical garden was expanded to 32 feet as well as redesigned to use hydro-organic growing rather than traditional hydroponics. Vertical garden construction documents were updated to show mounting details.

- **Mechanical Systems**

  HVAC system was further optimized. Our SWEC will be used for our main source of cooling instead of water-to-water heat pump. The water-to-water heat pump is now used as a back up and booster for heating and cooling. Fire sprinkler system was updated. Solar thermal panels on roof are now shown (left out of previous mechanical model), and tilted for higher efficiency.

- **Electrical Systems**

  The PV panels made by SunPower were replaced by different panels made by LG due to sponsorship considerations. Solar panels were previously flat and now have a 5-10 degree tilt. A few lights moved. Some exterior lights were removed. Lighting plan was updated. The plan to add a high-voltage DC output to the PPS inverter was abandoned. The DRI-10 inverter now uses only the 4 ports shown in its manual, with the DC output used as a CHAdeMO car charger.

- **Structural**

  Structural plans were updated to reflect additional steel frame requirements from sub-contractor Design Space who fabricated modular steel foundation and frames. Structural calculations were updated to reflect changes, and additional calculations were included for carport.

- **Operations**

  Water truck delivery sequence was added for thermal mass to be used in radiant system.

[02/12/15] Revision

The Project Manual has been updated from the previous issue. Revisions include:

- **Architecture**

  We updated floor plan and elevations to improve passive solar design.

- **Mechanical Systems**

  The Mitsubishi Mini Split system was replaced with a centralized HVAC system, utilizing ducts and radiant ceiling for distribution of heating and cooling.

- **Electrical Systems**

  The AC-DC car charger was removed. Vehicle charging is now performed by our PPS demand-response inverter via the CHAdeMO protocol.

  The PV panels made by Stion were replaced by different panels made by SunPower due to sponsorship considerations.

[10/07/14] Revision

The Project Manual has been updated from the previous issue. Revisions include:

- **Architecture**

  We updated floor plan and elevations to improve passive solar design.

- **Mechanical Systems**

  Due to lack of availability of a properly sized residential absorption chiller, we replaced it with an electrical heat pump. The Mitsubishi Mini Split system allows ductless distribution of refrigerant to multiple indoor units which can be controlled independently.

- **Adaptive Behavior System**

  Recent research suggests that adaptive behavior systems are less efficient in reducing energy consumption than automated energy management systems. Hence we decided to optimize our control systems based on automation, weather data and smart scheduling.

03_ RULES COMPLIANCE CHECKLIST

CASA DEL SOL
Team Orange County

SECTION II: GENRAL RULES

01_ AUTHORITY
02_ ADMINISTRATION
03_ PARTICIPATION
04_ SITE OPERATION
05_ THE SOLAR ENVELOPE
06_ THE HOUSE
07_ VEGETATION
08_ ENERGY
09_ LIQUIDS
10_THE EVENT
11_CONTEST WEEK

03_Rules Compliance List

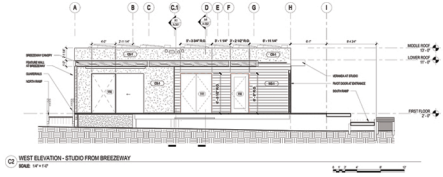
RULE	RULE DESCRIPTION	LOCATION DESCRIPTION	LOCATION
Rule 4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site	O-602
Rule 4-2	Construction Equipment	Specifications for heavy machinery	01 54 00
Rule 4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	N/A
Rule 4-4	Impact within the Solar Envelope	Drawing(s) showing the location, contact area, and bearing pressure of every component resting directly within the solar envelope	G-101
Rule 4-5	Generators	Specifications for generators (including sound rating)	N/A
Rule 4-6	Spill Containment	Drawing(s) showing the locations of all equipment, containers, and pipes that will contain liquids at any point during the event	P-101, M-101
Rule 4-6	Spill Containment	Specifications for all equipment, containers, and pipes that will contain fluids at any point during the event	22 12 19 22 11 16 22 11 23
Rule 4-7	Lot Conditions	Calculations showing that the structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists	Structural Calculations, see page 7-41
Rule 4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot	S-600
Rule 5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	G-201 & 202
Rule 5-2	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references	N/A
Rule 6-1	Structural Design Approval	List of, or marking on, all drawing and project manual sheets that will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual	Structural Drawings, all of S-Series
Rule 6-2	Finished Square Footage	Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically	G-101
Rule 6-2	Finished Square Footage	Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week	N/A
Rule 6-3	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route	G-103

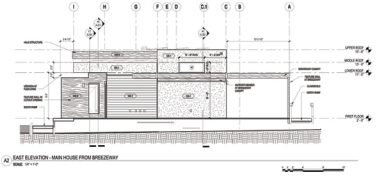
Rule 7-1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	L-401
Rule 7-2	Watering Restrictions	Drawing(s) showing the layout and operation of grey-water irrigation systems	P-103
Rule 8-1	PV Technology Limitations	Specifications for photovoltaic components	48 14 00
Rule 8-3	Batteries	Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand-alone, PV-powered devices	N/A
Rule 8-3	Batteries	Specifications for all primary and secondary batteries and stand-alone, PV-powered devices	N/A
Rule 8-4	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	N/A
Rule 8-4	Desiccant Systems	Specifications for desiccant system components	N/A
Rule 8-5	Village Grid	Completed interconnection application form	See below, page 131
Rule 8-5	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E-204
Rule 8-5	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	48 14 00
Rule 8-5	Village Grid	One-line electrical diagram	E-101
Rule 8-5	Village Grid	Calculation of service/feeder net computed load per NEC 220	See below, page 132
Rule 8-5	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	G-103
Rule 8-5	Village Grid	Elevation(s) showing the meter housing, main utility disconnect, and other service equipment	E-201
Rule 9-1	Container Locations	Drawing(s) showing the location of all liquid containers relative to the finished square footage	P-101
Rule 9-1	Container Locations	Drawing(s) demonstrating that the primary supply water tank(s) is fully shaded from direct solar radiation between 9 a.m. and 5 p.m. PDT or between 8 a.m. and 4 p.m. solar time on October 1	P-101, G-601
Rule 9-2	Team-Provided Liquids	Quantity, specifications, and delivery date(s) of all team-provided liquids for irrigation, thermal mass, hydronic system pressure testing, and thermodynamic system operation	See below, page 115 and 116
Rule 9-3	Greywater Reuse	Drawing(s) showing the layout and operation of grey-water reuse systems	P-103, P-104, L-102, M-101

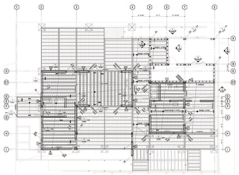
Rule 9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rain-water collection systems	P-104
Rule 9-6	Thermal Mass	Drawing(s) showing the locations of liquid-based thermal mass systems	0-603/604; M-201, M-100(U)
Rule 9-6	Thermal Mass	Specifications for components of liquid-based thermal mass systems	See Below, Page 115 and 116
Rule 9-7	Greywater Heat Recovery	Drawing(s) showing the layout and operation of grey-water heat recovery systems	N/A
Rule 9-8	Water Delivery	Drawing(s) showing the complete sequence of water delivery and distribution events	O-603
Rule 9-8	Water Delivery	Specifications for the containers to which water will be delivered	22 12 19
Rule 9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events	O-603
Rule 9-9	Water Removal	Specifications for the containers from which water will be removed	22 12 19
Rule 11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	X-101

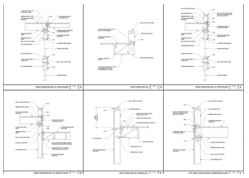
04_ STRUCTURAL CALCULATIONS

CASA DEL SOL
Team Orange County









04_Structural Calculations

Structural Narrative

Superstructure Discussion

Originally we intended to have a predominantly timber designed frame mitigates infiltration of heat and accommodates solar panels. However, due to seismic concerns we decided to sub-contract our modular framing in order to ease California State permitting. Our sub-contractor would not warranty their work without replacing the timber frame with steel. Out three main modules were sized to maximize space while still being able to be transported on one truck bed. The decking was modularized to accommodate the ease of assembly. Specialty connections of various shading elements has been detailed for construction. The free standing wall on decking will be attached to the exterior deck support framing, while the halo structure will be its own module to be connected in--situ.

STRUCTURAL DESIGN CALCULATIONS
FOR:
SINGLE STORY MODULAR RESIDENCE
(SERIAL NO. SCI-00796)

PROJECT:
CASA DEL SOL SOLAR HOUSE
TEAM ORANGE COUNTY
2015 SOLAR DECATHLON
IRVINE, CALIFORNIA

PREPARED FOR:

SILVER CREEK

2830 BARRETT AVENUE
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FAX: (951) 940-9232

PREPARED BY:

ACUMEN Engineering, Inc.

12808 SOUTH 600 EAST
DRAPER, UTAH 84020
(801) 571 - 9877
FAX (801) 571 - 9951

COVER SHEET	1	ROOF LIVE LOAD:	20 PSF	DESIGN CODE:	2013 CBC
DESIGN LOADS	2	FLOOR LIVE LOAD:	50 PSF	IMPORTANCE FACTOR:	1.0
FLOOR FRAMING	7	PARTITION LOAD:	N/A	RISK CATEGORY:	II
EXT. WALL FRAMING	12	ULT. WIND SPEED /	110 MPH	SPECTRAL RESPONSE	
ROOF FRAMING	16	EXPOSURE:	EXP. C	ACCELERATION: (Ss)	1.5 g
MR FRAME	19			(S1)	0.6 g
				SITE CLASS:	D

Title to these calculations remains with ACUMEN ENGINEERING, INC. The information herein is for the sole use of SILVER CREEK INDUSTRIES, INC. and shall be held confidential. Re-use or reproduction in whole or in part is prohibited.

Acumen Engineering, Inc.
12808 South 600 East
Draper, UT 84020
801-571-9877
acumeneng@msn.com

JOB TITLE Casa Del Sol
Single Story Modular Residence
JOB NO. _____ SHEET NO. 7
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____

www.struware.com

Code Search

Code: ASCE 7 - 10

Occupancy:

Occupancy Group = R Residential

Risk Category & Importance Factors:

Risk Category =	II
Wind factor =	1.00
Snow factor =	1.00
Seismic factor =	1.00

Type of Construction:

Fire Rating:

Roof =	0.0 hr
Floor =	0.0 hr

Building Geometry:

Roof angle (θ)	0.25 / 12	1.2 deg
Building length (L)	35.0 ft	
Least width (B)	30.0 ft	
Mean Roof Ht (h)	14.0 ft	
Parapet ht above grd	0.0 ft	
Minimum parapet ht	0.0 ft	

Live Loads:

Roof 0 to 200 sf: 20 psf
200 to 600 sf: 24 - 0.02Area, but not less than 12 psf
over 600 sf: 12 psf

Floor:

Typical Floor	50 psf
Partitions	N/A

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Draper, UT 84020
801-571-9877
acumeneng@msn.com

JOB TITLE Casa Del Sol
Single Story Modular Residence
JOB NO. _____ SHEET NO. 3
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____

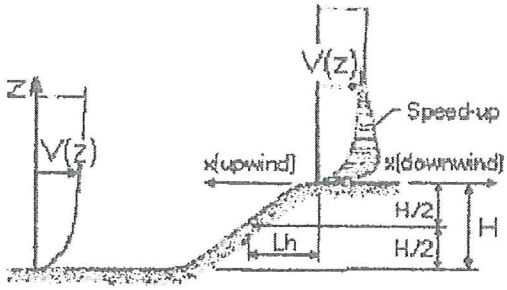
Wind Loads : ASCE 7- 10

Ultimate Wind Speed	110 mph
Nominal Wind Speed	85.2 mph
Risk Category	II
Exposure Category	C
Enclosure Classif.	Enclosed Building
Internal pressure	+/-0.18
Directionality (Kd)	0.85
Kh case 1	0.849
Kh case 2	0.849
Type of roof	Gable

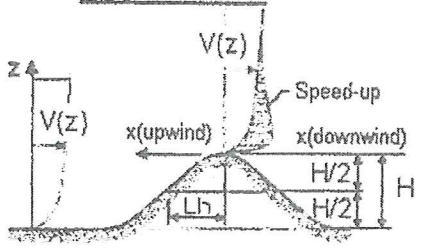
Topographic Factor (Kzt)

Topography		Flat
Hill Height	(H)	0.0 ft
Half Hill Length (Lh)		0.0 ft
Actual H/Lh	=	0.00
Use H/Lh	=	0.00
Modified Lh	=	0.0 ft
From top of crest: x =		50.0 ft
Bldg up/down wind?		downwind

H< 15ft;exp C
∴ Kzt=1.0



ESCARPMENT



2D RIDGE or 3D AXISYMMETRICAL HILL

H/Lh= 0.00		K_1 =	0.000
x/Lh = 0.00		K_2 =	0.000
z/Lh = 0.00		K_3 =	1.000
At Mean Roof Ht:			
	$Kzt = (1+K_1K_2K_3)^2$ =		1.00

Gust Effect Factor

h =	14.0 ft
B =	30.0 ft
/z (0.6h) =	15.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.47 Rigid structure

G = 0.85 Using rigid structure default

Rigid Structure

ë =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	427.1 ft
Q =	0.93
I_z =	0.23
G =	0.89 use G = 0.85

Flexible or Dynamically Sensitive Structure

Natural Frequency (η_1) =	0.0 Hz			
Damping ratio (β) =	0			
/b =	0.65			
/α =	0.15			
Vz =	92.9			
N_1 =	0.00			
R_n =	0.000			
R_h =	28.282	η =	0.000	h = 14.0 ft
R_B =	28.282	η =	0.000	
R_L =	28.282	η =	0.000	
g_R =	0.000			
R =	0.000			
G =	0.000			

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JOB TITLE Casa Del Sol
Single Story Modular Residence
JOB NO. _____ SHEET NO. 4
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____

Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only

Kz = Kh (case 1) = 0.85
Base pressure (qh) = **22.4 psf**
GCpi = +/-0.18

Edge Strip (a) = 3.0 ft
End Zone (2a) = 6.0 ft
Zone 2 length = 15.0 ft

Wind Pressure Coefficients

	CASE A				CASE B		
		θ = 1.2 deg					
Surface	GCpf	w/-GCpi	w/+GCpi		GCpf	w/-GCpi	w/+GCpi
1	0.40	0.58	0.22		-0.45	-0.27	-0.63
2	-0.69	-0.51	-0.87		-0.69	-0.51	-0.87
3	-0.37	-0.19	-0.55		-0.37	-0.19	-0.55
4	-0.29	-0.11	-0.47		-0.45	-0.27	-0.63
5					0.40	0.58	0.22
6					-0.29	-0.11	-0.47
1E	0.61	0.79	0.43		-0.48	-0.30	-0.66
2E	-1.07	-0.89	-1.25		-1.07	-0.89	-1.25
3E	-0.53	-0.35	-0.71		-0.53	-0.35	-0.71
4E	-0.43	-0.25	-0.61		-0.48	-0.30	-0.66
5E					0.61	0.79	0.43
6E					-0.43	-0.25	-0.61

Ultimate Wind Surface Pressures (psf)

1	13.0	4.9		-6.0	-14.1
2	-11.4	-19.4		-11.4	-19.4
3	-4.2	-12.3		-4.2	-12.3
4	-2.5	-10.5		-6.0	-14.1
5				13.0	4.9
6				-2.5	-10.5
1E	17.7	9.6		-6.7	-14.8
2E	-19.9	-27.9		-19.9	-27.9
3E	-7.8	-15.9		-7.8	-15.9
4E	-5.6	-13.6		-6.7	-14.8
5E				17.7	9.6
6E				-5.6	-13.6

Parapet

Windward parapet = 0.0 psf (GCpn = +1.5)
Leeward parapet = 0.0 psf (GCpn = -1.0)

Windward roof overhangs = 15.6 psf (upward) add to windward roof pressure

Horizontal MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)

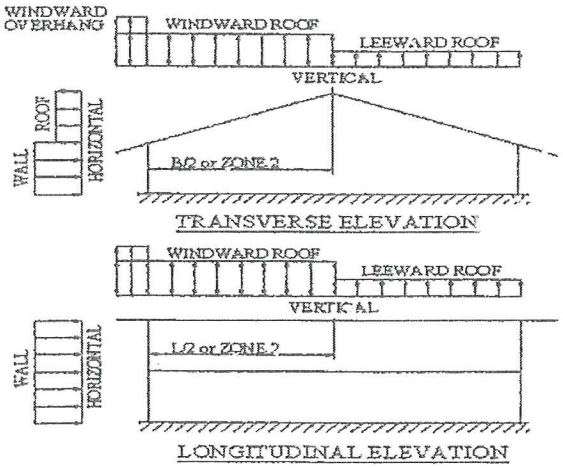
Interior Zone: Wall 15.4 psf
Roof -7.2 psf **
End Zone: Wall 23.2 psf
Roof -12.1 psf **

Longitudinal direction (parallel to L)

Interior Zone: Wall 15.4 psf
End Zone: Wall 23.2 psf

** NOTE: Total horiz force shall not be less than that determined by neglecting roof forces (except for MWFRS moment frames).

The code requires the MWFRS be designed for a min ultimate force of 16 psf multiplied by the wall area plus an 8 psf force applied to the vertical projection of the roof.



Acumen Engineering, Inc.
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JOB TITLE Casa Del Sol
Single Story Modular Residence
JOB NO. _____ SHEET NO. 5
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____

Wind Loads - Components & Cladding : h <= 60'

Kh (case 1) =	0.85	h =	14.0 ft
Base pressure (qh) =	**22.4 psf**	**a =**	3.0 ft
Minimum parapet ht =	0.0 ft	GCpi =	+/-0.18
Roof Angle (θ) =	1.2 deg		
Type of roof =	Gable		

Roof

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	75 sf	500 sf
Negative Zone 1	-1.18	-1.11	-1.08	-26.4	-24.8	-24.1	-24.4	-24.1
Negative Zone 2	-1.98	-1.49	-1.28	-44.3	-33.3	-28.6	-30.6	-28.6
Negative Zone 3	-2.98	-1.79	-1.28	-66.6	-40.0	-28.6	-33.4	-28.6
Positive All Zones	0.48	0.41	0.38	16.0	16.0	16.0	16.0	16.0
Overhang Zone 1&2	-1.70	-1.63	-1.60	-38.0	-36.4	-35.8	-36.0	-24.6
Overhang Zone 3	-2.80	-1.40	-0.80	-62.6	-31.3	-17.9	-23.5	-17.9

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0
Overhang soffit pressure equals adjacent wall pressure reduced by internal pressure of 4 psf

Parapet

qp = 0.0 psf

CASE A = pressure towards building (pos)
CASE B = pressure away from bldg (neg)

	Surface Pressure (psf)			User input
Solid Parapet Pressure	10 sf	100 sf	500 sf	40 sf
CASE A : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0
CASE B : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0

Walls

	GCp +/- GCpi			Surface Pressure (psf)			User input	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	50 sf	200 sf
Negative Zone 4	-1.17	-1.01	-0.90	-26.2	-22.6	-20.1	-23.7	-21.5
Negative Zone 5	-1.44	-1.12	-0.90	-32.2	-25.1	-20.1	-27.2	-22.9
Positive Zone 4 & 5	1.08	0.92	0.81	24.1	20.6	18.1	21.7	19.5

Note: GCp reduced by 10% due to roof angle <= 10 deg.

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JOB TITLE Casa Del Sol
Single Story Modular Residence
JOB NO. _____ SHEET NO. 6
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____

Seismic Loads: ASCE 7- 10 Strength Level Forces

Risk Category : II
Importance Factor (I) : 1.00
Site Class : D

Ss (0.2 sec) = 150.00 %g
S1 (1.0 sec) = 60.00 %g

Fa =	1.000	Sms =	1.500	S_{DS} =	1.000	Design Category =	D
Fv =	1.500	Sm1 =	0.900	S_{D1} =	0.600	Design Category =	D

Seismic Design Category = D
Number of Stories: 1
Structure Type: Moment-resisting frame systems of steel
Horizontal Struct Irregularities: 2) Reentrant Corners — See ASCE7 Sect 12.3.3.4
Vertical Structural Irregularities: 1a) Stiffness Irregularity—Soft Story
Flexible Diaphragms: Yes
Building System: **Moment-resisting Frame Systems**
Seismic resisting system: **Steel special moment frames**
System Structural Height Limit: **Height not limited**
Actual Structural Height (hn) = 14.3 ft
See ASCE7 Section 12.2.5 for exceptions and other system limitations

DESIGN COEFFICIENTS AND FACTORS

Response Modification Coefficient (R) = 8
Over-Strength Factor (Ωo) = 2.5
Deflection Amplification Factor (Cd) = 5.5
S_{DS} = 1.000
S_{D1} = 0.600

ρ = redundancy coefficient
Q_E = horizontal seismic force
D = dead load

Seismic Load Effect (E) = ρQ_E +/- $0.2S_{DS}$ D = ρQ_E +/- 0.200D
Special Seismic Load Effect (Em) = $\Omega o Q_E$ +/- $0.2S_{DS}$ D = 2.5 Q_E +/- 0.200D

PERMITTED ANALYTICAL PROCEDURES

Simplified Analysis - Use Equivalent Lateral Force Analysis

Equivalent Lateral-Force Analysis - Permitted

Building period coef. (C_T) = 0.028 — Cu = 1.40
Approx fundamental period (Ta) = $C_T h_n^x$ = 0.235 sec x= 0.80 — Tmax = CuTa = 0.329
User calculated fundamental period (T) = 0 sec — Use T = 0.235
Long Period Transition Period (TL) = ASCE7 map = 4
Seismic response coef. (Cs) = S_{DS}I/R = 0.125
need not exceed Cs = Sd1 I /RT = 0.319
but not less than Cs = 0.5*S1I/R = 0.038
USE Cs = 0.125

Design Base Shear V = 0.125W
See ASCE7 Sect 12.3.3.4 for 25% connection increase

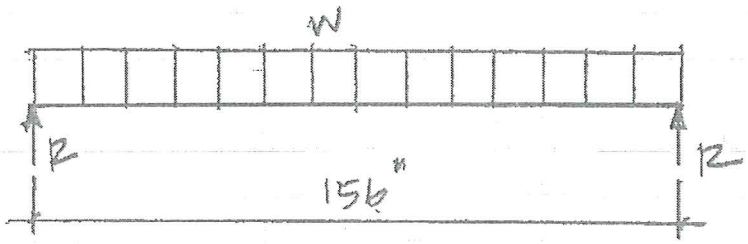
Model & Seismic Response Analysis - Permitted (see code for procedure)

ALLOWABLE STORY DRIFT

Structure Type: All other structures
Allowable story drift = 0.020hsx where hsx is the story height below level x

FLOOR CROSSMEMBER DESIGN

LOAD:



- TRY 24" CROSSMEMBER SPACING:

$$w = 2\left(50+8\right)\left(\frac{1}{12}\right) = 9.7 \text{ PLI}$$

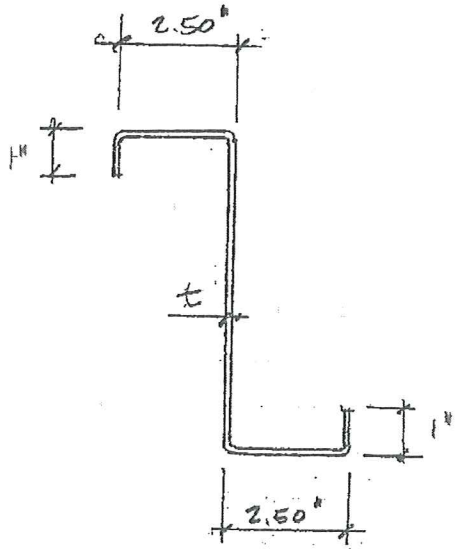
MOMENT:

$$M = \frac{9.7\,(156)^2}{8} = 29.5 \text{ IN·K}$$

∴ USE 7 × 2.5 × 1 × 11 GA CROSSMEMBERS @ 24" OC (M_{all} = 72.8 IN·K)

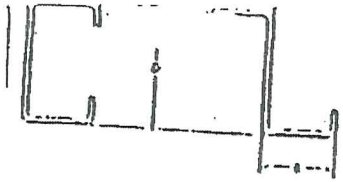
II CHASSIS DESIGN

D.) SECTIONAL PROPERTIES OF CROSS MEMBERS.

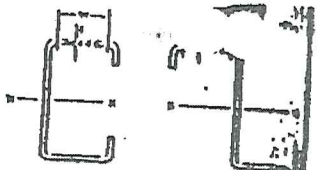


USE f_y = 36,000 psi STEEL; (F_b = 21.6 ksi)

MEMBER	t	I_x	S_x	M_{all}
7 x 2.5 x 1 x 14 GA	0.075" (14 GA)	7.66 IN^4	2.19 IN^3	47.3 IN·K
7 x 2.5 x 1 x 12 GA	0.105" (12 GA)	10.4 IN^4	2.98 IN^3	64.4 IN·K
7 x 2.5 x 1 x 11 GA	0.120" (11 GA)	11.76 IN^4	3.37 IN^3	72.8 IN·K



CHANNEL OR ZEE WITH STIFFENED FLANGES

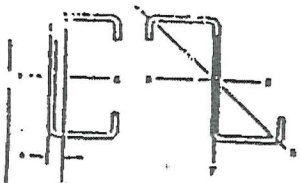


*Effective section for beam strength about the x-x axis where w/t of compression flange exceeds 28.4 for f_b = 20,000 psi and 23.2 for f_b = 30,000 psi.

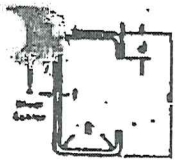
Nominal Size	Gage	t	Wt./Ft.	Beam Strength Effective S_x		Properties of Full Section								Column Factor		Dimensions of Sections					
				C-Z		Area	Axis x-x			Axis y-y				Axis 1-1	Product of Inertia	Q		C-Z			
				f_b = 20,000 psi	f_b = 30,000 psi	C-Z	I_x	S_x	r_x	C				I_1	I_{xy}	f_b = 20,000 psi	f_b = 30,000 psi	D	B	d	t	R	m
In.	No.	In.	Lbs.	In.³	In.³	Sq. In.	In.⁴	In.³	In.	I_y In.⁴	S_y In.³	r_y In.	$\bar{x}$ In.	$r_{min.}$ In.	In.⁴			In.	In.	In.	In.	In.	In.
12 x 3½	10	0.135	9.42	9.37	9.37	2.70	56.2	9.37	4.56	4.03	1.55	1.22	0.918	1.00	13.1	0.751	0.703	12.0	3.50	1.0	0.135	5/16	1.41
	12	0.105	7.31	7.31	7.32	2.10	43.8	7.31	4.57	3.09	1.18	1.21	0.881	1.00	10.1	0.689	0.640	12.0	3.50	0.9	0.105	5/16	1.41
10 x 3½	10	0.135	8.48	7.30	7.30	2.43	36.5	7.30	3.87	3.81	1.53	1.25	1.00	1.01	10.8	0.819	0.770	10.0	3.50	1.0	0.135	5/16	1.5
	12	0.105	6.57	5.70	5.64	1.89	28.5	5.70	3.89	2.93	1.16	1.25	0.975	1.01	8.36	0.756	0.705	10.0	3.50	0.9	0.105	5/16	1.4
	14	0.075	4.67	3.50	3.72	1.34	20.5	4.10	3.91	2.02	0.783	1.23	0.926	1.01	5.80	0.634	0.567	10.0	3.50	0.7	0.075	5/32	1.4
9 x 3½	10	0.135	7.77	6.04	6.04	2.23	27.2	6.04	3.49	3.08	1.35	1.17	0.965	0.947	8.51	0.852	0.803	9.0	3.25	1.0	0.135	5/16	1.4
	12	0.105	5.95	4.66	4.65	1.71	21.0	4.66	3.50	2.26	0.965	1.15	0.910	0.925	6.33	0.785	0.737	9.0	3.25	0.8	0.105	5/16	1.3
	14	0.075	4.28	3.29	3.15	1.23	15.3	3.40	3.53	1.63	0.689	1.15	0.888	0.928	4.56	0.674	0.607	9.0	3.25	0.7	0.075	5/32	1.3
	16	0.060	3.40	2.45	2.36	0.975	12.2	2.70	3.53	1.26	0.527	1.14	0.859	0.916	3.55	0.590	0.522	9.0	3.25	0.6	0.060	5/32	1.3
8 x 3	10	0.135	6.97	4.83	4.83	2.00	19.3	4.83	3.11	2.33	1.11	1.08	0.901	0.884	6.29	0.887	0.837	8.0	3.00	0.9	0.135	5/16	1.3
	12	0.105	5.40	3.78	3.78	1.55	15.1	3.78	3.12	1.79	0.840	1.07	0.873	0.860	4.85	0.821	0.774	8.0	3.00	0.8	0.105	5/16	1.3
	14	0.075	3.89	2.72	2.62	1.12	11.1	2.76	3.15	1.29	0.600	1.08	0.851	0.863	3.50	0.719	0.653	8.0	3.00	0.7	0.075	5/32	1.3
	16	0.060	3.08	2.06	1.95	0.885	8.79	2.20	3.15	0.997	0.458	1.06	0.822	0.851	2.73	0.635	0.565	8.0	3.00	0.6	0.060	5/32	1.3
7 x 2½	10	0.135	6.17	3.75	3.75	1.77	13.1	3.75	2.72	1.71	0.823	0.982	0.837	0.782	4.49	0.924	0.876	7.0	2.75	0.8	0.135	5/16	1.1
	12	0.105	4.86	2.90	2.98	1.39	10.4	2.98	2.74	1.38	0.723	0.996	0.857	0.793	3.61	0.861	0.814	7.0	2.75	0.8	0.105	5/16	1.1
	14	0.075	3.50	2.18	2.11	1.00	7.66	2.19	2.76	1.00	0.517	0.999	0.815	0.796	2.61	0.784	0.701	7.0	2.75	0.7	0.075	5/32	1.1
	16	0.060	2.77	1.67	1.59	0.795	6.10	1.74	2.77	0.773	0.393	0.986	0.786	0.785	2.03	0.646	0.615	7.0	2.75	0.6	0.060	5/32	1.1
6 x 2½	10	0.135	5.37	2.81	2.81	1.54	8.42	2.81	2.34	1.21	0.700	0.885	0.778	0.699	3.06	0.962	0.919	6.0	2.50	0.7	0.135	5/16	1.1
	12	0.105	4.23	2.24	2.24	1.21	6.72	2.24	2.35	0.983	0.570	0.900	0.774	0.710	2.48	0.905	0.858	6.0	2.50	0.7	0.105	5/16	1.1
	14	0.075	3.10	1.68	1.65	0.891	5.04	1.68	2.38	0.756	0.440	0.921	0.780	0.729	1.88	0.815	0.759	6.0	2.50	0.7	0.075	5/32	1.1
	16	0.060	2.46	1.31	1.26	0.705	4.01	1.34	2.39	0.583	0.333	0.910	0.751	0.718	1.46	0.744	0.674	6.0	2.50	0.6	0.060	5/32	1.1
5 x 2	10	0.135	4.43	1.88	1.88	1.27	4.69	1.88	1.92	0.651	0.480	0.715	0.644	0.570	1.68	0.994	0.968	5.0	2.00	0.7	0.135	5/16	0.9
	12	0.105	3.50	1.51	1.51	1.00	3.76	1.51	1.94	0.534	0.394	0.729	0.643	0.580	1.37	0.951	0.907	5.0	2.00	0.7	0.105	5/16	0.9
	14	0.075	2.53	1.12	1.12	0.726	2.80	1.12	1.96	0.390	0.283	0.733	0.622	0.583	0.998	0.858	0.811	5.0	2.00	0.6	0.075	5/32	0.9
	16	0.060	2.00	0.890	0.881	0.573	2.23	0.891	1.97	0.298	0.212	0.721	0.596	0.573	0.772	0.801	0.745	5.0	2.00	0.5	0.060	5/32	0.8
	18	0.048	1.61	0.706	0.681	0.461	1.80	0.722	1.98	0.244	0.173	0.727	0.594	0.577	0.629	0.737	0.670	5.0	2.00	0.5	0.048	5/32	0.8
4 x 2	10	0.135	3.96	1.38	1.38	1.14	2.76	1.38	1.56	0.601	0.466	0.727	0.712	0.571	0.458	1.00	0.998	4.0	2.00	0.7	0.135	5/16	0.9
	12	0.105	3.14	1.11	1.11	0.900	2.22	1.11	1.57	0.493	0.383	0.740	0.712	0.580	0.376	0.994	0.968	4.0	2.00	0.7	0.105	5/16	0.9
	14	0.075	2.27	0.832	0.832	0.651	1.67	0.832	1.60	0.361	0.276	0.745	0.689	0.583	0.998	0.926	0.885	4.0	2.00	0.6	0.075	5/32	0.9
	16	0.060	1.79	0.665	0.655	0.513	1.33	0.665	1.61	0.272	0.206	0.735	0.660	0.573	0.772	0.875	0.821	4.0	2.00	0.5	0.060	5/32	0.9
	18	0.048	1.44	0.529	0.508	0.413	1.08	0.540	1.62	0.226	0.169	0.740	0.660	0.577	0.629	0.810	0.738	4.0	2.00	0.5	0.048	5/32	0.9
3½ x 2	10	0.135	3.73	1.15	1.15	1.07	2.01	1.15	1.37	0.571	0.458	0.730	0.753	0.555	0.444	1.00	1.000	3.5	2.00	0.7	0.135	5/16	1.0
	12	0.105	2.95	0.927	0.927	0.847	1.62	0.927	1.38	0.469	0.376	0.744	0.753	0.564	0.361	1.00	0.991	3.5	2.00	0.7	0.105	5/16	1.0
	14	0.075	2.14	0.699	0.699	0.613	1.22	0.699	1.41	0.344	0.271	0.750	0.729	0.556	0.681	0.959	0.922	3.5	2.00	0.6	0.075	5/32	0.9
	16	0.060	1.68	0.559	0.551	0.483	0.979	0.560	1.42	0.264	0.203	0.740	0.699	0.547	0.529	0.914	0.861	3.5	2.00	0.5	0.060	5/32	0.9
	18	0.048	1.36	0.444	0.436	0.389	0.795	0.455	1.43	0.216	0.166	0.745	0.699	0.551	0.432	0.851	0.779	3.5	2.00	0.5	0.048	5/32	0.9
3 x 1½	12	0.105	2.59	0.679	0.679	0.742	1.02	0.679	1.17	0.319	0.300	0.655	0.649	0.488	0.610	1.000	1.000	3.0	1.75	0.7	0.105	5/16	0.9
	14	0.075	1.82	0.509	0.509	0.523	0.764	0.509	1.21	0.218	0.196	0.647	0.635	0.477	0.430	0.985	0.954	3.0	1.75	0.5	0.075	5/32	0.8
	16	0.060	1.47	0.416	0.416	0.423	0.624	0.416	1.22	0.181	0.162	0.654	0.635	0.482	0.354	0.949	0.910	3.0	1.75	0.4	0.060	5/32	0.8
	18	0.048	1.16	0.331	0.322	0.331	0.488	0.332	1.23	0.137	0.119	0.642	0.601	0.471	0.272	0.900	0.840	3.0	1.75	0.4	0.048	5/32	0.8

NOTE: The effective section modulii in bending about the y-y axis have not been tabulated. When one of the webs acts as a compression flange the section modulus should be calculated on the basis of the effective width as provided in Section 2.5 of the Design Specification. When the web acts as a tension flange the section modulus of the full section is effective.

For all of the sections listed in this table the moment of inertia, I_x, of the full section may be used in deflection calculations without appreciable error.



CHANNEL OR ZEE WITH STIFFENED FLANGES



DIMENSIONS: Equipment and forming practices vary with different manufacturers, resulting in minor variations in some These minor variations do not affect the published properties. Consult the manufacturer for actual weight per foot and

Project: DECK JOIST DESIGN
Location: Floor Joist (Deck)
Floor Joist
[2013 California Building Code(2012 NDS)]
1.5 IN x 7.25 IN x 11.0 FT @ 16 O.C.
#2 - Hem-Fir - Wet Use
Section Adequate By: 9.8%
Controlling Factor: Moment

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DEFLECTIONS	Center	
Live Load	0.39	IN L/335
Dead Load	0.06	in
Total Load	0.46	IN L/289

Live Load Deflection Criteria: L/240 Total Load Deflection Criteria: L/180

REACTIONS	A	B
Live Load	367 lb	367 lb
Dead Load	59 lb	59 lb
Total Load	425 lb	425 lb
Bearing Length	1.04 in	1.04 in

BEAM DATA	Center
Span Length	11 ft
Unbraced Length-Top	0 ft
Unbraced Length-Bottom	0 ft

Floor sheathing applied to top of joists-top of joists fully braced.
Floor Duration Factor 1.00

LOADING DIAGRAM

MATERIAL PROPERTIES
#2 - Hem-Fir

	Base Values	Adjusted
Bending Stress:	Fb = 850 psi	Fb' = 1173 psi
	Cd=1.00 CF=1.20 Cr=1.15	
Shear Stress:	Fv = 150 psi	Fv' = 146 psi
	Cd=1.00 Cm=0.97	
Modulus of Elasticity:	E = 1300 ksi	E' = 1170 ksi
	Cm=0.90	
Comp. ⊥ to Grain:	Fc - ⊥ = 405 psi	Fc - ⊥' = 271 psi
	Cm=0.67	

Controlling Moment: 1170 ft-lb
5.5 Ft from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2
Controlling Shear: 383 lb
At a distance d from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2

Comparisons with required sections:	Req'd	Provided
Section Modulus:	11.97 in3	13.14 in3
Area (Shear):	3.95 in2	10.88 in2
Moment of Inertia (deflection):	34.12 in4	47.63 in4
Moment:	1170 ft-lb	1284 ft-lb
Shear:	383 lb	1055 lb

JOIST LOADING

Uniform Floor Loading		Center	
Live Load	LL =	50	psf
Dead Load	DL =	8	psf
Total Load	TL =	58	psf
TL Adj. For Joist Spacing	wT =	77.3	plf

NOTES

Project: DECK BEAM DESIGN

Location: Uniformly Loaded Floor Beam
Uniformly Loaded Floor Beam
[2013 California Building Code(AISC 14th Ed ASD)]
HSS 10 x 2 x 3/16 x 8.0 FT / ASTM A500-GR.B-46
Section Adequate By: 657.3%
Controlling Factor: Moment

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StruCalc Version 9.0.1.4 6/25/2015 9:51:25 AM

DEFLECTIONS Center

Live Load	0.03	IN L/3539
Dead Load	0.01	in
Total Load	0.03	IN L/2945

Live Load Deflection Criteria: L/360 Total Load Deflection Criteria: L/240

REACTIONS

	A	B
Live Load	1400 lb	1400 lb
Dead Load	282 lb	282 lb
Total Load	1682 lb	1682 lb
Bearing Length	0.35 in	0.35 in

BEAM DATA Center

Span Length	8 ft
Unbraced Length-Top	8 ft

STEEL PROPERTIES
HSS 10 x 2 x 3/16 - A500-GR.B-46

Properties:

Steel Yield Strength:	Fy =	46	ksi
Modulus of Elasticity:	E =	29000	ksi
Tube Steel Section (X Axis):	dx =	10	in
Tube Steel Section (Y Axis):	dy =	2	in
Tube Steel Wall Thickness:	t =	0.174	in
Area:	A =	3.98	in2
Moment of Inertia (X Axis):	Ix =	41	in4
Section Modulus (X Axis):	Sx =	8.19	in3
Plastic Section Modulus (X Axis):	Zx =	11.1	in3
Plastic Section Modulus (Y Axis):	Zy =	3.34	in3

Design Properties per AISC 14th Edition Steel Manual:

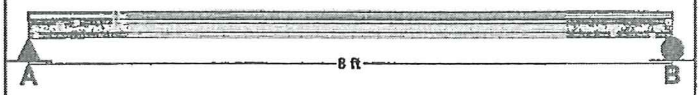
Flange Buckling Ratio:	FBR =	8.49	
Allowable Flange Buckling Ratio:	AFBR =	28.12	
Allowable Flange Buckling Ratio non-compact:	AFBR_NC =	35.15	
Web Buckling Ratio:	WBR =	54.47	
Allowable Web Buckling Ratio for Eqn. F7-5:	AWBR =	60.76	
Nominal Flexural Strength w/ Safety Factor:	Mn =	25479	ft-lb
Controlling Equation:	F7-1		
Web height to thickness ratio:	h/tw =	54.47	lb
Limiting height to thickness ratio for eqn. G2-2:	h/tw-limit =	56.24	
Cv Factor:	Cv =	1	
Controlling Equation:	G2-2		
Nominal Shear Strength w/ safety factor:	Vn =	60690	

Controlling Moment: 3364 ft-lb
4.0 ft from left support
Created by combining all dead and live loads.

Controlling Shear: -1682 lb
At support.
Created by combining all dead and live loads.

Comparisons with required sections:	Req'd	Provided
Moment of Inertia (deflection):	4.17 in4	41 in4
Moment:	3364 ft-lb	25479 ft-lb
Shear:	-1682 lb	60690 lb

LOADING DIAGRAM



FLOOR LOADING

		Side 1		Side 2	
Floor Live Load	FLL =	50	psf	0	psf
Floor Dead Load	FDL =	8	psf	0	psf
Floor Tributary Width	FTW =	7	ft	0	ft
Wall Load	WALL =	0	plf		

BEAM LOADING

Beam Total Live Load:	wL =	350	plf
Beam Total Dead Load:	wD =	56	plf
Beam Self Weight:	BSW =	15	plf
Total Maximum Load:	wT =	421	plf

NOTES

Project: EXT. WALL STUD DESIGN

Location: Column
Column
[2013 California Building Code(2012 NDS)]
1.5 IN x 7.25 IN x 12.0 FT @ 16 O.C.
#2 - Hem-Fir - Wet Use
Section Adequate By: 72.8%

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DEFLECTIONS

Deflection due to lateral loads only:	Defl = 0.22	IN = L/668
Live Load Deflection Criteria:		L/180

VERTICAL REACTIONS

Live Load:	Vert-LL-Rxn =	0	lb
Dead Load:	Vert-DL-Rxn =	24	lb
Total Load:	Vert-TL-Rxn =	24	lb

HORIZONTAL REACTIONS

Total Reaction at Top of Column:	TL-Rxn-Top =	154	lb
Total Reaction at Bottom of Column:	TL-Rxn-Bottom =	154	lb

COLUMN DATA

Total Column Length:	12	ft
Unbraced Length (X-Axis) Lx:	12	ft
Unbraced Length (Y-Axis) Ly:	0	ft
Column End Condtion-K (e):	1	
Axial Load Duration Factor	1.00	
Lateral Load Duration Factor (Wind/Seismic)	1.33	

COLUMN PROPERTIES

#2 - Hem-Fir

	Base Values	Adjusted
Compressive Stress:	Fc = 1300 psi	Fc' = 732 psi
	Cm=0.80 Cf=1.05 Cp=0.50	
Bending Stress (X-X Axis):	Fbx = 850 psi	Fbx' = 1560 psi
	Cd=1.33 CF=1.20 Cr=1.15 Cl=1.00	
Bending Stress (Y-Y Axis):	Fby = 850 psi	Fby' = 1560 psi
	Cd=1.33 CF=1.20 Cr=1.15	
Modulus of Elasticity:	E = 1300 ksi	E' = 1170 ksi

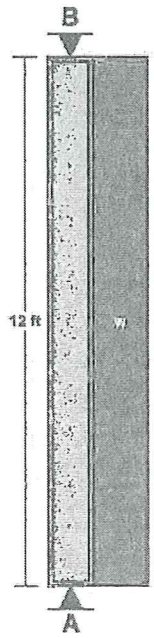
Column Section (X-X Axis):	dx =	7.25	in
Column Section (Y-Y Axis):	dy =	1.5	in
Area:	A =	10.88	in2
Section Modulus (X-X Axis):	Sx =	13.14	in3
Section Modulus (Y-Y Axis):	Sy =	2.72	in3
Slenderness Ratio:	Lex/dx =	19.86	
	Ley/dy =	0	

Column Calculations (Controlling Case Only):

Controlling Load Case: Axial Dead Load and Lateral loads (D + W or E)

Actual Compressive Stress:	Fc =	2	psi
Allowable Compressive Stress:	Fc' =	732	psi
Eccentricity Moment (X-X Axis):	Mx-ex =	0	ft-lb
Eccentricity Moment (Y-Y Axis):	My-ey =	0	ft-lb
Moment Due to Lateral Loads (X-X Axis):	Mx =	463	ft-lb
Moment Due to Lateral Loads (Y-Y Axis):	My =	0	ft-lb
Bending Stress Lateral Loads Only (X-X Axis):	Fbx =	423	psi
Allowable Bending Stress (X-X Axis):	Fbx' =	1560	psi
Bending Stress Lateral Loads Only (Y-Y Axis):	Fby =	0	psi
Allowable Bending Stress (Y-Y Axis):	Fby' =	1560	psi
Combined Stress Factor:	**CSF =**	**0.27**	

LOADING DIAGRAM



AXIAL LOADING

Live Load:	PL =	0 plf
Dead Load:	PD =	0 plf
Column Self Weight:	CSW =	24 plf
Total Load:	PT =	24 plf

LATERAL LOADING (Dy Face)

Uniform Lateral Load:	wL-Lat =	19 psf

NOTES

Project: HEADER DESIGN - 6'-0" MAX. OPNG.
Location: Multi-Loaded Multi-Span Beam
Multi-Loaded Multi-Span Beam
[2013 California Building Code(2012 NDS)]
(2) 1.5 IN x 7.25 IN x 6.0 FT (Weak Axis Bending - Flat Use)
#2 - Hem-Fir - Dry Use
Section Adequate By: 22.5%
Controlling Factor: Deflection

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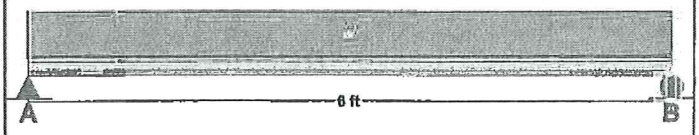
DEFLECTIONS	Center	
Live Load	0.47	IN L/154
Dead Load	0.02	in
Total Load	0.49	IN L/147

Live Load Deflection Criteria: L/120 Total Load Deflection Criteria: L/120

REACTIONS	A	B
Live Load	255 lb	255 lb
Dead Load	12 lb	12 lb
Total Load	267 lb	267 lb
Bearing Length	0.05 in	0.05 in

BEAM DATA	Center
Span Length	6 ft
Unbraced Length-Top	6 ft
Unbraced Length-Bottom	6 ft
Live Load Duration Factor	1.60
Notch Depth	0.00

LOADING DIAGRAM



UNIFORM LOADS	Center
Uniform Live Load	85 plf
Uniform Dead Load	0 plf
Beam Self Weight	4 plf
Total Uniform Load	89 plf

MATERIAL PROPERTIES
#2 - Hem-Fir

	Base Values	Adjusted
Bending Stress:	Fb = 850 psi	Fb' = 1877 psi
	Cd=1.60 Ci=1.00 CF=1.20 Cfu=1.15	
Shear Stress:	Fv = 150 psi	Fv' = 240 psi
	Cd=1.60	
Modulus of Elasticity:	E = 1300 ksi	E' = 1300 ksi
Comp. ⊥ to Grain:	Fc - ⊥ = 405 psi	Fc - ⊥' = 405 psi

Controlling Moment: 401 ft-lb
3.0 Ft from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2
Controlling Shear: 256 lb
At a distance d from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2

Comparisons with required sections:	Req'd	Provided
Section Modulus:	2.56 in3	5.44 in3
Area (Shear):	1.6 in2	21.75 in2
Moment of Inertia (deflection):	3.33 in4	4.08 in4
Moment:	401 ft-lb	850 ft-lb
Shear:	256 lb	3460 lb

NOTES

Project: HEADER DESIGN - 12'-0" MAX. OPNG.

Location: Multi-Loaded Multi-Span Beam
Multi-Loaded Multi-Span Beam
[2013 California Building Code(2012 NDS)]
(4) 1.5 IN x 7.25 IN x 12.0 FT (Weak Axis Bending - Flat Use)
#2 - Hem-Fir - Dry Use
Section Adequate By: 46.5%
Controlling Factor: Deflection

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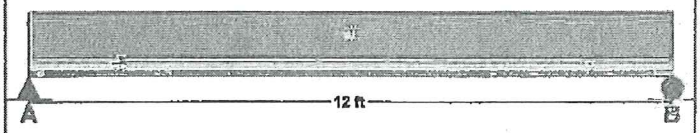
DEFLECTIONS	Center	
Live Load	2.07	IN L/70
Dead Load	0.36	in
Total Load	2.42	IN L/59

Live Load Deflection Criteria: L/40 Total Load Deflection Criteria: L/40

REACTIONS	A	B
Live Load	282 lb	282 lb
Dead Load	49 lb	49 lb
Total Load	331 lb	331 lb
Bearing Length	0.03 in	0.03 in

BEAM DATA	Center
Span Length	12 ft
Unbraced Length-Top	12 ft
Unbraced Length-Bottom	12 ft
Live Load Duration Factor	1.60
Notch Depth	0.00

LOADING DIAGRAM



UNIFORM LOADS	Center
Uniform Live Load	47 plf
Uniform Dead Load	0 plf
Beam Self Weight	8 plf
Total Uniform Load	55 plf

MATERIAL PROPERTIES
#2 - Hem-Fir

	Base Values	Adjusted
Bending Stress:	Fb = 850 psi	Fb' = 1877 psi
	Cd=1.60 Cl=1.00 CF=1.20 Cfu=1.15	
Shear Stress:	Fv = 150 psi	Fv' = 240 psi
	Cd=1.60	
Modulus of Elasticity:	E = 1300 ksi	E' = 1300 ksi
Comp. ⊥ to Grain:	Fc - ⊥ = 405 psi	Fc - ⊥' = 405 psi

Controlling Moment: 992 ft-lb
6.0 Ft from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2
Controlling Shear: -324 lb
At a distance d from right support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2

Comparisons with required sections:	Req'd	Provided
Section Modulus:	6.34 in3	10.88 in3
Area (Shear):	2.03 in2	43.5 in2
Moment of Inertia (deflection):	5.49 in4	8.16 in4
Moment:	992 ft-lb	1701 ft-lb
Shear:	-324 lb	6960 lb

NOTES

Project: JAMB STUD DESIGN (12' OPNG)
Location: Column
Column
[2013 California Building Code(2012 NDS)]
1.5 IN x 7.25 IN x 12.0 FT
#2 - Hem-Fir - Dry Use
Section Adequate By: 43.1%

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DEFLECTIONS

Deflection due to lateral loads only:	Defl = 0.36	IN = L/395
Live Load Deflection Criteria:		L/180

VERTICAL REACTIONS

Live Load:	Vert-LL-Rxn =	0 lb
Dead Load:	Vert-DL-Rxn =	24 lb
Total Load:	Vert-TL-Rxn =	24 lb

HORIZONTAL REACTIONS

Total Reaction at Top of Column:	TL-Rxn-Top =	232 lb
Total Reaction at Bottom of Column:	TL-Rxn-Bottom =	203 lb

COLUMN DATA

Total Column Length:	12 ft
Unbraced Length (X-Axis) Lx:	12 ft
Unbraced Length (Y-Axis) Ly:	0 ft
Column End Condtion-K (e):	1
Axial Load Duration Factor	1.00
Lateral Load Duration Factor (Wind/Seismic)	1.60

COLUMN PROPERTIES

#2 - Hem-Fir

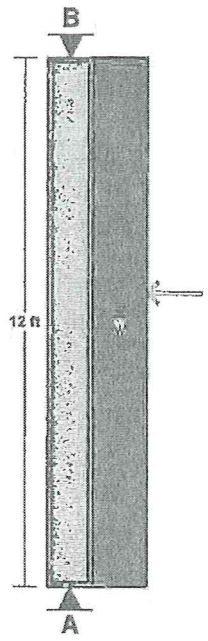
	Base Values	Adjusted
Compressive Stress:	Fc = 1300 psi	Fc' = 866 psi
	Cd=1.60 Cf=1.05 Cp=0.40	
Bending Stress (X-X Axis):	Fbx = 850 psi	Fbx' = 1632 psi
	Cd=1.60 CF=1.20 Cl=1.00	
Bending Stress (Y-Y Axis):	Fby = 850 psi	Fby' = 1632 psi
	Cd=1.60 CF=1.20	
Modulus of Elasticity:	E = 1300 ksi	E' = 1300 ksi

Column Section (X-X Axis):	dx =	7.25	in
Column Section (Y-Y Axis):	dy =	1.5	in
Area:	A =	10.88	in2
Section Modulus (X-X Axis):	Sx =	13.14	in3
Section Modulus (Y-Y Axis):	Sy =	2.72	in3
Slenderness Ratio:	Lex/dx =	19.86	
	Ley/dy =	0	

Column Calculations (Controlling Case Only):
Controlling Load Case: Axial Dead Load and Lateral loads (D + W or E)

Actual Compressive Stress:	Fc =	2	psi
Allowable Compressive Stress:	Fc' =	866	psi
Eccentricity Moment (X-X Axis):	Mx-ex =	0	ft-lb
Eccentricity Moment (Y-Y Axis):	My-ey =	0	ft-lb
Moment Due to Lateral Loads (X-X Axis):	Mx =	1015	ft-lb
Moment Due to Lateral Loads (Y-Y Axis):	My =	0	ft-lb
Bending Stress Lateral Loads Only (X-X Axis):	Fbx =	927	psi
Allowable Bending Stress (X-X Axis):	Fbx' =	1632	psi
Bending Stress Lateral Loads Only (Y-Y Axis):	Fby =	0	psi
Allowable Bending Stress (Y-Y Axis):	Fby' =	1632	psi
Combined Stress Factor:	CSF =	0.57	

LOADING DIAGRAM



AXIAL LOADING

Live Load:	PL =	0 lb
Dead Load:	PD =	0 lb
Column Self Weight:	CSW =	24 lb
Total Load:	PT =	24 lb

LATERAL LOADING

(Dy Face)

Uniform Lateral Load:	w-Lat = 15 plf
Point Load:	One
Live Load:	255 lb
Location:	5.3 ft

NOTES

Project: RAFTER DESIGN - 13' SPAN

Location: Roof Rafter
Roof Rafter
[2013 California Building Code(2012 NDS)]
1.5 IN x 11.25 IN x 13.0 FT @ 24 O.C.
#2 - Hem-Fir - Dry Use
Section Adequate By: 154.2%
Controlling Factor: Moment

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DEFLECTIONS Center

Live Load	0.11	IN L/1404
Dead Load	0.06	in
Total Load	0.17	IN L/936

Live Load Deflection Criteria: L/240 Total Load Deflection Criteria: L/180

RAFTER REACTIONS

	LOADS	REACTIONS
Upper Live Load @ A	130 plf	260 lb
Upper Dead Load @ A	65 plf	130 lb
Upper Total Load @ A	195 plf	390 lb
Lower Live Load @ B	130 plf	260 lb
Lower Dead Load @ B	65 plf	130 lb
Lower Total Load @ B	195 plf	390 lb

RAFTER SUPPORT DATA

	A	B
Bearing Length	0.64 in	0.64 in

RAFTER DATA Interior

Span Length 13 ft
Rafter Pitch 0.25 :12
Roof sheathing applied to top of joists-top of rafters fully braced.
Roof Duration Factor 1.25
Peak Notch Depth 0.00
Base Notch Depth 0.00

MATERIAL PROPERTIES

#2 - Hem-Fir

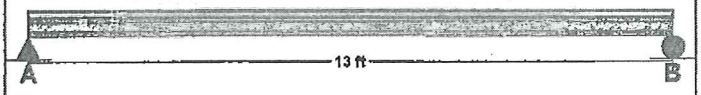
	Base Values	Adjusted
Bending Stress:	Fb = 850 psi	Fb' = 1222 psi
	Cd=1.25 CF=1.00 Cr=1.15	
Shear Stress:	Fv = 150 psi	Fv' = 188 psi
	Cd=1.25	
Modulus of Elasticity:	E = 1300 ksi	E' = 1300 ksi
Comp. ⊥ to Grain:	Fc - ⊥ = 405 psi	Fc - ⊥' = 405 psi

Controlling Moment: 1268 ft-lb
6.499 Ft from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2

Controlling Shear: 335 lb
At a distance d from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2

Comparisons with required sections:	Req'd	Provided
Section Modulus:	12.45 in3	31.64 in3
Area (Shear):	2.68 in2	16.88 in2
Moment of Inertia (deflection):	34.23 in4	177.98 in4
Moment:	1268 ft-lb	3222 ft-lb
Shear:	335 lb	2109 lb

LOADING DIAGRAM



RAFTER LOADING

Uniform Roof Loading

Roof Live Load:	LL =	20	psf
Roof Dead Load:	DL =	10	psf

Slope Adjusted Spans And Loads

Interior Span:	L-adj =	13	ft
Eave Span:	L-Eave-adj =	0	ft
Rafter Live Load:	wL-adj =	40	plf
Eave Live Load:	wL-Eave-adj =	40	plf
Rafter Dead Load:	wD-adj =	20	plf
Rafter Total Load:	wT-adj =	60	plf
Eave Total Load:	wT-Eave-adj =	60	plf

NOTES

Project: RAFTER DESIGN - 4.5' SPAN

Location: Roof Rafter
Roof Rafter
[2013 California Building Code(2012 NDS)]
1.5 IN x 5.5 IN x 4.5 FT @ 24 O.C.
#2 - Hem-Fir - Dry Use
Section Adequate By: 559.1%
Controlling Factor: Moment

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DEFLECTIONS Center

Live Load	0.01	IN L/3956
Dead Load	0.01	in
Total Load	0.02	IN L/2637

Live Load Deflection Criteria: L/240 Total Load Deflection Criteria: L/180

RAFTER REACTIONS

	LOADS	REACTIONS
Upper Live Load @ A	45 plf	90 lb
Upper Dead Load @ A	23 plf	45 lb
Upper Total Load @ A	68 plf	135 lb
Lower Live Load @ B	45 plf	90 lb
Lower Dead Load @ B	23 plf	45 lb
Lower Total Load @ B	68 plf	135 lb

RAFTER SUPPORT DATA

	A	B
Bearing Length	0.22 in	0.22 in

RAFTER DATA Interior

Span Length 4.5 ft
Rafter Pitch 0.25 :12
Roof sheathing applied to top of joists-top of rafters fully braced.
Roof Duration Factor 1.25
Peak Notch Depth 0.00
Base Notch Depth 0.00

MATERIAL PROPERTIES

#2 - Hem-Fir

	Base Values	Adjusted
Bending Stress:	Fb = 850 psi	Fb' = 1588 psi
	Cd=1.25 CF=1.30 Cr=1.15	
Shear Stress:	Fv = 150 psi	Fv' = 188 psi
	Cd=1.25	
Modulus of Elasticity:	E = 1300 ksi	E' = 1300 ksi
Comp. ⊥ to Grain:	Fc - ⊥ = 405 psi	Fc - ⊥' = 405 psi

Controlling Moment: 152 ft-lb
2.25 Ft from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2
Controlling Shear: 108 lb
At a distance d from left support of span 2 (Center Span)
Created by combining all dead loads and live loads on span(s) 2

Comparisons with required sections:	Req'd	Provided
Section Modulus:	1.15 in3	7.56 in3
Area (Shear):	0.86 in2	8.25 in2
Moment of Inertia (deflection):	1.42 in4	20.8 in4
Moment:	152 ft-lb	1001 ft-lb
Shear:	108 lb	1031 lb

LOADING DIAGRAM

RAFTER LOADING

Uniform Roof Loading

Roof Live Load:	LL =	20 psf
Roof Dead Load:	DL =	10 psf

Slope Adjusted Spans And Loads

Interior Span:	L-adj =	4.5 ft
Eave Span:	L-Eave-adj =	0 ft
Rafter Live Load:	wL-adj =	40 plf
Eave Live Load:	wL-Eave-adj =	40 plf
Rafter Dead Load:	wD-adj =	20 plf
Rafter Total Load:	wT-adj =	60 plf
Eave Total Load:	wT-Eave-adj =	60 plf

NOTES

Project: ROOF BEAM DESIGN - 21' SPAN

Location: Roof Beam
Roof Beam
[2013 California Building Code(AISC 14th Ed ASD)]
A36 C12x20.7 x 21.0 FT
Section Adequate By: 15.0%
Controlling Factor: Moment

Kevin C. Day, P.E.
Acumen Engineering, Inc.
12808 South 600 East
Draper, UT 84020

StruCalc Version 9.0.1.4 6/23/2015 10:50:47 AM

DEFLECTIONS Center

Live Load	0.16	IN L/1596
Dead Load	0.10	in
Total Load	0.26	IN L/965

Live Load Deflection Criteria: L/240 Total Load Deflection Criteria: L/180

REACTIONS

	A	B
Live Load	1418 lb	1418 lb
Dead Load	926 lb	926 lb
Total Load	2344 lb	2344 lb
Bearing Length	1.13 in	1.13 in

BEAM DATA

Span Length	21 ft
Unbraced Length-Top	21 ft
Unbraced Length-Bottom	0 ft
Roof Pitch	0.25:12

STEEL PROPERTIES
C12x20.7 - A36

Properties:

Yield Stress:	Fy =	36 ksi
Modulus of Elasticity:	E =	29000 ksi
Depth:	d =	12 in
Web Thickness:	tw =	0.26 in
Flange Width:	bf =	2.94 in
Flange Thickness:	tf =	0.5 in
Distance to Web Toe of Fillet:	k =	1.13 in
Moment of Inertia About X-X Axis:	Ix =	129 in4
Section Modulus About X-X Axis:	Sx =	21.5 in3
Plastic Section Modulus About X-X Axis:	Zx =	25.6 in3

Design Properties per AISC 14th Edition Steel Manual:

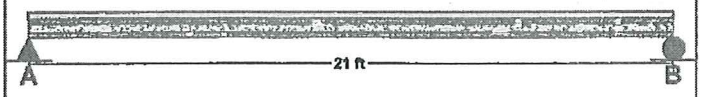
Flange Buckling Ratio:	FBR =	2.93
Allowable Flange Buckling Ratio:	AFBR =	10.79
Web Buckling Ratio:	WBR =	34.54
Allowable Web Buckling Ratio:	AWBR =	106.72
Controlling Unbraced Length:	Lb =	21 ft
Limiting Unbraced Length - for lateral-torsional buckling:	Lp =	3.32 ft
for Eqn. F2-2:	Lr =	12.13 ft
Elastic lateral-torsional buckling stress:	Fcr =	13.19 ksi
Nominal Flexural Strength w/ safety factor:	Mn =	14146 ft-lb
Controlling Equation:		F2-3
Web height to thickness ratio:	h/tw =	34.54
Limiting height to thickness ratio for eqn. G2-2:	h/tw-limit =	63.58
Cv Factor:	Cv =	1
Controlling Equation:		G2-3
Nominal Shear Strength w/ safety factor:	Vn =	43769 lb

Controlling Moment: 12305 ft-lb
10.5 ft from left support
Created by combining all dead and live loads.

Controlling Shear: -2344 lb
At support.
Created by combining all dead and live loads.

Comparisons with required sections:	Req'd	Provided
Moment of Inertia (deflection):	24.05 in4	129 in4
Moment:	12305 ft-lb	14146 ft-lb
Shear:	-2344 lb	43769 lb

LOADING DIAGRAM



ROOF LOADING

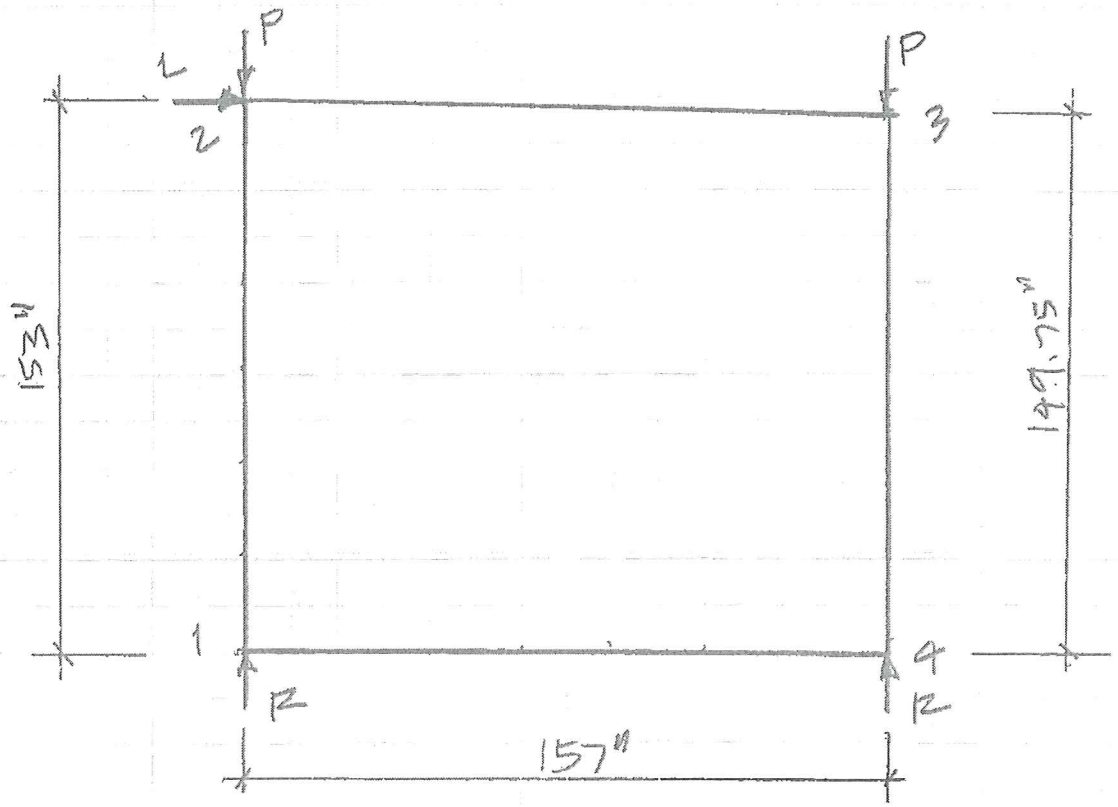
Side One:			
Roof Live Load:	LL =	20	psf
Roof Dead Load:	DL =	10	psf
Tributary Width:	TW =	6.8	ft
Side Two:			
Roof Live Load:	LL =	0	psf
Roof Dead Load:	DL =	0	psf
Tributary Width:	TW =	0	ft
Wall Load:	WALL =	0	plf

SLOPE/PITCH ADJUSTED LENGTHS AND LOADS

Adjusted Beam Length:	Ladj =	21	ft
Beam Self Weight:	BSW =	21	plf
Beam Uniform Live Load:	wL =	135	plf
Beam Uniform Dead Load:	wD_adj =	88	plf
Total Uniform Load:	wT =	223	plf

NOTES

TRANSVERSE FRAME DESIGN



GRAVITY LOADS:

$P = P_L + P_D$

$P_L = 1418\ \#$

$P_D = 926\ \#$

LATERAL LOADS:

$$L_W = 23.2(0.6)\left[\frac{162}{12}\left(\frac{1}{2}\right)\right]\left(\frac{21.5}{2}\right) = 1010\ \#$$

$$L_E = 0.125\left[\underbrace{(13.5)(21.5)(10)}_{\text{ROOF DL}} + \underbrace{\left(\frac{12.2}{2}\right)\left(\frac{21.5}{2}\right)(2)(10)}_{\text{EXT. WALL DL}}\right](2.5)(0.7) = 927\ \#$$

ΣL_D

VisualAnalysis 3.50.c Report (LOAD CASE: D + 0.75L + 0.75W)

20

06/23/15 16:02:55
Project: End Frame
File: C:\casadelsol.endframe.vap
Company: Acumen Engineering
Engineer: Kevin Day
Default Units: Inches, Kips, Degrees, °Fahrenheit, Seconds.

Nodal Reactions

Node	Load Case	FX K	FY K	MZ K-in
N1	Service Case 1	-0.3688	1.2513	-NA-
N4	"	-0.3892	2.7287	-NA-

Member Extreme Results

Member	Axial(lc) K	Vy(lc) K	Mz(lc) K-in	fc max(lc) ksi	fc min(lc) ksi
M1	-1.6121(1)	0.3688(1)	-27.88(1)	-0.2553(1)	-5.6525(1)
"	-1.6121(1)	0.3688(1)	28.5428(1)	5.0178(1)	-0.3794(1)
M2	-0.3970(1)	**-0.3697(1)**	-29.51(1)	-0.0426(1)	-1.4380(1)
"	-0.3970(1)	-0.3697(1)	28.5428(1)	1.3076(1)	-0.0878(1)
M3	**-2.3679(1)**	**0.3892(1)**	-29.51(1)	**-0.3967(1)**	**-5.9829(1)**
"	-2.3679(1)	0.3892(1)	**28.7724(1)**	**5.0507(1)**	-0.5355(1)
M4	**0.0000(1)**	-0.3608(1)	-28.77(1)	0.0331(1)	-2.1345(1)
"	0.0000(1)	-0.3608(1)	27.8790(1)	2.1345(1)	**-0.0331(1)**

Nodal Displacements

Node	Load Case	DX in	DY in	RZ deg
N1	Service Case 1	**0.0000**	**-0.0000**	-0.0207
N2	"	**0.3975**	-0.0017	**-0.0113**
N3	"	0.3971	**-0.0024**	-0.0125
N4	"	0.0000	-0.0000	**-0.0228**

Member Elements

Member	Section	Material	(1)Node	(2)Node	Length in	Weight K	Rz1	Rz2	One Way
M1	TS4x4x.	Steel	N1	N2	153.00	0.2204	Fix	Fix	Normal
M2	C12x20.	"	N2	N3	157.03	0.2712	"	"	"
M3	TS4x4x.	"	N3	N4	149.75	0.2157	"	"	"
M4	C10x15.	"	N1	"	157.00	0.1999	"	"	"

VisualAnalysis 3.50.c Report (LOAD CASE: D + W) 21

06/23/15 16:14:50
Project: End Frame
File: C:\hsmout.endframe.vap
Company: Acumen Engineering
Engineer: Kevin Day
Default Units: Inches, Kips, Degrees, °Fahrenheit, Seconds.

Nodal Reactions

Node	Load Case	FX K	FY K	MZ K-in
N1	Service Case 1	-0.4914	-0.0583	-NA-
N4	"	-0.5186	1.9103	-NA-

Member Extreme Results

Member	Axial(lc) K	Vy(lc) K	Mz(lc) K-in	fc max(lc) ksi	fc min(lc) ksi
M1	-0.4225(1)	0.4914(1)	-37.15(1)	-0.0006(1)	-7.1919(1)
"	-0.4225(1)	0.4914(1)	38.0315(1)	7.0255(1)	-0.1658(1)
M2	-0.5289(1)	**-0.4926(1)**	**-39.33(1)**	-0.0567(1)	-1.9160(1)
"	-0.5289(1)	-0.4926(1)	38.0315(1)	1.7423(1)	-0.1170(1)
M3	**-1.4295(1)**	**0.5186(1)**	-39.33(1)	**-0.1890(1)**	**-7.6322(1)**
"	-1.4295(1)	0.5186(1)	**38.3384(1)**	**7.0694(1)**	-0.3738(1)
M4	**0.0000(1)**	-0.4808(1)	-38.34(1)	0.0442(1)	-2.8441(1)
"	0.0000(1)	-0.4808(1)	37.1479(1)	2.8441(1)	**-0.0442(1)**

Nodal Displacements

Node	Load Case	DX in	DY in	RZ deg
N1	Service Case 1	0.0000	0.0000	-0.0276
N2	"	0.5296	-0.0004	-0.0151
N3	"	0.5291	-0.0015	-0.0167
N4	"	0.0000	-0.0000	-0.0303

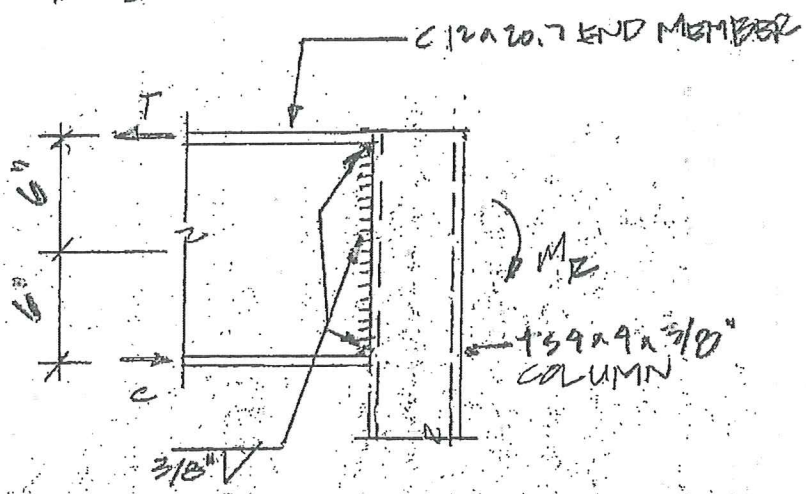
Member Elements

Member	Section	Material	(1)Node	(2)Node	Length in	Weight K	Rz1	Rz2	One Way
M1	TS4x4x.	Steel	N1	N2	153.00	0.2204	Fix	Fix	Normal
M2	C12x20.	"	N2	N3	157.03	0.2712	"	"	"
M3	TS4x4x.	"	N3	N4	149.75	0.2157	"	"	"
M4	C10x15.	"	N1	"	157.00	0.1999	"	"	"

TRANSVERSE FRAME DESIGN

COLUMN END CONNECTIONS

1) UPPER END



$M = 39.3$ IN·K

USE 3/8" FILLET WELDS, E70xx ELECTRODES

ALLOWABLE WELD STRESS = 0.30(70 ksi) = 21.0 ksi

EFFECTIVE THROAT = 0.707(3/8) = 0.265 IN

WELD STRENGTH PER INCH = 21.0(0.265) = 5.57 k/IN

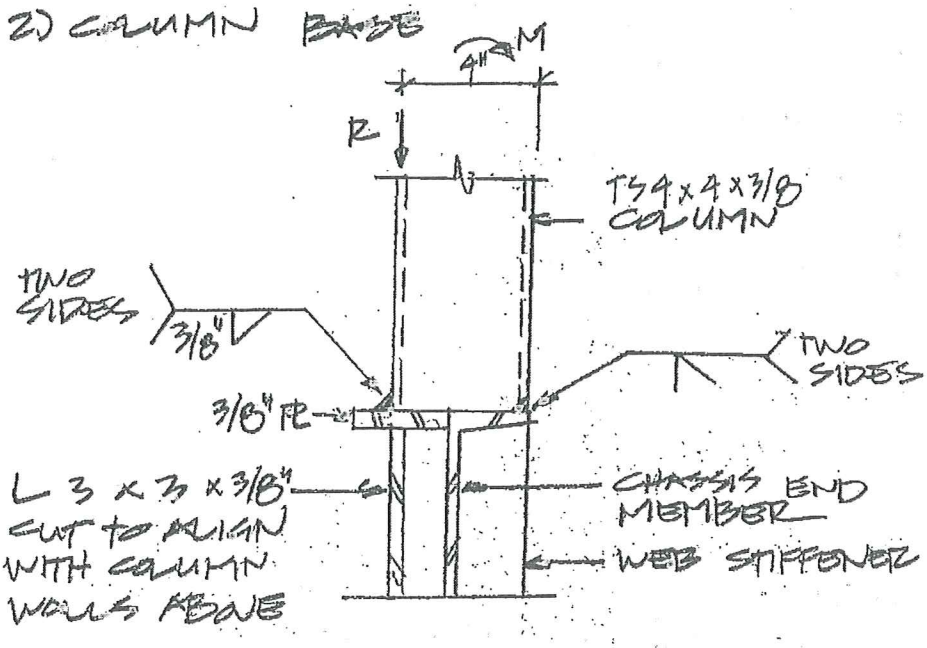
RESISTANT TO MOMENT:

$M_R = 5.57(2.2)(12) + 5.57(8.5)(6) = 431$ IN·K

TRANSVERSE FRAME DESIGN

COLUMN END CONNECTIONS

2) COLUMN BASE



$M = 37.2$ IN·K

USE 3/8" FILLET WELDS, E70XX ELECTRODES

ALLOWABLE WELD STRENGTH = 0.30(70 ksi) = 21.0 ksi

EFFECTIVE THROAT = 0.707 (3/8) = 0.265 IN

WELD STRENGTH PER INCH = 21.0 (0.265) = 5.57 K/IN

RESISTANCE TO MOMENT:

$$M_R = \underbrace{5.57\,(4")(4")}_{\text{SIDE OPPOSITE POINT OF ROTATION}} + \underbrace{5.57\,(4)(2)(2)}_{\text{TWO SIDES PERPENDICULAR TO POINT OF ROTATION}} = 178 \text{ IN·K} > M$$

LPA

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Team Orange – Solar Decathlon 2015

Irvine, CA

STRUCTURAL CALCULATIONS for CARPORT ROOF STRUCTURE

LPA Project No. 15005.10
June 2015

Structural Design Guidelines

Applicable Codes and Standards

The following codes and standards are specified:

2015 Solar Decathlon Building Code (SDBC)
2009 International Residential Code (IRC)

ASCE 7-05, Minimum Design Loads for buildings and Other Structures

The following structural design codes will be followed as specified by the governing codes and standards:

NDS, National Design Specification for Wood Construction (NDS)
AISC 230 Specification for Structural Steel Buildings

Structural Loading

Uniformly distributed live loadings.

The following values are specified by the applicable codes and standards or are higher values selected for use on this project

Wind:

Competition 85 mph (3-second gust), exposure category C – No Overturning, uplifting, or sliding with a safety factor of 2.

Permanent: 90 mph (3-second gust), exposure category C

Seismic Parameters

IRC Seismic Design Category (SDC) D_2 (See IRC R301.2.2) is used to calculate the design forces. The design base shear is found using the equivalent lateral force procedure with the following factors:

Short period map value (S_{DS}): 0.989 g

Assumed Site Class (Soil Factor): D

Railings:

200 lb (890 N) concentrated load applied in any direction at any point at the top of the rail

Interior Floor, Decks, Ramps:

50 psf (2.39 kPa) live load

Exterior Floor, Decks Ramps used for tour staging and egress purposes:

100 psf (4.79 kPa) live load

Roof:

20 psf (.958 kPA) live load

Temporary Paved Surface:

3,000 psf (143 kPa) maximum load-bearing pressure

Material Specifications:

Structural Timber: DF#1 – Solid Sawn
Structural Steel: ASTM A992, Fy = 50 ksi
Bolts & Plain Anchors: ASTM A307
Welding: E70XX electrodes

1.1 ROOF TAKEOFF

Great Room Roof Dead Load Takeoff

Roofing Type:	Roofing Material:	Weight (psf)
PV Panels	PV (18)	2
PV Racks	Aluminum	1
Exterior Membrane	TPO	0.4
Exterior Sheathing	3/4" Plywood	2.2
2x10 Joists @ 16" spacing	Douglas Fir	3
Insulation	Mineral Wool	4
Ceiling	1/2" Gypboard	2.2
Canopy Structure	Timber	
Miscellaneous	-	2.2
Roof Dead Load:	**17**	**psf**
Per California Building Code 2010:		
Roof Live Load:	**20**	**psf**

Master/Flex Roof Dead Load Takeoff

Roofing Type:	Roofing Material:	Weight (psf)
PV Panels	PV (18)	1.5
PV Racks	Aluminum	1
Exterior Membrane	PVC membrane	0.35
Exterior Sheathing	3/4" Plywood	2.2
2x10 Joists @ 16" OC	Douglas Fir	3
Insulation	Mineral Wool	4
Ceiling	1/2" Gyboard	2.2
Miscellaneous		1.75
Roof Dead Load:	**16**	**psf**
Per California Building Code 2010:		
Roof Live Load:	**20**	**psf**

1.2: FLOOR TAKEOFF :

Interior Floor Dead Load Takeoff

Interior Floor Dead Load Takeoff

Flooring Type:	Flooring Material	Floor (psf)			
Flooring	Bamboo	4			
Sheathing	3/4" Plywood	2.3			
Joists	2x10 DF1	7			
Miscellaneous		3			
		16.3			
Use (Rounding)		**17**	**psf**		
Per Solar Decathlon Building Code 2013:			**Floor Live Load**	**50**	**psf**

Outdoor Deck Dead Load Takeoff

Decking:	Decking Material:	Deck (psf)			
Deck	1" Hardwood	4			
Beams	Solid Sawn	-			
Miscellaneous		2			
		6			
Use (Rounding)		**6**			
Per Solar Decathlon Building Code 2013:			**Deck Live Load**	**100**	**psf**

	Project				Job Ref.	
CASA DEL SOL Team Orange County	Casa Del Sol					
	Section				Sheet no./rev.	
	Exterior Wall Takeoff				1	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	F.M.	2/12/2015				

1.3 EXTERIOR WALL TAKEOFF:

Exterior Wall Dead Load Takeoff

Wall Type	Wall Material:	Weight (psf)	Sources:
Exterior Finish	Fiber Cement Siding	3	Boise Cascade:Engineered Wood Products
Sheathing	5/8" OSB	2	Boise Cascade:Engineered Wood Products
Framing	2x8	2.2	Boise Cascade:Engineered Wood Products
Interior Finish	1/2" Gypsum Board	2.2	Boise Cascade:Engineered Wood Products
Miscellaneous		1.5	Boise Cascade:Engineered Wood Products
Wall Dead Load:	**11**	**psf**	

1.4 SEISMIC WEIGHT:

ROOF

Master Bedroom	Square Footage (ft2)	429.7133
	Dead Load (psf)	17
Great Room	Square Footage (ft2)	316.5466
	Dead Load (psf)	17
Deck	Square Footage (ft2)	1728.5032
	Dead Load (psf)	10

Total Roof Weight	**29.97**	**Kips**

EXTERIOR WALLS

Main House	Wall Length (ft)	78.2
	Average Wall Height (ft)	10
	Wall Area (ft2)	782
	Wall DL (psf)	13

Total Wall Weight	**10.17**	**Kips**

FLOOR

Area Type:	Area (ft2)	Dead Load (psf)
Interior	1000	17
Deck	1728.5032	12

Total Floor Weight	**37.74**	**Kips**

TOTAL

			Comments:
Total Weight=	**77.88**	**Kips**	*weight bearing on peirs*
Seismic Weight=	**35.05**	**Kips**	*weight of roof and half of wall*

CASA DEL SOL Team Orange County	Project: Casa Del Sol				Job Ref.
	Section: Master Flex/Great Room/Studio Roof Joist Calcs				Sheet no./rev.: 1
	Calc. by: F.M.	Date: 2/12/2015	Chk'd by	Date	App'd by / Date

ROOF JOISTS CALCULATIONS : Master Flex/Great Room/Studio:

GIVEN				
	Variable	**Value**	**Unit**	**Comments:**
Length of Beam:	L	14	ft	Reference Roof Plan Design
Cross Sectional Area:	A	**13.88**	in2	NDS Table 1B: Standard Dressed Sawn Lumber
Section Modulus	S	**21.39**	in3	
Moment of Inertia	I	**98.93**	in4	
Modulus of Elasticity	E	1700000	lb/in2	Framing Lumber Table 1: Posts and Timbers Design Values
Extreme Fiber Stress in Bending	F_b	1000	psi	
Horizontal Shear	F_v	180	psi	

ASSUMPTIONS				
	Beam Size	**2x10**	in x in	Douglas Fir-Larch No. 1
	Spacing	**16**	in. O.C	

CALCULATIONS			
Live Load Weight	LL	20	psf
Dead Load Weight	DL	17	psf
Distributed Load	w	49.33	PLF
Shear	V	690.67	lbs
Shear (@each connection)	V_c	345.33	lbs
Moment	M	1208.67	lbs*ft

SHEAR			
Cross Sectional Area_allowed	A_allowed	1.92	in^2
Check Condition	**(Area_allowed < A)**	**TRUE**	**Shear IS SATISFIED**

BENDING			
Section Modulus	S	14.50	in^3
Is assumption Correct?	**S < S_limit**	**TRUE**	**Bending IS SATISFIED**

DEFLECTION			
Allowed Deflection	Δ_allowed	0.7	in
Actual Deflection	Δ_actual	0.25	in
Check Condition	**(Δ_actual < Δ_allowed)**	**TRUE**	**Deflection IS SATISFIED**

Wood Beam

File = C:\PROGRA~2\ENERCA~1
ENERCALC, INC. 1983-2015, Build:6.15.1.19, Ver:6.15.1.19

Lic. # : KW-06008535 — Licensee : Ipa inc

Description : Team Orange - Carport 4x10 Beam

CODE REFERENCES

Calculations per
Load Combination Set : IBC 2012

Material Properties

Analysis Method : Allowable Stress Design
Load Combination : IBC 2012

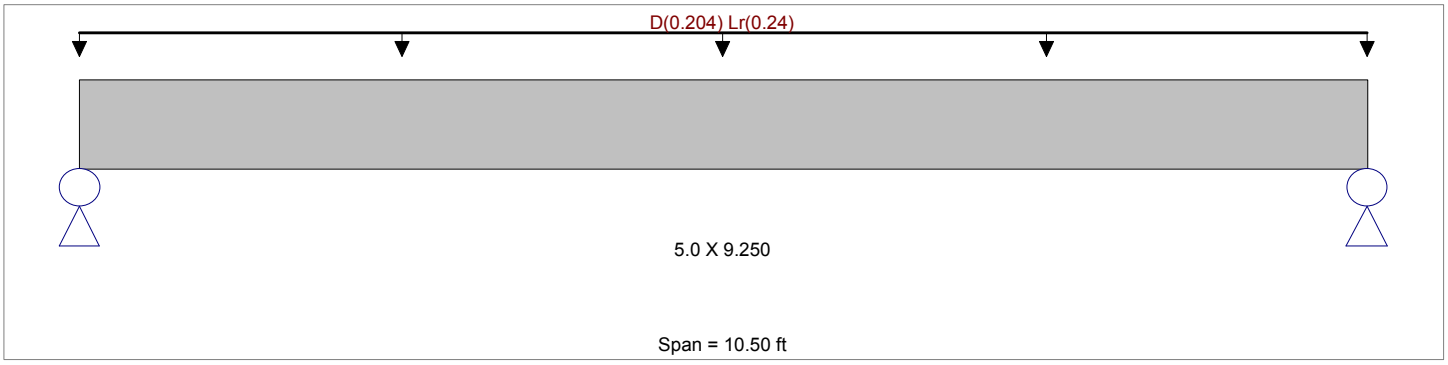
Wood Species : Douglas Fir - Larch
Wood Grade : No.1

Beam Bracing : Beam is Fully Braced against lateral-torsion buckling

Fb - Tension	1000 psi
Fb - Compr	1000 psi
Fc - Prll	1500 psi
Fc - Perp	625 psi
Fv	180 psi
Ft	675 psi

E : Modulus of Elasticity

Ebend- xx	1700 ksi
Eminbend - xx	620 ksi
Density	32.21 pcf



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loads
Uniform Load : D = 0.0170, Lr = 0.020 ksf, Tributary Width = 12.0 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio	=	0.703 : 1	Maximum Shear Stress Ratio	=	0.294 : 1
Section used for this span		5.0 X 9.250	Section used for this span		5.0 X 9.250
fb : Actual	=	1,053.79 psi	fv : Actual	=	66.07 psi
FB : Allowable	=	1,500.00 psi	Fv : Allowable	=	225.00 psi
Load Combination		+D+Lr+H	Load Combination		+D+Lr+H
Location of maximum on span	=	5.250 ft	Location of maximum on span	=	0.000 ft
Span # where maximum occurs	=	Span # 1	Span # where maximum occurs	=	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.118 in	Ratio =	1069
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360
Max Downward Total Deflection	0.105 in	Ratio =	1197
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment Length	Span #	Max Stress Ratios M	Max Stress Ratios V	C_d	$C_{F/V}$	C_i	C_r	C_m	C_t	C_L	Moment Values M	Moment Values fb	Moment Values F'b	Shear Values V	Shear Values fv	Shear Values F'v
+D+H													0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.460	0.192	0.90	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1080.00	0.96	31.17	162.00
+D+L+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.414	0.173	1.00	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1200.00	0.96	31.17	180.00
+D+Lr+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.703	0.294	1.25	1.200	1.00	1.00	1.00	1.00	1.00	6.26	1,053.79	1500.00	2.04	66.07	225.00
+D+S+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.360	0.151	1.15	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1380.00	0.96	31.17	207.00
+D+0.750Lr+0.750L+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.610	0.255	1.25	1.200	1.00	1.00	1.00	1.00	1.00	5.43	914.63	1500.00	1.77	57.34	225.00
+D+0.750L+0.750S+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00

Description : Team Orange - Carport 4x10 Beam

Load Combination / Segment Length	Span #	Max Stress Ratios M	V	C_d	$C_{F/V}$	C_i	C_r	C_m	C_t	C_L	Moment Values M	fb	F'b	Shear Values V	fv	F'v
Length = 10.50 ft	1	0.360	0.151	1.15	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1380.00	0.96	31.17	207.00
+D+0.60W+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.259	0.108	1.60	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1920.00	0.96	31.17	288.00
+D+0.70E+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.259	0.108	1.60	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1920.00	0.96	31.17	288.00
+D+0.750Lr+0.750L+0.450W+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.476	0.199	1.60	1.200	1.00	1.00	1.00	1.00	1.00	5.43	914.63	1920.00	1.77	57.34	288.00
+D+0.750L+0.750S+0.450W+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.259	0.108	1.60	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1920.00	0.96	31.17	288.00
+D+0.750L+0.750S+0.5250E+H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.259	0.108	1.60	1.200	1.00	1.00	1.00	1.00	1.00	2.95	497.14	1920.00	0.96	31.17	288.00
+0.60D+0.60W+0.60H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.155	0.065	1.60	1.200	1.00	1.00	1.00	1.00	1.00	1.77	298.29	1920.00	0.58	18.70	288.00
+0.60D+0.70E+0.60H					1.200	1.00	1.00	1.00	1.00	1.00			0.00	0.00	0.00	0.00
Length = 10.50 ft	1	0.155	0.065	1.60	1.200	1.00	1.00	1.00	1.00	1.00	1.77	298.29	1920.00	0.58	18.70	288.00

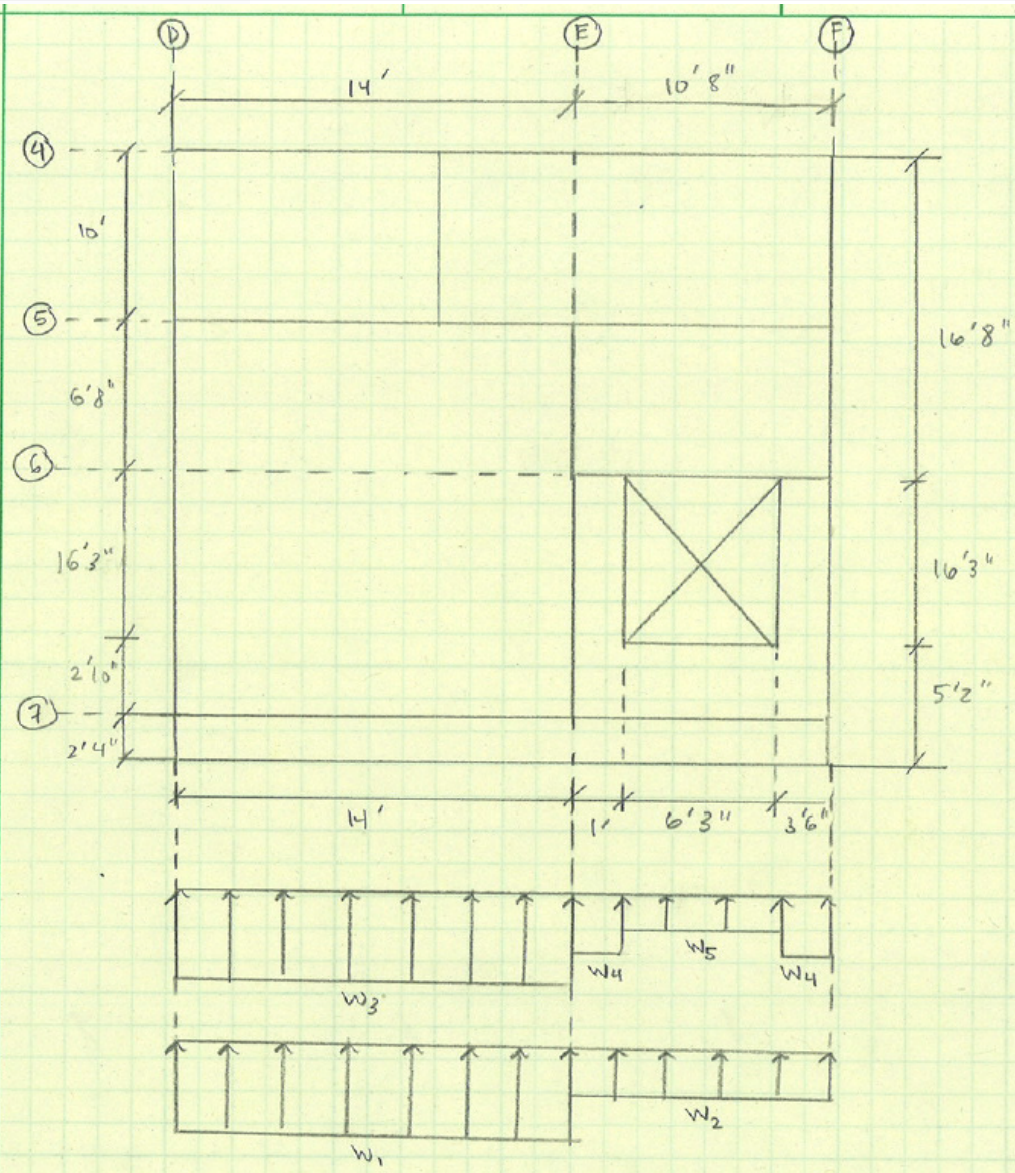
Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
Lr Only	1	0.1178	5.288		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	2.385	2.385
Overall MINimum	0.675	0.675
+D+H	1.125	1.125
+D+L+H	1.125	1.125
+D+Lr+H	2.385	2.385
+D+S+H	1.125	1.125
+D+0.750Lr+0.750L+H	2.070	2.070
+D+0.750L+0.750S+H	1.125	1.125
+D+0.60W+H	1.125	1.125
+D+0.70E+H	1.125	1.125
+D+0.750Lr+0.750L+0.450W+H	2.070	2.070
+D+0.750L+0.750S+0.450W+H	1.125	1.125
+D+0.750L+0.750S+0.5250E+H	1.125	1.125
+0.60D+0.60W+0.60H	0.675	0.675
+0.60D+0.70E+0.60H	0.675	0.675
D Only	1.125	1.125
Lr Only	1.260	1.260
L Only		
S Only		
W Only		
E Only		
H Only		
+D+H	1.125	1.125
+D+L+H	1.125	1.125
+D+Lr+H	2.385	2.385
+D+S+H	1.125	1.125
+D+0.750Lr+0.750L+H	2.070	2.070
+D+0.750L+0.750S+H	1.125	1.125
+D+0.60W+H	1.125	1.125
+D+0.70E+H	1.125	1.125
+D+0.750Lr+0.750L+0.450W+H	2.070	2.070
+D+0.750L+0.750S+0.450W+H	1.125	1.125



$W_1 = [(17+5)(35.667') + (10.5')(\frac{1}{2})(2)(11psf) + (11.67')(\frac{1}{2})(10psf)](0.152)$

$W_1 = 195$ PLF

$W_2 = [(17+5)(16.667)' + (10.5')(\frac{1}{2})(10psf)](0.152) =$

$W_2 = 64$ PLF

$W_3 = [(20psf)(2.73') + (11psf)(9')(\frac{1}{2})](0.152) =$

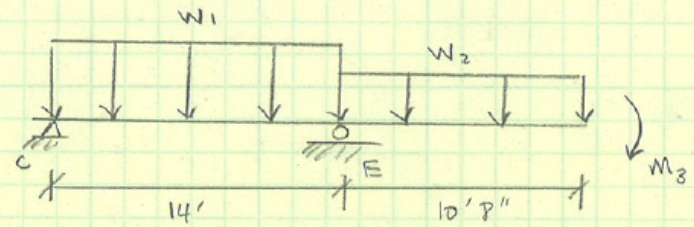
$W_3 = 15$ PLF

$W_4 = [(20\,psf)(21.41') + (11\,psf)(9')(\tfrac{1}{2})](0.152) =$

$W_4 = 73$ PLF

$W_5 = [(20\,psf)(5.16') + (11\,psf)(9')(\tfrac{1}{2})](0.152) =$

$W_5 = 23$ PLF

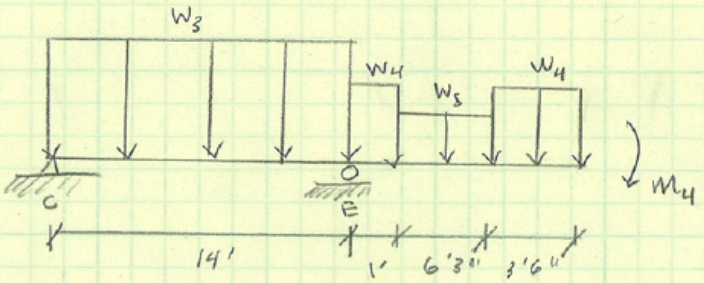


$\Sigma M_C = -(195)(14)(7) - (64)(10.66')(5.33') + R_{E_L}(14') = 0$

$(R_{E_L}{}^{\#1} = 1629$ lbs ↑$)$

$\Sigma F_y = -(195)(14) - (64)(10.667') + R_{C_L} + 1629 = 0$

$(R_{C_L}{}^{\#1} = 1789$ lbs ↑$)$



$\Sigma M_C = -(15)(14)(7) + R_{E_L}(14) - 73(1)(14.5) - (23)(6.25)(18.125) - (73)(3.25)(23) = 0$

$(R_{E_L}{}^{\#2} = 786$ lbs ↑$)$

$\Sigma F_y = -(15)(14) - (73)(1) - (73)(3.5) - (23)(6.25) + 786 + R_{CL} = 0$

$(R_{CL}{}^{\#2} = 104$ lbs ↓$)$

$R_{CL} = R_{CL}\#1 + R_{CL}\#2 = 1789 \text{ lbs} - 104 \text{ lbs} =$

$R_{CL} = 1685 \text{ lbs}$

$R_{EL} = R_{EL}\#1 + R_{EL}\#2 = 1629 \text{ lbs} + 786 \text{ lbs} =$

$R_{EL} = 2415 \text{ lbs}$

$M_3 = \frac{W_2 L^2}{2} = \frac{(64 \text{ PLF})(10.667')^2}{2} = 3641 \text{ lb-ft}$

$M_4 = \frac{(73 \text{ PLF})(1')^2}{2} + \frac{(23 \text{ PLF})(6.75')^2}{2} + \frac{(73 \text{ PLF})(3.5')^2}{2} = 1751 \text{ lb-ft}$

$M_{CF} = (M_3 + M_4)(1.3) = 7010 \text{ lb-ft}$

$\text{CHORD FORCE} = \frac{M_{CF}}{\text{Depth}} = \frac{7010 \text{ lb-ft}}{2.75'} = 2550 \text{ lbs}$

CHORD FORCE = 2550 lbs

[DIAPHRAM SHEAR CHECK]

$q_C = \frac{(1685 \text{ lbs})(1.3)(0.7)}{(38.08')} = 40 \text{ PLF}$

$q_{E\,(WEST)} = q_C = 40 \text{ PLF}$

$q_{E\,(EAST)} = \frac{(2415 \text{ lbs})(1.3)(0.7)}{(16.88')} = 130 \text{ PLF}$

$q_{allowable} = \frac{Q_{ultimate}}{\Omega_0} = \frac{640 \text{ PLF}}{2.0} = 320 \text{ PLF} > 130 \text{ PLF}$ ∴ ok ✓

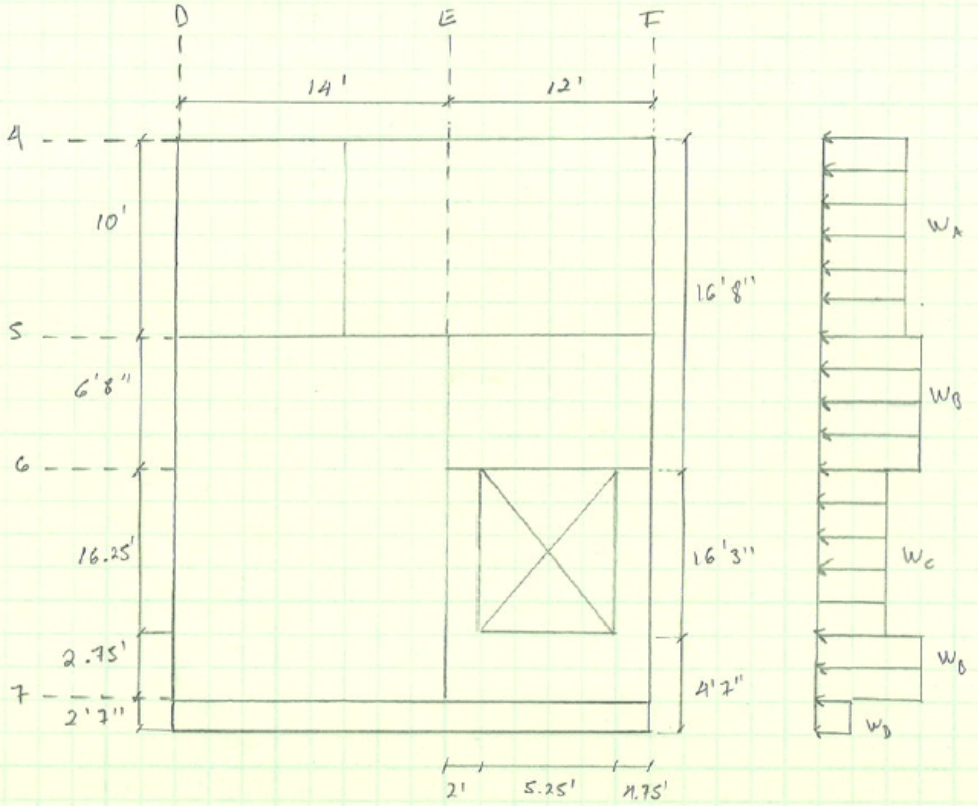
[CHORD FORCE CHECK]

$C.F.\,(4\tfrac{3}{17}) = \frac{WL^2}{8d_1} = \frac{(195 + 15 \text{ PLF})(14')^2}{8(35.75)'} = 144 \text{ lbs}\,(1.3)(0.7) = 131 \text{ lbs}$

$C.F.\,(4\tfrac{3}{6}) = \frac{WL^2}{8d_2} = \frac{(73 + 64 \text{ PLF})(10.667)'^2}{8(16.667)'} = 117 \text{ lbs}\,(1.3)(0.7) = 106 \text{ lbs}$

TOP PLATE SPLICE (TYPE A) = 500 lbs > 131 lbs ∴ ok ✓

TOPS



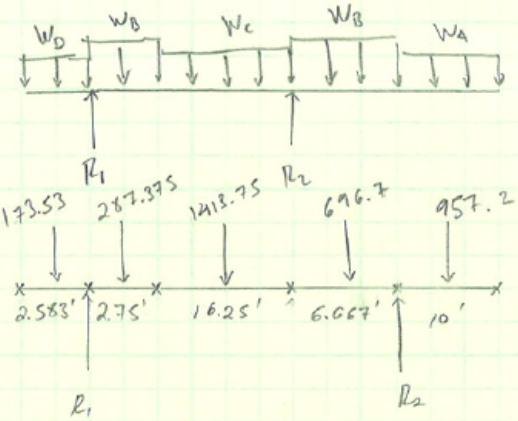
$W_A = [26'(17+5) + (\frac{10.5}{2})(11)(1)](.152) = 95.72\ PLF$

$W_B = [26'(17+5) + (\frac{10.5}{2})(11)(2)](.152) = 104.5\ PLF$

$W_C = [(4.75+2+11)'(17+5) + (\frac{10.5}{2})(11)(2)](.152) = 86.9\ PLF$

$W_D = [(17)(26)](.152) = 67.19\ PLF$

$W_A = 95.72$ PLF
$W_B = 104.5$ PLF
$W_C = 86.9$ PLF
$W_D = 67.14$ PLF



$$\sum M_1 = 0 = 173.53\left(\frac{2.583}{2}\right) - 287.375\left(\frac{2.75}{2}\right) - 1413.75\left(\frac{16.25}{2} + 2.75\right) + R_2(25.667) - 696.7\left(19 + \frac{6.667}{2}\right) - 957.2\left(19 + 6.667 + \frac{10}{2}\right)$$

$R_2 = 2.355$ kips

$R_1 = 1.17$ kips

D. Shear check

$$q_s = \frac{2355\text{ lb}(1.3)(.7)}{26'} = 82.4\text{ plf}$$

$$q_T = \frac{1170\text{ lb}(1.3)(.7)}{26'} = 41\text{ plf}$$

$$q_{allow} = \frac{640\text{ plf}}{2} = 320\text{ plf} > 82.4 \quad \text{OK}$$

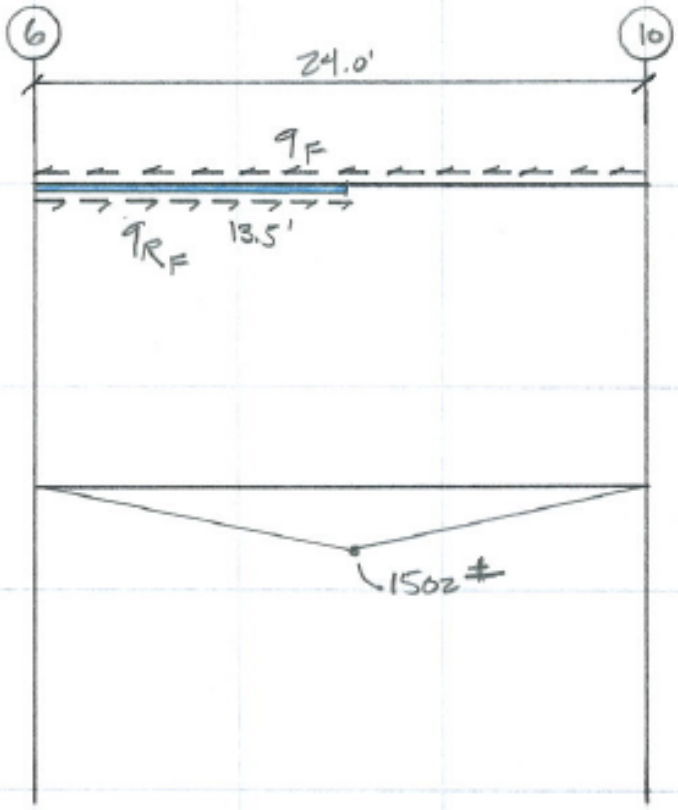
LATERAL ANALYSIS:

STUDIO ROOM DRAG FORCE: (LINE F)

FORCE TO LINE F = 3430#

q_F = 3430#/24.0' = 143 PLF

q_{R_F} = 3430#/13.5' = 254 PLF



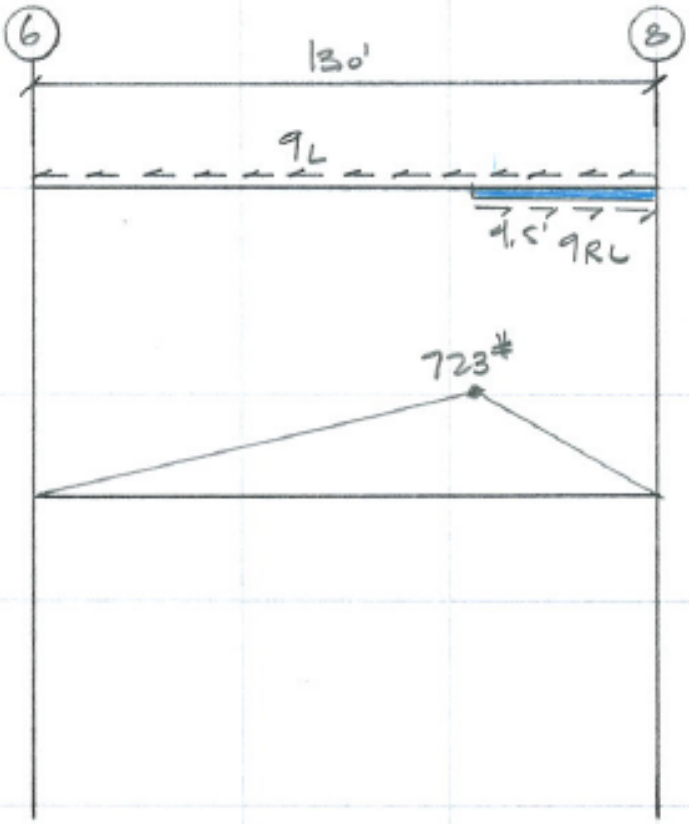
LATERAL ANALYSIS:

STUDIO ROOM DRAG FORCE: (LINE L)

FORCE TO LINE L = 1102#

q_L = 1102#/130' = 85 PLF

q_{R_L} = 1102#/4.5' = 245 PLF



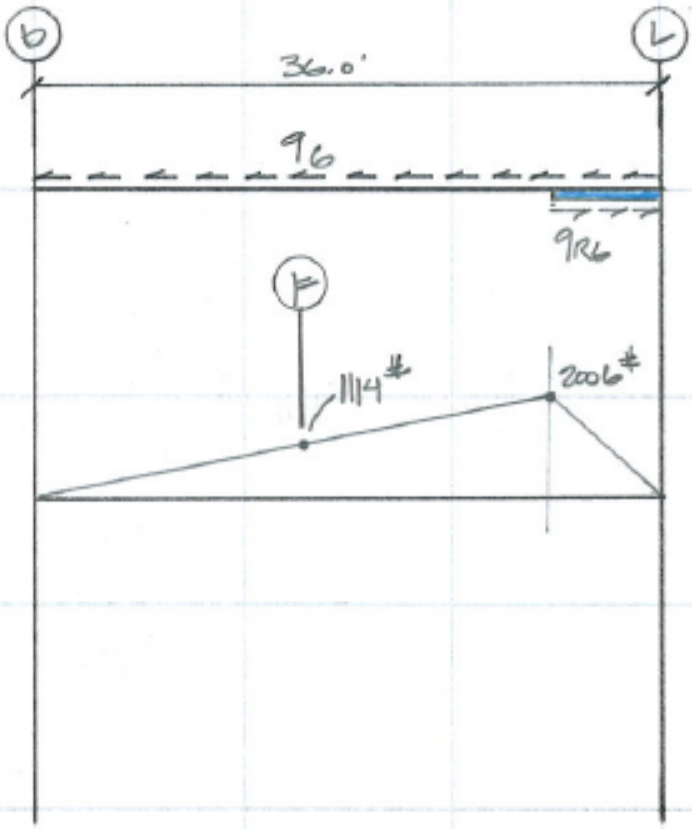
LATERAL ANALYSIS:

STUDIO ROOM DRAG FORCE: (LINE 6)

FORCE TO LINE 6 = 2,450#

9_6 = 2450#/36.0' = 68 PLF

9_{R_6} = 2450#/65' = 377 PLF



LATERAL ANALYSIS:

STUDIO ROOM DRAG FORCE: (LINE 8)

FORCE TO LINE 8 = 2450#

$q_8 = 2450^{\#} / 36' = 68$ PLF

$q_{R8} = 2450^{\#} / 9.25' = 265$ PLF

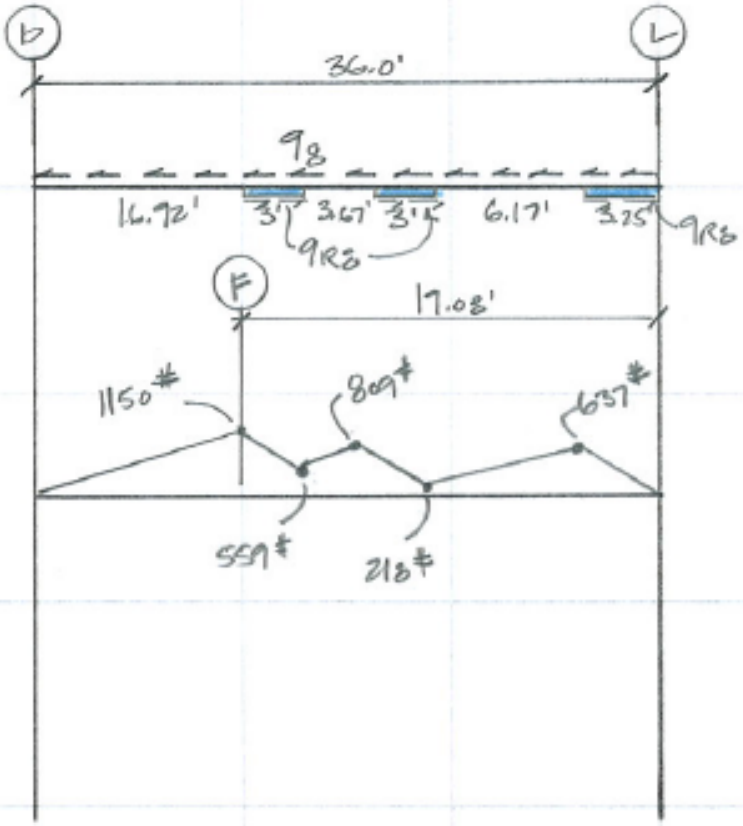


Table 1B Section Properties of Standard Dressed (S4S) Sawn Lumber

Nominal Size b x d	Standard Dressed Size (S4S) b x d in. x in.	Area of Section A in.^{2}	X-X AXIS Section Modulus S_{xx} in.^{3}	X-X AXIS Moment of Inertia I_{xx} in.^{4}	Y-Y AXIS Section Modulus S_{yy} in.^{3}	Y-Y AXIS Moment of Inertia I_{yy} in.^{4}	Approximate weight in pounds per linear foot (lbs/ft) of piece when density of wood equals: 25 lbs/ft^3	30 lbs/ft^3	35 lbs/ft^3	40 lbs/ft^3	45 lbs/ft^3	50 lbs/ft^3
Boards[1]												
1 x 3	3/4 x 2-1/2	1.875	0.781	0.977	0.234	0.088	0.326	0.391	0.456	0.521	0.586	0.651
1 x 4	3/4 x 3-1/2	2.625	1.531	2.680	0.328	0.123	0.456	0.547	0.638	0.729	0.820	0.911
1 x 6	3/4 x 5-1/2	4.125	3.781	10.40	0.516	0.193	0.716	0.859	1.003	1.146	1.289	1.432
1 x 8	3/4 x 7-1/4	5.438	6.570	23.82	0.680	0.255	0.944	1.133	1.322	1.510	1.699	1.888
1 x 10	3/4 x 9-1/4	6.938	10.70	49.47	0.867	0.325	1.204	1.445	1.686	1.927	2.168	2.409
1 x 12	3/4 x 11-1/4	8.438	15.82	88.99	1.055	0.396	1.465	1.758	2.051	2.344	2.637	2.930
Dimension Lumber (see NDS 4.1.3.2) and Decking (see NDS 4.1.3.5)												
2 x 3	1-1/2 x 2-1/2	3.750	1.56	1.953	0.938	0.703	0.651	0.781	0.911	1.042	1.172	1.302
2 x 4	1-1/2 x 3-1/2	5.250	3.06	5.359	1.313	0.984	0.911	1.094	1.276	1.458	1.641	1.823
2 x 5	1-1/2 x 4-1/2	6.750	5.06	11.39	1.688	1.266	1.172	1.406	1.641	1.875	2.109	2.344
2 x 6	1-1/2 x 5-1/2	8.250	7.56	20.80	2.063	1.547	1.432	1.719	2.005	2.292	2.578	2.865
2 x 8	1-1/2 x 7-1/4	10.88	13.14	47.63	2.719	2.039	1.888	2.266	2.643	3.021	3.398	3.776
2 x 10	1-1/2 x 9-1/4	13.88	21.39	98.93	3.469	2.602	2.409	2.891	3.372	3.854	4.336	4.818
2 x 12	1-1/2 x 11-1/4	16.88	31.64	178.0	4.219	3.164	2.930	3.516	4.102	4.688	5.273	5.859
2 x 14	1-1/2 x 13-1/4	19.88	43.89	290.8	4.969	3.727	3.451	4.141	4.831	5.521	6.211	6.901
3 x 4	2-1/2 x 3-1/2	8.75	5.10	8.932	3.646	4.557	1.519	1.823	2.127	2.431	2.734	3.038
3 x 5	2-1/2 x 4-1/2	11.25	8.44	18.98	4.688	5.859	1.953	2.344	2.734	3.125	3.516	3.906
3 x 6	2-1/2 x 5-1/2	13.75	12.60	34.66	5.729	7.161	2.387	2.865	3.342	3.819	4.297	4.774
3 x 8	2-1/2 x 7-1/4	18.13	21.90	79.39	7.552	9.440	3.147	3.776	4.405	5.035	5.664	6.293
3 x 10	2-1/2 x 9-1/4	23.13	35.65	164.9	9.635	12.04	4.015	4.818	5.621	6.424	7.227	8.030
3 x 12	2-1/2 x 11-1/4	28.13	52.73	296.6	11.72	14.65	4.883	5.859	6.836	7.813	8.789	9.766
3 x 14	2-1/2 x 13-1/4	33.13	73.15	484.6	13.80	17.25	5.751	6.901	8.051	9.201	10.35	11.50
3 x 16	2-1/2 x 15-1/4	38.13	96.90	738.9	15.89	19.86	6.619	7.943	9.266	10.59	11.91	13.24
4 x 4	3-1/2 x 3-1/2	12.25	7.15	12.51	7.146	12.51	2.127	2.552	2.977	3.403	3.828	4.253
4 x 5	3-1/2 x 4-1/2	15.75	11.81	26.58	9.188	16.08	2.734	3.281	3.828	4.375	4.922	5.469
4 x 6	3-1/2 x 5-1/2	19.25	17.65	48.53	11.23	19.65	3.342	4.010	4.679	5.347	6.016	6.684
4 x 8	3-1/2 x 7-1/4	25.38	30.66	111.1	14.80	25.90	4.405	5.286	6.168	7.049	7.930	8.811
4 x 10	3-1/2 x 9-1/4	32.38	49.91	230.8	18.89	33.05	5.621	6.745	7.869	8.993	10.12	11.24
4 x 12	3-1/2 x 11-1/4	39.38	73.83	415.3	22.97	40.20	6.836	8.203	9.570	10.94	12.30	13.67
4 x 14	3-1/2 x 13-1/4	46.38	102.41	678.5	27.05	47.34	8.051	9.661	11.27	12.88	14.49	16.10
4 x 16	3-1/2 x 15-1/4	53.38	135.66	1034	31.14	54.49	9.266	11.12	12.97	14.83	16.68	18.53
Timbers (5" x 5" and larger)[2]												
Post and Timber (see NDS 4.1.3.4 and 4.1.5.3)												
5 x 5	4-1/2 x 4-1/2	20.25	15.19	34.17	15.19	34.17	3.516	4.219	4.922	5.625	6.328	7.031
6 x 6	5-1/2 x 5-1/2	30.25	27.73	76.26	27.73	76.26	5.252	6.302	7.352	8.403	9.453	10.50
6 x 8	5-1/2 x 7-1/2	41.25	51.56	193.4	37.81	104.0	7.161	8.594	10.03	11.46	12.89	14.32
8 x 8	7-1/2 x 7-1/2	56.25	70.31	263.7	70.31	263.7	9.766	11.72	13.67	15.63	17.58	19.53
8 x 10	7-1/2 x 9-1/2	71.25	112.8	535.9	89.06	334.0	12.37	14.84	17.32	19.79	22.27	24.74
10 x 10	9-1/2 x 9-1/2	90.25	142.9	678.8	142.9	678.8	15.67	18.80	21.94	25.07	28.20	31.34
10 x 12	9-1/2 x 11-1/2	109.3	209.4	1204	173.0	821.7	18.97	22.76	26.55	30.35	34.14	37.93
12 x 12	11-1/2 x 11-1/2	132.3	253.5	1458	253.5	1458	22.96	27.55	32.14	36.74	41.33	45.92
12 x 14	11-1/2 x 13-1/2	155.3	349.3	2358	297.6	1711	26.95	32.34	37.73	43.13	48.52	53.91
14 x 14	13-1/2 x 13-1/2	182.3	410.1	2768	410.1	2768	31.64	37.97	44.30	50.63	56.95	63.28
14 x 16	13-1/2 x 15-1/2	209.3	540.6	4189	470.8	3178	36.33	43.59	50.86	58.13	65.39	72.66
16 x 16	15-1/2 x 15-1/2	240.3	620.6	4810	620.6	4810	41.71	50.05	58.39	66.74	75.08	83.42
16 x 18	15-1/2 x 17-1/2	271.3	791.1	6923	700.7	5431	47.09	56.51	65.93	75.35	84.77	94.18
18 x 18	17-1/2 x 17-1/2	306.3	893.2	7816	893.2	7816	53.17	63.80	74.44	85.07	95.70	106.3
18 x 20	17-1/2 x 19-1/2	341.3	1109	10813	995.3	8709	59.24	71.09	82.94	94.79	106.6	118.5
20 x 20	19-1/2 x 19-1/2	380.3	1236	12049	1236	12049	66.02	79.22	92.4	105.6	118.8	132.0
20 x 22	19-1/2 x 21-1/2	419.3	1502	16150	1363	13285	72.79	87.34	101.9	116.5	131.0	145.6
22 x 22	21-1/2 x 21-1/2	462.3	1656	17806	1656	17806	80.25	96.30	112.4	128.4	144.5	160.5
22 x 24	21-1/2 x 23-1/2	505.3	1979	23252	1810	19463	87.72	105.3	122.8	140.3	157.9	175.4
24 x 24	23-1/2 x 23-1/2	552.3	2163	25415	2163	25415	95.88	115.1	134.2	153.4	172.6	191.8

Table 1B Section Properties of Standard Dressed (S4S) Sawn Lumber (Cont.)

Nominal Size b x d	Standard Dressed Size (S4S) b x d in. x in.	Area of Section A in.^{2}	X-X AXIS Section Modulus S_{xx} in.^{3}	X-X AXIS Moment of Inertia I_{xx} in.^{4}	Y-Y AXIS Section Modulus S_{yy} in.^{3}	Y-Y AXIS Moment of Inertia I_{yy} in.^{4}	Approximate weight in pounds per linear foot (lbs/ft) of piece when density of wood equals: 25 lbs/ft^3	30 lbs/ft^3	35 lbs/ft^3	40 lbs/ft^3	45 lbs/ft^3	50 lbs/ft^3
Beams & Stringers (see NDS 4.1.3.3 and 4.1.5.3)												
6 x 10	5-1/2 x 9-1/2	52.25	82.73	393.0	47.90	131.7	9.071	10.89	12.70	14.51	16.33	18.14
6 x 12	5-1/2 x 11-1/2	63.25	121.2	697.1	57.98	159.4	10.98	13.18	15.37	17.57	19.77	21.96
6 x 14	5-1/2 x 13-1/2	74.25	167.1	1128	68.06	187.2	12.89	15.47	18.05	20.63	23.20	25.78
6 x 16	5-1/2 x 15-1/2	85.25	220.2	1707	78.15	214.9	14.80	17.76	20.72	23.68	26.64	29.60
6 x 18	5-1/2 x 17-1/2	96.25	280.7	2456	88.23	242.6	16.71	20.05	23.39	26.74	30.08	33.42
6 x 20	5-1/2 x 19-1/2	107.3	348.6	3398	98.31	270.4	18.62	22.34	26.07	29.79	33.52	37.24
6 x 22	5-1/2 x 21-1/2	118.3	423.7	4555	108.4	298.1	20.53	24.64	28.74	32.85	36.95	41.06
6 x 24	5-1/2 x 23-1/2	129.3	506.2	5948	118.5	325.8	22.44	26.93	31.41	35.90	40.39	44.88
8 x 12	7-1/2 x 11-1/2	86.3	165.3	950.5	107.8	404.3	14.97	17.97	20.96	23.96	26.95	29.95
8 x 14	7-1/2 x 13-1/2	101.3	227.8	1538	126.6	474.6	17.58	21.09	24.61	28.13	31.64	35.16
8 x 16	7-1/2 x 15-1/2	116.3	300.3	2327	145.3	544.9	20.18	24.22	28.26	32.29	36.33	40.36
8 x 18	7-1/2 x 17-1/2	131.3	382.8	3350	164.1	615.2	22.79	27.34	31.90	36.46	41.02	45.57
8 x 20	7-1/2 x 19-1/2	146.3	475.3	4634	182.8	685.5	25.39	30.47	35.55	40.63	45.70	50.78
8 x 22	7-1/2 x 21-1/2	161.3	577.8	6211	201.6	755.9	27.99	33.59	39.19	44.79	50.39	55.99
8 x 24	7-1/2 x 23-1/2	176.3	690.3	8111	220.3	826.2	30.60	36.72	42.84	48.96	55.08	61.20
10 x 14	9-1/2 x 13-1/2	128.3	288.6	1948	203.1	964.5	22.27	26.72	31.17	35.63	40.08	44.53
10 x 16	9-1/2 x 15-1/2	147.3	380.4	2948	233.1	1107	25.56	30.68	35.79	40.90	46.02	51.13
10 x 18	9-1/2 x 17-1/2	166.3	484.9	4243	263.2	1250	28.86	34.64	40.41	46.18	51.95	57.73
10 x 20	9-1/2 x 19-1/2	185.3	602.1	5870	293.3	1393	32.16	38.59	45.03	51.46	57.89	64.32
10 x 22	9-1/2 x 21-1/2	204.3	731.9	7868	323.4	1536	35.46	42.55	49.64	56.74	63.83	70.92
10 x 24	9-1/2 x 23-1/2	223.3	874.4	10274	353.5	1679	38.76	46.51	54.26	62.01	69.77	77.52
12 x 16	11-1/2 x 15-1/2	178.3	460.5	3569	341.6	1964	30.95	37.14	43.32	49.51	55.70	61.89
12 x 18	11-1/2 x 17-1/2	201.3	587.0	5136	385.7	2218	34.94	41.93	48.91	55.90	62.89	69.88
12 x 20	11-1/2 x 19-1/2	224.3	728.8	7106	429.8	2471	38.93	46.72	54.51	62.29	70.08	77.86
12 x 22	11-1/2 x 21-1/2	247.3	886.0	9524	473.9	2725	42.93	51.51	60.10	68.68	77.27	85.85
12 x 24	11-1/2 x 23-1/2	270.3	1058	12437	518.0	2978	46.92	56.30	65.69	75.07	84.45	93.84
14 x 18	13-1/2 x 17-1/2	236.3	689.1	6029	531.6	3588	41.02	49.22	57.42	65.63	73.83	82.03
14 x 20	13-1/2 x 19-1/2	263.3	855.6	8342	592.3	3998	45.70	54.84	63.98	73.13	82.27	91.41
14 x 22	13-1/2 x 21-1/2	290.3	1040	11181	653.1	4408	50.39	60.47	70.55	80.63	90.70	100.8
14 x 24	13-1/2 x 23-1/2	317.3	1243	14600	713.8	4818	55.08	66.09	77.11	88.13	99.14	110.2
16 x 20	15-1/2 x 19-1/2	302.3	982.3	9578	780.8	6051	52.47	62.97	73.46	83.96	94.45	104.9
16 x 22	15-1/2 x 21-1/2	333.3	1194	12837	860.9	6672	57.86	69.43	81.00	92.57	104.1	115.7
16 x 24	15-1/2 x 23-1/2	364.3	1427	16763	941.0	7293	63.24	75.89	88.53	101.2	113.8	126.5
18 x 22	17-1/2 x 21-1/2	376.3	1348	14493	1097	9602	65.32	78.39	91.45	104.5	117.6	130.6
18 x 24	17-1/2 x 23-1/2	411.3	1611	18926	1199	10495	71.40	85.68	99.96	114.2	128.5	142.8
20 x 24	19-1/2 x 23-1/2	458.3	1795	21089	1489	14521	79.56	95.47	111.4	127.3	143.2	159.1

1. According to the Southern Pine Inspection Bureau's (SPIB) Standard Grading Rules for Southern Pine Lumber: Section 265 stress rated boards:
   - Industrial 55 (IND 55) shall be graded as per No. 1 dimension
   - Industrial 45 (IND 45) shall be graded as per No. 2 dimension
   - Industrial 26 (IND 26) shall be graded as per No. 3 dimension

   See Table 4B for Southern Pine dimension lumber design values.

2. Neither Redwood nor Southern Pine are classified as Beams and Stringers or Posts and Timbers.

Table 4.2A Nominal Unit Shear Capacities for Wood-Frame Diaphragms

Blocked Wood Structural Panel Diaphragms[1,2,3,4]

Sheathing Grade	Common Nail Size	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Nailed Face at Adjoining Panel Edges and Boundaries (in.)	A SEISMIC: Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)												B WIND: Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)			
					6			4			2-1/2			2			6	4	2-1/2	2
					Nail Spacing (in.) at other panel edges (Cases 1, 2, 3, & 4)												Nail Spacing (in.) at other panel edges (Cases 1, 2, 3, & 4)			
					6			6			4			3			6	6	4	3
					v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_w (plf)	v_w (plf)	v_w (plf)	v_w (plf)
						OSB	PLY		OSB	PLY		OSB	PLY		OSB	PLY				
Structural I	6d	1-1/4	5/16	2	370	15	12	500	8.5	7.5	750	12	10	840	20	15	520	700	1050	1175
				3	420	12	9.5	560	7.0	6.0	840	9.5	8.5	950	17	13	590	785	1175	1330
	8d	1-3/8	3/8	2	540	14	11	720	9.0	7.5	1060	13	10	1200	21	15	755	1010	1485	1680
				3	600	12	10	800	7.5	6.5	1200	10	9.0	1350	18	13	840	1120	1680	1890
	10d	1-1/2	15/32	2	640	24	17	850	15	12	1280	20	15	1460	31	21	895	1190	1790	2045
				3	720	20	15	960	12	9.5	1440	16	13	1640	26	18	1010	1345	2015	2295
Sheathing and Single-Floor	6d	1-1/4	5/16	2	340	15	10	450	9.0	7.0	670	13	9.5	760	21	13	475	630	940	1065
				3	380	12	9.0	500	7.0	6.0	760	10	8.0	860	17	12	530	700	1065	1205
			3/8	2	370	13	9.5	500	7.0	6.0	750	10	8.0	840	18	12	520	700	1050	1175
				3	420	10	8.0	560	5.5	5.0	840	8.5	7.0	950	14	10	590	785	1175	1330
	8d	1-3/8	3/8	2	480	15	11	640	9.5	7.5	960	13	9.5	1090	21	13	670	895	1345	1525
				3	540	12	9.5	720	7.5	6.0	1080	11	8.5	1220	18	12	755	1010	1510	1710
			7/16	2	510	14	10	680	8.5	7.0	1010	12	9.5	1150	20	13	715	950	1415	1610
				3	570	11	9.0	760	7.0	6.0	1140	10	8.0	1290	17	12	800	1065	1595	1805
			15/32	2	540	13	9.5	720	7.5	6.5	1060	11	8.5	1200	19	13	755	1010	1485	1680
				3	600	10	8.5	800	6.0	5.5	1200	9.0	7.5	1350	15	11	840	1120	1680	1890
	10d	1-1/2	15/32	2	580	25	15	770	15	11	1150	21	14	1310	33	18	810	1080	1610	1835
				3	650	21	14	860	12	9.5	1300	17	12	1470	28	16	910	1205	1820	2060
			19/32	2	640	21	14	850	13	9.5	1280	18	12	1460	28	17	895	1190	1790	2045
				3	720	17	12	960	10	8.0	1440	14	11	1640	24	15	1010	1345	2015	2295

1. Nominal unit shear capacities shall be adjusted in accordance with 4.2.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.2.6. For specific requirements, see 4.2.7.1 for wood structural panel diaphragms. See Appendix A for common nail dimensions.
2. For species and grades of framing other than Douglas-Fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = [1-(0.5-G)], where G = Specific Gravity of the framing lumber from the *NDS* (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
3. Apparent shear stiffness values, G_a, are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for diaphragms constructed with either OSB or 3-ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_a values shall be permitted to be increased by 1.2.
4. Where moisture content of the framing is greater than 19% at time of fabrication, G_a values shall be multiplied by 0.5.

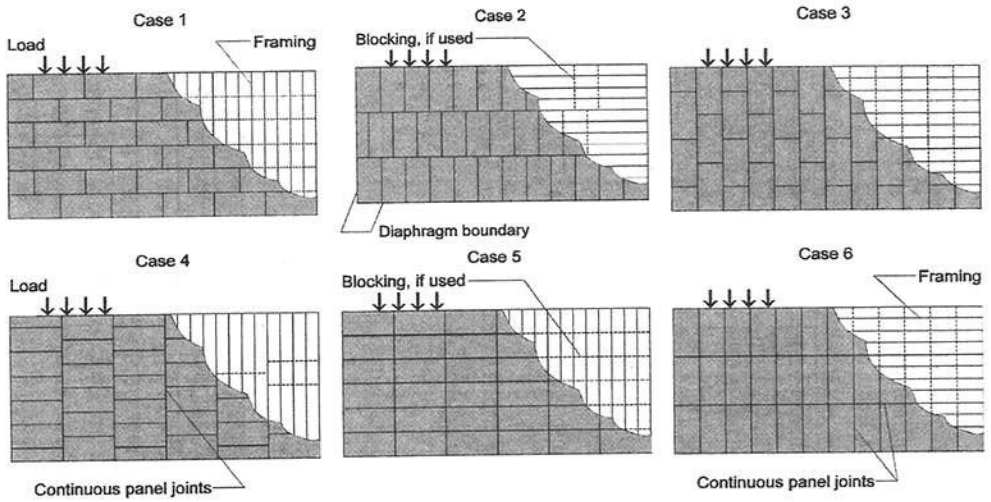


Table 4.2B Nominal Unit Shear Capacities for Wood-Frame Diaphragms

Blocked Wood Structural Panel Diaphragms Utilizing Multiple Rows of Fasteners (High Load Diaphragms)[1,2,3,4]

Sheathing Grade	Common Nail Size	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Nailed Face at Adjoining Panel Edges and Boundaries (in.)	Lines of Fasteners	A SEISMIC: Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)										B WIND: Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)			
						4			4			2-1/2			2-1/2				
						Nail Spacing (in.) at other panel edges (Cases 1, 2, 3, & 4)													
						6			4			4			3				
						v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_w (plf)	v_w (plf)	v_w (plf)	v_w (plf)
							OSB	PLY		OSB	PLY		OSB	PLY		OSB	PLY				
Structural I	10d	1-1/2	15/32	3	2	1210	40	24	1630	53	28	1750	50	27	2300	56	29	1695	2280	2450	3220
				4	2	1400	33	21	1830	48	27	2010	44	25	2580	51	28	1960	2560	2815	3610
				4	3	1750	50	27	2440	61	30	2570	59	30	2790	70	32	2450	3415	3600	3905
			19/32	3	2	1340	36	23	1760	52	29	1930	47	27	2510	54	29	1875	2465	2700	3515
				4	2	1560	29	20	1980	46	27	2220	40	25	2880	48	27	2185	2770	3110	4030
				4	3	1930	47	27	2640	60	31	2810	57	30	3580	64	32	2700	3695	3935	5010
			23/32	3	2	1460	33	22	1910	50	29	2100	45	27	2730	53	30	2045	2675	2940	3820
				4	2	1710	26	19	2140	43	27	2420	37	24	3130	45	27	2395	2995	3390	4380
				4	3	2100	45	27	2860	59	32	3050	56	31	3600	68	34	2940	4005	4270	5040
Sheathing and Single-Floor	10d	1-1/2	15/32	3	2	1050	43	21	1450	55	23	1530	53	23	2020	58	24	1470	2030	2140	2830
				4	2	1210	36	19	1630	50	22	1750	46	21	2210	55	23	1695	2280	2450	3095
				4	3	1530	53	23	2170	62	24	2260	61	24	2390	72	26	2140	3040	3165	3345
			19/32	3	2	1300	34	19	1720	49	23	1870	45	22	2450	52	23	1820	2410	2620	3430
				4	2	1510	27	16	1930	43	21	2160	37	20	2740	46	22	2115	2700	3025	3835
				4	3	1870	45	22	2580	57	24	2730	55	24	2970	68	26	2620	3610	3820	4160
			23/32	3	2	1420	30	18	1870	46	23	2040	42	22	2670	50	24	1990	2620	2855	3740
				4	2	1650	24	16	2100	40	21	2350	34	20	2890	45	23	2310	2940	3290	4045
				4	3	2040	42	22	2800	56	25	2960	53	25	3130	71	28	2855	3920	4145	4380

1. Nominal unit shear capacities shall be adjusted in accordance with 4.2.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.2.6. For specific requirements, see 4.2.7.1 for wood structural panel diaphragms. See Appendix A for common nail dimensions.
2. For species and grades of framing other than Douglas-Fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = [1-(0.5-G)], where G = Specific Gravity of the framing lumber from the *NDS* (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
3. Apparent shear stiffness values, G_a, are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for diaphragms constructed with either OSB or 3-ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_a values shall be permitted to be increased by 1.2.
4. Where moisture content of the framing is greater than 19% at time of fabrication, G_a values shall be multiplied by 0.5.

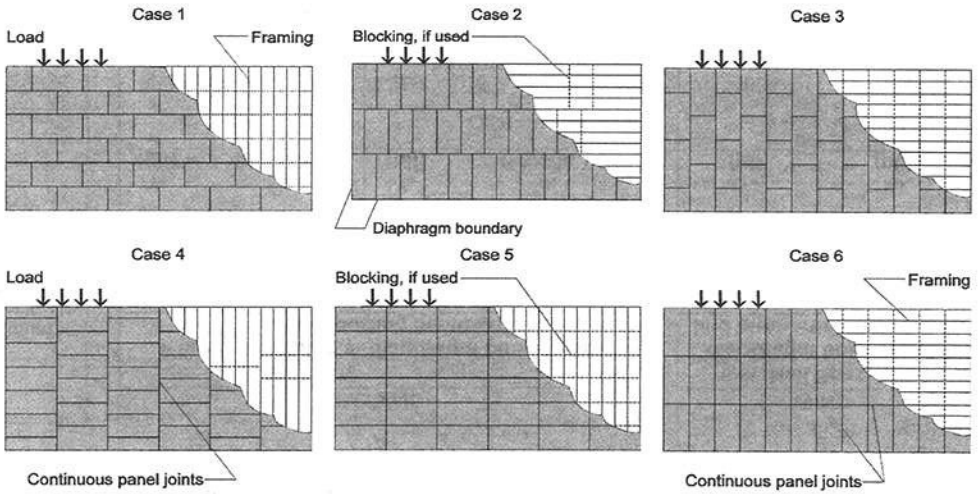


Table 4.3A Nominal Unit Shear Capacities for Wood-Frame Shear Walls[1,3,6,7]

Wood-based Panels[4]

Sheathing Material	Minimum Nominal Panel Thickness (in.)	Minimun Fastener Penetration in Framing Member or Blocking (in.)	Fastener Type & Size	A SEISMIC										B WIND			
				Panel Edge Fastener Spacing (in.)										Panel Edge Fastener Spacing (in.)			
				6			4			3			2				
				v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_w (plf)	v_w (plf)	v_w (plf)	v_w (plf)
					OSB	PLY		OSB	PLY		OSB	PLY		OSB	PLY				
Wood Structural Panels - Structural I[4,5]	5/16	1-1/4	Nail (common or galvanized box) 6d	400	13	10	600	18	13	780	23	16	1020	35	22	560	840	1090	1430
	3/8[2]	1-3/8	8d	460	19	14	720	24	17	920	30	20	1220	43	24	645	1010	1290	1710
	7/16[2]			510	16	13	790	21	16	1010	27	19	1340	40	24	715	1105	1415	1875
	15/32			560	14	11	860	18	14	1100	24	17	1460	37	23	785	1205	1540	2045
	15/32	1-1/2	10d	680	22	16	1020	29	20	1330	36	22	1740	51	28	950	1430	1860	2435
Wood Structural Panels – Sheathing[4,5]	5/16	1-1/4	6d	360	13	9.5	540	18	12	700	24	14	900	37	18	505	755	980	1260
	3/8			400	11	8.5	600	15	11	780	20	13	1020	32	17	560	840	1090	1430
	3/8[2]	1-3/8	8d	440	17	12	640	25	15	820	31	17	1060	45	20	615	895	1150	1485
	7/16[2]			480	15	11	700	22	14	900	28	17	1170	42	21	670	980	1260	1640
	15/32			520	13	10	760	19	13	980	25	15	1280	39	20	730	1065	1370	1790
	15/32	1-1/2	10d	620	22	14	920	30	17	1200	37	19	1540	52	23	870	1290	1680	2155
	19/32			680	19	13	1020	26	16	1330	33	18	1740	48	22	950	1430	1860	2435
Plywood Siding	5/16	1-1/4	Nail (galvanized casing) 6d	280	13		420	16		550	17		720	21		390	590	770	1010
	3/8	1-3/8	8d	320	16		480	18		620	20		820	22		450	670	870	1150
Particleboard Sheathing - (M-S "Exterior Glue" and M-2 "Exterior Glue")	3/8		Nail (common or galvanized box) 6d	240	15		360	17		460	19		600	22		335	505	645	840
	3/8		8d	260	18		380	20		480	21		630	23		365	530	670	880
	1/2			280	18		420	20		540	22		700	24		390	590	755	980
	1/2		10d	370	21		550	23		720	24		920	25		520	770	1010	1290
	5/8			400	21		610	23		790	24		1040	26		560	855	1105	1455
Structural Fiberboard Sheathing	1/2		Nail (galvanized roofing) 11 ga. galv. roofing nail (0.120" x 1-1/2" long x 7/16" head)				340	4.0		460	5.0		520	5.5			475	645	730
	25/32		11 ga. galv. roofing nail (0.120" x 1-3/4" long x 3/8" head)				340	4.0		460	5.0		520	5.5			475	645	730

1. Nominal unit shear values shall be adjusted in accordance with 4.3.3 to determine ASD allowable unit shear capacity and LRFD factored unit resistance. For general construction requirements see 4.3.6. For specific requirements, see 4.3.7.1 for wood structural panel shear walls, 4.3.7.2 for particleboard shear walls, and 4.3.7.3 for fiberboard shear walls. See Appendix A for common and box nail dimensions.
2. Shears are permitted to be increased to values shown for 15/32 inch sheathing with same nailing provided (a) studs are spaced a maximum of 16 inches on center, or (b) panels are applied with long dimension across studs.
3. For species and grades of framing other than Douglas-Fir-Larch or Southern Pine, reduced nominal unit shear capacities shall be determined by multiplying the tabulated nominal unit shear capacity by the Specific Gravity Adjustment Factor = [1-(0.5-G)], where G = Specific Gravity of the framing lumber from the *NDS* (Table 11.3.2A). The Specific Gravity Adjustment Factor shall not be greater than 1.
4. Apparent shear stiffness values G_a, are based on nail slip in framing with moisture content less than or equal to 19% at time of fabrication and panel stiffness values for shear walls constructed with either OSB or 3-ply plywood panels. When 4-ply or 5-ply plywood panels or composite panels are used, G_a values shall be permitted to be increased by 1.2.
5. Where moisture content of the framing is greater than 19% at time of fabrication, G_a values shall be multiplied by 0.5.
6. Where panels are applied on both faces of a shear wall and nail spacing is less than 6" on center on either side, panel joints shall be offset to fall on different framing members. Alternatively, the width of the nailed face of framing members shall be 3" nominal or greater at adjoining panel edges and nails at all panel edges shall be staggered.
7. Galvanized nails shall be hot-dipped or tumbled.

STRONG-DRIVE® SDS HEAVY-DUTY CONNECTOR *Screw*

SIMPSON Strong-Tie®

The Simpson Strong-Tie® Strong-Drive® SDS Heavy-Duty Connector screw is a ¼" diameter structural wood screw ideal for various connector installations as well as wood-to-wood applications. It installs with no predrilling and has been extensively tested in various applications. The SDS Heavy-Duty Connector screw is improved with a patented easy driving 4CUT™ point and a corrosion resistant double-barrier coating.

The #8x1¼" SD Wafer-Head screw is ideal for miscellaneous fastening applications. The needle point ensures fast starts and deep #2 Phillips drive reduces cam-out and stripping.

SDS FEATURES:

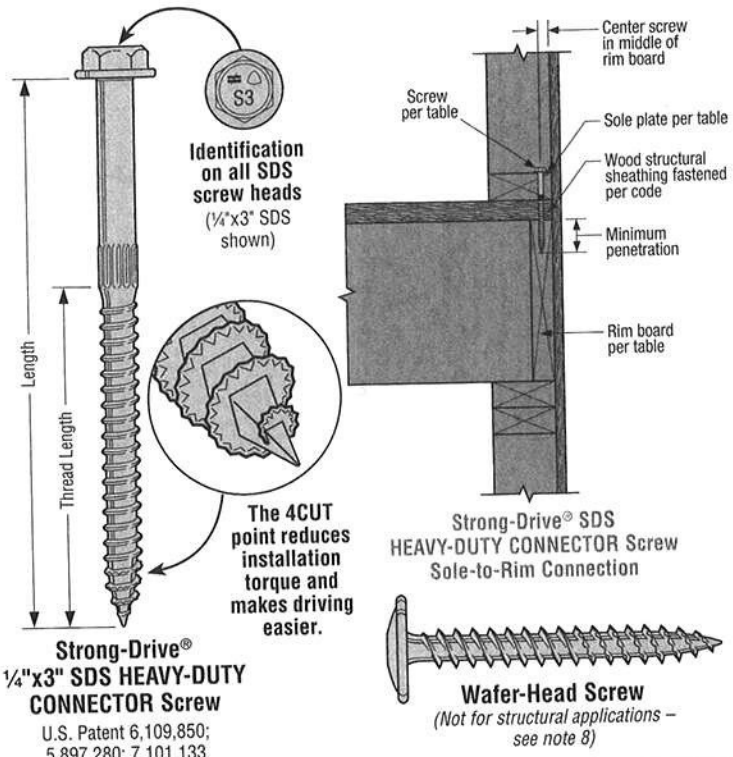
- The patented 4CUT point has a square core and serrated threads to reduce installation torque and make driving easier with no predrilling and minimal wood splitting.
- Available with a double-barrier coating or in Type 316 stainless steel. Carbon steel loads apply to corresponding stainless steel models.
- ⅜" hex washer head is stamped with the No-Equal sign and fastener length for easy identification after installation.

MATERIAL: Heat-treated carbon steel, Type 316 stainless steel

FINISH: SD8x1.25—Electro Galvanized;
SDS—Double Barrier (all lengths);
SDS—Type 316 Stainless Steel (1½" thru 3½" lengths)

CODES: See page 12 for Code Reference Key Chart.

WARNING: Industry studies show that hardened fasteners can experience performance problems in wet or corrosive environments. Accordingly, the SD8x1.25 should be used in dry, interior, and noncorrosive environments only.



These products feature additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

Simpson Strong-Tie® Strong-Drive® SDS HEAVY-DUTY CONNECTOR Screw and Wafer-Head Screw

Size (in.)	Model No.	Thread Length (in.)	Fasteners per Carton[6]	DF/SP Allowable Loads[4]						SPF/HF Allowable Loads[4]						Code Ref.
				Shear (100)[1]					Withdrawal[5] (100)	Shear (100)					Withdrawal[5] (100)	
				Wood Side Plate[3]		Steel Side Plate				Wood Side Plate[3]		Steel Side Plate				
				1½"	1¾" SCL	16 ga	14 ga & 12 ga	10 ga or Greater	Wood or Steel Side Plate	1½"	1¾" SPF LVL	16 ga	14 ga & 12 ga	10 ga or Greater	Wood or Steel Side Plate	
5/32 x 1¼	SD8x1.25[8]	—	—	—	—	50	50	50	—	—	—	45	45	45	—	170
¼ x 1½	SDS25112	1	1500	—	—	250	250	250	170	—	—	180	180	180	120	I5, L1, F20
¼ x 2	SDS25200	1¼	1300	—	—	250	290	290	215	—	—	180	210	210	150	
¼ x 2½	SDS25212	1½	1100	190	—	250	390	420	255	135	—	180	280	300	180	
¼ x 3	SDS25300	2	950	280	—	250	420	420	345	200	—	180	300	300	240	
¼ x 3½	SDS25312	2¼	900	340	340	250	420	420	385	245	245	180	300	300	270	
¼ x 4½	SDS25412	2¾	800	350	340	250	420	420	475	250	245	180	300	300	330	
¼ x 5	SDS25500	2¾	500	350	340	250	420	420	475	250	245	180	300	300	330	
¼ x 6	SDS25600	3¼	600	350	340	250	420	420	560	250	245	180	300	300	395	
¼ x 8	SDS25800	3¼	400	350	340	250	420	420	560	250	245	180	300	300	395	

Simpson Strong-Tie® Strong-Drive® SDS HEAVY-DUTY CONNECTOR Screw – Allowable Shear Values for Sole-to-Rim Connections

Size (in.)	Model No.	Sole Plate Nominal Size	Minimum Penetration into Rim Board (in.)	Allowable Loads								Code Ref.
				2x DF/SP Rim Board		2x SPF/HF Rim Board		1¼" Minimum LVL Rim Board		1¼" Minimum LSL Rim Board		
				DF/SP Sole Plate	SPF/HF Sole Plate	DF/SP Sole Plate	SPF/HF Sole Plate	DF/SP Sole Plate	SPF/HF Sole Plate	DF/SP Sole Plate	SPF/HF Sole Plate	
¼ x 4½	SDS25412	2x	2	250	190	190	190	190	190	220	190	I5, L1, F20
¼ x 5	SDS25500	2x	2	250	190	190	190	190	190	220	190	
¼ x 6	SDS25600	2x or 3x	2	250	190	190	190	190	190	220	190	

1. Screws may be provided with the 4CUT or Type 17 point.
2. Strong-Drive® SDS Heavy-Duty Connector screws install best with a low speed ½" drill with a ⅜" hex head driver.
3. Values are valid for connections between two members with full thread penetration into the main member. For other wood side plate values, see *Fastening Systems* catalog (C-F-14) pages 317-321.
4. Allowable loads are shown at the wood load duration factor of C_D=1.00. Loads may be increased for load duration per the building code up to a C_D=1.60.
5. Withdrawal loads shown are in pounds (lbs.) and are based on the entire threaded section installed into the main member. If thread penetration into the main member is less than the Thread Length as shown in the table, reduce allowable load by 172 lbs. x inches of thread not in main member. Use 121 lbs./inch for SPF.
6. Fasteners per Carton represent the quantity of screws that are available in bulk packaging. Screws are also available in mini bulk and retail packs. Refer to Simpson Strong-Tie® *Fastening Systems* catalog (C-F-14).
7. LSL wood-to-wood applications that require 4½", 5", 6" or 8" SDS screws are limited to interior-dry use only.
8. SD8x1.25 requires ¾" minimum penetration. DO NOT USE SD8x1.25 wood screws with structural connectors unless specified and stated in this catalog.
9. Where predrilling is required for Strong-Drive® SDS Heavy-Duty Connector screws, predrill diameter is 5/32".
10. Minimum spacing, edge, and end distance requirements are listed in ICC-ES ESR-2236. For smaller requirements, please contact Simpson Strong-Tie engineering.

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CCQ/ECCQ *Column Caps*

SIMPSON Strong-Tie®

This product is preferable to similar connectors because of a) easier installation, b) higher loads, c) lower installed cost, or a combination of these features.

Column caps provide a high-capacity connection for column-beam combinations. This design uses Simpson Strong-Tie® Strong-Drive® SDS Heavy-Duty Connector screws to provide faster installation and provides a greater net section area of the column compared to bolts. The SDS screws provide for a lower profile compared to standard through bolts.

MATERIAL: CCQ3, ECCQ3, CCQ4, CCQ4.62, ECCQ4, ECCQ4.62, CCQ6, ECCQ6—7 gauge; all others—3 gauge

FINISH: Simpson Strong-Tie® gray paint, available in HDG; CCOQ and ECCOQ—no coating

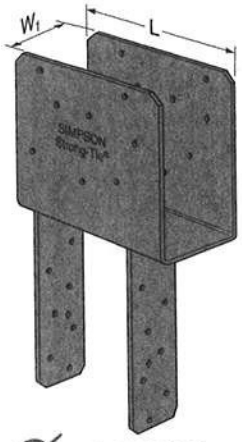
INSTALLATION:

- Install ¼"x2½" Strong-Drive SDS Heavy-Duty Connector screws, which are provided with the column cap. *(Lag screws will not achieve the same load.)*
- CCOQ and ECCOQ column cap only *(no straps)* may be ordered for field-welding to pipe or other columns. Dimensions are same as CCQ and ECCQ.
- For rough cut lumber sizes, provide dimensions. An optional W_2 dimension may be specified with any column size given. *(Note that the W_2 dimension on straps rotated 90° is limited by the W_1 dimension.)*

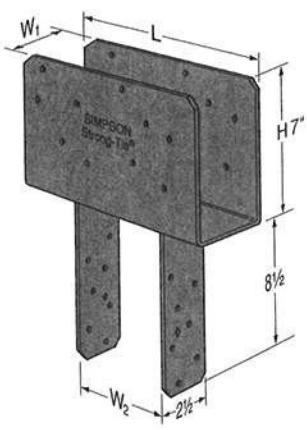
OPTIONS:

- For end conditions, specify ECCQ.
- Straps may be rotated 90° where $W_1 \geq W_2$ and for CCQ5-6.

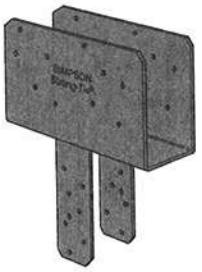
CODES: See page 12 for Code Reference Key Chart.



ECCQ46SDS2.5



CCQ46SDS2.5



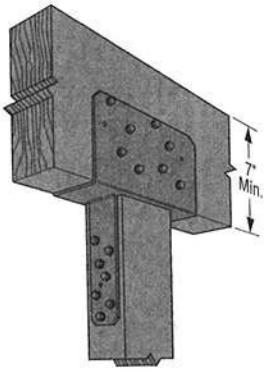
Optional CCQ with straps rotated 90°

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

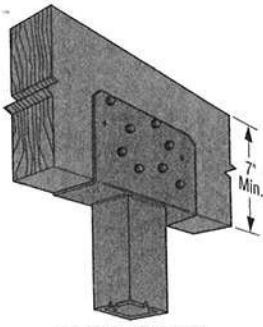
Model No.	Beam Width	Dimensions W1	W2	L CCQ	L ECCQ	H	No. of[8] ¼"x2½" SDS Screws Beam	Post	Allowable Loads (DF/SP) CCQ Uplift (160)	CCQ Down (100)	ECCQ Uplift (160)	ECCQ Down (100)	Code Ref.	CCOQ/ECCOQ Model No. (No Legs)
CCQ3-4SDS2.5	3⅛	3¼	3⅝	11	8½	7	16	14	5680	16980	3695	6125	I12, L4, F11	CCOQ3-SDS2.5 ECCOQ3-SDS2.5
CCQ3-6SDS2.5	3⅛	3¼	5½	11	8½	7	16	14	5680	19250	3695	9625		
CCQ44SDS2.5	4x	3⅝	3⅝	11	8½	7	16	14	5680	19020	4040	7655		CCOQ4-SDS2.5 ECCOQ4-SDS2.5
CCQ46SDS2.5	4x	3⅝	5½	11	8½	7	16	14	7145	24065	4040	12030		
CCQ48SDS2.5	4x	3⅝	7½	11	8½	7	16	14	7145	24065	4040	16405		
CCQ4.62-3.62SDS	4½	4⅝	3⅝	11	8½	7	16	14	5680	19020	4040	7655	170	CCOQ4.62-SDS2.5 ECCOQ4.62-SDS2.5
CCQ4.62-4.62SDS	4½	4⅝	4⅝	11	8½	7	16	14	5680	24450	4040	9845		
CCQ4.62-5.50SDS	4½	4⅝	5½	11	8½	7	16	14	7145	28585	4040	12030		
CCQ5-4SDS2.5	5⅛	5¼	3⅝	11	8½	7	16	14	5680	26635	4040	10045	I12, L4, F11	CCOQ5-SDS2.5 ECCOQ5-SDS2.5
CCQ5-6SDS2.5	5⅛	5¼	5½	11	8½	7	16	14	7245	28190	5535	15785		
CCQ5-8SDS2.5	5⅛	5¼	7½	11	8½	7	16	14	7245	31570	5535	21525		
CCQ64SDS2.5	6x	5½	3⅝	11	8½	7	16	14	5680	28585	4040	12030		CCOQ6-SDS2.5 ECCOQ6-SDS2.5
CCQ66SDS2.5	6x	5½	5½	11	8½	7	16	14	7145	30250	4040	18905		
CCQ68SDS2.5	6x	5½	7½	11	8½	7	16	14	7145	37815	4040	25780		
CCQ6-7.13SDS2.5	6x	5½	7⅛	11	8½	7	16	14	7145	37815	4040	24490	160	
CCQ74SDS2.5	6¾	6⅞	3⅝	11	8½	7	16	14	5680	33490	4040	13230	I12, L4, F11	CCOQ7.12-SDS2.5 ECCOQ7.12-SDS2.5
CCQ76SDS2.5	6¾	6⅞	5½	11	8½	7	16	14	7245	37125	5535	20790		
CCQ77SDS2.5	6¾	6⅞	6⅞	11	8½	7	16	14	7245	41580	5535	25515		
CCQ78SDS2.5	6¾	6⅞	7½	11	8½	7	16	14	7245	41580	5535	28350		
CCQ7.1-4SDS2.5	7	7⅛	3⅝	11	8½	7	16	14	5680	34730	4040	18375	160	CCOQ7.12-SDS2.5 ECCOQ7.12-SDS2.5
CCQ7.1-6SDS2.5	7	7⅛	5½	11	8½	7	16	14	7245	38500	5535	28875		
CCQ7.1-7.1SDS2.5	7	7⅛	7⅛	11	8½	7	16	14	7245	57750	5535	36750		
CCQ7.1-8SDS2.5	7	7⅛	7½	11	8½	7	16	14	7245	52500	5535	39375		
CCQ86SDS2.5	8x	7½	5½	11	8½	7	16	14	7245	41250	5535	25780		CCOQ8-SDS2.5 ECCOQ8-SDS2.5
CCQ88SDS2.5	8x	7½	7½	11	8½	7	16	14	7245	51565	5535	35155		
CCQ96SDS2.5	8¾	8⅞	5½	11	8½	7	16	14	7245	48125	5535	26950		CCOQ9-SDS2.5 ECCOQ9-SDS2.5
CCQ98SDS2.5	8¾	8⅞	7½	11	8½	7	16	14	7245	53900	5535	36750		
CCQ106SDS2.5	10x	9½	5½	11	8½	7	16	14	7245	52250	5535	32655		CCOQ10-SDS2.5 ECCOQ10-SDS2.5

1. Uplift loads have been increased for wind or earthquake with no further increase allowed; reduce where other loads govern.
2. Down loads may not be increased for short-term loading and shall not exceed the post capacity. See pages 245-246 for common post allowable loads.
3. Uplift loads do not apply to splice conditions.
4. Spliced conditions must be detailed by the Designer to transfer tension loads between spliced members by means other than the column cap.
5. Column sides are assumed to lie in the same vertical plane as the beam sides. CCQ4.62 models assume a minimum 3½" wide post.
6. Structural composite lumber columns have sides that show either the wide face or the edges of the lumber strands/veneers. Values in the tables reflect installation into the wide face. See technical bulletin T-SCLCOLUMN for values on the narrow face (edge).
7. ECCQ uses 14 Strong-Drive® SDS Heavy-Duty Connector screws into the beam and 14 Strong-Drive SDS Heavy-Duty Connector screws into the post.
8. Beam depth must be a minimum 7".
9. For 5¼" engineered lumber, use 5½" models.
10. CCOQ and ECCOQ welded to steel column will achieve same load as CCQ and ECCQ. Steel column width shall not be less than beam width. Weld by Designer.

CCOQ4-SDS2.5



Typical CCQ46SDS2.5 Installation



CCOQ Installation on Steel Column

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HUCQ Heavy-Duty Joist Hangers

SIMPSON Strong-Tie®

The HUCQ series are heavy-duty joist hangers that incorporate Simpson Strong-Tie® Strong-Drive® SDS Heavy-Duty Connector screws. Designed and tested for installation at the end of a beam or on a post, they provide a strong connection with fewer fasteners than nailed hangers. See page 117 for structural composite lumber hangers.

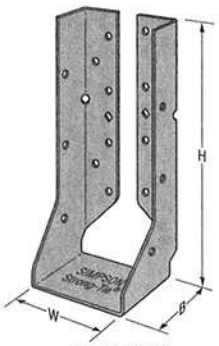
MATERIAL: 14 gauge

FINISH: Galvanized. Most models available in stainless steel or ZMAX® coating.

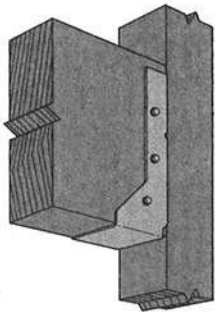
INSTALLATION: • Use all specified fasteners. See General Notes.
- Install ¼"x2½" Strong-Drive SDS Heavy-Duty Connector screws, which are provided, in all round holes. *(Lag screws will not achieve the same load.)*
- For use on solid sawn wood members.

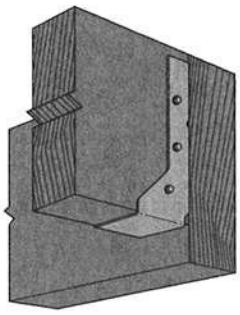
OPTIONS: These hangers cannot be modified.

CODES: See page 12 for Code Reference Key Chart.



HUCQ410


Typical HUCQ Installation on a Post


Typical HUCQ Installation on a Beam

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

Model No.	Dimensions			Fasteners		Allowable Loads								Code Ref.
						DF/SP				SPF/HF				
	W	H	B	Face	Joist	Uplift (160)	Floor (100)	Snow (115)	Roof (125)	Uplift (160)	Floor (100)	Snow (115)	Roof (125)	
HUCQ310-SDS	2⁹⁄₁₆	9	3	8-SDS ¼"x2½"	4-SDS ¼"x2½"	1370	3120	3590	3900	985	2245	2585	2810	F23
HUCQ210-2-SDS	3¼	9	3	12-SDS ¼"x2½"	6-SDS ¼"x2½"	2510	4680	4955	4955	1805	3370	3570	3570	
HUCQ410-SDS	3⁹⁄₁₆	9	3	12-SDS ¼"x2½"	6-SDS ¼"x2½"	2510	4680	4955	4955	1805	3370	3570	3570	L12, F23, I9
HUCQ412-SDS	3⁹⁄₁₆	11	3	14-SDS ¼"x2½"	6-SDS ¼"x2½"	2510	5460	5560	5560	1805	3930	4005	4005	
HUCQ210-3-SDS	4⅜	9	3	12-SDS ¼"x2½"	6-SDS ¼"x2½"	2510	4680	4955	4955	1805	3370	3570	3570	F23
HUCQ610-SDS	5½	9	3	12-SDS ¼"x2½"	6-SDS ¼"x2½"	2520	4680	5380	5715	1815	3370	3875	4115	I9, L12, F27
HUCQ612-SDS	5½	11	3	14-SDS ¼"x2½"	6-SDS ¼"x2½"	2520	5315	5315	5315	1815	3825	3825	3825	

1. Uplift loads have been increased for wind or earthquake loading. Reduce where other loads govern.
2. See page 101 for additional engineered wood product sizes.
3. Structural composite lumber columns have sides that show either the wide face or the edges of the lumber strands/veneers. Values in the tables reflect installation into the wide face. See technical bulletin T-SCLCOLUMN for values on the narrow face (edge).

LOAD TABLE EXPLANATION

This icon identifies products approved for installation with the Simpson Strong-Tie® Strong-Drive® SD Connector screw. See page 27 for more information.

Min/Max: Refers to min. or max. nailing for products with round and triangle holes. Min. nailing uses round holes, and max. nailing uses round and triangle holes to achieve maximum load.

Load Duration: Assumed duration factor used to determine the allowable load.

Code Ref.: See page 12 for the Code Reference Key Chart, to determine which code reports include this product.

Allowable Design Loads: The maximum load that a connection is designed to provide. There may be multiple design loads acting in different directions *(up, down, lateral, perpendicular, etc.)* imposed on a connection.

Joist Size: This shows the size of joist member.

Model No.: This is the Simpson Strong-Tie product name.

Gauge: Product material

Nails: This shows the fastener quantity and type required to achieve the table loads.

Uplift | **Floor, Snow, Roof**

Installed Cost Index: This indicates the products relative installed cost *(combined cost and installation cost).*

Joist Size	Model No.	Ga	Dimensions (in.) W	H	B	Min/Max	Fasteners Header	Joist	DF/SP Allowable Loads Uplift (160)	Floor (100)	Snow (115)	Roof (125)	Installed Cost Index (ICI)	Code Ref.
SAWN LUMBER SIZES														
DBL 2X6	LUS26-2	18	3⅛	4⅞	2	—	4-16d	4-16d	1165	1030	1180	1280	Lowest	I7, I27, F6, L5, L17
	U26-2	16	3⅛	5	2	—	8-16d	4-10d	740	1150	1305	1410	+65%	I7, F6, L17
	HUS26-2/HUSC26-2	14	3⅛	5⁹⁄₁₆	2	—	4-16d	4-16d	1235	1065	1210	1305	+172%	
	HU26-2/HUC26-2	14	3⅛	5⅜	2½	Min	8-16d	4-10d	760	1190	1345	1445	+233%	I7, I27, F6, L5, L17
		14	3⅛	5⅜	2½	Max	12-16d	6-10d	1135	1785	2015	2165	+254%	I7, F6, L17

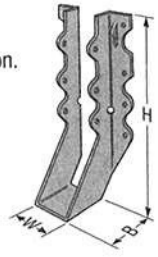
This icon identifies products that are available with additional corrosion protection. See pages 13-15 for additional information.

Dimensions W, H, B: This shows the product dimensions *(width, height and base in this case.)* referenced in the product drawing.

NAILS: 16d = 0.162" dia. x 3½" long, 10dx1½ = 0.148" dia. x 1½" long. See page 22-23 for other nail sizes and information.

Throughout this catalog a footnote will typically be provided indicating the required nail diameter and length.

All installations should be designed only in accordance with the allowable load values set forth in this catalog.



Product Drawing: Provides a graphic presentation of the product with dimensional information *(often cross referenced to the table).*

CATALOG DEFINITION:
Deflection: The distance a point moves when a load is applied.

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LUS/HUS/HHUS/HGUS *Double Shear Joist Hangers*

SIMPSON Strong-Tie

This product is preferable to similar connectors because of a) easier installation, b) higher loads, c) lower installed cost, or a combination of these features.

See Hanger tables on pages 77-82. See Hanger Options on pages 233-243 for hanger modifications, which may result in reduced loads.

All hangers in this series have double shear nailing. This innovation distributes the load through two points on each joist nail for greater strength. It also allows the use of fewer nails, faster installation, and the use of standard nails for all connections. *(Do not bend or remove tabs.)*

MATERIAL: See tables, pages 77-82.

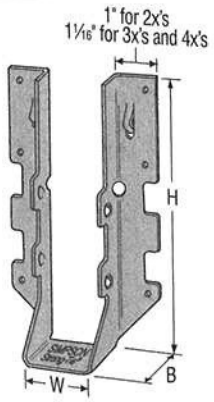
FINISH: Galvanized. Some products available in stainless steel or ZMAX® coating; see Corrosion Information, pages 13-15.

INSTALLATION • Use all specified fasteners. See General Notes.

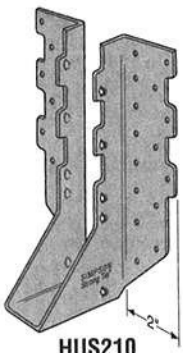
- Nails must be driven at an angle through the joist or truss into the header to achieve the table loads.
- Not designed for welded or nailer applications.
- 16d sinkers (0.148" dia. x 3¼" long) may be used where 10d commons are specified with no reduction in load. Where 16d commons are specified, 10d commons or 16d sinkers (0.148" dia. x 3¼" long) may be used at 0.85 of the table load.
- With 3x carrying members, use 16dx2½" nails into the header and 16d commons into the joist with no load reduction.
- With 2x carrying members, use 10dx1½" nails into the header and 10d commons into the joist, reduce the load to 0.64 of the table value.
- Use stainless-steel (SS) nails with stainless-steel (SS) hangers.

OPTIONS: • LUS hangers cannot be modified.

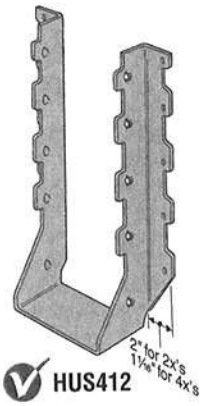
- HUS hangers available with the header flanges turned in for 2-2x (3⅛") and 4x only, with no load reduction. See the HUSC Concealed Flange illustration.



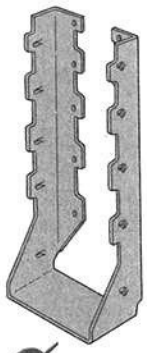
LUS28



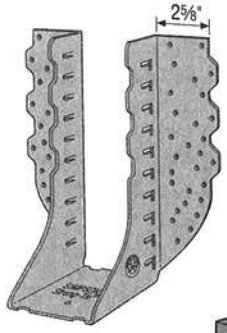
HUS210
(HUS26, HUS28, and HHUS similar)



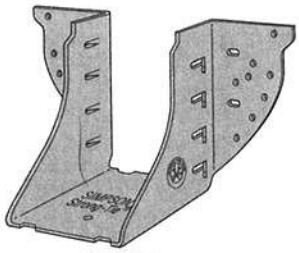
HUS412



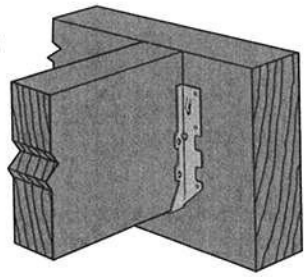
HUSC
Concealed Flanges
(not available for HHUS, HGUS and HUS2x)



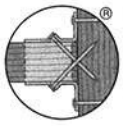
HGUS3.25/12



HGUS46



Typical LUS28 Installation
use 0.148x3" (10d common) or 0.148x3¼" (16d sinker) nail



Double-Shear Nailing Top View

Double-Shear Nailing Side View Do not bend tab

Dome Double-Shear Nailing Side View *(available on some models)*

U.S. Patent 5,603,580

FACE MOUNT HANGERS – SOLID SAWN LUMBER (DF/SP)

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

Joist Size	Model No.	Ga	Dimensions (in.) W	H	B	Min/ Max	Fasteners Header	Joist	DF/SP Allowable Loads Uplift (160)	Floor (100)	Snow (115)	Roof (125)	Installed Cost Index (ICI)	Code Ref.
SAWN LUMBER SIZES														
2X4	LU24	20	1⁹⁄₁₆	3⅛	1½	—	4-16d	2-10dx1½	265	555	635	685	Lowest	I7, I27, F6, L5, L17
2X4	LUS24	18	1⁹⁄₁₆	3⅛	1¾	—	4-10d	2-10d	490	670	765	825	+3%	
2X4	U24	16	1⁹⁄₁₆	3⅛	1½	—	4-16d	2-10dx1½	265	575	655	705	+67%	I7, F6, L17
2X4	HU26	14	1⁹⁄₁₆	3¹⁄₁₆	2¼	—	4-16d	2-10dx1½	335	595	670	720	+295%	
DBL 2X4	LUS24-2	18	3⅛	3⅛	2	—	4-16d	2-16d	440	800	910	985	Lowest	I7, I27, F6, L5, L17
DBL 2X4	U24-2	16	3⅛	3	2	—	4-16d	2-10d	370	575	655	705	+33%	I7, F6, L17
DBL 2X4	HU24-2/HUC24-2	14	3⅛	3¹⁄₁₆	2½	—	4-16d	2-10d	380	380	595	720	+240%	
2x6	LUS26	18	1⁹⁄₁₆	4¾	1¾	—	4-10d	4-10d	1165	865	990	1070	Lowest	I7, I27, F6, L5, L17
2x6	LU26	20	1⁹⁄₁₆	4¾	1½	—	6-16d	4-10dx1½	565	835	950	1030	+6%	
2x6	U26	16	1⁹⁄₁₆	4¾	2	—	6-16d	4-10dx1½	585	865	980	1055	+43%	I7, F6, L17
2x6	LUC26Z	18	1⁹⁄₁₆	4¾	1¾	—	6-16d	4-10dx1½	730	845	965	1040	+160%	
2x6	HU26	14	1⁹⁄₁₆	3¹⁄₁₆	2¼	—	4-16d	2-10dx1½	335	335	595	720	+179%	
2x6	HUS26	16	1⅝	5⅜	3	—	14-16d	6-16d	1550	2720	3095	3335	+276%	I7, I27, F6, L5, L17
DBL 2X6	LUS26-2	18	3⅛	4⅞	2	—	4-16d	4-16d	1165	1030	1180	1280	Lowest	
DBL 2X6	U26-2	16	3⅛	5	2	—	8-16d	4-10d	740	1150	1305	1410	+65%	I7, F6, L17
DBL 2X6	HUS26-2/HUSC26-2	14	3⅛	5⁹⁄₁₆	2	—	4-16d	4-16d	1235	1065	1210	1305	+172%	
DBL 2X6	HU26-2/HUC26-2	14	3⅛	5⅜	2½	Min	8-16d	4-10d	760	1190	1345	1445	+233%	I7, I27, F6, L5, L17
DBL 2X6	HU26-2/HUC26-2	14	3⅛	5⅜	2½	Max	14-16d	6-10d	1135	1785	2015	2165	+254%	I7, F6, L17

See footnotes on page 79.

CODES: See page xx for Code Reference Key Chart.

FACE MOUNT HANGERS – SOLID SAWN LUMBER (DF/SP)

SIMPSON Strong-Tie

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

Joist Size	Model No.	Ga	Dimensions (in.) W	H	B	Min/ Max	Fasteners Header	Joist	DF/SP Allowable Loads Uplift (160)	Floor (100)	Snow (115)	Roof (125)	Installed Cost Index (ICI)	Code Ref.
SAWN LUMBER SIZES														
TPL 2x6	LUS26-3	18	4⅝	4⅛	2		4-16d	4-16d	1165	1030	1180	1280	*	160
	U26-3	16	4⅝	4¼	2		8-16d	4-10d	740	1150	1305	1410	*	
	HU26-3/HUC26-3	14	4 1/16	5½	2½	Min	8-16d	4-10d	760	1190	1345	1445	*	
		14	4 1/16	5½	2½	Max	12-16d	6-10d	1135	1785	2015	2165	*	
2x8	LUS26	18	1 9/16	4¾	1¾	—	4-10d	4-10d	1165	865	990	1070	Lowest	I7, I27, F6, L5, L17
	LU26	20	1 9/16	4¾	1½	—	6-16d	4-10dx1½	565	835	950	1030	+6%	
	LUS28	18	1 9/16	6⅝	1¾	—	6-10d	4-10d	1165	1100	1255	1360	+23%	
	LU28	20	1 9/16	6⅝	1½	—	8-16d	6-10dx1½	850	1110	1270	1335	+39%	
	U26	16	1 9/16	4¾	2	—	6-16d	4-10dx1½	585	865	980	1055	+43%	I7, F6, L17
	LUC26Z	18	1 9/16	4¾	1¾	—	6-16d	4-10dx1½	730	845	965	1040	+160%	
	HU28	14	1 9/16	5¼	2¼	—	6-16d	4-10dx1½	610	895	1005	1085	+251%	
	HUS26	16	1⅝	5⅜	3	—	14-16d	6-16d	1550	2720	3095	3335	+276%	I7, I27, F6, L5, L17
	HUS28	16	1⅝	7	3	—	22-16d	8-16d	2000	3965	4120	4220	+409%	
DBL 2x8	LUS26-2	18	3⅛	4⅞	2	—	4-16d	4-16d	1165	1030	1180	1280	Lowest	
	LUS28-2	18	3⅛	7	2	—	6-16d	4-16d	1165	1315	1500	1625	+8%	
	U26-2	16	3⅛	5	2	—	8-16d	4-10d	740	1150	1305	1410	+65%	I7, F6, L17
	HUS28-2/HUSC28-2	14	3⅛	7 3/16	2	—	6-16d	6-16d	1550	1595	1815	1960	+188%	
	HU28-2/HUC28-2	14	3⅛	7	2½	Min	10-16d	4-10d	760	1490	1680	1805	+397%	
		14	3⅛	7	2½	Min	14-16d	6-10d	1135	2085	2350	2530	+418%	
TPL 2X8	LUS28-3	18	4⅝	6¼	2	—	6-16d	4-16d	1165	1315	1500	1625	*	160
	U26-3	16	4⅝	4¼	2	—	8-16d	4-10d	740	1150	1305	1410	*	
	HU26-3/HUC26-3	14	4 1/16	5½	2½	Min	8-16d	4-10d	760	1190	1345	1445	*	
		14	4 1/16	5½	2½	Max	12-16d	6-10d	1135	1785	2015	2165	*	
QUAD 2X8	HU28-4/HUC28-4	14	14	6⅛	6⅝	Min	10-16d	4-16d	900	1490	1680	1805	*	
		14	14	6⅛	6⅝	Max	14-16d	6-16d	1345	2085	2350	2530	*	
2x10	LUS28	18	1 9/16	6⅝	1¾	—	6-10d	4-10d	1165	1100	1255	1360	Lowest	I7, I27, F6, L5, L17
	LU28	20	1 9/16	6⅝	1½	—	8-16d	6-10dx1½	850	1110	1270	1335	+13%	
	LUS210	18	1 9/16	7 13/16	1¾	—	8-10d	4-10d	1165	1340	1525	1650	+15%	
	LU210	20	1 9/16	7 13/16	1½	—	10-16d	6-10dx1½	850	1390	1585	1715	+28%	I7, F6, L17
	U210	16	1 9/16	7 13/16	2	—	10-16d	6-10dx1½	1110	1440	1635	1685	+76%	
	LUC210Z	18	1 9/16	7¾	1¾	—	10-16d	6-10dx1½	1100	1410	1605	1735	+180%	
	HU210	14	1 9/16	7⅛	2¼	—	8-16d	4-10dx1½	610	1190	1345	1445	+225%	
	HUS210	16	1⅝	9	3	—	30-16d	10-16d	3000	4255	4445	4575	+450%	
DBL 2X10	LUS28-2	18	3⅛	7	2	—	6-16d	4-16d	1165	1315	1500	1625	Lowest	I7, I27, F6, L5, L17
	LUS210-2	18	3⅛	9	2	—	8-16d	6-16d	1745	1830	2090	2265	+34%	
	U210-2	16	3⅛	8½	2	—	14-16d	6-10d	1110	2015	2285	2465	+88%	I7, F6, L17
	HUS210-2/HUSC210-2	14	3⅛	9 3/16	2	—	8-16d	8-16d	3295	2125	2420	2615	+217%	I7, F23, L17
	HU210-2/HUC210-2	14	3⅛	8 13/16	2½	Min	14-16d	6-10d	1135	2085	2350	2530	+441%	I7, F6, L17
		14	3⅛	8 13/16	2½	Max	18-16d	10-10d	1895	2680	3020	3250	+467%	
	HUCQ210-2-SDS	14	2 9/16	9	3	—	12-¼"x2½" SDS	6-¼"x2½" SDS	2510	4680	4955	4955	*	F23
	HHUS210-2	14	3 5/16	9 5/32	3	—	30-16d	10-16d	4000	5635	6380	6880	*	F23
TPL 2X10	LUS28-3	18	4⅝	6¼	2	—	6-16d	4-16d	1165	1315	1500	1625	*	160
	LUS210-3	18	4⅝	8 3/16	2	—	8-16d	6-16d	1745	1830	2090	2265	*	
	U210-3	16	4⅝	7¾	2	—	14-16d	6-10d	1110	2015	2285	2465	*	
	HU210-3/HUC210-3	14	4 1/16	8 9/16	2½	Min	14-16d	6-10d	1135	2085	2350	2530	*	I7, F6, L17
		14	4 1/16	8 9/16	2½	Max	18-16d	10-10d	1895	2680	3020	3250	*	
	HHUS210-3	14	4 1/16	8⅞	3	—	30-16d	10-16d	4000	5635	6380	6880	*	
	HGUS210-3	12	4 15/16	9⅛	4	—	46-16d	16-16d	4095	9100	9100	9100	*	I7, F23
	HUCQ210-3-SDS	14	4⅝	9	3	—	8-¼"x2½" SDS	4-¼"x2½" SDS	2510	4680	4955	4955	*	F23
QUAD 2x10	HU210-4/HUC210-4	14	6⅛	8⅜	2½	Min	14-16d	6-16d	1345	2085	2350	2530	*	160
		14	6⅛	8⅜	2½	Max	18-16d	8-16d	1795	2680	3020	3250	*	
	HHUS210-4	14	6⅛	8⅞	3	—	30-16d	10-16d	4000	5635	6380	6880	*	F23, 160
	HGUS210-4	12	6 9/16	9⅛	4	—	46-16d	16-16d	4095	9100	9100	9100	*	
2x12	LUS210	18	1 9/16	7 13/16	1¾	—	8-10d	4-10d	1165	1340	1525	1650	Lowest	I7, I27, F6, L5, L17
	LU210	20	1 9/16	7 13/16	1½	—	10-16d	6-10dx1½	850	1390	1585	1715	+11%	
	U210	16	1 9/16	7 13/16	2	—	10-16d	6-10dx1½	1110	1440	1635	1685	+53%	I7, F6, L17
	LUC210Z	18	1 9/16	7¾	1¾	—	10-16d	6-10dx1½	1100	1410	1605	1735	+180%	I7, I27, F6, L5, L17
	HU212	14	1 9/16	9	2¼	—	10-16d	6-10dx1½	1135	1490	1680	1805	+347%	I7, F6, L17
	HUS210	16	1⅝	9	3	—	30-16d	10-16d	3000	4255	4445	4575	+378%	
DBL 2x12	LUS210-2	18	3⅛	9	2	—	8-16d	6-16d	1745	1830	2090	2265	Lowest	I7, I27, F6, L5, L17
	U210-2	16	3⅛	8½	2	—	14-16d	6-10d	1110	2015	2285	2465	+40%	I7, F6, L17
	LUS214-2	18	3⅛	10 15/16	2	—	10-16d	6-16d	1745	2110	2410	2610	+56%	
	HUS210-2	14	3⅛	9 9/16	2	—	8-16d	8-16d	3295	2125	2420	2615	*	
	HUS212-2/HUSC212-2	14	3⅛	10¾	2	—	10-16d	10-16d	3635	2660	3025	3265	*	
	HU212-2/HUC212-2	14	3⅛	10 9/16	2½	Min	16-16d	6-10d	1135	2380	2685	2890	*	
		14	3⅛	10 9/16	2½	Max	2 2-16d	10-10d	1895	3275	3695	3970	+411%	
	HUCQ210-2-SDS	14	2 9/16	9	3	—	12-¼"x2½" SDS	6-¼"x2½" SDS	2510	5460	5560	5560	*	F23

See footnotes on page 79.

CODES: See page 12 for Code Reference Key Chart.

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FACE MOUNT HANGERS – SOLID SAWN LUMBER (DF/SP)

SIMPSON Strong-Tie®

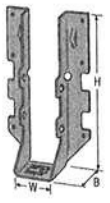
These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

CODES: See page 12 for Code Reference Key Chart.

Joist Size	Model No.	Ga	Dimensions (in.) W	H	B	Min/ Max	Fasteners Header	Joist	DF/SP Allowable Loads Uplift (160)	Floor (100)	Snow (115)	Roof (125)	Installed Cost Index (ICI)	Code Ref.
SAWN LUMBER SIZES														
4x10	LUS48	18	3⁹⁄₁₆	6¾	2	—	6-16d	4-16d	1165	1315	1500	1625	Lowest	I7, F6, L17
	LUS410	18	3⁹⁄₁₆	8¾	2	—	8-16d	6-16d	1745	1830	2090	2265	+19%	
	U410	16	3⁹⁄₁₆	8⅞	2	—	14-16d	6-10d	1110	2015	2285	2465	+74%	
	HUS410/HUSC410	14	3⁹⁄₁₆	8¹⁵⁄₁₆	2	—	8-16d	8-16d	3295	2125	2420	2615	+154%	
	HU410/HUC410	14	3⁹⁄₁₆	8⅝	2½	Min	14-16d	6-10d	1135	2085	2350	2530	+232%	
		14	3⁹⁄₁₆	8⅝	2½	Max	18-16d	10-10d	1895	2680	3020	3250	+253%	
	HUCQ410-SDS	14	3⁹⁄₁₆	9	3	—	12-¼"x2½" SDS	6-¼"x2½" SDS	2510	4680	4955	4955	*	I9, L12, F23
4x12	LUS410	18	3⁹⁄₁₆	8¾	2	—	8-16d	6-16d	1745	1830	2090	2265	Lowest	I7, F6, L17
	LUS414	18	3⁹⁄₁₆	10¾	2	—	10-16d	6-16d	1745	2110	2410	2610	+33%	
	U410	16	3⁹⁄₁₆	8⅞	2	—	14-16d	6-10d	1110	2015	2285	2465	+46%	
	HUS410/HUSC410	14	3⁹⁄₁₆	8⁵⁄₁₆	2	—	8-16d	8-16d	3295	2125	2420	2615	+114%	
	HUS412	14	3⁹⁄₁₆	10½	2	—	10-16d	10-16d	3635	2660	3025	3265	+129%	
	HU412/HUC412	14	3⁹⁄₁₆	10⁵⁄₁₆	2½	Min	16-16d	6-10d	1135	2380	2685	2890	+268%	
		14	3⁹⁄₁₆	10⁵⁄₁₆	2½	Max	22-16d	10-10d	1895	3275	3695	3970	+290%	
	HUCQ410-SDS	14	3⁹⁄₁₆	9	3	—	12-¼"x2½" SDS	6-¼"x2½" SDS	2510	4680	4955	4955	*	I9, L12, F23
	HUCQ412-SDS	14	3⁹⁄₁₆	11	3	—	14-¼"x2½" SDS	6-¼"x2½" SDS	2510	5460	5560	5560	*	F23
4x14	LUS410	18	3⁹⁄₁₆	8¾	2	—	8-16d	6-16d	1745	1830	2090	2265	Lowest	I7, F6, L17
	LUS414	18	3⁹⁄₁₆	10¾	2	—	10-16d	6-16d	1745	2110	2410	2610	+33%	
	U414	16	3⁹⁄₁₆	10	2	—	16-16d	6-10d	1110	2305	2615	2820	+93%	
	HUS412/HUSC412	14	3⁹⁄₁₆	10½	2	—	10-16d	10-16d	3635	2660	3025	3265	+129%	
	HU414/HUC414	14	3⁹⁄₁₆	12⅝	2½	Min	18-16d	8-10d	1515	2680	3020	3250	+333%	
		14	3⁹⁄₁₆	12⅝	2½	Max	24-16d	12-10d	2015	3570	4030	4335	+355%	
	HUCQ412-SDS	14	3⁹⁄₁₆	11	3	—	14-¼"x2½" SDS	6-¼"x2½" SDS	2510	5460	5560	5560	*	I9, L12, F23
4x16	U414	16	3⁹⁄₁₆	10	2	—	16-16d	6-10d	1110	2305	2615	2820	Lowest	I7, F6, L17
	HUS412/HUSC412	14	3⁹⁄₁₆	10½	2	—	10-16d	10-16d	3635	2660	3025	3265	+19%	
	HU416/HUC416	14	3⁹⁄₁₆	13⅝	2½	Min	20-16d	8-10d	1515	2975	3360	3610	+167%	
		14	3⁹⁄₁₆	13⅝	2½	Max	26-16d	12-10d	2015	3870	4365	4695	+178%	
6x6	U66	16	5½	5	2	—	8-16d	4-10d	740	1150	1305	1410	*	
	HU66/HUC66	14	5½	4⁹⁄₁₆	2½	Min	8-16d	4-16d	900	1190	1345	1445	*	
		14	5½	4⁹⁄₁₆	2½	Max	12-16d	6-16d	1345	1785	2015	2165	*	
6x8	U66	16	5½	5	2	—	8-16d	4-10d	740	1150	1305	1410	*	
	HU68/HUC68	14	5½	5¹³⁄₁₆	2½	Min	10-16d	4-16d	900	1490	1680	1805	*	
		14	5½	5¹³⁄₁₆	2½	Max	14-16d	6-16d	1345	2085	2350	2530	*	
6x10	U610	16	5½	8.5	2	—	14-16d	6-10d	1110	2015	2285	2465	*	
	HU610/HUC610	14	5½	7⅞	2½	Min	14-16d	6-16d	1345	2085	2350	2530	*	
		14	5½	7⅞	2½	Max	18-16d	8-16d	1795	2680	3020	3250	*	
	HUCQ610-SDS	14	5½	9	3	—	12-¼"x2½" SDS	6-¼"x2½" SDS	2520	4680	5380	5715	*	I9, L12, F23
6x12	HU612/HUC612	14	5½	9⅜	2½	Min	16-16d	6-16d	1345	2380	2685	2890	*	I7, F6, L17
		14	5½	9⅜	2½	Max	22-16d	8-16d	1795	3275	3695	3970	*	
	HUCQ610-SDS	14	5½	9	3	—	12-¼"x2½" SDS	6-¼"x2½" SDS	2520	4680	5380	5715	*	I9, L12, F23
	HUCQ612-SDS	14	5½	11	3	—	14-¼"x2½" SDS	6-¼"x2½" SDS	2520	5315	5315	5315	*	I9, L12, F23
6x14	HU614/HUC614	14	5½	11⅞	2½	Min	18-16d	8-16d	1795	2680	3020	3250	*	I7, F6, L17
		14	5½	11⅞	2½	Max	24-16d	12-16d	2695	3570	4030	4335	*	
	HUCQ610-SDS	14	5½	9	3	—	12-¼"x2½" SDS	6-¼"x2½" SDS	2520	4680	5380	5715	*	I9, L12, F23
	HUCQ612-SDS	14	5½	11	3	—	14-¼"x2½" SDS	6-¼"x2½" SDS	2520	5315	5315	5315	*	
6x16	HU616/HUC616	14	5½	12¹¹⁄₁₆	2½	Min	20-16d	8-16d	1795	2975	3360	3610	*	I7, F6, L17
		14	5½	12¹¹⁄₁₆	2½	Max	26-16d	12-16d	2695	3870	4365	4695	*	
	HUCQ612-SDS	14	5½	11	3	—	14-¼"x2½" SDS	6-¼"x2½" SDS	2520	5315	5315	5315	*	I9, L12, F23
8x8	HU88/HUC88	14	7½	6⅝	2½	Min	10-16d	4-16d	900	1490	1680	1805	*	160
		14	7½	6⅝	2½	Max	14-16d	6-16d	1345	2085	2350	2530	*	
8x10	HU810/HUC810	14	7½	8⅜	2½	Min	14-16d	6-16d	1345	2085	2350	2530	*	
		14	7½	8⅜	2½	Max	18-16d	8-16d	1795	2680	3020	3250	*	
8x12	HU812/HUC812	14	7½	10⅛	2½	Min	16-16d	6-16d	1345	2380	2685	2890	*	
		14	7½	10⅛	2½	Max	22-16d	8-16d	1795	3275	3695	3970	*	
8x14	HU814/HUC814	14	7½	11⅞	2½	Min	18-16d	8-16d	1795	2680	3020	3250	*	
		14	7½	11⅞	2½	Max	24-16d	12-16d	2695	3570	4030	4335	*	
8x16	HU816/HUC816	14	7½	13⅝	2½	Min	20-16d	8-16d	1795	2975	3360	3610	*	
		14	7½	13⅝	2½	Max	26-16d	12-16d	2695	3870	4365	4695	*	

1. Uplift loads apply to 10d and 16d header fasteners. Uplift loads have been increased for wind or earthquake loading with no further increase allowed. Reduce where other loads govern.
2. 10d commons or 16d sinkers may be used instead of the specified 16d at 0.84 of the table load value.
3. 16d sinkers may be used instead of the specified 10d commons with no load reduction. *(16d sinkers are not acceptable for HDG applications.)*
4. MIN nailing quantity and load values—fill all round holes; MAX nailing quantity and load values—fill all round and triangle holes.
5. DF/SP loads can be used for SCL that has fastener holding capacity of Doug Fir.
6. Truss chord cross-grain tension may limit allowable loads in accordance with ANSI/TPI 1-2007. Simpson Strong-Tie® Connector Selector™ Software includes the evaluation of cross-grain tension in its hanger allowable loads. For additional information, contact Simpson Strong-Tie.
7. **NAILS:** 16d = 0.162" dia. x 3½" long, 10d = 0.148" dia. x 3" long, 10dx1½ = 0.148" dia. x 1½" long. See page 22-23 for other nail sizes and information.

**Hangers do not have an Installed Cost Index.*



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TOP FLANGE HANGERS JB/JBA/LB/LBAZ/BA/B/HHB *Joist, Beam and Purlin Hangers*

SIMPSON Strong-Tie®

This product is preferable to similar connectors because of a) easier installation, b) higher loads, c) lower installed cost, or a combination of these features.

The new, next-generation LBAZ and JBA hangers provide higher loads for 2x10, 2x12 and 2x14 members in 14 gauge and 18 gauge steel, respectively. The new nail locations on the JBA enable effective use with nailers.

The B and BA hangers are cost effective hangers featuring min/max joist nailing option. Min Nailing featuring Positive Angle Nailing targets moderate load conditions whereas the Max Nailing generates capacities for higher loads. The unique two level embossment provides added stiffness to the top flange.

See tables on pages 87-91. See Hanger Options on pages 233-243 for hanger modifications, which may result in reduced loads.

MATERIAL: See tables, pages 87-91.

FINISH: BA, JB, JBA, LB, LBAZ and B—Galvanized; HHB–all saddle hangers and all welded sloped and special hangers—Simpson Strong-Tie® gray paint. BA, LB, B and HHB may be ordered hot-dip galvanized, specify HDG.

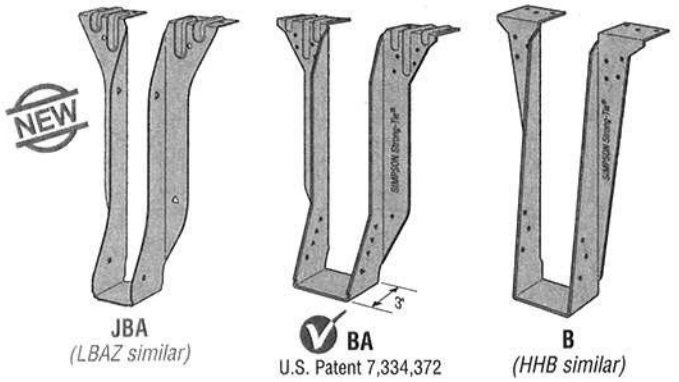
INSTALLATION: • Use specified fasteners. See General Notes and nailer table notes.

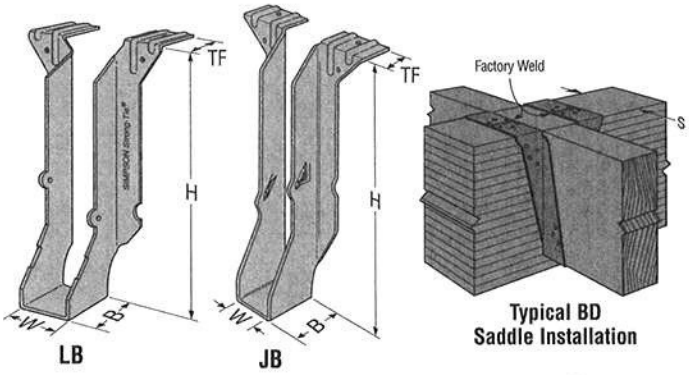
- LBAZ, BA, B and HHB may also be welded to steel headers with weld size to match material thickness *(approximate thickness shown)*. The minimum required weld to the top flanges is ⅛" x 2" *(⅛" x 1 7/16" for LBAZ)* fillet weld to each side of each top flange tab for 14 and 12 gauge and 3/16" x 2" fillet weld to each side of each top flange tab for 7 gauge. Distribute the weld equally on both top flanges. Welding cancels the top and face nailing requirements. Consult the code for special considerations when welding galvanized steel. The area should be well-ventilated *(see page 17 for welding information)*. Weld on applications produce the maximum allowable down load listed. For uplift loads refer to technical bulletin T-WELDUPLFT.
- Ledgers must be evaluated for each application separately. Check TF dimension, nail length and nail location on ledger.
- Refer to technical bulletin T-SLOPEJST for information regarding load reductions on selected hangers which can be used without modification to support joists which have shallow slopes (≤¾:12).

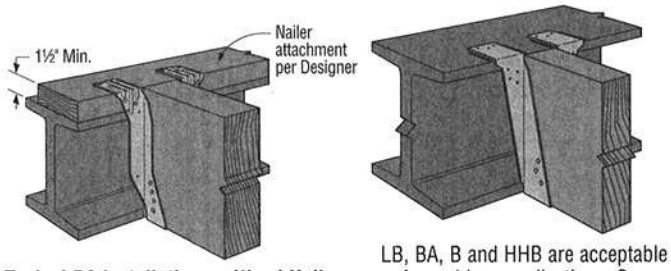
OPTIONS: B and HHB

- Other widths are available; specify W dimension *(the minimum W dimension is 1 9/16" for B and 3¼" for HHB)*.
- See Hanger Options, pages 233-243. BA, JB, JBA, LB and LBAZ hangers cannot be modified. Use LBV as an alternative for the JBA/LBAZ.

CODES: See page 12 for Code Reference Key Chart.







Nailer Table[6]

Model No.	Nailer	Top Flange Nailing	Joist Nailing	Allowable Loads		
				Uplift[1] (160)	DF/SP	SPF/HF
NEW JB210A, NEW JB212A, NEW JB214A	2x	6-10dx1½	2-10dx1½	315	1265	965
	3x	6-16dx2½	2-10dx1½	315	1290	—
LB26	2x	4-10dx1½	2-10dx1½	—	850	—
LB28	2x	4-10dx1½	2-10dx1½	—	915	—
NEW LB210AZ, NEW LB212AZ, NEW LB214AZ	2x	6-10dx1½	2-10dx1½	375	1265	1065
	3x	6-16dx2½	2-10dx1½	375	1290	—
LB216	2x	4-10dx1½	2-10dx1½	—	1150	—
BA	2x	10-10dx1½	2-10dx1½	265[3]	2220	1755
	2-2x	14-10d	2-10dx1½	265[3]	2695	2235
	3x	14-16dx2½	2-10dx1½	265[3]	3230	—
	4x	14-16d	2-10dx1½	265[3]	3230	—
B	2-2x	14-10d	6-10dx1½	710[4]	3615	2770
	3x	14-16dx2½	6-10dx1½	830[4]	3725	—
	4x	14-16d	6-10dx1½	830[4]	3800	—

1. Uplift values are for DF/SP nailers only. Refer to technical bulletin T-NAILERUPLFT for SPF values.
2. For joist members 2½" or wider, 16dx2½" joist nails should be installed for additional uplift loads on the 3x and 4x nailer applications of 970 lbs. and 1010 lbs. respectively.
3. If joist nailing is increased to (8)-10dx1½, higher uplift loads are allowed. See technical bulletin T-NAILERUPLFT.
4. If joist nailing is increased to (6)-16dx2½, higher uplift loads are allowed for joist members at least 2½" wide. See technical bulletin T-NAILERUPLFT.
5. Attachment of nailer to supporting member is by the Designer.

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TOP FLANGE HANGERS – SOLID SAWN LUMBER (DF/SP)

SIMPSON Strong-Tie

DON'T FEEL LIKE SIFTING THROUGH THIS TABLE? Visit ***www.strongtie.com/software*** to learn more about our new Joist Hanger Selector software.

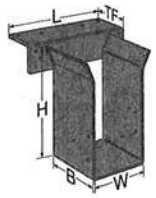
These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

Joist or Purlin Size	Model No.	Ga	Dimensions W	H	B	TF	Fasteners Header	Joist	DF/SP Allowable Loads Uplift (160)	Floor (100)	Snow (115)	Roof (125)	Installed Cost Index (ICI)	Code Ref.
SAWN LUMBER SIZES														
2x4	HU24TF	12	1⁹⁄₁₆	3⁷⁄₁₆	2¼	2½	6-16d	2-10dx1½	295	2090	2100	2100	Lowest	
DBL 2x4	HU24-2TF	12	3⅛	3⁷⁄₁₆	2½	2½	8-16d	2-10d	375	2600	2600	2600	Lowest	
2x6	JB26	18	1⁹⁄₁₆	5⅞	1½	1⁵⁄₁₆	4-10d	2 PRONG	—	1040	1040	1040	Lowest	
	LB26	14	1⁹⁄₁₆	5⅞	1½	1½	4-16d	2-10dx1½	290	1380	1380	1380	+117%	
	HU26TF	12	1⁹⁄₁₆	5⅞	2¼	2½	10-16d	4-10dx1½	590	2275	2330	2335	+568%	
	W26	12	1⁹⁄₁₆	5⅞	2½	2½	2-10d	2-10dx1½	—	2200	2200	2200	+890%	
DBL 2x6	HUS26-2TF	14	3⅛	5⅞	2	1¾	6-16d	4-16d	1235	2820	3000	3000	Lowest	
	WNP26-2	12	3⅛	5⅞	2½	2³⁄₁₆	2-10d	2-10d	—	3255	3255	3255	+33%	
	HU26-2TF	12	3⅛	5⅞	2½	2½	10-16d	4-10d	750	3725	3900	3900	+87%	I10, F9, L11
2x8	JB28	18	1⁹⁄₁₆	7¼	1½	1⁵⁄₁₆	4-10d	2 PRONG	—	1050	1050	1050	Lowest	
	LB28	14	1⁹⁄₁₆	7¼	1½	1½	4-16d	2-10dx1½	290	1270	1270	1270	+98%	
	HU28TF	12	1⁹⁄₁₆	7⅛	2¼	2½	10-16d	4-10dx1½	590	2335	2335	2335	+563%	
	W28	12	1⁹⁄₁₆	7⅛	2½	2½	2-10d	2-10dx1½	—	2200	2200	2200	+570%	
DBL 2x8	HUS28-2TF	14	3⅛	7¼	2	1⅞	8-16d	6-16d	1550	3455	3720	3895	Lowest	
	WNP28-2	12	3⅛	7⅛	2½	2³⁄₁₆	2-10d	2-10d	—	3255	3255	3255	+16%	
	HU28-2TF	12	3⅛	7⅛	2½	2½	12-16d	4-10d	750	3900	3900	3900	+75%	
2x10	JB210A	18	1⁹⁄₁₆	9³⁄₁₆	2	1⁷⁄₁₆	6-16d	2-10dx1½	315	1685	1685	1685	—	160
	LB210AZ	14	1⁹⁄₁₆	9³⁄₁₆	2	1⁷⁄₁₆	6-16d	2-10dx1½	380	1865	1865	1865	—	170
	HU210TF	12	1⁹⁄₁₆	9⅛	2¼	2½	12-16d	4-10dx1½	590	2335	2335	2335	+359%	
	W210	12	1⁹⁄₁₆	9⅛	2½	2½	2-10d	2-10dx1½	—	2200	2200	2200	+360%	
DBL 2x10	HUS210-2TF	14	3⅛	9¼	2	1½	10-16d	8-16d	2590	3585	3925	4155	Lowest	
	WNP210-2	12	3⅛	9⅛	2½	2³⁄₁₆	2-10d	2-10d	—	3255	3255	3255	+9%	
	HU210-2TF	12	3⅛	9⅛	2½	2½	14-16d	6-10d	1125	4170	4170	4170	+67%	I10, F9, L11
TPL 2x10	HU210-3TF	12	4¹¹⁄₁₆	9⅛	2½	2½	14-16d	6-16d	1325	4150	4150	4150	Lowest	
2x12	JB212A	18	1⁹⁄₁₆	11⅞	2	1⁷⁄₁₆	6-16d	2-10dx1½	315	1685	1685	1685	—	160
	LB212AZ	14	1⁹⁄₁₆	11⅞	2	1⁷⁄₁₆	6-16d	2-10dx1½	380	1865	1865	1865	—	170
	W212	12	1⁹⁄₁₆	11	2½	2½	2-10d	2-10dx1½	—	2200	2200	2200	+317%	
	HU212TF	12	1⁹⁄₁₆	11	2¼	2½	14-16d	6-10dx1½	885	2335	2335	2335	+339%	I10, F9, L11
DBL 2x12	HUS212-2TF	14	3⅛	11⅞	2	2¼	10-16d	8-16d	2000	4435	4535	4605	Lowest	I10, F9
	WNP212-2	12	3⅛	11	2½	2³⁄₁₆	2-10d	2-10d	—	3255	3255	3255	+12%	
	HU212-2TF	12	3⅛	11	2½	2½	16-16d	6-10d	1125	4325	4660	4880	+48%	I10, F9, L11
TPL 2x12	HU212-3TF	12	4¹¹⁄₁₆	11	2½	2½	16-16d	6-16d	1325	4550	4885	5105	Lowest	
2x14	JB214A	18	1⁹⁄₁₆	13⅞	2	1⁷⁄₁₆	6-16d	2-10dx1½	315	1685	1685	1685	—	160
	LB214AZ	14	1⁹⁄₁₆	13⅞	2	1⁷⁄₁₆	6-16d	2-10dx1½	380	1865	1865	1865	—	170
	W214	12	1⁹⁄₁₆	13	2½	2½	2-10d	2-10dx1½	—	2200	2200	2200	+188%	
	HU214TF	12	1⁹⁄₁₆	13	2¼	2½	16-16d	6-10dx1½	885	2660	2745	2800	+189%	
DBL 2x14	HUS214-2TF	14	3⅛	13⅞	2	2¼	12-16d	8-16d	2590	4435	4535	4605	Lowest	
	WNP214-2	12	3⅛	13	2½	2³⁄₁₆	2-10d	2-10d	—	3255	3255	3255	+2%	
	HU214-2TF	12	3⅛	13	2½	2½	18-16d	8-10d	1500	4335	4335	4335	+33%	
TPL 2x14	HU214-3TF	12	4¹¹⁄₁₆	13	2½	2½	18-16d	8-16d	1765	4835	5050	5050	Lowest	I10, F9, L11
2x16	LB216	14	1⁹⁄₁₆	15⅞	2	1½	4-16d	2-10dx1½	290	1425	1425	1425	Lowest	
	W216	12	1⁹⁄₁₆	15	2½	2½	2-10d	2-10dx1½	—	2200	2200	2200	+122%	
	HU216TF	12	1⁹⁄₁₆	15	2¼	2½	18-16d	8-10dx1½	1180	2845	2955	3030	+199%	
DBL 2x16	WNP216-2	12	3⅛	15	2½	2³⁄₁₆	2-10d	2-10d	—	3255	3255	3255	Lowest	
	HU216-2TF	12	3⅛	15	2½	2½	20-16d	8-10d	1500	4335	4335	4335	+34%	

1. N54A fasteners are supplied with hangers.
2. 16d sinkers may be used where 10d commons are called out with no load reduction.
3. Uplift loads are based on DF/SP lumber and have been increased for wind or earthquake loading with no further increase allowed. For normal loading applications such as cantilever construction refer to Simpson Strong-Tie® Connector Selector™ software or conservatively divide the uplift load by 1.6. For SPF use 0.86 x DF/SP uplift load.
4. **NAILS:** 16d = 0.162" dia. x 3½" long, 10d = 0.148" dia. x 3" long, 10dx1½ = 0.148" dia. x 1½" long. See page 22-23 for other nail sizes and information.

CODES: See page 12 for Code Reference Key Chart.

**Installed Cost Index not available on these models.*



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HRS/ST/PS/HST/HTP/LSTA/LSTI/MST/MSTA/MSTC/MSTI *Strap Ties*

SIMPSON Strong-Tie®

Straps are designed to transfer tension loads in a wide variety of applications.

HRS—A 12 gauge strap with a nailing pattern designed for installation on the edge of 2x members. The HRS416Z installs with Simpson Strong-Tie® Strong-Drive® SDS Heavy-Duty Connector screws.

LSTA and MSTA—Designed for use on the edge of 2x members, with a nailing pattern that reduces the potential for splitting.

LSTI—Light straps that are suitable where pneumatic-nailing is necessary through diaphragm decking and wood chord open web trusses.

MST—Splitting may be a problem with installations on lumber smaller than 3½"; either fill every nail hole with 10dx1½" nails or fill every-other hole with 16d common nails. Reduce the allowable load based upon the size and quantity of fasteners used.

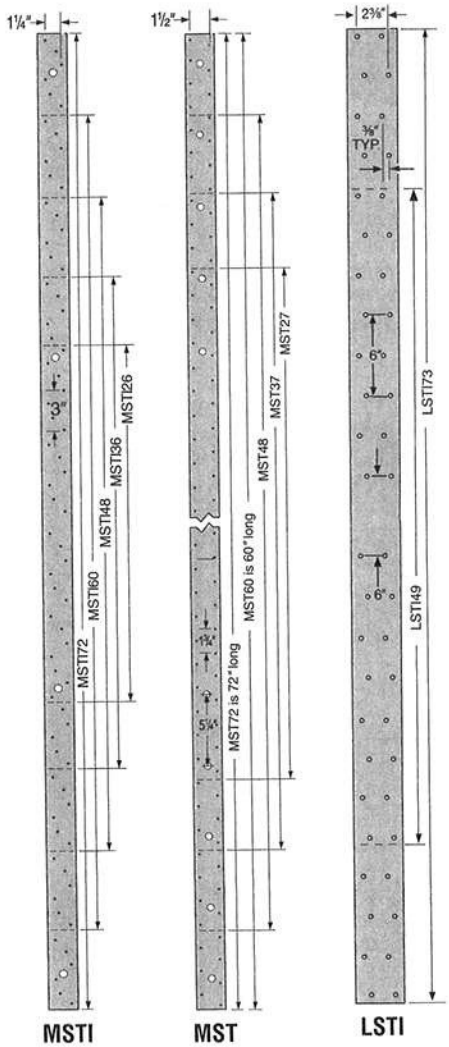
MSTC—High Capacity strap which utilizes a staggered nail pattern to help minimize wood splitting. Nail slots have been countersunk to provide a lower nail head profile.

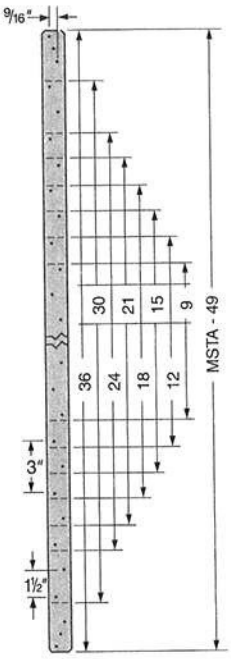
FINISH: PS–HDG; HST3 and HST6–Simpson Strong-Tie® gray paint; all others–galvanized. Some products are available in stainless steel or ZMAX® coating; see Corrosion Information, pages 13-15.

INSTALLATION: Use all specified fasteners. See General Notes.

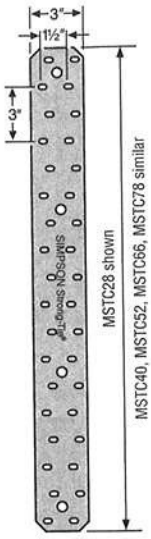
OPTIONS: Special sizes can be made to order. Contact Simpson Strong-Tie.

CODES: See page 12 for Code Reference Key Chart.
MSTC and RPS meet code requirements for reinforcing cut members (16 gauge) at top plate and RPS at sill plate.
International Residential Code®– 2000/2006 R602.6.1
International Building Code®– 2000/2006 2308.9.8
(For RPS, refer to page 223.)

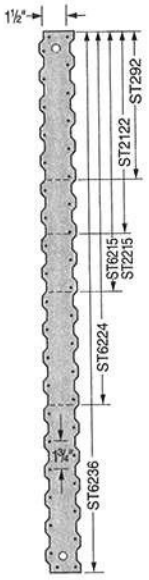




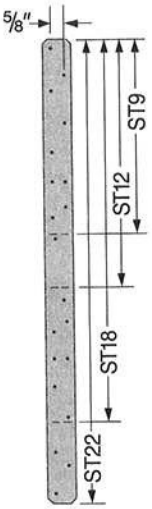
LSTA and MSTA
(Pilot holes not shown)



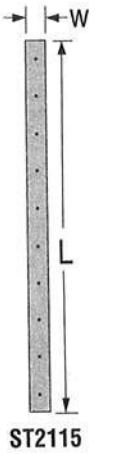
MSTC



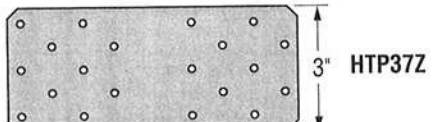
ST



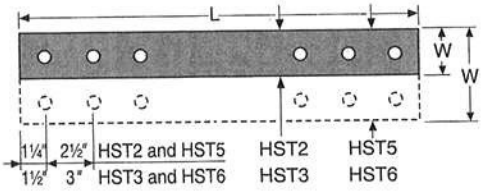
ST9, ST12, ST18, ST22



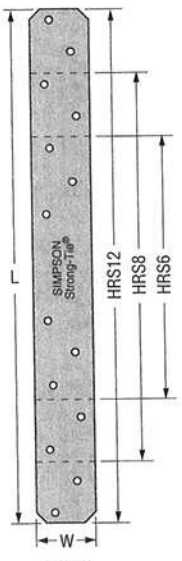
ST2115



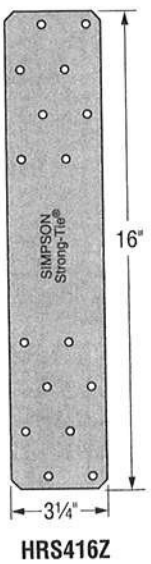
HTP37Z



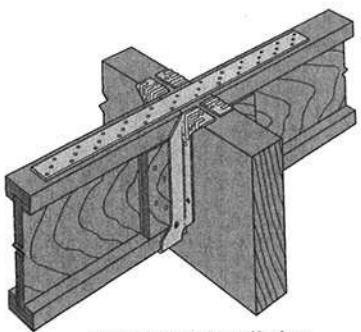
HST



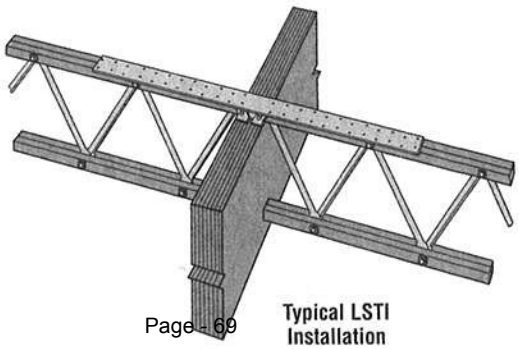
HRS



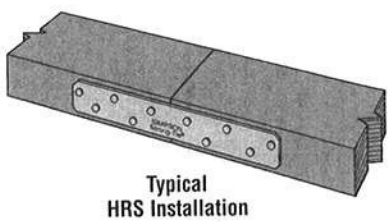
HRS416Z



Typical MSTI Installation
(MIT hanger shown)
LSTI similar



Typical LSTI Installation



Typical HRS Installation

HRS/ST/PS/HST/HTP/LSTA/LSTI/MST/MSTA/MSTC/MSTI *Strap Ties*

SIMPSON Strong-Tie

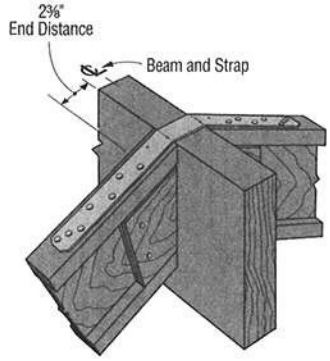
CODES: See page 12 for Code Reference Key Chart.

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

Model No.	Ga	Dimensions W	Dimensions L	Fasteners (Total)	Allowable Tension Loads (DF/SP) (160)	Allowable Tension Loads (SPF/HF) (160)	Code Ref.
LSTA9	20	1¼	9	8-10d	740	635	I4, L3, L5, F2
LSTA12		1¼	12	10-10d	925	795	
LSTA15		1¼	15	12-10d	1110	950	
LSTA18		1¼	18	14-10d	1235	1110	
LSTA21		1¼	21	16-10d	1235	1235	
LSTA24		1¼	24	18-10d	1235	1235	
ST292		2⅛6	9⅝6	12-16d	1265	1120	
ST2122		2⅛6	12⅜6	16-16d	1530	1505	
ST2115		¾	16⅝6	10-16d	660	660	
ST2215		2⅛6	16⅝6	20-16d	1875	1875	
LSTA30	18	1¼	30	22-10d	1640	1640	
LSTA36		1¼	36	24-10d	1640	1640	
LSTI49		3¾	49	32-10dx1½	2975	2555	
LSTI73		3¾	73	48-10dx1½	4205	3830	
MSTA9		1¼	9	8-10d	750	645	
MSTA12		1¼	12	10-10d	940	810	
MSTA15		1¼	15	12-10d	1130	970	
MSTA18		1¼	18	14-10d	1315	1130	
MSTA21		1¼	21	16-10d	1505	1290	
MSTA24		1¼	24	18-10d	1640	1455	
MSTA30	16	1¼	30	22-10d	2050	1820	
MSTA36		1¼	36	26-10d	2050	2050	
MSTA49		1¼	49	26-10d	2020	2020	F2, L3, L5
ST6215		2⅛6	16⅝6	20-16d	2095	1900	I4, IL14, L3, L5, F2
ST6224		2⅛6	23⅝6	28-16d	2540	2540	I4, L3, L5, F2
ST9		1¼	9	8-16d	885	760	I4, L3, L5, F2
ST12		1¼	11⅞	10-16d	1105	950	
ST18		1¼	17¾	14-16d	1420	1330	
ST22		1¼	21⅞	18-16d	1420	1420	
MSTC28		3	28¼	36-16d sinkers	3455	2980	
MSTC40		3	40¼	52-16d sinkers	4745	4305	
MSTC52		3	52¼	62-16d sinkers	4745	4745	
HTP37Z		3	7	20-10dx1½	1850	1600	L5
MSTC66	14	3	65¾	76-16d sinkers	5860	5860	I4, L3, L5, F2
MSTC78		3	77¾	76-16d sinkers	5860	5860	
ST6236		2⅛6	33⅜6	40-16d	3845	3845	
HRS6	12	1⅜	6	6-10d	605	525	L5, F26
HRS8		1⅜	8	10-10d	1010	880	
HRS12		1⅜	12	14-10d	1415	1230	
MSTI26		2⅛6	26	26-10dx1½	2745	2325	I4, L3, L5, F2
MSTI36		2⅛6	36	36-10dx1½	3800	3220	
MSTI48		2⅛6	48	48-10dx1½	5065	4290	
MSTI60		2⅛6	60	60-10dx1½	5080	5080	
MSTI72		2⅛6	72	72-10dx1½	5080	5080	
HRS416Z		3¼	16	16-SDS ¼"x1½"	2835	2305	170

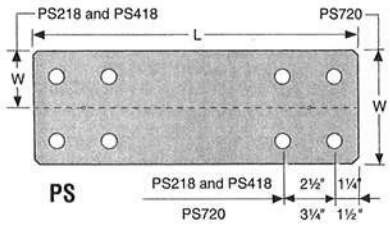
1. Loads include a 60% load duration increase on the fasteners for wind or earthquake loading.
2. 10dx1½" nails may be substituted where 16d sinkers or 10d are specified at 100% of the table loads except where straps are installed over sheathing.
3. 10d commons may be substituted where 16d sinkers are specified at 100% of table loads.
4. 16d sinkers (0.148" dia. x 3¼" long) or 10d commons may be substituted where 16d commons are specified at 0.84 of the table loads.
5. Use half of the nails in each member being connected to achieve the listed loads.
6. Tension loads apply for uplift when installed vertically.
7. **NAILS:** 16d = 0.162" dia. x 3½" long, 16d Sinker = 0.148" dia. x 3¼" long, 10d = 0.148" dia. x 3" long. 10dx1½ = 0.148" dia. x 1½" long. See page 22-23 for other nail sizes and information.

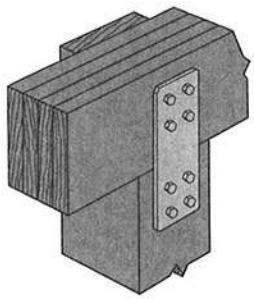


Typical LSTA Installation
(Hanger not shown)
Bend strap one time only, max 12/12 joist pitch.

Model No.	Material Thickness Gauge	Dim. W	Dim. L	Bolts Qty	Bolts Dia	Code Ref.
PS218	7 ga	2	18	4	¾	180
PS418		4	18	4	¾	
PS720		6¾	20	8	½	

1. PS strap design loads must be determined by the Designer for each installation. Bolts are installed both perpendicular and parallel-to-grain. Hole diameter in the part may be oversized to accommodate the HDG. Designer must determine if the oversize creates an unacceptable installation.
2. For allowable tension loads, see page 230.





Typical PS720 Installation

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HST/MST/MSTC/MSTA *Strap Ties*

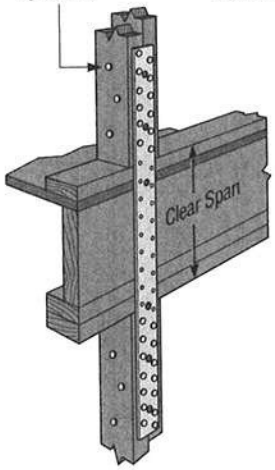
SIMPSON Strong-Tie

CODES: See page 12 for Code Reference Key Chart.

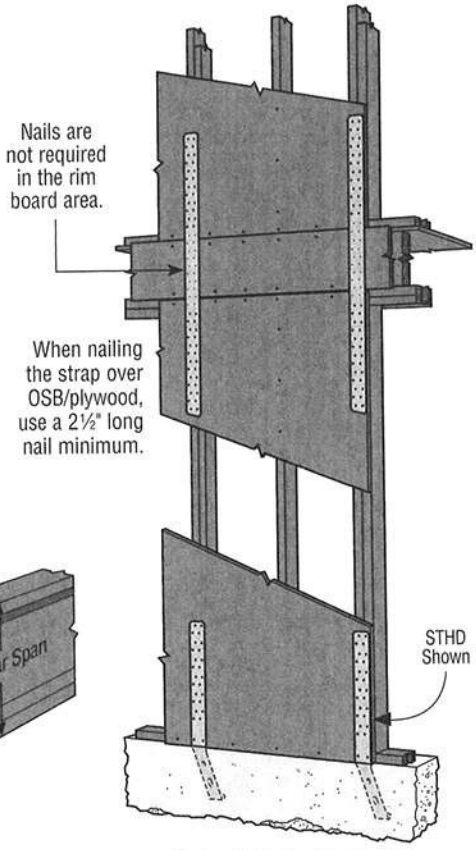
These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

Floor-to-Floor Clear Span Table

Model No.	Clear Span	Fasteners (Total)	Allowable Tension Loads (DF/SP)	Allowable Tension Loads (SPF/HF)
			(160)	(160)
MSTA49	18	26-10d	2020	2020
	16	26-10d	2020	2020
MSTC28	18	12-16d sinkers	1155	995
	16	16-16d sinkers	1540	1325
MSTC40	24	20-16d sinkers	2310	1985
	18	28-16d sinkers	2695	2320
	16	32-16d sinkers	3080	2650
MSTC52	24	36-16d sinkers	3465	2980
	18	44-16d sinkers	4235	3645
	16	48-16d sinkers	4620	3975
MSTC66	30	48-16d sinkers	4780	4120
	24	54-16d sinkers	5380	4640
	18	64-16d sinkers	5860	5495
	16	68-16d sinkers	5860	5840
MSTC78	30	64-16d sinkers	5860	5495
	24	72-16d sinkers	5860	5860
	18	76-16d sinkers	5860	5860
MST37	24	14-16d	1725	1495
	18	20-16d	2465	2135
	16	22-16d	2710	2345
MST48	24	26-16d	3215	2780
	18	32-16d	3960	3425
	16	34-16d	4205	3640
MST60	30	34-16d	4605	3995
	24	40-16d	5240	4700
	18	46-16d	6235	5405
MST72	30	48-16d	6505	5640
	24	54-16d	6730	6345
	18	62-16d	6730	6475



Floor-to-Floor Tie Installation showing a Clear Span



Typical Detail with Strap Installed Over Sheathing

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

Model No.	Ga	Dimensions		Fasteners (Total)			Allowable Tension Loads (DF/SP)		Allowable Tension Loads (SPF/HF)		Code Ref.
		W	L	Nails	Bolts		Nails	Bolts	Nails	Bolts	
					Qty	Dia	(160)	(160)	(160)	(160)	
MST27	12	2 1/16	27	30-16d	4	½	3700	2165	3200	2000	I4, L3, F2
MST37		2 1/16	37½	42-16d	6	½	5080	3025	4480	2805	
MST48		2 1/16	48	50-16d	8	½	5310	3675	5190	3410	
MST60	10	2 1/16	60	68-16d	10	½	6730	4485	6475	4175	
MST72		2 1/16	72	68-16d	10	½	6730	4485	6475	4175	
HST2	7	2½	21¼	—	6	⅝	—	5220	—	4835	
HST5		5	21¼	—	12	⅝	—	10650	—	9870	
HST3	3	3	25½	—	6	¾	—	7680	—	6660	
HST6		6	25½	—	12	¾	—	15470	—	13320	

1. Loads include a 60% load duration increase on the fasteners for wind or earthquake loading.
2. Install bolts or nails as specified by Designer. Bolt and nail values may not be combined.
3. Allowable bolt loads are based on parallel-to-grain loading and these minimum member thicknesses: MST–2½"; HST2 and HST5–4"; HST3 and HST6–4½".
4. Use half of the required nails in each member being connected to achieve the listed loads.
5. When installing strap over wood structural panel sheathing, use 2½" long nail minimum.
6. Tension loads apply for uplift as well when installed vertically.
7. **NAILS:** 16d = 0.162" dia. x 3½" long, 16d Sinker = 0.148" dia. x 3¼" long, 10dx1½ = 0.148" dia. x 1½" long. See page 22-23 for other nail sizes and information.

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CS/CMST *Coiled Straps*

SIMPSON Strong-Tie

CMSTC provides nail slots for easy installation; it can be cut to length. CS are continuous utility straps which can be cut to length on the job site. Packaged in lightweight *(about 40 pounds)* cartons.
FINISH: Galvanized. Some products available in ZMAX® coating; see Corrosion Information, page xx-xx.
INSTALLATION: • Use all specified fasteners. See General Notes.

- Wood shrinkage after strap installation across horizontal wood members may cause strap to buckle outward.
- Refer to the applicable code for minimum nail penetration and minimum wood edge and end distances.
- The table shows the maximum allowable loads and the nails required to obtain them. Fewer nails may be used; reduce the allowable load as shown in footnote #3.
- The cut length of the strap shall be equal to twice the "End Length" noted in the table plus the clear span dimension.
- CMST only–Use every other round hole if the wood tends to split. Use round and triangle holes for comparable MST loads, providing wood does not tend to split.
- For lap slice and alternate nailing information, refer to technical bulletin T-CMST.
- CS straps are available in 25' lengths, order CS14-R, CS16-R, CS18-R, CS20-R or CS22-R.

CODES: See page 12 for Code Reference Key Chart.

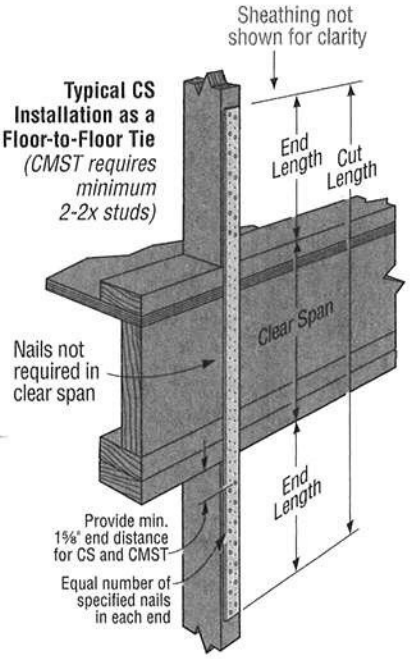
These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

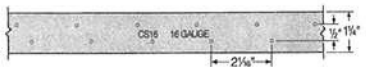
Model No.	Total L	Ga	DF/SP Fasteners	DF/SP End Length	SPF/HF Fasteners	SPF/HF End Length	Allowable Tension Loads (160)	Code Ref.
CMST12	40'	12	74 - 16d	33"	84 - 16d	38"	9215	I4, L3, F2
			86 - 10d	39"	98 - 10d	44"	9215	
CMST14	52½'	14	56 - 16d	26"	66 - 16d	30"	6490	
			66 - 10d	30"	76 - 10d	34"	6490	
CMSTC16	54'	16	50 - 16d sinker	20"	58 - 16d sinker	25"	4585	
CS14	100'	14	26 - 10d	15"	30 - 10d	16"	2490	
			30 - 8d	16"	36 - 8d	19"	2490	
CS16	150'	16	20-10d	11"	22 - 10d	13"	1705	
			22 - 8d	13"	26 - 8d	14"	1705	
CS18	200'	18	16 - 10d	9"	18 - 10d	11"	1370	
			18 - 8d	11"	22 - 8d	12"	1370	
CS20	250'	20	12 - 10d	6"	14 - 10d	9"	1030	
			14 - 8d	9"	16 - 8d	9"	1030	
CS22	300'	22	10 - 10d	7"	12 - 10d	7"	845	
			12 - 8d	7"	14 - 8d	8"	845	

1. Fastener quantities and end lengths are calculated using an increase for wind or seismic loading.
2. Use half of the required nails in each member being connected to achieve the listed loads.
3. Calculate the connector value for a reduced number of nails as follows: $\text{Allowable Load} = \frac{\text{No. of Nails Used}}{\text{No. of Nails in Table}} \times \text{Table Load}$

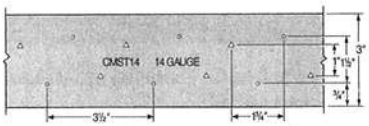
   Example: CMSTC16 in DF/SP with 40 nails total. *(Half of the nails in each member being connected)* $\text{Allowable Load} = \frac{\text{40 Nails (Used)}}{\text{50 Nails (Table)}} \times 4585 \text{ lbs} = 3668 \text{ lbs}$
4. Tension loads apply for uplift when installed vertically.
5. **NAILS:** 16d = 0.162" dia. x 3½" long, 16d Sinker = 0.148" dia. x 3¼" long, 10d = 0.148" dia. x 3" long. See page 22-23 for other nail sizes and information.



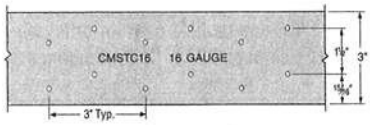
Typical CS Installation as a Floor-to-Floor Tie *(CMST requires minimum 2-2x studs)*



CS16 Hole Pattern *(all other CS straps similar)*

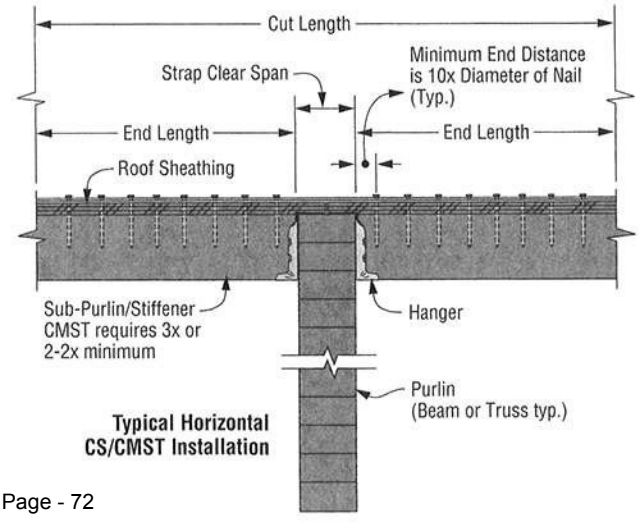


CMST14 Hole Pattern *(CMST12 similar)*



CMSTC16 Hole Pattern

Gauge stamped on part for easy identification



Typical Horizontal CS/CMST Installation

NOT SURE HOW MUCH COIL STRAP YOU NEED?
Simpson Strong-Tie has a web-based app, the Coil Strap Length Calculator, which can help you quickly determine the cut length of each strap and the total amount of coil strap needed for each application on a project.

For more information or to access, go to ***www.strongtie.com/software.***

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H/TSP Seismic & Hurricane Ties

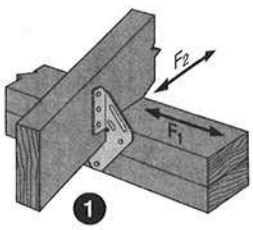
SIMPSON Strong-Tie®

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

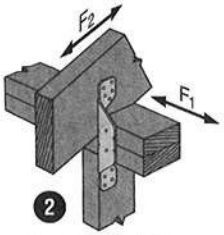
These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.

Model No.	Ga	Fasteners			DF/SP Allowable Loads			Uplift with 8dx1½ Nails (160)	SPF/HF Allowable Loads			Uplift with 8dx1½ Nails (160)	Code Ref.
		To Rafters/ Truss	To Plates	To Studs	Uplift (160)	Lateral (160) F_1	Lateral (160) F_2		Uplift (160)	Lateral (160) F_1	Lateral (160) F_2		
H1	18	6-8dx1½	4-8d	—	585	485	165	455	400	415	140	370	I17, L5, L6, F16
H2A	18	5-8dx1½	2-8dx1½	5-8dx1½	575	130	55	—	495	130	55	—	IP1, L18, F25
H2ASS	18	5-SS8D	2-SS8D	5-SS8D	400	130	55	400	345	130	55	345	170
H2.5A	18	5-8d	5-8d	—	600	110	110	575	535	110	110	495	I17, L5, L6, F16
H2.5ASS	18	5-SS8d	5-SS8d	—	440	75	70	365	380	75	70	310	170
H2.5T	18	5-8d	5-8d	—	545	135	145	425	545	135	145	425	IP1, L18, F25
H3	18	4-8d	4-8d	—	455	125	160	415	320	105	140	290	I17, L6, F16
H4	20	4-8d	4-8d	—	360	165	160	360	235	140	135	235	I17, L5, L6, F16
H5	18	4-8d	4-8d	—	455	115	200	455	265	100	170	265	
H6	16	—	8-8d	8-8d	950	—	—	—	820	—	—	—	I17, F16
H7Z	16	4-8d	2-8dx1½	8-8d	985	400	—	—	845	345	—	—	
H8	18	5-10dx1½	5-10dx1½	—	745	75	—	630	565	75	—	510	L5, L10, L18, F26
H10A Sloped	18	9-10dx1½	9-10dx1½	—	855	590	285	—	760	505	285	—	I17, L5, L18, F25
H10A	18	9-10dx1½	9-10dx1½	—	1140[7]	590	285	—	1015	505	285	—	
H10ASS	18	9-SSN10	9-SSN10	—	970	565	170	—	835	485	170	—	170
H10AR	18	9-10dx1½	9-10dx1½	—	1050	490	285	—	905	420	285	—	
H10S[9,10]	18	8-8dx1½	8-8dx1½[10]	8-8d	1010	660	215	550	870	570	185	475	IP1, L18, F25
H10A-2	18	9-10dx1½	9-10dx1½	—	1245	815	260	—	1070	700	225	—	L18, F25
H10-2	18	6-10d	6-10d	—	760	455	395	—	655	390	340	—	I17, L6, F16
H11Z	18	6-16dx2½	6-16dx2½	—	830	525	760	—	715	450	655	—	170
H14	18	1 12-8dx1½	13-8d	—	1350[7]	515	265	—	1050	480	245	—	IP1, L18, F25
		2 12-8dx1½	15-8d	—	1350[7]	515	265	—	1050	480	245	—	
TSP	16	9-10dx1½	6-10dx1½	—	740	310	190	—	635	265	160	—	F26
		9-10dx1½	6-10d	—	890	310	190	—	765	265	160	—	

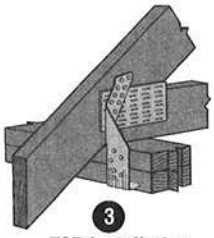
1. Loads have been increased for wind or earthquake loading with no further increase allowed: reduce where other loads govern.
2. Allowable loads are for one anchor. A minimum rafter thickness of 2½" must be used when framing anchors are used on each side of the joist and on the same side of the plate *(exeption: connectors installed such that nails on opposite side don't interfere).*
3. Allowable DF/SP uplift load for stud to bottom plate installation *(see detail 15)* is 390 lbs. (H2.5A); 265 lbs. (H2.5ASS); 360 lbs. (H4) and 310 lbs. (H8). For SPF/HF values multiply these values by 0.86.
4. Allowable loads in the F_1 direction are not intended to replace diaphragm boundry members or cross grain bending of the truss or rafter members.
5. When cross-grain bending or cross-grain tension cannot be avoided in the members, mechanical reinforcement to resist such forces may be considered.
6. Hurricane Ties are shown on the outside of the wall for clarity and assume a minimum overhang of 3½". Installation on the inside of the wall is acceptable *(see General Instructions for the Installer notes u on page 17).* For uplift Continuous Load Path, connections in the same area *(i.e. truss to plate connector and plate to stud connector)* must be on the same side of the wall. See T-HTIECONPATH for more information.
7. Southern Pine allowable uplift loads for H10A = 1340 lbs. and for the H14 = 1465 lbs.
8. Refer to Simpson Strong-Tie® technical bulletin T-HTIEBEARING for allowable bearing enhancement loads.
9. H10S can have the stud offset a maximum of 1" from rafter *(center to center)* for a reduced uplift of 890 lbs. (DF/SP) and 765 lbs. (SPF).
10. H10S nails to plates are optional for uplift but required for lateral loads.
11. Some load values for the stainless-steel connectors shown here are lower than those for the carbon-steel versions. Ongoing test programs have shown this to also be the case with other stainless-steel connectors in the product line that are installed with nails. Visit ***www.strongtie.com/corrosion*** for updated information.
12. **NAILS:** 16dx2½ = 0.162" dia. x 2½" long, 10d = 0.148" dia. x 3" long, 10dx1½ = 0.148" dia. x 1½" long, 8d = 0.131" dia. x 2½" long, 8dx1½ = 0.131" dia. x 1½" long. See page 22-23 for other nail sizes and information.
13. **SCREWS:** Strong-Drive® SD #9x1½" (model SD9112) = 0.131" dia. x 1½" long *(for the models marked with the orange flag only).* Full table loads apply.

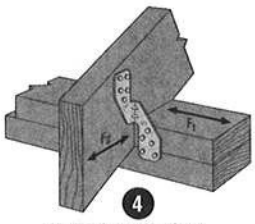


1 H1 Installation

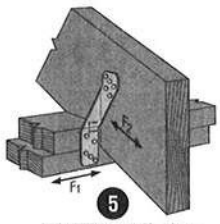


2 H2A Installation

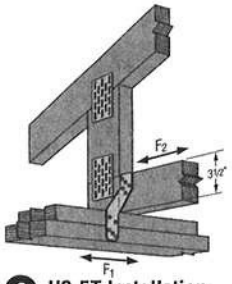

3 TSP Installation



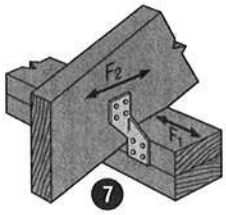
4 H2.5A Installation
(Nails into both top plates)



5 H2.5T Installation
(Nails into both top plates)

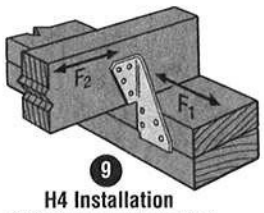


6 H2.5T Installation

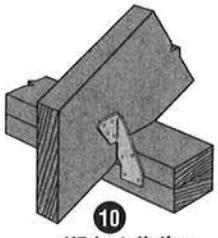


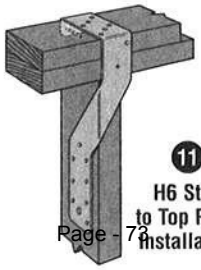
7 H3 Installation
(Nails into upper top plate)

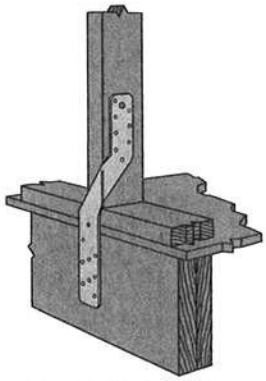
8 H4 Installation
(see footnote 3)

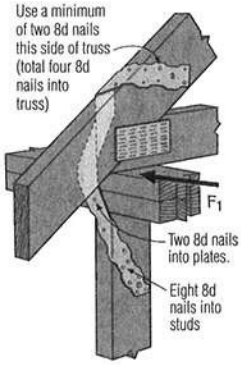


9 H4 Installation
(Nails into upper top plate)


10 H5 Installation
(Nails into both top plates)


11 H6 Stud to Top Plate Installation


12 H6 Stud to Band Joist Installation



13 H7Z Installation

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LTP4/LTP5/A34/A35 *Framing Angles & Plates*

SIMPSON Strong-Tie®

The larger LTP5 spans subfloor at the top of the blocking or rim joist. The embossments enhance performance.

The LTP4 Lateral Tie Plate transfers shear forces for top plate-to-rim joist or blocking connections. Nail holes are spaced to prevent wood splitting for single and double top plate applications. May be installed over plywood sheathing.

The A35 anchor's exclusive bending slot allows instant, accurate field bends for all two- and three-way ties. Balanced, completely reversible design permits the A35 to secure a great variety of connections.

MATERIAL: LTP4/LTP5–20 gauge; all others–18 gauge

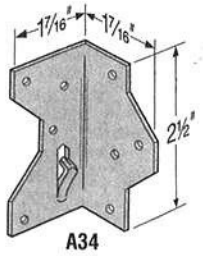
FINISH: Galvanized. Some products available in stainless steel or ZMAX® coating; see Corrosion Information, pages 13-15.

INSTALLATION: • Use all specified fasteners. See General Notes.
• A35–Bend one time only.

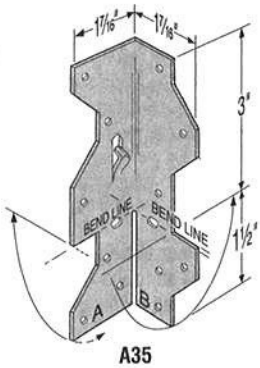
CODES: See page 12 for Code Reference Key Chart.

These products are available with additional corrosion protection. Additional products on this page may also be available with this option, check with Simpson Strong-Tie for details.

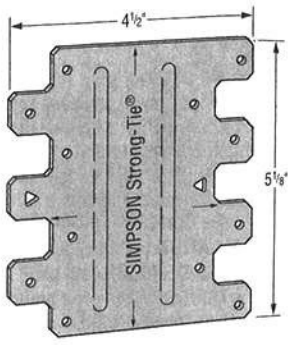
These products are approved for installation with the Strong-Drive® SD Connector screw. See page 27 for more information.



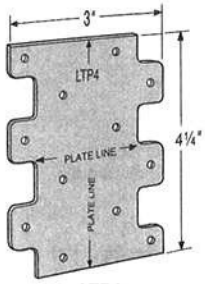
A34



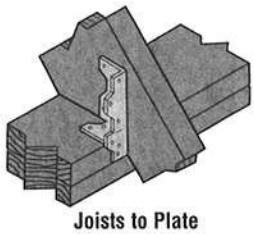
A35

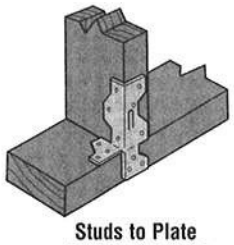


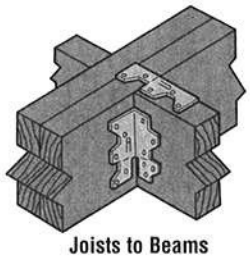
LTP5

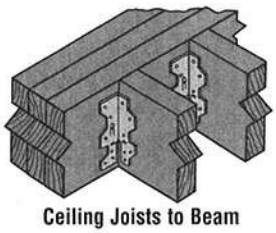


LTP4


Joists to Plate with A Leg Inside

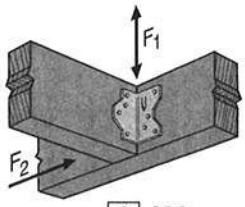

Studs to Plate with B Leg Outside


Joists to Beams

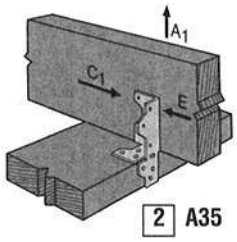

Ceiling Joists to Beam

Model No.	Type of Connection	Fasteners	Direction of Load	DF/SP Allowable Loads Floor (100)	DF/SP Roof (125)	DF/SP (160)	SPF/HF Allowable Loads Floor (100)	SPF/HF Roof (125)	SPF/HF (160)	Code Ref.
A34	1	8-8dx1½	F_1	395	485	515	340	415	445	IP1, L5, L18, F13
			F_2[5]	395	455	455	340	390	390	
A35	2	9-8dx1½	A_1, E	295	365	395	255	315	340	
			C_1	210	210	210	180	180	180	
	3	12-8dx1½	A_2	295	365	380	255	315	325	
			C_2	295	365	370	255	315	320	
			D	230	230	230	200	200	200	
	4	12-8dx1½	F_1	595	695	695	510	600	600	
			F_2[5]	595	670	670	510	575	575	
LTP4	5	12-8dx1½	G	580	670	670	500	570	575	I14, L5, F13
			H	580	600	600	500	515	515	
LTP5	6	12-8dx1½	G	580	620	620	500	535	535	IP1, L18, F25
			H	545	545	545	470	470	470	

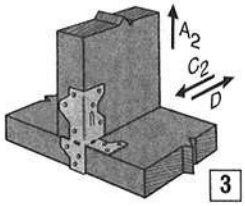
1. Allowable loads are for one anchor. When anchors are installed on each side of the joist, the minimum joist thickness is 3".
2. Some illustrations show connections that could cause cross-grain tension or bending of the wood during loading if not reinforced sufficiently. In this case, mechanical reinforcement should be considered.
3. LTP4 can be installed over ⅜" wood structural panel sheathing with 8dx1½ nails and achieve 0.72 of the listed load, or over ½" and achieve 0.64 of the listed load. 8d commons will achieve 100% load.
4. The LTP5 may be installed over wood structural panel sheathing up to ½" thick using 8dx1½ nails with no reduction in load.
5. Connectors are required on both sides to achieve F_2 loads in both directions.
6. **NAILS:** 8dx1½ = 0.131" dia. x 1½" long.
See page 22-23 for other nail sizes and information.



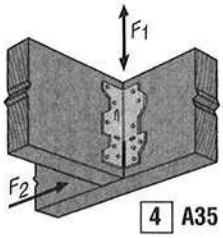
1 A34



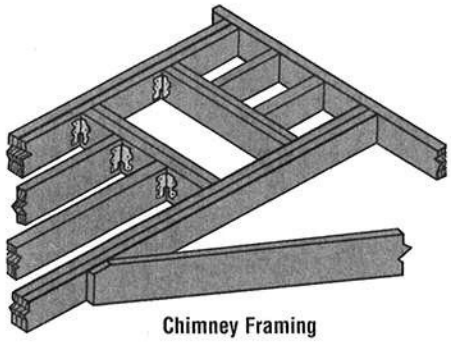
2 A35

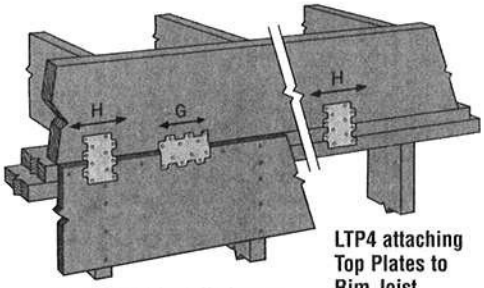


3 A35



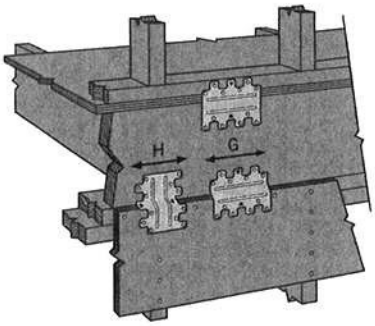
4 A35


Chimney Framing



5 LTP4 Installed over Wood Structural Panel Sheathing

LTP4 attaching Top Plates to Rim Joist



6 LTP5 Installed over Wood Structural Panel Sheathing

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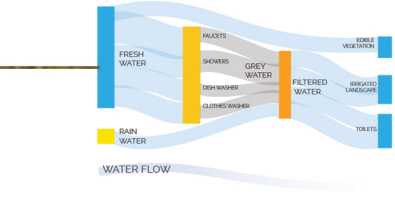
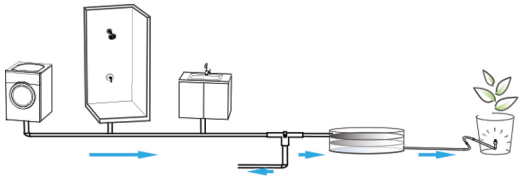
05_ DETAILED WATER BUDGET

CASA DEL SOL
Team Orange County





05_Detailed Water Budget

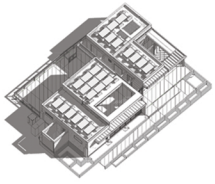
California is currently facing a D4 exceptional drought and diminishing water reservoirs. To combat the effects of the drought, Casa del Sol will implement many water-saving techniques such as xeriscaping, water-efficient appliances, rainwater harvesting, filtered grey water reuse, drip irrigation, and soil humidity irrigation controllers. The water budget is based on the tanks located in the North-West corner and the mechanical room. In compliance with rule 9-1, the region will be fully shaded throughout the day. The weather is not forecasted to rain during the competition, so rainwater tanks will be filled during the fresh water delivery. Fresh water is stored in one tank with a capacity of 500 gallons. Greywater is stored in two separate 250 gallons tanks: one in the northwest region and one in the mechanical room. The total waste-water capacity is 500 gallons. Landscaping will be irrigated with rain and grey water. Edible plants located in the backyard will be watered with the irrigation controller with fresh water. Edible plants are grown on a hydroponics system to further reduce water consumption.

Task (Day)	Gallons/Task	Task/Day	Loss	Total
Fire Sprinkler	30	1	0%	**30**
Pre- Fill System (Hot water tank)	200	1	0%	**200**
Testing	100	1	0%	**100**
Rain Water Fill	300	1	0%	**300**
Friday (Day 12)				
Clothes Washer	15	1	0%	15
Dishwasher	3	1	0%	3
Hot Water	15	1	10%	16.5
				34.5
Saturday (Day 13)				
Clothes Washer	15	1	0%	15
Hot Water	15	2	10%	33
				48
Sun (Day 14)				
Clothes Washer	15	1	0%	15
Dishwasher	3	1	0%	3
Hot Water	15	1	10%	16.5
				34.5
Monday (Day 15)				
Clothes Washer	15	2	0%	30
Hot Water	15	3	10%	49.5
				79.5
Tuesday (Day 16)				
Dishwasher	3	1	0%	3
Hot Water	15	3	10%	49.5
				52.5
Wednesday (Day 17)				
Clothes Washer	15	2	0%	30
Hot Water	15	3	10%	49.5
				79.5
Thursday (Day 18)				
Dishwasher	3	1	0%	3
Hot Water	15	2	10%	33
				36
Friday (Day 19)				
Clothes Washer	15	1	0%	15
Dishwasher	3	1	0%	3
Hot Water	15	1	10%	16.5
				34.5
Total water needed for competition tasks				**1029**

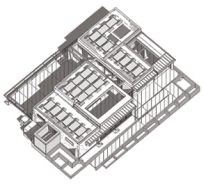
Summarize Water Budget	
Fire Sprinkler	**30**
Pre- Fill System (Hot water tank	**200**
Testing	**100**
Rain Water Fill	**300**
Dishwasher	**15**
Hot Water	**264**
Clothes Washer	**120**
Total	**909**

06_ SOLAR ENERGY GENERATION, DISTRIBUTION, AND CONSUMPTION

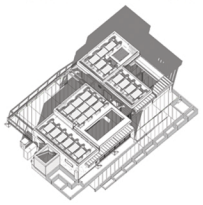
CASA DEL SOL
Team Orange County



C1 SHADE PERSPECTIVE ON OCT 15 AT 9 AM
SCALE: N.T.S.



C3 SHADE PERSPECTIVE ON OCT 15 AT 12:00 PM
SCALE: N.T.S.



C5 SHADE PERSPECTIVE ON OCT 15 AT 3:00 PM
SCALE: N.T.S.

06_Solar Energy Generation, Distribution, and Consumption

Energy Generation

Casa del Sol produces electric energy with an array of photovoltaic (PV) panels on its roof. It also has two solar thermal panels to heat water. Additional power, if needed, can be drawn from the electric power grid.

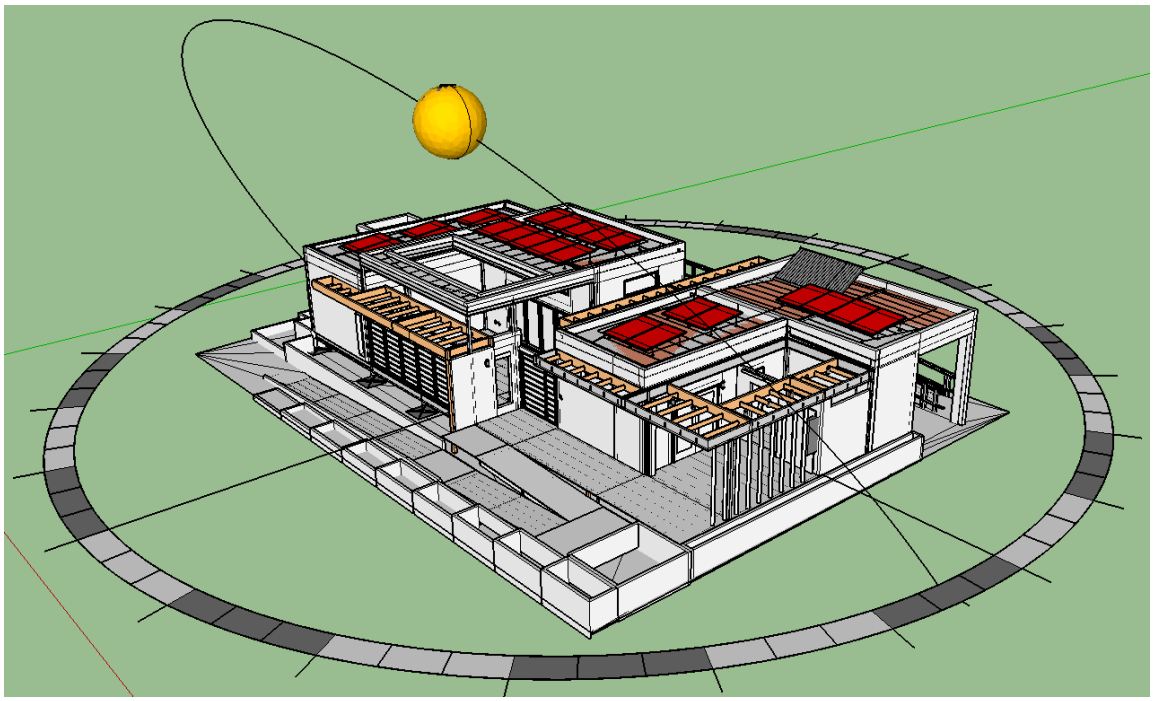


Figure 1: 3D model of Casa del Sol including sun path, showing the placement of 24 PV panels (red) and two solar thermal panels (gray).

The PV array consists of 24 LG monocrystalline Si panels, totaling a nominal power of 7.32 kW, at a south-tilt of 10 degrees. They are grouped into three equal strings, each operating at about 250 V. The array is sized to produce > 12 MWh per year (Fig. 2d), making Casa del Sol a net-positive energy home, and to guarantee full score in the Energy Balance contest.

The solar thermal system consists of two Ritter collector panels with a total of 24 evacuated tubes, mounted at 30 degrees south-tilt. The panels feature built-in “tracking” along the azimuth angle via parabolic mirrors running behind the evacuated tubes. This technology allows high heat gain even on cloudy days (Fig. 2c) and supplies our hot water tank with reliable thermal energy.

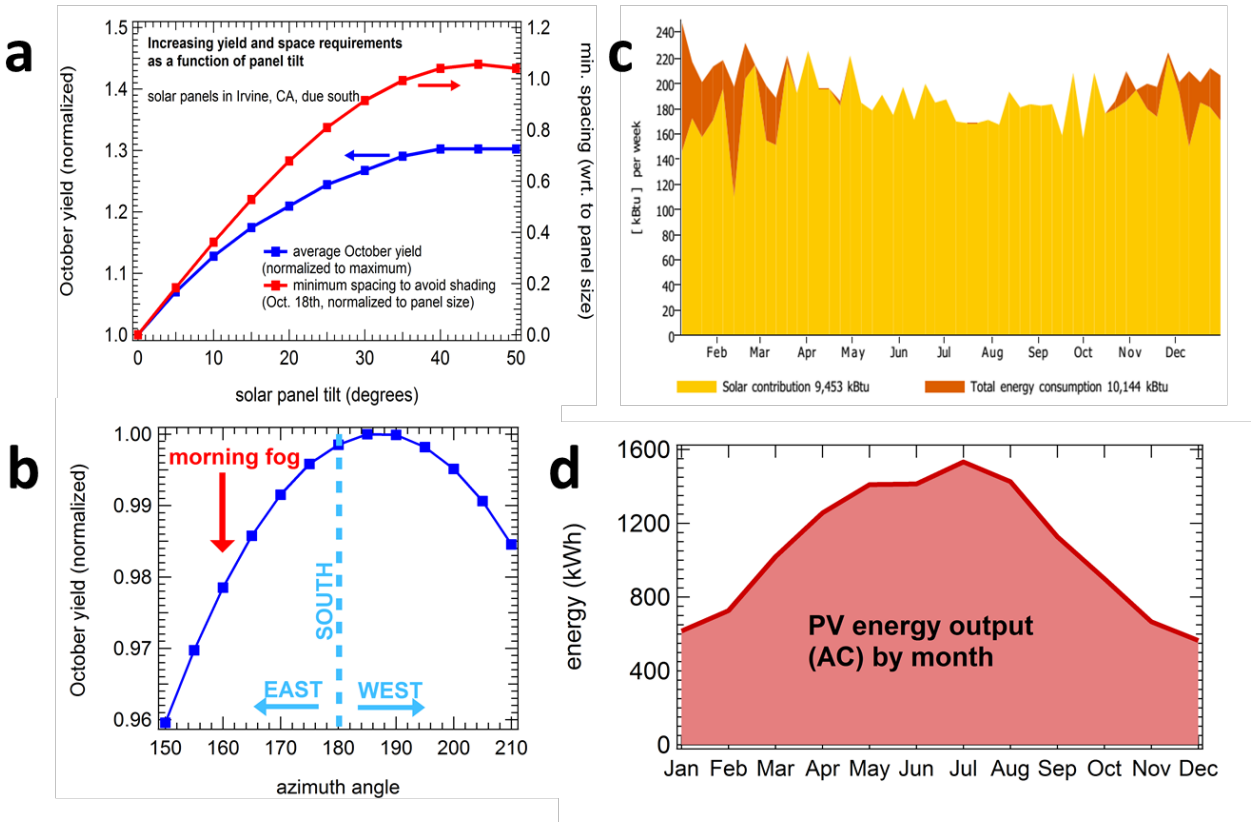


Figure 2: Calculations for solar energy harvesting. All PV calculations performed in NREL's PV-Watts tool, all solar thermal calculations performed in T*SOL Pro 5.5. Panel a) and b) apply to both PV and solar thermal technologies. Panel a) shows the increase in yield (left axis) with increasing tilt angle, also resulting in increasing spacing requirements due to shading (right axis). Panel b) shows that the optimum azimuth angle is not 180 degrees, but slightly to the West, due to frequent morning fog blocking the sun. Panel c) shows that the solar fraction for all of our hot water demands is close to 100% for most of the year. Panel d) shows the monthly harvested electrical energy, adding up to about 12,500 kWh per year.

Energy Distribution

Team Orange County developed an innovative AC/DC micro-grid for Casa del Sol that uses the locally generated solar power more efficiently and is compatible with future demand-response smart grids.

Figure 3 shows a schematic of our power distribution plan. At the heart of it works a 10 kW AC/DC bidirectional inverter that can take power both from our PV array and the grid, and supply that power to both AC and DC loads. The idea behind this design is to power DC loads (such as the EV, HVAC and lighting) directly with DC power that is produced by our solar roof. This is more efficient than conventional designs where the solar power is transformed to AC power first, then transformed back to DC power. Every conversion is associated with losses of 10 - 20%, or even more for inefficient transformations at the device level. These losses are the reason why "wall warts" get warm. We minimize the transformation losses by using a house-wide 12 – 24 VDC bus for LED lighting and other small loads, powered by a highly efficient, centralized AC/DC converter cabinet.

The inverter features a special CHAdeMO EV charging port that allows ultra-efficient DC-DC charging of the electric car during the day, and common charging from the AC grid during the night.

Lastly, while the rules of the Solar Decathlon 2015 prevent battery banks as well as any backflow of energy from the EV's battery to house loads or the grid, we are designing our AC/DC microigrid to be ready for that after the competition. Working with our sponsor SoCal Edison, we will make Casa del Sol ready for future demand-response smart grids, where bidirectional use of the EV's and other battery banks can reduce stress on the grid while saving money for the home owner.

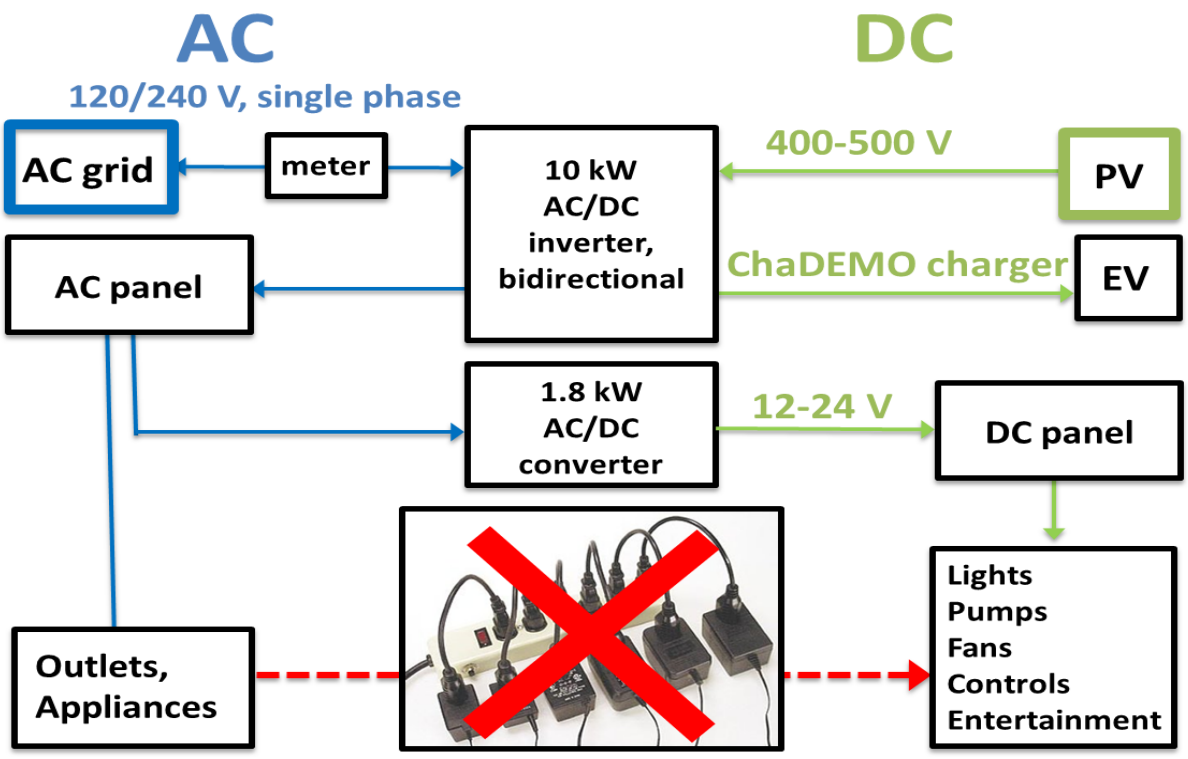


Figure 3: Power distribution diagram. Our AC/DC microgrid is designed around a cutting-edge, fully bidirectional inverter, demonstrating two main innovations. 1) The electric vehicle (EV) can be charged directly from solar-generated DC power via a special CHAdeMO charger, without going through AC power during the day. At night, charging power is drawn from the AC grid, like in a conventional charger. 2) Highly efficient AC/DC converters power a dedicated, low-voltage DC bus. This bus is used to power the LED lighting system along with a number of low power loads, which in a common home are powered through inefficient 'wall-warts'.

Energy Consumption

Casa del Sol is designed to minimize the need for electric energy, by using passive solar strategies and an EMCS to reduce HVAC and lighting load, by using most energy-efficient appliances, and by utilizing hot water from the solar thermal system. This aims at (i) scoring full points in the Energy Balance contest of the Solar Decathlon 2015 competition and (ii) less dependence on the power grid during the further lifetime of the home.

Our ambitious goal is to use less than 175 kWh during the 9 competition days and less than 10,000 kWh in an average year. This includes a fully functional operation of the home itself and charging the electric vehicle every day for a 25 mile commute. Since our PV array will produce about 12,500 kWh over the course of a year, this also makes Casa del Sol a net-positive energy home.

Commuting will for the first time be one of the ten contests and requires us to have an electrical vehicle that can accommodate two decathletes. Based on the published energy consumption for the Solar Decathlon 2013, only 2 out of 19 teams (Norwich and Austria) would have had capacity to charge an EV while still staying within the energy budget of 175 kWh.

To charge our car in the most efficient way possible, we will feed direct current (DC) from our PV array to a DC-DC charger during the day. Using DC charging during the day has the advantage of avoiding losses from AC/DC conversion. This is realized by use of a bi-directional AC/DC inverter made by Princeton Power Systems, which can output DC power in a voltage range of 250-600 VDC, and is developed to charge a Nissan Leaf via CHAdeMO. During the day, the charger draws from the PV array, while at night or low-light conditions it is supported from the AC grid (Fig. 3b).

We aim to further increase electrical efficiency by supplying DC power to a number of low to medium power loads. An innovative 12 - 24 VDC bus can power HVAC systems and pumps, lights and window actuators, like the EV also backed up from the AC grid through the bidirectional inverter.

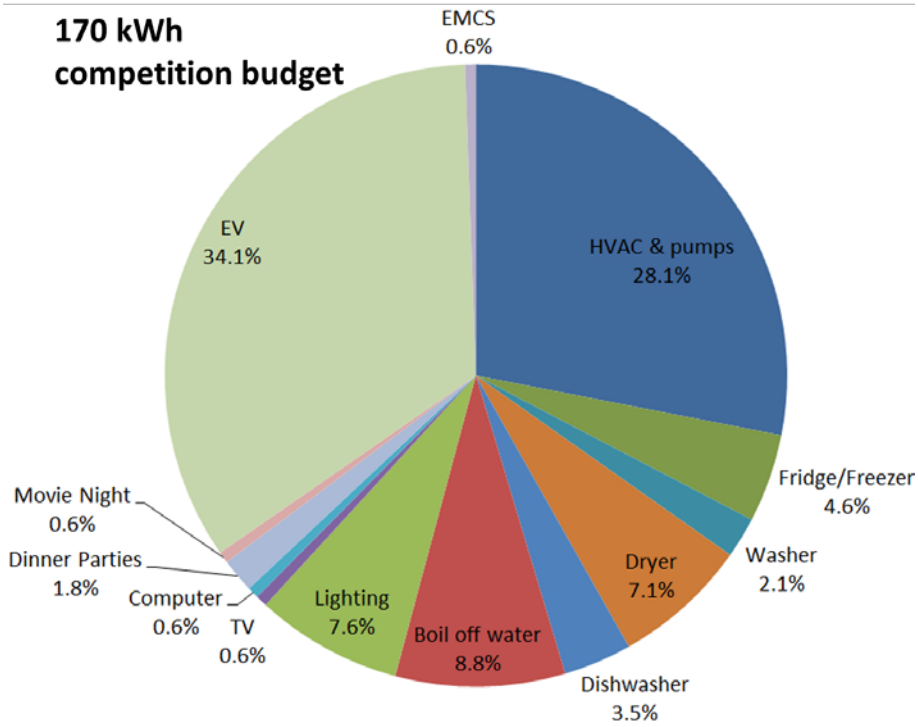


Figure 4: Estimated 170 kWh energy budget for the nine competition days of Solar Decathlon 2015.

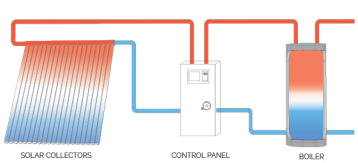
To estimate our energy budget during the competition, we break down loads as follows:

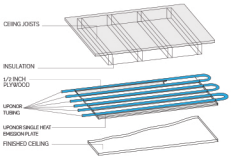
- HVAC system and pumps: Based on simulations in DesignBuilder and IESVE, we expect a load of about 8 kWh/day (333 W/h) in October to stay within the comfort zone at all times. (143.5 h total)
- Fridge/Freezer: Our model (Bosch B11CB50SSS) is Energy Star rated at 41 W to stay within the specified temperature range at all times. (191.5 h total)
- Clothes washer: Our model (Bosch WAP24200UC) is Energy Star rated at 450 Wh per load. (8 loads total)
- Clothes dryer: Our model (Hydromatic SafeMate Hybrid Electric) is a new invention that utilizes hot water as the heating liquid medium, supported by traditional electric heating. Tests to determine the electric load are ongoing, we conservatively estimate 0.8 kWh per load. (8 loads total)
- Dishwasher: Our model (Bosch SPX5ES55UC) is Energy Star rated at 1205 Wh per load. (5 loads total)
- Cooking contest: Preliminary experiments suggest that we need about 2.5 kWh to evaporate 5lb of water. (6 loads total)
- Lighting: Our home, despite having extensive outdoor living areas, stays just below the title 24 benchmark of 0.5 W/sqft. We thus will use 500 Wh for every hour that we are required to have the lights on at full power. (26 h total)
- TV: An energy-efficient TV (LED backlit) can run on about 30W. (34 h total)
- Computer: An energy-efficient laptop can run on about 30W. (34 h total)

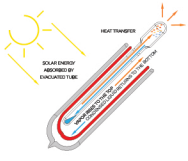
- Dinner Parties: Using recipes that require only modest cooking, we will feed and entertain our guests using about 1.5 kWh. (2 loads total)
- Movie Night: Using energy-efficient LED projector and stereo system, we will entertain our guests using about 1.0 kWh. (1 load total)
- EMCS: Our Energy Management Control System is designed to run 24/7 but use very little energy when idle, averaging about 5 W. (191.5h total)
- EV: Our electric vehicle (Nissan Leaf) is EPA rated at 129 MPGe in the city, equivalent to 6.53 kWh per 25 mile commute. Benefitting from our efficient DC-DC charger during the day, we expect to recharge the battery for 25 miles with about 7 kWh of electric energy. (8 loads total)

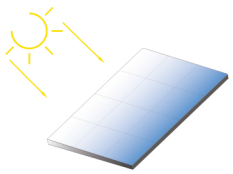
07_ ENERGY ANALYSIS AND HVAC SYSTEM

CASA DEL SOL
Team Orange County









07_Energy Analysis and HVAC System

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HVAC APPROACH

CONSTRUCTION BUILDING APPROACH

3. MODELING METHODS

4. CLIMATE ANALYSES

5. BUILDING MODELING

HEATING AND COOLING LOADS

INTERNAL GAINS

INSULATION

NATURAL VENTILATION

INFILTRATION

RELATIVE HUMIDITY

SOLAR GAIN

6. HVAC

CONSIDERED HVAC OPTIONS

FINAL DESIGN

HVAC ENERGY ANALYSIS

7. REFERENCES

1. INTRODUCTION

Team Orange's Casa Del Sol was conceived as a home that will meet the needs of Southern California residents both economically and ecologically. One of the biggest ways that Team Orange achieved this goal was by designing a net-zero energy home. To do this, we maximized energy produced and lowered energy demand and consumption. To lower the home's demand for energy, we implemented passive solar architectural elements that take advantage of the specific weather in Irvine, California. Well-placed windows and overhangs can decrease the loads on the heating ventilation and air conditioning (HVAC) system. We also lowered the home's energy consumption by making use of energy-efficient appliances and innovative technology in the electrical systems. Solar thermal collectors are incorporated into the HVAC system, decreasing its electricity consumption. In addition, Casa Del Sol showcases a cutting-edge AC/DC microgrid that avoids power losses associated with converting between AC and DC power.

Running energy simulations and performing energy analysis was an integral part of the design process. In order to minimize the energy consumption of the home we needed to analyze the effects of weather, architecture, insulation, mechanical and electrical systems, and appliances on the heating and cooling loads of the home. Energy simulations provided the data we needed to design HVAC and other elements for optimal performance and the lowest energy consumption possible.

The following sections will detail our design approach, modeling methods and the results of our energy models. The sections include analysis of heating and cooling loads throughout the year, natural ventilation, HVAC models, and some of our innovative technologies.

2. APPROACH TO DESIGN PROCESS

Team Orange County uses a common engineering design method called the iterative process, which requires a constantly modified alteration to the model or design once new data is collected. The most recent results are effectively relayed to the whole team to help interpret the changes in design and efficiently update various model decisions. This process is exhibited in a cycle, which is repeated until the optimal design is reached.

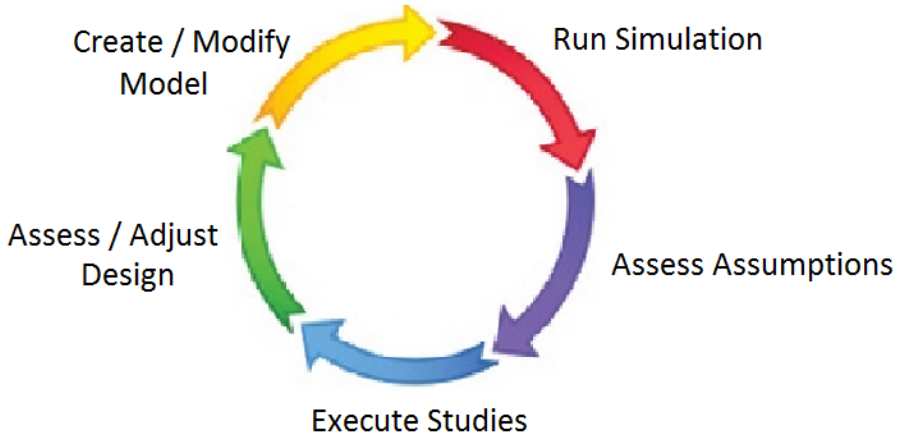


Figure 1: Iterative Design Process

HVAC APPROACH

Before entering the iterative design method, the team conducted research on current, innovative technologies that can be applied to the HVAC system. Then, brainstorming was conducted to narrow down on which innovation best applied to the system. More in-depth research was commenced on the chosen technology such as obtaining quotes of its efficiency, size, flow rate, cost and other imperative details relating with the models. After choosing several different types of HVAC systems (split, radiant, centralized forced-air), the iterative design process is applied. By using the specifications given by the companies, the three different systems were simulated in a program called Integrated Environmental Solutions Virtual Environment **[1]**, producing results that were later analyzed. Based on the data analysis, the project has undergone adjustments to improve the efficiency of the systems. The simulations minimized our team's use of items that may have been wasteful expenses. The design process was repeated several times, throughout our research until the final system was chosen. After, building the system commences which starts the iterative process all over again to improve any errors that come up during testing.

HVAC modeling is intricate and an understanding of heat flow is imperative to interpreting data, so this was backed up by 'hand calculations' in using energy conservation and heat transfer equations. Other programs were also used to simulate model systems to get a better understanding of the analysis.

CONSTRUCTION BUILDING APPROACH

In creating the optimal construction design for the house of Casa Del Sol, there was a competition held amongst architectural students to develop a design. The winning design that was chosen underwent several iterations till the house met all the standards of the competition and demand for shading and prevalent winds. A small model was then created to give a three-dimensional representation to show the whole team. Even smaller models were 3-D printed. Then, the house design underwent the iteration process again to cut down the cost. Energy simulations of the building were conducted on a program called DesignBuilder to discover the best thickness of insulation to install into the walls.

The house is then built and will undergo numerous tests going through the iterative process once again. Improvements will be made that were not accounted for in modeling until the house is in its optimal construction, fitting all components of systems, including the HVAC system.

3. MODELING METHODS

The following is a list of software that was used to develop, design, analyze, and optimize Casa Del Sol.

Autodesk Revit 2013- A BIM (Building Information modeling) software that lets users design 3D structures with 2D drafting elements and view details about the structure. The Casa Del Sol Revit model served as the primary architectural reference to workgroups and has been converted to other software file formats as needed.

OpenStudio- OpenStudio is a collection of software tools to support whole building energy modeling using EnergyPlus and advanced daylight analysis using Radiance. The building geometry was accessed via SketchUp plugin and the building loads were simulated. Heating and cooling loads for the ceiling, walls and windows were generated with OpenStudio.

DesignBuilder- DesignBuilder comprises a core 3-D modeler and 9 modules, which work together to provide in-depth analysis of energy use, consumption, and execution for a building. It was used to evaluate different alternative design scenarios for HVAC systems controls and lighting.

IESVE- Allows you to choose from a variety of modules and mix and match to suit your needs. You can use the suite to test different design options, identify best passive solutions, compare low-carbon technologies, and draw conclusions on energy use, CO_2 emissions, occupant comfort, light levels, airflow, Part L, BREEAM, LEED, EPC ratings, etc. The component-based HVAC module, ApacheHVAC was used to build and run simulations on the HVAC and control system.

Microsoft Excel- The most popular spreadsheet program was used to store, compare, graph, calculate, present and share data that was essential to the design and engineering of the house.

Climate Consultant- A tool for weather data analysis, which seamlessly links with EPW format weather data. This software develops graphs that analyze the weather data and even helps show some potential strategies to allow your home to achieve 100% thermal comfort. It recommends everything from home orientation relative to the sun's path as well as wind speed and direction.

4. CLIMATE ANALYSIS

Weather data from Southern California Edison's Santa Ana weather station recorded in 2013 was used in our Energy Modeling to test and verify our energy-saving options. Though many weather data sets are available through the National Renewable Energy Laboratory's National Solar Radiation Database [2] as well as the Department of Energy's EnergyPlus Energy Simulation Software [3], we chose to pick weather data that is more recent and more likely to simulate the conditions of Irvine during the competition. For example there is TMY3, typical meteorological year (TMY) weather data for the energy analysis, data from John Wayne airport derived from a 30 year period (1976-2005) but we believe that local Santa Ana weather data will much better simulate the climate in Irvine during October 2015.

Figure 2b has the three triangles in the innermost circle show the minimum, average, and maximum velocity of the winds from each direction. The wind wheel integrates wind velocity and direction data with concurrent temperatures and humidity and can be animated hourly, daily, or monthly. Casa del Sol is oriented and designed to take advantage of this natural convection that is available in our region. The orientation of the house is in the Southern direction to take advantage of the prevailing ocean breezes that blow in the Southwest direction [4].

As seen from the temperature range chart in figure 2a, we designed for the hottest day of the year, occurring sometime in September, and the coldest day of the year, in January. This way we can accurately determine our maximum heating/cooling loads.

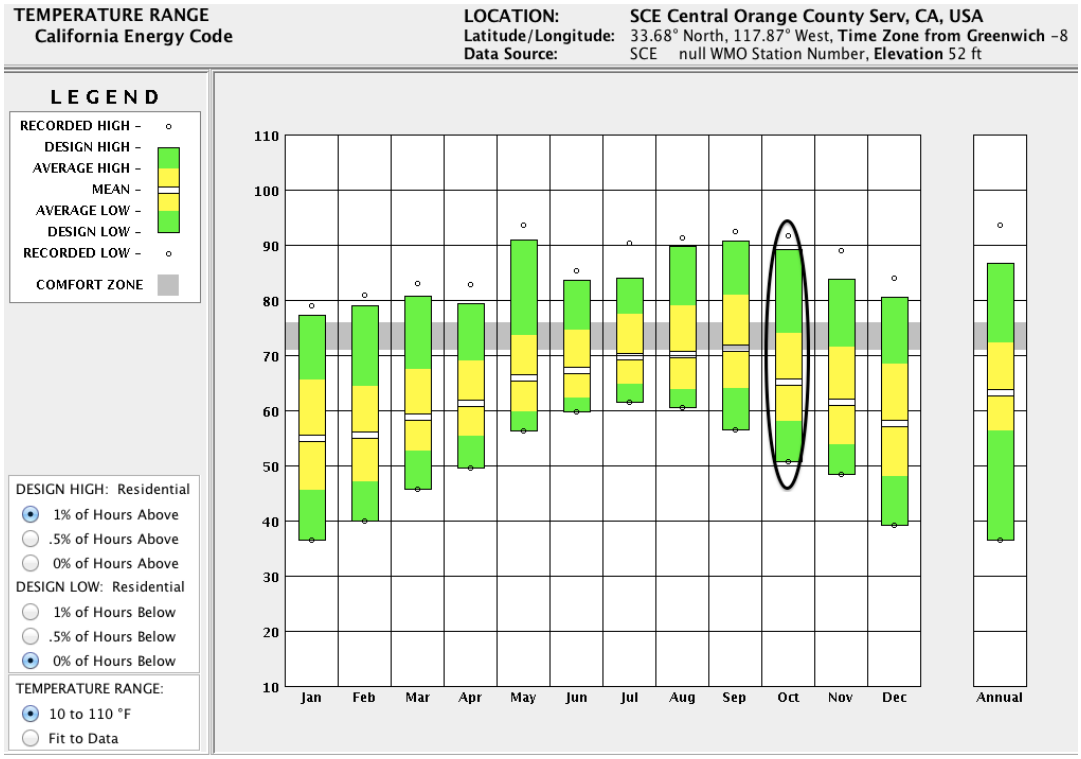


Figure 2(a)

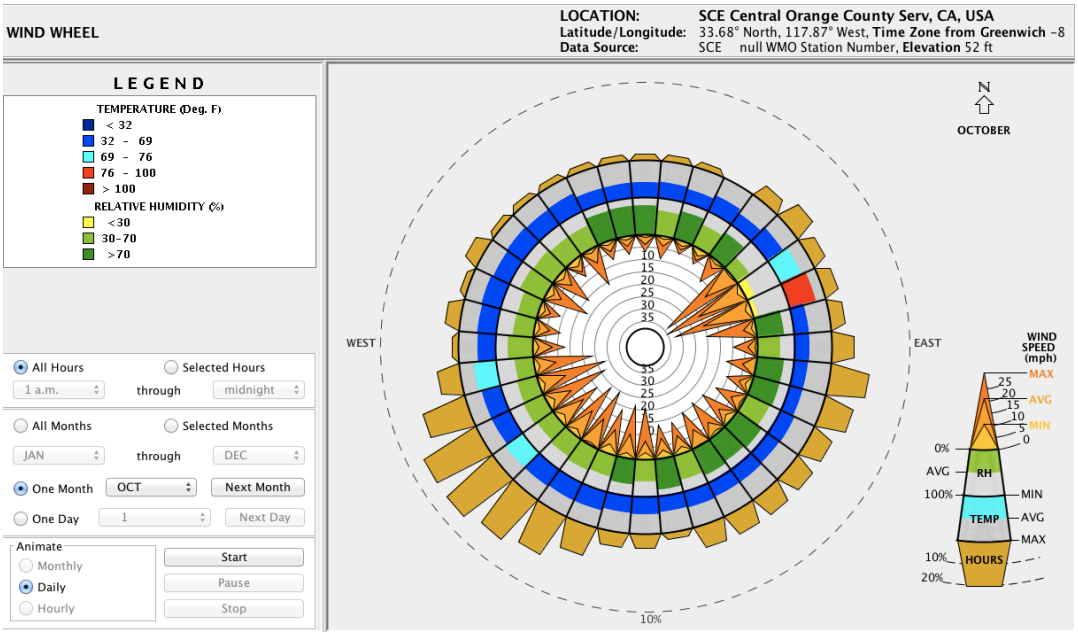


Figure 2(b)

Figure 2: Average Design Temperature (a) Wind Wheel (b)

In accordance to the Solar Decathlon Rules, our comfort zone for this program was set from 71-76F. A psychrometric chart was used to show how to design HVAC systems and building envelopes that can modify or filter these external weather conditions to create comfortable indoor environments. In Figure 3 below, the temperature (bottom axis) and humidity ratio (right axis) for different design strategies are plotted for every hour of the year with the color indicating whether it is in the comfort zone (blue trapezoid) or out of the comfort zone (everywhere else). We selected the appropriate design strategies highlighted on the table in the upper left corner of the psychrometric chart in Figure 3, also known as the Design Strategies box. The Design Strategies box shows the percentage of hours that each strategy would be used to maintain comfortable conditions inside the home for the given climate Based upon this simple analysis, our strategies will maintain the comfort zone for 100% of the year (8760 out of 8760 hours), which gives us a good indication that everything we account for in this program complies with our complex and innovative design. This program was used for our initial decision on what our design for the HVAC system needed to include to provide comfort to the residents. Further analysis done by the programs mentioned in the previous section “modeling methods” helped us finalize our design.

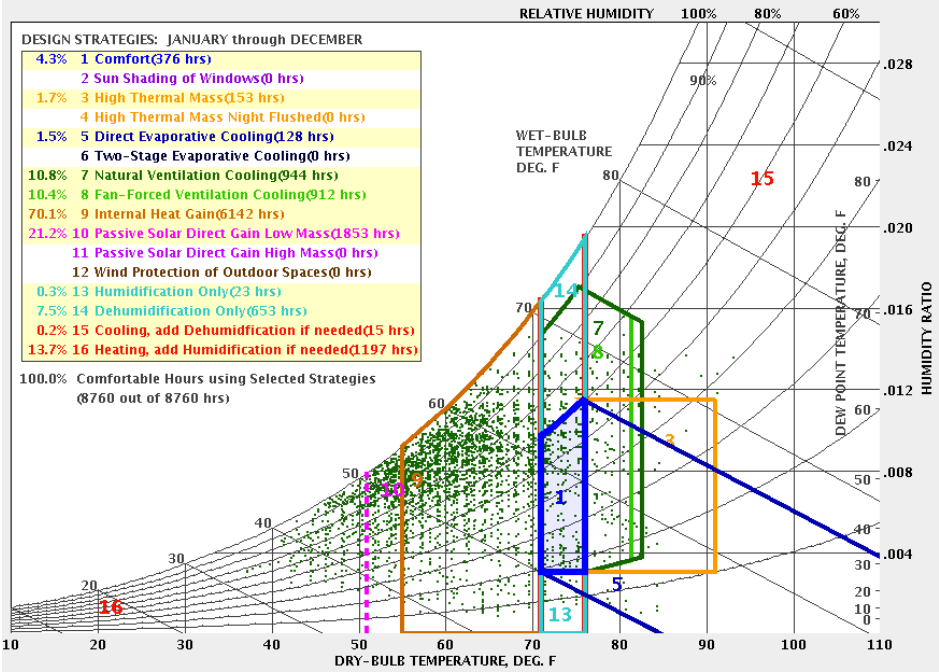


Figure **3**: Psychrometric chart with all design conditions accounted for

5. BUILDING MODELING

Energy simulations were conducted through two main software platforms, DesignBuilder and IESVE. These simulations were used to calculate building heating and cooling loads throughout the competition week as well as annually. They take into account the following:

- Internal Gains
- Building Envelope
  - Insulation materials & thickness, windows, etc.
  - Shading structures
- Natural Ventilation
- Infiltration Rates

The loads were then used to size Casa Del Sol's HVAC equipment.

Not only were the simulations used to provide load calculations, but also to give feedback to design features of the house. For example, as the architecture changes, it affects the energy loads of the house and, therefore, the HVAC. The energy model also gives feedback to the architectural team regarding placement of windows, shading structures, and etc.

The use of two different energy modeling software was to provide assurance that the load calculations were a good estimate for the HVAC equipment.

HEATING AND COOLING LOADS

	Design Day Load Calc			
Software	Heating (kBTU/h)	Cooling (kBTU/h)	Heating (kW)	Cooling (kW)
IESVE	13.0	15.3	3.8	4.5
Design Builder	12.8	14.2	3.8	4.2

Table 1: Maximum Daily Load Calculations for Casa Del Sol

The design daily load calculations as determined by both energy simulation software packages are presented in the table above. Both IESVE and DesignBuilder demonstrated very similar load calculations, providing confidence in the analysis. The simulation took into account the following: internal heat gains, building envelope (e.g., wall and insulation materials & thickness, windows, etc.), shading structures, natural ventilation, and infiltration rates of undesired air. The numbers represented in the table are the maximum heating and cooling loads by taking the worst of winter and summer. As expected for Southern California, the cooling loads were slightly higher than the heating loads.

INTERNAL GAINS

Internal gains are the exchange of heat between the equipment within the home and the indoor environment. This heat can come as sensible heat as well as latent heat and can come from occupants, lighting, the refrigerator, dryer, clothes washer, etc.

Internal gains play a huge role in terms of energy performance of the home. In the heating season, it can be beneficial and aid in heating, however, in the cooling season it will hurt the home. For Southern California, generating hot water for heating during the day is much less of a challenge than generating chilled water at night for cooling. Therefore, it is important to keep the internal gains low to reduce the amount of energy needed for cooling.

One of the ways that this is achieved is by excluding the clothes washer and dryer from the conditioned space. This takes the heat gain from both of the equipment out of the equation.

In addition to strategic placement of equipment, Casa Del Sol is using LED lights throughout the house to minimize not only heat gain but energy consumption as well.

Every other piece of equipment within the home was picked with the idea of energy consumption in mind. All equipment is energy-efficient and, therefore, results in lower heat gain.

Table 2 shows the approximate heat gain of the internal loads for Casa Del Sol. In order for this information to be useful in an energy simulation, there must be a corresponding schedule. The schedule was created based

on the most demanding day of the Solar Decathlon 2015 competition and was used for design day load calculations.

Internal Load	Approximate Heat Gain (W)	Schedule
Refrigerator	100	24 hours
Lights	200	4 hours
Dish Washer	300	2 hours
Cooking	1500	2 hours
Miscellaneous	100	24 hours
Occupants	70	16 hours

Table 2: Internal Loads

Additionally, heat gains can enter the home by ventilation, infiltration, and solar gains. Each source of heat gains were taken account in the simulations as well.

BUILDING ENVELOPE

The building envelope is a barrier between the indoor environment and the outdoor environment. The thicknesses of insulation in the floors, ceilings, and walls were simulated to see what was best suited for the conditions of Irvine, California. Simulations were also done on the effects of windows and shading structures on the heating and cooling load calculations.

INSULATION

Insulation is one of the biggest contributing factors to a low heating and cooling load as they are meant to resist the flow of heat transfer from the ambient to the indoor environment. Casa Del Sol used the Midori Haus, a passive house in Santa Cruz, as a starting point for simulations. Afterwards, iterations were done to optimize insulation in the walls, roof, and raised floors.

The following simulations were compared to a base case of:

- R-Value of 28 in walls
- R-Value of 46 in roofs
- R-Value of 32 in raised floors

Walls

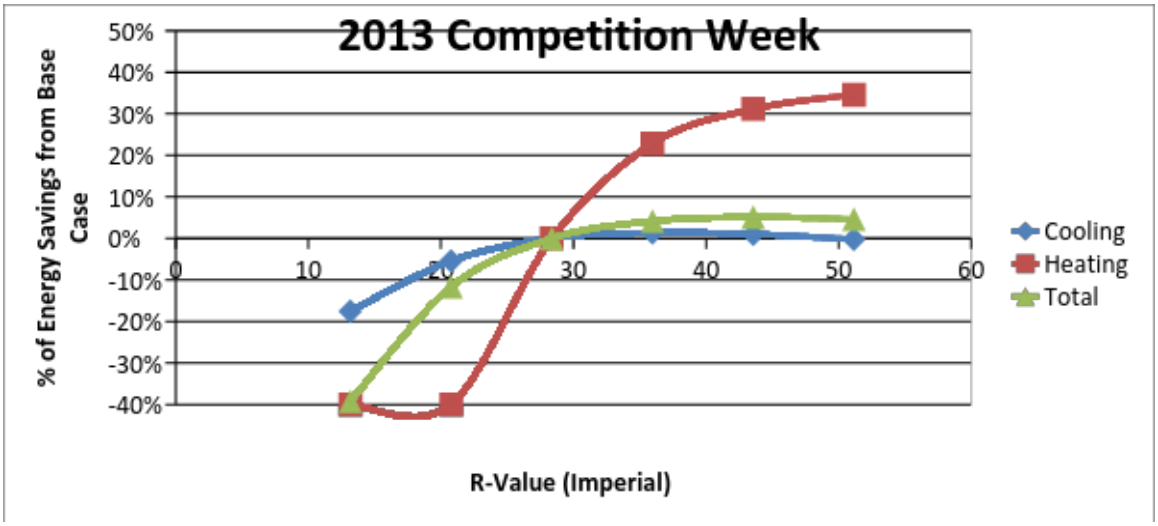


Figure 4: Effects of R-Value in Walls for the 2013 Competition Week

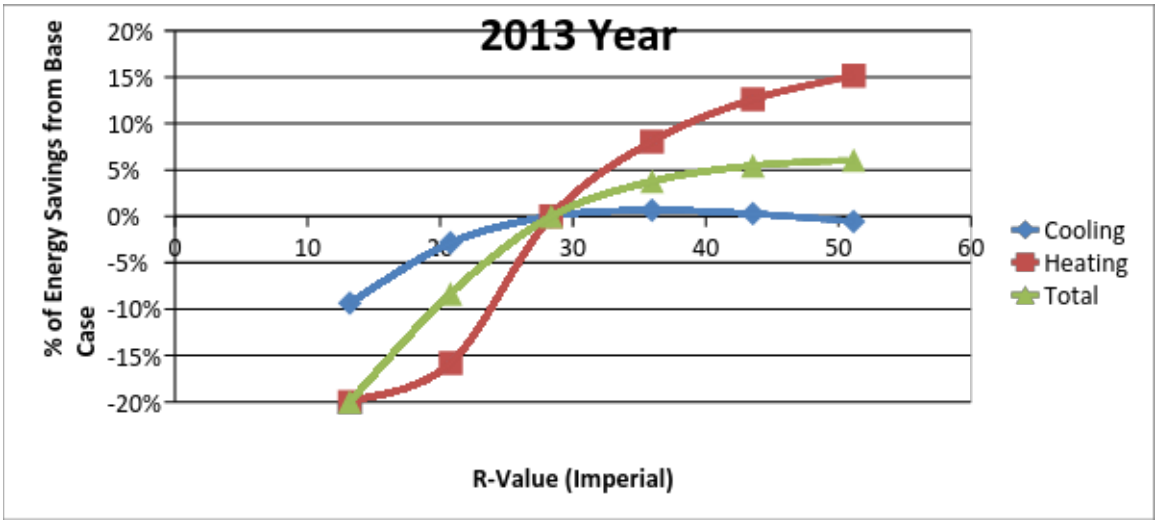


Figure 5: Effects of R-value in Walls for the 2013-Year

The simulations for the competition week and annually show the deviation from base case concerning increasing and decreasing R-values. Increasing R-values result in greater energy savings from the base case for heating than cooling. However, the magnitude of energy saved is far greater in cooling than heating. This is taken

into account in the total amount of heating and cooling saved. Several iterations were done in similar fashion to see energy savings from different base cases. In the end, for the climate in Orange County, an R-value of 28 is the most cost-effective solution for Casa Del Sol.

Roof

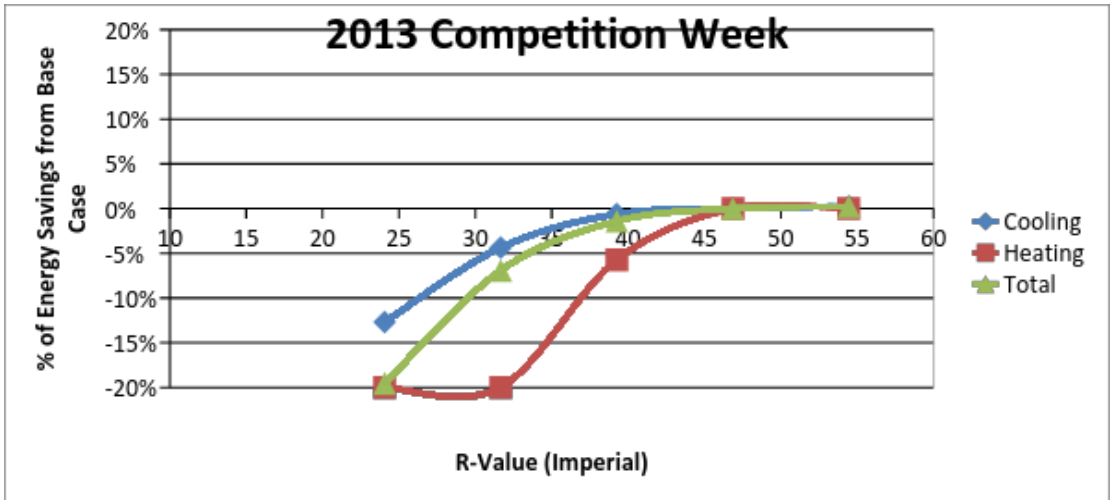


Figure 6: Effects of R-Value in Roof for the 2013 Competition Week

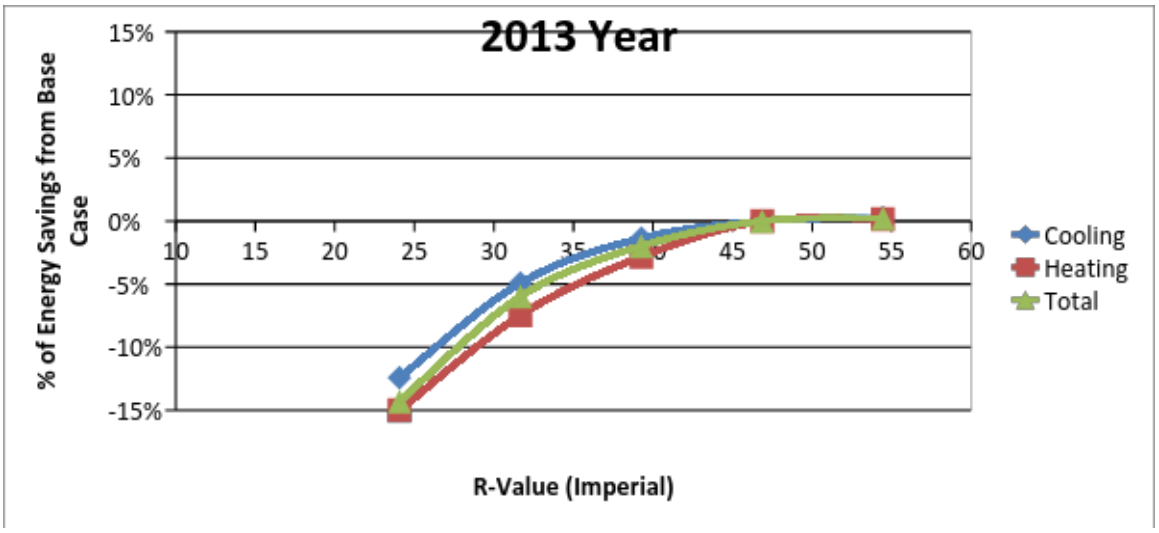


Figure 7: Effects of R-value in Roof for the 2013 Year

The trend for insulation in the roof was similar to those of the walls except that the roof showed a more cohesive behavior for both heating and cooling. From the figures, the energy savings plateau after an R-value of 46.

Raised Floors

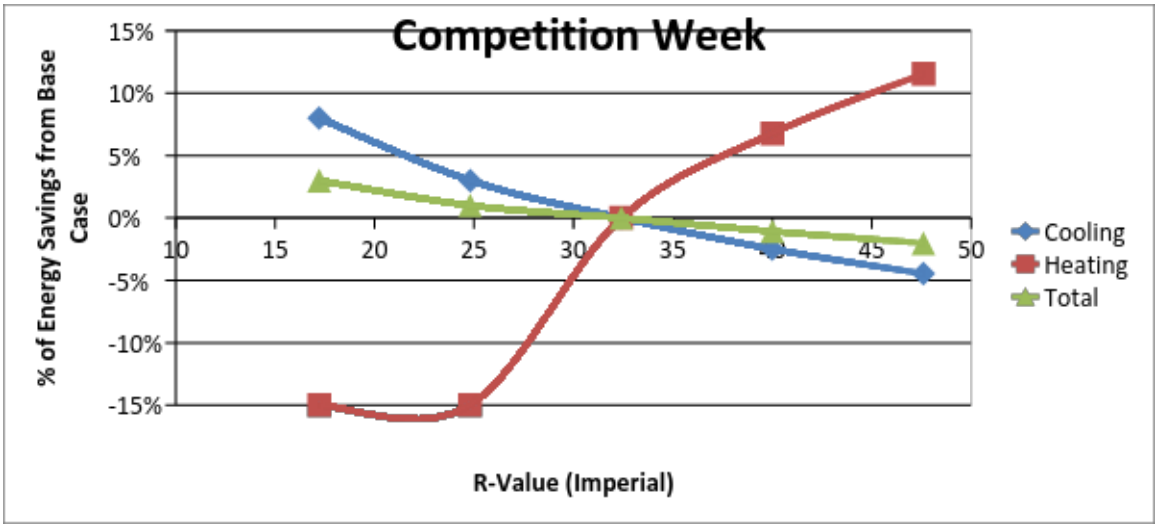


Figure 8: Effects of R-Value on Raised Floor for the 2013 Competition Week

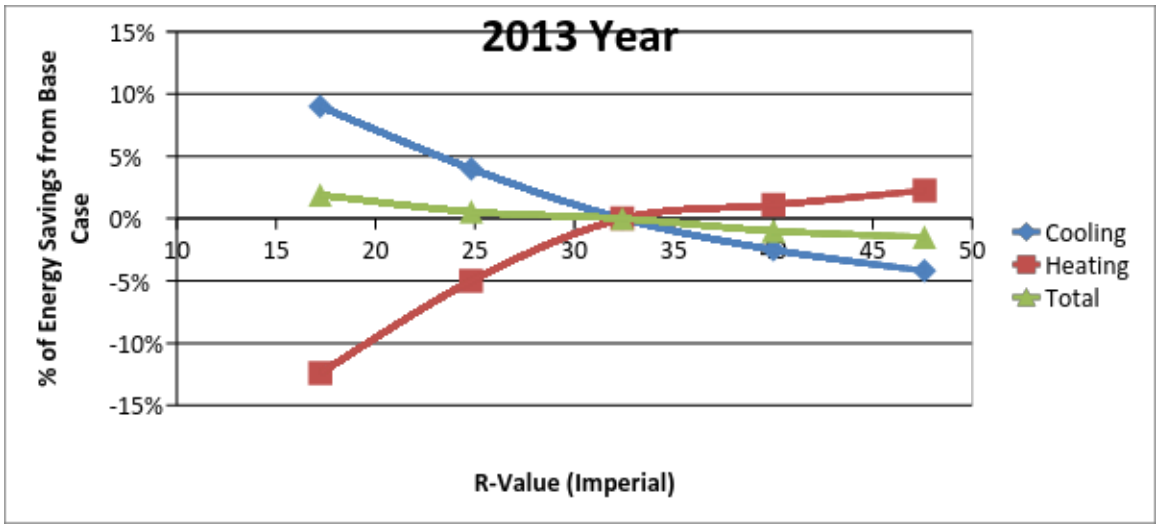


Figure 9: Effects of R-Value on Raised Floor for the 2013 Year.

The simulation results for the raised floors were the most interesting for Casa Del Sol. It demonstrated that increasing the thermal resistance of the raised floor actually decreased the savings for cooling but increased the savings for heating. This is reflective of the cool draft from convection during the cooling season that can provide cooling for the surface. With a lower R-Value, the floors can lose heat gain much faster, thus higher energy savings. During the heating season, the low R-Values allow heat loss from the home resulting in negative energy savings. Casa Del Sol chose to go with an R-value of 32 for the raised floor because the energy savings to go less than an R-value of 20 does not have a huge impact. Rather, an R-value of 32 will help reduce the heat loss during the heating season.

NATURAL VENTILATION

In Orange County, free cooling is available when the weather permits. Casa Del Sol features automated windows linked up to temperature sensors that will open up when outdoor temperatures are cooler than indoor temperatures. This eliminates the need to physically operate windows and will always ensure that free cooling is taken advantage of. As part of the design process for Team Orange, careful ventilation studies were performed to validate the use of our energy management control system (EMCS). Our EMCS will monitor and maintain temperature by opening windows and engaging fans when necessary.

Throughout the simulations, the following parameters were used:

- To simplify the analysis, one of our two zones were focused.
- No forced convection strategies were included such as fans and the HVAC system.
- All windows were opened to their maximum.
- All doors were opened (unless stated otherwise) to reduce the temperature within the house during its hottest periods.
- In order to properly simulate forced convections and induce natural ventilation, a general supply diffuser was defined based on the wind conditions for the simulated time of day for that particular case scenario.
- Heat gains through solar radiation at the time of the simulation were also included in the simulation.
- Window surface temperature and house surface temperature were set to the *simulated* dry bulb temperature for the 7th of September at noon (see figures below; hot case scenario: 84°F and for the 7th of December at 5pm (cold case scenario: 60°F).

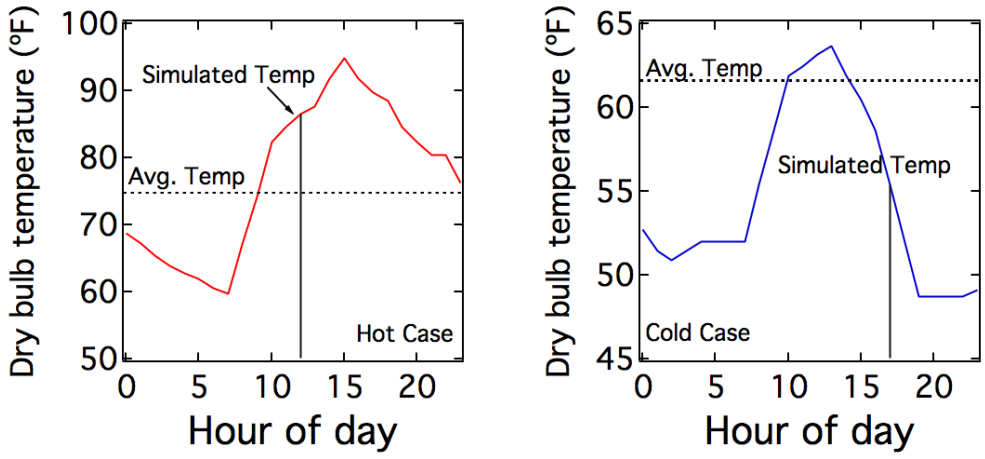


Figure 10: Hot case (left) Cold case (right)

- To see the effect of radiant heat gains, components were added to account for radiant heat due to inhabitants and appliances (1500 W).
- Based on recommended R-values for insulation (see above), the walls were simulated to have an R-value of 28 for the walls, an R-value of 46 for the roof, and an R-value of 32 for the floors.

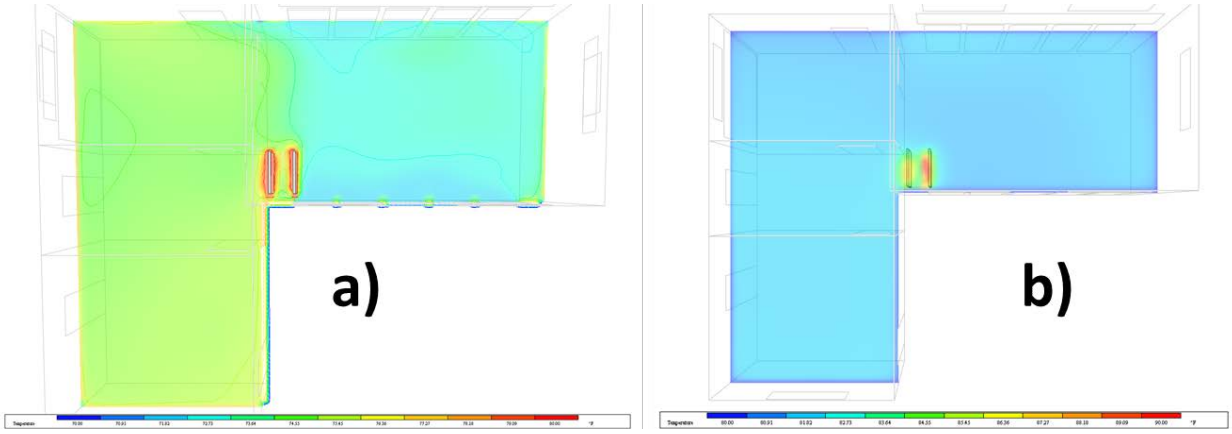


Figure 11: Effect of natural ventilation on a hot day. Internal temperature of the main unit is shown for windows closed (a) and open (b).

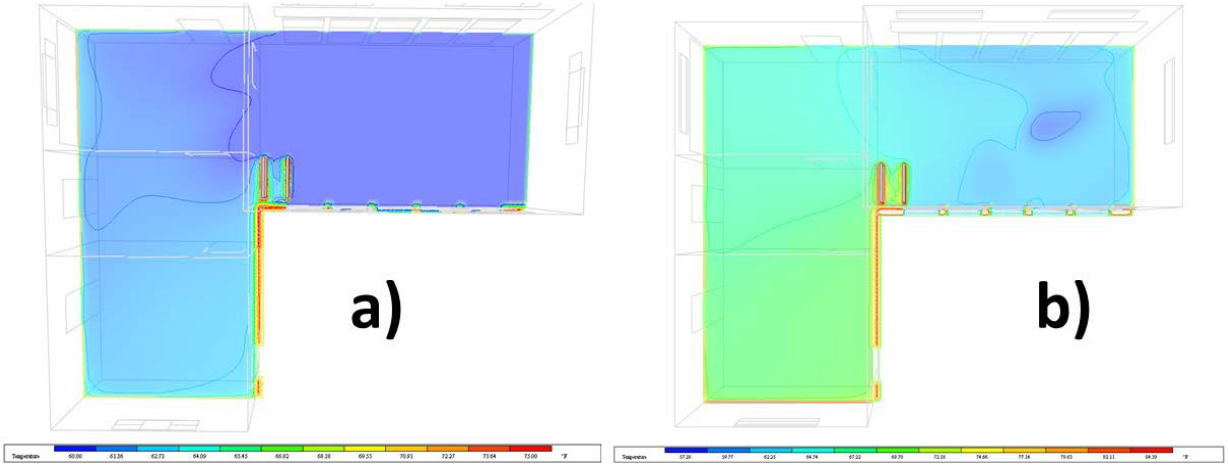


Figure 12: Effect of natural ventilation on a cold day. Internal temperature of the main unit is shown for windows closed (a) and open (b).

The results from the simulations are summarized in the tables below:

Room	Average temperature (°F)
Main Bedroom	75.5
Main Bathroom	74
Living Area	72.3
Flex Room	74

Table 3: Hot Case Scenario w/ doors *open*

Room	Average temperature (°F)
Main Bedroom	81.2
Main Bathroom	81.2
Living Area	81.2
Flex Room	81.2

Table 4: Hot Case Scenario w/doors *closed*

Room	Average temperature (°F)
Main Bedroom	63
Main Bathroom	63
Living Area	61
Flex Room	61

Table 5: Cold Case Scenario w/doors *open*

Room	Average temperature (°F)
Main Bedroom	71
Main Bathroom	71
Living Area	62
Flex Room	71

Table 6: Cold Case Scenario w/doors *closed*

Based on our simulations, we find that by utilizing natural ventilation through the use of windows and opening all the doors in the living room, our house remains within the thermal envelope requirement for the competition during warmer months. To validate these results, the same conditions were simulated except the doors were closed and we find that the house warms up to an average of 81°F. We caution that while these results were simulated with the greatest accuracy possible concerning the materials chosen for the competition, we are encouraged by the possibility of taking advantage of free cooling in order to keep temperatures cooler during the warmer months, thus minimizing the need to use our HVAC system and reduce the amount of energy consumed through its use.

In addition, simulating cooler months, we find that if the doors are closed, the house is well insulated. We do take notice that the living room is significantly cooler within this zone because of the air exchange that occurs near the windows making it feel cooler.

INFILTRATION

Infiltration is undesired ambient air entering the home through gaps in the building envelope and by opening and closing doors. It is an important factor in terms of energy savings.

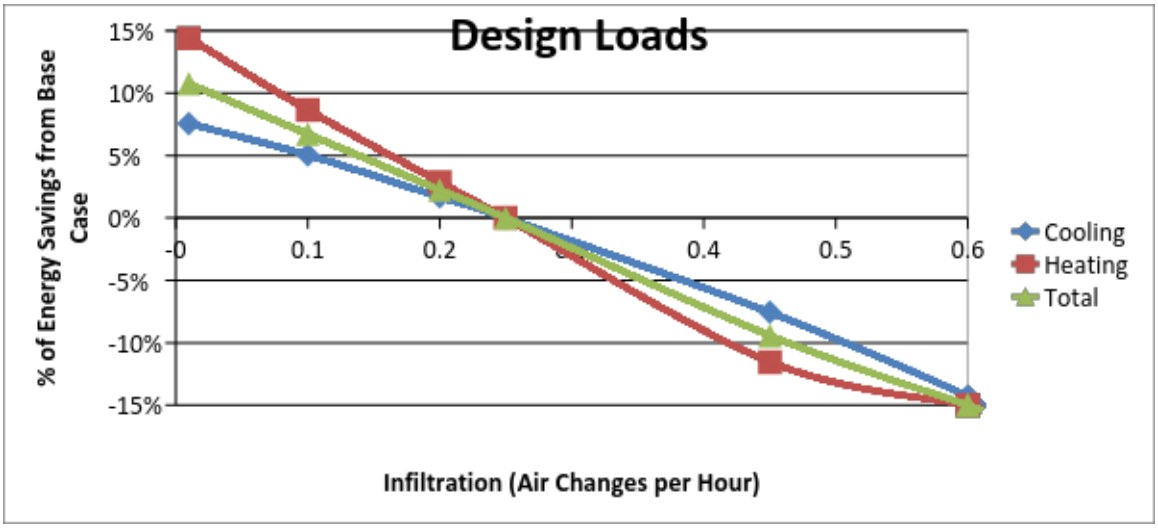


Figure 13: Effects of Infiltration on Design Loads

The effects of infiltration on design loads shows that decreasing the infiltration rates results in energy savings and increasing infiltration rates will result in energy costs. With higher infiltration rates, there will be more uncontrollable air, which causes the indoor temperatures to swing. Having a tight envelope is beneficial by preventing heat loss and heat gain throughout the day. The base case for the simulation run was 0.25 air changes per hour, which is typical of a well-sealed house. Casa Del Sol, however, is aiming for even lower infiltration rates, which will be obtained through by doing a blower door test during the construction phase before the competition. With this, an infiltration rate of .005 - .010 air changes per hour can be achieved.

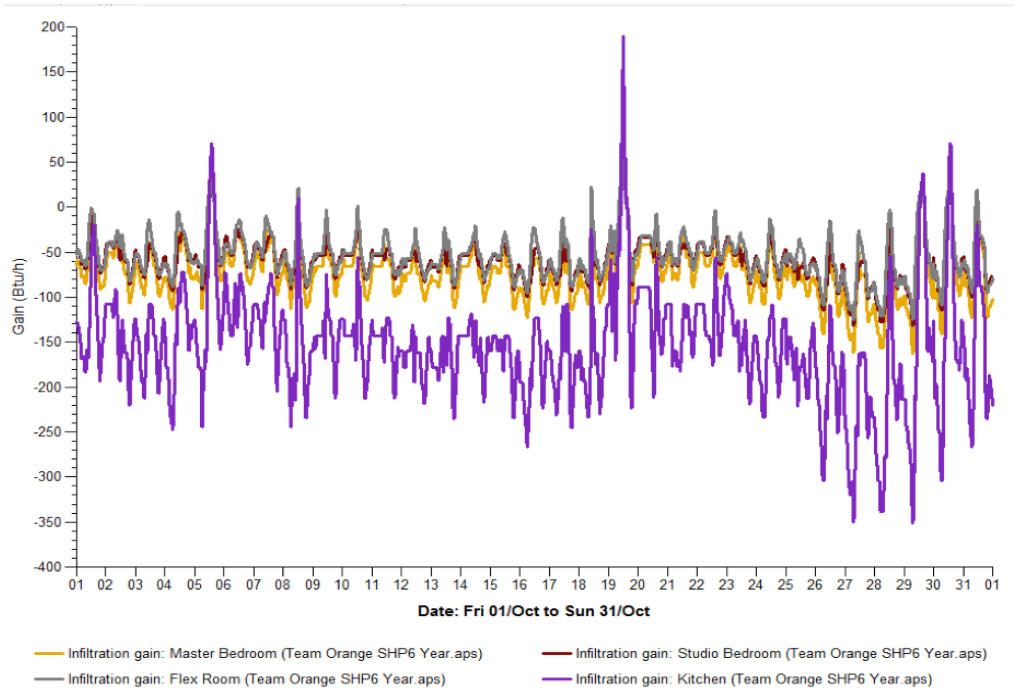


Figure 14: Infiltration Gain of the House for October

Infiltration is undesired ambient air entering the home through gaps in the building envelope and when opening and closing doors. It is an important factor in terms of energy savings. Comparing the results in the master bedroom, to the studio room, flex room, and kitchen, the room that experiences the most infiltration gain or loss is the kitchen. This needs to be considered when running our HVAC system during heating or cooling mode since it experiences the most undesired air.

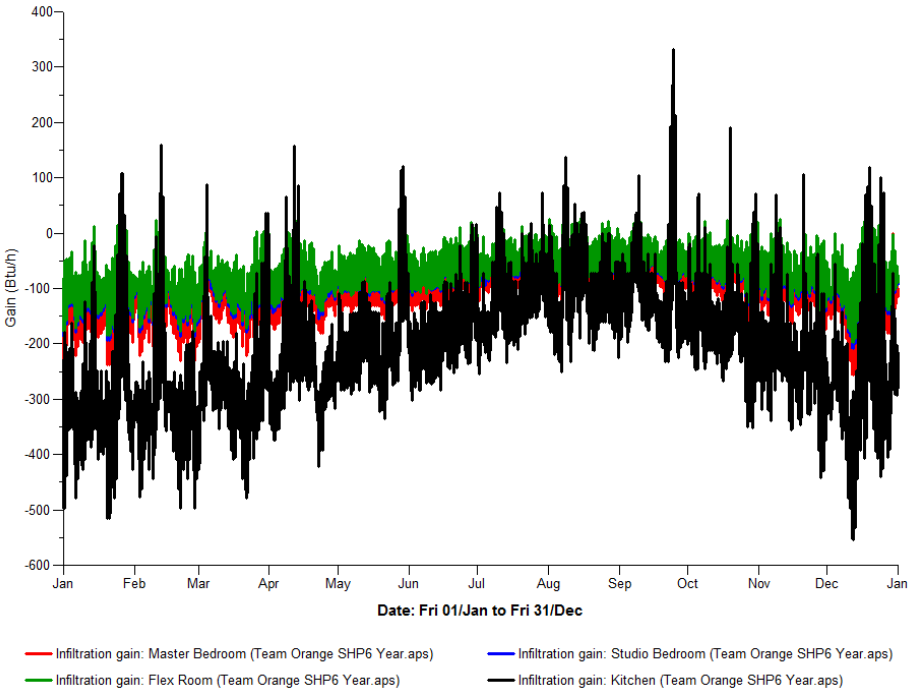


Figure 15: Infiltration Gain of the House for Entire Year

Notice how the graph not only peaks in the positive but also peaks below zero. This is infiltration loss, which is also known as exfiltration. Exfiltration is when the air inside the house creeps outside the house, which is very inefficient. It can be seen in the graph that on September 24th close to noon, the infiltration gain is at its peak of 153 Btu/h compared to the whole year. The infiltration loss peaks at -256 Btu/h in the month of December. This amount of unwanted air being lost or gained into the house needs to be fixed or calculated for the HVAC system.

Below is a graph of the daily profile of infiltration at its peak in the year, occurring on October 19th with an infiltration gain of 190 Btu/h.

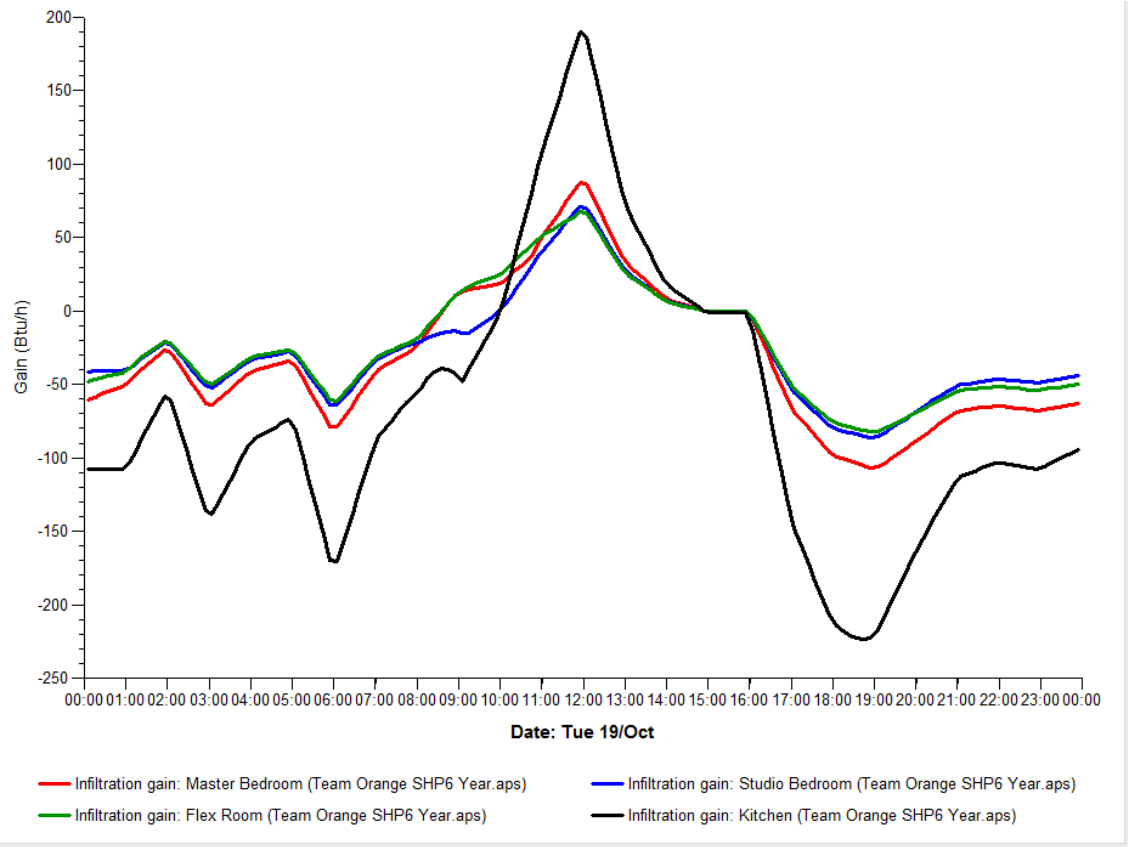


Figure 16: Infiltration Gain Daily Profile (October 19)

RELATIVE HUMIDITY

Relative humidity is the amount of moisture in the atmosphere compared to what the air can contain at that certain temperature. When the air cannot contain any more moisture, the extra moisture condenses into dew. Figure 17 exhibits the water vapor pressure of the air expressed as a percentage of the saturation vapor pressure. According to the graph, August would have the highest percentage, which the peak would be 83%. It is important to know the humidity in the house because the water vapor holds heat can affect the temperature inside. We have designed for sensors to record the temperature to know the right time to turn on the HVAC system and dehumidify. Notice how throughout all the rooms the relative humidity are similar, which makes sense because it should not be changing between rooms, which validates the data that is being collected.

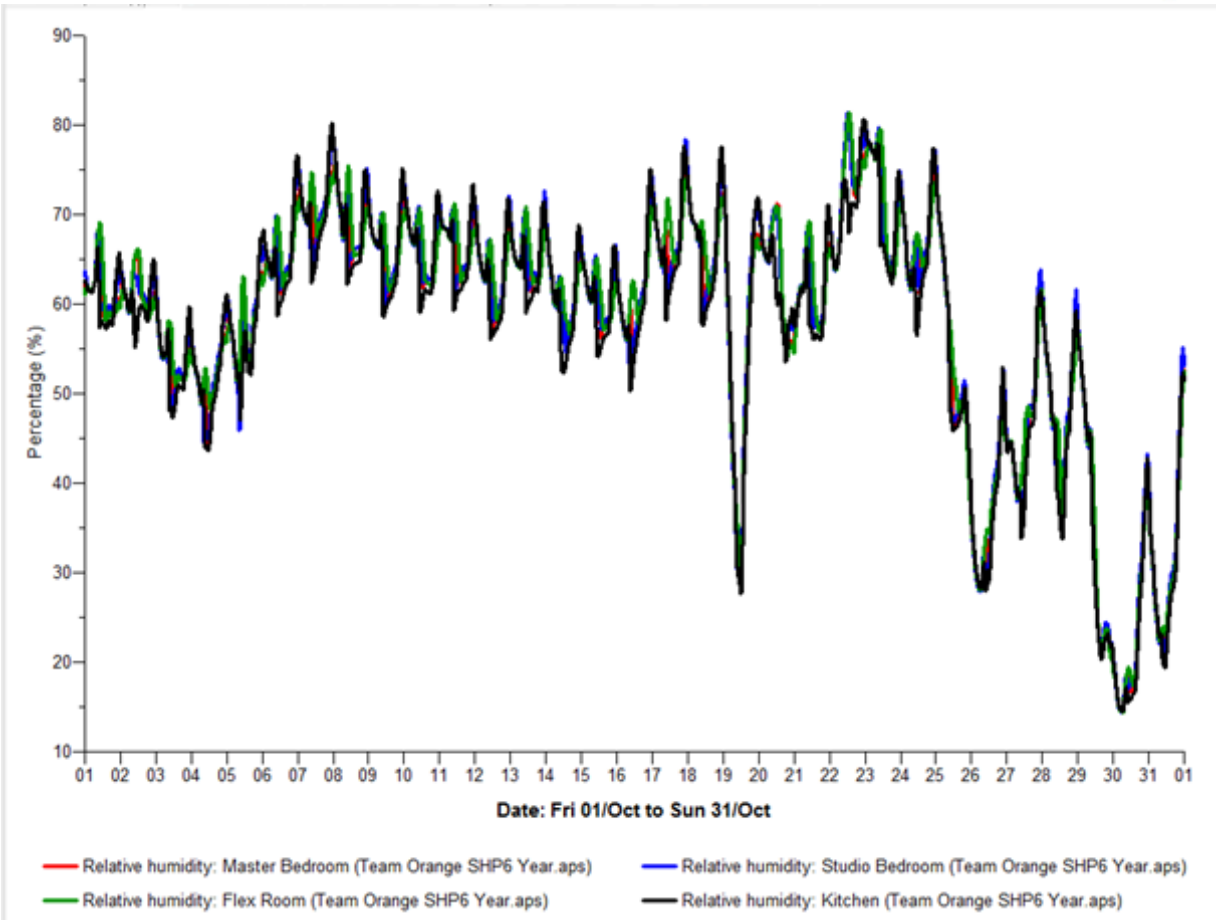


Figure 17: Relative Humidity of the House for October

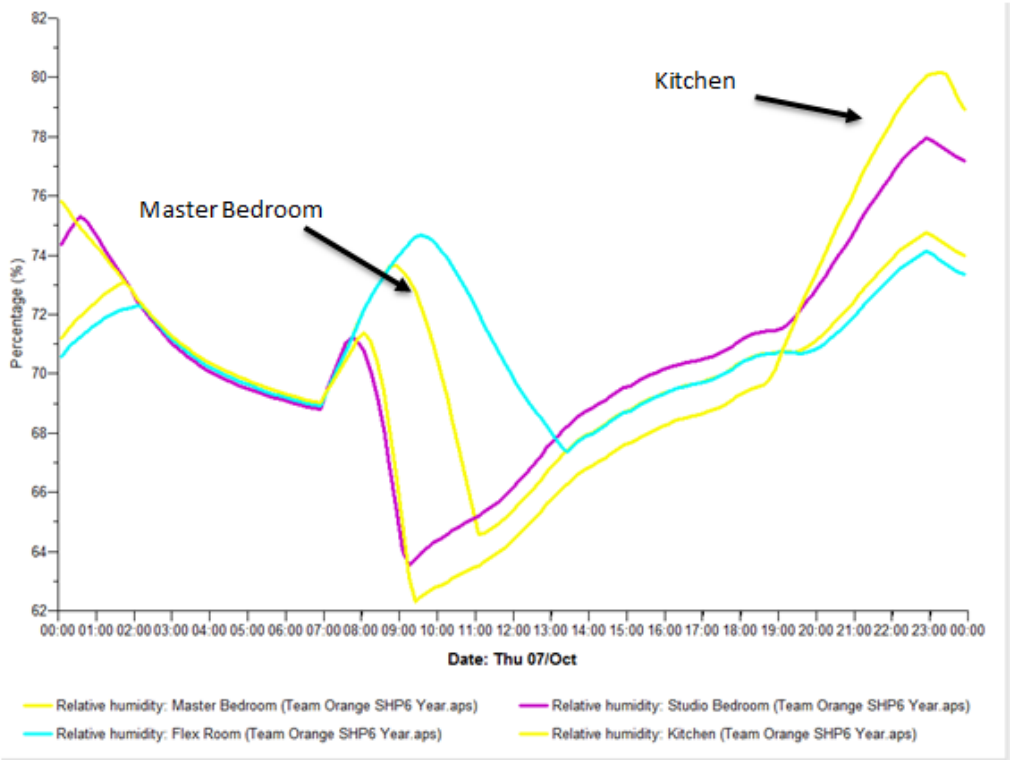


Figure 18: Relative Humidity of the House for Daily Profile

Displayed in the graph above is the peak relative humidity in the month of October where it reaches the highest at 80% for the kitchen. Notice how the humidity rises and falls where it does not stay constant in a day setting.

SOLAR GAIN

The graph below expresses the solar gain on the home. The solar gain graphs from IESVE **[5]** show the solar radiation absorbed on the internal surfaces of the room, plus solar radiation absorbed in glazing and transferred to the room by conduction. There is less solar gain during the summer months when the sun is directly over the home compared to the winter when the sun angle is lower. This graph shows that it is optimal to have maximized solar gains during the winter so it can use the heat of the sun to warm the house and to reduce space-heating demand. While during the summer, solar gain needs to be controlled so that it minimizes cooling loads in the house.

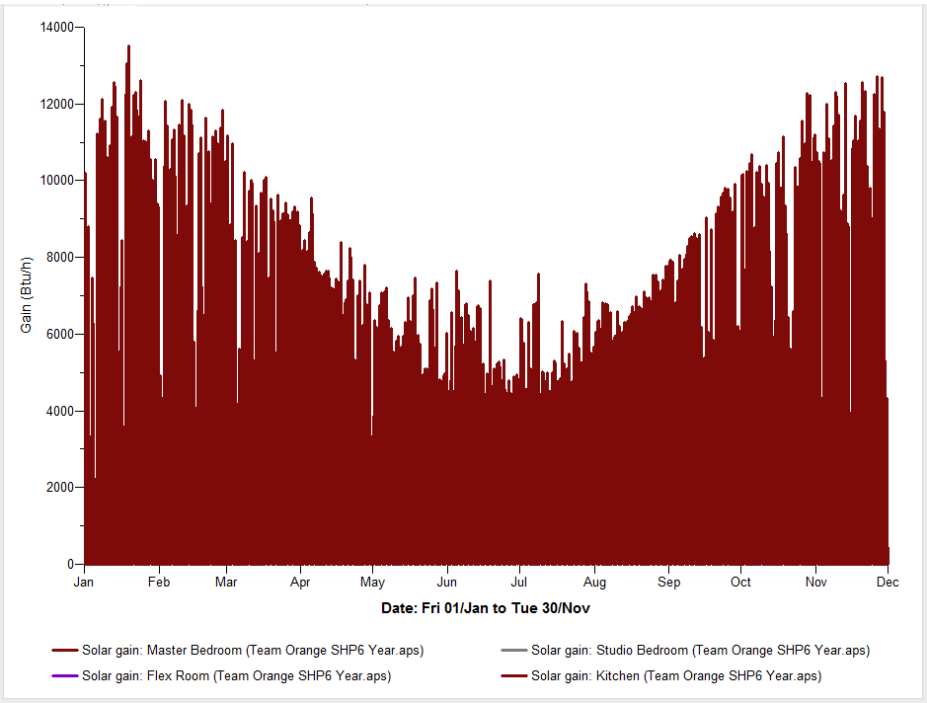


Figure 19: Solar Gain of the Entire House for the Year

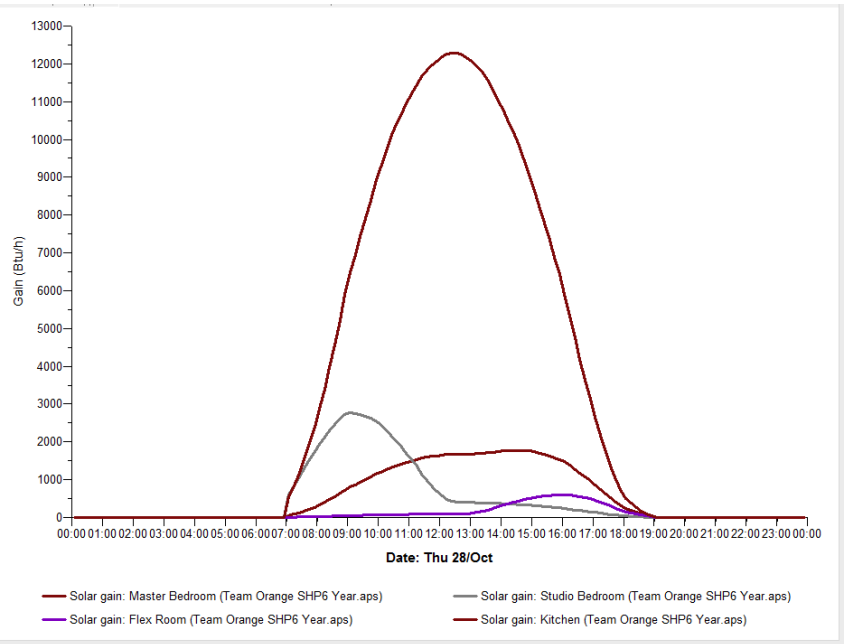


Figure 20: Solar Gain of the Entire House for Daily Profile

6. HVAC

This section outlines and discusses the heating ventilation and air-conditioning (HVAC) unit that will be implemented into Casa Del Sol. Many different ideas were considered until Team Orange County reached the development of the final HVAC design.

CONSIDERED HVAC OPTIONS:

Throughout the course of the design process for Casa Del Sol, three options were compared: the Mini Split Heat Pump System, the Whole House Fan/ Central HVAC System, and the Radiant System.

Mini-Split Heat Pump System:

The multi-zone heat pump system was a cost-effective option with the ease of installation and excellent zonal control. Consisting of a single outdoor heat pump connecting to multiple indoor air handlers, the system allows for precise space conditioning leading to energy savings. Because this system is ductless, it takes out the energy losses associated with the ductwork of a traditional forced air system. The system also comes with a variable speed compressor allowing it to speed up or slow down according to room conditions, ensuring efficiency during run time.

Whole house fan/ Central HVAC system:

The Central HVAC system is a forced air system that utilizes the thermal energy of hot and chilled water. At the heart of the system is an air-handling unit that provides heating and cooling by supplying air through cold and hot coils to the home. The coils ran on hot water that would be generated during the day from solar collectors and chilled water generated at night through the use of an evaporator and a water-to-water heat pump. The advantages of this system were the ability to incorporate the hot water from the collectors as well as taking advantage of the cool nights to help chill water. A water-to-water heat pump would be more efficient than an air sourced heat pump resulting in larger energy savings. The chilled water would also be stored in a storage tank decreasing the necessary run time of the heat pump. In addition to that, the system would be able to provide minimum ventilation and use of operable windows could be fully optimized by simulating a whole house fan.

Radiant System:

These results show minimal power consumption, making the radiant system our main source for cooling and heating. In our design, we were considering where to place the radiant system (either in the flooring of Casa del Sol or in the ceiling). Because radiant systems can take a longer time to heat or cool areas of the home, we decided that using a radiant ceiling was best. Radiant ceilings have the ability to accelerate fast when needing to make a significant change in the heating load. This contrasts with radiant floors because objects such as furniture and rugs placed on top of the radiant flooring system can impede energy flow from the radiant system

to the environment. Radiant ceilings are also more cost effective than radiant flooring, making them more ideal for our house.

HVAC Energy Consumption:

The total energy consumption of the mini split system over the course of 8 days is projected to be about 28 kW in comparison to an astounding energy consumption of 7.6 kW from the radiant system. However, these values are most likely deflated as they assumed a constant EER and COP rating which is normally not the case. Also, the energy for pumps included in the radiant system was not included. Run time of each system was also not included. It is expected that the water-to-water heat pump in the radiant system is less than the mini-split heat pump due to the ability to store thermal energy for the radiant system. This will significantly lower the energy usage of the radiant system.

	Energy Consumption (kWh)			
	Cooling		Heating	
	Radiant	Mini Split	Radiant	Mini Split
Day 1	0.9	1.1	0	0.8
Day 2	0.1	0.1	0	2.7
Day 3	0.2	0.3	0	6.4
Day 4	0.6	0.7	0	4.1
Day 5	0.7	1.1	0	1.9
Day 6	0.7	0.8	0	0.8
Day 7	1.9	2.2	0	1.8
Day 8	2.5	2.9	0	0.1
Total	**7.6**	**9.2**	**0**	**18.6**

Table 7: Energy Consumption

FINAL DESIGN

Our home incorporates the use of an intricate design that utilizes a thermal load as its main source of heating and cooling the home. For maximum efficiency, our house consolidates the use of a radiant heating and cooling system in the ceiling of our home as well as natural ventilation and a whole house fan backup system if the radiant system fails to keep the home within the 71-76F comfort zone.

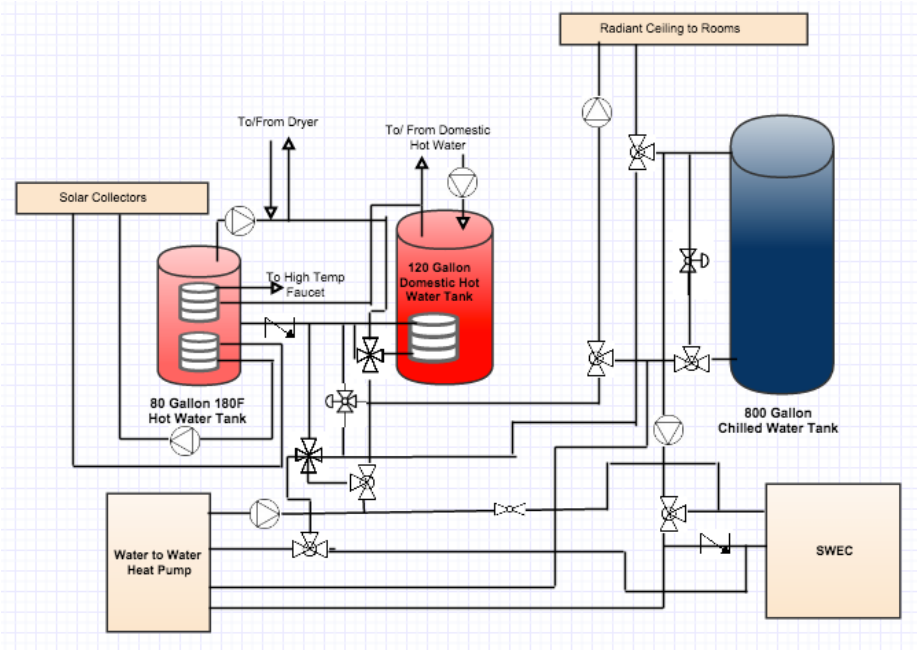


Figure 21: Finalized home design with Radiant ceiling

Radiant Ceiling:

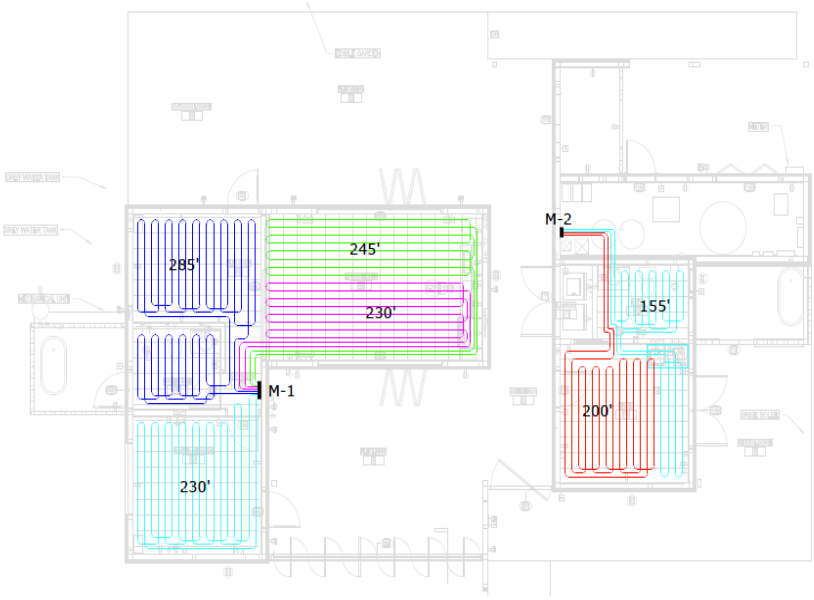


Figure 22: Final Radiant model of our home as designed by Uponor

The radiant system with a ducted whole house fan backup is the system we chose for our final design. Since we will be using a majority of the energy collected from the photovoltaic panels to power other applications in our home, the radiant system will help us cut down on our energy usage and cover more than 50% of the heat exchange occurring within the conditioned space.

Working with our radiant heating and cooling company Uponor, we decided to use their ½" hePEX for installation in the ceiling. The hePEX is a specially designed type of PEX tubing that allows for flexibility and recovery from kinked piping. Collaborating with their engineers, we were able to collect the following results:

Area Served	Area (ft²)	Zone No.	Manifold No.	Cooling				
				Setpoint(F)	Fl. Surface(F)	(Btu/ft²/hr)	(Btu/hr)	EWT/LWT
Main Level								
Master Bedroom	148	1	M-1	76	68	18.0	2664	54/62
Flex Room/Bathroom	200	2	M-1	76	68	18.0	3600	54/62
Living Room/Kitchen	267	3	M-1	76	68	18.0	4806	54/62
Studio/Bathroom	203	4	M-2	76	68	18.0	3654	54/62

Table 8(a)

Area Served	Area (ft²)	Zone No.	Manifold No.	Heating				
				Setpoint(F)	Fl. Surface(F)	(Btu/ft²/hr)	(Btu/hr)	EWT/LWT
Main Level								
Master Bedroom	148	1	M-1	76	82	10.0	1480	110/100
Flex Room/Bathroom	200	2	M-1	76	82	9.8	1960	110/100
Living Room/Kitchen	267	3	M-1	76	87	17.4	4646	110/100
Studio/Bathroom	203	4	M-2	76	85	13.7	2781	110/100

Table 8(b)

Area Served	Area (ft²)	Zone No.	Manifold No.	Flow	
				GPM	HD Loss (Ft.)
Main Level					
Master Bedroom	148	1	M-1	0.7	5.5
Flex Room/Bathroom	200	2	M-1	1.0	12.6
Living Room/Kitchen	267	3	M-1	1.3	5.2
Studio/Bathroom	203	4	M-2	1.0	2.7

Table 8(c)

From the above tables, we see that the minor flow rates and low power consumption will provide the desired efficient cooling and heating for our home.

Solar Collectors:

During the warmer seasons, the solar collectors will be able to absorb more heat from the sun than in the cooler seasons.

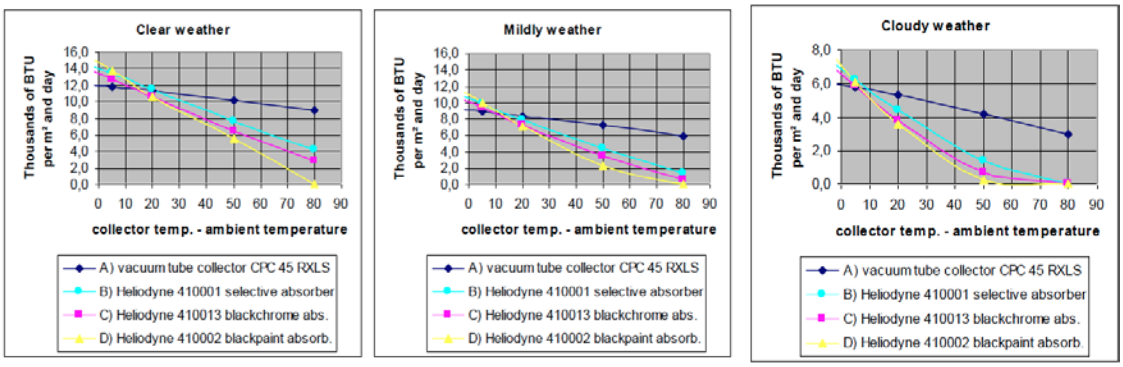
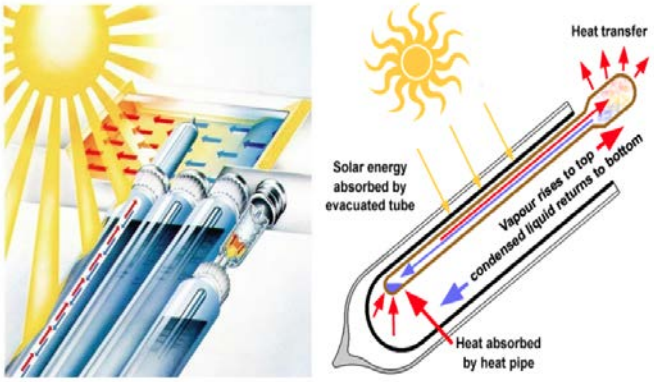


Figure 23: Yearly energy yield comparison between flat plate collectors and evacuated tube collectors

Researching whether we wanted flat plate collectors or evacuated tube collectors, Figure 23 shows a study based off of parameters from the SRCC [6] provided by Ritter Group, USA [7] showing that their evacuated tube collectors would work better in our application of the home. The solar thermal collectors consist of multiple evacuated glass tubes. As the tubes collect heat, it is transferred into water that is circulated to the heat pipe. The heat pipe is a long hollow copper pipe inside the tube collector containing the water heated by the sunlight. This heated water rises in the heat tube and travels to the solar tank, where the heat is stored. The heated water is then used to fulfill various requirements in the house such as space heating and domestic hot water use. For our dryer and hot water tap we need the water temperature to reach 180F consistently throughout the year.



(a) (b)

Figure 24: Illustration of several tube collectors connected to the manifold where heat transfer occurs. Figure 24b is an illustration of inside a tube collector with the evacuated tube (outermost border), the absorbent plate (black), and the heat tube (gold). The bulb at the top of the heat tube is connected to the manifold for heat transfer.

In order to generate more heat from the solar thermal unit, we decided to choose evacuated tube collectors instead of flat plate collectors because it will provide Casa del Sol with more heat than a flat plate collector on cloudy days. They will be able to operate more efficiently than flat plate collectors during months with less sun because the collectors rely on a vacuum seal to prevent heat losses. This becomes important during extreme

conditions such as rain and snow. Their heat will be easily transferred between the solar collectors to the high-temperature storage tank.

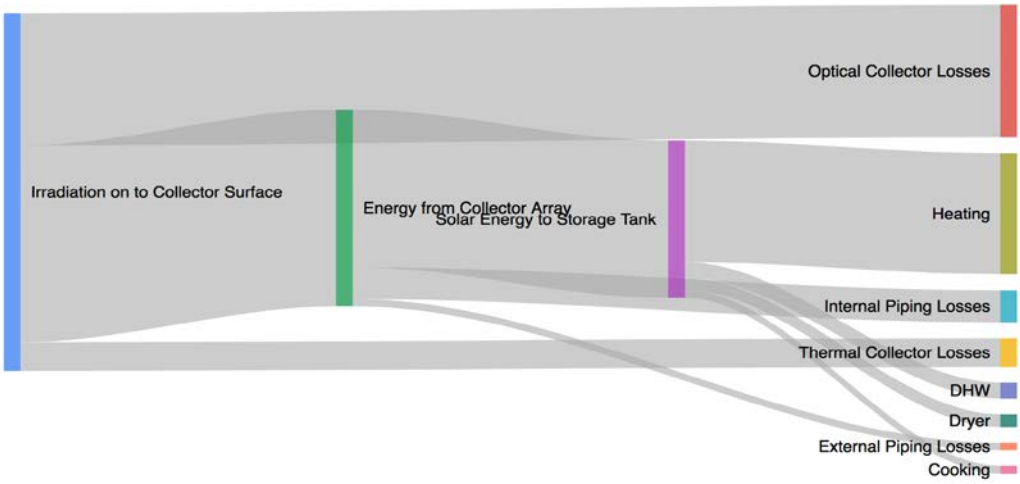


Figure 25: Sankey diagram showing energy flow from the solar thermal collectors

Many houses have used glycol in their evacuated tube system. The collectors we have chosen, however, will contain water as their heating medium. We expect this to be a more efficient, safer, and less corrosive option than any form of glycol. During the day, we will have the solar thermal collectors absorb as much heat as they can and then distribute the hot water to the storage tank. Any excess heat will be ejected through the radiator. At night, we will use the evaporator to absorb excess heat and then bring the water back to the chilled storage tank at a lower temperature that when it left. The cool water will be circulating throughout the radiant system when the temperature of the house needs to be brought down.

Water boiling- Hot Water Tap

As part of the Solar Decathlon competition, we are required to evaporate 5 lb of water several times. Even using a highly efficient induction stove, this is a very energy-intensive task. We, therefore, did some calculations and experiments (ongoing) to (i) estimate the energy requirement and (ii) minimize it by optimizing the boiling procedure.

Theoretical:

We calculated the amount of energy required to vaporize 2.268 kg of water (competition requires a minimum starting mass of 2.721 kg) assuming steady-state, adiabatic conditions, water boiling at 100˚C, atmospheric pressure of 1 atm and equal temperature of pot and water:

$$E_{TOT} = E_h + E_v + E_p \qquad \text{(Eq. 1)}$$

where

E_{TOT} = Total energy required

$E_h = mC_p\Delta T$ (Eq. 2)

where

m = mass of water

C_p = specific heat capacity of water

ΔT = change in temperature

$E_v = mH_v$ (Eq. 3)

where

m = mass of water

H_v = latent heat of vaporization of water

$E_p = m_pC_{pp}\Delta T$ (Eq. 4)

where

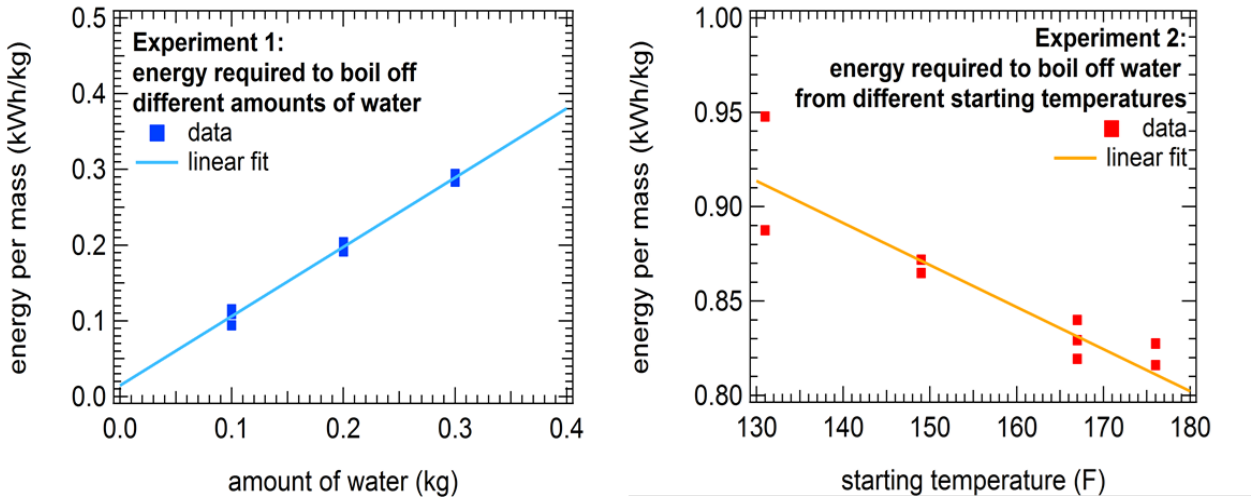
m_p = mass of pot

C_{pp} = specific heat capacity of pot

ΔT = change in temperature

E_{TOT} = 0.246 kWh + 1.424 kWh + 0.015 kWh = 1.685 kWh (theoretical - no heat loss)

Experimental: Using an induction hot plate with a compatible pot, a power meter, and thermocouple, we measured the total energy used to evaporate water in a number of experiments. The first experiment (Fig 28a) was done to verify a linear relationship between required energy and the mass of water. In a second experiment (Fig 28b) we tested the effect of using preheated water to start the evaporation process. We found that there is a roughly linear relationship, with warmer water requiring less energy to evaporate. The data suggests that starting with 180 F instead of 90 F water will save about 15 % energy. This finding led us to pursue a hot water tap (180 F) for the kitchen. This tap will be powered by our solar thermal system and will help reduce the use of electric energy.



(a) (b)

Figure 26: Results of water boiling experiments. Panel (a) shows a linear relation between mass of evaporated water and consumed energy, as expected. Panel (b) shows that starting with higher temperature water reduces the energy necessary to evaporate it, saving about 15% when starting with 180F water compared to 90F water.

Dryer

Team Orange County is using an innovative Hydromatic Technologies dryer by SafeMate to lower energy consumption. This dryer is the first ever to receive the EPA Energy Star rating and works by using hot paraffin around the drum to dry clothes. Hot water at 180 F, heated by our solar thermal system, is used to pre-heat the paraffin, which is then boosted electrically to the operating temperature needed. This effectively lowers the energy consumption, as energy is only needed to heat the paraffin from 180 F and spin the drum. An added benefit is that fires from lint are impossible in this dryer. Based on initial tests we expect an energy requirement of only 1.6 kWh to completely dry a load of 6 large towels. Final tests have been recorded in the following table:

Testing Condition	6 Towels	12 Towels
Energy used (kWh)	0.336	0.645
Time to dry (h)	1.5	2.5
Temperature of water (F)	180	179
Remaining Moisture Content (%)	0	-0.36

Table 9: Test results for the SafeMate dryer powered by hot water.

The results impressively show that our dryer is able to consistently dry the Solar Decathlon towels within the time frame required, using much less energy compared to a standard dryer. Moreover the thermal energy comes from our solar hot water collectors, reducing dependence on the power grid.

Sub-Wet Evaporative Chiller (SWEC):

The Sub-Wet Evaporative Chiller (SWEC) is a Nexajoule, Inc. design [8] that efficiently chills water for cooling systems in residential or commercial buildings. The SWEC's two-stage evaporation system chills water below the wet-bulb temperature of outside air, making the estimated limit for the temperature that the chilled water can be from the SWEC to be around the dew point of the outdoor air. There are four independent streams that each allow air to pass through a heat exchanger, an evaporative media, and a second heat exchanger in order to reduce the dry and wet bulb temperature of the air stream. Next an evaporative media chills the water and air through evaporation. Finally, the chilled air pre-cools the next air stream located in the second heat exchanger and then it is exhausted. The chilled water gets stored in a sump within the unit until it provides a sufficient flow rate to supply water to the building or to a storage tank.

Initially choosing the water-to-water heat pump as our main source of cooling, our final design includes the SWEC for the following reasons:

- It chills water to lower temperatures than standard cooling towers.
- It has a better cooling efficiency than a standard chiller.
- It does not bring humidity into the building due to its separation from the building space.

Stratification Tank:

When designing our HVAC system, one challenge was constructing it to cool our home with low energy consumption. With an efficient radiant system and our SWEC system allowing our home to cool without humidification, the development of our cold-water storage is crucial for our home design to function productively. Allowing our cooling load to incorporate both water as a thermal mass throughout our radiant system and using our thermal water storage tank, we are able to produce and store cold water when it is the most ideal time for our system to do so. Scheduling to be filled with water on the competition site October 3rd, we plan on safely draining our tank into a water truck while on our construction site then refilling it at the competition site. An 800-gallon water tank is incorporated into our system to recirculate and chill water while trying to maintain its temperature without major latent losses.

The thermocline is the area in a lake or body of water that changes temperature more frequently with depth than other areas of water above or below it. The more dense the water is, the more cool. This means that heat will enter and leave the tank primarily from the highest part of the tank, allowing for the rest of the tank to remain chilled and insulated at a steady temperature. In extremer, more cool conditions the

thermocline creates stratification. Stratification within our tank allows for distinctive and even layers of temperature and density, each layer with equal pressure, to keep the tank functioning properly.

In order to promote such a system, we installed specially engineered perforated single pipe diffusers (see figure 27) throughout the chilled storage tank to allow for laminar flow and resistance to vertical mixing. The octagonal shape is important in allowing symmetry for equally spaced openings and allowing the top and bottom diffuser to direct flow upwards and downwards in the tank, generating a thermocline from a gravity current. The octagonal piping system also allows for half of the total flow to go to each of the diffusers, balancing the system. Temperature sensors will regulate each layer of our tank to monitor the stratification. This design is the most efficient way to regulate and control our radiant cooling loads.

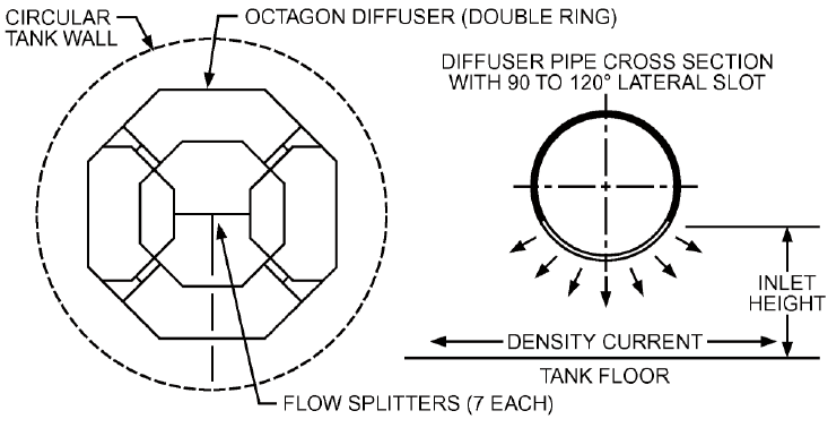


Figure 27: Design of diffusers throughout the chilled water tank for stratification from HVAC&R ASHRAE Research Project 1185

Water-to-Water Heat Pump:

A water-to-water heat pump resembles a smaller scaled chiller and contains both a source side and load side water-to-refrigerant heat exchanger. Our Water Furnace Envision water-to-water heat pump will collaborate with the hot water storage tank and the radiant system as a backup for space heating, cooling, and heat rejection on days when the solar thermal collector and the SWEC are not able to change the temperature of the water to the desired range. With a 17.5 energy efficiency rating (EER) and a coefficient of performance (COP) of 3.1, we are confident that this heat pump will provide desired water temperatures with lower energy usage. During the refrigeration cycle, heat will be transferred from one side of the heat pump to the other. The load side of the heat pump will be attached to our radiant system and will provide water to be circulated throughout the system for cooling and heating. In the circumstance of excess heat, the heat pump will reject heat to

the hot water loop. When the hot water has reached a level where it does not need excess heat from the heat pump, the SWEC will be used to expel the excess heat.

HVAC ENERGY ANALYSIS

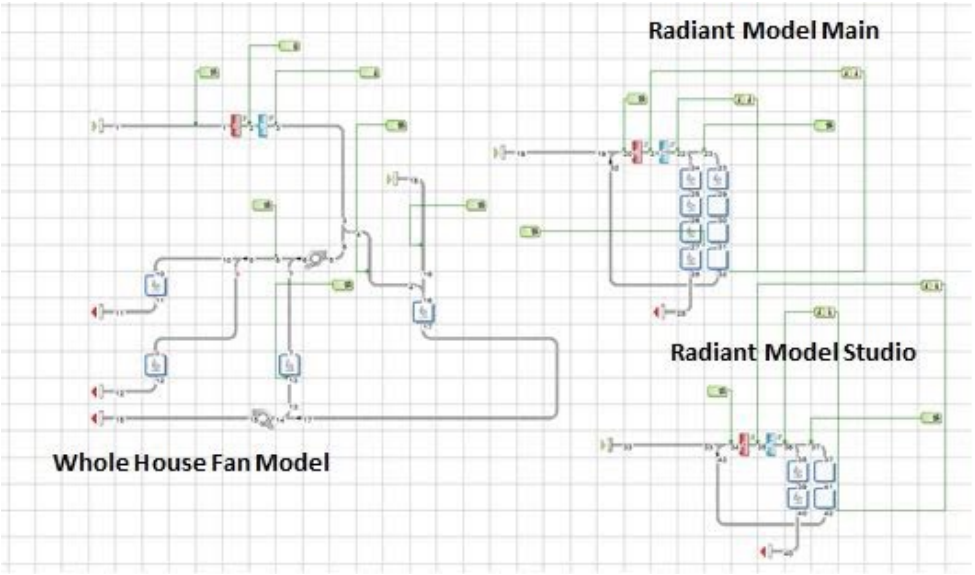


Figure 28: ApacheHVAC model of our final design in IES

Modeling our design in engineering software was a complexity in itself. Many of our systems are not found in standard energy software programs (our SWEC for example), so we had to model them to similar items that were available in the program. Another challenge arose when modeling the radiant ceiling. Because the radiant ceiling uses latent heat transfer between water and air, we had to model that energy released or absorbed as air into the rooms. We were able to do this by creating a “new room” on top of our conditioned space that was 2” thick. This “new room” is where the radiant ceiling allows for the exchange of energy between the rooms while the actual rooms are where that temperature change occurs.

Results from our energy model can be seen in the figure below. Our HVAC system is set with controllers to know when it needs to be turned on and off, creating the jumps seen in the graph.

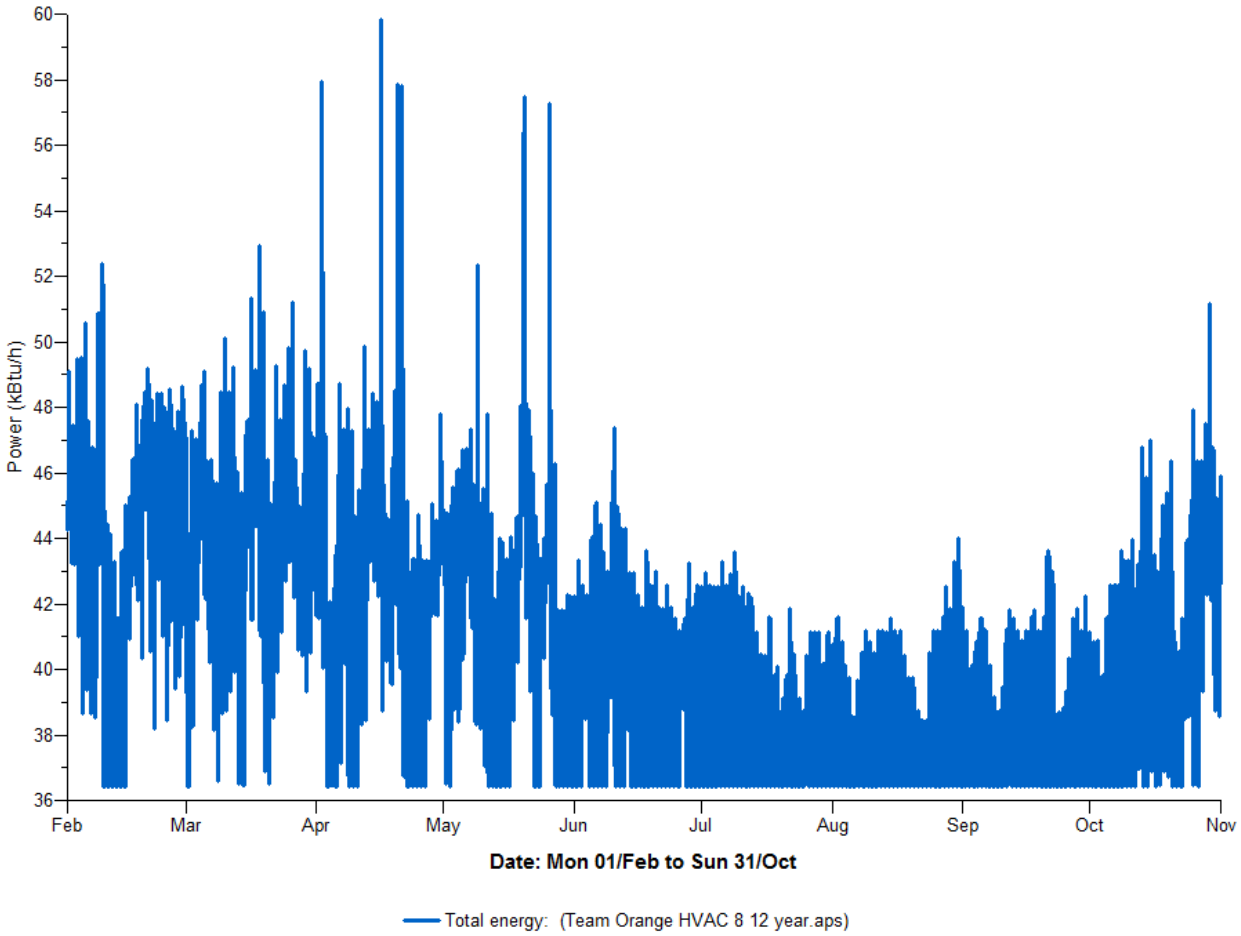


Figure 29(a): HVAC energy loads throughout year

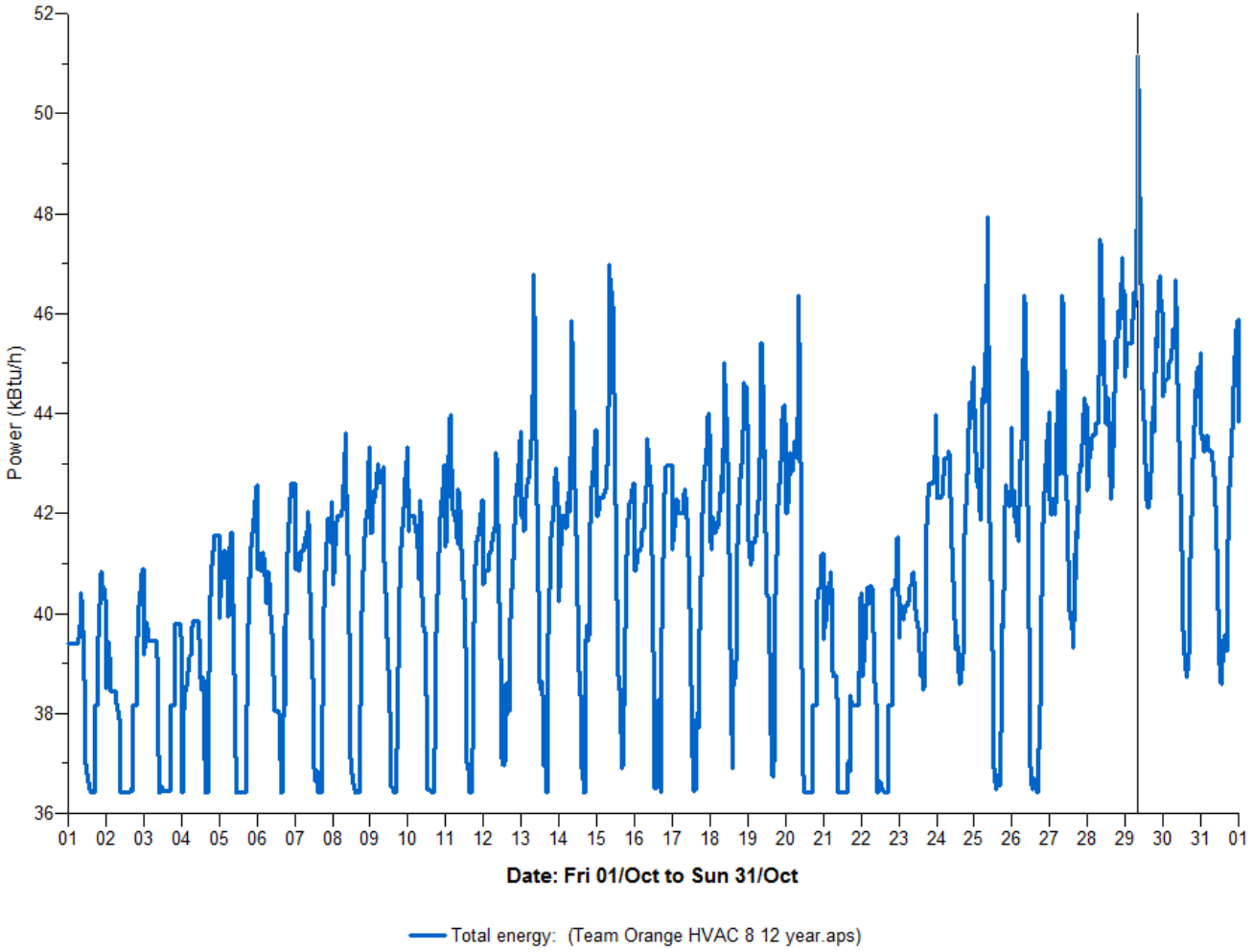


Figure 29(b): Total energy for the month of October

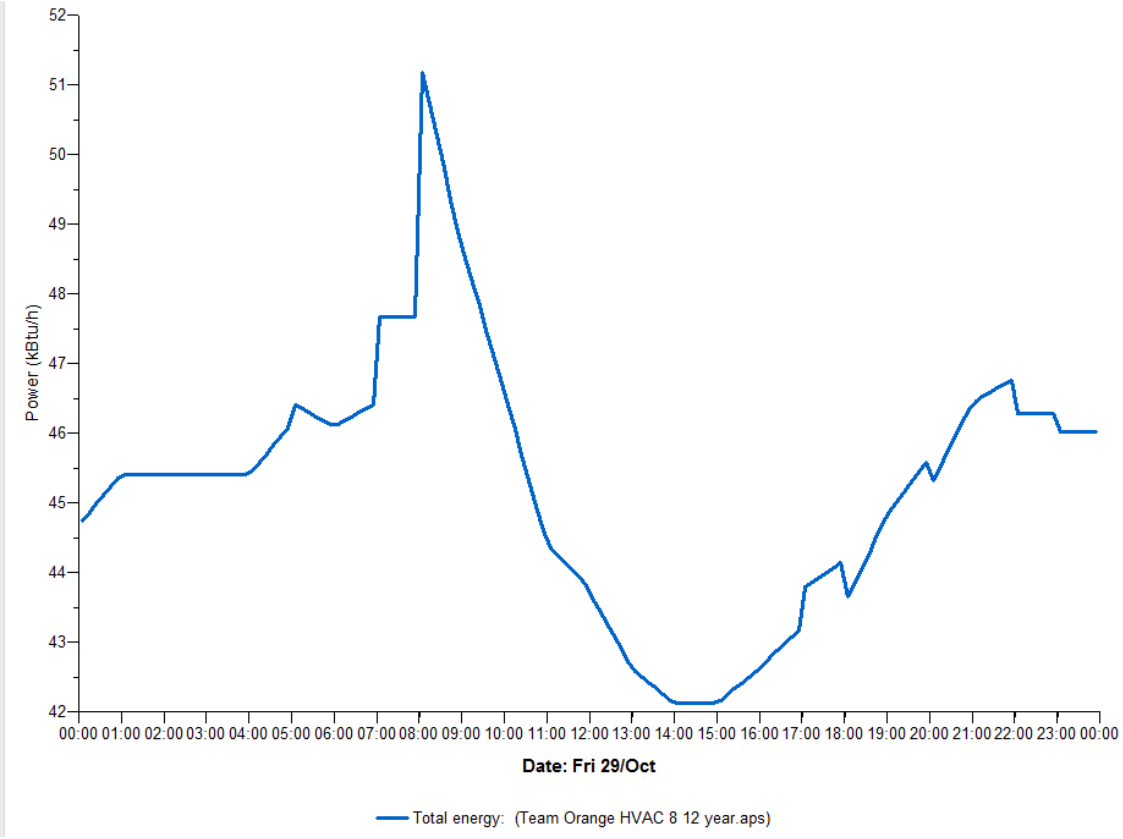


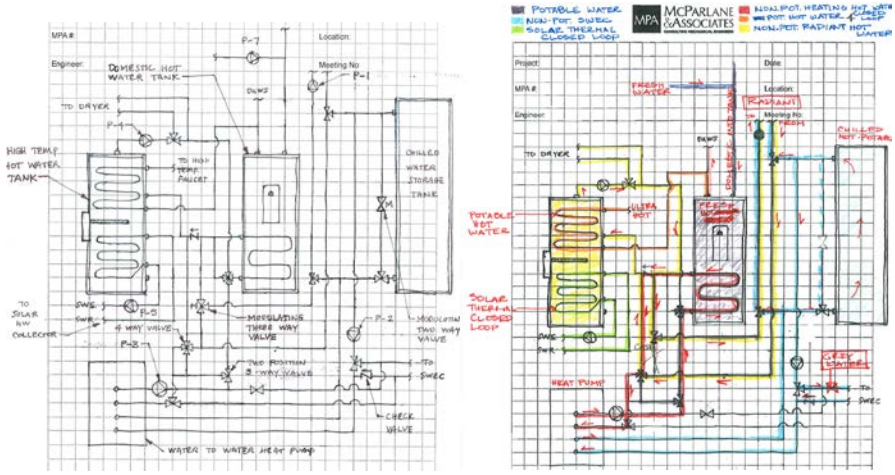
Figure 29 (c): Daily energy profile for maximum energy load day

The peak energy and power used for our HVAC system occurs on October 29th.

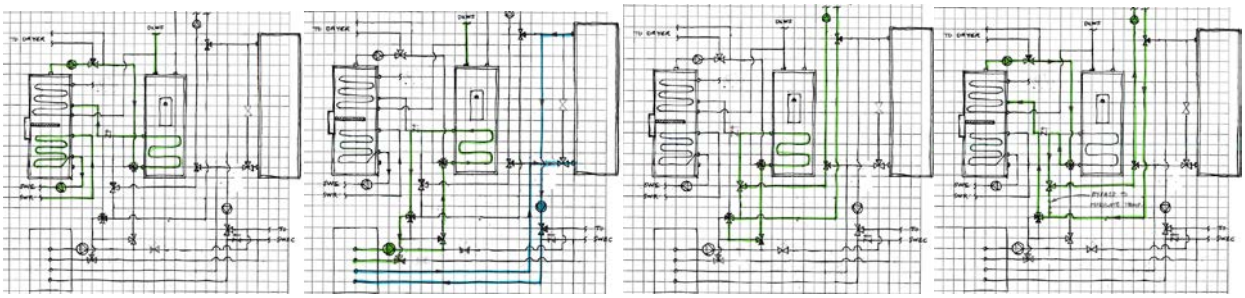
Variable Name	Line Colour	File Name	Location	Type	Value	Lock
Total energy (kBtu/h)			Model	Power (kBtu/h)	47.673	

Table 10: Peak energy and power for the month of October

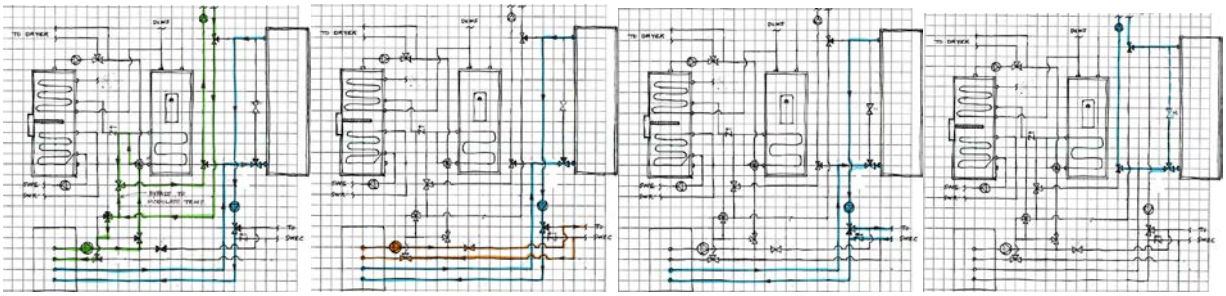
These simulations were run with the whole house fan and radiant system simultaneously, meaning that these values are the maximum amounts that our home will be using. IESVE software also does not take into consideration which values are thermal energy and which are from electrical loads. Even without these considerations, the values from these graphs correlate with the energy budget we allocated towards our HVAC system. Overall, the results provide confidence that our home will perform well in the competition and throughout the year in the Southern California region.



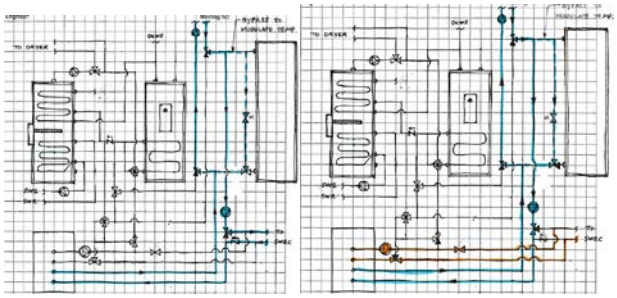
30(a) 30(b)



30(c) 30(d) 30(e) 30(f)



30 (g) 30(h) 30(j) 30(k)



30(m) 30(n)

Our HVAC system operates in different modes to account for different design conditions and keep the home within the comfort zone at all times. Figure 30(a): General schematic of our HVAC model. Sketch of central HVAC design, centered around a water-to-water heat pump and SWEC that is connected to solar thermal collectors, domestic hot water, high-temperature tank, cold water tank and a radiant ceiling distribution system. Figure 30(b): Each control mode all on one page. Figure 30(c): Solar thermal collectors are operating to heat the 80-gallon tank while the 80-gallon tank is heating the domestic hot water (DHW) tank. Figure 30(d): Heating DHW tank with water-to-water heat pump while water-to-water pump also charges chilled water tank. Figure 30(e): Space heating with DHW tank. Figure 30(f): DHW tank depleted, space heating with solar tank. Figure 30(g): space heating with water-to-water heat pump while also charging chilled water tank. Figure 30(h): Charge Chilled water tank with water-to-water heat pump. Reject heat to SWEC. Figure 30(j): Charging chilled water tank with SWEC, Optional supplemental cooling using water-to-water heat pump with waste heat rejection to DHW tank (see Figure 30d)) or rejected to space heat (see figure 30(g)). Figure 30(k): Space cooling with chilled water tank. Figure 30(m): Space cooling with SWEC. Optional supplemental cooling using water-to-water heat pump to reject waste heat to DHW tank (see figure 30(d)). Figure 30(n): Space cooling with water-to-water heat pump. Reject heat to SWEC.

DC–DC Low–Voltage Lighting System:

Traditional lighting systems use high voltage AC power distribution to power older forms of light bulbs such incandescent bulbs. However, with today's lighting moving to lower power needs, the Lumencache lighting system offers both low-voltage power consumption as well digital communication with its devices. Typical LED luminaries, even with the low power needs, require bulky circuits to account for the AC-to-DC conversion from the power grids to lights. But with the Greentech Wave already beginning to change power grids from High-Voltage-AC to High-Voltage-DC, Team Orange decided to move with the wave, and apply a DC-DC lighting system. And with the DC output of solar PV panels, it became very fitting to apply DC-to-DC to Casa del Sol's lighting system.

The Lumencache lighting system also features the accessibility of communication to lighting devices. Due to low energy needs, the lighting system features your typical Internet cat5e cables as a means of wiring. Through the use of cat5e cables, both power and data are provided within the same wiring, allowing for ease of installation as well as accessibility to each light's digital capabilities (see figure 30). In technology's move towards the Internet of Things, it was important for Team Orange's control system to have communication to the light's digital protocol. Overall, through the energy efficiency as well as accessibility of the system, Casa del Sol will be braced for the future of DC power in the Greentech Wave and device communications in the Internet of Things.

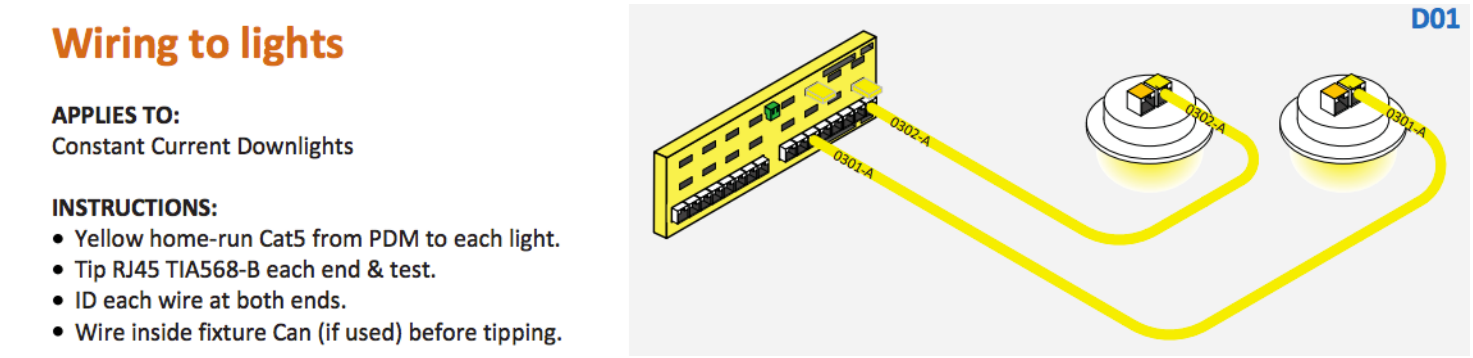


Figure 30: Cat5e connections from LED's to Lumencache's innovative Power Distribution Module (PDM)

7. REFERENCES

[1] IESVE https://www.iesve.com/software

[2] National Renewable Energy Laboratory http://rredc.nrel.gov/solar/old_data/nsrdb/

[3] U.S. Department Of Energy EnergyPlus Software

http://apps1.eere.energy.gov/buildings/energyplus/

[4] Prevailing wind directions: http://www.wrcc.dri.edu/htmlfiles/westwinddir.html

[5] Solar Gains reference in IESVE Vista User Guide:

http://www.iesve.com/downloads/help/Thermal/Vista.pdf

[6] SRCC Certification ratings

http://www.solar-rating.org/

[7] Ritter

http://ritter-group-usa.com/

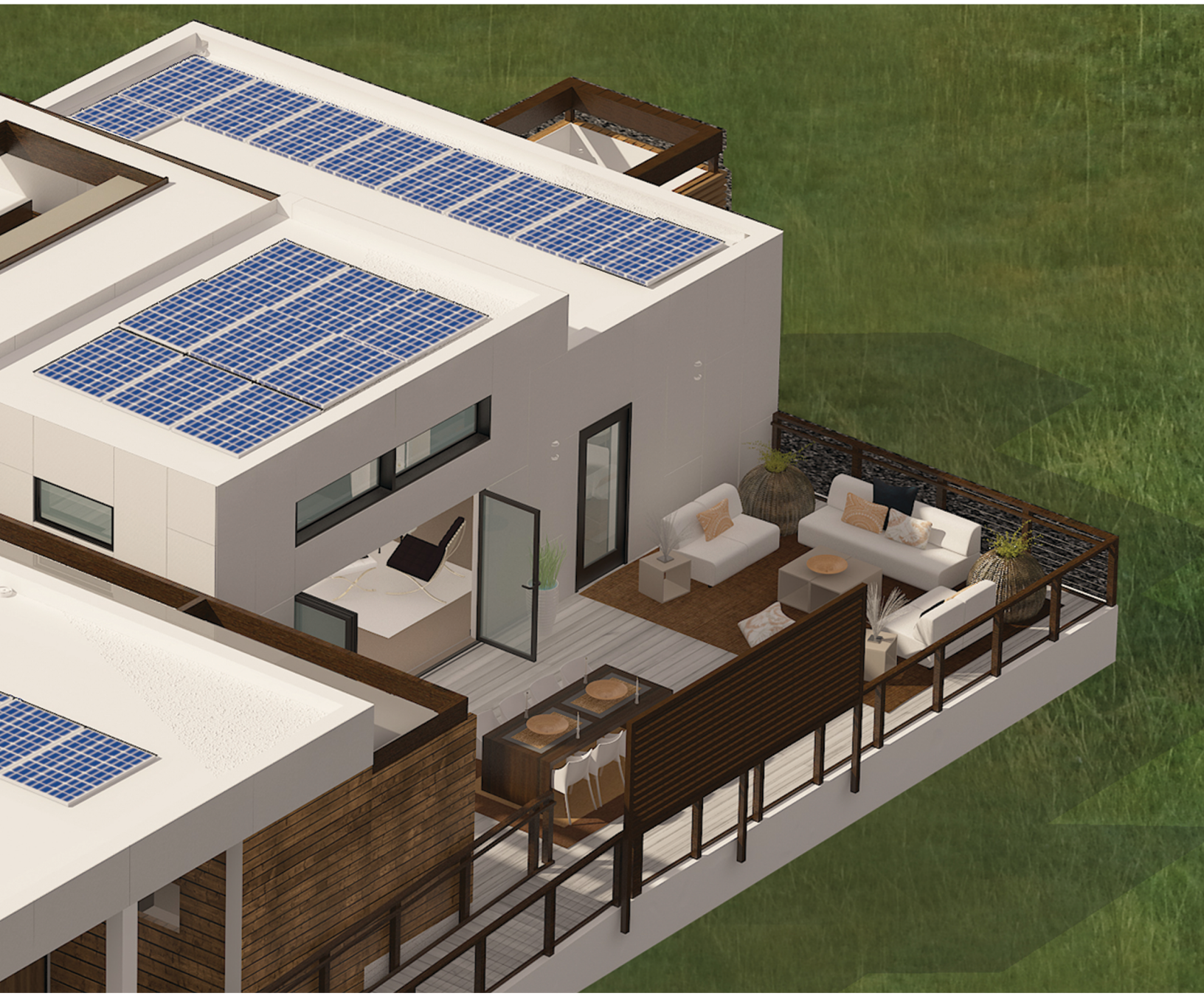
[8] SWEC: Emerging Products Report Project PPYYSCEXXXX

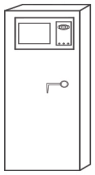
[9] Lumencache Low-Voltage Lighting System

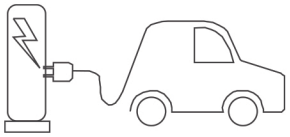
http://lumencache.lighting/resources/

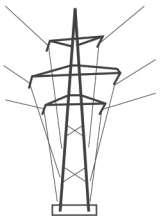
08_ SUMMARY OF UNLISTED ELECTRICAL COMPONENTS

CASA DEL SOL
Team Orange County









08_Summary of Unlisted Electrical Components

The following components used in Casa del sol do not have a UL listing:

A) The electrical equipment assembly identified as Demand Response Inverter "DRI-10" from Princeton Power Systems ["PPS"] will be a factory-modified version of a model currently manufactured [including UL Listing under US 72130613 01] and marketed on a worldwide basis.

   The modifications by Princeton Power Systems to provide the "DRI-10" prescribed in the construction documents will include:

   (1) Provision of an electric vehicle charger DC cord and plug based on the CHAdeMO protocol [this will replace the DRI-10's storage battery-charging port]; PPS is submitting this for UL evaluation, and they advise that UL certification is expected at the end of June 2015.

   Working closely with our partners at PPS and OMB Electrical Engineers, this change will be well-documented to assure a safe and compliant Code-conforming installation. Note that plans to include an additional high-voltage DC output port were abandoned.

B) A prototype of a sub-wet bulb chiller will be supplied by Nexajoule. All components of the chiller carry UL listings. Working closely with our partners at McParlane Mechanical Engineers and OMB Electrical Engineers, the prototype will be well documented to make sure that code compliance and safety are guaranteed. See documentation below.

C) Low-voltage (12 VDC) window actuators used for automated window operation.

D) Low-voltage (12 VDC) control boards for lighting control (LumenCache).

E) Low-voltage (12 VDC) controller for Halo lighting.

All other electrical components carry an approved testing agency's listing per Section 6-7 of the SD 2015 Building Code.

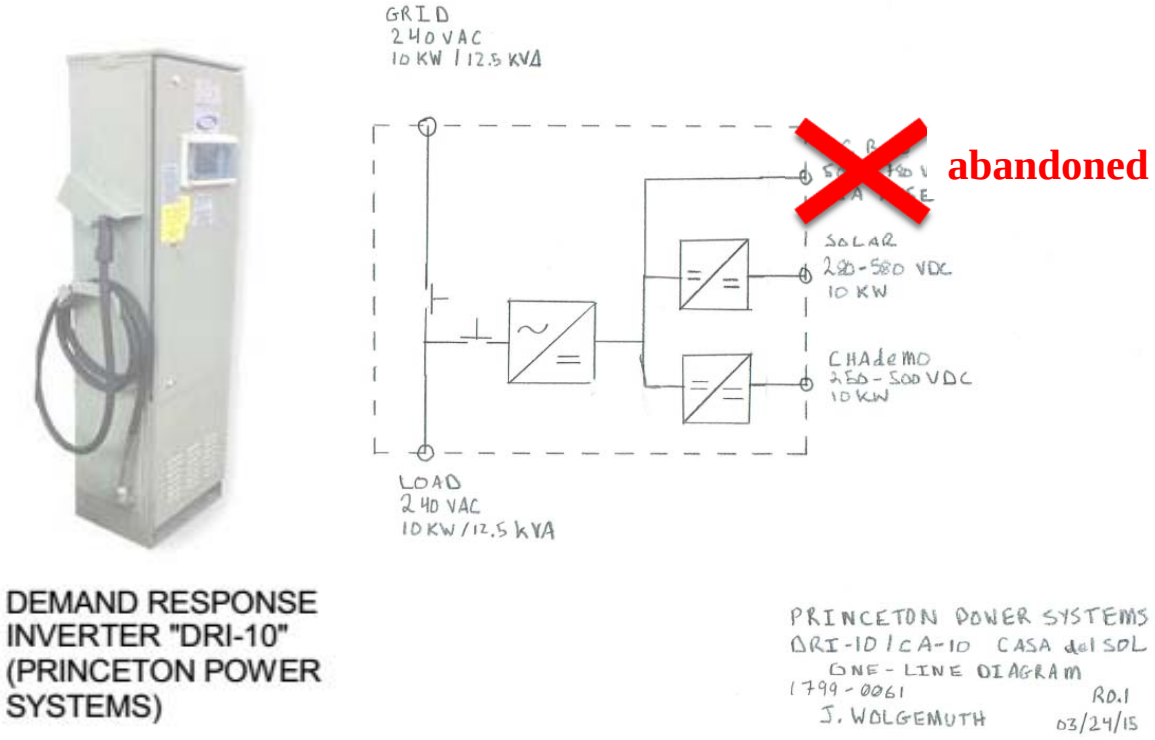


Figure 31: Diagram provided by Princeton Power Systems showing modifications to DRI-10 inverter, to include CHAdeMO charging port. Note that plans to include an additional high-voltage DC output port were abandoned. See E-101 for more information.

March 24, 2015

Mr. Moritz Limpinsel
Project Engineer, Team Orange County
University of California, Irvine
2337 Natural Sciences II
Irvine, California 92679

Re: UL Listing for SWEC Air Conditioning Unit

Dear Moritz,

The purpose of this letter is to identify how Nexajoule's Sub Wet-Bulb Evaporative Chiller (SWEC) addresses UL listing requirements for safety.

The SWEC device uses evaporative cooling in conjunction with a novel heat exchange configuration to chill water. This process uses no refrigerants or compressors. Only pumps and fans are used to reduce the water temperature below the wet bulb temperature of ambient air. This results in a dramatic reduction in energy usage compared to even the most efficient chillers that are commercially available today.

The SWEC device has not yet been submitted for UL testing because it is not yet being manufactured for commercial sale. Nexajoule is currently in the process of optimizing and testing the SWEC system to determine long term performance and reliability in real world applications. Nexajoule anticipates the system will be ready for UL testing somewhere in the 1-3 year timeframe, depending upon how quickly testing can be completed and a commercial partner/manufacturer can be identified.

The SWEC system utilizes fans, DC power supplies, pumps, switches, and a power cord that are each individually UL Listed. The SWEC system is designed to ensure that the components do not operate outside of the manufacturers' recommended conditions. The wiring between components is installed in accordance with NEC requirements, and the design prevents the components from being exposed to environmental conditions that would compromise their integrity or safety.

Nexajoule will work closely with UC Irvine to assist in setup and installation of the system, thereby ensuring the system is operated as intended.

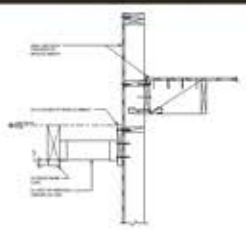
We are excited to be part of your team! Please feel free to contact me if you have any questions or concerns.

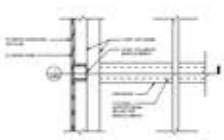
Sincerely,

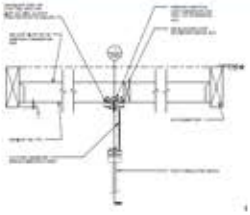
Eric E. Jarvis, Ph.D.
President
Nexajoule, Inc.
2265 Dartmouth Avenue
Boulder, Colorado 80305
ejarvis@nexajoule.com

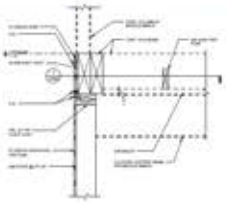
09_ SUMMARY OF RECONFIGURABLE FEATURES

CASA DEL SOL
Team Orange County









09_Summary of Reconfigurable Features

The California State flower opens and closes as it adjusts to the light of the sun, a method emulated by Casa Del Sol in order to promote the indoor-outdoor California lifestyle. Pivot panels connect our outdoor living room to our surrounding neighborhood, and accordion kitchen windows open to a spacious deck for outdoor dining. As we are in the northern hemisphere, the sun hangs in the southern sky. To protect residents from the sun and moderate solar heat gain, southern shading elements have been placed over windows and living spaces including a tensile structure providing cover for an outdoor living room. The tensile structure will be closed to protect the house against the intense summer sun, and remain open to embrace the warm winter sun (see Figure 31). Automated clerestory windows and windows on the kitchen core and bedrooms of our home open to cool, prevailing ocean winds. The western side of the kitchen contains an adjustable flat-screen screen that doubles as a partition between two spaces. Functionally, it is to be slid to create privacy for the flex room. It is unattached to the house.

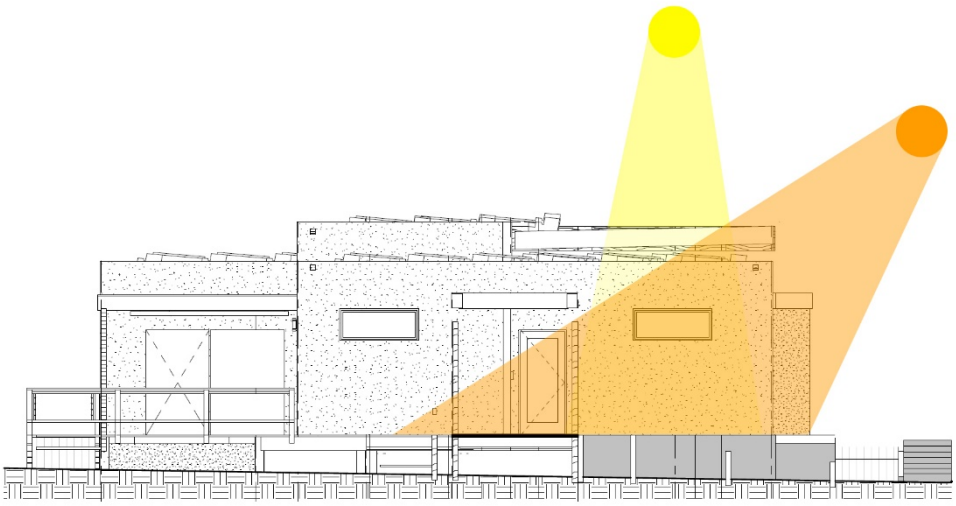
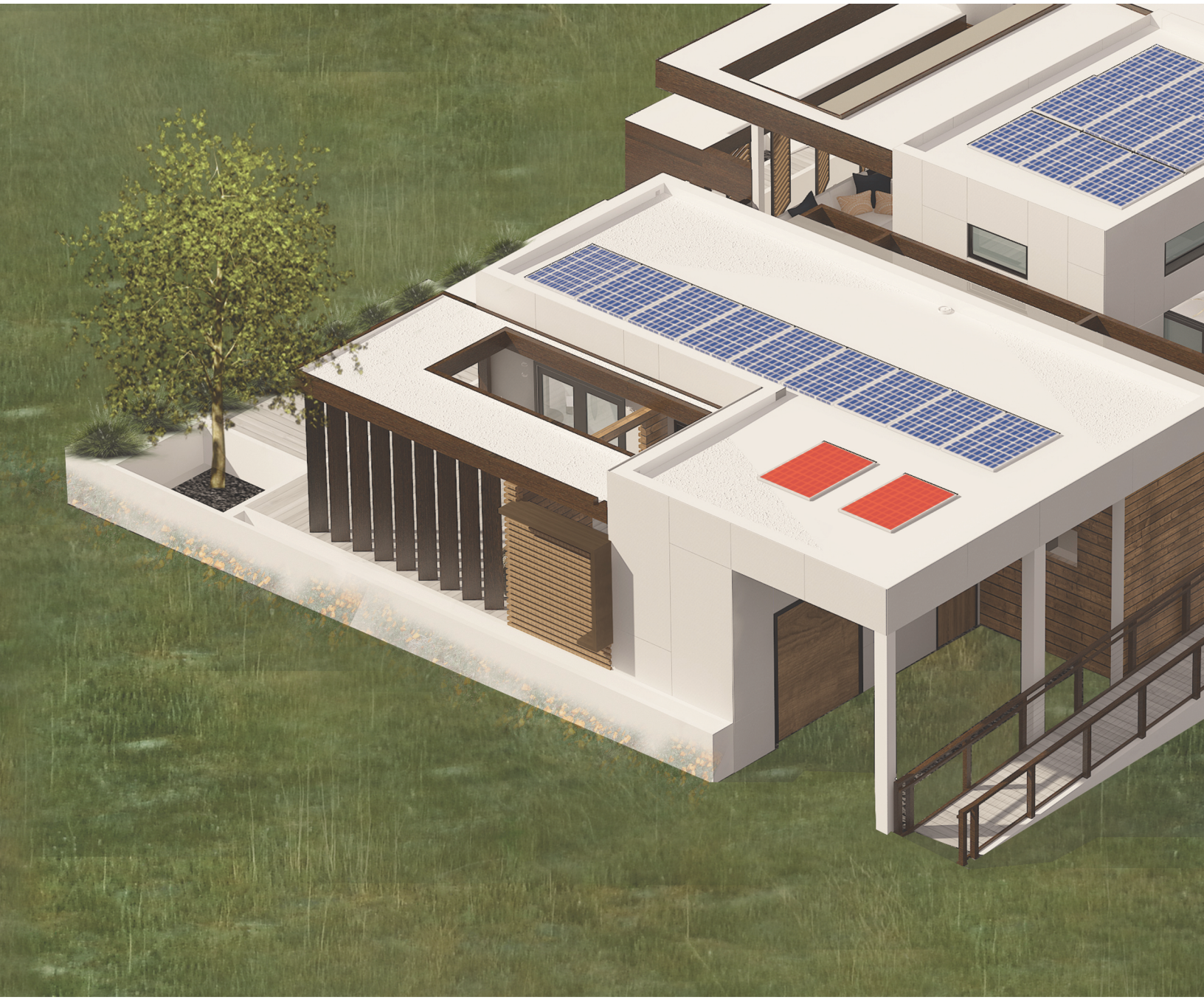
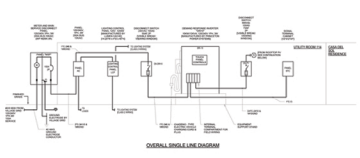


Figure 32: Tensile structure will be closed to protect the house against the intense summer sun, and remain open to embrace the warm winter sun.

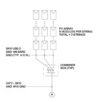
10_ INTER-CONNECTION APPLICATION FORM

CASA DEL SOL
Team Orange County



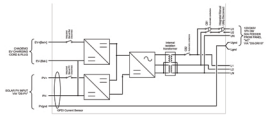


OVERALL SINGLE LINE DIAGRAM

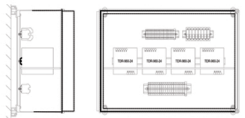


SOLAR PHOTOVOLTAIC SYSTEM
(ROOFTOP MOUNTED)

1 SINGLE LINE DIAGRAMS



DEMAND RESPONSE INVERTER "DRI-10"
(PRINCETON POWER SYSTEMS)



1 POWER CONVERTER CABINET "PCC"

10_Interconnection Application Form

Team Orange County, lot # 203

PV Systems

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
LG	3 string of 8 panels LG MonoX 305 W	7320 W

Total DC power of all arrays is kW (in tenths)

INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or KW)	Quantity
Princeton Power Systems	DRI-10	280-600 V	10 kW	1

Total AC power of all inverters is kVA or kW (in whole numbers)

REQUIRED INFORMATION

The following information must be included in the project manual or construction documents. If located in the construction documents, list the drawing locations in this section of the project manual. (Example: B3/E-201)

	Location
One-Line Electrical Schematic	E-101
Calculations of service/feeder net computed load and neutral load (NEC 220)	E-101, & below, p 138
Plan view of the lot showing the house, decks, ramps, tour paths, the service point, and the distribution panel or load center	G-103

Electrical Engineer: Euiso Kim, euisok@uci.edu

CASA DEL SOL
RESIDENTIAL SERVICE LOADS
ELECTRICAL LOAD CALCULATION

1.0 RESIDENTIAL SERVICE MAIN "SEE" - 1 UNIT - 1,000 SQ. FT.

1 a.	GENERAL LIGHTING (PER NEC 220.12) AT 3VA/SQ. FT.		=	3 KVA
b.	SMALL APPLIANCE CIRCUIT (PER NEC 220.52 (2) AT 1500VA EA. (1 PER UNIT)		=	6 KVA
c.	LAUNDRY (1) AT 1500VA (PER NEC 220.52(B)		=	2 KVA
		TOTAL (1)	=	11 KVA
2	PERMANENTLY CONNECTED APPLIANCES			
	DISHWASHERS (1) AT 1200VA-120V		=	1.2 KVA
	GARBAGE DISPOSALS (1) AT 1125VA-120V		=	1 KVA
	MICROWAVE/EXHAUST UNIT (1) AT 900VA-120V		=	1 KVA
	ELECTRIC DRYER (1) 5.0KVA-208-1PH		=	5 KVA
	ELECTRIC RANGE (1) AT 8.0 KVA-208V-1PH		=	8 KVA
		TOTAL (2)	=	16 KVA
3	HVAC SYSTEM			
	CU-1 - (1) AT 11.8 FLA - 208V-1 PH		=	2 KVA
	FC-1 - (2) AT 6.0 FLA -208V-1 PH		=	2 KVA
		TOTAL (3)	=	5 KVA
		SUB-TOTAL (1 + 2 + 3)	=	32 KVA
4	EV CHARGER (ESTIMATED LOAD)	TOTAL (4)	=	7 KVA
		TOTAL (1.0)		39 KVA
		DIVIDED BY 240V-1 PHASE	=	161 AMPS

PROVIDE A 200A 120/240V - 1 PHASE - 3W RESIDENTIAL MAIN

11_ QUANTITY TAKEOFF OF COMPETITION

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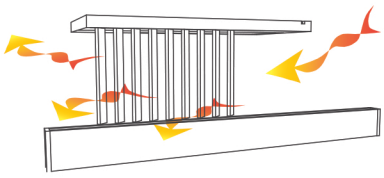
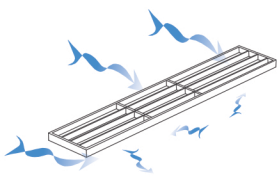
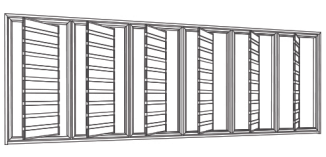
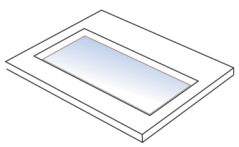








11_Quantity Takeoff of Competition Prototype House

Division	Brief Description	Detailed Description	_(Qty_)	Unit
Division 01				
01 54 19	Typical House Crane	80-ton truck-mounted crane, plus crew.	2	Day
Division 05				
05 52 13	Aluminum Railings, Hollaender system	Railing, pipe, aluminum, satin finish, 2 rails, 3'-6" high, posts @ 5' O.C., 1-1/2" dia, shop fabricated	27	L.F.
05 21 19	Steel Web Flanges	W10x22 Steel Web Flanges supporting floor diaphragm and resting on Jacks.	12	Ea
Division 06				
06 43 13	Wood Stairs/Ramps	Temporary, ramps, plywood, 3/4" plywood on 2" x 12" joists, 16" O.C.	300	S.F.
06 11 16	2 X 6 Stud Walls	Wood framing, partitions, standard & better lumber, 2" x 8" studs, 16" O.C., 10' high, includes single bottom plate and double top plate, excludes waste	40	L.F.
06 06 10.16	Roof Beams, 8x12, for main 3 modules	Douglas Fir #1, 8x12, for main 3 modules	360	L.F.
06 16 33	Floor Sheathing, Top, 3/4" Plywood		988	S.F.
06 16 33	Floor Sheating, Bottom, 1/2" Plywood		988	S.F.
06 06 10	Beams supporting Veranda, 6x12	Douglas Fir #1	32	L.F.
06 06 10	Beams supporting Veranda, 4x12	Douglas Fir #1	31	L.F.
06 16 36	Roof Sheathing, 1/2" Plywood		988	S.F.
06 06 10	Roof Joists, 2x12, for main 3 modules	Douglas Fir #1	675	L.F.
06 06 10	Roof Joists, 2x10, car-port and halo structure	Douglas Fir #1	484	L.F.
06 06 10	Inner Halo Beams, 4x10	Douglas Fir #1	82	L.F.
06 06 10	Outer Halo Beams, 8x10	Douglas Fir #1	48	L.F.
06 10 63	2 X 6 Stud Walls, Exterior Custom	Wood framing, partitions, standard & better lumber, 2" x 8" studs, 16" O.C., 10' high, includes single bottom plate and double top plate, excludes waste	140	L.F.
06 15 13	2X6 Deck Framing DF1	Porch or deck framing, treated lumber, joists, 2" x 6"	2256	S.F.
06 43 16	1"x6" nom. Heat Treated Ash &Poplar Ext. Railings	Moldings, trim, exterior, 1" x 4" and 1" x 6" railing with balusters 4" O.C.	110	L.F.

Division 07				
07 62 00	SHEET METAL FLASHING AND TRIM	Sheet metal flashing, aluminum, flexible, mill finish, .013" thick, including up to 4 bends	600	L.F
07 42 23	Wood Wall Panels	Engineered Bambo-Exterior grade siding	1265	S.F.
07 21 13	Exterior Wall Insulation	EPS Rigid Foam 1" Thick	TBD	S.F.
07 21 00	Cavity Wall Insulation	Mineral Wool 5.5" Thick	TBD	S.F.
07 21 00	Floor Insulation	Mineral Wool 7.5" Thick	988	S.F.
07 21 00	Ceiling Insulation	Mineral Wool 11.5" Thick	988	S.F.
07 27 26	FLUID-APPLIED MEMBRANE AIR BARRI-ERS	Tremco ExoAir 220 Fluid Applied Vapor Per-meable Air Barrier Membrane	2500	S.F.
07 42 93	Soffit panels	4 x 8 x 1/2" ProdEX Panels w/ Bakelite core w/ natural wood veneer (Nux Panels) by PRODEMA	650	S.F.
07 44 56	Mineral Fiber Reinforced Cementitious Panels	Magnesium Oxide Board (MgO Boards): 4 x 8 x 1/2" boards by Jet Products	1700	S.F.
07 54 23	Thermoplastic Polyolefin Roofing	Single-Ply Membrane, butyl, 1/16" thick, Elasto-meric Sheet Membrane Conventional Roofing System, heat welded seams, fully adhered	1950	SF
07 92 00	Joint Sealants	Residential Sealant Modified Urethane Acrylic Sealant	TBD	Each
Division 08				
08 11 00	Pivot Panel Door	Exterior Metal frame door 3'-4" x 7'-0" tall, made from 2" x 3" metal hollow rectangular bar, and 1/2" x 3 1/2" wood siding core.	6	Each
08 71 00	Door Hardware (for Pivot Panels)	Bottom Flush Bolt Lock (#8558T11) & Roller Catches (#8040A14) top & bottom by McMas-ter Carr - 128-3/4 Light Duty Center Hung Pivot Set by Rixson - Satin Bronze	6	Each
08 14 00	Wood Door (Front Gate)	5' x 6' wood door w/ 4 x 4 dug fir stile and rail core, w/ cable cross bracing, and 1/2" x 3 1/2" wood siding both sides.	1	Each
08 71 00	Door Hardware (for Front Gate)	Nero Contemporary Gate Latch by 360 Yard-ware - Dorma CP1000 Heavy Duty Center Hung Pivot Set (Oil Rubbed Bronze)	1	Each
08 51 13	Operable Pivot Window	Solar Innovations Pivot Window	4	Each
08 51 13	Casement Window (Lower South of Master Bed-room))	1'-2" x 5'-6" tall Casement Wood window, frame, & screens by Solar Innovations	1	Each
08 51 13	Mulled Window (West Master Bedroom)	6'-0 x 2'-0" mulled window, frame, & screens containing a 2' x 2' casement window mulled to a 4' x 2' fixed window by Solar Innovations	1	Each

08 51 13	Mulled Window (South Living Room Clearstory)	12'-0 x 2'-0" mulled window and frame containing a 6' x 2' fixed window mulled to a 6' x 2' fixed window by Solar Innovations	1	Each
08 51 13	Pivot Window (Flex Bedroom)	6'-0 x 2'-0" pivot window, frame, & screens by Solar Innovations	1	Each
08 51 13	Fixed Window (Kitchen Clearstory)	4'-0 x 2'-0" fixed window and frame by Solar Innovations	1	Each
08 51 13	Fixed Window (Studio Bathroom)	2'-0" x 7'-0" tall fixed window and frame by Solar Innovations	1	Each
08 41 13	Aluminum-Framed Entrances and Storefronts	Exterior Door, 4 Panel, Folding, fully tempered with glass thickness at 2 1/4", 36" x 84" per panel	2	Each
08 41 13	Aluminum-Framed Entrances and Storefronts	Exterior Door, Swing, Single, fully tempered with glass thickness at 2 1/4", 36" x 84"	4	Each
08 41 13	Aluminum-Framed Entrances and Storefronts	Exterior Door, Swing, Double, fully tempered with glass thickness at 2 1/4", 36" x 84" each	1	Each
08 14 00	Wood Door	Exterior, Swing, Single, Solid core with bamboo veneer faces, 36"x84"	1	Each
08 14 00	Wood Door	Exterior, Swing, Double, Solid core with bamboo veneer faces, 36"x84"	1	Each
08 14 00	Wood Door	Exterior, Bifold, Double, Solid core with bamboo veneer faces, 28"x84" per panel	1	Each
08 14 00	Wood Door	Exterior, Bifold, Single, Solid core with bamboo veneer faces, 28"x84" per panel	1	Each
08 14 00	Wood Door	Exterior, Sliding, Single, Solid core with bamboo veneer faces, 36"x84" per panel	1	Each
08 14 00	Wood Door	Exterior, Sliding, Single, Solid core with bamboo veneer faces, 60"x84" per panel	1	Each
08 14 00	Wood Door	Interior, Swing, Single, Solid core with bamboo veneer faces, 36"x84" per panel	2	Each
08 14 00	Wood Door	Interior, Pocket, Solid core with bamboo veneer faces, 36"x84" per panel	1	Each
08 14 00	Wood Door	Interior, Sliding, Single, Solid core with bamboo veneer faces, 44"x84" per panel	1	Each
Division 09				
09 29 00	Gypsum Board (Interior Finish)	Gypsum wallboard, on walls, standard, w/compound skim coat (level 5 finish), 1/2" thick	4000	S.F.
09 30 13	Ceramic Tile	Porcelain 12"x24" floor/wall Tile	200	S.F.
09 91 13	Typical Exterior Paint and Coating	Paints & Coatings, siding, exterior, Texture 1-111 or clapboard, oil base, stain 2 coats, brushwork	TBD	TBD S.F.
09 91 23	Typical Interior Paint and Coating	Paints & Coatings, walls & ceilings, interior, drywall or plaster, zero voc latex, 3 coats, smooth finish, roller	4000	S.F.

09 62 23	Bamboo Flooring	3/8” x 3 3/4” x 36” bamboo strip flooring, pre-finished	876	S.F.
09 62 29	Cork Flooring	12" x 36" x 1/2' floating cork plank with integrated low density sound absorbing cork underlayment	219	S.F.
Division 10				
10 28 00	Residential Bath Accessories	Project Source 4-piece polished phrome bathroom hardware set including towel bar, towel ring, toilet paper holder, and robe hook	2	Each
10 28 00	Residential Bath Accessories	CroydexModel # QB551043YW Kensington 27.56 in. H x 19.68 in. W Mirror in Chrome with Safety Backed Glass	2	Each
10 44 16	Fire Extinguisher	Kidde Kitchen Fire Extinguisher	2	Each
10 71 13	Exterior Sun Control Devices	Motorized Skylight Fabric Tension System (FTS) by Skyco (Light color translucent)	1	Each
Division 11				
11 31 00	Slide in Range/Oven	Bosch Induction, 30" Induction Slide-in Range Benchmark™ Series - HIIP054U	1	Each
11 31 00	Exhaust Hood	Bosch 29" Custom Insert Hood Custom Ventilation - DHL755BUC	1	Each
11 31 00	Kitchenette	Summit C48EL	1	Each
11 31 00	Refrigerator/Freezer	Bosch 24" Counter-Depth Bottom-Freezer 500 Series- B11CB50SSS	1	Each
11 31 00	Dishwasher	Bosch 24" Bar Handle Dishwasher Benchmark™ Series- SHX9PT55UC	1	Each
11 31 00	Clothes Washer	Bosch Ascenta Series WAP24200UC, 2.2 cft	1	Each
11 30 13	Clothes Dryer	Front-loading clothes dryer, 7.3-cu. ft. (0.207-cum) capacity with aluminized alloy steel, Safemate Hydromatic Dryer	1	Each
Division 12				
123530	Base Cabinet-Built In: 28"	Custom Cabinets, rule of thumb: kitchen cabinets, excl. counters & appliances, maximum	5.5	L.F.
123530	Base Cabinet-Double Door Sink Unit: 24"	Custom Cabinets	9.25	L.F.
123530	Upper Cabinet: 15"	Custom Cabinets	12.33	L.F.
123600	Countertop 28"	Silestone, Style “Cemento” Natural Quartz	12..33	L.F.
123600	Countertop 24"	Silestone, Style “Cemento” Natural Quartz	7	L.F.
Division 21				
21 13 13	Typical Wet Fire Sprinkler System	Sprinkler System Components, 6" fire cycle system, controls, includes panel, batteries, solenoid valves & pressure switches	998	SF
21 10 00	Fire Pipe	CPVC pipe, 1" diameter	110	LF

21 10 00	Fire Sprinkler Heads	Maximum Ceiling Temp: 100F, Temp Classification: Ordinary, Black, Liquid Alcohol to Orange at 135F or Red at 155F	8	EA
Division 22				
22 11 16	Hot Water Piping	SPEED INOX - Solar Piping	1	Set
22 11 23	Irrigation Pump	Rule Bilge Pump 2000 Submersible (24V)	1	Each
22 11 23	Irrigation Pump (for stand-alone irrigation)	Orion diaphragm pump, 1.2 GPM, 35psi (12V)	1	Each
22 11 23	Solar Pump	Paradigma, Flow Box Solar Pump	1	Each
22 11 23	Cold Water Pump	Grundfos 15-55f	3	Each
22 11 23	Hot Water Pump Circulator	Laing 8-24VDC Water Pump Circulator	3	Each
22 05 16	Typical Plastic Rough Plumbing Waste Water System, Piping, Fittings, 1 kitchen & 2 bath		922	SF
22 33 00	Domestic Hot Water Buffer Tank	WesTech 132 Gallon Double Coil Storage Tank	1	Each
22 33 30	Solar Water Tank	Paradigma, 119 gallon Sunny - Solar Storage Tank Height 71", Diameter 28"	1	Each
22 41 00	Toilet	Toto Aquia® Wall-Hung Dual-Flush Toilet, 1.6GPF & 0.9GPF with SanaGloss Dimensions: 21" L x 14 1/4" W x 19" H. Product Code: CT418FG	2	Each
22 41 00	Vanity/Bathroom Sink	Sandrigo Vanity. Assembled heigth 29.93in. Assembled Width 22.44in., Depth 26.38 in.	2	Each
22 41 00	Bathroom Faucet	Glacier Bay 1-Handle High-Arc Bathroom Vessel Faucet in chrome. Model # FM16C73C	2	Each
22 41 00	Kitchen Sink	Kraus 23-inch Undermount Single Bowl Steel Kitchen Sink	1	Each
22 41 00	Kitchen Faucet	Kraus Single Lever Pull Out Kitchen Faucet KPF-1622	1	Each
22 41 00	Shower Head and Shower Trim	Arzo 1-Handle 1-Spray Shower Faucet Trim Kit in Chrome-Model # T14286-SHQ- Assembled Depth 17 in, heigth 24in, width 7.25 in	2	Each
22 41 00	Shower Base	Aquatic 60 in. x 34 in. x 6 in Center Drain Shower Base	2	Each
22 41 00	Shower Floor	Bamboo shower floor, 30" x 60", custom built in shop from 1 x 4 bamboo lumber	2	Each
22 41 00	Shower valve	Delta MultiChoice Universal Tub and Shower Valve Body Rough-In Kit Model # R10000-UNBX	2	Each
22 41 00	Bathtub Valve	Kohler 1/2" ceramic high-flow valve system	2	Each
22 41 00	Bathtub	Schon Colton 5.25 ft. Center Drain Freestanding Bathtub	2	Each
22 41 00	Bathtub Faucet	Verdanza 2-Handle Deckplate Roman Tub Faucet Model # 65878-0004. Assembled Height 8.6 in	2	Each

22 41 00	Bathtub Drain	Watts 1-1/2 in. White Plastic Bath Drain Kit - Chrome Trim	2	Each
22 41 00	Shower Drain	Oatey 2 in./3 in. ABS Low-Profile Shower Drain with 4-1/4 in. Strainer	2	Each
22 56 00	Expansion Tank	Paradigma 4.8 Gallon Expansion Tank Model No: 08-2138	1	Each
Division 23				
23 09 13	Control Panel for Window Actuators	Functional Fenestrations: CP-3RQ-20A Control Panel	1	Each
23 09 13.13	Window Actuators	Functional Fenestrations: EM_327-810	4	Each
23 31 00	Galvanized Steel Round Duct	8" Round Duct	TBD	L.F
23 31 00	Galvanized Steel Round Elbow Duct	8" 90 degree Elbow	5	Each
23 31 00	Galvanized Steel Boot Fitting	8"x14"x8" Rectangular Fitting	4	Each
23 31 00	Galvanized Rount Tee Duct	8"x8"x8"	2	Each
23 34 16	Centrifugal HVAC Exhaust Fan	Cook Model: 120SQN10D 1000 CFM at 0.3" ESP	1	Each
23 34 16	Centrifugal HVAC Supply Fan	Cook Model: 70SQN15D 200 CFM at 0.1" ESP	1	Each
23 37 13	Diffuser Grilles	8"x14" Sidewall Diffuser Grills	4	Each
23 56 13	Solar thermal evacuated tube collectors	Paradigma CPC 12 OEM Series - Evacuated Tubes. Heat transfer liquid: water. Max working pressure: 150 psi. Module dimensions: 64.5" x 54.75" x 4".	2	Each
23 71 16	Chilled-Water Thermal Storage	ProTank Insulated 750 Gallon Water Tank	1	Each
23 82 41	Water-to-Water Heat Pump	Climate Master (TMW) 3 Tons	1	Each
23 82 29	Radiator	Myson Select Radiator 21 VN 10138 Btu	3	Each
23 83 15	Heat Transfer Panel	Joist Track Heat Transfer Panel	TBD	Each
23 83 15	Radiant Manifold Assembly	Uponor EP Heating/Cooling Manifold Assembly	1	Each
23 83 15	Radiant Piping	Wirsbo hePEX 1/2"	1,000	L.F
23 83 15	Pipe Fittings	1/2" ProPEX Fitting Assembly	TBD	Each
Division 25				
25 13 13	Global Controller	Alerton Ascent Control Module	1	Each
25 13 13	Expansion modules for I/O expansions	Alerton EXP-10-12-0; I/O expansion module with ten 12-bit inputs, 12 binary triac outputs, and 8 analog outputs	2	Each
25 13 13	Expansion modules for I/O expansions	Alerton EXP-22-0-0; input expansion module with twenty-two 12-bit inputs	1	Each
25 13 13	Expansion modules for I/O expansions	Alerton EXP-10-4-8; I/O expansion module with ten, 12-bit inputs, 4 binary triac outputs, 8 analog outputs	1	Each

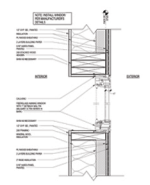
25 14 23	Single-door wall Mount enclosure	Hoffman Single-door wall-mount control panel CSD20166W 20" x 16: x 6"	1	Each
25 14 23	Single-door wall -mount enclosure	Hoffman single-door wall-mount control panel CSD30246W; 30" x 24" x 6"	1	Each
25 35 19	On/Off, Floating Point 3-way valve	3-way control valve, two position	8	Each
25 35 19	Modulating 3-way valve	Modulating 3-way control valve	2	Each
25 35 19	On/Off 2-way valve	2-way control valve - water source heat pump/evaporative cooler (V-5)	2	Each
25 35 16	Temperature Immersion Sensor	BAPI Temperature Immersion Sensor 10K-2 Thermistor 8" long; BAPI BA/10K2I8EUO	12	Each
25 35 16	Temperature, Humidity, and CO2 Sensor	Allerton MS4-MSTP-TH Microset 4 with temperature and humidity sensor	3	Each
25 35 16	Temperature and Humidity Sensor	Allerton MS4-THC Microset 4 with temperature, CO2, and humidity sensor	1	Each
25 35 16	Outside temperature and humidity sensor	Veris Industries HO3XMSTD; temperature and humidity sensor	1	Each
25 35 16	Radiant Ceiling temperature and humidity sensor	Veris Industries HO3XMSTD; temperature and humidity sensor	1	Each
25 35 16	Strap-on temperature sensor	BAPI BA/10K2-STP-JB	4	Each
25 36 19	Current Status and Relay	Status Monitor and Relay for pumps ; Veris H120	11	Each
Division 26				
26 28 17	Panel enclosure	Altech AKL4 terminal enclosure, or similar	2	Each
26 28 17	DC Disconnect	Square D Non-Fusible 600V 30A DC Disconnect HU361RB	2	Each
26 28 17	AC Disconnect	Square D Non-Fusible 240V 200A AC Disconnect DU324RB	1	Each
26 28 17	Din rail mounting kit	Altech DIN rail mounting kit for AKL4 enclosure	1	Set
26 28 17	Typical AC Load Panel		1	Each
26 27 16	Typical DC Load Panel		1	Each
26 22 00	AC/DC inverter	Princeton Power Systems DRI-10, bidirectional, 10kW	1	Each
26 22 19	AC-DC converter	Mean Well HEP-600-12, 600 W	2	Each
26 51 00	LED lighting control system	LumenCache, LibRE Power Distribution Module and BOS	4	each
26 51 00	LED lighting control system	LumenCache, LibRE Constant Current LED Driver, 300mA, 14W	52	each
26 51 00	LED lighting control system	LumenCache, LibRE 40" Enclosure with Temperature Controlled Fan	2	each
26 51 00	LED Linear Strip Light	RGB Outdoor LED Strip Light	60	Ft
26 51 00	LED lighting control system	LumenCache, LibRE Decora Dimming Switch with SIB	25	each
26 51 00	LED lighting control system	Sensors - Occupancy / Daylight - Allowance	5	Each
26 51 00	LED lighting control system	Miscellaneous Wire and Hardware	1	set

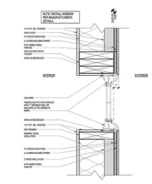
26 51 00	LED lights	LumenCache 12W Round 160 mm w/ Glass Trim, Warm Light Flood, F006CRJB-B37-3030-12W-1000-FLD.A	24	Each
26 51 00	LED lights	LumenCache 12W Round 160 mm White Trim,Warm Light Flood, F007C160-B37-3030-12W-0890-FLD.A (Garage / Carport & Utility Room)	4	Each
26 51 00	LED lights	LumenCache 7W Round IP66 White Trim, Warm Light Flood,(Outside Areas)	11	Each
26 22 00	DC-DC 24V LED driver	Solid Apollo glass touch RBG controller	1	Each
26 xx xx	Window actuator control board	Rollertrol SWITCHED Controller Skylight Window Actuator	2	each
26 xx xx	Window actuators	Rollertrol Window Actuator	6	each
26 09 17	Solar Thermal DHW Controller	Paradigma Systa Aqua Controller	1	Each
26 10 00	120V outlets	typical	33	Each
26 10 00	120V outlets	typical, weatherproof	8	Each
26 10 00	120/240V outlets	typical, 18" AFF	4	Each
26 27 19	Low voltage outlets	Multi-connector outlets for 12/5V	3	Each
Division 27				
27 21 16	Internet Router	TP-LINK TL-WR841N router	1	Each
27 22 26	Laptop/Computer	Toshiba Satellite P50-BBT2N22	1	Each
Division 28				
28 31 00	Fire Alarm System	Fire Detection System, excluding wires & conduits	1	Each
Division 31				
31 48 23	Large Steel adjustable Standard Pier for foundation	Central Piers Inc, 7"-11" inches height adjustable.	12	Each
31 48 23	Large Steel adjustable Seismic Pier for foundation	Central Piers Inc, 6"-12" inches height adjustable.	8	Each
31 50 24	Foundation Pads, plywood	Typical 3/4" CDX Plywood	20	Each
31 50 24	Distributive Footing Pads, Elastomeric	1" elastomeric pads, under plywood footings	20	Each
Divsion 32				
32 91 13.16	Mulch	Shredded bark mulch (3" deep)	500	S.F.
32 91 13.19	Topsoil	Topsoil w/ pH range 5-7 w/ additives (12" deep)	650	S.F.
32 93 13	Senecio serpens	1 gallon pot Blue Chalksticks	11	Each
32 93 13	Rosmarinus officinalis 'Huntington Carpet'	1 gallon pot Huntington Carpet Rosemary	8	Each
32 93 33	Aloe striata	5 gallon pot Coral Aloe	5	Each

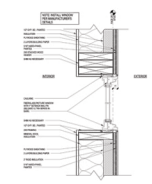
32 93 33	Arctostaphylos manzanita 'Dr. Hurd'	48" box Dr. Hurd Manzanita	1	Each
32 93 33	Phormium 'surfer'	5 gallon pot New Zealand Flax	13	Each
32 93 33	Dianella caerulea 'Little Jess'	5 gallon pot Little Jess	43	Each
32 93 33	Salvia clevlandii	5 gallon pot Cleveland Sage	5	Each
32 93 33	Agave deserti	5 gallon pot Desert Agave	11	Each
32 93 43	Platanus racemosa	60" box California Sycamore	1	Each
32 94 33	Exterior planter	2x4 wood crate planter (varying dimensions)	14	Each
32 95 00	Greenwall	Decorative succulent greenwall	36	S.F.
32 95 00	Vertical garden	Wood pallet + rolling planter vertical vegetable garden	87	S.F.
Division 48				
48 14 00	Photovoltaic Panels	LG Mono X series 305 W	24	Each
48 14 00	Mounting equipment	Ballast mounted equipment	1	set

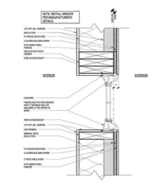
12_ CONSTRUCTION SPECIFICATIONS

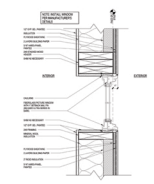
CASA DEL SOL
Team Orange County

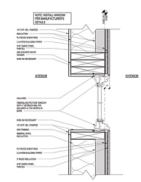


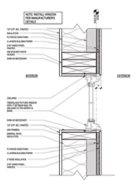












12_Construction Specifications

Division 01 - General Requirements
Division 06 – Wood, Plastics, and Composites
Division 07 – Thermal and Moisture Protection
Division 08 – Openings
Division 09 – Finishes
Division 10 – Specialities
Division 11 – Equipment
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Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC)
Division 25 – Integrated Automation
Division 26 – Electrical
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Division 28 – Electronic Safety and Security
Division 32 – Exterior Improvements
Division 48 – Electrical Power Generation

SECTION 01 54 99 - FORKLIFT TRUCKS

PART 1 – GENERAL

1.01. SUMMARY

A. Forklift trucks will transport building materials from staging areas to the place of work

PART 2 – PRODUCTS

1.02. PRODUCT INFORMATION

A. Manufacturers
   1. Cargotec

B. Materials
   1. Model: Kalmar DCG90-180
   2. Lifting Capacity: 9,000-18,000
   3. Load Centre: 600-1200
   4. Wheel Base: 2,800-3,750 mm
   5. Engine: Volvo, Cummins
   6. Transmission: Dana, ZF

PART 3 – EXECUTION

3.01. INSTALLERS

A. Licensed operators only.

3.02. INSTALLATION

A. Prepare ground by cleaning, removing projections, clearing obstructions, and cordoning off safe working zone, and as otherwise recommended in temporary crane manufacturer's written instructions.

B. Inspect forklift per operational specifications.

C. Allow only licensed operators to operate machinery, manage lifts, and issue signals and commands.

D. Ensure placement of components complies with foundational spacing and load requirements.

E. Correct deficiencies in or remove and reinstall forklifts that do not comply with requirements.

END OF SECTION

SECTION 061500 - WOOD DECKING

Part 1 General

1.1 Summary

A. 2x6 Douglas Fir to be used for wood patio decking

Part 2 Products

2.2 Wood Materials

A. Wood fabricated from old growth timber is not permitted.

2.3 Products

1. Location: Outside Patio and Decking
2. Nominal Size: 2” X 6”

Part 3 Execution

3.1 Installation

A. Set work to required levels and lines, with members plumb, true to line, cut, and fitted

B. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction

C. Framing Standard: Comply with AF&PA’s “Details for Conventional Wood Frame Construction” unless otherwise indicated

D. Securely attach work to substrates, complying with the following:

1. CABO NER-272 for power-driven fasteners
2. Published requirements of metal framing anchor manufacturer
3. Tiger Deck resurfacing guide on their website

E. Secure decking to framing with concealed decking fasteners or secure paver grid to the deck surface with approved fasteners

F. Secure stair treads and risers by gluing and nailing screwing to carriages

G. Countersink fastener heads, fill flush, and sand filler

H. Extend treads over carriages and finish with bullnose edge

END OF SECTION

SECTION 06 16 00 - SHEATHING

Part 1-General

1.1 Summary

A. This section includes the sheathing of Casa Del Sol

1.2 Submittals

A. Product data

Part 2-Products

2.1 Products

A. Wood Panel Products, General

B. Treated Plywood

C. Wall Sheathing

1. Structural 1 Plywood Wall Sheathing
2. Thickness: 15/32” Structural 1

D. Roof Sheathing

1. Plywood Roof Sheathing: Structural Sheathing
2. Thickness: 15/32” Structural 1

E. Subflooring and Underlayment

1. Plywood Floor Sheathing: Structural Sheathing
2. Thickness: ¾” Tongue and Groove and 5’8” Tongue and Groove

Part 3-Execution

3.1 Installation

A. Fasteners: Provide fasteners of size and type that comply with International Building Code, International Residential Code, Wood Frame Construction Manual, and National Design Specification.

B. Fastening Methods:

1. Wall, Floor and Roof Sheathing:
    a. Nail to wood framing

END OF SECTION

SECTION 07 92 00 - JOINT SEALANTS

PART 1 GENERAL

1.01. SUMMARY

A. Section Includes:

1. Residential sealant.

1.02. REFERENCES

a. Federal Specifications:

1. Federal Specification TT-S-00230C, Type S, Class A.

b. American Society for Testing and Materials (ASTM):

1. ASTM C-920, Grade NS, Class 25.
2. ASTM C-834 type OP, Grade-18 C.

c. American Architectural Manufacturers Association (AAMA):

1. AAMA 808.3.

1.03. SUBMITTALS

a. Manufacturer shall provide data sheet prior to installation of product.

1.04. DELIVERY, STORAGE, AND HANDLING

a. Product shall be delivered to site in sealed containers from manufacturer.

b. Product shall be stored between 35 F and 80 F for no more than 18 months from date printed on cartridge.

1.05. WARRANTY

a. No warranty is provided for this item.

PART 2 PRODUCTS

2.01. PRODUCT INFORMATION

a. Manufacturers:

1. DuPont; 4417 Lancaster Pike, Chestnut Run Plaza 728, Wilmington, DE 19805; 1-800-44-TYVEK (8-9835); http://www.construction.tyvek.com.
2. Fortifiber Building Systems Group. 300 Industrial Drive, Fernley, NV 89408. Phone: (800) 773-4777. Email: buildingproducts@fortifiber.com.
3. Dow Chemical. Phone: (866) 583-2583.

b. Materials:

1. DuPont Residential Sealant Modified Urethane Acrylic Sealant.
2. Fortifiber Residential Sealant.
3. Great Stuff Gaps and Cracks Foam Sealant.
4. Great Stuff Window and Door Foam Sealant.

2.02. PRODUCT SUBSTITUTIONS

a. Product substitutions shall be allowed based on local availability subject to approval of The Construction Manager.

PART 3 EXECUTION

3.01. INSTALLERS

a. Only a qualified installer shall use this product. Qualified installers will be determined by the Project Manager, Construction Manager, or Health and Safety Officer.

3.02. EXAMINATION

a. All surfaces must be clean and dry. Remove all foreign matter and contaminants. Only apply when sealant, surface, and air temperatures remain above freezing. Do not apply on substrates or surfaces that are above 160 F. Do not apply on exterior surfaces when rain is immediately expected with 4-6 hours.

3.03. INSTALLATION

a. Cut nozzle at a 45 degree angle. Cured bead should be between 1/8” and ½”. Use recommended foam backer rod or bond breaker tape for larger gaps; follow guidelines from rod and tape manufacturers for correct backer rod and tape sizes related to joint size.
b. Prior to any use, it is always recommended that the sealant be applied on the substrate surface to test adhesion.
c. Using a caulking gun, apply and tool sealant with adequate pressure to spread the sealant against the back-up material at the bottom and sides of the joint.
d. Clean up tools with soap and water.
e. Allow 4 to 6 hours curing time before applying paint.

3.04. RELOCATION CONSIDERATIONS

a. Repair:
    1. Cracked sealant shall be stripped and reapplied.

3.05. SITE QUALITY CONTROL

a. Sealant shall be allowed to fully dry prior to painting or continuation of work adjacent to sealed area.
b Beads shall be evenly applied and smooth after curing.

3.06. ATTACHMENTS

A. Manufacturer supplied data sheet is attached.

END OF SECTION

SECTION 07200 - INTERIOR PARTITION- INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Provide glass fiber insulation for exterior partitions as indicated in building plans.

1.02 MATERIALS PROVIDED IN OTHER SECTIONS

A. Section 09250-Gypsum Board
B. Section 09260-Gypsum Board Systems
C. Section 09100-Metal Support Systems

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM).
   1. C 665 Specification for Mineral Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
   2. E 84 Test Method for Surface Burning Characteristics of Building Materials.
   3. E 136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C.
   4. C 518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer's product literature, samples and installation instructions for specified insulation.

1.05 DELIVERY, STORAGE AND HANDLING

A. Protect insulation from physical damage and from becoming wet, soiled, or covered with ice or snow. Comply with manufacturer's recommendations for handling, storage and protection during installation.
B. Label insulation packages to include material name, production date and/or product code.

1.06 LIMITATIONS

A. Do not use unfaced insulation in exposed applications where there is potential for skin contact and irritation.
B. Kraft and standard foil facings will burn and must not be left exposed. The facing must be installed in substantial contact with the unexposed surface of the ceiling, wall or floor finish. Protect facing from any open flame or heat source.

PART 2 PRODUCTS

2.01 MANUFACTURERS ACCEPTED

A. Owens-Corning.
B. Foam Control
C. ThermaFiber

2.04 THERMAL BATT INSULATION

A. Type: Unfaced glass fiber thermal insulation complying with ASTM C 665, Type I.
B. Size:
   Wood Frame Insulation:
   1. Refer to drawings
C. Surface Burning Characteristics:
   1. Maximum flame spread: 10
   2. Maximum smoke developed: 10
      When tested in accordance with ASTM E 84.
D. Combustion Characteristics:
   Unfaced insulation passes ASTM E 136 test.

E. Dimensional Stability:
Linear shrinkage less than 0.1%

2.06 GYPSUM BOARD

A. Refer to Section (09250) (09260) for detailed specifications.
B. Type: 1/2" thick, type “x” gypsum panels.
C. Type: 5/8" thick, type “x” gypsum panels.

2.07 FRAMING

A. 2x8” wood framing typical in walls
B. 2x12” wood framing in ceiling
C. Steel Zees, 10” depth

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION

A. Examine substrates and conditions under which insulation work is to be performed. A satisfactory substrate is one that complies with requirements of the section in which substrate and related work is specified.
B. Obtain installer's written report listing conditions detrimental to performance of work in this section. Do not proceed with installation of insulation until unsatisfactory conditions have been corrected.
C. Clean substrates of substances harmful to insulation.

3.02 INSTALLATION - GENERAL

A. Comply with manufacturer's instructions for particular conditions of installation in each case.
B. Batts may be friction-fit in place until the interior finish is applied.
Install batts to fill entire stud cavity. If stud cavity is less than 96" in height, cut lengths to friction-fit against floor and ceiling tracks.
Walls with penetrations require that insulation be carefully cut to fit around outlets, junction boxes and other irregularities.
C. Where walls are not finished on both sides or insulation does not fill the cavity depth, supplementary support must be provided to hold product in place.
D. Where insulation must extend higher than 8 feet, temporary support can be provided to hold product in place until the finish material is applied.

3.03 GYPSUM BOARD INSTALLATION

A. Refer to Section (09250) (09260) for proper installation of gypsum board.

3.04 PROTECTION

A. Protect installed insulation as recommended by manufacturer.

END OF SECTION

SECTION 07 21 13 – FOAM BOARD INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes rigid expanded polystyrene (EPS) insulation as indicated in building plans.

1.02 REFERENCES

A. ASTM C 578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
B. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials
C. ICC ES AC12 – Acceptance Criteria for Foam Plastic Insulation.

1.03 SUBMITTALS

A. Submit insulation manufacturer's product literature and installation instructions, including:
    1. Physical properties in compliance with ASTM C578 Type specified.
    2. EPS Code Compliance: Provide ICC ES code report for EPS foam with evidence of compliance with code. Submit current compliance report numbers from ICC ES with conformance to the International Building Code (IBC) and International Residential Code (IRC). Code report shall include compliance with ICC ES AC12 (Foam Plastic) dated June 2006.
    3. Third Party certification of flame spread and smoke developed indexes
B. 20-year in-service, non-prorated thermal performance warranty.

1.04 DELIVERY, STORAGE & HANDLING

A. Deliver insulation in packages labeled with material Type and R-value.
B. Store in original unopened packaging above ground, and protected from moisture and sunlight prior to installation.
C. Product should not be exposed to open flame or other ignition sources.

PART 2 PRODUCTS

2.01 MATERIAL COMPATIBILITY

A. The insulation must be compatible with all components of the intended application.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation: 2" thick on exterior side of exterior walls

3.02 HAZARDS

A. Polystyrene melts at high temperature and molten droplets may cause skin burns.
B. Non-hazardous in finished form. Residual quantities of process chemicals, styrene and blowing agents are insignificant. The product is organic and therefore combustible if exposed to intense heat or a fire.

END OF SECTION

SECTION 07 25 00 - WEATHER BARRIERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Weather barrier membrane
B. Seam Tape
C. Flashing
D. Fasteners

1.2 REFERENCES

A. ASTM International
   1. ASTM C920; Standard Specification for Elastomeric Joint Sealants
   2. ASTM C1193; Standard Guide for Use of Joint Sealants
   3. ASTM D882; Test Method for Tensile Properties of Thin Plastic Sheeting
   4. ASTM D1117; Standard Guide for Evaluating Non-woven Fabrics
   5. ASTM E84; Test Method for Surface Burning Characteristics of Building Materials
   6. ASTM E96; Test Method for Water Vapor Transmission of Materials
   7. ASTM E1677; Specification for Air Retarder Material or System for Framed Building Walls
   8. ASTM E2178; Test Method for Air Permeance of Building Materials
   9. ASTM E2357; Standard Test Method for Determining Air Leakage of Air Barrier Assemblies
B. AATCC – American Association of Textile Chemists and Colorists
   1. Test Method 127 Water Resistance: Hydrostatic Pressure Test
C. TAPPI
   1. Test Method T-410; Grams of Paper and Paperboard (Weight per Unit Area)
   2. Test Method T-460; Air Resistance (Gurley Hill Method)

1.3 SUBMITTALS

A. Refer to Section [01 33 00 Submittal Procedures] [insert section number and title].
B. Product Data: Submit manufacturer current technical literature for each component.
C. Samples: Weather Barrier Membrane, minimum 8-1/2 inches by 11 inch.
D. Quality Assurance Submittals
   1. Design Data, Test Reports: Provide manufacturer test reports indicating product compliance with indicated requirements.
   2. Manufacturer Instructions: Provide manufacturer's written installation instructions.
   3. Manufacturer's Field Service Reports: Provide site reports from authorized field service representative, indicating observation of weather barrier assembly installation.
E. Closeout Submittals
   1. Refer to Section 01 78 00 Closeout Submittals
   2. Weather Barrier Warranty: Manufacturer's executed warranty form with authorized signatures and endorsements indicating date of Substantial Completion.

1.4 QUALITY ASSURANCE

A. Qualifications

1. Installer shall have experience with installation of commercial weather barrier assemblies under similar conditions.
2. Installation shall be in accordance with weather barrier manufacturer's installation guidelines and recommendations.
3. Source Limitations: Provide commercial weather barrier and accessory materials produced by single manufacturer.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01 60 00 Product Requirements

B. Deliver weather barrier materials and components in manufacturer's original, unopened, undamaged containers with identification labels intact.

C. Store weather barrier materials as recommended by weather barrier manufacturer.

1.6 SCHEDULING

A. Review requirements for sequencing of installation of weather barrier assembly with installation of windows, doors, louvers and flashings to provide a weather-tight barrier assembly.

B. Schedule installation of weather barrier materials and exterior cladding within nine months of weather barrier assembly installation.

1.7 WARRANTY

A. Special Warranty

1. Special weather-barrier manufacturer's warranty for weather barrier for a period of ten (10) years from date of purchase.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Approved Manufacturers

a. DuPont

b. Kleenguard

c. C.Typar

2.2 MATERIALS

A. Basis of Design: spunbonded polyolefin, non-woven, non-perforated, weather barrier is based upon DuPont™ Tyvek® CommercialWrap® and related assembly components.

B. Performance Characteristics:
   1. Air Penetration: 0.001 cfm/ft^2 at 75 Pa, when tested in accordance with ASTM E2178. Type I per ASTM E1677. ≤0.04 cfm/ft^2 at 75 Pa, when tested in accordance with ASTM E2357
   2. Water Vapor Transmission: 28 perms, when tested in accordance with ASTM E96, Method B.
   3. Water Penetration Resistance: 280 cm when tested in accordance with AATCC Test Method 127.
   4. Basis Weight: 2.7 oz/yd^2, when tested in accordance with TAPPI Test Method T-410.
   5. Air Resistance: Air infiltration at >1500 seconds, when tested in accordance with TAPPI Test Method T-460.
   6. Tensile Strength: 38/35 lbs/in., when tested in accordance with ASTM D882, Method A.
   7. Tear Resistance: 12/10 lbs., when tested in accordance with ASTM D1117.
   8. Surface Burning Characteristics: Class A, when tested in accordance with ASTM E 84. Flame Spread: 10, Smoke Developed: 10.

2.3 ACCESSORIES

A. Seam Tape: 3-inch wide tape for commercial applications.

B. Fasteners:
   1. Manufacturers recommended Wrap Caps, as distributed by DuPont: #4 nails with large 1-inch plastic cap fasteners, or 1-inch plastic cap staples with leg length sufficient to achieve a minimum penetration of 5/8-inch into the wood stud.
   2. Masonry tap-con fasteners with manufacturers 2-inch diameter plastic cap fasteners.

C. Sealants
   1. Provide sealants that comply with ASTM C920, elastomeric polymer sealant to maintain watertight conditions.
   2. Products:
      a. Sealants recommended by the weather barrier manufacturer.

D. Adhesives:
   1. Provide adhesive recommended by weather barrier manufacturer.
   2. Products:
      a. Liquid Nails® LN-109
      b. Denso Butyl Liquid
      c. 3M High Strength 90
      d. SIA 655
      e. Adhesives recommend by the weather barrier manufacturer.

E. Primers:
   1. Provide flashing manufacturer recommended primer to assist in adhesion between substrate and flashing.
   2. Products:
      a. 3M High Strength 90

b. Denso Butyl Spray
c. SIA 655
d. Permagrip 105
e. ITW TACC Sta' Put SPH
f. Primers recommended by the flashing manufacturer

F. Flashing
1. Flexible membrane flashing materials for window openings and penetrations per manufacturers recommendations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify substrate and surface conditions are in accordance with weather barrier manufacturer recommended tolerances prior to installation of weather barrier and accessories.

3.2 INSTALLATION – WEATHER BARRIER

A. Install weather barrier over exterior face of exterior wall substrate in accordance with manufacturer recommendations.
B. Install weather barrier prior to installation of windows and doors.
C. Start weather barrier installation at a building corner, leaving 6-12 inches of weather barrier extended beyond corner to overlap.
D. Install weather barrier in a horizontal manner starting at the lower portion of the wall surface with subsequent layers installed in a shingling manner to overlap lower layers. Maintain weather barrier plumb and level.
E. Sill Plate Interface: Extend lower edge of weather barrier over sill plate interface 3-6 inches. Secure to foundation with elastomeric sealant as recommended by weather barrier manufacturer.
F. Window and Door Openings: Extend weather barrier completely over openings.
G. Overlap weather barrier
1. Exterior corners: minimum 12 inches.
2. Seams: minimum 6 inches.
H. Weather Barrier Attachment:
1. Attach weather barrier to studs through exterior sheathing. Secure using weather barrier manufacturer recommended fasteners, space 12 -18 inches vertically on center along stud line, and 24 inch on center, maximum horizontally.
I. Apply 4 inch by 7 inch piece of manufacturers compatible flashing or weather barrier manufacturer approved alternate to weather barrier membrane prior to the installation cladding anchors.

3.3 SEAMING

A. Seal seams of weather barrier with seam tape at all vertical and horizontal overlapping seams.
B. Seal any tears or cuts as recommended by weather barrier manufacturer.

3.4 OPENING PREPARATION (for use with non-flanged windows – all cladding types)

A. Flush cut weather barrier at edge of sheathing around full perimeter of opening.

B. Cut a head flap at 45-degree angle in the weather barrier at window head to expose 8 inches of sheathing. Temporarily secure weather barrier flap away from sheathing with tape.

3.6 OPENING PREPARATION (for use with flanged windows)

A. Cut weather barrier in an "I-cut" pattern. A modified I-cut is also acceptable.

1. Cut weather barrier horizontally along the bottom and top of the window opening.
2. From the top center of the window opening, cut weather barrier vertically down to the sill..
3. Fold side and bottom weather barrier flaps into window opening and fasten.

B. Cut a head flap at 45-degree angle in the weather barrier at window head to expose 8 inches of sheathing. Temporarily secure weather barrier flap away from sheathing with tape.

3.7 FLASHING (for use with flanged windows)

A. Cut [7-inch] [9-inch] wide manufacturers compatible a minimum of 12 inches longer than width of sill rough opening.

B. Cover horizontal sill by aligning manufacturers compatible edge with inside edge of sill. Adhere to rough opening across sill and up jambs a minimum of 6 inches. Secure flashing tightly into corners by working in along the sill before adhering up the jambs.

C. Fan manufacturers compatible at bottom corners onto face of wall. Firmly press in place. Mechanically fasten fanned edges.

D. On exterior, apply continuous bead of sealant to wall or backside of window mounting flange across jambs and head. Do not apply sealant across sill.

E. Install window according to manufacturer's instructions.

F. Apply 4-inch wide strips of manufacturers compatible at jambs overlapping entire mounting flange. Extend jamb flashing 1-inch above top of rough opening and below bottom edge of sill flashing.

G. Apply 4-inch wide strip of Manufacturers compatible as head flashing overlapping the mounting flange. Head flashing should extend beyond outside edges of both jamb flashings.

H. Position weather barrier head flap across head flashing. Adhere using 4-inch wide Manufacturers compatible over the 45-degree seams.

I. Tape head flap in accordance with manufacturer recommendations.

J. On interior, install backer rod in joint between frame of window and flashed rough framing. Apply sealant around entire window to create air seal. Apply sealant in accordance with sealant manufacturer's instructions and ASTM C 1193.

3.8 THRU-WALL FLASHING INSTALLATION

A. Apply primer per manufacturer's written instructions.

B. Install preformed corners and end dams bedded in sealant in appropriate locations along wall.

C. Starting at a corner, remove release sheet and apply membrane to primed surfaces in lengths of 8 to 10 feet.

D. Extend membrane through wall and leave ¼ inch minimum exposed to form drip edge.

E. Roll flashing into place. Ensure continuous and direct contact with substrate.

F. Lap ends and overlap preformed corners 4 inches minimum. Seal all laps with sealant.

G. Trim exterior edge of membrane 1-inch and secure metal drip edge per manufacturer's written instructions.

H. Terminate membrane on vertical wall. Terminate into reglet, counterflashing or with termination bar.

I. Apply sealant bead at each termination.

3.9 THRU-WALL FLASHING / WEATHER BARRIER INTERFACE AT BASE OF WALL

A. Overlap thru-wall flashing with weather barrier by 6-inches.

B. Mechanically fasten bottom of weather barrier through top of thru-wall flashing.

C. Seal vertical and horizontal seams with tape or sealing membrane.

3.10 FIELD QUALITY CONTROL

A. Notify manufacturer's designated representative to obtain [required] periodic observations of weather barrier assembly installation.

3.11 PROTECTION

A. Protect installed weather barrier from damage.

END OF SECTION

SECTION 076200 - SHEET METAL FLASHING AND TRIM

PART 1 – GENERAL INFORMATION

1.01-SUMMARY

A. This section incudes the following:

1. Sheet Metal

1.02 - SUBMITALS

A. Submit complete specification and shop drawings

PART 2 PRODUCTS

2.01- SHEET METAL

A. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required, not less than 0.032 inch (0.8 mm) thick

2.02 - ACCESSORIES

A. Fasteners: Wood screws, annular- threaded nails, self-tapping screws, self- locking rivets and bolts, and other suitable fasteners.

1. Fastener for Aluminum Sheet: Aluminum or Series 300 stainless steel.

PART 3 - EXECUTION

3.01 - INSTALLATION

A. Allow for thermal expansion; set true to line and level. Install Work with laps, joints, and seams permanently watertight and weatherproof; conceal fasteners where possible

B. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.

C. Fabricate nonmoving seams in sheet metal with flat-lock seams. For aluminum, form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

D. Aluminum Flashing and Trim: Coat back side of aluminum flashing and trim with bituminous coating where it will contact wood, ferrous metal, or cementitious construction.

E. Separate dissimilar metals with bituminous coating or plymer- modified, bituminous sheet underlayment.

END OF SECTION

SECTION 08 14 00 - WOOD DOORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

A. Solid-core doors with bamboo veneer faces.

1.02 SUBMITTALS

A. Shop Drawings: Indicate location, size, and hand of each door; elevation of each kind of door; construction details not covered in Product Data; and the following:

1. Dimensions and locations of mortises and holes for hardware.
2. Dimensions and locations of cutouts.
3. Undercuts.
4. Requirements for veneer matching.
5. Doors to be factory finished and finish requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Algoma Hardwoods, Inc.
2. Eggers Industries.
3. Graham Wood Doors; an Assa Abloy Group company.
4. Mohawk Doors; a Masonite company.
5. Oshkosh Door Company.
6. VT Industries, Inc.

2.02 FLUSH WOOD DOORS, GENERAL

A. WDMA I.S.1-A Performance Grade:

1. Standard Duty unless otherwise indicated.

B. Particleboard-Core Doors:

1. Particleboard: ANSI A208.1, Grade LD-1 or Grade LD-2, made with binder containing no urea-formaldehyde.

2.03 VENEER-FACED DOORS

A. Interior Solid-Core Doors:

1. Grade: Custom (Grade A faces).
2. Veneer Skin: 1/8 inch thick bamboo Component Material by Lamboo Inc.
3. Core: Particleboard.
4. Construction: Stiles and rails are bonded to core, then entire unit is abrasive planed before veneering. Faces are bonded to core using a hot press.

2.04 HARDWARE

A. Pocket Doors

1. Overhead sliding door hardware by Hafele
2. Door pull
3. Privacy Lock

B. Swing Doors

1. Privacy latch set

2. Hinges

C. Bifold Door - Mechanical Room

1. Passage latch set
2. Hinges

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation Instructions: Install doors to comply with manufacturer's written instructions and referenced quality standard, and as indicated.

B. Job-Fitted Doors: Align and fit doors in frames with uniform clearances and bevels as indicated below; do not trim stiles and rails in excess of limits set by manufacturer or permitted for fire-rated doors. Machine doors for hardware. Seal edges of doors, edges of cutouts, and mortises after fitting and machining.

1. Clearances: Provide 1/8 inch at heads, jambs, and between pairs of doors. Provide 1/8 inch from bottom of door to top of decorative floor finish or covering unless otherwise indicated. Where threshold is shown or scheduled, provide 1/4 inch from bottom of door to top of threshold unless otherwise indicated.

END OF SECTION

SECTION 085413 - FIBERGLASS WINDOWS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Fiberglass windows with painted exterior and interior finish of the following type(s):

1. Awning windows.
2. Picture windows.

1.02 SUBMITTALS

A. Reference Section 01 33 00 – Submittal Procedures; submit following items:

1. Product Data.
2. Shop Drawings: Include window schedule, window elevations, sections and details, and multiple window assembly details.
3. Samples:
   a. Color Samples: Minimum 1x4 inch (25x100 mm) paint color chips on fiberglass substrate.
4. Quality Assurance/Control Submittals:
   a. Qualifications: Proof of manufacturer's qualifications.
   b. U-Factor and structural rating charts required for AAMA and NFRC labeling requirements.
   c. Installation Instructions - AAMA 2400 & AAMA 2410 (Flush Fin Installation).

B. Closeout Submittals: Reference Section 01 78 00 – Closeout Submittals; submit following items:

1. Temporary window labels marked to identify windows that labels were applied to.
2. Maintenance instructions.
3. Special Warranties.

1.03 QUALITY ASSURANCE

A. Overall Standards: Comply with ANSI/AAMA/101/I.S.2, except as otherwise noted herein.

B. Qualifications

1. Manufacturer Qualifications
   a. Minimum ten years experience in producing fiberglass windows.
   b. Member AAMA, NFRC.

C. Certifications for insulated glass windows

1. AAMA: Windows shall be Silver Label certified with label attached to frame per AAMA requirements.
2. NFRC: Windows shall be NFRC certified with temporary U-factor label applied to glass and an NFRC tab added to permanent AAMA frame label.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Reference Section 01 66 00 – Product Storage and Handling

B. Provide cardboard corner boots and full stretch wrap shipping protection.

C. Follow manufacturer's instructions on label applied to windows.

1.05 WARRANTY

A. Residential Special Warranty:
1. Full Lifetime Warranty including glass breakage to original homeowner.
2. Transferability:
a.Permit unlimited transfer of ownership in first ten years.
b.Upon first transfer of ownership, warranty period shall become ten years from date of original purchase.
3. Guarantee windows against defects in materials and workmanship including costs for parts and labor. Wood veneer
surfaces are required to be finish coated per manufacturer's instructions.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Milgard Manufacturing, Inc; tel (800) MILGARD (645-4273); Address: 1010 54th Avenue East. Tacoma, WA 98424. FAX: (253) 926 -0848. Website: http://www.milgard.com/

B.Window Series: Milgard Ultra™.

C. Substitutions: Reference Section 01 25 13 – Product Substitution Procedures.

2.02 MATERIALS

A. Fiberglass: AAMA 305 glass fiber reinforced thermoset profile.

2.03 GENERAL
PERFORMANCE
REQUIREMENTS

A. Thermal Performance: Comply with NFRC 100.

B. Air Leakage, Water Resistance, Structural Test: Comply

with ANSI/AAMA /NWWDA 101/I.S.2. C. Forced-Entry

Resistance: Comply with CAWM 301-90.

2.04 WINDOW TYPES

F. Awning - 3410 Series, 1 inch (25 mm) nail fin setback
1. Frame: Minimum 3-1/4 inch (83 mm) deep, multi-chambered fiberglass pultrusion.
2. Sash: Minimum 2-3/8 inch (60.3 mm) deep, multi-chambered fiberglass pultrusion.
3. Structural Class: AP-C35.

4. Hardware:
a.Single steel arm rotary scissor operator: NO ROTARRY ARM OR SCISSOR OPERATOR
b.Dual lever locking mechanism.
c.Two bar stainless steel hinge.

5. Weatherstripping: Vinyl compression bulb seal.

G. Picture - 3310 Series, 1 inch (25 mm) nail fin setback
1. Frame: Minimum 3-1/4 inch (83 mm) deep, multi-chambered fiberglass pultrusion.
2. Sightlines: Equal to operating windows (except to double-hungs).
3. Structural Class: F-C50.

2.05 GLAZING

A. Insulated Glass Units: ASTM E 774, Class A, 7/8 inch (22 mm) thick overall:
1. Glazing Type: Clear/SunCoatMAX® Low-E, argon gas filled
2. Spacer type: EdgeGardMAX™ High Performace foam based warm edge spacer system.

2.06 GRIDS:

A. Grid Types:
1. No grids

2.07 INSECT SCREENS:

A. Provide tight-fitting screen for operating sash with hardware to allow easy removal.
1. Screen Cloth: Optional PureView™ low-visibility fiberglass mesh
2. Frame: Extruded aluminum frame - DHR, Case, Awn

2.08 FABRICATION

A. Fabricate frames and panels with milled and mitered joints and mechanically joined corners. Trim and finish corners to match adjacent surfaces.

B. Provide concealed metal reinforcement in sash frame for attaching lock mechanism.

C. Factory exterior wet silicone glaze with snap-on fiberglass glazing stops matching interior sash and frame finish, except where field glazing is required due to large window unit dimensions (over 40 sf (3.72 m2)). Insulating units shall be reglazeable without dismantling sash framing.

2.09 FINISH

A. Frame and Sash.
1. Exterior: Paint color is baked on enamel. Color: Milgard Brownstone
2. Interior: White baked on enamel.

C. Hardware: Painted Brownstone as supplied by Milgard.

D. Screen Frame Color:
1. Exterior Mounted Screens: Match frame to exterior window frame and sash color.
2. Interior Mounted Screens: Brownstone.

2.10 SOURCE QUALITY CONTROL

A. Inspect windows in accordance with manufacturer's Quality Control Program as required by AAMA Silver Label certification.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine openings in which windows will be installed.
1.Verify that framing complies with AAMA 2400 & AAMA 2410 (Flush Fin Installation).
2.Verify that fasteners in framed walls are fully driven and will not interfere with window installation.

B. Coordinate with responsible entity to correct unsatisfactory conditions.

C. Commencement of work by installer is acceptance of substrate conditions.

3.02 INSTALLATION

A. Install windows in framed walls in accordance with AAMA 2400.
1.Provide continuous shim support along full length of sill.

B. Do not remove temporary labels.

3.03 CLEANING

A. Reference Section 01 74 00 – Cleaning and Waste Management.

B. Remove temporary labels and retain for Closeout Submittals.

C. Clean soiled surfaces and glass using a mild detergent and warm water solution with soft, clean cloths.

END OF SECTION

SECTION 09 30 13 - PORCELAIN TILE

GENERAL

SECTION INCLUDES:

- MANUFACTURER: STONE SOURCE: 5429 MCCONNELL AVE, LOS ANGELES, CA 90066

- TILES AND ACCESSORIES:
    - Folded Bianco Glazed Porcelain-Bathroom Floor/Wall Tile
      Size: 24"x24" (23.62"x23.62") – 500 SQ FT.
    - Mutina Phenomenon ; Bianco Air Textured Porcelain-Kitchen Backsplash
      Size: 12”x12” (11.81”x11.81”) – 37 SQ FT.

- REFERENCES

    - American National Standards Institute (ANSI):
        - ANSI A108/A118/A136.1 - Specifications for the Installation of Ceramic Tile.
        - ANSI A137.1 - Specifications for Ceramic Tile.

    - American International (ASTM):
        - ASTM C 144 - Standard Specification for Aggregate for Masonry Mortar.
        - ASTM C 150 - Standard Specification for Portland Cement.
        - ASTM C 207 - Standard Specification for Hydrated Lime for Masonry Purposes.
        - ASTM C 503 - Specification for Marble Building Stone (Exterior).
        - ASTM C 615 - Specification for Granite Dimension Stone.
        - ASTM C 629 - Specification for Slate Dimension Stone.
        - ASTM C 847 - Standard Specification for Metal Lath.
        - ASTM C 1028 - Standard Test Method for Determining the Static Coefficient of Friction or Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method.
        - ASTM D 4397 - Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.

    - Tile Council of North America (TCNA): TCA Handbook for Ceramic Tile Installation, 2007.

- PERFORMANCE REQUIREMENTS

    - Static Coefficient of Friction: Tile on walkway surfaces shall meet or exceed the following values as determined by testing in conformance with ASTM C 1028.
        - Level Surfaces: Minimum of 0.6 (Wet).
        - Step Treads: Minimum of 0.6 (Wet).
        - Ramp Surfaces: Minimum of 0.8 (Wet).

- SUBMITTALS

    - Submit under provisions of Section 01 30 00 - Administrative Requirements.

    - Product Data: Manufacturer's data sheets on each product to be used, including:
        - Preparation instructions and recommendations.
        - Storage and handling requirements and recommendations.
        - Installation methods.

- Shop Drawings: Indicate tile layout, patterns, color arrangement, perimeter conditions, junctions with dissimilar materials, control and expansion joints, thresholds, ceramic accessories, and setting details.
- Selection Samples: For each product specified, two complete sets of color charts representing manufacturer's full range of available colors and patterns.
- Selection Samples: For each finish product specified, two full-size samples of the actual product, range of available color, and patterns.
- Verification Samples: For tile 8 by 8 inches (203 by 203 mm) and smaller, mount actual units on minimum 12 by 12 inch (305 by 305 mm) plywood panels and grout with selected grout. For larger tile, submit two units of each type, and grout chart indicating selections.
- Manufacturer's Certificates: Certify products meet or exceed specified requirements. When applicable, submit a Master Grade Certificate signed by the manufacturer and the installer certifying that products meet or exceed the specified requirements of ANSI A137.1.
- Maintenance Data: Include recommended cleaning methods, cleaning materials, and maintenance coatings.

- QUALITY ASSURANCE
  - Installer Qualifications: Company specializing in performing the work of this section with minimum two years experience.
  - Single Source Responsibility: Obtain each type and color of tile from a single source. Obtain each type and color of mortar, adhesive and grout from the same source.
  - General: Provide tile that complies with ANSI A137.1 where applicable for types, compositions and other characteristics indicated. Provide tile in the locations and of the types colors and pattern indicated on the Drawings.
    - Factory Blending: For tile exhibiting color variations within the ranges selected under Submittal of samples, blend tile in the factory and package so tile taken from one package shows the same range of colors as those taken from other packages.
    - Mounting: For factory mounted tile, provide back or edge mounted tile assemblies as standard with the manufacturer, unless otherwise specified.
    - Factory Applied Temporary Protective Coatings: Where indicated under tile type, protect exposed surfaces of tile against adherence of mortar and grout by precoating with a continuous film of petroleum paraffin wax applied hot. Do not coat unexposed tile surfaces.

- DELIVERY, STORAGE, AND HANDLING
  - Deliver and store products in manufacturer's unopened packaging until ready for installation.
  - Protect setting materials from freezing or overheating in accordance with manufacturer's instructions.
  - Store tile and setting materials on elevated platforms, under cover and in a dry location and protect from contamination, dampness, freezing or overheating.

- PROJECT CONDITIONS
  - Do not install adhesives in an unventilated environment.
  - Maintain ambient and substrate temperature of 50 degrees F (10 degrees C) during tiling and for a minimum of 7 days after completion.

- EXTRA MATERIALS
    - See Section 01600 - Product Requirements, for additional provisions.
    - Deliver extra sets of hardware items for Owner's use in maintenance.
        - Provide for Owner's use a minimum of 2 percent of the primary sizes and colors of tile specified, boxed and clearly labeled.
    - Requests for substitutions will be considered in accordance with provisions of Section 01 60 00 - Product Requirements.
- TILE SETTING MATERIALS
    - Silicone Sealant: Silicone sealant, moisture and mildew resistant type, white; use for shower floors and shower walls.
- EXAMINATION
    - Acceptability of Surfaces: Inspect surfaces to be tiled to ensure proper bonding can be achieved, and to verify that surfaces are free of curing membranes, oil, grease, wax and dust.
    - Substrate Tolerances: Before tiling, inspect surfaces to be tiled to verify that the following tolerances are not exceeded. If tolerances are exceeded, provide specified leveling coat to achieve specified tolerances.
        - Walls: 1/8 inch in 8 feet (3 mm in 2.4 m) for dry-set mortar, epoxy and organic adhesives.
        - Floors: 1/8 inch in 10 feet (3 mm in 3 m) for dry-set mortar and epoxy; 1/16 inch in 3 feet (1.5 mm in 1 m) for organic adhesive.
- PREPARATION
    - Layout: Determine locations of control and expansion joints before starting tile work. Layout tile work to minimize cuts less than one-half tile in size.
- INSTALLATION
    - General: Comply with ANSI A108/A118/A136.1 and manufacturer's recommendations. Comply with applicable TCA Handbook for Tile Installation requirements as listed below.
    - Tiles can be installed using standard installation methods for thinset adhesives. A grout joint of 1/8" or greater is recommended. Use high quality adhesive from manufacturers such as Laticrete and Mapei, following manufacturers' recommendations, depending on conditions.
    - Walls, Interior, Wood or Metal Studs:
        - TCA W243, gypsum board thin-set.
        - TCA W244C, interior, thin-set.
        - TCA W244E, exterior, cementitious backer unit.
        - TCA W244F, fiber cement underlayment.
        - TCA W245, coated glass mat water-resistant gypsum backer board.
        - TCA W246, cementitious-coated foam backer board.
        - TCA W247, fiber-reinforced water-resistant gypsum backer board.
        - TCA W260, spot-bonding epoxy cementitious backer unit.
- CLEANING AND PROTECTION
    - Cleaning: Clean with a neutral detergent.

- Protection: Prohibit foot and wheeled traffic from floors for a minimum of 3 days. Where traffic is unavoidable, provide large flat boards in walkways and wheelways for a minimum of 7 days after installation. Protect from construction dirt and debris with heavy-duty, non-staining construction paper, masked in place.

END OF SECTION

SECTION 09 62 23 - ENGINEERED FLOORING

PART 1- GENERAL

1.01 SECTION INCLUDES

A. Classics Engineered Flooring

B. Maintenance materials.

C. Finish moldings

1.02 REFERENCES

A. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.

B. ASTM F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.

C. ASTM F710 - Practice for Preparing Concrete Floors. Concrete ph determination.

1.03 SUBMITTALS

A. Submit product data in accordance with Section (01 30 00) (01 33 00), including manufacturer's installation and maintenance instructions.

B. Shop Drawings: Show floor pattern layout.

1.04 QUALITY ASSURANCE

A. Installer: Shall be experienced in the wood and/or vinyl tile flooring industry and shall have a minimum of five (5) years experience in the installation of similar products.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver the flooring to a preferred 35-55% relative humidity job site in unopened cartons. Protect flooring from exposure to moisture. Moisture producing activities such as drywall, concrete, masonry, painting and grouting must be complete and cured prior to delivery of wood flooring.

B.Cartons of wood should be stored in dry, well ventilated storage areas or warehouses. Never store cartons of flooring outdoors. The ideal storage area environment should be kept at 35-55% relative humidity and 60-75ºF . Do not store cartons of flooring directly on concrete floors.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Provide permanent HVAC operation (2 week minimum) and permanent lighting prior to installation.

B. Maintain room temperature between 60ºF minimum and 75ºF and relative humidity between 35% minimum and 55% maximum, prior, during and after the installation. Keep in mind that if the relative humidity drops below 35% for extended periods, the flooring may shrink causing unsightly splits and gaps.

C. Do not install flooring until all other significant construction work is complete.

2.01 MATERIALS

A. Flooring: Classic engineered Hardwood Flooring with Permion UV-cured finish in the wood species, color or special order color.

1. Species/Color: Maple w/ walnut stain

2. Dimensions:

Width; 6”

Thickness: 3/8”

Length: 24” Variable: 5” – 20”

Wear layer thickness: 1/12”

Number of plys: 5PRODUCTS

3. Finish: UV cured factory applied finish.

4. Construction: Engineered multi-ply laminated construction.

5. Edge detail/End detail: %EDGE_END%

6. Milling: Tongue and groove sides, end matched.

7. Fire Ratings: Class C when tested in accordance with ASTM E84.

B. Adhesive: Hartco 57 moisture-cured adhesive.

C. Mechanical fasteners: as recommended for machine but not less than 1-3/16” in length.

8. Hardness Information- Natural wood products have no minimum hardness specifications since hardness is characteristic of the species and cannot be controlled. The most widely accepted test is the Janka Ball test (ASTM D1037-96A) and the results are only used to compare the PSI rating of one species against another. Individual values may vary due to denseness of cell structure, grain of wood, etc. Ratings refer to the hardness of the face species only.

2.03 ACCESSORIES

A. Transition Strips:

1. Tee-transistion strip: **10 linear feet**
2. End- Transition trim: **40 linear feet**.

3.01 EXAMINATION

A. Concrete Subfloor

1. Verify that the substrate is clean and free of laitance, loose material, grease, oil,

coatings and other contaminants that will interfere with the bonding of the

adhesive. Concrete surface sealers must be removed if present.

2. Verify that the substrate is flat, smooth, free from cracks, holes, and ridges and other

defects impairing performance or appearance.

3. Verify that new slab cure is a minimum of 30 days, preferably 60 days.

4. Verify the concrete is visually sound and dry. Calcium Chloride Moisture Tests

(ASTM F1869) must be performed for warranty consideration. Using Hartco 57 in direct to concrete applications moisture vapor transmission must not exceed 3 lbs./1000 square feet/24 hrs. If vapor transmission rate exceeds 3 lbs/1000 square feet/24hrs and is less than 12 lbs./1000 square feet/24hrs. apply Armstrong VapArrest moisture retardant system as directed.

5. Concrete Alkalinity: Verify that pH levels of the concrete are 5-10 (ASTM F710).

B. Wood Subfloors

1. Must be dry, clean, structurally sound, flat to within 3/16" in 10 ft., well nailed and/or glued, free of voids and with flat joint alignment.

2. Ensure that all nail heads are set flush with or below surface.

3. Must be sanded smooth to remove varnish, high edges, chips, or other contaminants. Use thick 5/8" (16mm) or 3/4" (19mm) APA-CDX grade underlayment plywood or equivalent. Allow 1/8"-1/4" (3,2-6,4mm) expansion space between sheets with staggered joints.

4. Leave 3/4" (19mm) minimum expansion space at all vertical obstructions.3

C. All Subfloors

1. Coordinate work with that of other trades prior to installation so that no discrepancies may exist with installation of doors, frames, saddles, floor drains or any materials that would interfere in any other way.

2. Notify Architect of moisture test results and any unsatisfactory conditions. Do not begin installation until unsatisfactory conditions have been corrected. Beginning of installation means substrate and job site conditions have been accepted as suitable. Do not begin installation until unsatisfactory conditions have been corrected. Beginning of installation means substrate and job site conditions have been accepted as suitable. Failure to call attention to defects or imperfections will be construed as acceptance and approval of the sub-floor. Installation indicates acceptance of substrates with regard to conditions existing at the time of installation.

3.02 PREPARATION

A. Scour all concrete surfaces, except when using floating method, using 3 ½ open coat (20 grit) sand paper.

B. Sweep and vacuum substrate, and ensure that surface is free of oil, grease, wax, dust, or any other foreign substances.

C. Use Armstrong S-194 Patch, Underlayment and Embossing Leveler with S-195 Latex Underlayment Additive to patch cracks, holes and depressions of small areas. Sand and/or scour patched areas smooth after material is cured. Use only quality materials and products which do not contain gypsum.

D. If approved self-leveling underlayments are used, they must dry sufficiently (run moisture test) and be sanded smooth before installing floor. Armstrong is not responsible for strength, adhesion, or general performance of underlayments as proper compounding andpreparation of subsurface is the responsibility of the installer.

3.03 INSTALLATION

NOTE: A direct-bond (glue or mechanical fastener) or floating installation must be specified. Complete installation instructions for both types of installations are included in each carton of hardwood flooring.

A. Floating floor will utilize Armstrong 2-1 foam underlayment.

B. Follow manufacturer's installation instructions supplied in each carton of material.

C. Spread adhesive using recommended trowel per manufacturer's instructions.

D. Always install while adhesive is still wet.

E. Spread adhesive only over surface that can be finished within working time of adhesive.

F. It is extremely important to remove excess adhesive while still fresh. Use Hartco 57 adhesive remover. Cured adhesive cannot be removed.

G. Install trim, molding and transition strips per manufacturer's installation instructions.

3.04 PROTECTION

A. Protect finished floor from abuse by other trades using heavy Kraft paper or equivalent.

Keep traffic out of spaces and areas where flooring is being installed until adhesive has set. Light foot traffic after 10-12 hours. Normal traffic after 24 hours.

3.05 CLEANING AND MAINTENANCE

A. Reference Section 01 74 00: Cleaning and Waste Management

1. Repair or replace damaged installed products.
2. Clean installed products in accordance with manufactuer's instructions.

END OF SECTION

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SECTION 09 91 13 - EXTERIOR PAINT AND COATINGS

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS (NEED TO INCLUDE SOMETHING ABOUT CERAMIC PAINTING) CHECK NOTES

- SECTION INCLUDES
    - Exterior paint and coatings systems including surface preparation.
- RELATED SECTIONS
    - Section 06 20 00 - Finish Carpentry.
    - Section 06 40 00 - Architectural Woodwork.
    - Section 08 11 13.16 - Custom Hollow Metal Doors and Frames.
    - Section 09 21 16.23 - Gypsum Board Shaft Wall Assemblies.

PART 2 - PRODUCTS

2.01 EXTERIOR COATING

- REFERENCES
    - Material Safety Data Sheets / Environmental Data Sheets: Per manufacturer's MSDS/EDS for specific VOCs (calculated per 40 CFR 59.406). VOCs may vary by base and sheen.
    - South Coast Air Quality Management District (SCAQMD): Rule 1113 - Architectural Coatings.
    - Green Seal, Inc.:
        - GS-11 Standard for Paints and Coatings.(1st Edition, May 20,1993)
        - GC-03 - Environmental Criteria for Anti-Corrosive Paints.
    - United States Green Building Council (USGBC): LEED-09 NC/CI/CS.
- SUBMITTALS
    - Submit under provisions of Section 01 30 00 - Administrative Requirements.
    - Product Data: For each paint system indicated, including.
        - Product characteristics.
        - Surface preparation instructions and recommendations.
        - Primer requirements and finish specification.
        - Storage and handling requirements and recommendations.
        - Application methods.
        - Cautions for storage, handling and installation.
    - Selection Samples: Submit a complete set of color chips that represent the full range of manufacturer's products, colors and sheens available.
    - Verification Samples: For each finish product specified, submit samples that represent actual product, color, and sheen.

- Only submit complying products based on project requirements (i.e. LEED). One must also comply with the regulations regarding VOCs (CARB, OTC, SCAQMD, LADCO). To ensure compliance with district regulations and other rules, businesses that perform coating activities should contact the local district in each area where the coating will be used.

- QUALITY ASSURANCE

    - Installer Qualifications: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

    - Paint exposed surfaces. If a color of finish, or a surface is not specifically mentioned, Architect will select from standard products, colors and sheens available.

    - Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels unless indicated.

    - Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
        - Finish surfaces for verification of products, colors and sheens.
        - Finish area designated by Architect.
        - Provide samples that designate primer and finish coats.
        - Do not proceed with remaining work until the Architect approves the mock-up.

- DELIVERY, STORAGE, AND HANDLING

    - Delivery: Deliver manufacturer's unopened containers to the work site. Packaging shall bear the manufacturer's name, label, and the following list of information.
        - Product name, and type (description).
        - Application and use instructions.
        - Surface preparation.
        - VOC content.
        - Environmental handling.
        - Batch date.
        - Color number.

    - Storage: Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

    - Store materials in an area that is within the acceptable temperature range, per manufacturer's instructions. Protect from freezing.

    - Handling: Maintain a clean, dry storage area, to prevent contamination or damage to the coatings.

- PROJECT CONDITIONS

    - Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

- EXTRA MATERIALS
    - Furnish extra paint materials from the same production run as the materials applied and in the quantities described below. Package with protective covering for storage and identify with labels describing contents. Deliver extra materials to Owner.
    - Furnish Owner with an additional one percent of each material and color, but not less than 1 gal (3.8 l) or 1 case, as appropriate.
- PRODUCTS
- MANUFACTURERS
    - Acceptable Manufacturer: Vista Paint, which is located at: 101 Prospect Ave.; Cleveland, OH 44115; Toll Free Tel: 800-524-5979; Tel: 216-566-2000; Fax: 440-826-1989; Email: request info (specifications@sherwin.com); Web: www.sherwin-williams.com/pro/services/architects_designers/?WT.mc_id=SWRedirect_ProServices_Architects
    - Acceptable Manufacturer: Sherwin-Williams, which is located at: 101 Prospect Ave.; Cleveland, OH 44115; Toll Free Tel: 800-524-5979; Tel: 216-566-2000; Fax: 440-826-1989; Email: request info (specifications@sherwin.com); Web: www.sherwin-williams.com/pro/services/architects_designers/?WT.mc_id=SWRedirect_ProServices_Architects
    - Requests for substitutions will be considered in accordance with provisions of Section 01 60 00 - Product Requirements.
- APPLICATIONS/SCOPE
    - Exterior Paints and Coatings:
        - Concrete: Cementitious siding, flexboard, transite, and shingles (non-roof).
        - Masonry: Concrete masonry units, cinder or concrete block.
        - Concrete: Concrete floors, patios, porches, steps and platforms,(Non-Vehicular)
        - Metal: Aluminum, galvanized steel.
        - Metal: Miscellaneous iron, ornamental iron, ferrous metal.
        - Wood: Floors(non-vehicular), and platforms.
        - Wood: Siding, trim, shutters, sash, and miscellaneous hardboard.
        - Architectural PVC, plastic, fiberglass.
        - Drywall: Gypsum board, and exterior drywall.
        - Vinyl: Siding, EIFS, synthetic stucco.
- PAINT MATERIALS - GENERAL
    - Paints and Coatings.
        - Unless otherwise indicated, provide factory-mixed coatings. When required, mix coatings to correct consistency in accordance with manufacturer's instructions before application. Do not reduce, thin, or dilute coatings or add materials to coatings unless such procedure is specifically described in manufacturer's product instructions.
        - For opaque finishes, tint each coat including primer coat and intermediate coats, one-half shade lighter than succeeding coat, with final finish coat as

base color. Or follow manufactures product instructions for optimal color conformance.

- Primers: Where the manufacturer offers options on primers for a particular substrate, use primer categorized as "best" by the manufacturer.

- Coating Application Accessories: Provide all primers, sealers, cleaning agents, cleaning cloths, sanding materials, and clean-up materials required, per manufacturer's specifications.

- Color: Refer to Finish Schedule for paint colors, and as selected.

- LEED Requirements: Products in compliance with requirements of IEQ Credit 4.2 USGBC LEED-09 NC/CI/CS.

- EXTERIOR PAINT SYSTEMS

  - WOOD: Siding, Trim, Shutters, Sashes, Hardboard-Bare/Primed.
    - Stain/Paint - Water Reducible Systems:
      - Semi-Transparent or Paint

- EXAMINATION

  - Do not begin installation until substrates have been properly prepared; notify Architect of unsatisfactory conditions before proceeding. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

  - Proceed with work only after conditions have been corrected and approved by all parties, otherwise application of coatings will be considered as an acceptance of surface conditions.

  - Previously Painted Surfaces: Verify that existing painted surfaces do not contain lead based paints, notify Architect immediately if lead based paints are encountered.

- SURFACE PREPARATION

  - General: Surfaces shall be dry and in sound condition. Remove oil, dust, dirt, loose rust, peeling paint or other contamination to ensure good adhesion.
    - Remove mildew before painting by washing with a solution of 1 part liquid household bleach and 3 parts of warm water. Apply the solution and scrub the mildewed area. Allow the solution to remain on the surface for 10 minutes. Rinse thoroughly with clean water and allow the surface to dry a minimum of 48 hours before painting. Wear protective glasses or goggles, waterproof gloves, and protective clothing. Quickly wash off any of the mixture that comes in contact with your skin. Do not add detergents or ammonia to the bleach/water solution.
    - Remove items including but not limited to thermostats, electrical outlets, switch covers and similar items prior to painting. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.
    - No exterior painting should be done immediately after a rain, during foggy weather, when rain is predicted, or when the temperature is below 50 degrees F (10 degrees C), unless products are designed specifically for these conditions. On large expanses of metal siding, the air, surface and

material temperatures must be 50 degrees F (10 degrees F) or higher to use low temperature products.

- Cement Composition Siding/Panels: Remove all surface contamination by washing with an appropriate cleaner, rinse thoroughly and allow to dry. Existing peeled or checked paint should be scraped and sanded to a sound surface. Pressure clean, if needed, with a minimum of 2100 psi pressure to remove all dirt, dust, grease, oil, loose particles, laitance, foreign material, and peeling or defective coatings. Allow the surface to dry thoroughly. The pH of the surface should be between 6 and 9, unless the products are designed to be used in high pH environments.

- Exterior Composition Board (Hardboard): Some composition boards may exude a waxy material that must be removed with a solvent prior to coating. Whether factory primed or unprimed, exterior composition board siding (hardboard) must be cleaned thoroughly and primed with an alkyd primer.

- Drywall - Exterior: Must be clean and dry. All nail heads must be set and spackled. Joints must be taped and covered with a joint compound. Spackled nail heads and tape joints must be sanded smooth and all dust removed prior to painting. Exterior surfaces must be spackled with exterior grade compounds.

- Plaster: Must be allowed to dry thoroughly for at least 30 days before painting, unless the products are designed to be used in high pH environments. Room must be ventilated while drying; in cold, damp weather, rooms must be heated. Damaged areas must be repaired with an appropriate patching material. Bare plaster must be cured and hard. Textured, soft, porous, or powdery plaster should be treated with a solution of 1 pint household vinegar to 1 gallon of water. Repeat until the surface is hard, rinse with clear water and allow to dry.

- Wood: Must be clean and dry. Prime and paint as soon as possible. Knots and pitch streaks must be scraped, sanded, and spot primed before a full priming coat is applied. Patch all nail holes and imperfections with a wood filler or putty and sand smooth.

- INSTALLATION

  - Apply all coatings and materials with the manufacturer's specifications in mind. Mix and thin coatings according to manufacturer's recommendations.

  - Do not apply to wet or damp surfaces. Wait at least 30 days before applying to new concrete or masonry. Or follow manufacturer's procedures to apply appropriate coatings prior to 30 days. Test new concrete for moisture content. Wait until wood is fully dry after rain or morning fog or dew.

  - Apply coatings using methods recommended by manufacturer.

  - Uniformly apply coatings without runs, drips, or sags, without brush marks, and with consistent sheen.

  - Apply coatings at spreading rate required to achieve the manufacturers recommended dry film thickness.

  - Regardless of number of coats specified, apply as many coats as necessary for complete hide, and uniform appearance.

  - Inspection: The coated surface must be inspected and approved by the Architect just prior to the application of each coat.

- PROTECTION
    - Protect finished coatings from damage until completion of project.
    - Touch-up damaged coatings after substantial completion, following manufacturer's recommendation for touch up or repair of damaged coatings. Repair any defects that will hinder the performance of the coatings.

END OF SECTION

SECTION 09 91 23 - INTERIOR PAINTS AND COATINGS

GENERAL

SECTION INCLUDES:

- Interior paint,finishes and coatings systems (LEED-09 NC/CI/CS Compliant) including surface preparation.

- **RELATED SECTIONS**

  - Section 06 20 00 - Finish Carpentry.

  - Section 06 40 00 - Architectural Woodwork.

  - Section 09 21 16.23 - Gypsum Board Shaft Wall Assemblies.

- **REFERENCES**

  1. Material Safety Data Sheets / Environmental Data Sheets: Per manufacturer's MSDS/EDS for specific VOCs (calculated per 40 CFR 59.406). VOCs may vary by base and sheen.

  2. South Coast Air Quality Management District (SCAQMD): Rule 1113 - Architectural Coatings.

  3. Green Seal, Inc.:
     - GS-11 Standard for Paints and Coatings.(1st Edition, May 20,1993)
     - GC-03 - Environmental Criteria for Anti-Corrosive Paints.

  4. United States Green Building Council (USGBC): LEED-09 NC/CI/CS.

- **SUBMITTALS**

  1. Submit under provisions of Section 01 30 00 - Administrative Requirements.

  2. Product Data: For each paint system indicated, including.
     - Product characteristics.
     - Surface preparation instructions and recommendations.
     - Primer requirements and finish specification.
     - Storage and handling requirements and recommendations.
     - Application methods.
     - Cautions for storage, handling and installation.

  3. Selection Samples: Submit a complete set of color chips that represent the full range of manufacturer's products, colors and sheens available.

  4. Verification Samples: For each finish product specified, submit samples that represent actual product, color, and sheen.

  5. Only submit complying products based on project requirements (i.e. LEED). One must also comply with the regulations regarding VOCs (CARB, OTC, SCAQMD, LADCO). To ensure compliance with district regulations and other rules, businesses that perform coating activities should contact the local district in each area where the coating will be used.

- **QUALITY ASSURANCE**

    1. Installer Qualifications: A firm or individual experienced in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

    2. Paint exposed surfaces. If a color of finish, or a surface is not specifically mentioned, Architect will select from standard products, colors and sheens available.

    3. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels unless indicated.

    4. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
        - Finish surfaces for verification of products, colors and sheens.
        - Finish area designated by Architect.
        - Provide samples that designate primer and finish coats.
        - Do not proceed with remaining work until the Architect approves the mock-up.

- **DELIVERY, STORAGE, AND HANDLING**

    1. Delivery: Deliver manufacturer's unopened containers to the work site. Packaging shall bear the manufacturer's name, label, and the following list of information.
        - Product name, and type (description).
        - Application and use instructions.
        - Surface preparation.
        - VOC content.
        - Environmental handling.
        - Batch date.
        - Color number.

    2. Storage: Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

    3. Store materials in an area that is within the acceptable temperature range, per manufacturer's instructions. Protect from freezing.

    4. Handling: Maintain a clean, dry storage area, to prevent contamination or damage to the coatings.

- **PROJECT CONDITIONS**

    1. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

- **EXTRA MATERIALS**

    1. Furnish extra paint materials from the same production run as the materials applied and in the quantities described below. Package with protective covering for storage and identify with labels describing contents. Deliver extra materials to Owner.

2. Furnish Owner with an additional one percent of each material and color, but not less than 1 gal (3.8 l) or 1 case, as appropriate.

- **MANUFACTURERS**

1. Acceptable Manufacturer: Vista Paint, which is located at: 101 Prospect Ave.; Cleveland, OH 44115; Toll Free Tel: 800-524-5979; Tel: 216-566-2000; Fax: 440-826-1989; Email: request info (specifications@sherwin.com); Web: www.sherwin-williams.com/pro/services/architects_designers/?WT.mc_id=SWRedirect_ProServices_Architects

2. Acceptable Manufacturer: **Address:** 13911 Gannet St, Santa Fe Springs, CA 90670 **Phone:** (562) 921-7426; Web:http://samples.wilsonart.com/

- **APPLICATIONS/SCOPE**

1. Interior Paints and Coatings:(LEED-09 NC/CI/CS COMPLIANT)
   - Wood: Walls, ceilings, doors, trim and similar items.
   - Drywall: Drywall board, Gypsum board.
   - Marker Board: 309 Finish black

- **PAINT MATERIALS - GENERAL**

1. Paints and Coatings.
   - Unless otherwise indicated, provide factory-mixed coatings. When required, mix coatings to correct consistency in accordance with manufacturer's instructions before application. Do not reduce, thin, or dilute coatings or add materials to coatings unless such procedure is specifically described in manufacturer's product instructions.
   - For opaque finishes, tint each coat including primer coat and intermediate coats, one-half shade lighter than succeeding coat, with final finish coat as base color. Or follow manufactures product instructions for optimal color conformance.

2. Primers: Where the manufacturer offers options on primers for a particular substrate, use primer categorized as "best" by the manufacturer.

3. Coating Application Accessories: Provide all primers, sealers, cleaning agents, cleaning cloths, sanding materials, and clean-up materials required, per manufacturer's specifications.

4. Color: Refer to Finish Schedule for paint colors, and as selected.

5. LEED Requirements: Products in compliance with requirements of IEQ Credit 4.2 USGBC LEED-09 NC/CI/CS.

- **INTERIOR PAINT SYSTEMS (LEED-09 NC/CI/CS COMPLIANT)**

1. DRYWALL - (Walls, Ceilings, Gypsum Board and similar items)
   - Medium to Light Texture
   - Latex Systems:
     - 1st Coat: S-W ProMar 200 Zero VOC Interior Latex Primer, B28W2600 (4 mils wet, 1.5 mils dry).
     - 2nd Coat: S-W ProMar 200 Zero VOC Latex Flat, B30-2600 Series.

- 3rd Coat: S-W ProMar 200 Zero VOC Latex Flat, B30-2600 Series (4 mils wet, 1.6 mils dry per coat).

- **EXAMINATION**

1. Do not begin installation until substrates have been properly prepared; notify Architect of unsatisfactory conditions before proceeding. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

2. Proceed with work only after conditions have been corrected and approved by all parties, otherwise application of coatings will be considered as an acceptance of surface conditions.

3. Previously Painted Surfaces: Verify that existing painted surfaces do not contain lead based paints, notify Architect immediately if lead based paints are encountered.

- **SURFACE PREPARATION**

1. General: Surfaces shall be dry and in sound condition. Remove oil, dust, dirt, loose rust, peeling paint or other contamination to ensure good adhesion.
    - Remove mildew before painting by washing with a solution of 1 part liquid household bleach and 3 parts of warm water. Apply the solution and scrub the mildewed area. Allow the solution to remain on the surface for 10 minutes. Rinse thoroughly with clean water and allow the surface to dry a minimum of 48 hours before painting. Wear protective glasses or goggles, waterproof gloves, and protective clothing. Quickly wash off any of the mixture that comes in contact with your skin. Do not add detergents or ammonia to the bleach/water solution.
    - Remove items including but not limited to thermostats, electrical outlets, switch covers and similar items prior to painting. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.
    - No exterior painting should be done immediately after a rain, during foggy weather, when rain is predicted, or when the temperature is below 50 degrees F (10 degrees C), unless products are designed specifically for these conditions. On large expanses of metal siding, the air, surface and material temperatures must be 50 degrees F (10 degrees F) or higher to use low temperature products.

2. Cement Composition Siding/Panels: Remove all surface contamination by washing with an appropriate cleaner, rinse thoroughly and allow to dry. Existing peeled or checked paint should be scraped and sanded to a sound surface. Pressure clean, if needed, with a minimum of 2100 psi pressure to remove all dirt, dust, grease, oil, loose particles, laitance, foreign material, and peeling or defective coatings. Allow the surface to dry thoroughly. The pH of the surface should be between 6 and 9, unless the products are designed to be used in high pH environments.

3. Drywall - Interior: Must be clean and dry. All nail heads must be set and spackled. Joints must be taped and covered with a joint compound. Spackled nail heads and tape joints must be sanded smooth and all dust removed prior to painting.

4. Plaster: Must be allowed to dry thoroughly for at least 30 days before painting, unless the products are designed to be used in high pH environments. Room must be ventilated while drying; in cold, damp weather, rooms must be heated. Damaged areas must be repaired with an appropriate patching material.

Bare plaster must be cured and hard. Textured, soft, porous, or powdery plaster should be treated with a solution of 1 pint household vinegar to 1 gallon of water. Repeat until the surface is hard, rinse with clear water and allow to dry.

5. Wood: Must be clean and dry. Prime and paint as soon as possible. Knots and pitch streaks must be scraped, sanded, and spot primed before a full priming coat is applied. Patch all nail holes and imperfections with a wood filler or putty and sand smooth.

- **INSTALLATION**

    1. Apply all coatings and materials with the manufacturer's specifications in mind. Mix and thin coatings according to manufacturer's recommendations.

    2. Do not apply to wet or damp surfaces. Wait at least 30 days before applying to new concrete or masonry. Or follow manufacturer's procedures to apply appropriate coatings prior to 30 days. Test new concrete for moisture content. Wait until wood is fully dry after rain or morning fog or dew.

    3. Apply coatings using methods recommended by manufacturer.

    4. Uniformly apply coatings without runs, drips, or sags, without brush marks, and with consistent sheen.

    5. Apply coatings at spreading rate required to achieve the manufacturers recommended dry film thickness.

    6. Regardless of number of coats specified, apply as many coats as necessary for complete hide, and uniform appearance.

    7. Inspection: The coated surface must be inspected and approved by the Architect just prior to the application of each coat.

- **PROTECTION**

    1. Protect finished coatings from damage until completion of project.

    2. Touch-up damaged coatings after substantial completion, following manufacturer's recommendation for touch up or repair of damaged coatings. Repair any defects that will hinder the performance of the coatings.

END OF SECTION

SECTION 102800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.01 SECTION REQUIREMENTS

A. Submittals: Product Data.

PART 2 - PRODUCTS

2.01 TOILET AND BATH ACCESSORIES

A. Manufacturers: Project Source

1. Basis-of-Design: Product indicated on Drawings or Architect approved equal.

B. Product Detail:

1. Basis-of-Design: Project Source Seton Model# 297-0001.
    a. Toilet Tissue Dispenser
    b. Robe Hook
    c. Towel Bar
    d. Towel Ring
2. Mounting: Per manufacturer's installation guide.
3. Material and Finish: Polished chrome

2.02 MATERIALS

A. Stainless Steel: ASTM A 666, Type 304, No. 4 finish (satin), 0.0312-inch (0.8-mm) minimum nominal thickness unless otherwise indicated.

C. Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6063-T6 or 6463-T6.

D. Sheet Steel: ASTM A 1008/A 1008M, 0.0359-inch (0.9-mm) minimum nominal thickness.

E. Galvanized-Steel Sheet: ASTM A 653/A 653M, G60 (Z180).

F. Chromium Plating: ASTM B 456, Service Condition Number SC 2 (moderate service).

G. Baked-Enamel Finish: Factory-applied, gloss-white, baked-acrylic-enamel coating.

H. Galvanized-Steel Mounting Devices: ASTM A 153/A 153M, hot-dip galvanized after fabrication.

I. Fasteners: Screws, bolts, and other devices of same material as accessory unit, tamper and theft resistant when exposed, and of galvanized steel when concealed.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install accessories using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Adjust accessories for unencumbered, smooth operation and verify that mechanisms function properly. Replace damaged or defective items. Remove temporary labels and protective coatings.

END OF SECTION

SECTION 10 71 13 - EXTERIOR SUN CONTROL DEVICES

PART 1 GENERAL

1.1 SUMMARY

A. Work of this Section includes fabric awnings and metal awning frames systems.

1.2 RELATED SECTIONS

1. Section 06200 – Finish Carpentry

1.3 REFERENCES

A. A. Structural welding code steel AWS D1.1
B. B. Structural welding code steel AWS D1.2
C. C. General contractors license in the states of California, Nevada and Arizona.
D. D. Los Angeles City Approved Fabricators license.
E. E. Worker's Compensation Insurance certificate.
F. F. General liability insurance certificate in excess of $4 million.
G. G. Vehicle insurance certification.

1.4 SUBMITTALS

A. A. General: Submit each item in this article according to the Condition of the contract and Division 1 Specification Sections.
B. B. Shop Drawings: Show shop and erection details, including cut, copes, connections holes and welds. Show welds, both shop and field, by the current recommended symbols of the AWS. Do not fabricate members until shop drawings have been reviewed.
C. C. Include engineering calculations showing wind load requirements of the local Building Department and include fastener and erection details, signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 QUALITY ASSURANCE

Requirements of Awning manufacturer and Awning Contractor, contractor must provide proof of certifications:

A. Have been in continuous operation as a professional fabric awning manufacturer for a minimum of ten (10) years prior to this contract.
B. Hold a valid general contractor's license for a minimum of five (5) years.
C. Welder Qualifications: The personnel manufacturing the metal awning frames must certified welders.
D. Provide written welding procedure specifications.
E. Professional Engineer Qualifications: A professional engineer who is legally authorized to practice in the jurisdiction where project is located and who is experienced in providing engineering services for installing fabric awnings similar to those indicated fro this project and with a record of successful in service performance.
F. OSHA 10 Hour Construction Industry Certified Training.
G. OSHA Fall Protection Training.
H. Job site installation crew must include one CPR trained member on the job site at all times of the installation.
I. The installation crews must have a copy of the awning company's Code of Safety practices at the job site during times of installation.

J. Hold daily Safety Tail Gate Meetings before start of installation work.
K. When forklifts are used at the job site, the operator must be Fork Lift Operation Trained.
L. N. The awning fabricator must provide proof they have an ongoing written Quality Assurance program for five (5) years or more.
M. The awning fabricator must provide proof of it full-time Quality Assurance manager.
N. The awning manufacturer must provide proof of $4 million general liability insurance coverage.
O. The awning manufacturer must provide proof of workers compensation insurance coverage.
P. It is recommended that the awning contractor be a current member of a professional trade association, i.e., Professional Awning Manufacturers Association, the Western Canvas Products Association or other established related trade association.

1.6 WARRANTY

A. A. Warrant frame materials and workmanship against defects for a period of one (1) year from date of substantial completion of the Work.
B. B. Warrant fabric materials and workmanship against defects for a minimum period of five (5) years, on a prorated basis, from the date of substantial completion of the work and/or offer the same warranty offered by the fabric mill that manufactured or supplied the fabric.

PART 2 PRODUCTS

2.1 AWNING MANUFACTURERS

A. Approved Manufacturers:
1. Eide Industries, Inc.
2. Skyco Inc.
3. J. Miller Canvas

2.2 AWNINGS

A. A. Awning shapes:
B. 1. Patio Canopy
C. B. Fabric: 100 percent acrylic fiber, color as selected by Architect, manufactured exterior grade fabric awning material that carries a minimum five (5) year manufacturer's warranty. Based on the city's requirements, the architect is to specify if the fabric must be flame retardant to meet California Fire Marshal requirements or equal.
D. C. Frames: Minimum 1-inch square 16GA galvanized steel ASTM A 500 tubing or 1" square .125 ASTM B 221 aluminum tubing, welding to AWS standards with welds ground smooth. Frames designed for wind loads, snow loads and seismic requirements as required by structural engineering requirements.
E. D. Frames: All corners are to be mitered or completely welded to AWS standards.
F. E. Metal welding: All joints must be mitered or completely welded to AWS standards, ground smooth, primed and painted.
G. Use Aluminum Awning Rail molding to attach fabric cover to head bar.
H. G. Anchors: Anchoring hardware shall be galvanized, zinc-coated 3/8" diameter or greater.
I. H. Painting: Two coats of polyester powder coat required when the awning installation is within 4 miles of the ocean or Painting: Shop primer shall conform to FS TT-P-615d (2). Type 1. Use Rustoleum brand paint 2185 zinc –rich spray when further than 4 miles from the ocean.
J. I. Caulking: Acrylic latex or silicone sealant at head bar and wall junction.

K. J. Use aluminum side molding to attach material to head bars.
L. K. Sewing tread, must be Gore Tenara® brand or equal.

2.3 FABRICATION

A. A. Fabricate awning and frames in strict accordance with the reviewed shop drawings, written welding procedure specifications and the reference standards.
B. Awning Frame Finish: Frames and metal components are to be polyester powder coat painted.

PART 3 INSTALLATION

3.1 INSTALLATION

A. Minimum ten (10) years awning installation experience required by the awning contractor.
B. Buildings are to be field measured by the awning contractor prior to awning manufacture and awning installation.
C. Install awnings and frames in strict accordance with the Drawings and the reviewed shop drawings, and provide appropriate building code requirements and aligned and plumb.
D. Welding procedures and operation shall comply with the referenced standard. Welding electrodes shall comply with ASTM A 233, E-70 Series. Grind smooth exposed welds; finish welds to the inside.
E. Installation firm must hold a current contractor's license.

END OF SECTION

SECTION 113100 - RESIDENTIAL APPLIANCES

PART 1 GENERAL

1.01. SUMMARY

A. Section Includes:

1. Clothes care.
2. Oven.
3.Hot Water Faucet.
3. Dishwasher.
4. Refrigerator.
5. Ranges.
6. Vent hood.
7. Kitchenette

B. Related Sections: Section(s) related to this section include:

1. Section 12 35 30 Residential Casework.
2. Section 12 36 00 Countertops.
3. Section 22 11 16 Domestic Water Piping.

1.02. QUALITY ASSURANCE

A. Product testing of each appliance to be undertaken on IVC campus.

1.03. DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials from package retailer or other source to Team OC build site.

B. Transportation to Competition: Ship installed unless otherwise noted.

1.04. WARRANTY

A. Product Warranty: Refer to Conditions of the Contract for purchase warranty provisions.

PART 2 PRODUCTS

2.01. PRODUCT INFORMATION

A. Clothes Care

1. Washers
    a. Basis of design: Energy Star compliant front load washer equal or equivalent to
        (a) Manufacturer: Bosch
        (b) Model: Ascenta Series-WAP24200UC
2. Dryers
a. Basis of design: Energy Star compliant electric dryer equal or equivalent to
        (a) Manufacturer: Safemate
        (b) Model: Hybrid/Solar Electric Clothes Dryer- HYE3500CGEED

B. Range/ Oven

1. Slide-in induction cooktop and oven
    a. Basis of design: Provide built-in range and oven equal or equivalent to
        (a) Manufacturer: Bosch
        (b) Model: 30" Induction Slide-in Range Benchmark™ Series - HIIP054U

C. Dishwashers

1. Built-in Dishwasher.
    a. Basis of design: Provide built-in dishwasher equal or equivalent to
        (a) Manufacturer: Bosch
        (b) Model: 24" Bar Handle Dishwasher Benchmark™ Series- SHX9PT55UC

D. Refrigerator

1. Top-Freezer Refrigerators
a. Basis of design: Provide Energy Star compliant refrigerator equal or equivalent to
(a) Manufacturer: Bosch
(b) Model: 24" Counter-Depth Bottom-Freezer 500 Series-B11CB50SSS

F. Vent Hood
1. Under Cabinet Ventilation
a. Basis of design: Provide ventilation equal or equivalent to
(a) Manufacturer: Bosch
(b) Model: 29" Custom Insert Hood Custom Ventilation - DHL755BUC

G. Kitchenette
1. All-in-one kitchenette
a. Basis of design: Provide all-in-one kitchen unit equal or equivalent to
(a) Manufacturer: Summit
(b) Model: 48" wide all-in-one kitchenette with two coil burners, a cycle defrost refrigerator-freezer, sink, and storage cabinet-C48EL

2.02. ACCESSORIES

A. Plumbing connections per appliance specs.
B. Electrical connections per appliance specs.
C. Mounting brackets and fasteners per casework design.

PART 3 EXECUTION

3.01. INSTALLERS

A. All appliances installed by student labor with electrical and plumbing connections installed by or under proper supervision of licensed electrician/plumber.

3.02. EXAMINATION

A. All appliance connections and project plumbing/electrical systems approved by licensed electrician/plumber before appliance testing.

3.03. INSTALLATION

A. General Conditions:
1. Properly prepare substrates and coordinate casework rough-in work before installation
2. Thoroughly clean and prepare surfaces in accordance to manufacturer recommendations prior to installation.

B. Installation Procedure
1. Securely mount to substrate.
2. Install appliances plumb and level and in proper relationship to adjacent construction.
3. Connect appliances to building utility, supply and waste systems as applicable.
4. Test for proper operation and drainage. Adjust until proper operation is achieved.

3.04. RELOCATION CONSIDERATIONS

A. Shipping and on-site commissioning
1. Place protective coverings on appliances during shipping and keep appliances covered until ready for on-site commissioning

B. Repair, touch up, or replace
1. Identify damage and assess proper course of action before Substantial Completion.

3.05. SITE QUALITY CONTROL

A. Prior to powering on:

1. Project electrical and plumbing systems have been inspected by licensed electrician/plumber.

2. All appliance connections and installations are to be inspected against a checklist of inspection inventory by student labor or licensed electrician or plumber per requirement.

3.06. COMMISSIONING

A. Upon proper connection and systems inspections all appliances are to have their entire use cycle tested.

END OF SECTION

SECTION 123600 - ENGINEERED QUARTZ

PART 1- GENERAL

1.1 SUMMARY

A. Section Includes: Engineered Quartz countertops.

B. Products:
1. Kitchen Countertops - TM Difiniti Silver Lake
2. Studio Backsplash - Wilsonart Via Augusta Q4024

1.2 REFERENCES

A. ASTM International

1. ASTM C97 – Absorption and Bulk Specific Gravity of Dimension Stone
2. ASTM C99 – Modulus of Rupture of Dimension Stone
3. ASTM C170 – Compressive Strength of Dimension Stone
4. ASTM C217 – Weather Resistance of Slate
5. ASTM C482 – Bond Strength of Ceramic Tile to Portland Cement
6. ASTM C484 – Thermal Shock Resistance of Glazed Ceramic Tile
7. ASTM C501 – Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser
8. ASTM C531 – Linear Shrinkage and Coefficient of Thermal Expansion of Chemical- Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes
9. ASTM C880 – Flexural Strength of Dimension Stone
10. ASTM C1026 – Resistance of Ceramic Tile to Freeze-Thaw Cycling
11. ASTM C1028 – Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method
12. ASTM C1243 – Relative Resistance to Deep Abrasive Wear of Unglazed Ceramic Tile by Rotating Disc
13. ASTM D256 – Izod Pendulum Impact Resistance of Plastics
14. ASTM D2047 – Static Coefficient of Friction of Polish-Coated Floor Surfaces by the James Machine
15. ASTM E84 – Surface Burning Characteristics of Building Materials

B. American National Standards Institute (ANSI)

1. ANSI Z124.6 – Stain Resistance
2. ANSI/N 42.14 – Radiation

C. National Electrical Manufacturers Association (NEMA)

1. NEMA LD3-3.5 – Boiling Water Resistance
2. NEMA LD 3-3.6 – High Temperature Resistance

D. ISO (International Organization for Standardization)

1. ISO 9002 – Model for Quality Assurance in Production
2. ISO 14001 – Environmental Management Systems

E. Others

1. NSF – ANSI/NSF Standard 51
2. MEA – New York Materials and Equipment Acceptance
3. OHSAS – 18001- Occupational Health & Safety System
4. GREENGUARD – “Children and Schools”
5. SCS – Certified recycled content
6. Kosher

1.3 SUBMITTALS

A. Shop Drawings: Include layout, dimensions, materials, finishes, cutouts, and attachments.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Contract Documents are based on products by Terrazzo & Marble Supply Co. and Wilsonart

B. Substitutions: [Under provisions of Division 01.] [Not permitted.]

2.2 MATERIALS

A. Quartz Sheet:
   1. Product: DIFINITI.
   2. Composition: 93% quartz, granite or recycled glass held together with a pigmented binder. Including some of nature's strongest minerals, DIFINITI™ is resistant to stains and scratches.
   3. Color: Silver Lake
   4. Thickness: 2 cm
   5. Finish: Polished
   6. Physical characteristics:
      a. Physical characteristics to meet all of the performance criteria of DIFINITI with regard to physical strength, chemical resistance, ease of maintenance and appearance.

B. Quartz Sheet:
   1. Product: Wilsonart Quartz.

   2. Composition: 93 percent quartz aggregate combined with polyester resin binders and proprietary pigments that are fabricated into slabs using vacuum vibrocompaction technology.
   3. Color: Augusta Q4024
   4. Thickness: 2 cm
   5. Finish: Polished

2.3 ACCESSORIES

A. Adhesive: Type recommended by quartz manufacturer.
   1. Epoxy or Polyester Adhesive tinted to match quartz surface: Akemi Professional Stone Products

2.4 FABRICATION

A. Cut quartz panels accurately to required shapes and dimensions.

B. Radius exposed edges.

C. Fabricate with hairline joints.

D. Cut holes for sink and faucets.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean surfaces to receive fabrications; remove loose and foreign matter than could interfere with adhesion.

3.2 INSTALLATION

A. Install fabrications in accordance with manufacturer’s instructions and approved Shop Drawings.

B. Adhere fabrications with continuous beads of adhesive.

C. Set plumb and level. Align adjacent pieces in same plane.

D. Install with hairline joints.

E. Fill joints between fabrications and adjacent construction with joint sealer; finish smooth and flush.

3.3 INSTALLATION TOLERANCES

A. Maximum variation from level and plumb: 1/8 inch in 10 feet, noncumulative.

B. Maximum variation in plane between adjacent pieces at joint: Plus or minus 1/16 inch.

3.4 CLEANING

A. Clean fabrications in accordance with manufacturer's instructions.

3.5 PROTECTION

A. Protect installed fabrications with nonstaining sheet coverings.

END OF SECTION

SECTION 123530 - RESIDENTIAL CASEWORK

PART 1 PRODUCTS

1.01 COMPONENTS

A. Cabinet Construction: CLEAF Thermal Structured Surface boards tempered hardboard gables.

1. 5/8” Full top construction
2. 1/8” back panel with 5/8” fastening strips behind
3. Integrated cut-out finger pull. Shape is routed into an applied solid-wood edging. Use stock at least 1-1/2 in. wide. Result in a nearly 1-in. space for fingers.

B. Inside construction: CLEAF Thermal Structured Surface boards bonded to 5/8” industrial grade particleboard case construction and shelves, solid color PVC banding on all case edges with banding on finished sides.

1. Base cabinets have 5/8” shelves full in depth and are adjustable on steel shelf pins
2. Doors attach with 100 degree opening soft close hinges; door/ drawer bumpers permanently attached

1.02 HARDWARE

A. Concealed hardwood dowel joinery where sides meet tops and bottoms

B. 5/8” fastening strips behind

C. Steel shelf pins

D. Gloss high pressure plastic laminate with two-tone edge banding with face color being 1/4" thick.

1.03 FABRICATION

A. Shop assemble casework for delivery to site in units easily handled and to permit passage through building openings.

B. Fabricate corners and joints without gaps or inaccessible spaces or areas where dirt or moisture could accumulate.

1.04 FINISHES

A. Metro CLEAF Thermal Structured Surface boards

1. Decorative papers that are treated with melamine resins that under heat and pressure become part of the panel itself hence, Thermo Structured Surface (TSS).
2. Application of an irreversible thermal hardening treatment and the special preparation and processing, allow remarkable 3dimensional effects, bringing the surface to life and endowing it with extraordinary technical performance.

END OF SECTION

SECTION 21 13 13 – WET – PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Design, installation and testing shall be in accordance with NFPA 13d or IRC P2904 except for specified exceptions.

B. The design and installation of a hydraulically calculated automatic wet system complete and ready for operation for entire project

C. Related Sections

1. Section 22 11 16: Domestic Water Piping.
2. Section 22 11 23: Domestic Water Pumps.

1.2 REFERENCES

A. National Fire Protection Association (NFPA):

1. 13-2002 Installation of Sprinkler Systems
2. 101-22003 Safety to Life from Fire in Buildings and Structures (Life Safety Code)
3. 170-1999 Fire Safety Symbols

B. Underwriters Laboratories, Inc. (UL):

C. Factory Mutual Engineering Corporation (FM):

1. Approval Guide – 2001

D. Uniform Building Code – 1997

E. Foundation for Cross-Connection Control and Hydraulic Research-2005.

1.3 SUBMITTALS

A. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to NFPA 13. Include a site plan showing the piping to the water supply test location.

B. Manufacturers Data Sheets:

1. For backflow preventers, provide flow test curves from UL, FM, or the Foundation for Hydraulic Research and Cross-Connection Control to verify pressure loss calculations.
2. Provide for materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data sheet describes items in addition to that item being submitted, clearly identify proposed item on the sheet.

1.4 QUALITY ASSURANCE

A. Materials and Equipment: All equipment and devices shall be of a make and type listed by UL and approved by FM, or other nationally recognized testing laboratory for the specific purpose for which it is used. All materials, devices, and equipment shall be approved by the VA.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Products should be carefully stored prior to installation.

PART 2 PRODUCTS

2. PRODUCT INFORMATION

A. Manufacturer:

1. To Be Decided.

B. Piping and Fittings

1. Sprinkler systems in accordance with NFPA 13. Use nonferrous piping in MRI Scanning Rooms.
2. CPVC Tubing shall be used for Piping.

C. Sprinklers:

1. Model to be decided.

D. Valves

1. Valves in accordance with NFPA 13.
2. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves

3. The wet system control valve shall be a listed indicating type valve. Control valve shall be UL
Listed and FM Approved for fire protection installations. System control valve shall be rated for
normal system pressure but in no case less than 175 PSI. (No Substitutions Allowed).
4. Alarm valve shall be UL Listed and Factory Mutual Approved. The alarm valve shall be equipped with a removable cover assembly. The alarm valve shall be listed for installation in the
vertical or horizontal position. The alarm valve shall be equipped with gauge connections on the

system side and supply side of the valve clapper. The alarm valve shall be equipped with an
external bypass to eliminate false water flow alarms. The alarm valve trim piping shall be
externally galvanized. Maximum water working pressure to 250 PSI.
5. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends
threaded with iron pipe threads.

E. Fire Department Siamese Connection
1. Brass, flush wall type, exterior fire department connection with brass scutcheon plate, and a minimum of two 65 mm (2-1/2 inch) connections threaded to match those on the local fire protection service, with polished brass caps and chains. Provide escutcheon with integral raised letters "Automatic Sprinkler". Install an automatic ball drip between fire department connection and check valve with drain piping routed to the exterior of the building or a floor drain.

F. Gauges
1. Provide gauges as required by NFPA 13.

2.02. PRODUCT SUBSTITUTIONS

A. No substitutions shall be allowed without the approval of the Fire Suppression designer.

PART 3 EXECUTION

3.1 INSTALLERS

A. Installation shall be accomplished by the qualified installer. Provide a qualified technician, experienced
in the
installation and operation of the type of system being installed, to supervise the installation and testing
of the system.

3.2 INSTALLATION

A. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into
place without springing or forcing. In any situation where bending of the pipe is required, use a standard
pipe-bending template. Install concealed piping in spaces that have finished ceilings. Where ceiling
mounted equipment exists, such as in operating and radiology rooms, install sprinklers so as not to
obstruct the movement or operation of the equipment. Sidewall heads may need to be utilized. Locate
piping in stairways as near to the ceiling as possible to prevent tampering by unauthorized personnel,

and to provide a minimum headroom clearance of 2250 mm (seven feet six inches). To prevent an
obstruction to egress, provide piping clearances in accordance with NFPA 101.
B. Drains: Pipe drains to discharge at safe points outside of the building or to sight cones attached to drains
of adequate size to readily carry the full flow from each drain under maximum pressure. Do not provide
a direct drain connection to sewer system or discharge into sinks. Install drips and drains where
necessary and required by NFPA 13.
C. Inspector's Test Connection: Install and supply in conformance with NFPA 13, locate in a secured area,
and discharge to the exterior of the building.
D. Kitchen Ventilator Hood Fire Protection: Provide piping from the building sprinkler system to the stub-
out point on the ventilator control cabinet. Size piping in accordance with manufacturer specifications.
E. Affix cutout disks, which are created by cutting holes in the walls of pipe for flow switches and non-
threaded pipe connections to the respective waterflow switch or pipe connection near to the pipe from
where they were cut.
F. Sleeves: Provide for pipes passing through masonry or concrete. Provide space between the pipe and the
sleeve in accordance with NFPA 13. Seal this space with a UL Listed through penetration fire stop
material.
G. Provide pressure gauge at each water flow alarm switch location and at each main drain connection.
H. For each fire department connection, provide the symbolic sign given in NFPA 170 and locate 2400 to
3000 mm (8 to 10 feet) above each connection location. Size the sign to 450 by 450 mm (18 by 18
inches) with the symbol being at least 350 by 350 mm (14 by 14 inches).
I. Securely attach identification signs to control valves, drain valves, and test valves. Locate hydraulic
placard information signs at each sectional control valve where there is a zone water flow switch.

3.3 RELOCATION CONSIDERATIONS

A. Upon relocation the entire system must be commissioned approved for service before occupation.

3.4 SITE QUALITY ASSURANCE

A. Preliminary Testing: Flush newly installed systems prior to performing hydrostatic tests in order to
remove any debris which may have been left as well as ensuring piping is unobstructed. Hydrostatically
test system, including the fire department connections, as specified in NFPA 13, in the presence of the
Contracting Officers Technical Representative (COTR) or his designated representative. Test and flush
underground water line prior to performing these hydrostatic tests.
B. Final Inspection and Testing: Subject system to tests in accordance with NFPA 13, and when all

necessary corrections have been accomplished, advise COTR/Resident Engineer to schedule a final

inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test.

3.5 COMMISSIONING

A. Furnish the services of a competent instructor for not less than two hours for instructing personnel in the

operation and maintenance of the system, on the dates requested by the COTR/Resident Engineer.

3.6 ATTACHMENTS

A. Manufacturer's Cut Sheets for Sprinklers are attached.

END OF SECTION

SECTION 22 11 16 – DOMESTIC WATER PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Stainless steel insulated supply and return lines for residential solar heated domestic hot water systems. The piping will run throughout the house to kitchens, baths, sinks, toilets, showers, and clothes washers.

PART 2 PRODUCTS

2.1 SPEED INOX – SOLAR PIPING

A. Manufacturer: Ritter

B. Technical data

i. Pipe diameter: 5/8”
ii. Coil Length: 50 ft
iii. Content per coil: 2.1 gal
iv. Minimum bend radius: 3.5”
vi. Max pressure: 150 psi
vii. Temperature Stability: long term: 250 F, short term: 350 F
viii. Piping material: stainless steel AISI 316L

D. Accessories

i. Mounting clamps
   a. Size: speed INOX 5/8” R6
   b. Material: galvanized steel
   c. Part No. 88-2074

ii. Pipe end connection
   a. Size: speed INOX 5/8” x 1/2”, speed INOX 5/8” x 3/4”
   b. Material: brass
   c. Part No. 1/2” – 88-2065, 3/4” – 88-2062

iii. Transition Piece
   a. Size: speed INOX 5/8” x 1/2” compression, speed INOX 5/8” x 15 mm compression, speed INOX 5/8” x speed INOX 5/8”.
   b. Material: brass
   c. Part No. ½” 88-2066, 15 mm 88-7078, 5/8” 88-2080

iv. T piece
   a. Size: speed INOX 5/8” x 5/8” x 5/8”
   b. Part No. T-piece: 88-2079

PART 3 EXECUTION

3.1 INSTALLATION

A. Follow Manufacturer specified instructions.

END OF SECTION

SECTION 22 11 23 - DOMESTIC WATER PUMPS

PART 1 GENERAL

1.01. SUMMARY

A. Section includes:

1. Circulating pump for domestic water system.
2. Grey and cold water pump for landscaping
3. Solar water heater pump

B. Related Sections

1. Section 22 11 16: Domestic Water Piping.

1.02. SUBMITTALS

A. Manufacturer shall provide cut sheets and product documentation as well as samples prior to installation.

1.03. QUALITY ASSURANCE

A. Manufacturer shall have significant experience producing residential bathroom and kitchen plumbing hardware.

1.04. DELIVERY, STORAGE, AND HANDLING

A. Items shall be delivered in the manufacturer's original packaging to the construction site.

B. Products shall be stored in boxes until construction begins to prevent damaging finishes.

1.05. WARRANTY

A. Manufacturer shall provide a limited warranty against defects.

PART 2 PRODUCTS

2.01. PRODUCT INFORMATION

A. Manufactures:

1. Rule Bilge Pump 2000 Submersible (24V)
    a. Description: Submersible Bilge Pump
    c. 24 VDC
2. Paradigma 88-2061
    a. Description: Flow box solar - solar pump station
    c. 110V motor
3. Grundfos ALPHA 15-55f
    a. Description: Cast iron flange with terminal box
    c. 115V motor
4. Laing D5 720 B
    a. Description: D5 series vario bronze circulator
    c. 8-24 VDC

2.02. PRODUCT SUBSTITUTIONS

A. Substitutions shall be allowed on the basis of availability with the approval of the Project Manager and Mechanical Engineer.

3.01. INSTALLERS

A. A qualified plumber shall install the products listed herein. Qualified personnel will be determined by experience or at the discretion of the Project Manager and/or Construction Manager.

3.02. EXAMINATION

A. All substrate surfaces shall be fully installed, clean, and dry at the start of installation.

3.03. INSTALLATION

A. Install products according to manufacturer's recommended installation procedures.

3.04. RELOCATION CONSIDERATIONS

A. Fixtures shall remain in place during transportation and relocation.

3.05. SITE QUALITY CONTROL

A. Fixtures shall be protected from surrounding or following construction activities to prevent damage to the finishes.

3.06. COMMISSIONING

A. Installed fixtures shall be tested prior to operation of the home to ensure proper installation.

3.07. ATTACHMENTS

A. Manufacturer's Submittal Sheets are provided for all products listed herein.

END OF SECTION

SECTION 22 33 30 – SOLAR WATER HEATING TANKS

PART 1 GENERAL

1.1 SECTION REQUIREMENTS

A. Summary

1. 119 gallon insulated tank for heating and holding hot water. Tank will provide DHW for house. Primary heating comes from heat exchange through internal coils with solar thermal supply. Backup heating provided by an electrical water heater.

PART 2 PRODUCTS

2.1 HOT WATER TANK

1. Acceptable Manufacturers
    a. Paradigma
    b. SunEarth Inc.
    c. Lochinvar
2. Specification
    a. Capacity: Per mechanical engineers drawings
    b. Max tank pressure & temperature: 150 psi & 200 °F
    c. Max upper and lower coil pressures: 230 psi
    d. Max upper and lower coil temperatures: 320 °F
3. Piping Connections
    a. Cold water DCW 1” diameter NPT 5”
    b. Solar Return ¾” diameter NPT
    c. Solar Supply ¾” diameter NPT
    d. Boiler Return* ¾” diameter NPT
    e. Boiler Supply* ¾” diameter NPT
    f. Hot water DHW 1” NPT
    g. Circulation C ¾” NPT
4. Power Supply*
5. Tank Material
    a. Tank is a vertical DHW tank, glass lined, with two internal coils. Hard PU foam insulation with foil-clad casing. Insulation thickness is 2” thick. Has a protective magnesium anode 1 ¼”.

PART 3 EXECUTION

3.1 Installation

A. Follow Manufacturer specified instructions.

END OF SECTION

SECTION 224100 – RESIDENTIAL PLUMBING FIXTURES

PART 1 GENERAL

1.01. SUMMARY

A. Section Includes:
   1. Residential fixtures for bathroom and kitchen including sinks, toilets, shower hardware, and sink hardware.

B. Related Sections:
   1. Section 22 11 16: Domestic Water Piping.
   2. Section 22 13 16: Sanitary Waste and Vent Piping.

1.02. SUBMITTALS

A. Manufacturer shall provide cut sheets and product documentation as well as samples prior to installation.

1.03. QUALITY ASSURANCE

A. Manufacturer shall have significant experience producing residential bathroom and kitchen plumbing hardware.

1.04. DELIVERY, STORAGE, AND HANDLING

A. Items shall be delivered in the manufacturer's original packaging to the construction site.

B. Products shall be stored in boxes until construction begins to prevent damaging finishes.

1.05. WARRANTY

A. Manufacturer shall provide a limited warranty against defects.

PART 2 PRODUCTS

2.01. PRODUCT INFORMATION

A. Materials:
   1. Kitchen Sink
      a. single bowl under-mount stainless kitchen sink
      b. Dimensions: 23" x 18" x 10"
      c. Finish: Acrylic
   2. Kitchen Faucet
      a. Single lever handle, the high-arch swing spout includes a pullout spray head with two flow options and pause function
      b. Dimensions: Height 9-7/8" Length 7"Width 2"
      c. Finish: Polished Chrome.
   3. Kitchen Hot Water Faucet
      a. InSinkErator instant hot water dispenser
      b. Dimensions: 5 x 5 x 21 inches
      c. Finish: Stainless steel
   4. Bathroom Faucet
      i. a.Solid brass construction, ceramic disc valve, single control operation, 5-1/2" spout
      ii. b. Dimensions: Height 7-3/4"Length 5-1/2"Width 2-1/4"
      iii. c. Finish: Brushed Nickel
   5. Toilet
      a. Single Flush one-piece comfort height toilet
      b. Dimensions: Height 28-3/16" Length 27-3/4" Width 18-3/4"
      c. Finish: White ceramic.
      d. Flush Rate: 1.28 gpf.
   6. Shower Basin
      a. Center drain shower base
      b. Dimensions: 6" x 60" x 34"

c. Finish: White.

7. Shower Valve
    a. Pressure-balancing with Pex Expansion and brass construction
    b. Dimensions: Length 2-3/4"Width 6-1/8"
    c. Flow Rate: 5.0 gpm

8. Shower Trim Kit
    a. Shower faucet trim with push-button diverter and cross handle
    b. Dimensions: Height 6-1/2" Length 10-5/8 Width 6-1/2"
    c. Finish: Brushed Nickel

9. Shower drain
    a. 2”/3” ABS low-profile shower drain with strainer
    b. Dimensions: 6.5” x 3.5” x 6.5”
    c. Finish: Brushed Nickel

10. Indoor Shower Floor
    a. Ceramic Tile

11. Outdoor Shower Floor
    a. Wood Flooring with non-slip finish

2.02. PRODUCT SUBSTITUTIONS

A. Substitutions shall be allowed on the basis of availability with the approval of the Project Manager and Mechanical Engineer.

PART 3 EXECUTION

3.01. INSTALLERS

A. A qualified plumber shall install the products listed herein. Qualified personnel will be determined by experience or at the discretion of the Project Manager and/or Construction Manager.

3.02. EXAMINATION

A. All substrate surfaces shall be fully installed, clean, and dry at the start of installation.

3.03. INSTALLATION

A. Install products according to manufacturer’s recommended installation procedures.

3.04. RELOCATION CONSIDERATIONS

A. Fixtures shall remain in place during transportation and relocation.

3.05. SITE QUALITY CONTROL

A. Fixtures shall be protected from surrounding or following construction activities to prevent damage to the finishes.

3.06. COMMISSIONING

A. Installed fixtures shall be tested prior to operation of the home to ensure proper installation.

3.07. ATTACHMENTS

A. Manufacturer’s Submittal Sheets are provided for all products listed herein.

END OF SECTION

Section 23 31 00 – HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.01. SUMMARY

A. Ductwork and accessories for HVAC including the following:

1. Outside air for minimum ventilation
2. Exhaust air for whole house ceiling fan

B. Related Sections:

1. Section 23 34 16: Centrifugal HVAC Fans
2. Section 08 51 13: Aluminum Windows
3.

1.02. REFERENCES

A. American Society for Testing and Materials (ASTM):

1. A167-99(2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
2. A653-09 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process
3. A1011-09aStandard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

B. Sheet Metal and Air Conditioning Contractors National Association (SMCA):

1. 2nd Edition – 2005 HVAC Duct Construction Standards, Metal and Flexible
2. 1st Edition - 1985 HVAC Air Duct Leakage Test Manual.

1.03. QUALITY ASSURANCE

A. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

B. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.

C. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance

1.04. DELIVERY, STORAGE, AND HANDLING

A. Keep pipes clean and sealed when possible on construction site to avoid pollution by dust and other particles.

PART 2 PRODUCTS

2.01. PRODUCT INFORMATION

A. Manufacturers
   1. Control Air
   2. Johns Manville Corp.
   3. Ducts, Inc.

B. Materials

1. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.

2. Specified Corrosion Resistant Systems: Stainless steel sheet, ASTM A167, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.

3. Duct Construction and Installation:

a. Regardless of the pressure classifications outlined in the SMACNA Standard fabricate and seal the ductwork in accordance with the manufacturer's pressure specification.

2.03. PRODUCT SUBSTITUTIONS

A. Related products meeting the same standards are allowed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Qualified installer will be installing all ductwork.

END OF SECTION

SECTION 25.09.13 – INTEGRATED AUTOMATION ACTUATORS AND OPERATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Actuator for pivot windows
B. Related sections: 08 51 13

1.02 QUALITY ASSURANCE

A. EM series has a slim casing and low-noise operation.
B. Push/Pull Force up to 300 N (68 lb), to operate 327mm - 603mm chain versions.
C. Actuator has stainless steel chain for rigidity and durability.
D. UL Recognized.
E. UL cable 1 meter included, black color.
F. Tested to 10,000 cycles.

1.03 WARRANTY

A. 2-year manufacturer's warranty; requires use according to Installation Guide recommendations.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Items shall be delivered in the manufacturer's original packaging to the construction site.
B. Products shall be stored in boxes until construction begins to prevent damaging finishes.

PART 2 PRODUCTS

2.01 PRODUCT FORMATION

A. Manufacturer: Functional Fenestration Inc.
   1. Supply voltage 24 VDC
   2. Aluminum profile

PART 3 EXECUTION

3.01 INSTALLATION

A. System Layout
   1. It is important to look at the diagrams of your system layout from FFI and understand how the components are to be connected together. Control panels must be placed in the correct locations of the building to operate as planned. There are 3 ways for FFI controllers to interface with home automation systems: by dry contact, by RS-232 protocol, and by RS-422 protocol.

B. System Connections
   1. Always keep data cable at least 18 inches away from an AC power line.
   2. If it is necessary to cross AC power, do so at a 90 degree angle to reduce electrical interference.
   3. Do not run data cabling with power lines inside conduit.
   4. Do not bend data wire any tighter than 4 times the diameter of the cable; any more will risk breaking conductors inside the jacket.
   5. Run data cable "High and Tight" by keeping cables away from other objects and securing them when possible.

C. Data Connections
   1. CAT5/5e cable is best for long runs. CAT6 cable is not recommended.
   2. RJ-25 (6P6C) modular connectors are required for FFI control panels.
   3. Always test your data cables.
   4. Before installing, also read the FFI Cables Data Sheet for important instructions.

5. Do not add non-essential components or disconnect internal wires or components!
6. Controllers have a QAUX port and a QEYE port as shown below. Multiple controllers and control panels can be connected by EYE to AUX ports, or by AUX to AUX ports, but never by EYE to EYE ports. This applies to other FFI components as well such as bridges.

7. RQ controller orientation in the control panel may vary, so please pay close attention to each RQ controller to be certain you are connecting to the correct ports. See “RQ Controller Connections” page for more information.

END OF SECTION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions of the Contract, General Conduct of the Work and Special Requirements, and Division 1 Specification Sections, apply to this Section.

1.2 OVERVIEW

A. This document contains the specification and input/output summaries for the Energy Monitoring and Control System (EMCS) for Team Orange's Casa del Sol. The system architecture shall utilize intelligent distributed control modules, located in the utility room, which communicates over a local controller network. The EMCS shall provide Direct Digital Control (DDC), monitored and adjusted by a JACE controller which combines integrated control, supervision, data logging, alarming, scheduling, and network management functions with Internet connectivity. This EMCS for the HVAC components and lighting shall interface with other microprocessor based home subsystems as shown on the drawings and as specified.

1.3 RELATED SECTIONS

A. Specification sections where others will install appurtenances to accommodate control devices

1. Section 22.11.23 (Domestic Water Pumps)
2. Section 22.33.30 (Solar Water Heater)

B. Specifications where equipment is purchased by others that will have EMCS controllers provided and to be installed at factory (i.e. factory-installed controls)

1. Section 23.56.13 (Solar Thermal Collectors)
2. Section 26.31.00 (PV System and Inverter)
3. Section XX.XX.XX (Radiant Ceiling)

C. 3rd – Party interfacing is required on this project according to the following specification sections for each sub-system.

1. Section 23.82.41 (Water-to-Water Heat Pump)
2. Section 23.71.16 (Chilled Water Thermal Storage)
3. Section 26.56.26 (Low voltage lighting)
4. Section XX.XX.XX (Sub-wet buld evaporative cooler)

1.4 REFERENCES

A. ANSI/ASHRAW 135-2010: BACnet™ – A Data Communication Protocol for Building Automation Systems: This shall include the standard and all published addenda. Please refer to www.bacnet.org for published addenda.

1.5 DEFINITIONS

A. **Application Controller**, for this specification, musy be an AAC (Advanced Application Controler). These would be used on Primary and Terminal Equipment.

B. **EMCS** refers to the Energy Monitoring and Control System. (It is often referred to as CCS, Central Control System, BAS, Building Automation System, or ATC, Automatic Temperature Control).

C. **Gateway** refers to the interface (hardware and/or software) to provide seamless integration by non-EMCS equipment manufacturers

D. **I/O** refers to Input/Output. The “I/O” device means the “Input/Output Device”

E. **OEM** stands for the Original Equipment Manufacturer, and refers to the manufacturer of the equipment being provided that includes a microprocessor based building sub-system [radiant ceiling, solar thermal collectors, PV system and Inverter]

F. **Object Table(s)** refer(s) to the detailed listing(s) of BACnet objects and the functional requirements using the various operator interfaces for the system. Within this document it is interchangeable with “Points List(s)” or “I/O Summary”

G. **Primary Equipment** refers to Heating, Cooling and/or Air Moving SOURCE equipment. This includes DHW, domestic hot water system (pumps, valves, sensors, etc), CWTS (pumps, evaporative cooler, valves, sensors), WSHP (pumps, valves, sensors), STC (solar tube collectors, pumps, valves, sensors)

H. **Terminal Equipment** refers to Heating, Cooling and/or Air Moving equipment connected to the Primary Equipment and directly serving a conditioned zone within the house

1.6 MANUFACTURERS

A. Climatec Technologies, as installed by Climatec branch offices, located in Irvine, CA

B. Allerton (hardware and software only) as installed by Climatec

C. Lumencache, as installed by GTO, located in California

1.7 SCOPE OF WORK

A. Responsibilities:

1. Furnish and install all necessary hardware, wiring, computing equipment and software required to provide and complete and functional system necessary to perform the design intent given in the sequences of operations and as definied in this specification

2. Responsible for coordinating the work required of the OEM when there is a 3rd – party sub-system provided in this project

3. Coordinate with al other trades

B. System Requirements

1. All material and equipment used shall be standard components, regularly manufactured, available, and not custom designed especially for this project. All systems and components, except site specific software, shall have previously been thoroughly tested and proven in actual use prior to installation on this project.

2. The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.

3. Controllers used for primary and terminal equipment (all equipment) shall be fully programmable. Application Specific Controllers are not acceptable.

4. All functions required of a controller, either by this specification or in the sequence of control provided for the project, must be performed entirely within that controller.

5. The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

C. Equipment

1. System Hardware

1. Provide the following

1) Operator workstation(s) when necessary

2) All control modules

3) All relays, switches, sensing devices, including devices required to perform the function listed in the Points List(s)

4) All monitoring, power, and control wiring

5) Connect to (physical wiring and or/via programming) the integration gateway module(s) and software provided by the OEM, to interface with the following third-party equipment

a) Chilled Water Tank System

b) Lighting Controls

c) Bi-directional inverter and PV system

d) Sub-wet bulb evaporative cooler

e) Water-to-water heat pump

D. Points List(s)

1. The system as specified shall monitor, control, and calculate all of the points/objects and perform all the functions as listed in the sequences of operations

2. All objects/points, including Application Controller level objects, shall be exposed as BACnet Objects

E. Codes and Regulations

1. All electrical equipment and material and its installation (including programming) shall conform to the current requirements of the following authorities:

a. Occupational Safety and Health Act (OSHA)
b. National Electric Code (NEC), 2008
c. International Fire Code, 2009
d. International Mechanical Code, 2009
e. International Energy Conservation Code, 2009
f. International Fuel Gas Code, 2009
g. International Building Code, 2009
h. International Existing Building Code, 2009
i. International Plumbing Code, 2009

2. All distributed, application controllers supplied shall be in compliance with the following listings and standards:

a. UL916 for Open Energy Management

b. CE Electro Magnetic Compatibility

c. BACnet Testing Lab (BTL) listed.

3. The control system manufacturer shall have quality control procedures for design and manufacture of environmental control systems for precise control and comfort, indoor air quality, HVAC plant operation, energy savings and preventative maintenance.

4. Where two or more codes conflict, the most restrictive shall apply. Nothing in this specification or related documentation shall be construed to permit work not conforming to applicable codes.

F. Home Ethernet Connection Cabling

1. The home Ethernet shall be provided on site.
2. Major Systems Cabling : CAT-5e will be provided

---- End of PART 1 ----------

PART 2A PRODUCTS, SOFTWARE

2A.1 NETWORKING/COMMUNICATIONS

A. The design of the hardware and software shall network with the global router provided. This network shall be implemented via a shared Ethernet system using IP communication protocol.

B. BACnet communication protocol is the required protocol for all tiers of the network

2A.2 BAS INTERFACING WITH 3RD-PARTY SUB-SYSTEMS

A. General: Primary and terminating equipment/systems will be controlled, monitored, and programmed through a Graphical User Interface (GUI) software of the EMCS. Sub-systems not using the same communication protocol will be converted to integrate all sub-systems into one interface

B. Gateway: The gateway(s) required for the sub-system(s) shall be provided by the equipment OEM. The gateway(s) are further specified below:

1. All system information specified in the sequence of operation and related documents shall be available to the EMCS. Read and write capabilitiy, as indicated by a points list provided by the OEM, shall be provided to the mechanical and electrical equipment indicated and be available to the EMCS system. The OEM shall provide normal operating limits (i.e. maximum current, high and low temperature limits). The equipment OEM will expose all available objects as BACnet objects

C. A Modbus interface may be used only when a BACnet interface is not available from the equipment OEM.

2A.3 GLOBAL CONTROLLER/ROUTER

A. TP-LINK router

B. General – Global Controller

1. Allerton – Ascent Control Module

a. The controller is a microprocessor based communication devices. One of the functions is to provide a communications gateway between a controller network and an IP Ethernet network.

b. The controller will communicate via IP and be connected to a Ethernet infrastructure

c. The controller will support up to six global controllers

d. The global controller shall provide a port which can be connected to the workstation, portable computers, or modems

e. The controller will provide full arbitration between multiple users, whether they are communication through the same or different global controllers

f. The controller is responsible for routing global information from the various controller networks which may be installed in the house

g. The global controller will not contain a mechanical hard-drive, only one removeable microSD card

C. Memory: each global controller shall have sufficient memory to support its own operating system and databased including:

D. Control processed

E. Energy management applications

F. Alarm management

G. Historical/Trend Data for 100% of all physical I/O for all programs in any controller connected to this global controller

H. Maintenance Support Applications

I. Custom Proccesses

J. Operator I/O

2A.4 Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, application controllers, sensors, and actuators

2A.5 Integrated On-Line Diagnostics: Each Global Building Controller shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all subsidiary equipment. The global controller shall provide both local and remot communication of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each global controller and shall not require the connection of an operator I/O device

A. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

B. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all Global Building Controllers /Routers to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for all critical Global Building Controller /Router configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

1. Upon restoration of normal power, the Global Building Controller /Router shall automatically resume full operation without manual intervention.

2. Should Global Building Controller /Router memory be lost for any reason, the user shall have the capability of reloading the Global Building Controller /Router via the Local Area Network (LAN).

C. Communications:

1. The controller network shall use BACnet™ as its native communication protocol. The communication between controllers shall be ARCNET or MS/TP at least 76.8 Kbps.

2. The Global Building Controller /Router shall utilize FLASH memory, battery backed RAM or firmware which shall allow for operating system updates to be performed remotely via TCP/IP or UDP/IP.

2A.6 APPLICATION CONTROLLERS

A. Acceptable

1. Allterton – EXP-10-4-8
2. Allerton – EXP-22-0-0
3. Allerton – EXP 10-12-0

B. GENERAL – Application Controllers

1. Application controllers must use BACnet as the native communication protocol between controllers
2. Each application controller must be capable of standalone direct digital operation utilizing its own processor, non-volatile flash memory, input/output
3. Application controllers for primary equipment shall be expandable to the specified I/O point requirements. Each controllers shall accommodate multiple I/O expander modules
4. Each application controller shall be fully programmable and shall permit all point data, algorithms, and application software within the controllers to be customized as required by this specification and the approved sequence of operation
5. Each application controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller.
6. Each application controller shall be configured on the workstation as a BACnet device. All points shall be configured as BACnet objects. Each controller shall include self-test diagnostics which allow the controller to automatically relay to the global controller
7. Each application controller should be capable of performing event notifications (alarming)
8. Each application controller should be capable of scheduling, either by using an on-board real-time clock or by receiving the time from the global controller. If time is received from the global controller, the application controller must be able to retain the time during a break in communication so that the application controller can move between different modes until communication is restored
9. Each application controller shall contin both software and firmware to perform full DDC PID control loops
10. Each application controller shall contain a port for the interface of maintenance
11. Input-output processing:
    a. Digitial outputs shall be relays or triacs, 24VAC or VDC minimum. Each output shall be configurable as normally open or normally closed
    b. Universal inputs shall be capable of 0-20 mA, dry contact, and 0-5VDC, 2-10 VDC, or 0-10 VDC.
    c. Analog output shall be electronic, voltage mode 0-10VDC, 2-10VDC or current mode 4-20 mA.
    d. Temperature Zone Sensor input shall provide one thermistor input, one timed local override switch, and a CO2/humidity sensor
    e. All programming sequences shall be stored in non-volatile memory. All programming tools shall be provided as part of the system.

12. Each application controller shall support various types of zone temperature/humidity/CO2 sensor with built-in local override switches
13. Each application controller for window actuators will have an integral direct coupled electronic actuator. The actuator will provide on-off/floating point control. The assembly shall mount directly to the awning window. The actuator will not require an limit switches and shall be electronically protected against overload
14. Each application controller for HVAC applications will have an integral direct coupled electronic actuators. The valve/actuator assembly will be mounted directly
15. Each application controller shall have a LED indication for visual status of communication and power
16. In the event of loss of communication, the application controller shall control from the resident schedule and control program which maintains the assign space conditions (temperature, humidity), appropriate for the time of day until communication is restored
17. Primary Equipment shall be controlled using three application controllers with adequate I/O's and resource capacity

3. LAPTOP COMPUTER(S)

A. For this project, a laptop computer with the control system software and databses will be provided

4. FIELD HARDWARE/INSTRUMENTATION

A. Input Devices – General Requirements

1. Temperature sensors shall be of the type and have accuracy ratings as indicated and/or required for the application and shall permit accuracy rating of within 1% of the temperature range of their intended use
2. Sensors used for humidity applications shall be averaging type and have an accuracy of 3% of the intended use
3. Outside air temperature/humidity sensors shall have the minimum range of 0 to 100% RH and -40°F to 122°F
4. Room temperature/humidity sensors shall have an accuracy of $\pm$ 0.36 °F in the range of 32°F to 116°F and an accuracy of $\pm$3% at 10 to 90% RH
5. Chilled water temperature sensors shall have an accuracy of $\pm$ 0.36 °F in the range of 32°F to 158°F
6. Hot water temperature sensors shall have an accuracy of $\pm$ 0.36 °F in the range of 32°F to 158°F
7.

5. SENSORS

A. Electronic Sensors: Vibration and corrosion resistant for wall, immersion, duct, or strap-on mounting as required

1. Thermistor temperature sensors as follows:
   a. Accuracy: $\pm$0.36°F
   b. Wire : Twisted, shielded-pair cable
   c. Insertion Elements in Chilled Water Tank: 12 points, spaced approximated 9" apart: use to probe the temperature stratification
   d. Room Sensors: will be installed on exterior walls including insulating bases

e. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight

f. Radiant Ceiling: single point, attached to ceiling joist in between glass-fiber insulation: use to determine temperature and humidity in ceiling

2. Humidity Sensors

a. Accuracy: ±3% full range

b. Room sensors : With cover matching room thermoststs

c. Radiant ceiling: with element guard and mounting plate

3. Equipment operation sensors

a. Status inputs for fans: current-sensing relay

b. Status inputs for pumps: current-sensing relay

6. CONTROL VALVES

A. Control Valves: Factory fabricated of type, body materials, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated

B. Manufacturers

1. Bellimo

C. The control valves shall accurately control the flow from 0% to 100% full rate flow with an equal percentage flow characteristics. The flow shall not vary more than ±5% due system fluctuations across the valve with a minimum of 2PSI across the valve

D. Forged brass body, chrome plated bass ball and stem, female NPT union ends

E. All actuators shall be electronically programmed by use of handheld programming device or external computer software. Actuators for two-positions shall fail in place

7. WINDOW ACTUATORS

A. Window actuators: factory fabricated

B. Manufacturers

1. RollerTrol

C. The window actuators shall accurately control the opening and closing of six window awnings

D. All actuators shall be controlled electronically and is also equipped with manual override provided by resident

8. CONTROL PANEL 120-Volt ENCLOSED POWER SUPPLY

A. Each EMCS shall have a “packaged” power supply in the same enclosure

---- End of PART 2A ----------

PART 2B PRODUCTS, SOFTWARE

A. SYSTEM CONFIGURATION

1) Database creation and modification: all changes shall be done utilizing standard procedures

2) The system shall permit the operator to perform, as a minimm the following:

a. Add and delete points/objects

b. Modify point parameters

c. Create and modify control sequences and programs

d. Reconfigure application programs

3) All data points/objects within the database shall be completely accessible as independent variables for custom programming, calculation, or manipulation

B. APPLICATION PROGRAMMING

1) The system software shall include all DDC control algorithms resident in dividual control modules.

2) The clarity of the programming sequence must be such that the user has the ability to verify that the system programming meets the specifications. The programming must be documented and labeled to provide the user with an understandable and exact representation of each segment of the sequence of operation and for ease of troubleshooting

3) Provides tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs . The programming language shall have the following features:

a. The language shall be Graphical oriented or English language oriented

b. A full-screen character editor/programming environment shall be provided.

c. The programming environment shall have a debugging capability that shall provide error messages for syntax and execution errors

d. The programming language shall support conditional statements (IF/THEN/ELSE/ELSE-IF) using compound Boolean (AND, OR, and NOT), and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons

e. The programming language shall support floating-point arithmetic using the following operators: +, -, /, x, square root, and x-to-the-y-power. The following mathematical functions also shall provide: natural log, log, trigonometric functions (sine, cosine, etc), absolute value, and minimum/maximum value from a list of values

f. The program language shall have predefined variables that represent time of day, day of week, month of the year, and the date. Values from all the above shall be readable by the language so that they can be used in a program for such purposes as IF/THEN comparisons, calculations, etc.

g. The language shall be able to read the values of the variables and use them in the programming statement logic, comparisons, and calculations

C. DIRECT DIGITAL CONTROL SOFTWARE

a. The system shall continuously perform DDC functions at the local control

module in a stand-alone mode.

b. Each local control module shall perform the following functions

    1. Identify and report alarm conditions
    2. Execute all application programs as indicated on the Object Table(s)
    3. Execute DDC algorithms

c. It is preferred that each local control module should be able to trend and store data

d. In the event of power failure, all points under its control shall move to the failure mode as indicated in the Points List. All DDC software for this feature shall reside in the respective control module

    1. Power failures shall cause the control module to go into an orderly shutdown with no loss of program memory
    2. Power failure at any control module shall be reported at the workstation
    3. The restart program shall automatically restart affected field equipment

D. SOFTWARE USER INTERFACE

a. The on-online graphics, scheduling, and events shall be gathered from specification or cut-sheets

b. All of the system objects, schedules, and events shall be represented as BACnet objects

c. On-line graphics:

    1. Equipment graphic:

        a. All controlled equipment (Mechanical, Electrical, Primary, Terminal, etc) shall have a representative equipment graphic.
        b. The latest version of the EMCS vendor's animated graphics software shall be used to its fullest extent in the creation of the equipment graphics. Fans, pumps, etc
        c. Object in alarm condition shall be shown red and signify "Alarm" on the graphics
        d. The device communication status shall be displayed on all equipment online graphics
        e. The program run state shall be displayed on all equipment on-line graphics
        f. An on-line text description of the Sequence of Operation shall be provide if necessary

d. System Summary Graphics

    1. Each integrated system of combination of systems will have a separate graphic that accurately represents the relative order/arrangement of equipment and components installed, and shows the inter-relationships and inter-dependence between key components of each system and combination of systems

a. Example-1: when multiple pieces of mechanical equipment within a *system* are intended to operate in series or in parallel, with duty/standby

b. Example-2: when primary equipment supply units and zone/terminal distribution units are linked

c. Example-3: chiller “plants” show key components of main system including chilled water loops, evaporative cooler, pumps, isolation and temperature control valves and interconnected pumping. Include summary of connected load equipment cooling requests

d. Example-4: heating “plants” show key components of main system including chilled water loops, hot water tanks, water-to-water heat pump pumps, isolation and temperature control valves and interconnected pumping. Include summary of connected load equipment heating requests

2B.4 The following application software, per “programs” in System Pints/Objects Lists(S), shall be provided for the purposed of optimizing energy consumption while maintaining occupant comfort

1. Reset (Source Temperature Optimization)

   a. The system shall automatically perform source optimization for all evaporative coolers and hot water tanks in response to the needs of other downstream pieces of equipment by increasing or decreasing supply temperature setpoints (i.e. chilled/hot water). In addition, the outside temperature shall provide for starting and stopping primary mechanical equipment based on zone occupancy and/or zone conditions

   b. The reset program will allow setpoints for various equipment in the heating/cooling chain to be reset between a minimum and maximum setpoint based on actual requirements.

2. Set Back/Set Up (Day/Night Setback)

   a. The system shall allow the space temperature to drift down or up within a preset (adjustable) unoccupied temperature range. The heating/cooling shall be activated upon reaching the end of the DNS range and shall remain activated until the space temperature returns to the DNS range

   b. The system shall be capable of closing all windows and exhaust fan units

   c. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled

   d. Users shall be able to define, modify, or delete the following:

      1. DNS setpoint temperature(s)

      2. Temperature band for night heating operation

      3. Period when the DNS is to be activated

3. Time Local Override (TLO)

   a. The system shall have TLO input points/objects which permit the occupants to request an override of equipment which has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from local input devices. Local input devices shall be push button or ON/OFF switches

4. Space Temperature Control (STC)
    a. There will be **no** temperature setpoints, but rather a control during occupied modes such that the temperature within each zone is maintained between 71°F and 75°F during the day and the night
    b. An occupied/unoccupied modes may be scheduled by time, date, or day of the week via BACnet
    c. The cooling and heating ranges may be decreased(increased) under demand control conditions to reduce the cooling(heating) load on the building during the demand control period.
5. Historical data and trend analysis. A variety of historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the foolowing ways
    a. Continuous point histories: Global controllers shall store point files for all analog and binary inputs/outputs. The point routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all physical hardware input/output points shall be collected during the warranty period, to allow the user to immediately analyze equipment performance and all problem-related events
    b. Control loop performance trends: global controlles shall provide sampling capabilitiy with operator-adjustable resolution of 10-300 seconds in one-second increments for verification of control loop performance
    c. Extended Sample Period Trends: Measured and calculated analog and binary data shall be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 2 hours, in one-minute intervals shall be provided.
    d. Data Storage and Archiving: Trends data shall be stored localled and upoded to a hard disk when desired. Uploads will occur based on user-defined interval, manual command, or when trend buffers are full All trend data shall be available in disk file for later use
6. Runtime Totals: Global controller shall automatically accumulate and store runtime hours for binary input and output points
    a. Users have the ability to define a warning limit for runtime and is unique for each user
7. Alarm and Audit Logs
    a. The software shall automatically create audit and alarm logs
        1. Audit logs track all actions and changes made by operator
        2. Alarm logs records all alarms that have been generated, acknowledged, deleted, etc.

--End of PART 2B----------

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that systems are complete and ensure that the systems are capable of being started and operated in a safe and normal condition before attempting to operate the EMCS systems.

B. Beginning of work means acceptance of existing conditions.

3.2 GENERAL INSTALLATION

A. Install equipment level and plumb.

B. Install software in control units and, as applicable, in laptop computer(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

3.3 WIRING INSTALLATION

A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these specifications.

B. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with requirements of applicable Specification Division 26 sections and all national, state, and local electrical codes. All the wiring shall be installed in accordance with the current National Electrical Code (NEC).

C. Provide wiring as required by functions as specified and as recommended by equipment manufacturer's to serve specified control functions.

D. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the University’s Physical Plant BAS Group's representative prior to rough-in.

E. The term "control wiring" is defined to include the providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices in pilot circuits of contactors, starters, relays, etc., and wiring for valve and damper operators.

F. Install signal, communication, and fiber-optic cables according to Division 26 Section "Control/ Signal Transmission Media", and as follows:

1. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

2. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

G. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

H. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

I. Provide auxiliary pilot duty relays on motor starters as required for control function.

J. All exposed control wiring and control wiring in the mechanical, electrical, telephone, and similar rooms shall be installed in raceways. All other wiring shall be installed neatly and inconspicuously above ceilings.

K. Install exposed control wiring system in conduit for electric/electronic control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. UL plenum-rated cable shall be provided when located in ceiling spaces. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines with adequate support. Both conduit and plenum wiring shall be supported from or anchored to structural members. Conduit or plenum wiring supported from or anchored to piping, duct supports, the ceiling suspension system, is not acceptable. Wiring buried in slab-on-grade concrete or explosion-proof areas shall be in rigid metal conduit. Provide adequate strain relief for all field terminations.

L. Number-code or color-code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.

3.4 CONTROL DEVICE INSTALLATION

A. All room sensors and thermostats shall be mounted so as to be accessible in accordance with ADA Guidelines, unless otherwise noted on the drawings.

B. Remote control devices not in local panels shall be accessible for adjustment and service below 7' above finished floor whenever possible.

C. Locate all temperature control devices wired under Division 26.

D. Install guards on thermostats in the following locations:

1. Entrances.

2. Public areas.

3. Where indicated.

E. Local controllers shall be mounted at eye level for accessibility and service, and located within 50' of the system served, unless otherwise shown on the plans.

F. Freestanding enclosures and panels shall be supported on steel unistrut frames, or approved equal, and be securely anchored to the floor and be well braced.

G. Enclosures and panels mounted directly to the wall shall be provided with a minimum airspace of 1" between the enclosure and the wall.

H. A minimum of 3' working clearance shall be provided in front of all enclosures and panels; clearance shall be ensured to permit the enclosure door to open at least 90° from its closed position.

I. Mounting height shall be a maximum 6'-6" to the top of the enclosure.

J. Shall be suitable for use in environments having an ambient temperature range of 31°F to 104°F and a relative humidity of up to 95% noncondensing.

K. There shall be no pneumatic equipment or device installed in a Global Building Controller enclosure.

L. A field-installed, 14-gage galvanized steel drip shield shall be provided where enclosures and panels may be subjected to dripping water.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Ground equipment: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 CONTROL POWER

A. Power supply for all control panels handling network, building or primary equipment and for control panels serving emergency and/or critical equipment, locations or points shall be connected via a dedicated EMCS circuit to the building Normal/Emergency, Standby-Optional electrical panel. A grounding conductor shall be run from building service entrance panel ground bus. Conductor shall be insulated and isolated from other grounded conductors and building conduit system.

B. Provide power for Application Controllers and all associated control components from nearest applicable electrical control panel or as indicated on the electrical drawings—coordinate with Electrical Contractor.

C. Power for each control panel shall be provided through a switch (standard light switch) located inside the panel. A standard duplex receptacle shall also be provided inside the control panel. The receptacle shall be unswitched.

D. The Enclosed Power Supply, as specified in Part 2 of these specifications shall be installed according to the Manufacturer’s instructions and located in the upper-left corner inside the EMCS Control Panel.

1. When the control transformer is installed inside the control panel, the panel must be properly ventilated and all 120 volt wiring protected against Arc Flash Hazards.

2. If the control transformer must be installed outside of the control panel due to space constraints, then they will be attached to the top or side of the panel and all 120 volt wiring will be protected from Arc Flash Hazards.

3. All 120 volt wiring needs to be completely isolated so that maintenance personnel are only exposed to 50 volts or less while servicing the control system components.

SECTION 26 56 26 - LOW VOLTAGE LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Low Voltage Lighting Fixtures
2. Hubs
3. Transformers
4. Wire

1.2 RELATED WORK

A. Applicable sections relative to providing primary power for landscape lighting.

1.3 REFERENCES

A. Uniform Building Code

B. National Electric Code latest edition

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's product data, storage and handling requirements and recommendations and installation methods.

B. Specification Sheets: Submit manufacturer's specifications sheets including manufacturer's standard warranty.

C. Voltage Drop Calculations: Submit voltage drop calculations for each electrical run from transformer to hubs, including installed watts, actual watts consumed and wire size and length for each run.

D. As-Builts: Submit reproducible as-builts of the complete system as actually installed. Include specific dimension of location of hubs, wire runs, sleeves, transformers and fixtures.

E. Warranty Certificates: Submit completed registration of Warranty Certificates.

F. Maintenance Schedule: Submit a maintenance schedule for the lighting system. Include scope of work and interval of maintenance.

1.5 QUALITY ASSURANCE

A. LITE Certified: Installing contractor shall be LITE Certified. Contact The Lite Program at 800-955-4831.

B. Experience: Installing contractor shall have a minimum of 5 year's experience in successful completion of projects with similar scope and scale. Submit list of 5 projects nearest this project locale. Include address, contact name, date of installation and approximate cost of lighting installation.

C. Night Time Demonstration: Provide mockups of energized fixtures, groups of fixtures, alternate lamps and appurtenances to review lighting effects during hours of darkness.

D. Pre-installation Meeting: Schedule a pre-installation meeting as directed by the owner/landscape architect.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site in manufacturer's original, unopened container and packaging, with labels clearly identifying the product name and manufacturer.

B. Store materials in clean dry areas in accordance with manufacturer's instructions. Keep materials in manufacturer's original, unopened packaging until installation.

C. Protect materials and finish during handling and installation to prevent damage.

1.7 WARRANTY

A. Guarantee installation, workmanship and equipment for period of one year from date of acceptance. Perform warranty service work, at no cost to Owner, on site and within 5 days of notification.

B. Indicate manufacturer's standard warranty for each component to repair or replace due to corrosion or manufacturers defect in materials as listed for each component per approved shop drawings.

PART 2 – PRODUCTS

2.1 MANUFACTURER

A. Basis of Design: Lumencache
B. Straight Road Electronics
C. Redwood Intelligent Lighting

2.2 MATERIALS

A. Light Fixtures
   a. Down Light Fixtures
   b. Wall Sconce
   c. LED Strip Lights

B. LED Lamps

C. Hubs

D. Transformers

1. **General Requirements:**
   a. All Transformers shall be agency listed, shall be rated a minimum of 150C.
   b. Transformers hall not drop down in voltage at the transformer itself more than 1 volt.

c. Transformers shall have a lifetime guarantee.
d. Transformers shall have primary fusing which is replaceable.

E. Wire

a. Cat5e cable

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify site conditions are acceptable to begin work.

B. Coordinate with other trades and provide required appurtenances to insure sleeves and other equipment will properly integrate landscape lighting with other site improvements.

C. Verify site measurement, grades, chase line sleeves, plant locations, utilities and other improvements, existing or proposed that impact the work.

3.2 PREPARATION

A. Provide mockups for owner review.

3.3 INSTALLATION

A. General
   1. Install system in accordance with UBC, NEC, local code, manufacturer's specifications and installation instructions.

   2. Coordinate location of power source, transformer and equipment out of direct view and concealed to greatest extent practical. Avoid locations easily accessible to the public.

   3. All dimensions and conditions shall be verified prior to the start of construction. It shall be the responsibility of the installing contractor to ensure that this is conducted. Any discrepancies shall be reported immediately to the owner.

   4. All fixture locations shall be verified with the landscape architect as lighting plans are diagrammatic and are not intended to show exact fixture locations.

   5. A field mark out shall be completed and/or acquired by the contractor prior to the commencement of any project where trenching equipment is used.

B. Fixtures
   1. All fixtures shall be installed according to the manufacturer's specifications.

C. Transformers
   1. All transformers shall be installed according to the manufacturer's specifications.

D. Wire

   1. Each LED is connected to a separate cat5e cable
   2. Home-Run cat5e cables to the Power Distribution Module

3.4 FIELD QUALITY CONTROL

A. Site Tests:
   1. Check voltage with digital voltmeter. Insure fixture receives between 10 and 18 volts (15 volts for PAR 36).

   2. Check amperage with amp probe for secondary wires. Do not exceed maximum allowed amps for cable size used.

   3. Check amperage at transformer. Do not exceed maximum allowable amps on posted label of transformer.

   4. Confirm and demonstrate result of testing in Owner’s presence.

3.5 ADJUSTING/DEMONSTRATION

A. Adjust fixtures during hours of darkness with Owner present. Provide lamps within appropriate wattage range for fixture, shields, lenses and optional appurtenances as directed to achieve desired aesthetic effects as determined in field. Lamp indicated on drawings is for bidding and initial review only.

B. Demonstrate care, operation and maintenance of system components to satisfaction of Owner and maintenance staff.

C. Turn over Maintenance Tools and Manual and spare parts.

END OF SECTION

SECTION 23 34 16 – CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

A. Description: Fan shall be duct mounted, direct driven centrifugal square inline.

B. Certifications: Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (UL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.

C. Construction: The fan shall be of bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 18 gauge galvanized steel with integral duct collars. Bolted access doors shall be provided on three sides, sealed with closed cell neoprene gasketing. Housing shall be pre-drilled to accommodate universal mounting feet for vertical or horizontal installation. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM and static pressure. Unit shall be shipped in ISTA certified transit tested packaging.

PART 2 - PRODUCT

A. Wheel: Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. An aerodynamic aluminum inlet cone shall be provided for maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05, Balance Quality and Vibration Levels for Fans.

B. Motor: shall be heavy duty type with permanently lubricated sealed bearings and furnished at the specified voltage, phase and enclosure Motor: Motor shall be NEMA design B with a minimum of class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure.

C. Fan model per mechanical schedule.

D. Storage: If the fan is stored for any length of time prior to installation, completely fill the bearings with grease or moisture-inhibiting oil. Refer to Lubricants on page 6. Also, store the fan in its original crate and protect it from dust, debris and the weather. To maintain good working condition of a SQN when it is stored outdoors, or on a construction site, follow the additional steps below:

1. Cover the inlet and outlet, and belt tunnel opening to prevent the accumulation of dirt and moisture in the housing.

2. Periodically rotate the wheel and operate dampers (if supplied) to keep a coating of grease on all internal bearing parts.

3. Periodically inspect unit to prevent damaging conditions

E. Immediately, upon receipt of a fan, carefully inspect the fan and accessories for damage and shortage

1. Turn the wheel by hand to ensure it turns freely and does not bind

2. Inspect dampers for free operation of all moving parts.

3. Record on the Delivery Receipt any visible sign of damage.

PART 3 - EXECUTION

A. Installation

1. Motor Installation :To prevent damage to the fan during shipping, motors 5 HP and larger, and extremely heavy motors (cast iron ors evere duty) are shipped loose and must be field mounted.

2. Wiring Installation: All wiring should be in accordance with local ordinances and the National Electrical Code, NFPA 70. Ensure the power supply (voltage, frequency, and current carrying capacity of wires) is in accordance with the motor name plate. Refer to the Wiring Diagrams

3. Direct drive: Wire the electrical box on the blower housing.

B. Warranty

1. For a period of one (1) year after date of shipment, manufacturer to replace any parts found to be defective without charge, except for shipping costs which will be paid by owner.

END OF SECTION

SECTION 23 37 13 – DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.01 SUMMARY

A. Description: designed for both outside air ventilation and whole house ceiling fan exhaust

B. Related Sections:
   1. Section 23 31 00: HVAC Ducts and Casings
   2. Section 23 34 16: Centrifugal HVAC Fan

1.02 QUALITY ASSURANCE

A. Ceiling and side wall diffusers shall be TITUS Model 250-AA (aluminum with miscellaneous steel components) of the sizes and mounting types shown on the plans and outlet schedule. Diffuser shall have curved deflectors, which are individually adjustable from the face of diffuser to regulate air volume and angle of discharge. Diffusers shall be built in one-, two-, three- or four-Way discharge patterns. The diffusers shall be constructed of 0.051 aluminum with miscellaneous steel components.

B. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315∞F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

C. Optional opposed blade damper shall be constructed of heavy gauge steel and shall be installed on the neck of the diffuser. Damper must be operable from the face of the diffuser by placing a standard screwdriver between the curved deflectors.

D. The manufacturer shall provide published performance data for the ceiling/side wall diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

PART 2 - PRODUCT

2.01 PRODUCT INFORMATION

A. Manufacturers allowed
   a. Titus HVAC
   b. Greenheck
   c. Construction Specialties Inc.

B. Install in either the ceiling or the side wall

C. Available with 1-way, 2-way, 3-way, or 4-way pattern

D. Louvers are individually adjustable from the face of the diffuser. Louvers regulate air volume as well as angle of discharge

E. Diffuser material is aluminum with miscellaneous steel components.

PART 3 - EXECUTION

3.01 INSTALLATION

A. A qualified mechanic shall install the products here in. Qualified personnel will be determined by experience or at the discretion of the Project Manager and/or competition manager.

3.02 EXAMINATION

A. All items shall to be installed shall by fully cleaned and dry at the start of installation.

3.03 RELOCATION CONSIDERATIONS

A. Fixtures shall remain in place during transportation and relocation

END OF SECTION

SECTION 23 56 00- EXPANSION TANK

PART 1 GENERAL

1.1 Summary

A. A fixed membrane tank designed to handle water expansion and pressure control.

PART 2 PRODUCTS

2.1 Solar Expansion Tank

A. Manufacturers allowed

1. Paradigma
2. Amtrol
3. SunEarth

B. Technical Data

1. Per mechanical drawings

C. Technical Characteristics

1. Shell material: Carbon steel
2. Connection material: Carbon steel, MPT
3. Membrane material: Butyl rubber
4. Exterior coating: Epoxy-polyester powder coated in white
5. Max. working pressure: 150 psi / 10 bar
6. Max. operating temperature: 212 F / 100 C
7. v. Factory pre-charge: 36 psi / 2.5 bar

PART 3 EXECUTION

3.1 Installation

A. Follow Manufacturer specified instructions.

END OF SECTION

SECTION 23 56 13 – HEATING SOLAR COLLECTORS

PART 1 GENERAL

1.1 SECTION REQUIREMENTS

A. Summary
   1. Evacuated solar thermal collectors gather solar radiation to heat working fluid. Working fluid will be pumped into hot water storage tank.

PART 2 PRODUCTS

2.1 SOLAR THERMAL COLLECTORS

A. Evacuated Tube Collector
   1. Manufacturers Allowed:
      a. Paradigma
      b. Solflex
      c. Ritter
   2. Specification:
      a. 18 Evacuated tubes
   4. Performance
      a. Thermal Performance Rating: 24 kBtu/Day/panel
      b. Output per square feet: 975 BTU/ft^2
   5. Tilt: 10° from horizontal
   6. Max working pressure: 150 psi
   7. Material
      a. Collector material // glass material: Al/Cu/glass/silicone/PBT/EPDM/TE//borosilicate glass 3.3
      b. Selective absorber coating: aluminum nitride
   8. Heat transfer fluid: Water
   9. Frame color // Plastic parts color: aluminum grey // black (RAL 9004)

PART 3 EXECUTION

3.1 INSTALLATION

A. Follow manufacturer specifications.

END OF SECTION

SECTION 23 71 16 – CHILLED WATER THERMAL STORAGE

PART 1 GENERAL

1.01. SUMMARY

A. Section includes: 800 gallon cold water tank

1.02. SUBMITTALS

A. Manufacturer shall provide cut sheets and product documentation as well as samples prior to installation.

1.03. QUALITY ASSURANCE

A. Manufacturer shall have significant experience producing insulated vertical water storage tanks

1.04. DELIVERY, STORAGE, AND HANDLING

A. Items shall be delivered in the manufacturer's original packaging to the construction site.

B. Products shall be stored in boxes until construction begins to prevent damaging finishes.

1.05. WARRANTY

A. Manufacturer shall provide a limited warranty against defects.

PART 2 PRODUCTS

2.01 PRODUCT INFORMATION

A. Manufacturers:

I. ProTank

II. Granite Environmental, Inc.

III. US Plastic Corp.

B. Materials

1. HDPE (Polyethylene) Tank
2. 2" Painted Polyurethane Foam Insulation
3. 48" diameter x 113" height, or equivalent volume

2.02. PRODUCT SUBSTITUTIONS

A. Substitutions shall be allowed on the basis of availability with the approval of the Project Manager and Mechanical Engineer.

PART 3 EXECUTION

3.01. INSTALLERS

A. A qualified technician shall install the products listed herein. Qualified personnel will be determined by experience or at the discretion of the Project Manager and/or Construction Manager.

3.02. EXAMINATION

A. All surfaces shall be fully installed, clean, and dry at the start of installation.

3.03. INSTALLATION

A. Install products according to manufacturer's recommended installation procedures.

3.04. RELOCATION CONSIDERATIONS

A. Fixtures shall remain in place during transportation and relocation.

3.05. SITE QUALITY CONTROL

A. Fixtures shall be protected from surrounding or following construction activities to prevent damage to the finishes.

3.06. COMMISSIONING

A. Installed fixtures shall be tested prior to operation of the home to ensure proper installation.

3.07. ATTACHMENTS

A. Manufacturer's Submittal Sheets are provided for all products listed herein.

END OF SECTION

SECTION 238241 – WATER – TO – WATER HEAT PUMP

PART 1 GENERAL

1.1 SUMMARY

A. The water-to-water heating/cooling units shall be supplied completely factory built for an entering source water temperature range from 20° to 120°F [-6.7° to 48.9°C] and entering load water temperature range from 50° to 130°F [10.0° to 54.4°C] as standard. All equipment listed in this section must be rated in accordance with Air-Conditioning, Heating and Refrigeration Institute / International Standards Organization (AHRI / ISO) and Environmental Testing Laboratories for United States and Canada (ETL-US-C). The units shall have the ETL-US-C label.

B. All units shall be fully quality tested by factory run testing under normal operating conditions and water flow rates as described herein. Quality control system shall automatically perform via computer: triple leak check, pressure tests, evacuate and accurately charge system, perform detailed heating and cooling mode tests, and quality cross check all operational and test conditions to pass/fail data base. Detailed report card will ship with each unit displaying all test performance data. Note: If unit fails on any cross check, system shall not be allowed unit to ship. Serial numbers will be recorded by factory and furnished to contractor on report card for ease of unit warranty status. Each unit shall be pallet mounted and shipped in clear shrinkwrap for visual shipping damage inspection.

C. The units shall be warranted by the manufacturer against defects in materials and workmanship for a period of five years on all parts, and ten years on the compressor and refrigerant circuit parts with a service labor allowance during the first two/five years. Equipment shall be completely assembled, piped and internally wired. Capacities and characteristics as listed in the schedule and the specifications that follow.

PART 2 PRODUCTS

2.1 CASING AND CABINET

A. All units must have multiple access panels for serviceability of compressor compartment. The heat pumps shall be fabricated from heavy gauge galvanized steel with powder coat paint finish and a stainless steel front access panel. Both sides of the steel shall be painted for added protection. All interior surfaces shall be lined with 1/2 inch [12.7mm] thick, dual density, acoustic type glass fiber insulation. Insulation placement shall be designed in a manner that will eliminate any exposed edges.

B. Cabinets shall have separate holes and knockouts for entrance of line voltage and low voltage control wiring. All factory-installed wiring passing through factory knockouts and openings shall be protected from sheet metal edges at openings by plastic ferrules.

C. Unit(s) shall have exterior indicator lights showing,

   a. 1) compressor operation (on/off)
   b. 2) unit “fault” status.

   Contractor shall be responsible for providing control circuitry and indicator lights for units not providing this feature.

2.2 REFRIGERANT CIRCUIT

A. Units shall have a sealed refrigerant circuit including a high efficiency scroll compressor designed

for heat pump operation, a thermostatic expansion valve for refrigerant metering, a reversing valve, coaxial (tube in tube) refrigerant to water heat exchangers, and safety controls including a high pressure switch, low pressure switch (loss of charge), and low temperature sensors. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service. 120 units shall have 2 independent refrigeration circuits. Activation of any safety device shall prevent compressor operation via a microprocessor lockout circuit.

B. Hermetic compressors shall be internally sprung. The compressor(s) shall have a dual level vibration isolation system. Compressor(s) will be mounted on rubber grommets to a large heavy gauge compressor mounting plate, which is then isolated from the cabinet base with rubber grommets for maximized vibration attenuation. Compressor shall have thermal overload protection. Refrigerant to water heat exchangers shall be of copper inner water tube and steel refrigerant outer tube design, rated to withstand 625 PSIG [3101 kPa] working refrigerant pressure and 500 PSIG [3101 kPa] working water pressure. Plate to plate heat exchangers are not acceptable.

C. Refrigerant metering shall be accomplished by thermostatic expansion valve only. Expansion valves shall be dual port balanced types with external equalizer for optimum refrigerant metering. Units shall be designed and tested for operating ranges of entering water temperatures from 20° to 120°F. Reversing valve shall be four-way solenoid activated refrigerant valve, which shall default to heating mode should the solenoid fail to function.

2.3 ELECTRICAL

A. CXM Control - A microprocessor-based compressor controller (CXM) shall be provided to monitor and control unit operation. The control shall provide compressor sequencing (120 size), high and low pressure monitoring, field selectable water coil low temperature sensing, over/under voltage monitoring, and unit performance sentinel (UPS). The control shall also provide for water valve connection, a test mode, short cycle protection, random start-up, as well as fault LED, fault memory, and intelligent fault retry.

B. The control shall employ quick attach harness assemblies for low voltage connections to the control board to aid in troubleshooting or replacement. An integral terminal block with screw terminals shall be provided on the control for all field low voltage connections. A circuit breaker protected 75VA transformer shall be employed. Line voltage box lugs shall be provided for unit wiring. Units shall have knockouts for entrance of low and line voltage wiring.

2.4 PIPING

A. Supply and return water connections shall be of gasketed brass swivel union type and provide a working pressure rating to 450 psi [3101 kPa]. For 120 units, copper threaded fittings are mechanically fastened to the cabinet, eliminating the need to use a back-up wrench when making field piping connections. The threaded copper adaptors shall be low-temperature soldered to prevent misshaping or weakening of the fitting, eliminating potential start-up piping leaks. All water piping shall be insulated to prevent condensation at low liquid temperatures.

2.5 ACCESSORIES & OPTIONS

A. Hot Water Generator

1. An optional heat reclaiming desuperheater coil of vented double-wall construction suitable for potable water shall be provided. The coil and hot water circulating pump shall be factory mounted inside the unit. A high limit and low compressor discharge line temperature switch shall be provided to disable the pump when these conditions occur.

B. Cupro-Nickel Heat Exchanger

1. An optional corrosion resistant CuNi coaxial heat exchanger shall be factory installed in lieu of standard copper construction.

C. Flow Controller (field installed)

1. A self-contained module shall provide all fluid pumping, fill and connection requirements for ground-source closed-loop systems up to 20 GPM. The Flow Controller shall provide 1” pump isolation valves and 3-way service valves. Pump heads shall be removable from the volute for easy replacement. The Flow Controller shall be enclosed in a polystyrene case and fully insulated with urethane foam to prevent condensation. The Flow Controller shall have a 5- year warranty on all parts.

D. Hose Connection Kit (field installed)

1. An accessory hose kit shall provide 150psi 1” rubber hose with brass fittings equipped with service pressure/temperature ports for connection between the unit and Flow Controller.

PART 3 EXECUTION

3.1 INSTALLATION

A. Follow manufacturer’s manual.

3.2 WARRANTY INFORMATION

A. Residential class heat pumps to be backed by a ten-year limited warranty on all unit parts, including the following accessories when installed with manufacturer units: Flow Controllers, Thermostats & Electric Heaters.

END OF SECTION

SECTION 262416 - PANELBOARDS

PART 1 – GENERAL

1.01 ALL PANELBOARDS

A. Provide products listed and labeled by Underwriters Laboratories Inc. as suitable for the purpose indicated.

B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature:

C. Short Circuit Current Rating:

D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.

E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
   1. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.

G. Conductor Terminations: Suitable for use with the conductors to be installed.

H. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
   2. Boxes: Galvanized steel unless otherwise indicated.
      a. Provide wiring gutters sized to accommodate the conductors to be installed.
   3. Fronts:
   4. Lockable Doors: All locks keyed alike unless otherwise indicated.

I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

1.02 OVERCURRENT PROTECTIVE DEVICES

END OF SECTION

SECTION 262716 - ELECTRICAL CABINETS AND ENCLOSURES

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Hinged cover enclosures
B. Cabinets
C. Terminal blocks
D. Accessories

1.2 RELATED SECTIONS

A. Section 260529 – Hangers and Supports for Electrical Systems

1.3 REFERENCES

A. Quality Control
B. NECA Standard of Installation (National Electrical Contractors Association)
C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
D. NEMA ICS 4 - Terminal Blocks for Industrial Control Equipment and Systems
E. NFPA 70 - National Electrical Code

1.4 SUBMITTALS FOR REVIEW

A. Section 260500- Submittals: Procedures for submittals.
B. Product Data: Provide manufacturer's standard data for enclosures and cabinets.

1.5 SUBMITTALS FOR INFORMATION

A. Section 260500- Submittals: Submittals for information.
B. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

1.6 MAINTENANCE MATERIALS

A. Contract Closeout
B. Furnish two of each key.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Hoffman

B. Wiegmann.

2.2 HINGED COVER ENCLOSURES

A. Construction: NEMA 250, Type 1 or 4X steel enclosure as required for the application or shown on the plans.

B. Covers: Continuous hinge, held closed by flush latch operable by key.

C. Provide interior metal panel with stand off brackets for mounting terminal blocks and electrical components; finish with white enamel.

D. Enclosure Finish: Manufacturer's standard enamel or brushed stainless steel.

E. Provide metal barriers to form separate compartments wiring of different systems and voltages.

2.3 CABINETS

A. Boxes: Galvanized steel

B. Box Size: 24-inches (600-mm) wide x 24 inches (600 mm) high x 6-inches (150- mm) deep, minimum, increase dimensions as required for application.

C. Provide interior metal panel with stand off brackets for mounting terminal blocks and electrical components; finish with white enamel.

D. Fronts: Steel, flush or surface as indicated with concealed trim clamps, door with concealed hinge, and flush lock keyed to match branch circuit panelboard. Finish with gray baked enamel.

E. Knockouts: None

F.Provide metal barriers to form separate compartments wiring of different systems and voltages.

G. Provide mounting rack for free-standing equipment.

2.4 TERMINAL BLOCKS

A. Terminal Blocks: NEMA ICS 4

B. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 volts.

C. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 300 volts.

D. Provide ground bus terminal block, with each connector bonded to enclosure.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with NECA "Standard of Installation".

B. Install enclosures and boxes plumb. Anchor securely to wall and structural supports at each corner under the provisions of Section 260529.

C. Install cabinet fronts plumb.

D. All cabinets and enclosures shall be hinged cover enclosures as noted in 2.2 above except the following locations shall be cabinet type as noted in 2.3 above:

1. Electrical Rooms
2. Mechanical Rooms
3. Systems Rooms
4. Above accessible ceilings (only when indicated on the drawings)
5. Flush wall applications where indicated on the drawings.
6. Cabinet type enclosures shall not be acceptable in exterior or wet locations.

3.2 CLEANING

A. Clean electrical parts to remove conductive and harmful materials.

B. Remove dirt and debris from enclosure.

C. Clean finishes and touch up damage.

END OF SECTION

SECTION 262726 - WIRING DEVICES

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

3.01 INSTALLATION

A. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.

B. Coordinate locations of outlet boxes provided under Section 260537 as required for installation of wiring devices provided under this section.

C. Install wiring devices in accordance with manufacturer's instructions.

D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.

F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.

G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

H. Install wiring devices plumb and level with mounting yoke held rigidly in place.

I. Install wall switches with OFF position down.

J. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

K. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.

END OF SECTION

SECTION 262817 - ENCLOSED CIRCUIT BREAKERS

PART 1 PRODUCTS

1.1 ENCLOSED CIRCUIT BREAKERS

A. Description: Units consisting of molded case circuit breakers individually mounted in enclosures.

B. Provide products listed and labeled by Underwriters Laboratories Inc. as suitable for the purpose indicated.

C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature: Between 23 degrees F and 104 degrees F.

D. Short Circuit Current Rating:

E. Conductor Terminations: Suitable for use with the conductors to be installed.

F. Provide solidly bonded equipment ground bus in each enclosed circuit breaker, with a suitable lug for terminating each equipment grounding conductor.

G. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:

H. Provide externally operable handle with means for locking in the OFF position.

1.2 MOLDED CASE CIRCUIT BREAKERS

A. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.

B. Interrupting Capacity:
   1. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
   2. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.

C. Conductor Terminations:
   1. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.

D. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.

END OF SECTION

SECTION 263100 - PHOTOVOLTAIC SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. These specifications cover Photovoltaic (PV) System (s) requirements including, but not limited to equipment, hardware, software, documentation, labor, materials, and supervision required for the installation of grid-connected PV systems.

B. Section Includes, but is not limited to the following:

1. Infrastructure, wiring, connections, and testing.
2. Solar panels and panel arrays.
3. Disconnects.
4. DC combiners.
5. Inverters.
6. Monitoring equipment and Control software.
7. Metering equipment and interfacing with utility company meter.
8. Identifications and signs.
9. Training.

1.02 RELATED REQUIREMENTS

A. Division 01 - General Requirements

B. Division 02: Existing Conditions.

C. Division 05: Metals.

D. Division 06: Woods, Plastics, and Composites.

E. Division 07: Thermal and Moisture Protection.

F. Section 26 0500: Common Work Results for Electrical.

G. Section 26 0800: Electrical Systems Commissioning.

H. Section 26 0513: Basic Electrical Materials and Methods.

I. Section 26 0519: Low Voltage Wires (600 Volt AC).

J. Section 26 0526: Grounding and Bonding.

K. Section 26 0533: Raceways, Boxes, Fittings, and Supports.

L. Section 26 2600: Power Distribution Units.

M. Section 26 5200: Emergency Power Systems.

N. Section 27 1014:Structured Cabling (New Sites).

O. Division 32: Exterior Improvements.

1.03 REFERENCES

A. Installation, inspections and tests shall be in accordance with the most current applicable codes and standards.

1. ANSI Z21.83 – Solar Photovoltaic Performance and Safety.

2. ANSI C2-1999 – National Safety Code.

3. AMSE PTC 50 – Solar Photovoltaic Performance.

4. ASCE 7-05 – Standard for Minimum Design Loads for Buildings and Other Structures, Chapter 13.

5. CBC – California Building Code.

6. CEC – California Electrical Code.

7. DSA-IR 18 – Division of the State Architect Interpretation of Regulations Document 16-A.

8. IEEE 929-2000 – Recommended Practice for Utility Interface of Photovoltaic Systems.

9. IEEE 1262-195 – Recommended Practice for Qualification of Photovoltaic (PV) Modules and Panels.

10. IEEE 1537 – Standards for Interconnecting Distributed Resources with Electric Power Systems.

11. NFPA72 – National Fire Code.

12. NFPA 853 – Solar Photovoltaic near Buildings.

13. NRTL – Nationally Recognized Testing Laboratory.

14. UL 1703 – Flat-Plate Photovoltaic Modules and Panels.

15. UL 1741 – Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Systems.

16. LADWP Solar Program Guidelines.

17. SCE Solar Program Guidelines.

1.04 SUBMITTALS

A. Shop Drawings

1.05 QUALITY CONTROL

A. The Contractor shall have a California Solar or Electrical Contractor's license.

1. Components and interconnection wiring shall be installed by state certified electricians. Contractor or Installer's electricians shall be certified in accordance with Labor Code sections 3099, and 3099.2 and section 209.0 of the California Code of Regulations.

B. Contractor shall have adequate experience installing systems of similar size and complexity.

1. Qualifications of Installer: Minimum five years experience installing products and systems of similar scope and complexity.

2. Installer shall have completed at least five projects of equivalent scope and complexity.

3. Installer shall submit certification from the equipment manufacturer indicating that installer is an authorized representative of the equipment manufacturer and is trained on the installations of the specified PV system products.

4. Installer shall maintain a fully equipped service organization capable of furnishing repair service to the equipment.

5. Installer shall furnish a letter from manufacturer of equipment certifying equipment has been installed according to factory standards and that system is operating properly.

6. Contractor shall have completed and commissioned a minimum of five service agreements that provide similar support services to those needed for this project.

7. System startup and testing shall be performed under the direct observation of the Project Inspector and OAR.

C. Materials and equipment installed shall be new and listed as an approved technology by the California Energy Commission (CEC) Emerging Technology Buydown Program.

D. The installer shall provide the system components required by code and for the safety of the District's service personnel.

E. System components shall operate per industry standards.

1.06 WARRANTY

A. System shall be warranted in accordance with state regulations for photovoltaic systems.

1. The PV System Equipment Manufacturer shall provide a ten year material warranty at 90 percent of its rated power, and 20 years at 80 percent of its rated power.

2. System warranties and materials, fabrication and execution guaranties shall be in effect during the Solar License Agreement.

B. System components (other than PV modules) shall be guaranteed against defects in materials, fabrication and execution for a minimum of three years from date of system acceptance. Provide labor and materials to repair, reprogram, or replace components at no charge to the Owner during the warranty period. Corrective work or system modifications shall be updated on user documentation and archived software disks.

1. Warranty shall include annual on-site inspection, including: system testing (operating current of each electrical system), system adjustments and routine maintenance.

2. Repair or replacement of defective parts.

3. System performance monitoring and historical data access for customer via secure website. Data is required to include: system energy and power production, ambient temperature, wind speed, and insolation.

a. The system shall be connected ahead of the facilities computer network firewall. Provide necessary work, materials and installation to connect the system to the MPOE.

4. Daily system monitoring by vendor, including reporting of problems to customer and dispatch of resources for expeditious resolution of problems.

5. The maintenance agreement shall include a response time of four hours for major system failures (emergency service), and 48 hours for minor repairs (routine service). Proposed agreement shall include biannual site visits for preventative maintenance inspection so that systems are validated prior to the warranty expiration date.

C. Provide a list of applicable warranties for equipment and components, this list shall include warranty information, names, addresses, telephone numbers, and procedures for filing a claim and obtaining warranty services.

D. Respond to the Owner's request for warranty service within four hours during normal business hours. For calls, submit records of the nature of the call, the work performed, and the parts replaced or service rendered.

1.07 TRAINING

A. Provide a factory employed instructor to provide full instructions to designated District personnel in the system's operation, maintenance, and programming. Training shall be specifically oriented to installed equipment and systems.

1. The instruction period shall be scheduled and coordinated by the OAR.

2. Provide four hours of onsite owner familiarization and training for the installed system. Training shall include system overview, override commands, normal and emergency operation and response, programming features and report generation. District employees attending this training session shall be provided with the following documentation:

a. System layout point to point connection diagram.

b. System components cut sheets.

c. Operations and maintenance data.

d. Safety rules for the operations and maintenance of PV systems.

PART 2 – PRODUCTS

A. Photovoltaic system requirements

1. Provide complete photovoltaic system consisting of photovoltaic modules and associated balance of system components necessary for connection to facility electrical system.

2. Provide photovoltaic system and associated components suitable for wind loads, snow loads, seismic loads, and other structural design considerations of the installed location.

3. Provide photovoltaic system and associated components suitable for continuous operation under the service conditions at the installed location.

4. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or Intertek (ETL) as suitable for the purpose indicated.

5. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system.

6. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

7. Arrange array to minimize shading during peak production periods.

B. Photovoltaic modules

1. Acceptable Module Types: Premium monocrystalline silicon panels complying with specified requirements will be considered for this project.

2. General Requirements:

    a. Photovoltaic Modules: Factory assembled; consisting of photovoltaic cells, frame, junction box, cables for series connection, and bypass diodes for shade tolerance; rated for 600 V DC; listed as complying with UL 1703.

    b. Photovoltaic Modules: Comply with IEC 61646.

    c. Frame: Anodized aluminum.

    d. Factory-Installed Junction Box: Weatherproof, with factory-installed terminals and bypass diodes.

    e. Factory-Installed Cables: Type USE-2 or listed photovoltaic (PV) wire with polarized locking connectors.

    f. Unless otherwise indicated, specified module performance characteristics are rated under Standard Test Conditions (STC).

C. Mounting equipment for photovoltaic modules

1. Acceptable Mounting Equipment:

    a. Everest CrossRail

b. Solar Wedge, Professional Solar Products

c. Unirac

2. General Requirements:

a. Mounting of 3 strings of 8 panels each (as specified above) to flat roof

A. Inverters:

1. Inverters shall be listed on the California Energy Commission's PTC list and must qualify for eligibility under the California Solar Initiative (CSI) Program, and the LADWP Solar Incentive Program.

2. The PV system shall have at least one inverter. Inverter units shall be solid state device capable of accepting the output of the photovoltaic panels and providing rated output as indicated in construction documents.

a. The inverter shall be equipped with the following items:

1. DC input disconnect.

2. Surge protection.

3. Ground fault interrupter.

4. Isolation transformer.

5. AC output circuit breaker.

6. Data Monitoring System.

3. The inverter shall be able to sustain an overload across its output terminals up to 150 percent load, while supplying any load within its rating and without reducing its output voltage.

4. The inverter shall be capable of at least 300 percent current for short circuit conditions. If the short circuit is sustained, the inverter shall shutdown and disconnect automatically from the load bus.

5. Each inverter unit shall be equipped with fault sensing and static isolation, and with an output circuit breaker for removal of faulted module(s) from the system.

6. Power semiconductors in the inverter shall be fused with fast acting fuses to prevent cascading failures. Each fuse shall be provided with a blown fuse and alarm indicating diodes on the control panel.

7. AC Inverter System Output:

   a. Voltage regulation plus or minus 0.5 percent balance load. plus or minus two percent for 50 percent unbalanced load.

   b. Voltage adjustment range plus or minus five percent manually.

   c. Frequency regulation 0.1 percent.

   d. Phase Displacement:

      1) Balanced load, 120 percent plus or minus one percent.

      2) Fifty percent unbalanced, 120 percent plus or minus three percent.

E. Inverters:

   1. Approved Manufacturers:

      a. Basis of Design: Princeton Power (DRI-10)

      b. Advanced Energy Industries, Inc.(AESolaron)

      c. PV Powered Inc

      d. Equal or better Energy Commission approved inverters may be submitted for review by the Owner. Installations shall not be allowed without written consent from the Owner. Proposed inverters shall have equal or smaller footprint.

F. Combiner Box: As recommended by the PV modules manufacturer.

   1. The system shall have at least a terminal box or boxes, providing the electrical the electrical string(s) a waterproof entry to the conduit leading to the combiner box(es).

   2. The terminal box and combiner box can be one physical unit.

   3. The PV system shall have a combiner box(es), containing fuses and a bus to combine the outputs of the strings. A set of wires shall run from the combiner box to the inverter(s).

   4. Combiner output shall be compatible with inverter input.

G. Edge Connector: As indicated by the PV module manufacturer.

1. Method of electrical interconnection for PV laminates shall be by means of a factory supplied plug connecting cable.

2. Cables measuring 12 to 18 inches shall be supplied with a male-type connector on each end, or with newer technology as recommended by the solar array manufacturer.

3. Each laminated light for PV modules shall be provided with a factory supplied female-type connector.

H. Accessories: Junction boxes, anchors, wiring lugs and other accessories shall be provided in accordance with Division 26 requirements, and in compliance with California Electrical Code requirements and the PV modules manufacturing recommendations.

2.02 SYSTEM RATING

A. System shall be sized to provide the KW system output indicated on drawings at full load rated power.

B. The systems shall be rated for outdoor installation. The system equipment shall be capable of operating under the locations maximum and minimum documented temperatures during summer and winter times. The entire system must be rated and warranted to withstand and operate under these conditions.

C. Rated PV system capacity must be specified in direct current (DC) kilowatts peak under both STC and PTC conditions.

1. The STC or Standard Test Conditions rating assumes direct current referred as “kWdc-stc”. It is also refer as kilowatts peak, or “kWp”. Specific PV module manufacturer maximum and minimum power data must be specified for this rating.

2. The PTC rating or PV USA Test Conditions rating is based on 1,000 Watts per square meter solar irradiance, 20 degree Celsius ambient temperature and one meter per second wind speed.

2.03 STRUCTURAL IMPACT AND WIND LOADING

A. The PV array weight shall add no more than eight pounds per square foot to the facility roof structure in the array area.

B. PV arrays shall be seismically restrained from falling off the roof or excessive movement on the roof. Panels shall be installed to resist sliding and pop-up resulting from lateral and vertical seismic forces and displacements per CBC.

PART 3 – EXECUTION

3.01 GENERAL

A. PV system shall not be used for any purpose other than its intended functions.

B. Equipment mounted in exterior locations shall be rated NEMA 3R.

C. Semiconductor devices shall be hermetically sealed. Vacuum tubes shall not be used.

D. Relays shall be dust tight.

E. Wiring methods for power distribution and controls shall be as defined in the Division 26 specifications. Wire types shall conform to manufacturers' recommendations.

F. Bolted connections of bus bars, lugs, and cables shall be in accordance with the requirements of applicable codes and standards.

G. Power connection shall be marked and torque to the required value.

H. Commissioning requirements of Divisions 01 and 26 apply to this section.

I. Coordinate the Work with other aspects of roofing, mechanical, structural, and electrical systems to obtain a complete and operating system.

3.02 SYSTEM INSTALLATION

A. Terminations shall be in terminal cabinets or on equipment terminals.

B. Conductors shall be installed within conduits, boxes, and terminal cabinets in a totally enclosed installation. Provide conductors required to connect incoming and outgoing circuits.

C. Wiring within equipment and terminal cabinets shall be installed to conform to contract documentation and NFPA 72 standards. Wiring shall be cabled, laced, and securely fastened in place so that no weight is imposed on equipment or terminals.

D. Conductors shall be color-coded and tagged with code markers at terminal cabinets, and equipment. A wire index shall be typed and installed on terminal cabinet doors. Index shall be covered with clear plastic adhesive covers. Wiring shall be identified as to building and location of devices.

E. Complete installation shall comply with local building codes, manufacturer's instructions, and applicable industry standards.

F. Location of boxes and raceways on Drawings is approximate, unless dimensions are indicated. Do not scale Drawings to determine locations and routing of conduits.

Location of the infrastructure and equipment shall conform to architectural features of the building and other Work already in place, and must be ascertained in the field before the start of Work.

G. Drawings generally indicate Work to be provided, but do not indicate all bends, transitions or special fittings required to clear beams, girders or other Work already in place. Investigate conditions where conduits are to be installed, and furnish and install required fittings.

H. The roof shall be inspected prior to start of any work. Any observed deficiencies shall be brought up to the attention of the OAR prior to commencing any work.

I. Loose gravel on the area designated for the PV arrays shall be removed. The collected gravel shall be removed.

J. Prepare framing to receive PV modules in accordance with manufacturer's recommendations and in compliance with accepted shop drawings.

K. Adequate ventilation shall be provided to ensure that system components are operated within their environmental ratings.

L. Provide warning signs as required by applicable codes.

3.03 MONITORING

A. Provide an on-site Data Acquisition System (DAS). The DAS shall be equipped to log the information critical to the evaluation of system performance, including AC current energy production, solar irradiance, ambient temperature, and wind speed.

B. The information shall be stored on the logger at 15-minute intervals and transmitted to a District designated processing facility. Information shall be stored and backed-up per CEC and utility company requirements.

C. Provide annual reports of system's performance on the anniversary of the system.

1. The report shall include a full-color chart showing the predicted energy output for a typical year, the predicted energy output for the current year, and the actual energy produced in each month of the year.

2. The report shall be prepared for each individual system in the site, and as an aggregate for the entire site's electrical energy production.

3. The DAS shall include a data logger, modem for data retrieval, NEMA 4 enclosure, dry bulb measuring device, anemometer, solar sensor and radiation shield.

3.04 TESTING

A. Demonstrate in presence of the Project Inspector, and Commissioning Agent that circuit and wiring tests are free of shorts and grounds and that installation performs as specified herein and within manufacturer's guidelines.

B. PV modules shall be factory tested for design performance.

C. Inverter shall be factory tested for performance; results shall be included in the Operation and Maintenance Manual.

D. Provide commissioning and system startup.

E. Defects resulting from tests shall be corrected prior to substantial completion.

F. Software Modifications:

1. Provide the services of a factory trained and authorized technician to perform system software modification, upgrades or changes. Response time of the technician to the Project site shall not exceed 24 hours.

3.05 SERVICE MANUALS

A. Contractor shall deliver to OAR, three copies of the service manuals. Each manual shall include the following:

1. Installation manuals, programming manuals, user manuals, and part numbers if applicable for every major system component. Catalog cut sheets are not acceptable.

2. A printed copy of the system configuration, including system labeling codes, and passwords.

3. An electronic copy of the system configuration program on compact disk.

4. Final test report.

5. Detailed explanation of the operation of the system.

6. Instructions for routine maintenance.

7. Detailed wiring diagrams and updated shop drawings that include revisions made in the field via plan changes, RFIs, Field Change Directives, and any other construction change documents including interface details with other systems.

8. Provide a CD ROM electronic copy of the updated system As-Built Drawings to the OAR, prepare this copy in the latest version of AutoCAD; along with the

electronic copy provide a full size bond copy. Include one CD-ROM of the up-dated As-Built Drawings into each of the Service Manuals. CD and folded drawings shall be secured and inserted into the Service Manuals via a three-hole punched protective CD case and protective envelopes for the drawings.

9. Materials and required deliverables shall be submitted to the OAR.

3.06 PROTECTION

A. Protect the Work of this section until Substantial Completion.

3.07 CLEANUP

A. Remove rubbish, debris, and waste materials and legally dispose of off Project site.

END OF SECTION

SECTION 26 32 13 - STANDBY POWER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY:

A. This section details general requirements for equipment used for Emergency and Standby power systems, including engine generators, automatic transfer switches and related accessory equipment.

1.2 RELATED SECTIONS:

A. Section 01301- Design Guidelines for Energy and Environment

B. Section 01701 - Building Systems Identification and Labeling

C. Section 01771 - Contract Record Documents

D. Section 260901 – Campus Central Metering System Design Criteria

1.3 QUALITY ASSURANCE:

A. The Engineer of Record is responsible for designing a system in accordance with applicable portions of the NFPA Codes, Rhode Island Emissions Standards, NFPA, UL and NEMA Standards.

B. Emergency and Standby Power system design shall be in accordance with NFPA 110.

C. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 SUBMITTALS:

A. Product Data: Submit product literature detailing equipment ratings, dimensions, mounting and installation details, applicable wiring diagrams, enclosure type and accessories.

1.5 EMERGENCY GENERATOR DESIGN CRITERIA:

A. Where engine generators are installed for powering of Standby power loads, they shall be configured to power the following:
   1. All Emergency /Life Safety loads
   2. Building Automation System controls
   3. Building telecommunications rooms
   4. Identified standby power loads (for example, local boiler and one hot water circulating pump set to reduce the chance of building freeze-up upon an extended power outage).
   5. Storm water sump pumps and sewage ejector pumps
   6. Identified User loads (computer systems, lab equipment, etc.)

B. Exercise care in the configuration and sizing of standby power loads to minimize generator size. Generators shall be sized for the full load and starting needs of all connected Emergency Life Safety and legally required Standby loads; provide generator capacity for lower-priority Optional Standby loads only where the required legally required and optional Standby load exceeds the Emergency capacity. For example, where there are Optional standby loads and an electric fire pump, provide load-shed controls to lock out the Optional standby loads when the fire pump is called to run on the generator; size the generator for only the fire pump load, assuming the fire pump load is larger than the standby power load.

C. The standby power system shall be designed to accommodate the type of loads placed on the system (i.e., motors, UPS, HID lighting, etc.).

D. Review NEC requirements for isolation and bonding requirements of neutral and ground connections at generators and automatic transfer switches.

E. Preference is for generators to be located indoors.

F. Any noise issues shall be closely coordinated with the University. All systems shall be designed to comply with city noise ordinances.
   1. Generators shall have critical-grade silencers.
   2. Exterior-mounted generator enclosures, if required, shall be premium- sound attenuated.
   3. Remote-mounted radiators shall be low-noise, sound attenuated where required.
   4. Noise considerations to include generator air intake and exhaust louvers.

G. Generator Fuel Source: Provide Life Cycle cost analysis for generator fuel type where so directed, based on generator size and availability of natural gas supply. Natural gas is the preferred fuel source in locations where it is readily available at the required minimum gas pressure. Diesel fuel is generally more economical in larger (over 150 KW) sizes. Considerations for diesel fuel include: locations for fuel storage capacity, required secondary spill containment and leak detection for storage tanks, piping and fuel filling systems.

H. Fuel Capacity: Where diesel generators are utilized, provide onsite fuel storage for a minimum of 36 hours run time at 75% load.

I. Fuel Handling:
   1. Fuel filling station shall have spill containment and be provided with spill absorption kit.
   2. Fuel storage tanks and piping shall be of double wall construction. Provide leak detection system for underground fuel storage tanks and piping systems. Leak detection system to be connected to Building Automation Systems for alarms.
   3. Remote located tanks (indoor or underground) to have local fuel tank level indicator and high level alarm monitor at the fuel filling location.

J. Generator Supervisory Monitoring:
   1. Generators “run” status alarms to be connected to building fire alarm and to Building Automation System for supervisory monitoring.
   2. Provide remote generator alarm annunciator panel, per NFPA 110, adjacent to fire alarm panel.
   3. Provide remote generator shut-down switch, under a break-glass cover, outside the generator room per NFPA 110.

K. Generator Controls:
   1. Generators over 100 KW to be provided with electronic generator controls; provide MODBUS communications protocol and data connections for integration of generator operating parameters (“run”/”pre-alarm”/”alarm” status, “Volts”/”KW”/”KVA” load data and fuel tank level) into campus metering system. See section 260901 – CAMPUS CENTRAL METERING SYSTEM DESIGN CRITERIA for details.
   2. Generators under 100 KW may be provided with either hard-wired “run”/”alarm”/”pre-alarm” and “low fuel level” dry contacts or MODBUS communications protocol data connections for connection into the Campus Metering System.

L. Remote Radiators:
   1. Installations incorporating remote-mounted radiators for cooling to be coordinated and designed per manufacturer requirements, including design and sizing of secondary heat exchangers, coolant circulating pumps, expansion tanks, glycol feeders, consideration of coolant head pressure, supervisory controls and alarm monitoring points.
   2. Preferred remote radiator configuration is vertical discharge.

M. Vibration Isolation:
   1. Provide vibration isolation dampeners on generator mounting connection points.
   2. Provide vibration dampeners on all prepackaged generator enclosure connection points, where mounted on or within buildings.

N. Signage:
    1. Provide signage at building service equipment detailing location of generator and service disconnects.

1.6 AUTOMATIC TRANSFER SWITCHES:

A. Provide separate UL-1008 listed transfer switches for emergency life safety, legally required standby and optional standby loads.

B. Transfer switches shall be closed-transition type.

C. Ratings: Transfer switches shall have sufficient short circuit ratings for use on the proposed distribution system; note that many smaller switch sizes have reduced interrupting ratings.

D. Provide transfer switches with integral power meter (volts/amps/Kw); with MODBUS communications protocol; connect meter outputs and transfer switch position contacts into campus metering system. Transfer switches used for Critical loads (such as for Research facilities) shall also have position contacts monitored by the building automation system.

E. Provide transfer switches with panel-mounted local “load/no-load” test switches; provide remote dry contact closure for remote transfer switch enable operation (start generator and transfer load to generator until contact is opened), Connect contact to campus metering system interface.

PART 2 PRODUCTS

2.1 GENERATORS

A. Manufacturers:
    1. Caterpillar
    2. Cummins/Onan

B. Generators shall be 1,800 RPM, continuous standby rated.

2.2 AUTOMATIC TRANSFER SWITCHES

A. Manufacturers:
    1. ASCO 7000 series
    2. RussElectric RMTD -series

PART 3 EXECUTION

3.1 ELECTRICAL DEVICE COORDINATION

A. Ensure that standby power system electrical overcurrent and protective devices are properly calibrated and set, including settings for all transfer switch functions.

B. Provide hardcopy of all transfer switch settings within the transfer switch cabinets.

3.2 FIELD TESTING

A. Field test the complete sequence of standby power system operation, including power failure, load shed (if applicable) and operation of all supervisory signals and controls. The Engineer of Record shall determine the particular field acceptance testing requirements for each project in coordination with FM Operations and Engineering staff.

B. Field testing of the generator shall include a full load test for a minimum 4-hour period with temporary resistive load banks and installation acceptance tests as required by NFPA 110, including cold start and load acceptance tests.

C. Field test to ensure that generator room is within required tolerances for overheating, airflow, and that exhaust system is free of leaks and restrictions.

D. Ensure that any generator automatic exerciser features within transfer switches, generator control panels or fire pump control panels are disabled “off”.

E. Standby power systems and equipment shall be commissioned to verify proper setup, calibration and recording of standby power system data into the Campus Metering system and remote system operation from Campus Metering system.

END OF SECTION

SECTION 265100 - INTERIOR LIGHTING

PART 1 GENERAL

1.01 SUMMARY OF LUMINAIRES

A. Provide products that comply with requirements of NFPA 70, Title 24 and ANSI.

B. Provide products that are listed and labeled as complying with UL 1598, where applicable.

C. Provide RGB fixtures that comply with all building code requirements of Title 24.

D. Provide products listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

E. Comply with ASHRAE 90.1 lighting power density (LPD) of 0.6 W/sf

F. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.

G. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.

H. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.

1.02 QUALITY ASSURANCE

A. Product testing of each fixture to be undertaken on IVC campus.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Delivery- Deliver materials from package retailer or other source Team OC build site.

B. Transportation to Competition- Ships installed unless otherwise specified.

1.04 Warranty

A. Product Warranty- Refer to Conditions of the Contract for purchase warranty provisions.

PART 2 PRODUCTS

2.01 SUMMARY OF PRODUCTS

A. Outdoor Fixtures

1. Ramp/ Downlight Light- Pathway Lighting for Outdoor Landscaping and Security
2. Spot Light- Accent Landscape Ground Stake Mounted Fixture
3. RGB LED Linear Strip Light- Accent/ Task Fixture Mounting will vary
4. Wall Sconce- Ambient Wall Mounted Fixture
5. String Light- Ambient Flex Dining

B. Interior Fixtures

1. LED Linear Strip Light- Accent/ Task Fixture- Mounting will vary
2. Recessed Downlight- Ambient Light
3. Kitchen Pendants- Downlight, Ambient Wall Mounted Fixture

END OF SECTION

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 PRODUCTS

1.1 IDENTIFICATION REQUIREMENTS

A. Identification for Equipment:

1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.

B. Identification for Conductors and Cables:

1. Color Coding for Power Conductors 600 V and Less: Comply with Section 260519.
2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.

1.2 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:

1. Materials:

B. Identification Labels:

1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.

1.3 WARNING SIGNS AND LABELS

A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.

B. Warning Signs:

1. Materials:
2. Minimum Size: 7 by 10 inches unless otherwise indicated.

C. Warning Labels:

1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
3. Minimum Size: 2 by 4 inches unless otherwise indicated.

END OF SECTION

SECTION 272200 – DATA COMMUNICATIONS HARDWARE

Part 1 - GENERAL

1.1 SUMMARY

A. This section includes information on the control equipment. These include the:

1. DHT11 Temperature/Humidity Sensor
2. Bluefruit EZS-Link Module
3. ATMEGA 328P
4. Netgear- Nighthawk Dual-Band Wireless-AC router

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Sensors

1. DHT11 Temperature/Humidity Sensor.
    a. Product Description and/or specifications
2. Measurement Range: 20-90% Relative Humidity
3. Humidity Accuracy: +/- 5% Relative Humidity
4. Temperature Accuracy +/- 2°C
5. Resolution: 1
6. Package: 4Pin Single Row
7. Measurement Range: 0°C to 50°C
8. Response Time: 6s to 30s

B. Bluetooth Communication Hardware

1. Bluefruit EZ-Link
    a. Product Description and/or specifications
2. Regular SPP Serial Link device
3. Automatically detect and change Baude rate
4. DTR/RTS/DSR flow control pins sync to computer serial port
5. Bluetooth Dongle Asus BT211
    a. Product Description and/or specifications
6. Standards: Bluetooth V2.1 + EDR
7. Adaptive Frequency Hopping (AFH)
8. USB 2.0(type A) Interface
9. Data rate: Up to 3 Mbps
10. RF Power Class: 4dBm (typical)
11. Range: Up to 100m in free space
12. Frequency Band: 2.400 to 2.4835 GHz unlicensed ISM Band
13. Modulation: GFSK (1Mbps), 4-DQPSK (2Mbps), 8-DPSK (3Mbps)

C. Microcontroller

1. ATMEGA 328P

a. Product Description and/or specifications

1. Flash: 32Kbytes
2. Pin Count: 32
3. Max Operating Frequency: 20MHz
4. CPU: 8-bit AVR
5. Number of Channels: 16
6. Max I/O pins: 23
7. External Interrupts: 24
8. USB Interface: No
9. USB Speed: No

PART 3- EXECUTION

A. Comply with all manufacturers' written recommendations and specifications

SECTION 272226 – LAPTOP

Part 1 - GENERAL

1.1 Summary

A. This will be the main component for the control center for our house. It will take in data, push out data, and output control signals

Part 2 - PRODUCTS

2.1 Satellite P50-BBT2N22

A. Manufacturer: Toshiba, or approved equal

B. Technical Data

1. 4th Gen Intel i7
2. Windows 8.1
3. 500 GB HDD
4. AC Adapter: 120W (19V 6.3A) 100-240V/50-60Hz

C. Scope of Delivery

1. Laptop
2. AC Adapter

Part 3- EXECUTION

3.1 Installation

A. Comply with all manufacturers' written recommendations and specifications

SECTION 283100 - FIRE DETECTION AND ALARM

PART 1 PRODUCTS

1.1 MANUFACTURERS

A. Residential Fire Systems Inc. or equal.

1.2 FIRE ALARM SYSTEM

A. Fire Alarm System: Provide a new automatic fire detection and alarm system:
   1. Provide all components necessary, regardless of whether shown in the contract documents or not.
   2. Protected Premises: Entire building shown on drawings.
   3. Comply with the following; where requirements conflict, order of precedence of requirements is as listed:
      a. ADA Standards for Accessible Design.
      b. The requirements of the local authority having jurisdiction, which is Orange County Fire Authority (OCFA).
      c. Applicable local codes.
      d. The contract documents (drawings and specifications).
      e. NFPA 72; where the word "should" is used consider that provision mandatory; where conflicts between requirements require deviation from NFPA 72, identify deviations clearly on design documents.
   4. Evacuation Alarm: Multiple smoke zones; allow for evacuation notification of any individual zone or combination of zones, in addition to general evacuation of entire premises.
   5. Voice Notification: Provide emergency voice/alarm communications with multichannel capability; digital.
   6. General Evacuation Zones: Each smoke zone is considered a general evacuation zone unless otherwise indicated, with alarm notification in all zones on the same floor, on the floor above, and the floor below.
   7. Program notification zones and voice messages as directed by Owner.
   8. Fire Command Center: Location indicated on drawings.
   9. Master Control Unit (Panel): New, located at fire command center.

B. Supervising Stations and Fire Department Connections:
   1. Public Fire Department Notification: By on-premises supervising station.
   3. Means of Transmission to On-Premises Supervising Station: Directly connected noncoded system.

C. Circuits:
   1. Initiating Device Circuits (IDC): Class B, Style A.
   2. Signaling Line Circuits (SLC) Within Single Building: Class B, Style 0.5.
   3. Notification Appliance Circuits (NAC): Class B, Style W.

D. Power Sources:
   1. Primary: Dedicated branch circuits of the facility power distribution system.
   2. Secondary: Storage batteries.
   3. Capacity: Sufficient to operate entire system for period specified by NFPA 72.
   4. Each Computer System: Provide uninterruptible power supply (UPS).

1.3 COMPONENTS

A. General:
   1. Provide flush mounted units where installed in finish areas; in unfinished areas, surface mounted unit are acceptable.

2. Provide legible, permanent labels for each control device, using identification used in operation and maintenance data.

B. Fire Alarm Control Units, Initiating Devices, and Notification Appliances: Analog, addressable type; listed by Underwriters Laboratories as suitable for the purpose intended.

C. Master Control Unit: As specified for Basis of Design above, or equivalent.

F. Circuit Conductors: Copper or optical fiber; provide 200 feet extra; color code and label.

G. Surge Protection: In accordance with IEEE C62.41.2 category B combination waveform and NFPA 70; except for optical fiber conductors.

H. Locks and Keys: Deliver keys to Owner.

I. Instruction Charts: Printed instruction chart for operators, showing steps to be taken when a signal is received (normal, alarm, supervisory, and trouble); easily readable from normal operator's station.
   1. Frame: Stainless steel or aluminum with polycarbonate or glass cover.
   2. Provide one for each control unit where operations are to be performed.
   3. Obtain approval of Owner prior to mounting; mount in location acceptable to Owner.
   4. Provide extra copy with operation and maintenance data submittal.

END OF SECTION

SECTION 329300 - PLANTS

PART 1 - GENERAL INFORMATION

1.01 SECTION INCLUDES

A. Planting materials

1.02 RELATED SECTIONS

A. 32 94 00 - Planting Accessories

B. 32 95 00 - Exterior Planting Support Structures

PART 2 - PRODUCTS

2.01 PLANTING MATERIALS

A. General

Only vegetation included in the plant schedule will be grown at either Irvine Valley College or donor facilities using indoor greenhouses or protected outdoor growing areas. Plants will be verified to be healthy, pest free and ANSI Z60.1 compliant before being selected for use and again before final installation.

B. Suppliers

1. Valley Crest Landscape Development
2. Alegria Fresh
3. Groundcover:
4. *Arctostaphylos 'Emerald Carpet'* (Emerald Carpet Manzanita)
5. *Rosmarinus Officinalis 'Huntington Carpet'* (Huntington Carpet Rosemary)

C. Shrubs

1. *Arctostaphylos manzanita 'Dr. Hurd'* (Dr. Hurd Manzanita)
2. *Salvia clevlandii* (Cleveland Sage)
3. *Jacobaea maritima* (Dusty Miller)
4. *Agave Parryi* (Parr's Agave)
5. *Agave 'Blue Glow'* (Blue Glow Agave)

D. Edibles

Will be selected from the group below based on appearance and health.

1. Kale (multiple varieties)
2. Lettuce (multiple varieties)
3. Bok Choy
4. Arugula
5. Mint
6. Cilantro
7. Chives
8. Oregano
9. Rosemary
10. Sage
11. Radish (multiple varieties)
12. Parsley
13. Mint (multiple varieties)
14. Basil (multiple varieties)
15. Swiss chard
16. Tomatillo
17. Tomatoes

E. Mulch

A blend of shredded bark and/or organic compost that posses an appropriate water retention rating for its application.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All groundcover and shrubs for will be installed in planters before they are finally installed around the house. All edibles will be grown in soil filled containers that freely install onto the vertical garden.

B. Shrubs and groundcover:

1. Verify all plants are ANSI Z60.1 compliant and are in healthy, presentable condition.
2. Irrigate all pots until soil is fully saturated with water.
3. Place pots into planter and shim using post construction waste wood to bring all vegetation to the same level.
4. Cover pots surface with mulch to hide individual pot borders.
5. Install planters filled with vegetation around the house, first at the IVC build site and then again at the OC Great Park competition site.

C. Edibles:

1. Verify all plants are ANSI Z60.1 compliant and are in healthy, presentable condition.

2. Transport edibles in containers from Alegria Fresh to the vertical garden once the house is fully assembled at the competition site.

3.02 MAINTENANCE

A. Shrubs, groundcover, and edibles

1. Plant maintenance will involve the following activities on an as needed basis:
   a. Pruning and weeding
   b. Watering and fertilizing
   c. Adjustment of plant location or height
   d. Organic pest control
2. Plants will be steadily exposed to increasing levels of direct sunlight and temperature in an effort to acclimate them to predicted competition conditions.
3. Plants may only be stored in areas that are protected from heavy machinery and/or any other operation or event that could pose a threat to the health and appearance of the vegetation.

END OF SECTION

SECTION 329400 - PLANTING ACCESSORIES

PART 1 - GENERAL INFORMATION

1.01 SECTION INCLUDES
1. Planter materials

1.02 RELATED SECTIONS
1. 32 93 00 - Plants

PART 2 - PRODUCTS

2.01 2X4 WOOD CRATE PLANTER MATERIALS (DIMENSIONS VARY)
A. Wood:
   1. 2”x4” Douglas Fir
B. Hardware:
   1. ⅝” DIA galvanized machine bolts w/ iron washers
C. Heavy plastic liner
D. Other:
   1. Potted plant material (refer to sheets L-101, L401 for full plant list)
   See Landscape sheets L-101 and L-202 for complete planter box dimensions

PART 3 - EXECUTION

3.01 PREPARATION AND CONSTRUCTION
A. PLANTER BOXES
1. All nails and/or other hazardous parts (rotten sections, splintered ends, etc.) will be removed from the wood before it used for construction.
2. All planter materials will be assembled at the IVC build site under the supervision of an on-site construction manager who has demonstrated full comprehension of all related construction documents.

3.02 STORAGE AND HANDLING
1. For the duration of the construction period the planters will be housed in a well protected area of the Irvine Valley College campus dedicated to storage of Team OC construction materials and supplies.

3.03 INSTALLATION AND MAINTENANCE
1. Planters will be checked prior to, as well as during the competition to ensure they are retaining their structural integrity as well as providing their plants with an adequate growing environment.
2. Planters are not allowed to be installed around the house until all their plants are verified to be healthy, pest free and ANSI Z60.1 compliant.
3. Depending on the situation at hand, planters may need to be repaired or replaced.

END

SECTION 329500 - EXTERIOR PLANTING SUPPORT STRUCTURES

PART 1 - GENERAL INFORMATION

1.01 SECTION INCLUDES

1. Edible vertical garden manufacturers
2. Planter box construction

1.02 RELATED SECTIONS

1. 32 93 00 - Plants

PART 2 - PRODUCTS

2.01 EDIBLE VERTICAL GARDEN MANUFACTURER OPTIONS

1. RainHarvest Systems Gro-wall vertical gardening system
    a. 48.5” x 26.5” square inch system @ $300.00
    b. Conventional drip heads and irrigation
    c. Modular format allows easy expansion
2. Woolly Pocket wally five living wall planter kit
. 112” x 36” square inch system @ $500.00
    a. Digital trip timer
    b. Conventional drip heads and irrigation
3. GroVert MC
. 20” x 20” square inch system @ $36.95
    a. Irrigation equipment sold separately @ $22.95
    b. Modular format allows easy expansion

2.02 PLANTER BOX WOOD

1. All exterior planter boxes will be constructed from post construction waste wood collected from Tierra Verde Industries, located within the Orange County Great Park.
2. All wood will be stored outdoors within the IVC construction site until it is needed.

See Landscape sheets L-202 for complete edible vertical garden dimensions
See Landscape sheets L-101 and L-202 for complete planter box dimensions

PART 3 - EXECUTION

3.01 PREPARATION AND CONSTRUCTION

A. Edible vertical garden:

1. A professional engineer will verify the format in which the vertical garden is installed can support the total weight placed upon it by soil, plants, irrigation and mounting equipment.
2. The vertical garden, sans plants and soil, will be installed on the house at the IVC build site under the supervision of an on-site construction manager who has demonstrated full comprehension of all related construction documents.
3. Plants in soil containers will only be mounted once the house has been completely installed at the OC Great Park competition site.
4. The drip irrigation system will be tested only once plants and soil are installed, after the house has been assembled at the competition site.

3.02 STORAGE AND HANDLING

A. EDIBLE VERTICAL GARDEN

1. For the duration of the construction period the plants for the edible vertical garden will be grown at the Alegria Fresh farm in the Orange County Great Park.
2. As the competition nears, the edible vertical garden will be assembled and installed, sans plants and soil, onto the house in order to ensure it can be installed correctly once the house is on the competition site.

3.03 INSTALLATION AND MAINTENANCE

A. Edible vertical garden:

1. Prior to its installation a professional engineer will verify that the substructure of the house can withstand the weight of the edible vertical garden.
2. The supporting frame will be the first component transported to, and installed in, the back outdoor living area. The wire frame and plastic hangers will follow, and the rolling planters will be installed last.
3. Plants will be watered based on calculations performed by the edible vertical garden's automated watering system.

END OF SECTION

SECTION 481400 – SOLAR ENERGY ELECTRICAL POWER GENERATION EQUIPMENT

PART 1 PRODUCTS

1.1 PHOTOVOLTAIC SYSTEM REQUIREMENTS

A. Provide complete photovoltaic system consisting of photovoltaic modules and associated balance of system components necessary for connection to facility electrical system.

B. Provide photovoltaic system and associated components suitable for wind loads, snow loads, seismic loads, and other structural design considerations of the installed location.

C. Provide photovoltaic system and associated components suitable for continuous operation under the service conditions at the installed location.

D. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) or Intertek (ETL) as suitable for the purpose indicated.

E. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system.

F. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

G. Arrange array to minimize shading during peak production periods.

1.2 PHOTOVOLTAIC MODULES

A. Acceptable Module Types: Premium monocrystalline silicon panels complying with specified requirements will be considered for this project.

B. General Requirements:
   1. Photovoltaic Modules: Factory assembled; consisting of photovoltaic cells, frame, junction box, cables for series connection, and bypass diodes for shade tolerance; rated for 600 V DC; listed as complying with UL 1703.
   3. Photovoltaic Modules: Comply with IEC 61646.
   4. Frame: Anodized aluminum.
   5. Factory-Installed Junction Box: Weatherproof, with factory-installed terminals and bypass diodes.
   6. Factory-Installed Cables: Type USE-2 or listed photovoltaic (PV) wire with polarized locking connectors.
   7. Unless otherwise indicated, specified module performance characteristics are rated under Standard Test Conditions (STC).

1.3 MOUNTING EQUIPMENT FOR PHOTOVOLTAIC MODULES

A. Acceptable Mounting Equipment: Everest CrossRail system or equal.
   1. Leave generic or Ask Lindsey
   2. Everything else is generic

B. General Requirements:
   1. Mounting of 3 strings of 8 panels each (as specified above) to flat roof

END OF SECTION