HARVEST | TEAM CAPITOL dc

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2013

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As Built Project Manual

22 August 2013

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SUMMARY OF CHANGES

Significant changes to the project manual that have occurred between submissions have been outlined below. The Construction Drawings should also be reviewed for relevant revisions.

August 23, 2013 Revision

The Project Manual and Drawing Set have been updated from the previous issue. Revisions include:

- CS-001: Cover sheet updated
- G-001: Sheet list updated
- G-104: Sheet added
- C-103: Deck footing locations updated
- C-201: Drawings updated
- C-202: Drawings updated
- L-201: Drawings updated
- L-202: Drawings updated
- L-301: Sheet added
- L-302: Sheet added
- L-303: Sheet added
- L-501: Sheet added
- S-521: Drawings updated
- S-522: Drawings updated
- S-701: Drawings updated
- A-101: Casework changed in kitchen
- A-102: Furniture changed, room finish schedule updated
- A-111: Vent locations updated
- A-121: Lighting locations updated, RCP legend updated
- A-201: Southern shading screen updated, both rainscreens updated
- A-202: Both rainscreens updated
- A-301: Mechanical room updated, spray foam insulation in floor cavity updated
- A-302: Spray foam insulation in floor cavity updated
- A-303: Spray foam insulation in floor cavity updated
- A-304: Spray foam insulation in floor cavity updated
- A-305: Spray foam insulation in floor cavity updated
- A-311: Wall sections updated
- A-312: Wall sections updated
- A-318: Separation wall section updated
- A-319: Separation wall section updated
- A-401: Casework updated, appliances updated
- A-402: Appliances updated
- A-411: Casework updated, furniture updated

- A-501: Wood framing detail connections updated, SIP detail connections updated
- A-502: Wood framing detail connections updated, SIP detail connections updated
- A-503: Wood framing detail connections updated, SIP detail connections updated
- A-504: Wood framing detail connections updated, SIP detail connections updated
- A-505: Wood framing detail connections updated, SIP detail connections updated
- A-506: Wood framing detail connections updated, SIP detail connections updated
- A-507: Wood framing detail connections updated, SIP detail connections updated
- A-508 Wood framing detail connections updated, SIP detail connections updated
- A-511: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated
- A-512: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated
- A-513: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated
- A-514: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated
- A-515: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated
- A-516: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated
- A-521: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated, Southern shading screen connection updated
- A-522: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated, Southern shading screen connection updated, Roof assembly updated
- A-523: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated, Roof assembly updated
- A-524: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated, Roof assembly updated
- A-525: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated, Roof assembly updated
- A-526: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated, Roof assembly updated
- A-527: Wood framing detail connections updated, SIP detail connections updated, Rainscreen details updated, Roof assembly updated
- A-528: Sheet added
- A-531: Wood framing detail connections updated, SIP detail connections updated
- A-532: Wood framing detail connections updated, SIP detail connections updated
- A-533: Wood framing detail connections updated, SIP detail connections updated
- A-541: Wood framing detail connections updated
- A-601: Schedules updated

- A-602: Schedules updated
- A-603: Schedules updated, doors updated
- A-604: Southern shading screen drawings updated
- A-605: Sheet added
- A-701: Sheet added
- A-711: Sheet added
- A-712: Sheet added
- A-713: Sheet added
- A-714: Sheet added
- A-715: Sheet added
- A-716: Sheet added
- A-717: Sheet added
- A-718: Sheet added
- A-719: Sheet added
- A-720: Sheet added
- A-721: Sheet added
- A-722: Sheet added
- A-723: Sheet added
- A-731: Sheet added
- A-732: Sheet added
- A-733: Sheet added
- A-734: Sheet added
- A-735: Sheet added
- A-736: Sheet added
- F-101: Drawing updated
- P-001: Schedules updated
- P-101: Tank locations updated
- P-102: Tank locations updated, water heater tank location updated
- P-503: Sheet added
- M-001: Schedules and symbols updated
- M-101: Ductwork updated
- M-102: Ductwork updated
- M-201: Ductwork updated
- M-501: Drawing updated
- E-001: Schedules and symbols updated
- E-101: Drawing updated
- E-102: Lighting locations updated
- E-601: Sheet updated
- E-603: Drawing updated

- O-101: Sheet updated
- O-102: Sheet updated
- O-103: Sheet added

February 14, 2013 Revision

The Project Manual and Drawing Set have been updated from the previous issue. Revisions include:

- C-103: View added to sheet
- L-001: Sheet added
- L-102: Sheet added
- L-103: Sheet added
- L-201: Sheet added
- L-202: Sheet added
- S-104: Switch to PV framing plan
- S-105: Switched to floor decking plan
- S-106: Added roof decking plan
- S-107: Sheet added
- S-401: Deck reinforcement update, and PV detail added
- S-411: Footing noted to adjust to 12” elevation change
- S-512: Sheet added
- S-521: Sheet added
- S-522: Sheet added
- S-701: Sheet added
- A-111: Roof slope changed
- A-121: Radiant ceiling panels removed, ceiling height changed
- A-305: Sheet added
- A-401: Sheet updated
- A-402: Sheet updated
- A-411: Sheet updated
- A-508: Sheet added
- A-551: Views added to sheet
- A-601: Schedules updated
- A-602: Windows schedule sheet added
- A-603: Door schedule sheet added
- A-604: Passive screen system added
- F-101: Fire suppression updated
- M-001: Schedules updated
- M-101: HVAC supply ductwork updated
- M-102: Radiant ceiling panels removed, and return ductwork updated

- M-501: Mechanical system diagram updated
- E-001: Sheet updated
- E-101: Electrical distribution plan updated
- E-102: Lighting plan updated
- E-601: Sheet updated
- E-602: Sheet updated
- E-603: Sheet added
- O-101: Sheet updated
- O-102: Sheet updated
- Overall project changes: SIP removed from under wide flange, spray in insulation between wide flanges. Windows/Door manufacturer switched from Intus to Western Windows, all window and door details reflect this change to Western Windows. SIP at roof to not slope but be flat, and tapered insulation to be built up to drain.

November 20, 2012 Revision

The Project Manual and Drawing Set have been updated from the previous issue. Revisions include:

- A-121: Major updates have been completed to the RCP to accommodate new fixture design
- P-001: Added ST to abbreviations and Solar Thermal specification to schedules
- P-501 & P-502: Detailed equipment callouts
- M-501: Detailed equipment callouts
- E-001: Adjusted abbreviations, provided load calculations, adjusted electrical panel schedule and notes, and new lighting fixtures and incorporated into lighting fixture schedule
- E-101: Modified general sheet notes and major updates have been made to electrical distribution plan from prior submission to meet code
- E-102: Lighting plan has been updated to accommodate new fixtures and switch locations, Damp & Wet location fixtures have been specified
- E-601: One-Line diagrams have been added and modified to accommodate both the construction and competition sites
- E-602: Major updates have been made to the Three-Line diagram has been to meet code compliance
- F-101: Separate compartments are not created and comment has been verified
- S-101: PSF added to each footing location
- S-411: Drawing A5, notes have been added to accommodate 12” adjustment

RULES COMPIANCE CHECKLIST

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” Series
Rule 4-2	Construction Equipment	Specifications for heavy machinery	01 54 19
Rule 4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	C-103
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	C-201, C-202
Rule 4-5	Generators	Specifications for generators (including sound rating)	Section 01 50 00
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	P-001, P-101, P-102, P-103, M-001
Rule 4-7	Lot Conditions	Calculations showing that the structural design remains compliant even if 12 in. (45.7 cm) of vertical elevation change exists	Structural Calculations
Rule 4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 12 in. (45.7 cm) of vertical elevation change exists on the lot	S-411
Rule 5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	C-102, C-201, C-202
Rule 5-2	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references	Not Applicable

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	S-001, S-101, S-102, S-103, S-104, S-105, S-106, S-107, S-201, S-301, S-401, S-411, S-501, S-511, S-512, S-521, S-522, S-601, S-701, S-901, S-902
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	Not Applicable
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-103
Rule 7-2	Watering Restrictions	Drawing(s) showing the layout and operation of greywater 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	Not Applicable
Rule 8-3	Batteries	Specifications for all primary and secondary batteries and stand-alone, PV-powered devices	Not Applicable
Rule 8-4	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	Not Applicable
Rule 8-4	Desiccant Systems	Specifications for desiccant system components	Not Applicable
Rule 8-5	Village Grid	Completed interconnection application form	Project Manual Page 22
Rule 8-5	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	A-112, E-101, E-602, E-603

Rule 8-5	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E-602, 48
Rule 8-5	Village Grid	One-line electrical diagram	E-601
Rule 8-5	Village Grid	Calculation of service/feeder net computed load per NEC 220	E-001
Rule 8-5	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	G-103, A-101, L-101
Rule 8-5	Village Grid	Elevation(s) showing the meter housing, main utility disconnect, and other service equipment	Not Applicable
Rule 9-1	Container Locations	Drawing(s) showing the location of all liquid containers relative to the finished square footage	P-102
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	G-901, P-101
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	Not Applicable
Rule 9-3	Greywater Reuse	Drawing(s) showing the layout and operation of greywater reuse systems	P-103
Rule 9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	L-101
Rule 9-6	Thermal Mass	Drawing(s) showing the locations of liquid-based thermal mass systems	Not Applicable
Rule 9-6	Thermal Mass	Specifications for components of liquid-based thermal mass systems	Not Applicable
Rule 9-7	Greywater Heat Recovery	Drawing(s) showing the layout and operation of greywater heat recovery systems	Not Applicable
Rule 9-8	Water Delivery	Drawing(s) showing the complete sequence of water delivery and distribution events	P-101, P-102, O-103

Rule 9-8	Water Delivery	Specifications for the containers to which water will be delivered	22 12 00
Rule 9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events	O-103
Rule 9-9	Water Removal	Specifications for the containers from which water will be removed	22 13 53
Rule 11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	G-103

STRUCTURAL CALCULATIONS

CODES

The structural loads were developed in accordance with the 2009 International Building Code, 2013 Solar Decathlon Building Code and the 2010 California Building Code.

LOAD DATA

Dead Loads

Floor: 40 psf
Roof: 15 psf
See Appendix A for detailed calculations

Live Loads

Floor: 50 psf
Roof: 20 psf
Mechanical Room: 150 psf

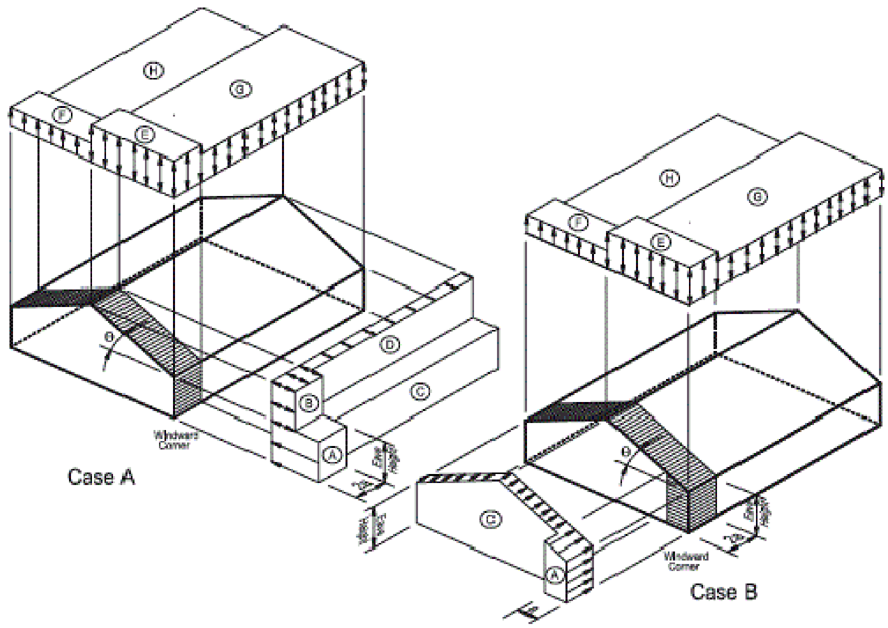
Seismic Loads

Module 1: see Appendix B
Module 2: see Appendix C

Wind Loads

Method 1 – Simplified Procedure
Exposure Category C
Basic wind speed: 85 mph
$p_s=\lambda K_{zt} I p_{s30}$
$\lambda=1.21$
$K_{zt}=1$
$I=1.0$

	Horizontal Pressures				Vertical Pressures				Overhang	
	A	B	C	D	E	F	G	H	E_{OH}	G_{OH}
p_{s30} (psf)	11.5	-5.9	7.6	-3.5	-13.8	-7.8	-9.6	-6.1	-19.3	-15.1
p_s (psf)	13.9	-7.1	**9.2**	-4.2	-16.7	-9.4	**-11.6**	-7.4	-23.4	**-18.3**



SERVICEABILITY CRITERIA

Floor Deflection

Typical: *l*/360, use 1.0D+1.0L
Supporting glass: *l*/600, use 1.0D+1.0L
Check floor deflection during permanent condition and craning condition.

Story Drift

Wind story drift: *h*/400, use 1.0D+1.0W
Seismic story drift: 0.020*h*, use 0.9D+1.0E
Check story drift during permanent condition.

OVERTURNING, SLIDING, UPLIFTING

Seismic

Module 1

Overturning:

M_R=48.7k×6.05ft=295k-ft

M_{OT}=12.5k×10.2ft+3.78k×1.92ft=135k-ft

F.S.=M_R/M_{OT}=2.18≥2

Sliding:

Assume coefficient of friction, μ_s, of 0.90 for neoprene on asphalt.

F_R=0.90×48.7k=43.8k

F_{SL}=12.5k+3.78k=16.3k

$F.S.=F_R/F_{SL}=2.69\geq2$

Module 2

Overturning:

$M_R=35.6k\times6.05ft=215k\text{-}ft$

$M_{OT}=8.84k\times10.2ft+3.03k\times1.92ft=96.0k\text{-}ft$

$F.S.=M_R/M_{OT}=2.24\geq2$

Sliding:

Assume coefficient of friction, μ_s, of 0.90 for neoprene on asphalt.

$F_R=0.90x35.6k=32.0k$

$F_{SL}=8.84k+3.03k=11.9k$

$F.S.=F_R/F_{SL}=2.69\geq2$

<u>Wind</u>

Module 1

Overturning:

$M_R=48.7k\times6.05ft=295k\text{-}ft$

$M_{OT}=9.20psf\times9.25ft\times37.5ft\times6.05ft+11.6psf\times12.0ft\times37.5ft\times6ft=50.6k\text{-}ft$

$F.S.=M_R/M_{OT}=5.83\geq2$

Sliding:

Assume coefficient of friction, μ_s, of 0.90 for neoprene on asphalt.

$F_R=0.90\times48.7k=43.8k$

$F_{SL}=9.20psf\times9.25ft\times37.5k=3.19k$

$F.S.=F_R/F_{SL}=13.7\geq2$

Uplifting:

$F_R=48.7k$

$F_{UP}=11.6psf\times12.0ft\times37.5ft=5.22k\text{-}ft$

$F.S.=F_R/F_{UP}=9.33\geq2$

Module 2

Overturning:

$M_R=35.6k\times6.05ft=215k\text{-}ft$

$M_{OT}=9.20psf\times9.25ft\times26.5ft\times6.05ft+11.6psf\times10.0ft\times26.5ft\times5ft=29.0k\text{-}ft$

$F.S.=M_R/M_{OT}=7.41\geq2$

Sliding:

Assume coefficient of friction, μ_s, of 0.90 for neoprene on asphalt.

$F_R=0.90\times35.6k=32.0k$

$F_{SL}=9.20psf\times9.25ft\times26.5ft=2.25k$

$F.S.=F_R/F_{SL}=14.2\geq2$

Uplifting:

$F_R=35.6k$

F_{UP}=11.6psf×10.0ft×26.5ft=3.07k-ft
F.S.=F_R/F_{UP}=11.6≥2

MEMBER SIZING

Columns

P_u=14.9k
Try HSS4x4x¼
øP_n=95.5k≥P_u=14.9k
Use HSS4x4x¼

Floor Beams

P_u=2.57k
V_u=4.41k
M_{ux}=18.3k-ft
M_{uy}=0.538k-ft
Try W10x12
ϕP_n=150k≥P_u=2.57k
ϕV_n=4.41k≥V_u=4.41k
ϕM_{nx}=46.9k≥M_{ux}=18.3k
ϕM_{ny}=6.14k≥M_{uy}=0.538k
Interaction equation: 0.486<1.00
Use W10x12 for perimeter beams
Use W10x15 (noncompact shape) for beams requiring web penetrations

Roof Beams

P_u=1.42k
V_u=2.66k
M_{ux}=10.7k-ft
M_{uy}=1.83k-ft
Try W8x10
ϕP_n=126k≥P_u=1.42k
ϕV_n=36.2k≥V_u=2.66k
ϕM_{nx}=32.9k≥M_{ux}=10.7k
ϕM_{ny}=5.89k≥M_{uy}=1.83k
Interaction equation: 0.642<1.00
Use W8x10 for perimeter beams
Use W8x12 (noncompact shape) for beams requiring web penetrations

Crane Attachment

P_u=22.6k

Try 3” std. pipe for post
Tensile yield:
$\phi P_n=0.9F_yA_g=65.2k\geq P_u=22.6k$
Tensile rupture:
Assume all cross-sectional elements are welded.
U=1
$\phi P_n=0.75F_uA_e=93.1\geq P_u=22.6k$
Use 3” std. pipe for post
Use $^5/_8$” plate for eye hook
Use $^3/_8$” weld for eye hook-to-post connection
Use $^1/_4$" weld for other crane attachment connections

Bracing

$P_u=15.8k$
Try PL2½x¼
Tensile yield:
$\phi P_n=0.9F_yA_g=20.3k\geq P_u=17.5k$
Tensile rupture:
Assume all cross-sectional elements are welded.
U=1
$\phi P_n=0.75F_uA_e=25.4\geq P_u=17.5k$
Use PL2½x¼

DIAPHRAGM

Floor

3N 18 Gauge
Support fasteners: $^5/_8$” puddle welds, 36/7 pattern
Sidelap fasteners: 4-#10 TEK screws

Roof

1.5B 18 Gauge
Support fasteners: $^5/_8$” puddle welds, 36/7 pattern
Sidelap fasteners: 4-#10 TEK screws

FOUNDATIONS

Allowable bearing pressure: 3000 psf

Module 1

Maximum unfactored vertical reaction=12.1k
$A_{req'd}=12.1k/3000psf=2.02ft^2$

Use 28” diameter footing.

Module 2

Maximum unfactored vertical reaction=9.91k

$A_{req'd}$=9.91k/3000psf=1.65ft^2

Use 28” diameter footing.

DETAILED WATER BUDGET

FUNCTION	WATER USE (GALLONS)	CALCULATIONS		NOTES
		GAL	EVENTS	
Hot Water Draws	270	15	18	Assumes 18 draws of 15 gallons (Return Type: Greywater)
Water Vaporization	3.75	0.625	6	Assume 6 draws of 5 pounds (Return Type: None)
Dishwasher	21	4.2	5	Assume 5 loads of 15 gallons (Return Type: Blackwater)
Clothes Washer	120	15	8	Assume 8 loads of 4.2 gallons
Vegetation	0			Greywater filtration for plants
Fire Protection	182	182	1	
HVAC Storage Tanks	440	440	1	Tank size for space heating at night/tank size for space cooling during the day
Testing	0	0	1	
Initial Systems Fill	50	50	1	
Safety Factor	108.675			10% Contingency
WATER REQUIRED	**1195.425**	gallons		Estimated Water Usage

SUMMARY OF UNLISTED ELECTRICAL COMPONENTS

Team Capitol dc is not using any unlisted electrical components.

SUMMARY OF RECONFIGURABLE FIGURES

Team Capitol dc is not using any reconfigurable figures at this time.

INTERCONNECTION APPLICATION FORM

Team Capitol DC: Lot 115

PV SYSTEMS

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
Yingli	32 Yingli 245W Panels YL245P-29b on a metal rack system	7840 Watts

Total DC power of all arrays is 7.84 kW.

INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or KW)	Quantity
Enphase Micro-Inverters	M215-60-2LL-S22/S23	240	6.88kVa	32

Total AC power of all inverters is 6.88 kVA

REQUIRED INFORMATION

	Location
One-Line Electrical Schematic	Sheet E-601
Calculations of service/feeder net computed load and neutral load (NEC 220)	See page 20 for Chart
Plan view of the lot showing the house, decks, ramps, tour paths, the service point, and the distribution panel or load center	Sheet E-101, G-102

Team Capitol dc's Electrical Engineer is Caroline Litchfield. Her contact information may be found in the Team Officer Contact Information database on the Solar Decathlon Yahoo Group as required per Rule 3-2.

CALCULATIONS OF SERVICE/FEEDER, NET COMPUTER LOAD, AND NEUTRAL LOAD

SINGLE-UNIT RESIDENTIAL LOAD CALCULATION SHEET

ONE BEDROOM UNIT A

LOAD	SF	VA/SF	PER UNIT	# OF UNITS	TOTAL		DEMAND FACTORS <3KVA	DEMAND FACTORS 3<X>120	DEMAND FACTORS >120	DEMAND	
LIGHTING	865	3	2.60	1	2.60	7.10	100%	35%	25%	4.43	
SMALL APPLIANCE			4.50	1	4.50		3.00	1.15	0.00		
OVEN/RANGE			11.00	1	11.00	11.00	100%			11.00	
DISHWASHER			0.79	1	0.79	0.79	75%			0.60	
GARBAGE DISPOSAL			1.18	1	1.18	1.18	75%			0.89	
VENT HOOD			0.52	1	0.52	0.52	75%			0.39	
WATER HEATER			4.50	1	4.50	4.50	75%			3.38	
MICROWAVE (FUTURE)			1.50	1	1.50	1.50	75%			1.13	
DRYER			5.00	1	5.00	5.00	75%			3.75	
WASHER			1.10	1	1.10	1.10	75%			0.83	
EF-1			0.05	1	0.05	0.05	75%			0.04	
WBP			1.13	1	1.13	1.13	75%			0.85	
STP			0.51	1	0.51	0.51	75%			0.38	
HEAT PUMP			5.43	1	5.43	5.43	100%			5.43	
AHU			1.13	1	1.13	1.13	100%			1.13	
EH-1			0.50	1	0.50	0.50	100%			0.50	
EH-2			0.50	1	0.50	0.50	100%			0.50	
EH-3			0.50	1	0.50	0.50	100%			0.50	
										35.71	KVA
		120/240, 1-PH								148.79	AMPS
		SERVICE SIZE								150	AMPS

ENERGY ANALYSIS AND DISCUSSION

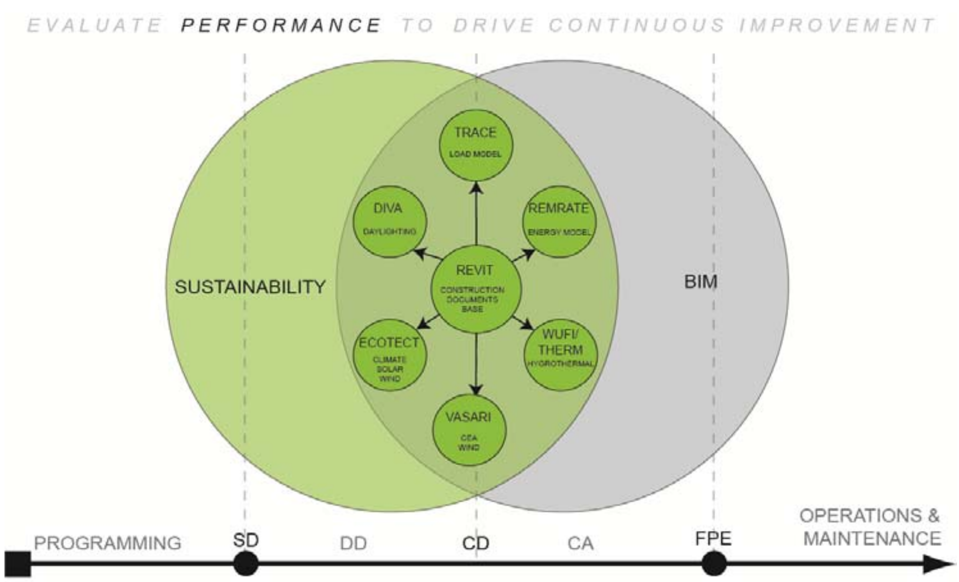
1.0 – BUILDING PERFORMANCE ANALYTICS AND TESTING

1.1 - STATE OF THE INDUSTRY

As the field of sustainable design evolves, designers and owners concurrently are starting to measure sustainable benefits in terms of their impact on human health, environment, and cost implications. This indicates that the performance of a building is becoming a requirement for assessing sustainable building design and in evaluating post-design to document the effect of sustainability measures. As designers, we approach effectual architectural design by interpreting myriad elements; program, budget, construction schedule,a climate, context, materials, aesthetics, owner vision, energy, and others. For the past decade, broader, more comprehensive perspectives of influences have been emerging - more than these earlier precedents. As these ingredients become foundations for building analysis, the way building behavior is measured is clearly emerging as one of the most important components in design. One such methodology is an adoption of rapid modeling, or "building performance analytics" (BPA) as a new process of sustainable building design.

For the past decade, broader and more comprehensive perspectives of influences have been emerging in our approach to building design and evaluation. New more aggressive building standards such as those already implemented in San Francisco, New York City and Washington, D.C. are already acting as drivers to predict energy use. Evolving codes and third-party green certification requires architectural analysis to address questions about sustainability within a timeframe fast enough to provide meaningful feedback to the design team from the beginning of the integrated design process, and to the owner through facility performance evaluation after occupancy.

Building Information Modeling (BIM) and sustainability were symbiotic components of our evaluation. Together they propelled our HARVEST HOME design from performance modeling, through energy evaluation, into the building’s future life cycle and O&M tracking when occupied. CUA has designed a new course launched this Fall, ARPL 535 Building Performance Analytics, to educate students about the methodology of passively evaluating architecture as the first step to Net-Zero sustainable design.



The Performance Integration Wheel
Diagram By Instructor: Patricia Andrasik, Course - ARPL 540 - Building Performance Analytics

1.2 – ANALYSIS OF HARVEST HOME

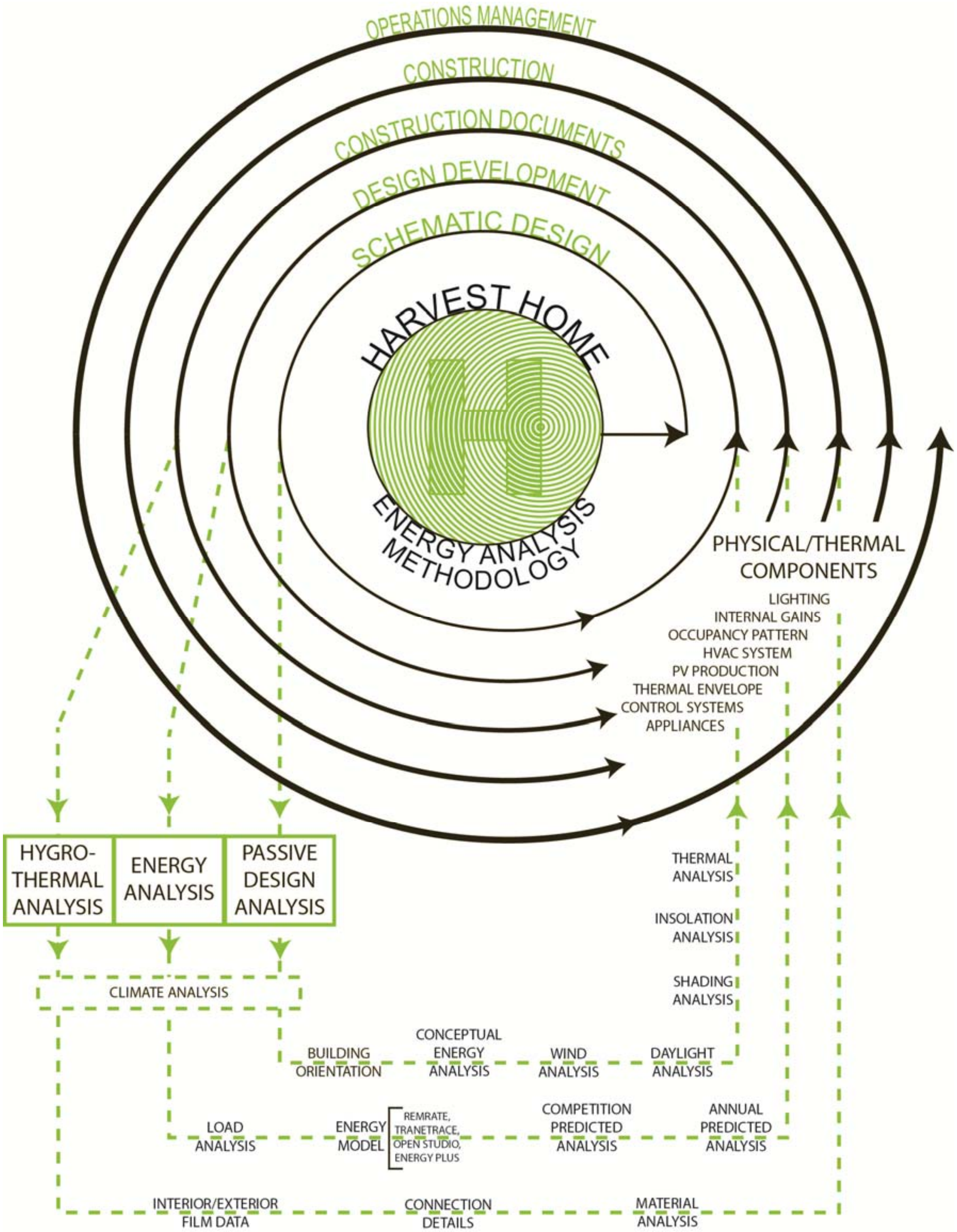
HARVEST HOME was designed for full integration between its climate, site, systems and occupant. Each of these components are meant to work collectively to optimize building performance. Team Capitol dc recognizes the need to design sustainably by significantly reducing the average energy consumption for a building of this type.

Designed for Irvine, CA, the home is able to conform to and take advantage of natural climate conditions in order to maximize energy efficiency. The building envelope prevents excessive infiltration rates while slowing the rate of thermal transmission through the walls, roof and floor as well as heat gain through the windows. Internal heat gain and energy consumption are reduced through the incorporation of efficient appliances, electronics and lighting. As temperature fluctuations within the home are minimized, mechanical systems that heat and cool the home can be reduced from the standard size thereby requiring less energy to operate. In order to offset the full use of energy consumption within the home, photovoltaic panels are installed on the roof as a means of renewably producing electricity from the sun's energy.

Multiple courses from The Catholic University of America, George Washington University and American University have provided a venue for the design process to take place. Through all phases, building performance analytics and testing have served as tools to illustrate, validate and quantify decisions made by Team Capitol dc. Over the past few years, HARVEST HOME has evolved from a simple building mass to a multifaceted, net-zero home that will operate successfully during both the competition week in October and year-round in its final location, in San Diego County, CA. As a team, we have earned a great amount of knowledge about both the necessity for sustainable design and its implementation in creating energy efficient architecture and hope to share our educational process with the public.

The Energy Analysis Methodology diagram, shown on the following page, represents visually the progression of the HARVEST HOME design through each phase of the design process. There is a close connection between analyses and testing that reflects the design of building components.

Birdseye View of HARVEST HOME



Energy Analysis Methodology describes the process of design and energy analysis for the HARVEST HOME.

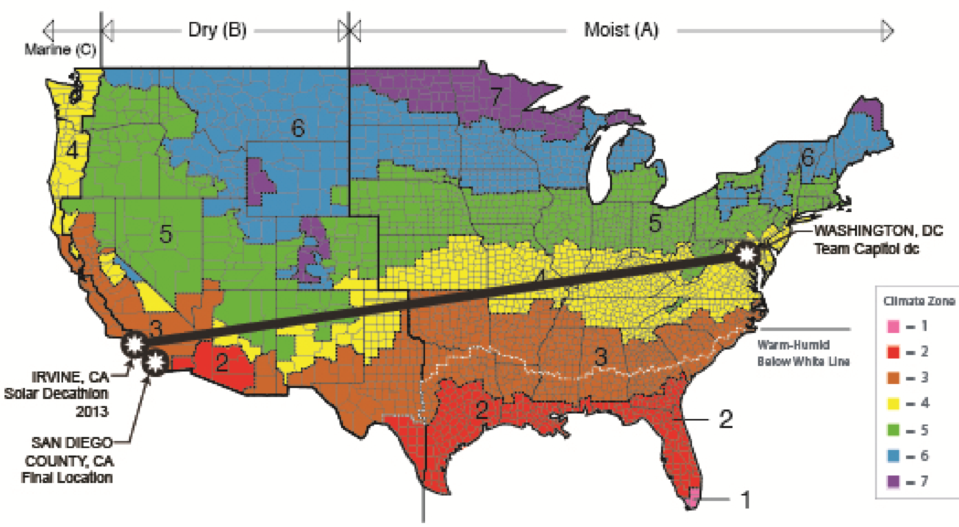
2.0 - CLIMATE ANALYSIS

2.1 - LOCATION

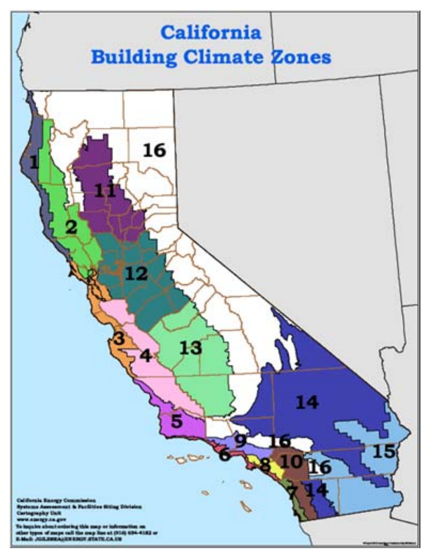
Since the first U.S. Department of Energy Solar Decathlon in 2002, the competition has been set in Washington, D.C. and in October of 2013, it will travel to the Orange County Great Park in Irvine, California. The change in site results in a dramatic change in climate type from that of Washington, D.C., which will lead to an evolution of design forms on the Solar Village. From the beginning of the design process, HARVEST HOME had the intention to perform in both the competition climate and a similar climate for the final location. The home will travel to San Diego County, CA, an hour away from the competition site, to become a transitional home for Wounded Warrior Homes.

According to the U.S. Department of Energy Climate Zone Map, Washington, D.C. lies within IECC Climate Zone 4, which is a Mixed-Humid climate region. Irvine, CA, on the other hand, is situated within IECC Climate Zone 3, which is a Hot-Dry climate region. Hot-Dry climates are warmer and receive less precipitation on average than a Mixed-Humid climate.

The state of California is divided into 16 different Climate Zones depending upon weather data patterns. Title 24, the state's Building Energy Efficiency Standards, uses the Climate Zones to determine prescriptive requirements and energy budgets for building uses. Both the competition location in Irvine, CA and the final location in San Diego, CA reside within California Building Climate Zone 6, therefore their energy requirements would be the same.



U.S. Department of Energy Climate Classification Map
Washington, D.C. – Climate Zone 4
Irvine, CA & San Diego, CA – Climate Zone 3



California Building Climate Zones Map
Irvine, CA & San Diego, CA – Climate Zone 6

2.2 - WEATHER DATA

Throughout the design process, weather data was used for analytics and testing to verify energy saving strategies. Weather data sets are available through the National Renewable Energy Laboratory's National Solar Radiation Data Base as well as the Department of Energy's EnergyPlus Energy Simulation Software website. The weather data is used for hourly dry bulb temperatures, relative humidity and solar irradiation.

Typical meteorological year (TMY) weather data for the energy analysis was retrieved from the weather station at Santa Ana John Wayne Airport, which is about 10 miles west of the competition site in the Orange County Great Park. Ideally, the selection of the weather data would most closely apply to the competition location of Irvine, CA. While a TMY data set is available for the location of El Toro, CA, which is much closer to the competition site, the data is provided from 1948-1980. Team Capitol dc decided to use the more accurate TMY3 data from Santa Ana, derived from a 1976-2005 period, rather than the outdated TMY El Toro data. Through the selection of the Santa Ana weather data, the weather of Santa Ana is assumed to be almost identical to the weather of Irvine and that the weather in 2013 is expected to be almost identical to the weather of previous years.

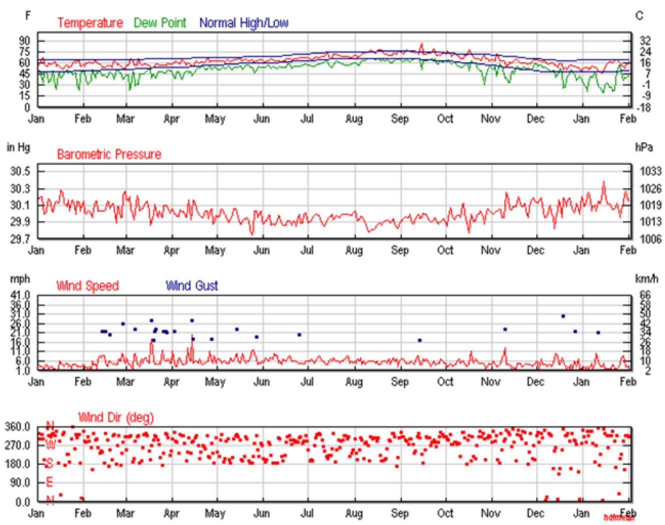
In addition to the competition site, HARVEST HOME is intended to perform equally in its final location, San Diego, CA. The following graph shows historic weather data, provided by Weather Underground, shows only minute variations between the two locations

CLIMATE DATA COMPARISON

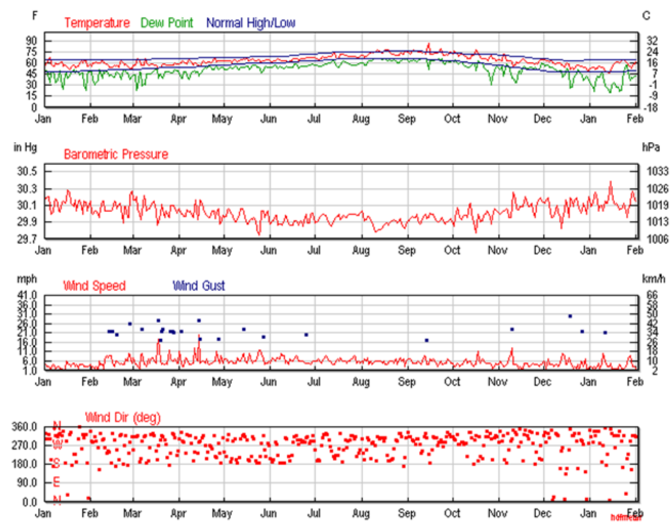
Data Point	FULL YEAR	
	Santa Ana	San Diego
Maximum Temp	102º F	101º F
Minimum Temp	38º F	41º F
Mean Temp	66º F	64º F
Annual Heating Degree Days	928	1075
Annual Cooling Degree Days	1366	913
Max Dew Point (summer)	68º F	69º F
Min Dew Point (winter)	-13º F	4º F
Average Wind Speed	4 mph	5 mph
Max Wind Gust	41 mph	39 mph

Source: www.wunderground.com

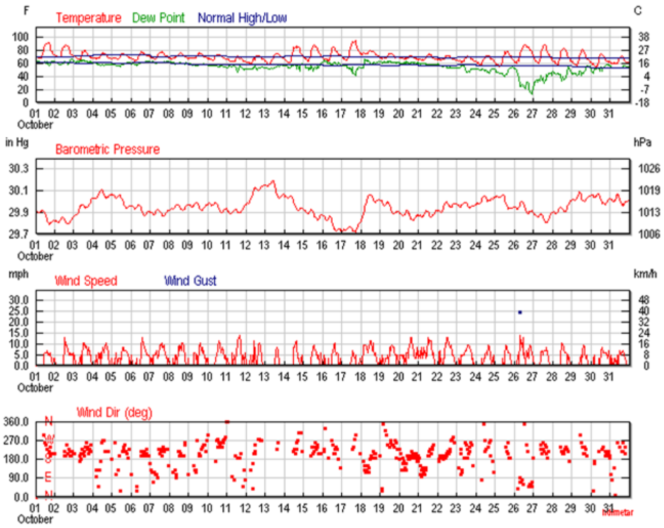
In addition to overall climate data ranges, the following graphs compare Santa Ana and San Diego climate behavior for both a full year and the month of the competition. Comparatively, each of the graphs display similar pits and peaks of data throughout the year as well as October.



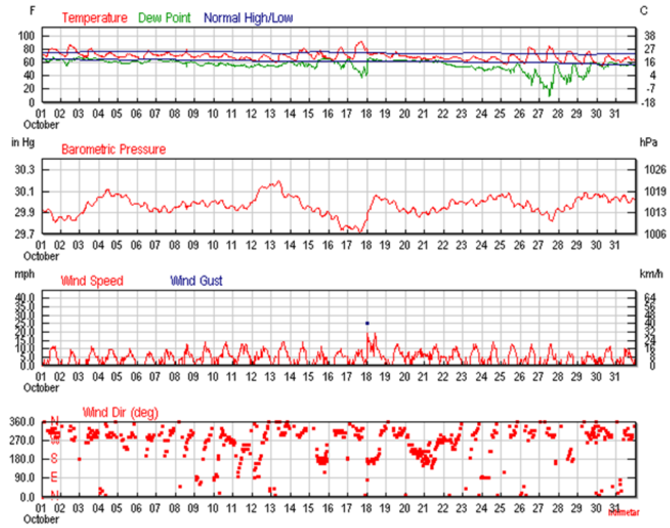
Weather Analysis
Santa Ana From Jan 2012 To Jan 2013
www.wunderground.com



Weather Analysis
San Diego From Jan 2012 To Jan 2013
www.wunderground.com



Weather Analysis
Santa Ana For October 2012
www.wunderground.com



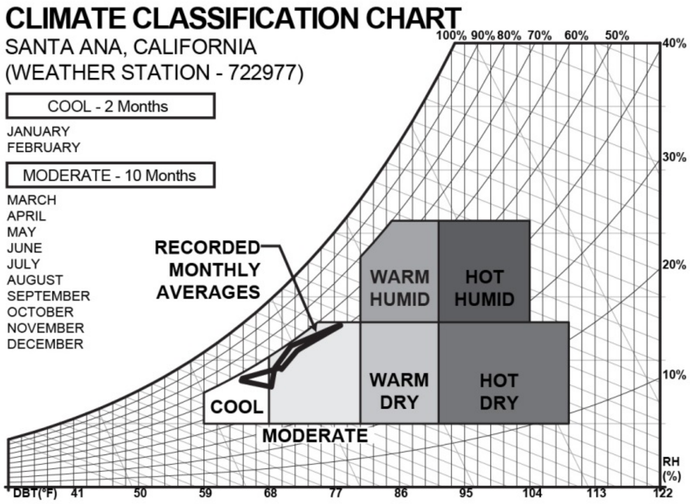
Weather Analysis
San Diego For October 2012
www.wunderground.com

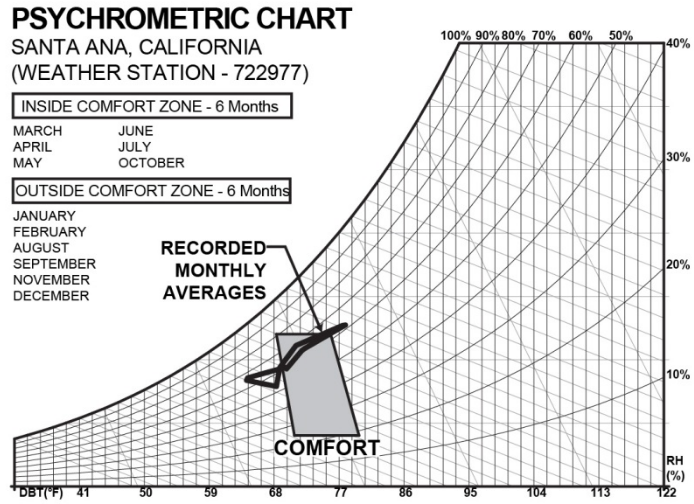
2.3 - CLIMATE AND COMFORT

The weather data from Santa Ana, CA can also be analyzed through a psychrometric chart, a visual tool that displays the thermodynamic properties of air relating to temperature and moisture. Throughout each month of the year, points are plotted on the chart to show temperature and humidity ranges. The monthly points will cluster to illustrate climate behavior which can vary between cool, moderate, warm humid, hot humid, warm dry and hot dry climate zones. Based upon the psychometric chart, Irvine, CA sits on the more humid side of a cool to moderate climate.

The psychrometric chart also displays a personal comfort box that encompasses the perfect combination of thermodynamic properties for an individual to be thermally comfortable within their surroundings. Comfort levels will vary depending upon the individual as well as the season; therefore ASHRAE Standard 55 developed an 80% approval for their assessment of personal comfort. When measured climate days are set outside of the personal comfort zone, the interior thermal environment must be conditioned. For Irvine, CA, the average dry bulb temperature ranges between 45°F and 80°F and the relative humidity ranges from 65% to 80%. Based upon the thermal comfort zone, Irvine, CA can be cooler, warmer and at times more humid than desirable, therefore, the HARVEST HOME must encompass, methods to heat, cool and dehumidify interior spaces.

The historic climate data shows the average temperature ranges from 55°F to 75°F during the month of October in Irvine, CA. However, given the specific location of the solar village on a tarmac within a retired airfield, there will be additional heat gain. As solar rays hit the dark surface, heat is absorbed and retained causing some heat transfer between the asphalt and the HARVEST HOME. If the home was placed on a grassy site or built into the ground, the temperature range would be closer to average. The HVAC system was ultimately sized to provide more cooling and heating than expected in order to compensate for temperature fluctuations or extra heat entering the home through the floor due to radiation and conduction from the tarmac on the competition site.



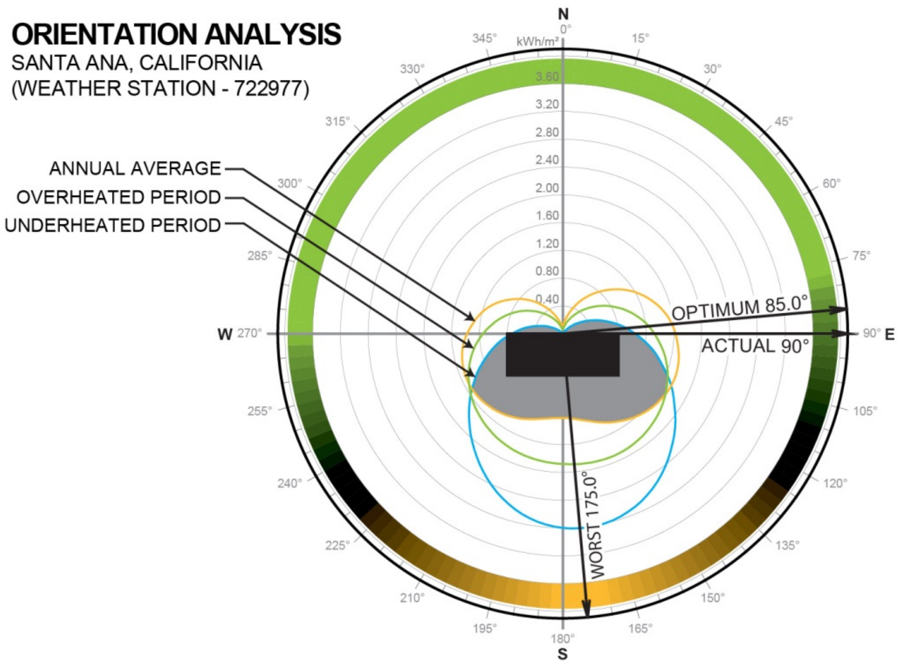


The climate for Irvine, CA falls within the Cool and Moderate Climate Classifications. For six months out of the year, additional measures must be applied to indoor thermal conditions to insure the occupant's personal comfort.

2.4 - ORIENTATION

The orientation of the building describes the direction of the primary building components in regards to the designated compass directions of north, south, east and west. Thorough climate analysis will reveal the optimum orientation for a building that will maximize the use of passive design strategies, such as passive heating/cooling, natural ventilation or rainwater collection. Overall, an optimum orientation will reduce energy consumption or provide climatic elements that aid in building performance.

For Irvine, CA, the optimum orientation is 85° to optimize passive strategy integration. However, the orientation of the HARVEST HOME is set at 90° to accommodate for the overall orientation of the Solar Village. Although the home is 5° out of plumb from the optimum orientation, there would be a negligible effect on efficiency of passive optimization strategies throughout the competition. For the final location in San Diego, Team Capitol dc will coordinate with Wounded Warrior Homes to insure the HARVEST HOME is optimally oriented.



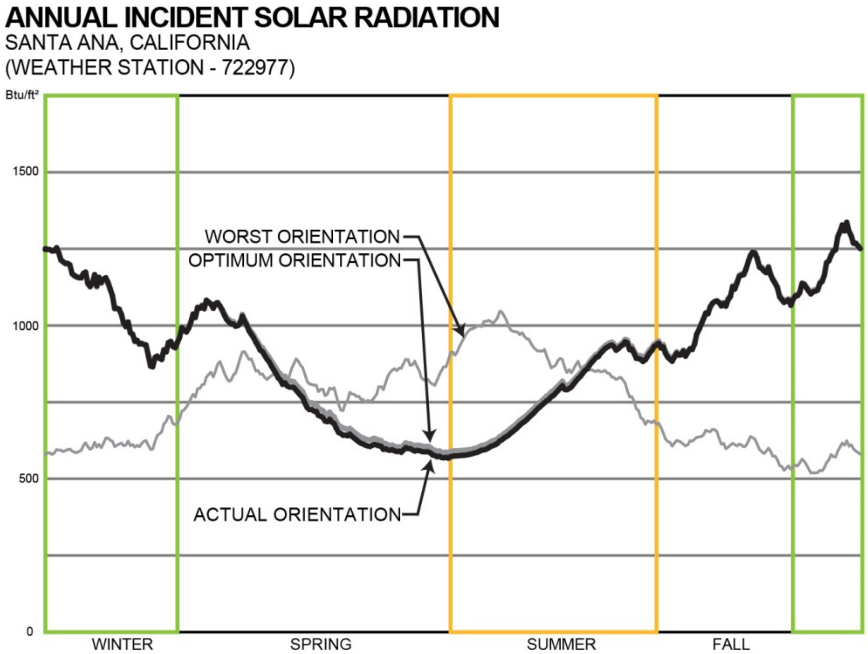
The Optimum Orientation for HARVEST HOME in Irvine, CA would be 85°, however, its Actual Orientation is 90° to match the overall orientation of the Solar Village. The reduction in Passive Strategy Potential is minimal.

2.5 – ANNUAL INCIDENT SOLAR RADIATION

Incident solar radiation can have an effect on both passive and active strategies within a building design. As solar rays become more perpendicular to a building surface, the greater amount of heat is produced on the surface. Climate analysis will reveal whether or not additional heat is desired during certain periods of the year, or if cooling is required.

Two methods of incident solar radiation measurement are conducted. Direct radiation is the amount of energy measured perpendicular to the sun's rays. Diffuse radiation is the amount of energy measured on a horizontal surface taking into account the energy that has been bounced within the atmosphere. Both direct and diffuse radiation must be analyzed for a holistic account of incident solar radiation upon a building.

For the HARVEST HOME, the optimum orientation provides low incident solar radiation in the summer and a higher incident solar radiation in the winter to provide additional passive heating to the building. The worst orientation supplies more heat energy in the summer and less heat energy in the winter thus requiring the mechanical systems to work harder to maintain an acceptable thermal comfort range. From an renewable energy perspective, high incident solar radiation is desired for roof-mounted photovoltaic panels to absorb a maximum amount of light energy. For passive design strategies, a lower radiation metric is desired on the vertical surfaces of the home to decrease internal heat gain and cooling loads.



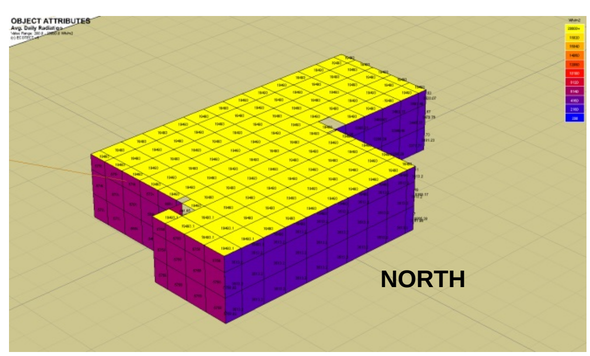
The annual incident solar radiation is higher during the winter months and lower in the summer months.

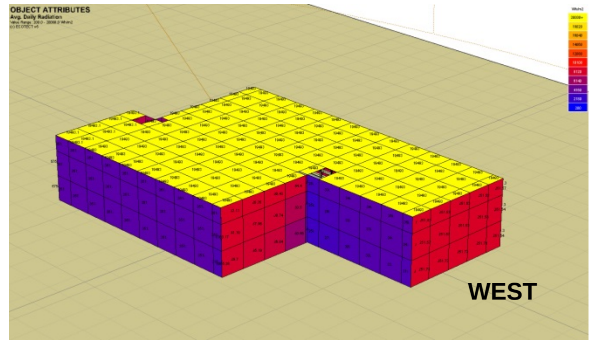
A complete insolation analysis must first consider the building orientation, then focus on specific strategies for insolation reduction, refer to Insolation Analysis Chapter, while maintaining an understanding of impacts to daylighting, refer to Daylighting Analysis Chapter. As a preliminary study, analyses of fenestration as it relates to the home's orientation have been conducted. The studies below indicate the sun's position with respect to the HARVEST HOME and which facades are directly impacted by the greatest amount of radiation. The diagrams below indicate four main color swatches used to describe radiation within the studies.

20k Wh/m2 | 12k Wh/m2 | 6K Wh/m2 | 2k Wh/m2

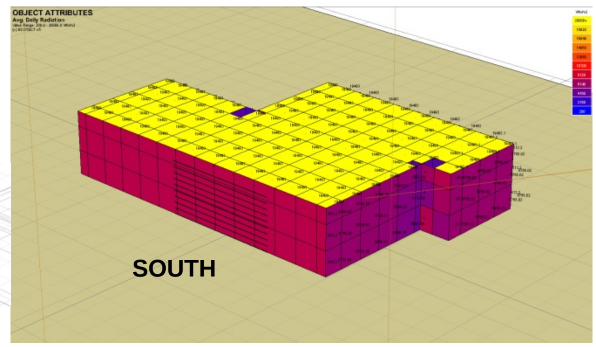
Overall, it is apparent that the roof receives the highest incident radiation therefore providing optimal solar energy for the photovoltaic panels. The white roof material reflects light thereby preventing heat absorption through the roof as described in the Building Envelope Analysis Chapter.

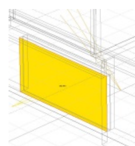
The northern façade receives the lowest amount of incident radiation and was selected to have the most penetrations along the Living Room and Bedroom. These areas provide maximum exterior views without acquiring internal heat gain.





The western façade holds the second highest level of insolation. Team Capitol dc decided to restrict glazing from this façade as it would increase internal loads of the Living Room space in the afternoons by 50% more than the highest level of all the facades. Since, a significant increase in electricity consumption is required for cooling loads, this façade did not receive fenestration.

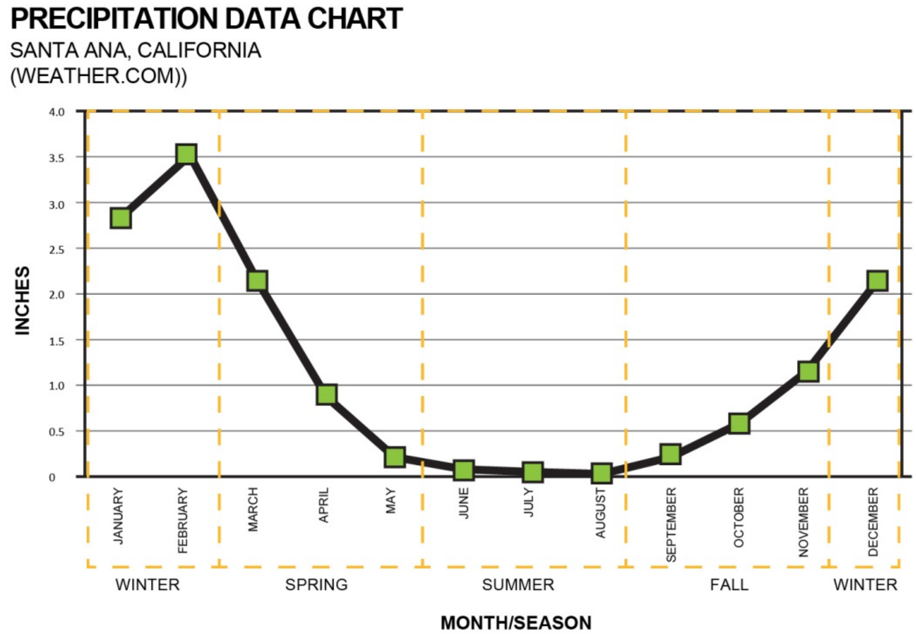




The southern façade has the third highest aggregate insolation, peaking at 662 Wh/m2 during the summer months. Since this façade receives the most indirect radiation at a lower level when compared to the remaining vertical surfaces, daylighting would be consistently provided and exterior views were desired within the kitchen area, glazing was introduced.

2.6 – PRECIPITATION

Precipitation data must be accounted in the design of a net zero home. For instance, in an area with high amounts of precipitation, cloud cover will affect the amount of solar incident radiation that hits the surface of the building. Additionally, these areas will have higher relative humidity percentages when compared to locations with less precipitation. Irvine, CA has greater precipitation in the winter and gradually decreases to almost no precipitation in the summer months. Therefore, the home will be subject to higher rates of insolation and humidity during the summer months as compared to winter months.

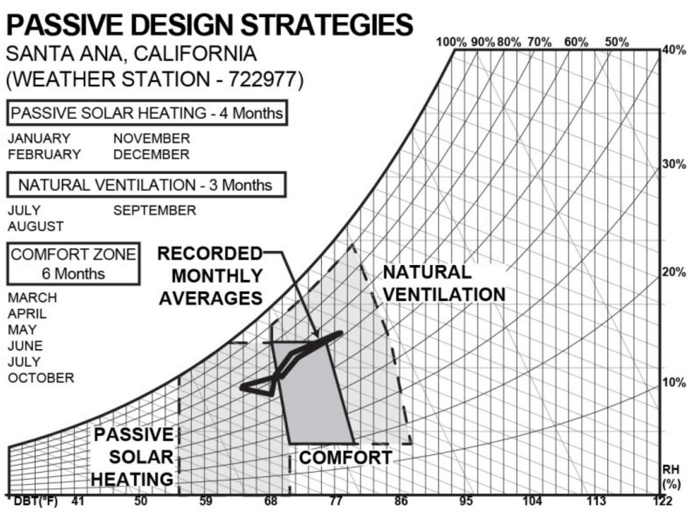


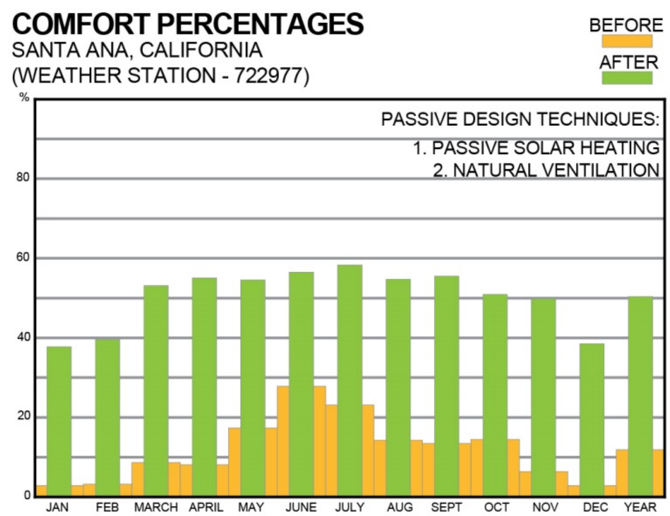
Precipitation data peaks in the winter months while the summer months receive very little precipitation.

2.7 - PASSIVE DESIGN STRATEGY POTENTIAL

The combination of weather data from Santa Ana, CA as well as the orientation of the home help to identify passive design strategies that will aid in the performance of the HARVEST HOME. From previous climate and comfort analysis, it has been determined that throughout the year, the home will require both the heating and cooling of interior spaces. Passive solar heating is a strategy that simply allows solar rays to penetrate the glazing to warm a room naturally. Alternatively by blocking these solar rays through shading devices, the excess heat gain can be prevented, refer to the Shading Analysis Chapter. Natural ventilation is another strategy that cools the home by filtering wind flows through the interior spaces, refer to Natural Ventilation Potential Chapter. Each of these strategies helps to extend the personal comfort zone on the psychrometric chart.

Passive solar heating, shading devices on the southern exposure and natural ventilation design strategies have been applied to the HARVEST HOME placing all 12 months within the personal comfort zone so that no additional conditioning is necessary. However, for cases of extreme weather, Team Capitol dc has implemented a full mechanical heating, cooling and ventilation system. Using the passive design strategies, HARVEST HOME will more than double the time that the interior environment will be within the personal comfort zone as compared to the baseline model.



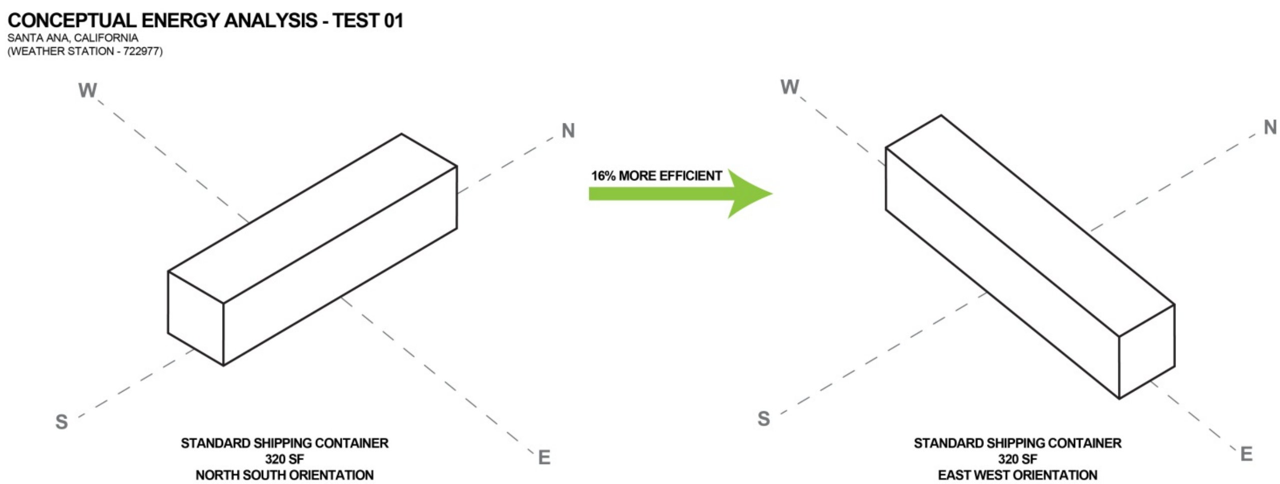


By applying both passive solar heating and natural ventilation design strategies to the HARVEST HOME, the recorded monthly temperatures are brought within the range of occupant comfort. Comfort percentages have more than doubles with the introduction of passive design strategies into the HARVEST HOME.

2.8 - CONCEPTUAL ENERGY ANALYSES

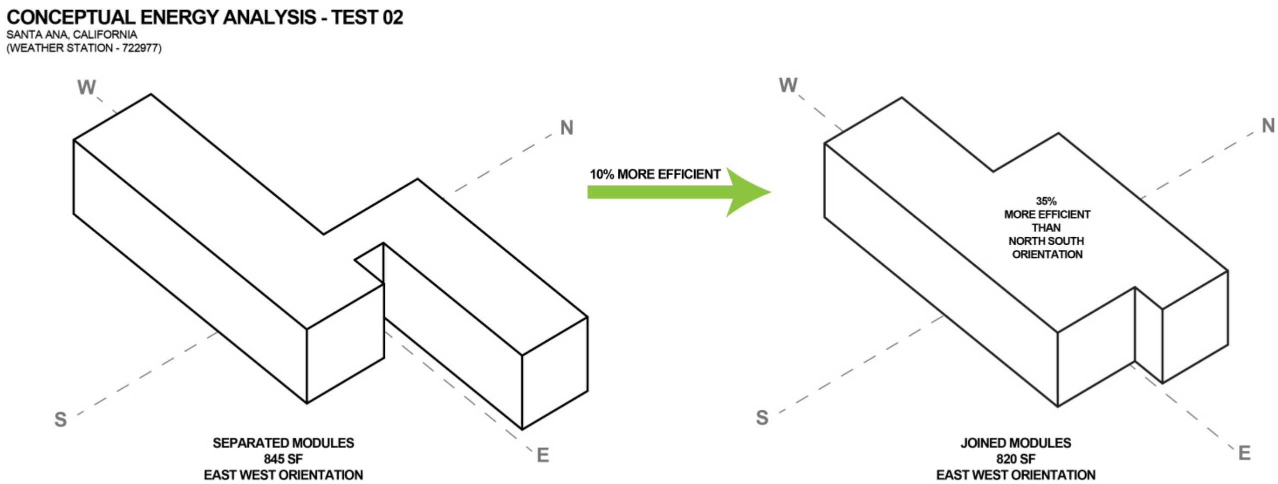
In order to determine the most efficient combination of orientation, form and building components, several iterations of Conceptual Energy Analyses (CEA) were run to compare approximate energy usage. This analysis occurs prior to the formal energy analysis, refer to the Competition Load and HVAC Analysis Chapter. CEA's provide energy calculations on early design concepts in order to determine the greatest efficiency. A CEA is not intended to provide accurate energy usage data as this is provided as the design is further developed and input into an energy model. A CEA will evaluate the location, weather data, orientation, building type, mass, glazing, percentage, thermal envelope, occupancy patterns, and mechanical systems as an input for the analysis. The output will result in a conceptual energy usage rate, cost implications, renewable energy potential, carbon emissions and load calculations. For the purposes of analysis of HARVEST HOME, energy usage rates were used as a comparative tool between massing options.

As Team Capitol dc was accepted into the U.S. Department of Energy Solar Decathlon 2013, the competition changed from Washington, D.C. to Irvine, CA. The design of the home was adjusted to accommodate its transportation via a flatbed truck so early design proposals were determined by standard shipping container dimensions at 8'-0" wide by 9'-6" tall by 40'-0" long. The first CEA analysis for the HARVEST HOME considered a shipping container mass that was first oriented north/south and second oriented east/west. The east/west orientation proved to be 16% more efficient in terms of anticipated energy usage which further proves the optimal orientation at 85° and success in using a 90° orientation. A similar orientation was used for future building mass iterations.

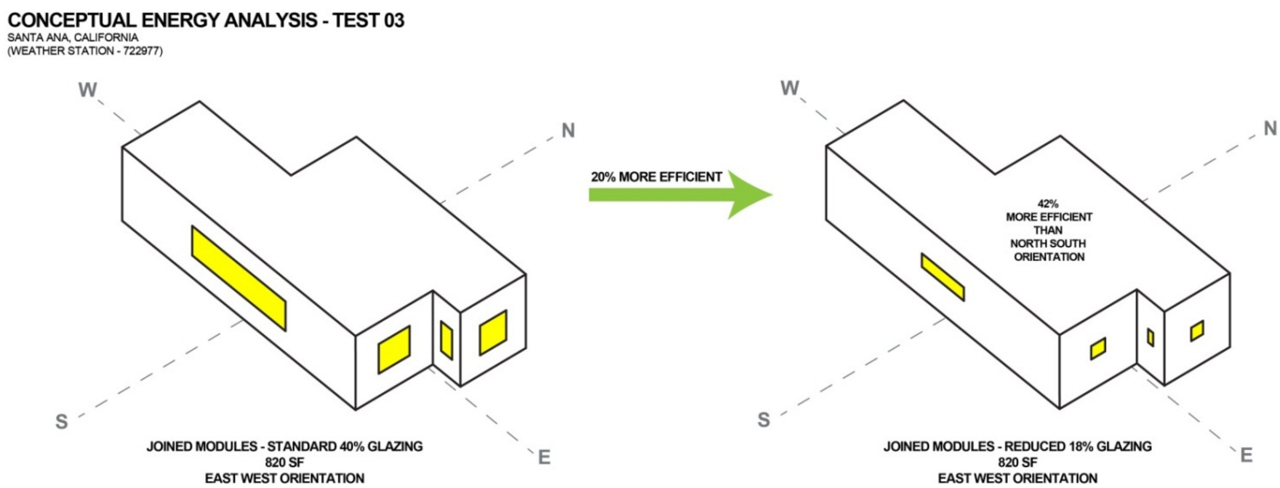


The maximum size of a home for the competition is 1000 square feet and the final decided square footage for HARVEST HOME was a delicate balance between functionality and building performance. If the home is smaller, it requires less energy to operate, however, the home was also designed with the intention to be livable and universally accessible. The square footage of the typical shipping container at 320 square feet was too small to satisfy the intentions of design and so an additional module was incorporated. The overall size of each module was then enlarged to gain square footage while also staying within transportation width and height guidelines.

In addition to transportation issues with the HARVEST HOME, the physical connection between the two modules was considered for constructability, spatial functionality, system connectivity and energy efficiency. The first option separated the two modules and incorporated a physical link. This option facilitates better assembly and disassembly as required for the competition. The second option joined the two modules into a single mass, which gained the home greater square footage while also providing a better physical connection between the mechanical, electrical and plumbing systems. Ultimately, the CEA comparison showed that the joined modules were 10% more efficient than the separated modules and 35% more efficient than the original north/south oriented shipping container. The reduction in surface area and square footage decreased the energy consumption overall.



Lastly a CEA was run on the joined module building mass comparing first, a standard 40% glazing and then a reduced 18% glazing. The reduced glazing area decreases the amount of infiltration and solar heating penetration that increase heating and cooling loads. Overall, the reduced glazing model was 20% more efficient than its predecessor and 43% more efficient than the north/south oriented shipping container.



3.0 - BUILDING ENVELOPE ANALYSIS

3.1 – BUILDING ENVELOPE AND PERFORMANCE

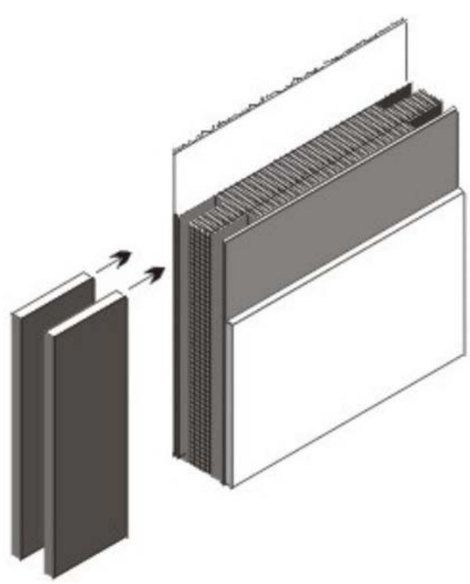
To insure compliance with required and voluntary construction codes, Team Capitol dc compared performance requirements for the building envelope. The required codes were the International Residential Code 2006 (IRC 2006), which is required for Washington, D.C., the International Residential Code 2012 (IRC 2012), which is required by the Department of Energy for Solar Decathlon entries and California Green Building Code Title 24, Part 11 (CalGreen). Voluntary standards used in the decision making process included ASHRAE 90.2: Energy Efficient Design of Low-Rise Residential Buildings, Energy Star Qualified Homes Version 3 (Energy Star v3), and the International Green Construction Code 2012 (IgCC 2012). Thermal resistance rates between codes are diverse, therefore the home was built according to the most strict, required code, which in this case is IRC 2012.

Thermal resistance is measured with R-Values to identify the rate at which heat travels through a particular thickness of material. As an R-Value becomes higher, it is illustrating a higher level of insulation within the material.

THERMAL RESISTANCE REQUIREMENTS

CODE NAME	WALL R-VALUE	FLOOR R-VALUE	ROOF R-VALUE
IRC 2006	R 13	R 19	R 30
IRC 2012	R 20	R 19	R 38
ASHRAE 90.2	R 15	R 19	R 22
Energy Star v3 (references IECC 2009)	R 13	R 13	R 30
IgCC 2012 (references IECC 2012)	R 20	R 19	R 38
CalGreen (California Energy Commission)	R 25 (for SIP)	R 30 (for SIP)	R 38 (for SIP)

The building envelope was designed and optimized based on several performance specifications including long-distance transportation, constructability, cost and energy efficiency. The basic assembly of the envelope included an outboard Structurally Insulated Panel (SIP), steel structure comprised of column, beam and decking components, wood studs for plumbing and electrical system integration and then finished with gypsum wallboard and paint. With these multiple components, continuity of thermal resistance as well as air tightness was integral to the construction process. For



instance, the SIPs were installed with a spline connection along the walls and roof to prevent breaks in the assembly. Additional insulation was provided within the floor cavity and around the ductwork to maintain the line of insulation from the roof, to the walls and to the floor.

Typical SIP Connected with Spline to Provide Continuous insulation
California Energy Commission Joint Appendix JA4

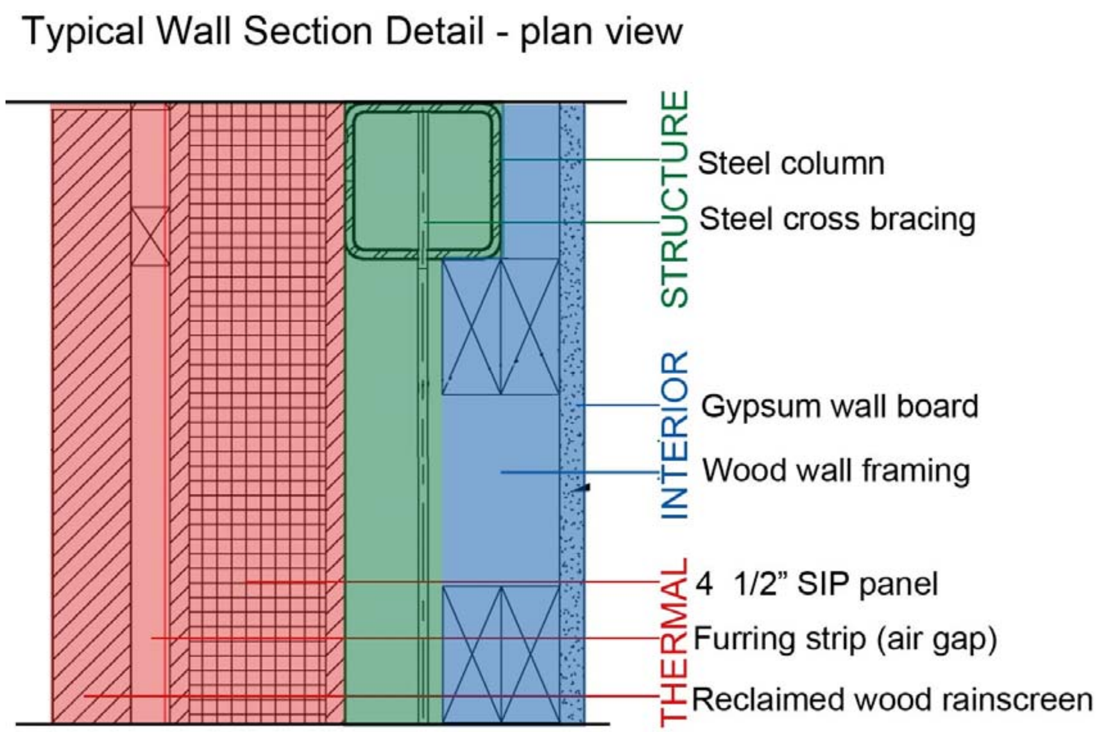
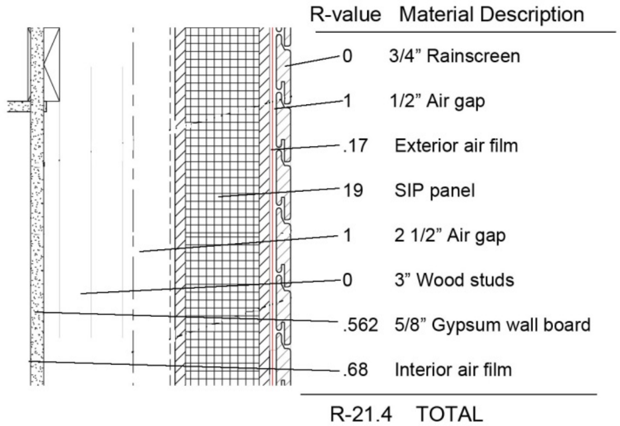


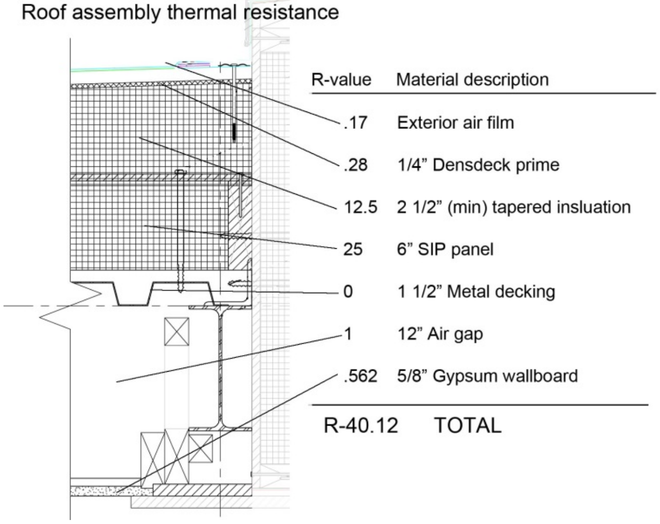
Diagram of Floor Plan Showing the Triple Layered Wall System Include Structural, Thermal and Systems Layers

Enclosure assembly optimization occurred during the design development and construction document phases of the design process to insure proper insulation values and to prevent areas of moisture or air penetration. The Building Science and Technology Course within CUA's Master of Science in Sustainable Design program was instrumental in evaluating these factors. Throughout the construction process, the proper installation of materials insured the intended performance of the building envelope. Following are wall, roof and wall assemblies of the HARVEST HOME detailing the comprehensive R-Value of material components.

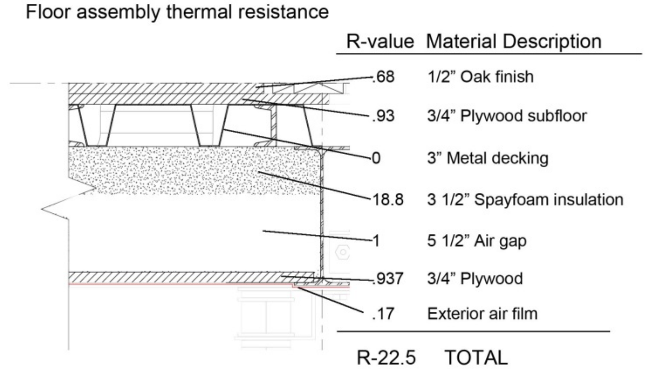
Wall assembly thermal resistance



Roof assembly thermal resistance



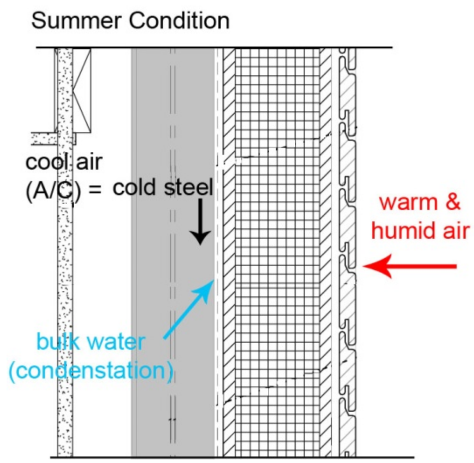
Floor assembly thermal resistance

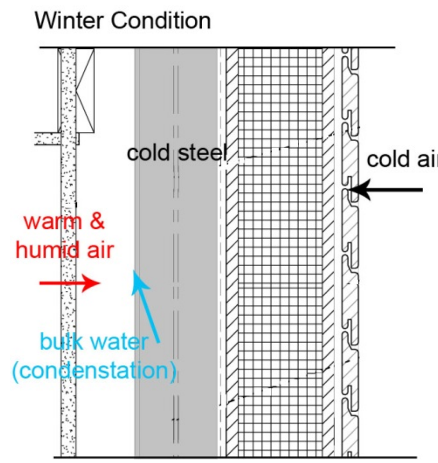


3.2 – HYGROTHERMAL ANALYSIS

The term hygrothermal combines the study of hygrometry, the measurement of humidity in the atmosphere, and thermal, referring to temperature, into one realm of study combining both humidity and thermal analysis. As a principal of thermodynamics, air will travel from hotter to cooler locations; vapor (atmospheric water) travels from an area of high vapor pressure to an area of lower vapor pressure. Varying temperatures and humidity levels create air pressure that can have either positive (natural ventilation) or negative (mold, damp, flooding) effects within a building depending upon the proper level of design and construction detailing.

Based upon the climate data of Santa Ana, CA, Team Capitol dc was able to identify the potential for condensation within the wall cavity, which could result in future mold growth. During the winter, the outside air is cold and dry while the inside air is warm and relatively humid. The travel of water vapor and heat through the wall cavity could cause condensation to form on the inboard side of the cold steel columns. During the summer, an opposite condition occurs where cool air on the inside will keep the steel cool. As warm humid air hits the outboard side of the cold steel, condensation could form. Although air sealing is not required by code for typical wood construction within this climate, the logic of thermodynamics infers a need to seal the exterior of the home from vapor penetration through the installation of a vapor retarder.



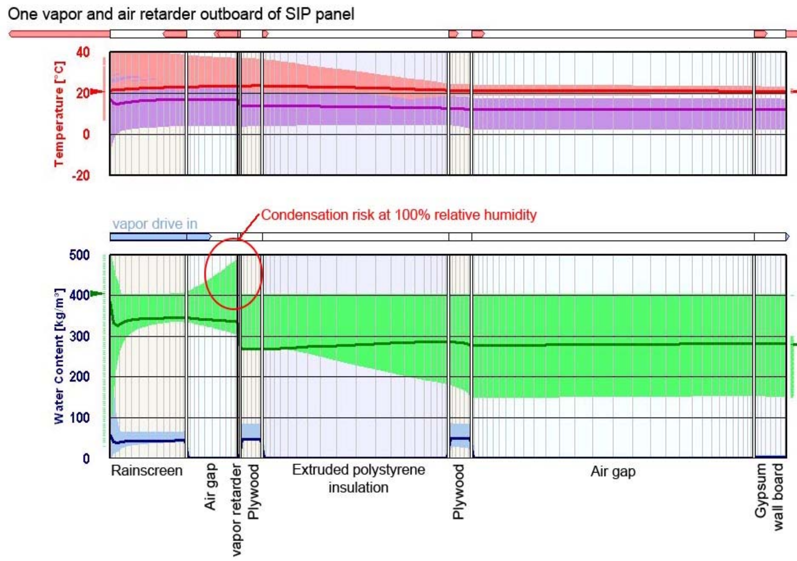


Further analysis through the use of software can test the hygrothermal performance of the enclosure to determine the exact risk for condensation within the wall cavity. The software includes WUFI, to test the water vapor infiltration rate, and THERM to examine the heat transfer rate, or R-Value, of the assembly. While it is not intended to mimic exact, realistic circumstances, design iterations can be compared for better or worse performance. Throughout the hygrothermal analysis of HARVEST HOME, water infiltration and thermal resistance results determined anticipated. The use of these two software programs in tandem provides greater incite into actual performance behavior rather than if they were used alone.

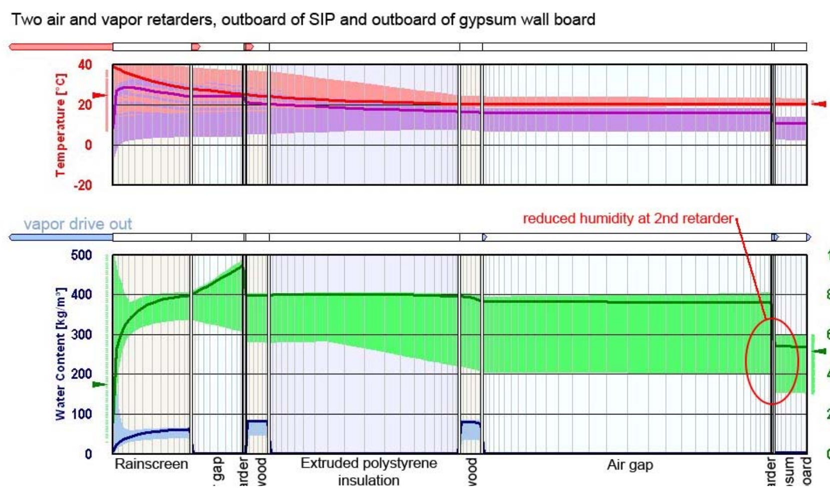
3.3 - VAPOR RETARDER LOCATION

The necessity for a vapor retarder as well as its location within a building component assembly are two major parameters that are analyzed through WUFI modeling software to determine the potential risk for condensation within a wall cavity.

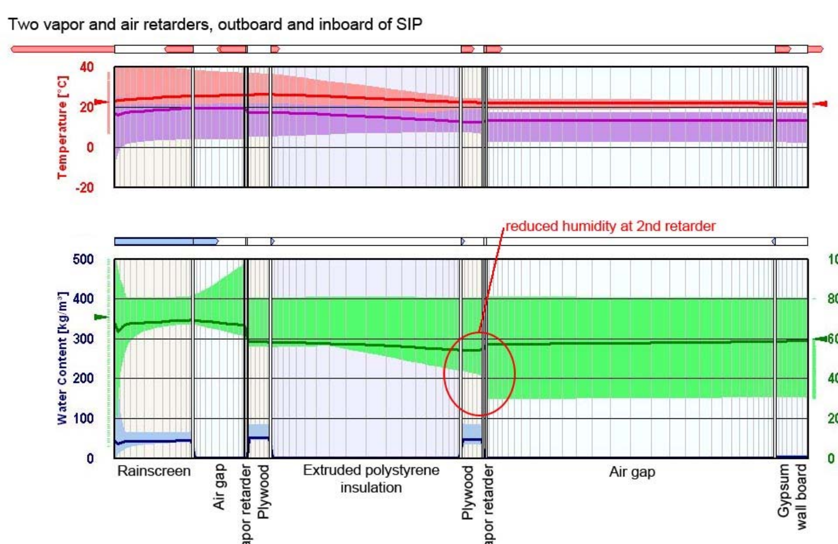
The current wall assembly for HARVEST HOME encompasses a fluid applied vapor and air retarder to the exterior side of the SIP. This is the only vapor retarder within the current design. The relative humidity (RH), which is the ratio of water vapor to air, is at risk of reaching 100% RH condensation point on the exterior surface of the SIP. The vapor retarder has been applied at this location preventing any moisture penetration into the wall cavity. As the water vapor continues to flow towards the interior of the home, the RH maintains levels between 35% and 80%, indicating that the vapor barrier placement is correct and there is no condensation risk inboard.



The previous analysis showed the RH level range of the interior space to be outside of the idea 35% to 60% range. This indicates that some vapor was traveling from the exterior to the interior of the wall cavity. In placing a vapor retarder outboard of the gypsum wallboard, the RH could be reduced within the interior space. The results of the analysis indicate that the vapor retarder reduced the RH levels to within the ideal range.



A third iteration tested the vapor retarder on the inboard face of the SIP. Similar to the previous analysis, the RH



inboard of the additional barrier is lower providing a potential reduction in humidity within the wood stud cavity where plumbing and electrical utilities are located.

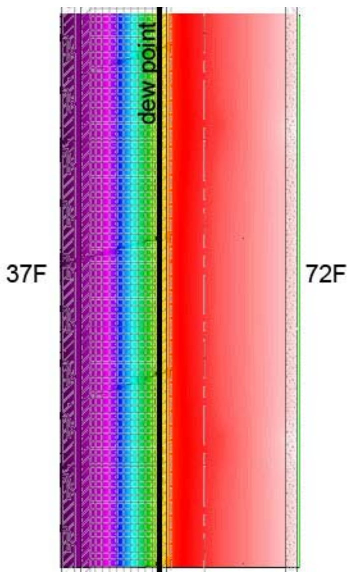
At the conclusion of total analysis, there is no potential for condensation within the wall assembly due to the location of the vapor retarder. This is accomplished through the liquid applied barrier that will shed bulk water when condensation is likely to occur throughout the year. The addition of vapor retarders to the inboard side of the existing retarder only reduces RH levels and has no effect on condensation potential.

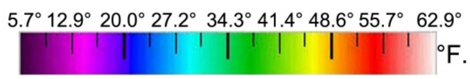
3.4 – NECCESITY FOR ADDED THERMAL RESISTANCE

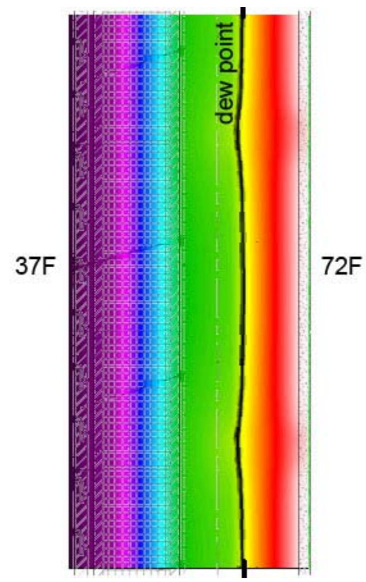
Within the current wall assembly, the wood stud cavity could be insulated with fiberglass batt insulation for greater heat resistance (R-value) of the total assembly while continuing to allow access to the embedded electrical wires and plumbing. The THERM software will calculate the overall R-Value of an assembly by adding and averaging the thermal resistance of each layer. THERM will be able to determine if the added insulation will be beneficial to the performance of the wall assembly by illustrating how heat transfers through the building components through the use of a color scale to denote temperature. When dry bulb temperature reaches the dew point or lower, the water vapor within the air will condense on a surface. As R-value is increased within a wall, the dew point line moves toward the warmer side of the assembly. THERM will help to identify the line of dew point within the wall assembly, which is also the point at which condensation will form.

For the HARVEST HOME wall assembly, it has been analyzed that condensation is not likely to occur within the wall cavity due to the location of the vapor retarder, however, in the potential of extreme weather circumstances, the added thermal resistance to the wall cavity could prevent moisture. Two models were tested within THERM, one without batt insulation in the wood stud cavity and the second with batt insulation. The exterior temperature was set to the lowest historic temperature at 37ºF based upon weather data from

Santa Ana, CA while the interior temperature was set to 72ºF. For a dry bulb temperature at 72 ºF with a relative humidity of 40%, the dew point is 45ºF. The first test, without added fiberglass insulation, relies on the SIP for thermal resistance where the average wall assembly temperature is 66ºF placing the dew point line within the SIP. The second test, with added fiberglass batt insulation, has an average wall assembly temperature of 55ºF bringing the dew point line within the wall stud cavity and closer to the interior space.







Baseline Wall Without Fiberglass Insulation

Baseline Wall With Fiberglass Batt Insulation

Due to the mild climate of Irvine, CA, there are no significant temperature fluctuations throughout the year; the average high temperatures reach 85ºF-90ºF while the average low temperatures fall to 42ºF-37ºF. The narrow temperature range does not require an extremely high R-value for building assemblies as a means of slowing thermal transmission to ease the labor of the mechanical systems. Additionally, by keeping the dew point line farther from the interior wood stud cavity, moisture and mold growth potential are reduced.

3.5 - WHITE VS. BLACK ROOF

Team Capitol dc designed the roof to be covered with a white EPDM (ethylene propylene diene monomer) rubber membrane to enhance building performance. Black EPDM membranes will absorb heat from solar rays creating added heat gain to the building causing mechanical systems to work harder to control interior temperatures. A white EPDM roof, on the other hand, will reflect solar rays preventing the added heat gain and reducing the work of the mechanical systems.

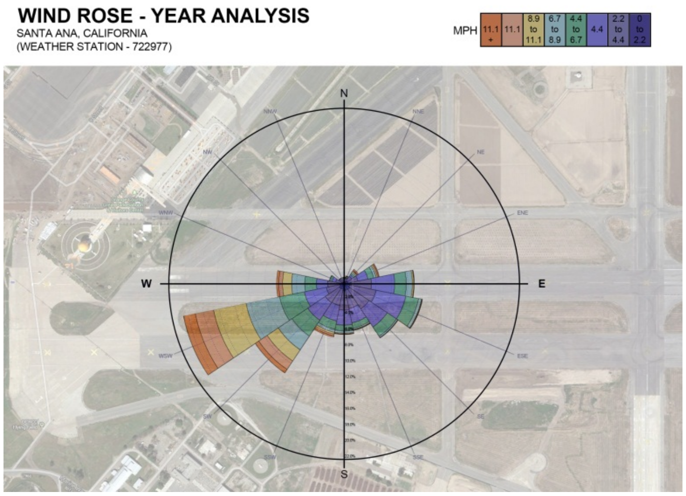
However, there is a risk of condensation in the roof cavity with a white EPDM membrane while a black EPDM membrane does not carry the same risk. A dark roof will hold heat causing the temperature in the wall cavity to be much hotter at the top. Based upon thermodynamic principles, the hot air will travel downwards towards the cooler portion of the air cavity also pushing water vapor downwards away from the roof. A light roof will not hold the same amount of heat, therefore, the air distribution in the cavity will cause hot air and water vapor to travel upwards. If the temperature within the roof cavity reaches the dew point, the water vapor would condense causing potential moisture and mold growth issues for the home.

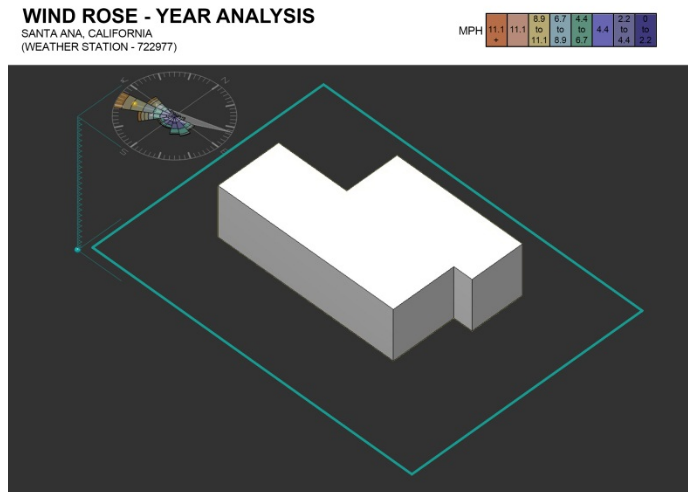
Team Capitol dc has identified this risk and made alterations to the details for wall construction components. Air tightness techniques have been incorporated to prevent moist air from penetrating the interior wall cavity. The installation of mesh tape at each SIP connection and liquid applied vapor retarder on the outside of the wall SIPs prevent moist air penetration from the exterior, as was shown in the previous WUFI models. The gypsum wallboard will also act as a barrier to prevent moist air from penetrating the cavity from the interior space. However, holes for electrical receptacle/switch boxes and light fixtures could be potential areas of weakness therefore airtight fixtures were specified and installed. Any additional holes in the SIP or electrical boxes were sealed with caulking to prevent even small amounts of air penetration. The significant reduction of water vapor within the wall cavity significantly reduces the risk for condensation within the roof cavity.

Construction Photo Showing White EPDM Roof Membrane

3.6 – NATURAL VENTILATION POTENTIAL

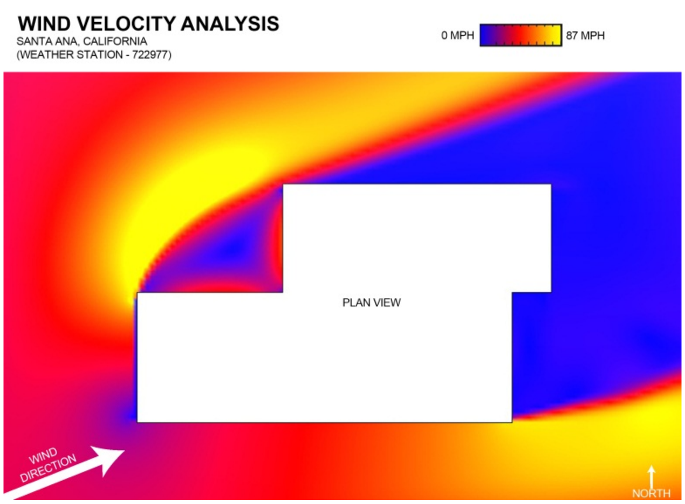
Wind flows can aid in natural ventilation to cool interior building spaces as well as reducing heat gain along building surfaces. Wind Roses display either the velocity or duration of wind flows or a combination of the two. The wind rose below is set on the tarmac of the Orange County Great Park and displays wind flow velocity within Irvine, CA. Wind flows primarily come from the south in this location but the strongest winds are expected to flow from the southwest orientation.

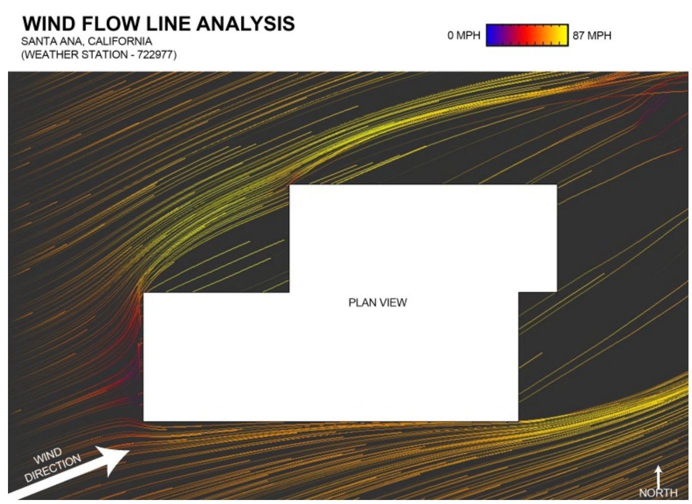


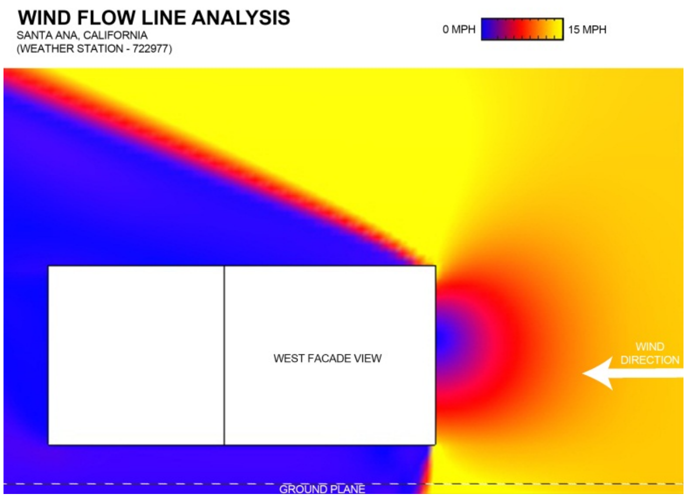


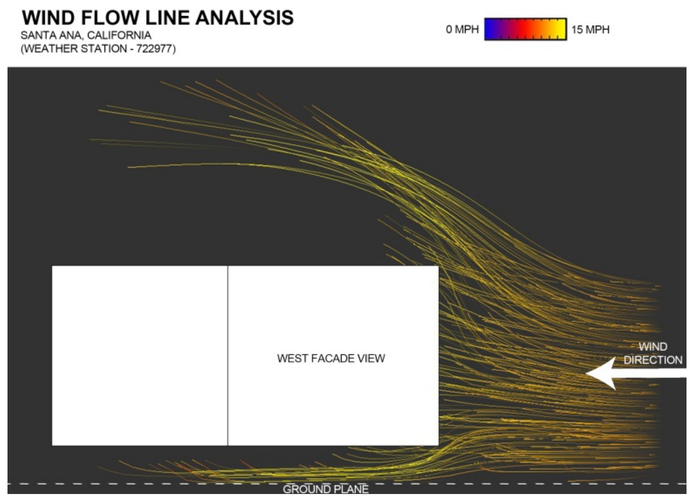
The following analyses show the wind velocity and wind flows when applied to the overall building massing. Large amounts of wind hit the western and southern façade of the building creating the opportunity to utilize natural ventilation strategies for the HARVEST HOME. As specified in the previously shown psychrometric charts, Natural Ventilation can provide a significant increase to the comfort level of the home without requiring energy to cool building spaces.

Looking towards the west building elevation, the velocity and wind flow diagrams also show that the whole surface of the southern façade is exposed to direct flows of wind. The southern façade is an excellent location to install large building openings to increase wind flow within the building. Although wind flows are also hitting the western façade of the building, it would not be as beneficial to provide a building opening due to increased solar radiation as the sun sets in the evening.









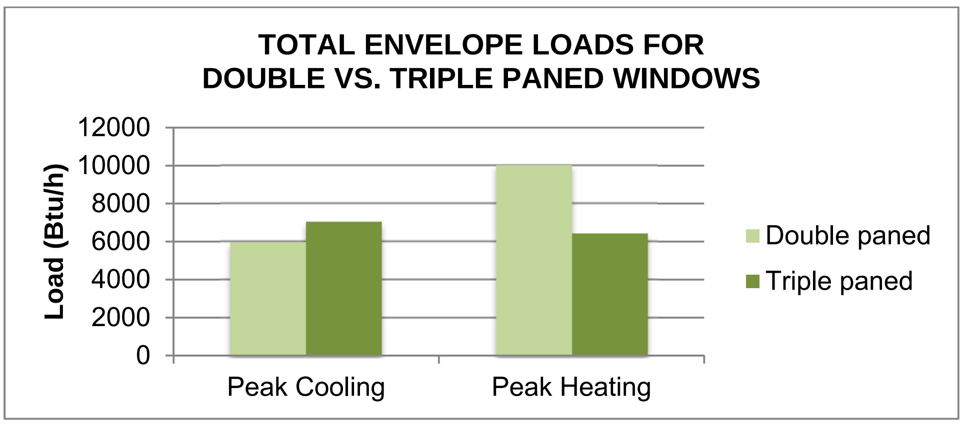
3.7 – GLAZING INTEGRATION

All aspects of HARVEST HOME's thermal envelope influence performance, including the quantity and type of glazing which was primarily integrated into the home to optimize passive design strategies such as passive solar heating, natural ventilation and daylighting. The entire glazing system was also intended to reduce heating and cooling loads with integral performance characteristics and materiality to the point of maintaining cost effectiveness.

Double paned and triple paned windows were both options for the home where the final selection was based upon the energy performance impact of HARVEST HOME and the overall system cost. Triple paned windows have a lower U-value, which is the reciprocal of R-value commonly used for glazing thermal resistance, as well as greater solar heat gain coefficient when compared to double paned windows. Triple paned windows are 1.5 times more costly than double paned windows.

A mechanical load model was run within Trane TRACE 700 to compare the potential heating and cooling loads for each option during the month of October in Irvine, CA to gain an accurate analysis of performance during the competition. The month of October has temperatures close to the annual average high and low temperatures, therefore the model would identify performance at both cool and warm weather conditions. The chart below illustrates the heating and cooling loads for the total envelope with either triple or double paned windows incorporated. The graphs display transmitted and absorbed solar radiation loads, which are the heating and cooling loads produced from the transfer of heat through the home's thermal envelope.

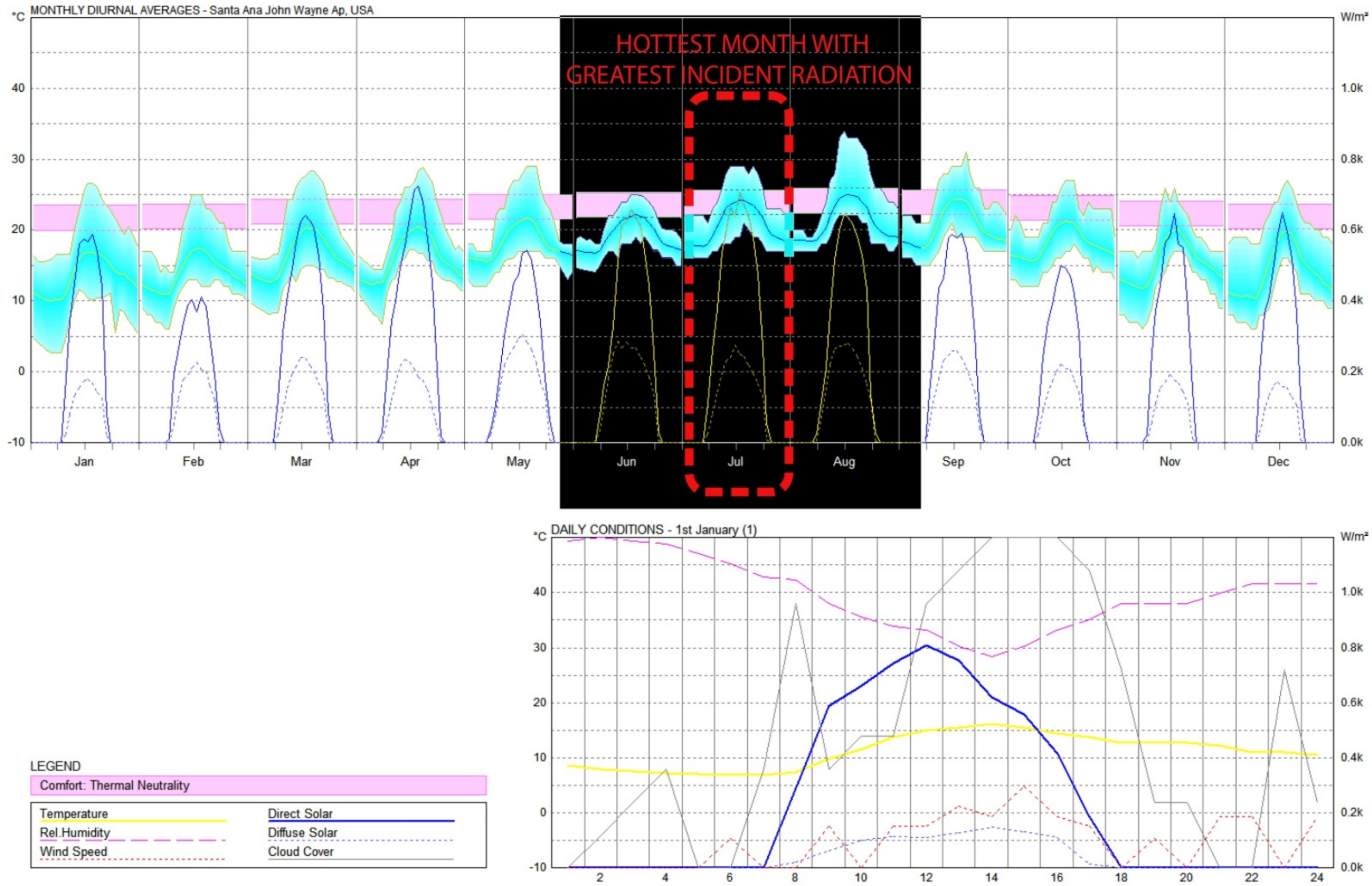
The use of triple pane windows will lower the home's peak heating loads by about 61% when less excess heat is escaping from the home. However, the peak-cooling load for the triple paned windows is 17% greater than for the double paned windows due to their higher insulation value preventing heat from escaping. Triple paned windows for the HARVEST HOME would cost $10,000, therefore, the initial cost is too great to justify the peak heating load reduction. Therefore, Team Capitol dc decided to install double paned glazing which is more cost effective and more energy efficient during warm days where cooling would be required, for example, throughout the competition period.



3.8 – INSOLATION ANALYSIS

Team Capitol has taken a thorough approach to analyzing the amount of insolation (**IN**cident **SOL**ar radi**ATION** or long wave radiation) hitting a surface. It is the most important passive design metric analysis for early design studies entailing the calculation of the sun's energy on a site and building mass through a solar load analysis (solar radiation analysis). The intensity of the sun can vary by the clarity of the atmosphere and the angle at which the sun strikes a surface, known as the "incident" angle, which is derived from climate analysis and the total radiation that is hitting the site.

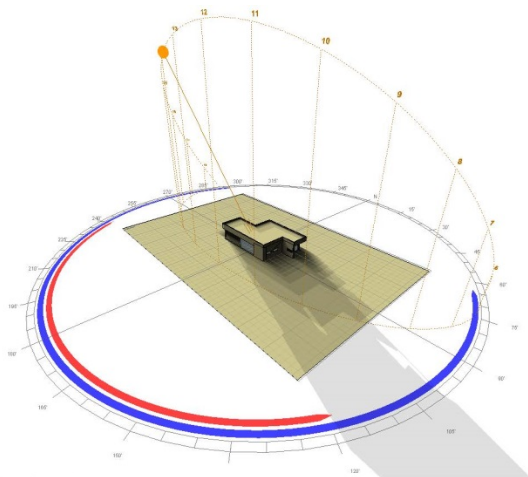
Diurnal averages indicate that July is the hottest month of the year with the greatest recorded incident radiation for the site within Irvine, CA using the John Wayne Santa Ana TMY3 weather file. The diurnal temperature range is the difference between the daily maximum and minimum temperature. Fluctuations in the diurnal temperature have many possible causes such as cloud cover, urban heat, land use change, aerosols, water vapor, greenhouse gases and can vary among different regions. In a typical project analysis, an indication of the hottest, brightest month indicates a requirement for more specific studies. However, the U.S. Department of Energy Solar Decathlon 2013 occurs in October and requires the design to be measured for that month in addition to annual rates and the more critical months, specific studies based on hourly metrics have been conducted to better inform shading design strategies.



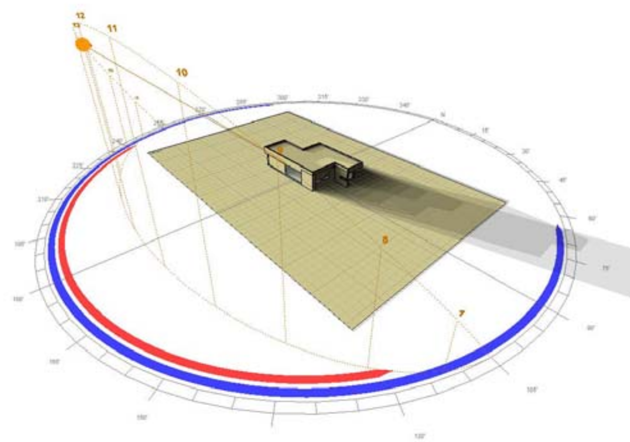
Monthly Diurnal Averages

The first step in the insolation analysis determined the surfaces' radiation levels in order to propose glazing locations. Since insolation is radiation hitting a specific surface, determining the amount blocked is the most effective way to minimize the initial solar impact. As a result of previous Climate Analysis for Incident Solar Radiation, metrics for optimal glazing and massing for each façade have been determined. Team Capitol dc identified that southern façade glazing is desired for exterior views and required for adequate foot-candle light levels. Refer to the Daylighting Section. The images below describe the southern façade glazing, depicting July with minimal exposure and October with the greatest exposure during the afternoon when the heat is highest.

The next step analyzed shading devices, which minimize or block solar energy, by first determining the transmitted internal load, then determining the specific shading screen design. All passive analyses were considered in the culmination of the internal loads, refer to the Internal Electrical Load Analysis section.



Solar Position at 2pm in July



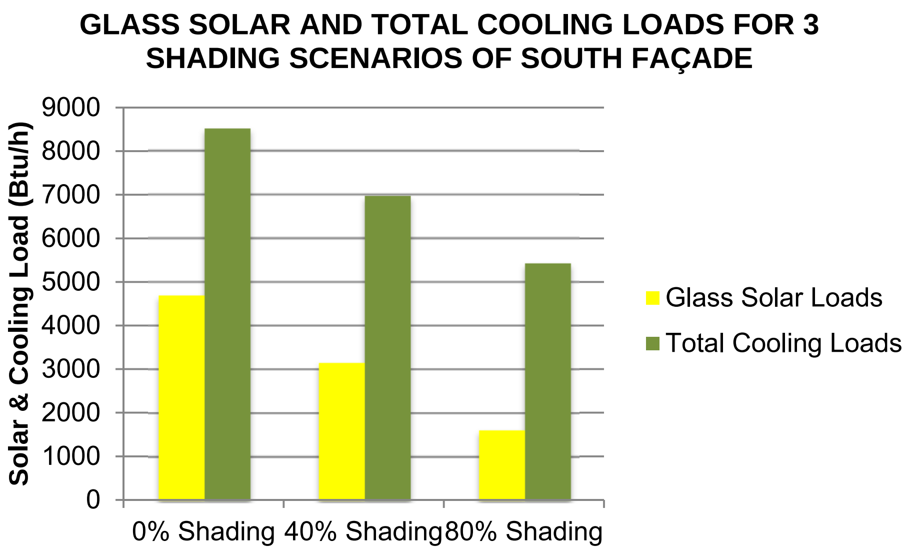
Solar Position at 2pm in October

RADITATION TYPES - *Incident* describes the amount of solar radiation hitting a selected surface and is derived in units of energy per area (Wh/m2 or BTU/hr/ft2). A*bsorbed* describes the amount of solar radiation being absorbed into the selected surface and *transmitted* is the amount of solar radiation passing through the selected surface typically used in either envelope or glazing studies. Insolation is not affected in any way by the surface properties of materials or by any internal refractive effects - only with the radiation actually striking the surface. Material properties only affect what subsequently occurs, which is the amount of solar radiation absorbed and/or transmitted by the surface and is dependant on such factors as the object's albedo, or SRI (solar reflective index) - the fraction of light hitting an object that is reflected by that object. Some radiation is absorbed in materials, some is transmitted through the material, and the remainder reflected depending on the material. Usually the absorbed solar radiation is converted to thermal energy, causing an increase in the object's temperature, which may be converted into another form of energy, or minimized depending upon material selection. Transmitted solar radiation is mitigated by active mechanical compensations within the internal load or passive measures such as exterior blockage.
TRANSMITTED RADIATION - A glazing study was conducted using the software Trane TRACE to determine the transmitted radiation during the competition in October and internal load impacts of blocking the radiation. The shading device must be removable to allow the occupant to exit the home through the sliding glass door within the southern glazing.

Three design scenarios were tested: 1) No exterior shading on the south façade; 2) Addition of an exterior shading screen that is in an open position, reducing the solar heat gain coefficient by 40%); and 3) Addition of an exterior shading screen that is in a closed position, reducing the solar heat gain coefficient of the southern façade by 80%.

The following chart shows how adding an external shade screen on the south façade decreases the home's transmitted solar loads as well as total cooling loads. The load of the transmitted solar radiation or "glass solar loads" are solely the amount of heat entering the home while the total cooling loads are the sum of the glazing solar loads, additional envelope loads (infiltration and conduction through doors, windows, floor, and ceiling), and internal loads (heat gain due to people, equipment, and lights).

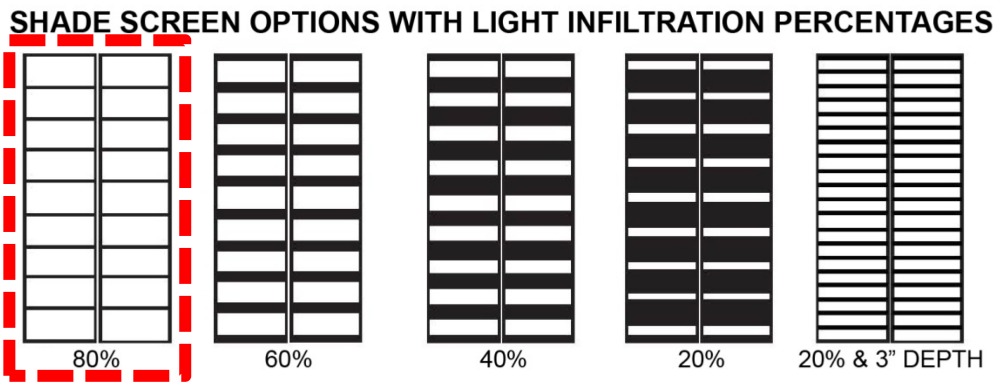
As shown in the chart, the total cooling loads decrease as glass solar loads decrease. As the shading on the south façade increased from 0% to 80%, glass solar loads decreased from 4704 Btu/h to 1617 Btu/h (66% decrease) and the total cooling loads decreased from 8531 Btu/h to 5444 Btu/h (36% decrease). This indicates that the total amount of energy required to cool the home is also expected to decrease by 36% for a typical afternoon when cooling is required. On a cool day when the outdoor temperatures are lower than the desired indoor temperature, the shade screen can be removed to use solar heat gain to the home's advantage by providing free heat. While the home's HVAC system was designed to provide enough cooling for the 0% shading scenario, these results are significant because they indicate that the shade screen will lower the peak cooling loads and allow the HVAC system to operate more efficiently. The metrics required to determine the insolation mitigation using a specific louver design however, require different software which measures insolation specifically, and design options that can be tested to determine optimal annual and daily metrics.



3.9 – SHADING ANALYSIS

The southern façade was determined within the initial Climate Analysis section to receive the highest amount of radiation and have the greatest potential for interior heat gain. The soffit above the southern glazing of HARVEST HOME passively provides a small level of shading, however, not enough to offset solar heat gain without the implementation of an additional solar shading device. The initial purpose of the shading screen was to prevent undesired solar heat gain on warm afternoons. On cool afternoons, the screen can be removed to take advantage of solar heat gain to warm the home. The insolation analysis yielded many synergies between other analyses and required alternative software, such as TRACE energy modeling.

Team Capitol dc used the software Revit BIM and DIVA for Rhino to model various shading devices to test on the southern glazing of the HARVEST HOME. The Rhino model of the shade screens used complicated geometry therefore the shading system was reconstructed in Revit, which made the transition to Ecotect for analysis much easier. Since the daylighting, transmitted radiation and the insolation analyses are symbiotic, the shading devices were reconstructed for the Daylighting Analysis in DIVA for Rhino and used as a starting point for the insolation analysis. Based upon the Daylighting Analysis section, any shade system that does not allow at least 30-40% of the available light into the space between sunrise and 5pm causes foot-candle levels to drop below 5FC requiring the use of electrical task lighting in the kitchen. The percentage associated with each design describes the amount of light the shade system infiltrates into the Kitchen. The system with the most successful daylighting potential (80%) was selected as the system to be modeled for the insolation analysis.



The louver with the most successful daylighting potential was used as a premise for the insolation studies

ANNUAL INSOLATION EVALUATION WITH SHADING - From this initial insolation analysis model, various options were created which also incorporated louvers. The following describes the shade options not necessarily in order of creation or testing, but in order of consequential success in blocking insolation, Refer to Annual Insolation with Shading Matric:

- [1] Baseline Case, No Blockage (Worst)
- [2] 1" Thick, 4" Deep, 8" Spaced Louvers
- [3] 2" Thick, 6" Deep Canopy
- [4] 1" Thick, 8" Deep, 8" Spaced Louvers
- [5] 1" Thick, 3" Deep, 3" Spaced Louvers (Best)

The ANNUAL INSOLATION WITH SHADING MATRIX below describes these comparisons of data. The PROFILE category describes the architectural shading design options in a building section view. The SHADING category displays the annual shadow range for the afternoon when the solar load peaks. The STEREOGRAPHIC INCIDENT RADIATION category maps annual insolation options as global spheres onto a plane peaking at 520 BTU/hr for this study. It 'birds-eye' view of the general shading potential. The DAILY AVERAGE SOLAR INCIDENT RADIATION describes more specific insolation metrics for each hour of the day and peaks at 600 W/m2 for this study.

The first option was generated by Ecotect's Optimized Shading Device simulation to create a 6' semi-permeated canopy [3]. This option yielded an annual average of 75% shading, and reducing peak BTU by 37%, and also allows direct radiation to impact the glazing in January, November and December. However, it is a large building attachment and not feasible for the intended design. Furthermore, it did not provide optimal passive lighting when analyzed for daylighting potential.

The next option was derived from the daylighting analysis where the introduction of intermediate louvers dually function as reflective devices to increase interior daylighting penetration, while minimizing solar impact. The louvers were modeled to have a 4" louver protrusion and were spaced 8" apart [2]. Although this option permitted solar impact on the glazing at the same BTU level as the unobstructed glass during mid-day from April through January, the 8" spacing was successful in maintaining a high daylighting penetration into the floor plate with a greater unobstructed view.

A sister option was created to test deeper louvers that resulted in a 8" louver protrusion spaced 8" apart [4] and was the most successful option for synergistic benefits (daylighting, transmitted radiation, and shading). First, it yielded a higher foot-candle level in the interior space. Per the Daylighting Analysis, the foot-candle levels near the window remained at the 80% level, like the 4" louvers, but there were slightly more foot-candles of light consistently behind the island counter. This option also yielded an annual average close to 90% shading, yet permitted solar impact on the glazing at the same BTU level as the unobstructed glass during mid-day from late February through January at noon, which is an advantage during cooler months. The average foot-candle readings overall were similar to the shallower 4" louvers, but the lighting was more even, concluding that the depth of the louver allowed more light to bounce creating a softer light with increased floor plate penetration and provided an unobstructed view to the outdoors.

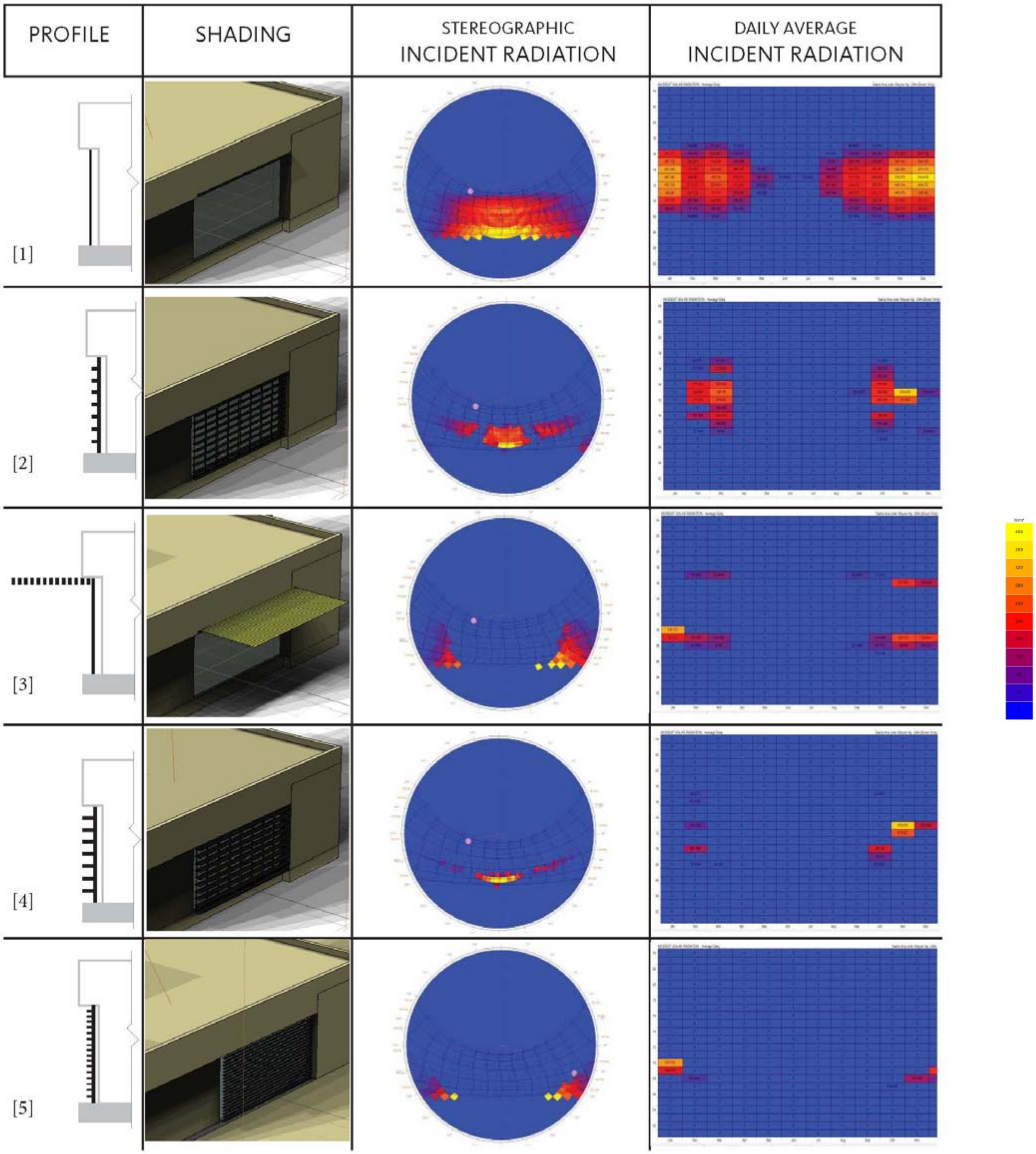
The annual occupant schedule is different from the competition schedule, a more user-friendly shading mechanism may be used for the final destination. During the hottest months, shading will still be provided while foot-candle levels remain and thermal loads are reduced. Due to the many synergistic benefits, the simple components, and no mechanical parts or assembly, this option is the most economical design for a permanent occupant.

The last option is an innovative louver system coined, the "Harvest Screen" and it is equipped with a climate-intuitive sensor for opening and closing the louvers. as project in two of their modeling classes at CUA, ARPL 555 The Parametric Model, and ARPL 553 Digital Design Fabrication. They were interested in incorporating this device into the HARVEST HOME, and started to design it using parametric tools and their own methods to design the system. The students and faculty members of the Solar Decathlon Team Capitol DC that were assembling this "Energy Discussion" report were determined to evaluate the actual solar performance of this shading system, and therefore included it as option [5] in this insolation study.

This sun shading 'screen' was designed to incorporate 3" louvers with 3" spacing [5]; the same proportion as option [4] however with slightly more obstructed views from the kitchen to the outdoors due to the tighter spacing. The insolation analysis interestingly revealed that this screen incorporates the most optimal results from each of the other options. Referring to the Annual Insolation with Shading Matrix, the system clearly possesses the greatest heat reduction potential during the summer months. For example, the 3" louvers yielded an annual average 90% shading, reducing peak BTU by almost 40% and also allows direct radiation to impact the glazing mostly during the months of January and February – specifically in the early morning and later evening when temperatures are inclined to be low, reaping the benefit of solar heat gain. The Annual Solar Exposure diagrams in the analysis indicate that the peak incident radiation using this screen does not exceed 150 W/m2, which is only 10% of the peak load of the Daily Average Incident Radiation of the annual studies occurring in the winter months.

The final option has a climate-intuitive shape memory alloy to mechanically open and close the louvers. This sun shading 'screen' was designed to incorporate 3" louvers with 3" spacing [5]; the same proportion as option [4] however with slightly more obstructed views from the kitchen to the outdoors due to the tighter spacing. The insolation analysis interestingly incorporated the most optimal results from each of the other options. For example, the 3" louvers yielded an annual average 90% shading, reducing peak BTU by almost 40% and also allows direct radiation to impact the glazing mostly during the months of January and February in the morning and evening when temperatures are inclined to be low. The screen will reap the benefit of solar heat gain and even potentially offset heating loads.

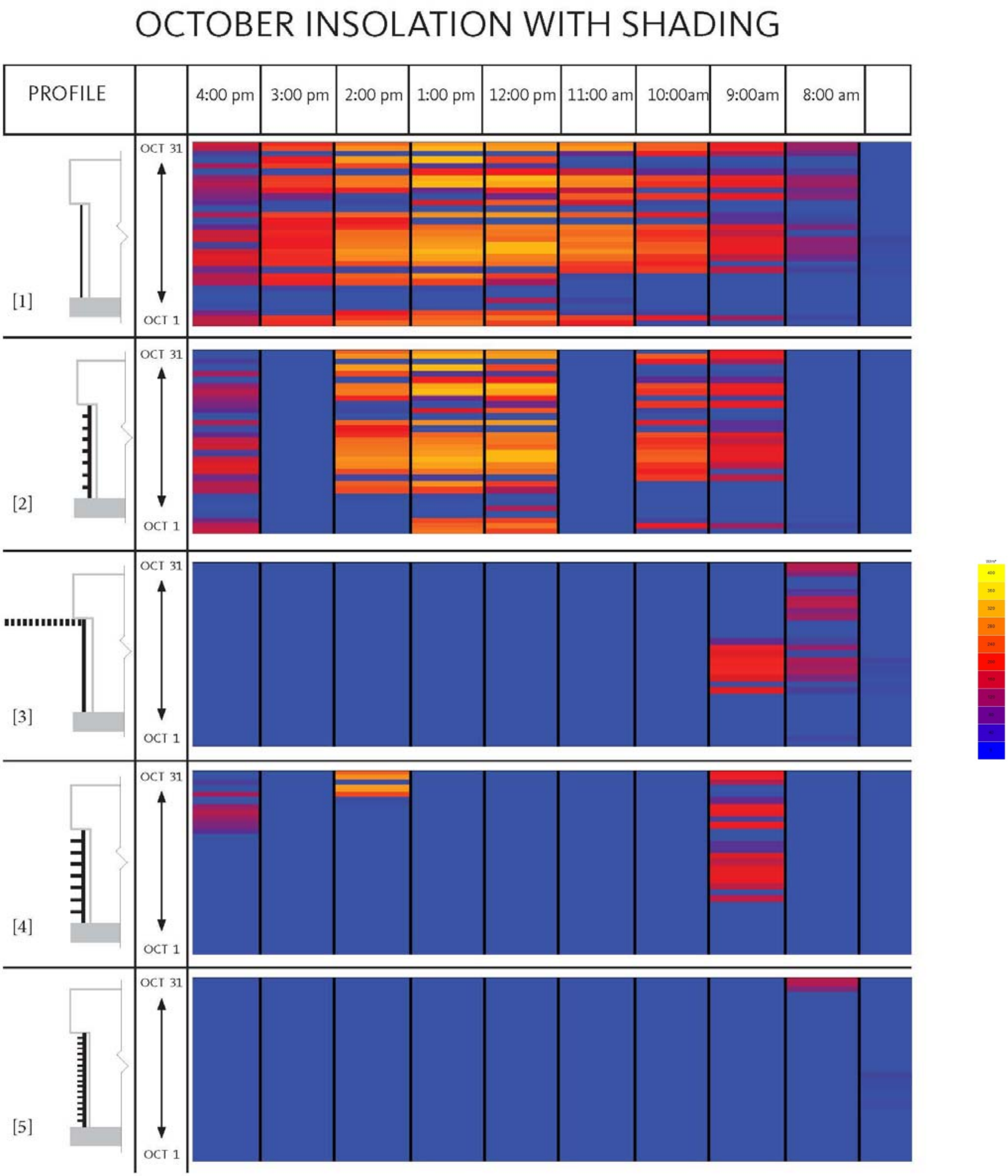
ANNUAL INSOLATION WITH SHADING



OCTOBER INSOLATION WITH SHADING - The analytical evidence that Team Capitol dc has generated suggests that solar impacts are minimal during the competition time. The OCTOBER INSOLATION WITH SHADING MATRIX below describes comparisons of specific incident radiation with respect to time intervals. The PROFILE category in this matrix describes the architectural shading design options in a building section view as in the previous matrix. The TIME category describes the times of the day when the building is likely to be occupied during the competition period. The ANNUAL SOLAR EXPOSURE diagrams indicate that the peak incident radiation does not exceed 150 W/m2, which is less than 10% of the peak load of the Average Daily Incident Radiation of the annual studies occurring in the winter months.

In order to accurately analyze the shading system options with respect to insolation for the specific competition period in October, hourly incidence metrics were simulated for 31 days from 8am – 4pm while daylight is present. The mean temperature in this region is 65°F with the average low at 55°F and the average high at 75°F. During this month, there is little need for mechanical heating, so the ability for the sun to permeate the shading to gain passive solar heating is irrelevant. Option [4] in this study yields a higher level of incident radiation at 9am, which in this case has the potential to create glare within the kitchen that would have to be balanced with artificial lighting, or internal blinds. Therefore, Option [5] appears to maintain a consistent reduction of insolation while maintaining the capability to mechanically operate based on temperature.

After the analysis of shading option [4], option [5] seemed beneficial, yet was not relevant since there is no immediate need for a mechanically derived device during October. However, considering the synergistic benefits found through analyzing the annual insolation with shading, including the signigicant annual reduction of shading, reducing the peak BTU, solar gains in the morning and evening during the coldest months, and more importantly – to feature a new technology which serves a catalyst to be implemented on a mass scale which would in fact significantly benefit hotter climates, the final shading design - option [5] - was selected to be featuerd in the Solar Decathlon.


OCTOBER INSOLATION WITH SHADING
PROFILE
4:00 pm
3:00 pm
2:00 pm
1:00 pm
12:00 pm
11:00 am
10:00am
9:00am
8:00 am
OCT 31
OCT 1
[1]
[2]
[3]
[4]
[5]

3.11 – FINAL 3-10 – HARVEST SCREEN

HARVEST SCREEN - The Harvest Shade Screens approach a centuries old building system, the shutter screen, through novel material technologies, optimal energy approaches, and industrialized fabrication processes. The screen design is the culmination of a mutli-year research agenda into environmental, user oriented building skins by the Emerging Technologies Graduate Concentration at the Catholic University of America's School of Architecture and Planning (CUArch) and Dynalloy Inc., an industry leader in the manufacturing and engineering of the shape memory alloy (SMA), Flexinol® wire, a trade name for Nitinol wire.

Located on a large section of operable glazing composing 20% of the HARVEST HOME's southern façade, the horizontal louvered systems serves a multi-faceted intent: insulate the building from direct solar radiation, control the passage of reflected light, allow cross ventilation, and maintain privacy. Pragmatically, the screens function based on historically established passive shading strategies and day-lighting and energy analysis conducted using the Rhinoceros 3D modeling environment plug-in, DIVA-For-Rhino as shown in the Shading Analysis Section. However, the Harvest Shade Screens imbued a more novel, techno-environmental potential. Through the design and development of a Nitinol wire actuator, the Harvest Shades Screens 'harvest' the latent energy of the sun to passively shade the south façade by closing the horizontal louvers through a rotational movement that requires no additional energy sources. This Phototrophic movement introduces an entirely new paradigm to the built environment, allowing for a 'living', 'breathing' architecture, programmed for energy optimization. The design of the Harvest Shade Screens fundamentally shifts kinetic shading technologies away from electrified sensors and actuators to a smart material capable of both sensing and actuating through unique chemical composition.

Rendering of the Harvest Screens

HISTORY OF SMA – NITINOL - Shape memory alloys (SMA) are not a necessarily new in contemporary consumerism. Research into SMAs began in the 1930's leading the discovery of the nickel-titanium alloy, Nitinol, in 1961. The nickel-titanium chemical make-up of Nitinol allows the material to contract when heated. Commonly manufactured as wire extrusions, the typical contraction will range between 2 and 5 percent of the overall length of wire. Nitinol alloys are made of a composition of roughly 55 to 65 percent Nickel and 44 to 55 percent Titanium. Changes to this chemical composition allows for significant impact on the transition temperature to achieved modification of the SMA.[1]

As stated, contemporary consumers are quite familiar with products that use SMA technology, though they may not be aware of the alloy. The properties of SMA's have been implemented on multiple scales within the medical industries ranging from orthodontic guide wires to cardiovascular application of self-expanding NiTi stents. Electronic applications for shape memory Nitinol include micro circuit breakers, PC mount relays, temperature controls and electronic locks, to name a few. However, in the built environment, specifically building energy systems, there are few applications of Nitinol wire. Systems of note include Nitinol actuated linear diffusers that change the position of heated and cooled air distribution, high and low respectively, through the passive actuation of the Nitinol wire by the heated forced air.[2] It is this energy potential, the capacity for linear actuation through the physical augmentation of the Nitinol wire by relative low induced energy,[3] that introduces novel kinetic architectures for optimal energy building skins.

THE ATOMS OF SMA - The actuation, or contraction, of the Nitinol wire is a solid-state phase transformation based on atomic-level characteristic of the nickel-titanium alloy (a martensitic transformation). The atomic-level changes are understood through three transformation periods, martensite, austenite, and hysteresis. Understanding of these phases allows for greater understanding of the application of the Nitinol wire in the Harvest Shade Screen.

At low temperatures the Nitinol wire is in a *martensite* crystal structure, refer to image below. This more complex structure represents the normative, or relaxed state of the wire. When heat is applied the wire exhibits a cubic crystal structure, or *austenite* structure. The atomic-level change from *martensite* to *austenite* results in a 4-5 percent strain or contraction of the wire. The resulting strain also exhibits a large mechanical force upwards of 25,000 PSI. During the austenite phase the crystal structure of the wire is deformed without breaking atomic bonds, allowing the reversal of the solid-phase change when cooled, and the alloy's 'shape memory.'[4] The NiTi alloy also exhibits a large *hysteresis*, the change in temperature between full *austenite* and full *martensite,* typically 25-50C. The large *hysteresis* phase means that the temperature of the wire changes without modifying the physical properties of the wire; therefore the wire exhibits a lag, or delayed change from full contraction to relaxation.

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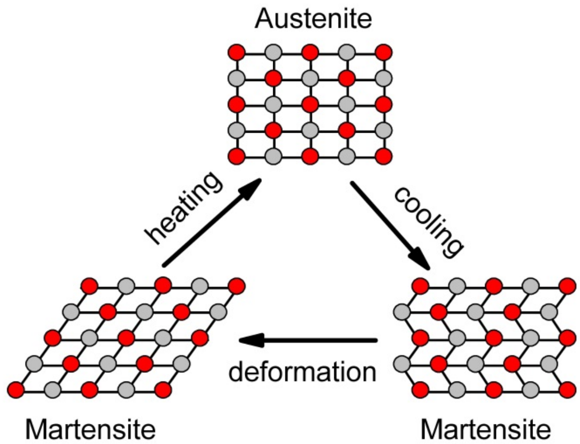
[1] "Introduction To Flexinol®." About FLEXINOL® Shape Memory Alloy Wire. Dynalloy, Inc., n.d. Web. 13 Nov. 2012. <http://www.dynalloy.com/AboutFlexinol.php>.
[2] http://www.titus-energysolutions.com/green/ecat/model.aspx?prodid=444&catid=186
[3] Commercially available wire transition at temperatures of 70C and 90C. In the context of the linear diffuser, chemical engineering of the Nitinol wire allows for transition temperatures ranging from 15C to 30C.
[4] "Technical Characteristics of FLEXINOL® actuator wires" About FLEXINOL® Shape Memory Alloy Wire. Dynalloy, Inc., n.d. Web. 13 Nov. 2012. < http://www.dynalloy.com/pdfs/TCF1140.pdf>.

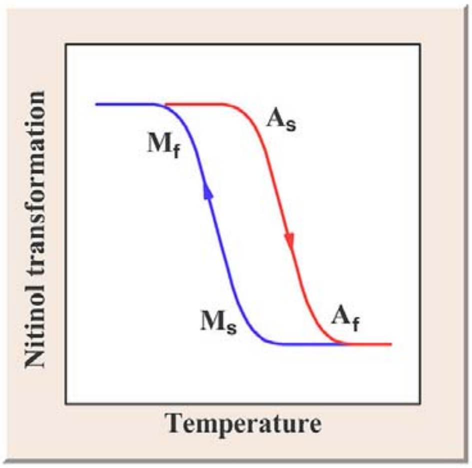


Atomic-Level Structural Deformation Of Nitinol During Martensitic Transformation

APPLICATION OF SMA - In the Spring of 2012, CUArch's Emerging Technologies Concentration established a research collaboration with Dynalloy Inc. an industry leader in the manufacture and engineering of Nitinol, trade named Flexinol® wire. Through this collaboration a series of prototypes were developed exploring the capacity of Flexinol® actuated shading system. Prototypes evaluated the physical properties of Flexinol® wire to actuate mechanical systems, the programming of embedded microprocessor for sensory driven actuation of electrically induced contraction, and computer numerically controlled (CNC) fabrication methods. Through these prototypes three design criteria were established including: (a) passive Flexinol® transformation through ambient air temperature (2) reduced design complexity through inline louver actuation and limited Flexinol® assemblies (3) reduced friction at axial rotation points with a10 grams maximum pull force required per louver.

In order to establish a shading mechanism that is passively actuated by the thermal exchange of energy through ambient air temperature an *austenite* temperature range was established by annual temperature data for Irvine, CA during the competition period, see section 3.9. The use of Flexinol® wire theoretically allows for the programming of transformation temperatures by changing the ratio of nickel to titanium, allowing a *martensite* transformation from 200C to cryogenic temperatures[5]. However, chemically programming of Flexinol® wire requires extensive engineering and analysis that fall beyond the scope of this project. Fortunately, based on precedent research, the established *austenite* temperature range, 15-20C, fell within an existing wire specification manufactured by Dynalloy Inc. The specified wire allowed a 2500 gram pull force during the cool, *martensite* phase, and a 2900 gram pull force during the heated *austenite* phase, resulting in a total actuation force of 400 grams.

[5] "Technical Characteristics of FLEXINOL® actuator wires" About FLEXINOL® Shape Memory Alloy Wire. Dynalloy, Inc., n.d. Web. 13 Nov. 2012. < http://www.dynalloy.com/pdfs/TCF1140.pdf>.



Hysteresis Diagram

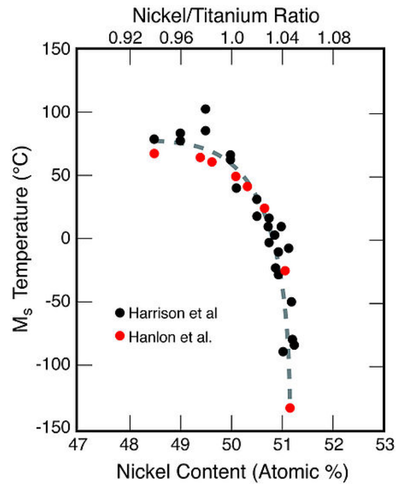


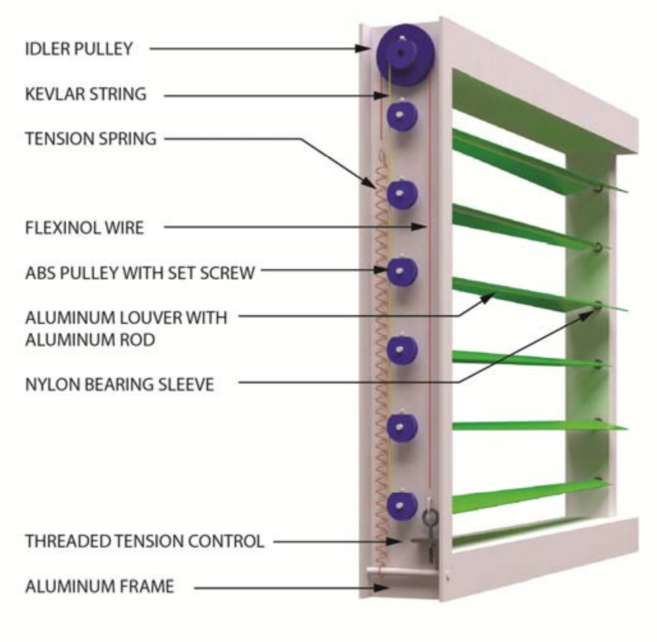
Chart Depicting Temperature Transformation Point Relative To Nickel-Titanium Ratio

ACTIVE PASSIVE - The use of Flexinol® actuated passive shading screen introduces novel approaches programmable material for optimal energy building skins. While the screens static passive system is designed to ensure adequate shading without the closure of the louvered façade during the October competition period, the capacity for increase insulation through automated closure for peak radiation period for the continuum of the year ensure optimal thermal protection. Furthermore, research into environmentally controlled kinetic shading devices introduces new horizons for intelligent building skins. In the case the HARVEST HOME, the residential building typology and end-user provide a unique opportunity to condition both *space* and *place.* In the context of skin loaded residential building energy consumption for heating and cooling loads represent 30 and 12 percent of total energy loads, respectively.[6] Residential builds also represent an occupancy type that is typically uninhabited during peak radiant gains. The capacity for a shade screen that can actively respond to increased radiant loads by closing and open during low temperature periods when heat gain is required without either a human actuated closure, or an energy consuming electronic motion radically shift the perception of a 'smart building,' or 'building automation system.' As described by Doris Kim Sung of University of Southern California in reference to her own work in SMA building skins, "when you're tired of opening and closing those blinds day after day, when you're on vacation and there's no one there on the weekend to be turning on and off the controls, or there's a power outage and you no electricity to rely on, SMA interactive facades will still be working tirelessly, efficiently and endlessly."[7]

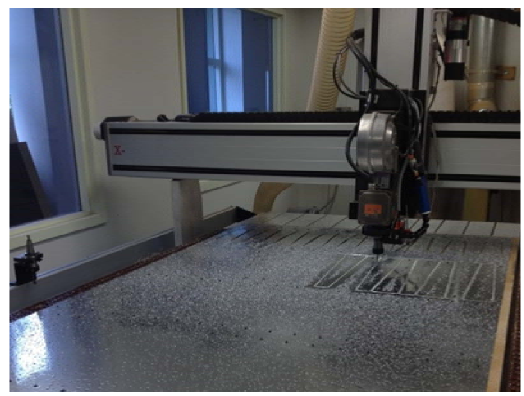
FLEXINOL® ACTUATOR - Through extensive collaboration with engineers at Dynalloy Inc. a fully integrated Flexinol® actuator assembly was developed. As stated earlier, the 15-20C temperature range for Irvine, Ca, fell within an existing wire specification manufactured by Dynalloy Inc. The specified wire allowed a 2500 gram force during the cool, *martensite* phase, and a 2900 gram force during the heated *austenite* phase, resulting in a total actuation force of 400 grams. In order to produce a rotational movement with limited friction an inline pulley system was developed that allowed a single Flexinol® wire to actuate the 32 of the 64 louvers on each operable screen bay. Each bay then carries two mirrored assemblies that act independent of the other. The inline pulleys work by applying a strain force, carried by a single spring that runs the length of the assembly, the spring ensures the Flexinol® wire remains under the prescribed 2500 gram load during the martensite

[6] "Energy Efficiency Trends in Residential and Commercial Buildings" U.S. Department of Energy, October 2008
[7] *Doris Kim Sung: Metal That Breathes*. TED Conferences, LLC, Oct. 2012. Web. 26 Nov. 2012. <http://www.ted.com/talks/doris_kim_sung_metal_that_breathes.html?utm_source=email>.

phase, allowing for proper actuation under specified heat. When heated, the contraction of the wire rotates a large idler pulley at the top the assembly, which then uniformly transfers rotational movement via Kevlar strings to each pulley of the assembly. Additionally, the specified wire has a transformation temperature range between 15C and 30C. This large range affords the system an added capacity to 'tune' the actuation point to a desired temperature. By placing a threaded connection at the base of the Flexinol® actuator assembly, additional strain can be placed on the wire. Added strain decreases the transition temperature allowing the end user to preprogram the exact actuation point to their desired temperature level. The resulting behavior is a smooth rotational movement that requires no additional energy. Furthermore, the large *hysteresis* period both slows the rotational closure of the louver and ensures that minute temperature fluctuations do not result in a continuous opening and closing cycles.



Screen Assembly Diagram


CNC milling of aluminum louvers

CONTROLLED FABRICATION Though the final assembly is intended to be simple with minimal parts, achieving simplicity requires control fabrication techniques. CNC fabrication equipment was used extensively in the screens production. In house fabrication facilities, specifically a 3-Axis-CNC mill provided both a controlled and cost efficient means of cutting each of the 250 louvers in the final assembly. CNC milling also insured accurate placement of holes for each of the 32 aluminum rods in the pulley assembly, this placement is pivotal in ensuring limited binding and friction during rotational movement. Finally, the novel tectonics of the pulley assembly required custom manufacturing of parts through 3D ABS printing.

DESIGN PARAMETERS - Pragmatically, the Harvest Shade Screens' design is based on four primary parameters: insulate the building from direct solar radiation, control the passage of reflected light, allow cross ventilation, and maintain privacy. Within the context of the HARVEST HOME residential prototype the shade screen design operate two distinct passive solar shading paradigms.

STATIC PASSIVE - The physical design of the Harvest Shade Screen is based on historically established passive shading strategies and energy and day-lighting analysis through Diva-for-Rhino. In order to establish a depth and spacing of the horizontal louver two key factors were calculated, site specific solar altitude during optimal / specified dates of shading and the window azimuth of louvers' location. The solar altitude, 50 degrees, was established by using the fall equinox at 12pm, which coincided with the start of the October competition period. The window azimuth for the southern exposed louver was calculated as 0 since the louver are exposed parallel to the southern azimuth. These two factors were then applied to the following algorithm to establish the depth-to-height (spacing) ratio for each louver : *Height = Depth * tan(solar elevation) / Cos (solar azimuth – window azimuth) or Height = D*1.2*. Therefore, the louver spacing was established at a one-to-one depth-to-height ratio. Further analysis through Diva-For-Rhino (see Daylighting), confirmed that the screen's transparency, and powder coated finish allowed for an optimal solar illumination, and the one-to-one ratio provided an optimal insulation from direct radiant heat gain.
Further esthetic modifications were applied to the screen system to provide a more rich texture when closed and additional reflected light when in the open position. First, the extruded louver shape was tapered into a truncated isosceles triangle providing a contiguous rhythm across the screen façade. To ensure the non-uniform shape provided adequate shading, louver spacing was proportional reduced based on the average of the profiles widths. Second, a 25-degree structural bend was placed along the louver longitudinal section. Again, the bend increases visual texture, but also directs reflected light onto the ceiling and bottom face of adjacent louvers throughout the day producing an illuminated wall section and reducing incidences of direct glare.

CONCLUSION - As the Harvest Screen can demonstrate, the intensity of the sun's energy is important for passive heating, cooling, and daylighting. Knowing the metrics for solar radiation has helped Team Capitol dc plan for our PV's, has helped us confirm our design decisions, helped to understand the implication of a new design technology, and has taught us that implementing radiation studies at the inception of a project can greatly improve how the building is informed, the efficiency by which a building is designed, and even can aid in planning interior spaces and the program to adjust to the maximize the natural potential of our greatest source of passive energy. The Team Capitol dc team has maximized the optimal shading potential on the most impacted façade with glazing in order to minimize the internal heat gain during the hottest months, maximize the thermal gain during the coldest months, simultaneously providing a high daylighting factor and foot-candle level which minimizes internal electrical loads due to artificial lighting fixtures.

4.0 - INTERNAL ELECTRICAL LOAD ANALYSIS

4.1 – INTERNAL ELECTRICAL LOADS

Once HARVEST HOME's thermal envelope was designed with passive design strategies, the electrical load was calculated to determine how much electricity is required for the specified energy efficient lighting, appliances, and electronics. The flat plate solar thermal collector on the roof harvests the sun's energy to produce hot water and when required uses supplemental heat supplied through an electric coil.

A control system has been implemented within HARVEST HOME to monitor equipment or devices on separate electrical circuits in order to meter the energy consumption of a single unit or the overall home. The electrical lighting and mechanical system can be controlled via a remote device such as a tablet or cellular telephone to create a more tailored and comfortable environment. The occupant can directly identify how behavior affects energy consumption rates in order to make sustainable lifestyle changes. Each of the components within the control system are intended to optimize personalization and the energy efficiency of the home.

4.2 – LIGHTING HARVEST HOME

As of 2010, residential lighting consumes, on average, about 22% of a households electrical use in California.[8] Lighting is integral to the comfort and functional success of the living environment where the visual complexity of daily tasks may range from low light tasks, such as folding laundry, to tasks that require high levels of light, such as sewing a button on a sleeve. Changes in scale and light occur frequently within a space, therefore Team Capitol dc designed a flexible lighting environment that can meet the occupant's needs and minimize the average energy consumption. HARVEST HOME was designed to integrate the daylighting and electrical lighting systems to maximize efficiency and comfort. The needs of the occupant will range from simple everyday tasks such as cooking breakfast to unique tasks such as entertaining. Lighting becomes both a technical necessity for everyday tasks and an ambient, physiological element for the living environment.

HARVEST HOME takes advantage of Daylight Harvesting, which utilizes the natural daylight within a space to offset the need for electrical light fixtures thereby reducing potential energy consumption. When acceptable levels of daylight are not available, energy efficient light fixtures will be used. Two categories of lighting systems exist within the home; the first system is main overhead lighting that provides general electrical lighting to a space when the daylighting is insufficient. The second system is task lighting, which is a smaller system for tasks that require extra light to supplement the overhead lighting or daylighting. Task lighting concentrates light on a single zone of space, such as undercabinet fixtures that provide additional light to the countertop surface.

Following is a diagram showing the desired light levels and equivalent incandescent bulb power for certain daily tasks.

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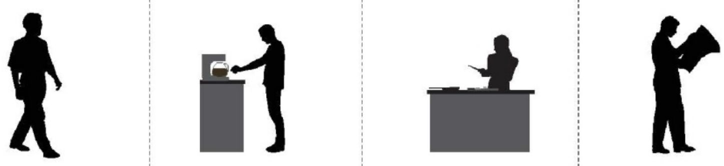
[8] California Energy Commission, "Buildings End-Use Energy Efficiency Lighting Research," <http://www.energy.ca.gov/research/buildings/lighting.html> Building Research, Lighting, last accessed July 2013.

LIGHTING LEVELS

GENERAL USE/ MOVEMENT 3 FC	SIMPLE TASKS 5-10 FC	LARGE SIZE OR HIGH CONSTRACT 30 FC	SMALL SIZE OR VISUALLY COMPLEX 50 FC
40 WATT BULB AT HALF POWER	40 WATT BULB	(4) 40 WATT BULBS	(6) 40 WATT BULBS
WALKING FROM BEDROOM TO BATHROOM	MAKING COFFEE	CHOPPING VEGETABLE	READING THE NEWSPAPER



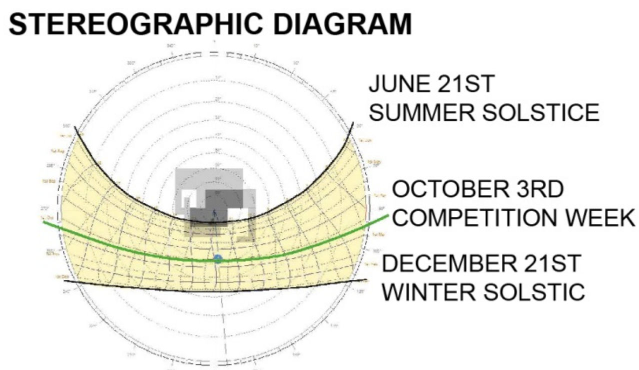
TEAM CAPITOL dc is committed to exceeding California's major energy standards in the design of the home and lighting systems. Title 20, California's Public Utilities and Energy Code, outlines residential and non-residential energy efficiency standards while Title 24, California's Building Energy Efficiency Standards, governs the design and construction of buildings. These standards require the light fixtures of HARVEST HOME to be T24 approved high efficacy lights and luminaires where efficacy considers light output versus electric input. For example, one 40W incandescent bulb outputs the same amount of light as a 9W compact fluorescent bulb and a 7W LED bulb. The LED bulb has a higher efficacy rating because it puts out more light per watt.

Within Title 24, approved high efficacy luminaires, which encompass both the fixture housing and the bulb, must be connected to their own switch in the kitchen, bathroom, closet and laundry rooms. Low efficacy luminaires may also be partnered with vacancy sensors and dimmer switches. Dimmer switches allow the light level to be gradually adjusted from high to low levels of light output varying the level of energy consumption and if luminaires are connected to a vacancy sensor, it must be able to bypass the dimming function to completely disconnect electricity to the fixture.

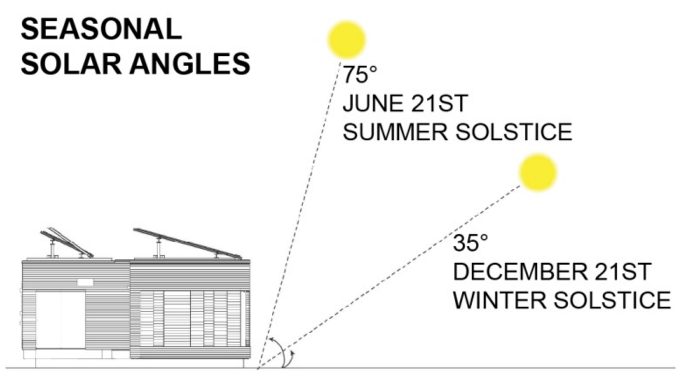
4.3 – DAYLIGHTING ANALYSIS

The use of natural daylight is the most energy efficient option to light a space. Daylight offsets the use of electrical light fixtures and has a more consistent quality and color of light than can be achieved by most lighting options. Team Capitol dc assessed the availability and quality of natural light for the competition location in Irvine, CA. Irvine lies on the 33rd parallel in the Northern Hemisphere meaning the home will be situated 33 degrees north of the equator for the competition, which will also define the seasonal height of the sun. The sun is higher in the sky during summer months and lower during winter months, which would allow direct solar rays to enter through the glass. Although the angle of solar rays will vary seasonally, the quality of light will remain consistent throughout the year.

Team Capitol dc used the software DIVA for Rhino to predict the foot-candles of light that will enter the home. Analyses were run considering both specific points in time, for detailed information, and average foot-candle levels for the year, for general information. Foot-candle levels are analyzed from a grid on the finish floor of the home where light has to travel the furthest and levels will be at the lowest point in the recorded range. Therefore, all surfaces closer to the light fixture will receive higher foot-candle levels.



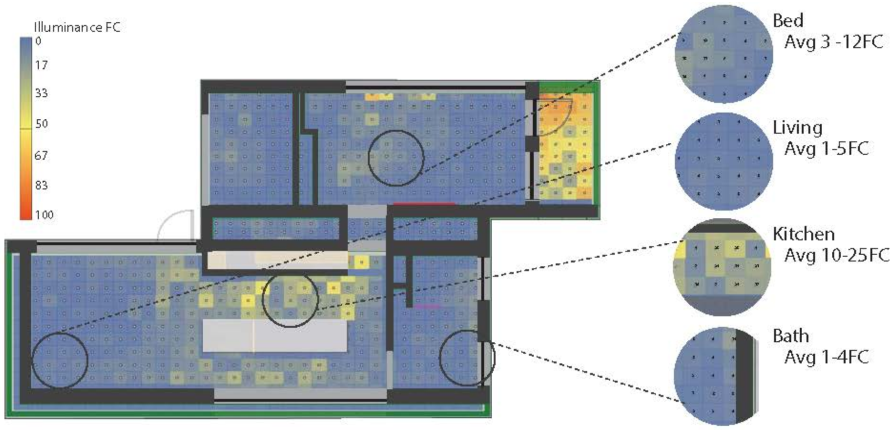
Annual Solar Variation Stereographic Data Diagram



Seasonal Solar Angles Along the 33rd Parallel

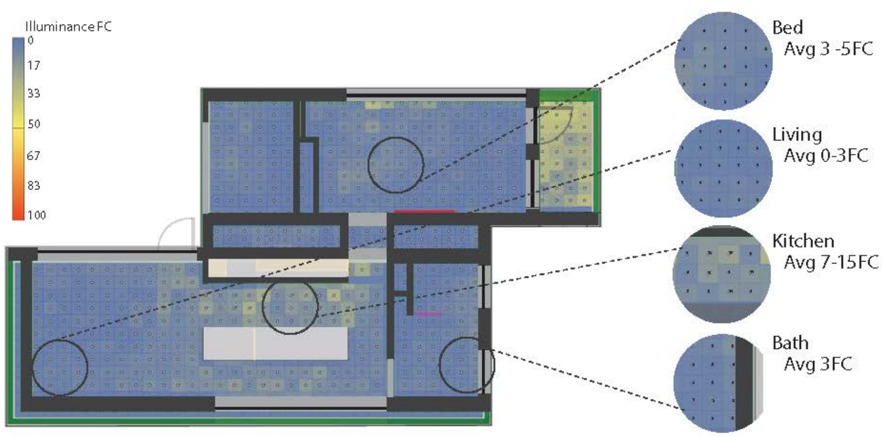
DAYLIGHT AUTONOMY ANALYSIS – Daylight Autonomy measures the percentage of time throughout the year when a target illuminance level, or light intensity, can be maintained by daylight alone where analysis can define an early understanding of light levels that enter a space. HARVEST HOME is required to maintain multiple target illuminance levels within a single space due to the variety of tasks that could be accomplished. Team Capitol dc studied average illuminance levels to determine the frequency of simple and/or complicated tasks that could be accomplished without the aid of electrical lighting. After the initial run of analyses, further in-depth research was completed for point-in-time, potential shading and glare analyses.

Generally, daylight autonomy grid analyses analyze light infiltration between 8am and 6pm. When applied to the floor of HARVEST HOME, levels were consistently maintained above 3 foot-candles in all spaces General tasks can be completed within all rooms at this level with no required supplementary electrical lighting. The kitchen requires more detailed tasks than other rooms, fortunately it received the highest levels of light allowing visually complicated tasks to be completed without supplementary electrical task lighting.



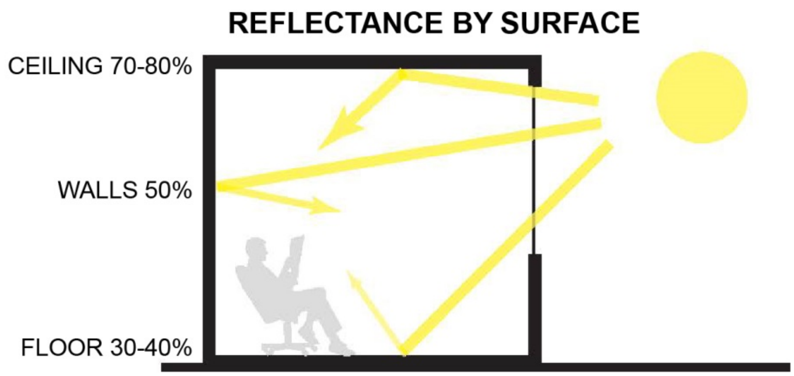
Daylight Autonomy Grid Analysis For An 8am To 6pm Occupancy

Since HARVEST HOME is a residence and will operate at all times of the day, a daylight autonomy grid analysis was completed for a full 24-hour time span. Most spaces maintained above the level of 3 foot-candles, however, dark spots in the bathroom and living room received between 0-1 foot-candles. During an average sunny day in Irvine, CA, only a small amount of electrical lighting will be needed.



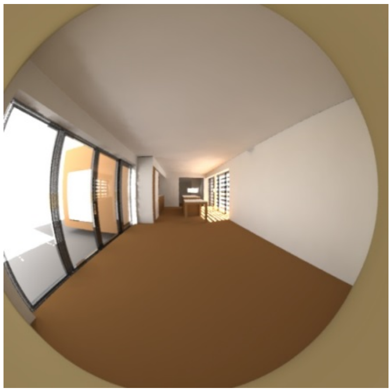
Daylight Autonomy Grid Analysis For An 8am To 6pm Occupancy

MATERIALITY AND REFLECTANCES – The orientation and quality of surfaces will affect the amount of light available within a space. Dark hued surfaces absorb rays and transmit less light into the space while light hues and glossy surfaces reflect rays and transmit greater amounts of light into a space. The strategic incorporation of surface hues and gloss factors to prevent issues with glare or discomfort. Light reflection will vary by material depending upon the orientation and placement of a surface within a space.



Surface Reflectance Percentages

Surface reflectance and color have direct and measurable effects on the amount of light that travels through a space. Below is an analysis of the HARVEST HOME living module containing a high reflectance white ceiling, white walls and wood floor. It is compared to an analysis will a low reflectance white ceiling, purple walls and woof floor. The higher reflectance analysis illustrates a higher average foot-candle level across the space, therefore the majority of selected finishes for HARVEST HOME are high reflectance.



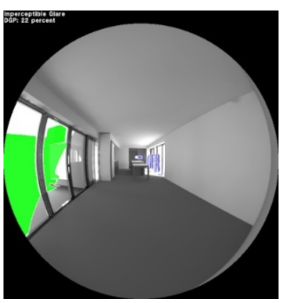
Living Module with High Reflectance Surfaces

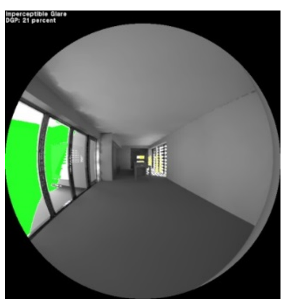
Living Module with Low Reflectance Surfaces

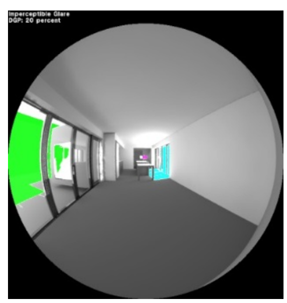
COMFORT AND GLARE – The combination of high reflectance surfaces with high illuminance could result in direct or reflected glare, which is a reduction in visibility caused by bright light levels. Direct glare is produced at the light source while reflected glare appears on the task surface. Each type is measured as a percentage daylight glare probability where glare below 40% is acceptable and above 40% is unacceptable. High measures of glare must be corrected. The southern glazing of the HARVEST HOME has been identified as a potential glare issues, therefore the area was analyzed from two points within the home to determine the actual glare impact.

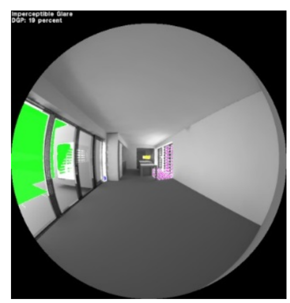
DAYLIGHT GLARE PROBABILITY	**%**
Imperceptible	<35%
Perceptible but not debilitating	35 – 40%
Disturbing	40 – 45%
Intolerable	>45%

The first glare analysis was a view looking from the living room toward the kitchen to determine if shading the southern glazing would have an effect on glare. From this location, the glare is imperceptible and shading does not appear to be necessary to prevent glare. The north living room glazing presents very little glare and will tend to be a darker space, which is ideal for tasks that include screens, such as the use of a computer or television. The following images provide a visual detail of glare within the HARVEST HOME at 11am and 2pm as well as with and without shading.

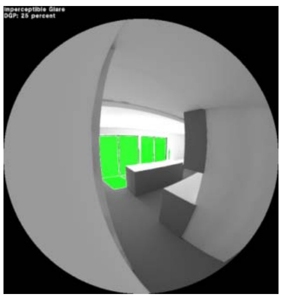

No Shade – 11am
22% Glare

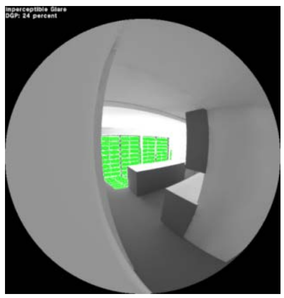

Shade With 60% Light – 11am
21% Glare

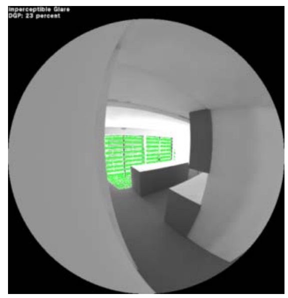

No Shade – 2pm
20% Glare

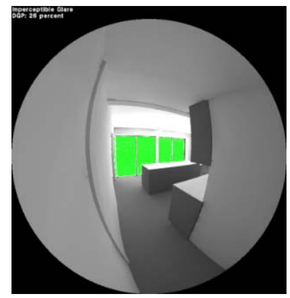

Shade With 60% Light – 2pm
19% Glare

The second glare analysis was a view looking from the door of the bedroom into the kitchen, which has the potential to produce glare with direct sight of the windows. Between 11am and 2pm the highest occurrence of glare occurred however the glare was registered as imperceptible in all cases. Although shading is not required to prevent glare, an analysis was produced to insure the shade itself did not cause glare. A shading system will be used for the southern glazing to prevent thermal gains as was discussed in the Insolation Analysis. The following images provide visual details of glare within the HARVEST HOME.


No Shade – 11am
25% Glare


Shade W/ 40% Light – 11am
24% Glare

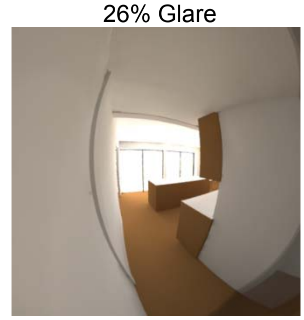

Shade W/ 20% Light – 11am
23% Glare

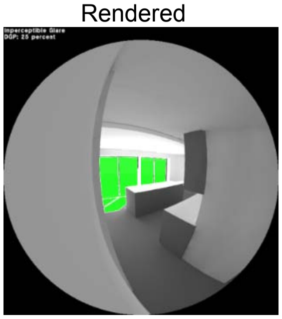

Shade W/ 3" Depth – 11am
26% Glare

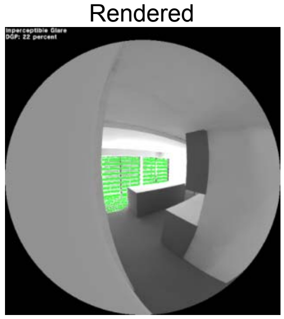

No Shade – 11am
Rendered

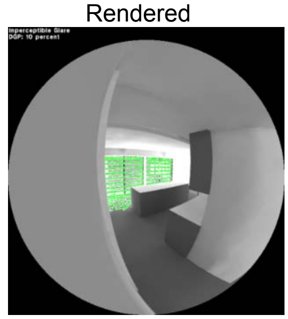

Shade W/ 60% Light – 11am
Rendered

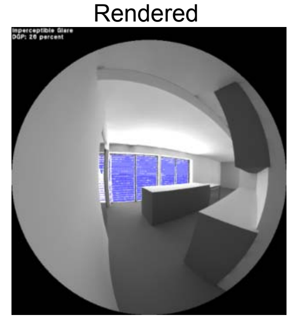

Shade W/ 40% Light – 11am
Rendered


Shade W/ 3" Depth – 11am
Rendered


No Shade – 2pm
25% Glare

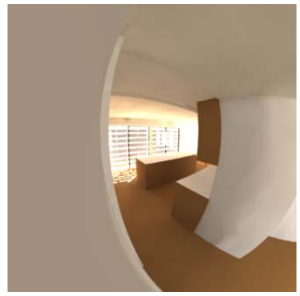

Shade W/ 40% Light – 2pm
22% Glare


Shade W/ 20% Light – 2pm
10% Glare

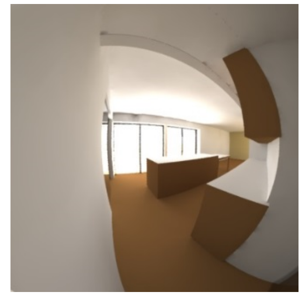

Shade W/ 3" Depth – 2pm
26% Glare

No Shade – 2pm
Rendered

Shade W/ 40% Light – 2pm
Rendered



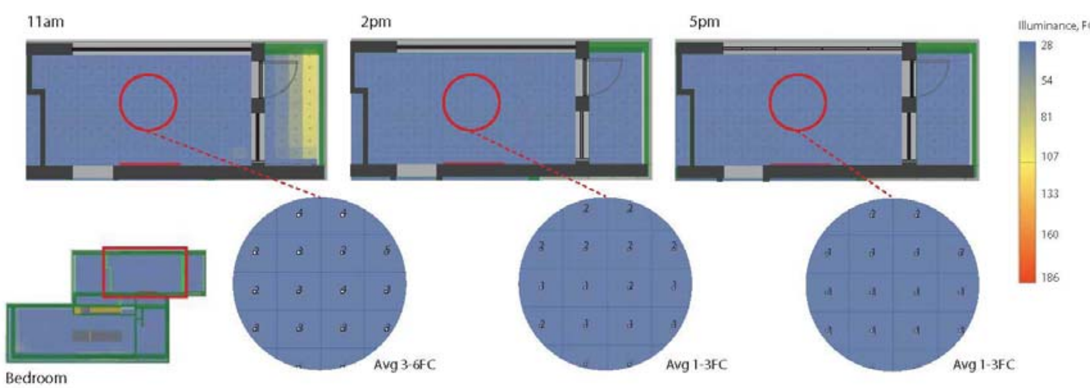
Shade W/ 20% Light – 2pm
Rendered



Shade W/ 3" Depth – 11am
Rendered

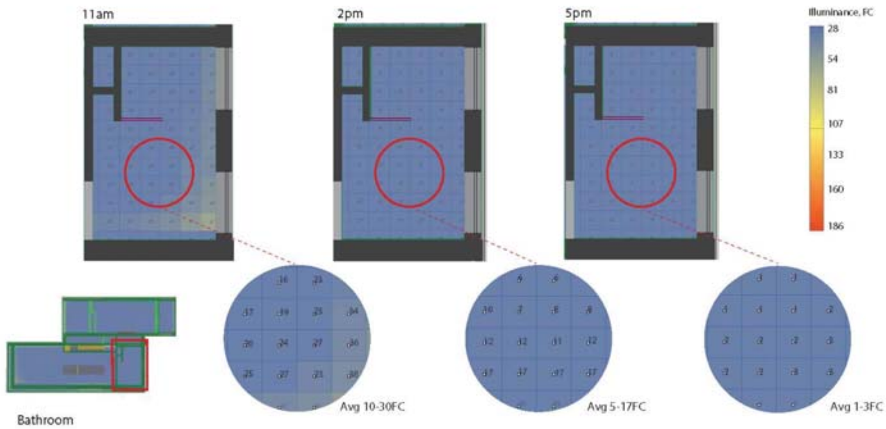
POINT IN TIME ANALYSIS – A point-in-time analysis examines a space at a particular moment and Team Capitol dc used this form of analysis to examine the separate rooms of the home for October 3rd at 11am, 2pm and 5pm to predict daylighting behavior during the competition. For the point-in-time analyses, the software program DIVA was used to allow the user to bounce a light ray between interior surface and the higher number of bounces results in a more accurate reading of the space. The average number of bounces is two, however, these analyses were run using 5 bounces for a higher level of accuracy. The overall level of foot-candles will identify how much light is entering a space and whether supplementary electrical lights are necessary. The consistency of foot-candle numbers can foretell dark spots, glare or potential heat gain within a room.

The Bedroom contains east and north facing glazing where the eastern windows will allow direct morning light. There is the potential for a dark spot in the center of the room at certain times of the day. From sunrise until 11am, the spaces average 5 foot-candles allowing simple tasks to be completed, however after 2pm the foot-candle levels will fall and may require supplementary lighting with the space. By 5pm, electrical lighting will be necessary.



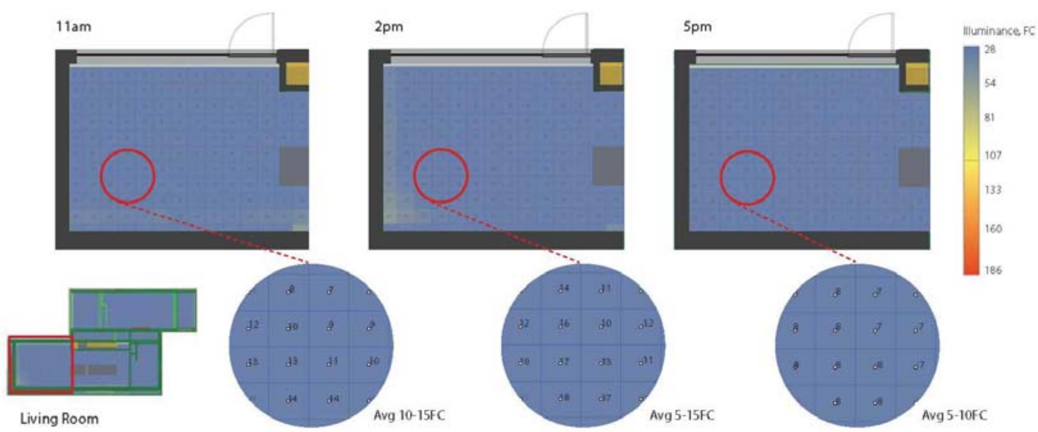
Bedroom Foot-Candle Levels At 11am, 2pm, And 5pm Via DIVA Point In Time Analysis For Irvine, CA On October 3rd

The Bathroom windows face east allowing direct light only during the morning hours, which provides enough daylighting to not require supplementary electrical lighting. By 2pm, the foot-candles will be lower but not require electrical lights in most cases, however, by 5pm, electrical lighting will be necessary.



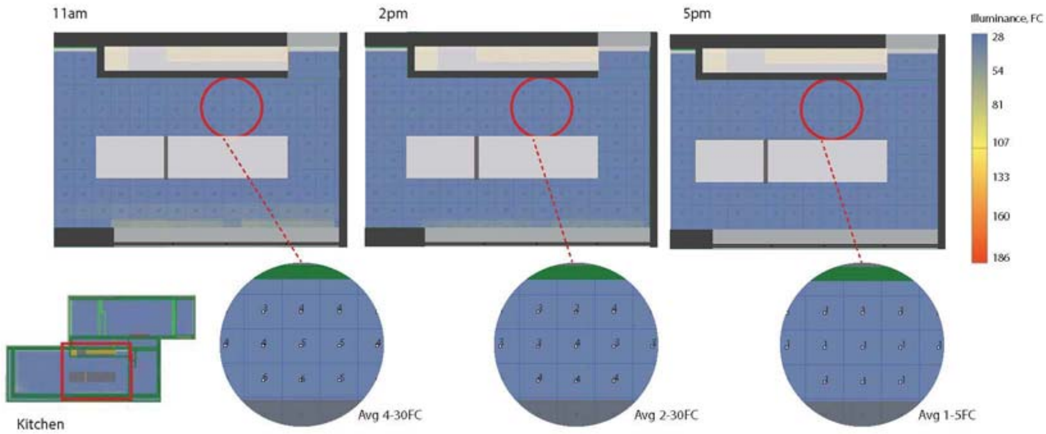
Bathroom Foot-Candle Levels At 11am, 2pm, And 5pm Via DIVA Point In Time Analysis For Irvine, CA On October 3rd

The Living Room contains north facing glazing providing an indirect, soft light, which is preferable for screen-based tasks, as discussed in the Glare analysis. However, the light levels in this space are lower and there is potential dark spot in the southwest corner of the room. The Living Room gains reflected direct light from the southern glazing within the Kitchen space where morning and afternoon daylighting do not require supplemental electrical lighting. Through 5pm, the space maintains above 5 foot-candles and unless the task is visually complicated, electrical lighting will not be needed until sunset.



Living Room Foot-Candle Levels At 11am, 2pm, And 5pm Via DIVA Point In Time Analysis For Irvine, CA On October 3rd

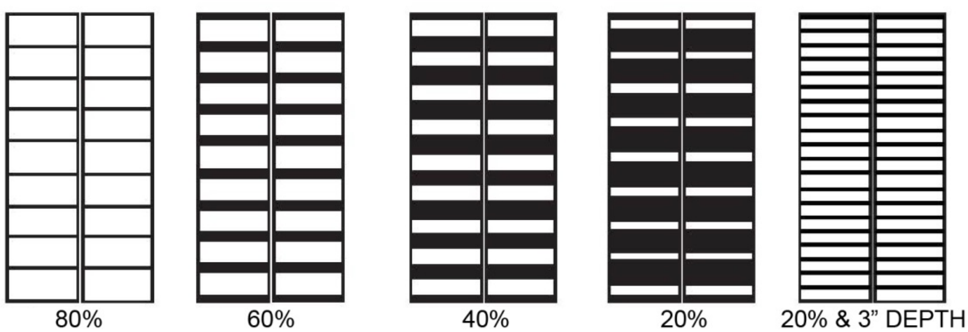
The Kitchen is the only room with south facing windows, therefore it is the only space to receive constant access to direct light. No shading was considered within this analysis so maximum light levels were allowed into the space. Morning light ranges from a maximum 30 foot-candles near the windows to a minimum of 4 foot-candles behind the center island casework. Task light may be necessary if the task is visually complicated, therefore undercabinet lights have been provided. Light levels drop to an inconsistent 2-5 foot-candles behind the island and 30 foot-candles at the window throughout 2pm. By 5pm light levels have dropped to 3-5 foot-candles at the window and 1 foot-candle behind the island therefore requiring electric light usage. The island countertop varies between 5-25 foot-candles while the north countertop ranges between 3-10 foot-candles.



Kitchen Foot-Candle Levels At 11am, 2pm, And 5pm Via A DIVA Point In Time Analysis For Irvine, CA On October 3rd

SHADING & DAYLIGHTING – Based upon previous insolation analyses, shading would be required along the southern glazing to prevent added heat gain. Two-dimension shade screens were tested with a variety of light infiltration percentages where the ideal shading option would block solar rays while also maintaining views to the exterior and adequate daylighting. A three-dimensional option was created with 3" deep louvers with an 8" vertical spacing to allow 20% light infiltration allows views and creates indirect lighting. While glare is not reduced, thermal gain is reduced allowing natural daylight penetration. Overall, any shade system that does not allow at lead 30-40% of light into a space between sunrise and 5pm will cause light levels behind the kitchen island to drop below 5 foot-candles thereby requiring the use of electrical lighting for all tasks.

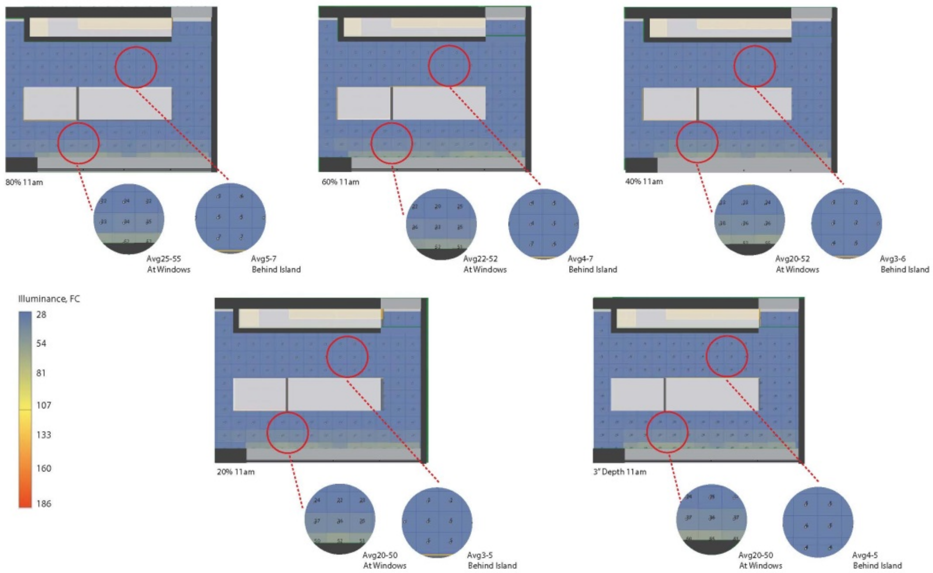
SHADE SCREEN OPTIONS WITH LIGHT INFILTRATION PERCENTAGES



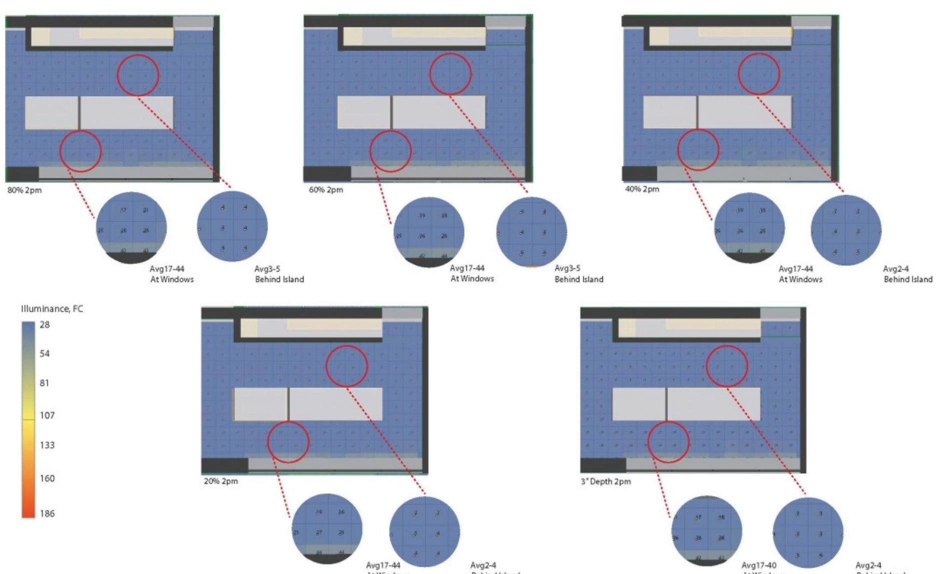
Each design describes the amount of available light allowed through the shade system.

The shade screens are designed to slide along a track to cover the exterior surface of the southern glazing. When insolation and heat gain are not an issue, the shade screens should be removed and slid into the wall pocket on the south façade.

Within the Kitchen, a shade system allowing 40-60% light infiltration is preferred at 11am. The space will maintain consistent 4-7 foot-candles behind the island and 25-35 foot-candles near the southern window. At 20% light infiltration, the space sporadically dropped to 3 foot-candles or below.



Around 2pm, the preferred 40-60% light infiltration shade produces light levels similar to the previous study. Behind the island held 3-5 foot-candles and 20-30 foot-candles near the southern window. Shade systems with less than 40% light infiltration lower light levels behind the island to 0-4 foot-candles. Systems with more than 60% light infiltration bring light levels above 30 foot-candles, which is similar to levels if no shade screen was used.



4.4 – ELECTRICAL LIGHTING INTEGRATION

HARVEST HOME was designed with flexible lighting that can be adjusted to fit a number of technical and psychological needs. LED lights were chosen for high efficacy ratings and the ability to render colors similar to natural daylight. The fixtures do not require humming ballasts, do not create excess heat and require very infrequent bulb replacement.

The overhead LED lights are supplied with a range of 0V to 10V allowing the bulbs to dim thereby reducing energy consumption and creates a spatial ambiance. Daylight harvesting will record the amount of daylight-supplied foot-candles within a room. Once the foot-candle measurements fall below the minimum required light level, the electrical light fixtures will turn on and dim to satisfy the minimum foot-candles. Daylight harvesting will reduce overall energy consumption while maintaining appropriate light levels.

The following table lists the types of light fixtures that were selected for the HARVEST HOME included bulb types, wattages and quantities. Out of the 45 total lighting fixtures inside and outside of the home, 40 contain LED bulbs and 5 are either compact or linear fluorescent bulbs. LED light fixtures supply approximately 89% of all lighting in the home.

HARVEST HOME LIGHT FIXTURES										
Light Fixture Type	Bulb Type	Wattage Per Fixture (W)	Quantity Per Room						Total Quantity	
			Living	Kitchen/ Hall	Bath-Room	Mech-anical Room	Laundry	Bed-Room	Interior	Exterior
4” Recessed Can	LED	11	4	7	2	0	1	6	**20**	**0**
4” Recessed Can Wet Location	LED	11	0	0	1	0	0	0	**1**	**2**
2½” Recessed Can	LED	5	0	0	0	0	0	2	**2**	**0**
22” Undercabinet	LED	10	0	2	0	0	0	0	**2**	**0**
9” Undercabinet	LED	3.8	0	1	0	0	0	0	**1**	**0**
Pendant	LED	6	0	3	0	0	0	0	**3**	**0**
Interior Wall Sconce	Fluorescent	24	0	0	2	0	0	0	**2**	**0**
Exterior Wall Sconce	Fluorescent	24	0	0	0	0	0	0	**0**	**1**
Interior Linear	Fluorescent	25	0	0	0	2	0	0	**2**	**0**
Exterior Linear	Led	16.38	0	0	0	0	0	0	**0**	**9**
		Total	**4**	**13**	**5**	**2**	**1**	**8**	**33**	**12**

In order to determine total rates of energy consumption for the competition and the full year, daily lighting schedules were created for each room of the home to determine the number of hours in the day that would require electrical lighting based upon the available daylighting.

COMPETITION LIGHTING SCHEDULE - Days 11 through 18 of the competition were included within the Competition Lighting Schedule. The home will be powered and competition tasks be completed on these particular days. Following are lighting schedule assumptions:

- Day 11 will require initial testing of lights to insure correct operation.
- Throughout Days 11-18, lights will be powered as they associate to required competitions and tasks.
- Days 11, 13, 15, 17 and 18 require all lights, including exterior fixtures, to be powered to full brightness for 3.5 hours on Public Tour days and 4 hours on non-Public Tour days.
- Public Tours take place on Days 11, 12, 13, 14 and 18. Lighting in the Bedroom will be required after 2pm while lighting within the main living module will remain off until 5pm.
- Lights for the Mechanical Room and Laundry Room are assumed to remain off at all times except for testing, lighting contests and Jury Walkthroughs.
- The exterior lights will be powered from 6pm to 11pm each competition day.

TOTAL LIGHTING HOURS IN EACH ROOM FOR EACH COMPETITION DAY

Day #	# Hours						
	Living	Kitchen/ Hall	Bathroom	Mechanical Room	Laundry	Bedroom	Exterior
Day 11	6.5	6.5	6.5	4.5	4.5	9.5	5
Day 12	3	3	2	0	0	5	5
Day 13	5.5	5.5	5.5	3.5	3.5	8.5	5
Day 14	5.5	5.5	5.5	3.5	3.5	8.5	5
Day 15	7	7	7	7	9	7	5
Day 16	7	8.5	7	7	7	7	5
Day 17	7	8.5	7	7	9	7	5
Day 18	5.5	5.5	5.5	3.5	3.5	8.5	5

One or all electrical light fixtures will be powered for an AVERAGE OF 8 HOURS A DAY.

One or all electrical light fixtures will be powered for a TOTAL OF 65 HOURS FOR THE COMPETITION.

TOTAL kWh OF LIGHTING FOR THE COMPETITION = 23.2 kWh

Daily competition kWh totals are available in the Total Competition Energy Consumption Section

YEAR ROUND LIGHTING SCHEDULE – After the home has been assembled in its final location in San Diego, CA, occupancy and light harvesting sensors will control the lighting to maximize natural daylighting and minimize energy consumption from electrical lighting fixtures. Following are lighting schedule assumptions:

- Sunrise and sunset times were acknowledged for the 15th day of each month where more hours of lighting will be required during winter months due to less hours of available daylight.
- The Living Room and Kitchen/Hall lights are assumed to be powered at the same time. The occupant is assumed to be within this area from afternoon until 10pm. All exterior light fixtures are assumed to follow the same schedule.
- Hours of light usage for the Bathroom, Mechanical Room and Laundry Room are assumed to remain fairly constant throughout the year.
- The Bedroom lights are assumed to be powered starting at 6am, when the occupant wakes, and the sun has not yet risen. The occupant is assumed to spend a few afternoon and even hours within the bedroom.

AVERAGE DAILY NUMBER OF LIGHTING HOURS IN EACH ROOM FOR EACH MONTH

Month	**Number of Hours Consumed**							
	Living	**Kitchen/ Hall**	**Bathroom**	**Mechanical Room**	**Laundry**	**Bedroom Closet**	**Bedroom**	**Exterior**
January *Sunrise:* 6:51 AM *Sunset:* 5:05 PM	6.25	6.25	3	0.1	1	2	6	6.25
February *Sunrise:* 6:32 AM *Sunset:* 5:34 PM	5.75	5.75	3	0.1	1	2	5	5.75
March *Sunrise: 6:59 AM Sunset: 6:57 PM*	4.25	4.25	3	0.1	1	2	3.5	4.25
April *Sunrise:* 6:19 AM *Sunset:* 7:19 PM	4	4	3	0.1	1	2	3.25	4
May *Sunrise:* 5:50 AM *Sunset:* 7:41 PM	3.5	3.5	3	0.1	1	2	2.75	3.5
June *Sunrise:* 5:40 AM *Sunset:* 7:58 PM	3.25	3.25	3	0.1	1	2	2.5	3.25
July *Sunrise:* 5:52 AM *Sunset:* 7:57 PM	3.25	3.25	3	0.1	1	2	2.5	3.25
August *Sunrise:* 6:12 AM *Sunset:* 7:33 PM	3.75	3.75	3	0.1	1	2	3	3.75
September *Sunrise:* 6:32 AM *Sunset:* 6:55 PM	4.25	4.25	3	0.1	1	2	3	4.5
October *Sunrise:* 6:53 AM *Sunset:* 6:15 PM	5	5	3	0.1	1	2	4	5
November *Sunrise:* 6:19 AM *Sunset:* 4:47 PM	6.5	6.5	3	0.1	1	2	6	6.5
December *Sunrise:* 6:43 AM *Sunset:* 4:44 PM	6.5	6.5	3	0.1	1	2	6.5	6.5

TOTAL ESTIMATED kWh OF LIGHTING FOR A FULL YEAR = 737.6Wh

4.5 - APPLIANCES/ELECTRONICS

Major appliances and electronics within the home are ENERGY STAR rated, meaning that they consume at least 20% less energy than similar models. ENERGY STAR provides the typical annual energy consumption for an average household consumption for each qualifying model. For example, according to the ENERGY STAR report of the home's dishwasher, it consumes 266 kWh per year assuming that it runs four loads per week. By dividing 266 kWh by (4 loads per week x 52 weeks per year), it can be calculated that the dishwasher roughly consumes 1.28 kWh per load. The same procedure was used to calculate the energy consumption of each ENERGY STAR appliance and electronics within HARVEST HOME. For non-qualifying appliances, the value of the peak power consumption, kW, was identified. The energy consumption of all appliances and electronics per task or per hour are shown in the table below.

ENERGY CONSUMPTION OF APPLIANCES & ELECTRONICS

Appliance	Energy Consumption or Power Requirement	Energy Consumption (kWh)		ENERGY STAR Rated?
		Per Task	Per Hour	
Dishwasher	266kWh Annual Consumption, 4 Loads/Week	1.28	--	X
Refrigerator & Freezer	440kWh Annual Consumption	--	0.05	X
Cooktop	2.5 kW 10" Burner (Right Front) @240V	--	2.50	
Vent hood	0.52 kW @ 120V	--	0.52	
Oven	2.5 kW @ 240V	--	2.50	
Clothes Washer	96kWh, 8 Loads/Week	0.23	--	X
Clothes Dryer	5.4kw Connected Load @ 240V	--	5.40	
Computer	25W Average Power	--	0.025	X
TV (large) – living room	93 kWh, 5 Hours/Day	--	0.05	X
TV (small) – bedroom	68.2 kWh, 5 Hours/Day	--	0.04	X
Speakers	50W Peak Power Handling Per Pair @120V	--	0.05	
Water pump – Harvest Table	100w @120v	--	0.10	

COMPETITION APPLIANCES & ELECTRONICS SCHEDULE – The daily energy consumption of all appliances and electronics during Days 11-19 of the competition was calculated by multiplying the energy consumption per task or hour by the number of tasks or hours required per day. Following are assumptions for the Appliances & Electronics Schedule:

- The home's clothesline is integrated into the landscaping and will be used as the primary method for drying clothes. Accordingly, the clothes dryer is only expected to run for a maximum of 30 minutes per laundry load.
- For each cooking task, the cooktop and vent hood will each be powered for one hour.
- For each dinner party on Days 11 and 13, the cooktop, vent hood, and oven will be powered for one hour and the speakers will be powered for two hours.
- For the movie night on Day 12, the large TV will be powered for three hours.
- For each home electronics task, the large TV and computer will be powered for the required number of hours.
- For all Public Exhibit Tour days excluding Day 19 (Day 11, Day 12, Day 13, Day 14, and Day 18), a small pump will run for 8 hours to circulate water to and from the Harvest Table.
- To account for possible fluctuations in electrical loads or appliances that are plugged in but not in use, the sum of the loads from the clothes washer, clothes dryer, refrigerator, cooktop, vent hood, oven, dishwasher, television, computer, and speakers was multiplied by ten percent, or 0.10, and recorded within the "Miscellaneous" category.

ANNUAL APPLIANCES & ELECTRONICS SCHEDULE – The annual consumption of all appliances and electronics was calculated by multiplying the energy consumption per task or hour by the expected number of tasks or hours that they will run for an entire year. Following are assumptions for the Appliances & Electronics Schedule:

- The washer was assumed to run for 4 loads per week and the dryer was also assumed to run for 30 minutes per load.
- The refrigerator was assumed to run for 24 hours every day of the year.
- The oven, vent hood, and cooktop were all assumed to run for 3 hours each week.
- The dishwasher was assumed to run 4 loads per week.
- The large TV, small TV, and computer were each assumed to be on for 5 hours per day.
- The speakers and landscaping pump were each assumed to be on for 1 hour per day.
- To account for fluctuations in electrical loads as well as additional appliances/equipment within the home in its final location (such as a microwave, toaster, or other electronics), the sum of the loads from the clothes washer, clothes dryer, refrigerator, cooktop, vent hood, oven, dishwasher, TVs, computer, and speakers was multiplied by twenty percent, or 0.20. This number was placed in the "Miscellaneous" category.

The energy consumption of all appliances and electronics during the competition and a full year is shown in the following table. The "Clothes Dryer" consumes the greatest amount of energy for both the competition and annual schedules. Miscellaneous loads are expected to be proportionally larger annually with the incorporation of additional equipment within the home after the competition, including a microwave, toaster oven, etc. In both cases, the energy consumption from equipment such as the computer, landscaping pump and speakers is very small in comparison to the energy consumption of larger kitchen appliances.

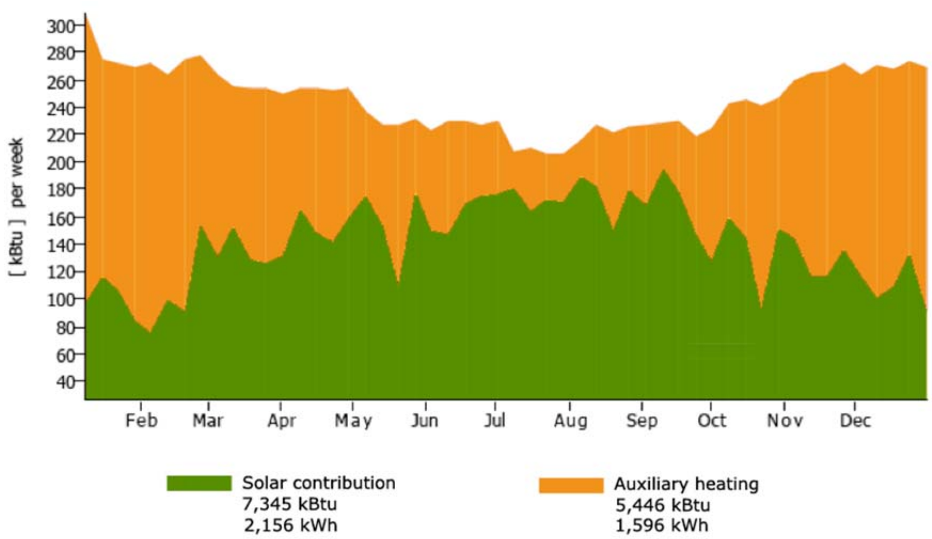
TOTAL CONSUMPTION OF ELECTRONICS		
Item	**Competition Consumption**	**Annual Consumption**
Clothes Dryer	24.3	561.6
Miscellaneous	11.2	480.4
Refrigerator & Freezer	9.8	440.0
Cooktop	20.0	390.0
Oven	5.0	390.0
Dishwasher	6.4	266.0
Large TV	1.9	93.0
Vent Hood	4.2	81.1
Small TV	0.0	68.2
Clothes Washer	2.1	48.0
Computer	0.9	45.6
Landscaping	4.0	36.5
Speakers	0.4	18.3
TOTAL CONSUMPTION OF ELECTRONICS (kWh)	**90.1**	**2918.7**

4.6 - WATER HEATING

In designing the HARVEST HOME, there were several options for the home's hot water system. For example, the standard electric water heater which was the least energy efficient option since a great amount of electricity is required to maintain a large volume of water at the desired 120°F temperature. Secondly, an on-demand or tankless water heater consume less energy than a standard electric water heater because electricity is only consumed when hot water is required. Team Capitol dc selected a solar thermal system that would harvest the sun's energy, which also complements the theme of HARVEST HOME.

The selected solar thermal system is comprised of a flat-plate solar collector and an 80-gallon tank which consumes up to 60% less energy than an equivalent gas or electric water heater and saves 2,792 kWh, or over $300 in California, per year. A flat plate collector was selected over an evacuated tube collector for this system because it is more rugged, requires less annual maintenance and is better suited for California's sunny and mild climate, where freezing and snowfall are not of concern. An 80-gallon tank was recommended due to its large storage capacity and efficiency when paired with the chosen flat plate collector.

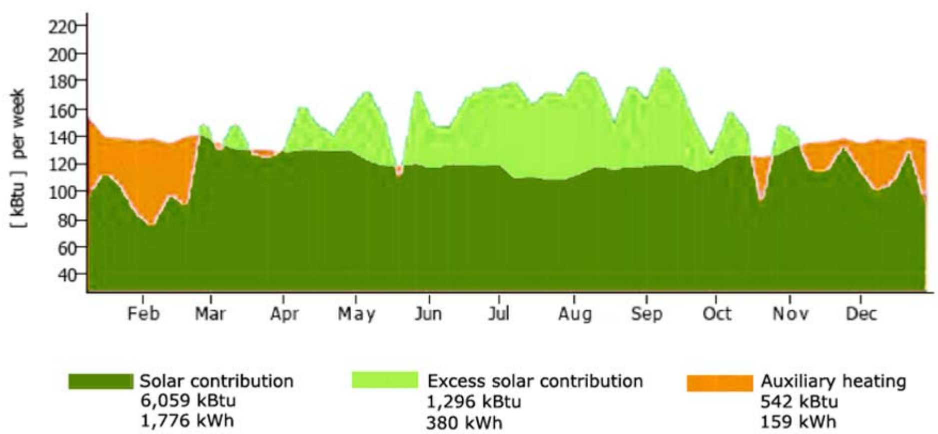
The following graph provided by SunMaxx Solar, illustrates the weekly energy consumption of the solar thermal system assuming the average daily consumption is 65 gallons. The green area represents the amount of energy contributed by the sun and the orange area represents the amount of additional auxiliary electricity required to maintain the hot water tank at 120ºF. The sum of the green and orange areas represents the combined amount of solar and electric energy required to heat the tank.



Weekly Energy Consumption of Solar Thermal System for a 65 Gallon Tank

At the beginning of October during the competition in Irvine, CA, the solar contribution is expected to be 130 kBtu per week, or 18.57 kBtu per day, and the total amount of electricity required for auxiliary heating, is equal to 90 kBtu per week, or 12.86 kBtu per day. Since one kBtu is equal to 0.293 kWh, this means that 3.77 kWh of electricity will be required per day for the hot water contests. This is a conservative estimate since 65 gallons of water will not be removed each day from the tank during the competition or during the year. However, it is a conservative estimate for analysis to account for the possibility of low levels of sunlight during the competition week.

Once HARVEST HOME has been assembled in its final location is will house 1 or 2 resident. The currently specified hot water tank has the capacity to provide 65 gallons of hot water per day, the home's future household will most likely not require this much hot water. The future household consumption of hot water can be estimated at 32.5 gallons which is have the 65 gallon tank capacity. Less auxiliary heating will be required when compared to the competition timeframe since less hot water will be consumed. The following graph illustrates the estimated energy produced by the solar thermal system for a daily hot water load of 32.5 gallons. The orange areas represent the amount of auxiliary heating that is required by the system. The dark green area represents the amount of solar energy that is provided for the tank to deliver 32.5 gallons of water at 120ºF. The light green area represents excess solar production, or additional energy that will be harvested from the flat plate collector, that will help keep the tank's temperature above 120ºF.



Weekly Energy Consumption of Solar Thermal System for 32.5 Gallon Daily Usage

No auxiliary heating is required between the months of April and September. Additionally, the small orange areas denoting auxiliary heating during the months of March, April, May, and June are considered negligible. Auxiliary heating is only required by the system for the months of October, November, December, January, and February. The amount of auxiliary heating, or electrical energy, required for these months is shown in the table below.

ESTIMATED MONTHLY HOT WATER ENERGY CONSUMPTION						
January	February	March	April - September	October	November	December
50.9	44.6	3.2	0	6.3	22.3	31.8

TOTAL ANNUAL ENERGY CONSUMPTION = 159kWh

5.0 – SPACE HEATING, COOLING & VENTILATION

5.1 – EVOLUTION OF HARVEST HOME'S HVAC SYSTEM

HARVEST HOMES heating, ventilation and air conditioning (HVAC) system intends to provide a comfortable indoor living environment. Originally, the home's HVAC system was designed to combine various components to minimize its energy consumption including radiant ceiling panels, an energy recovery ventilator, and a water-to-water heat pump coupled with chilled and hot water tanks. A large thermal storage tank connected to the chilled water tank would serve as a heat rejection reservoir when the system is in cooling mode, much like the ground in a geothermal heat pump system. The hot water tank would connect to a solar collector in a closed-loop solar thermal system. This design focused on minimizing the heat transfer between all components in order to optimize system efficiency.

The original system had several advantages, such as novelty and the potential energy savings in climates with very hot summers and very cold winters. However, the system also had various disadvantages including high equipment cost, estimated to exceed $20,000, a large footprint required for the mechanical closet and high quantity of water required for all tanks. In addition, it would be very difficult to combine all components into a single cohesive system thereby leading to potential control as well as maintenance issues.

Components such as the energy recovery ventilator and radiant ceiling panels were calculated to provide only a very small reduction of loads for California's climate. The complexity of the original HVAC system design was very difficult to model on energy modeling software such as Trane TRACE. Therefore, the software would not accurately estimate the energy consumption of the system during the competition or throughout a typical year of operation. Therefore, Team Capitol dc assessed whether the benefits of the original HVAC system design would outweigh the disadvantages.

When the competition site was moved from Washington, DC, to Irvine, California, the original system was tested for performance in California's climate. It was calculated that while the design would be energy and cost effective in a climate with very warm summers and cold winters, it would not be the case in a mild climate, such as Irvine, CA. The original system included over 9 pumps that were estimated to consume a great amount of energy in comparison to the rest of the system. HARVEST HOME is expected to experience small heating and cooling loads throughout a year in California therefore, it was determined that an air-to-air heat pump system would be more energy efficient than the original system.

Team Capitol dc ultimately designed an HVAC system to perform specifically for California's climate. This system includes a high-SEER air-to-air heat pump, central air handler located in the mechanical closet and ducted under-floor air distribution. The final system costs a fraction of the original system and is expected to consume less energy in California than the original system design. In addition, the simplicity offers significant control advantages and minimal required annual maintenance and repair. Lastly, it was easier to model the final system within energy modeling software such as Trane TRACE and therefore gain a more accurate estimate of anticipated energy consumption during the competition and a full year.

5.2 – MECHANICAL LOAD MODEL

Trane TRACE™ 700 software was used to create load and energy models for the HARVEST HOME. The load model determined the expected heating and cooling loads during the competition as well as the size of the HVAC system. It was also used to quantify improvements to the home's thermal envelope, as illustrated in the Glazing and Shading Analysis sections. A single load model was created for each day of the competition to calculate peak loads that fed into the energy model to estimated the home's HVAC energy consumption

WEATHER - A majority of the mechanical load model studies were conducted for the month of October to gain an accurate analysis of heating and cooling loads of the home during the competition. During the competition timeframe, dry bulb temperatures are expected to approach a high of 75°F and a low of 55°F indicating that cooling will be required during the day while heating will be required at night. As a result, the strategy for the design of the home's thermal envelope was to minimize cooling loads during the day and heating loads at night. In addition, an HVAC system was ultimately selected to not only be efficient but to also have the ability to quickly and easily switch from cooling to heating modes.

ZONES - Once the weather data was selected for the load model, the home was separated into four separate zone to analyze the cooling and heating loads for each separate zone. The four zones are the living room, kitchen, bathroom, and bedroom.

WINDOWS, FLOOR, ROOF - Envelope cooling and heating loads for the home relate to the amount of heat lost or gained through the windows, walls, ceiling/roof, and floor, Refer to Building Envelope Analysis Chapter. On TRACE, the dimensions and R-values of the building's walls, floors, and ceiling were inputted as well as the location, dimensions, U-values, and shading coefficients of all windows and external glass doors.

Realistic yet conservative infiltration values were incorporated for each zone to estimate the expected amount of infiltration. The Kitchen was modeled with 0.4 cfm of leakage per square foot of wall. Traffic patterns are estimated to travel back and forth through the southern façade, making the wall relatively leaky. The Living Room was modeled with 0.25 cfm of leakage per square foot of wall. This number assumes that there will be some leakage through the north-facing entry door. The Bathroom and Bedroom were both modeled with 0.15 cfm of leakage per square foot of wall. This value assumes that the insulation is between "good" (0.2 cfm per square foot) and "excellent" (0.1 cfm per square foot). Each room was modeled as a light room mass, meaning that there will be a 2-hour lag for envelope loads to enter the home. The following tables indicate the thermal envelope information that was inputted into the load model.

THERMAL VALUES OF BUILDING COMPONENTS	
Walls	R-20
Floors	R-19
Roof	R-38
Windows	0.33-0.45 U-value, 0.18-0.24 SHGC
Glass Doors	0.41-0.53 U-value

REFER TO BUILDING ENVELOPE ANALYSIS CHAPTER FOR DETAILED R-VALUES

HARVEST HOME ZONE DETAILS				
DETAIL	**ZONE**			
	KITCHEN	**LIVING**	**BEDROOM**	**BATHROOM**
Floor Area	187 sq ft	169 sq ft	172 sq ft	72 sq ft
Ceiling Height	9 ft	9 ft	9 ft	9 ft
External Wall Dimensions & Orientations	South: 14.8 ft x 9 ft	North: 15.0 ft x 9 ft	East: 9.3 ft x 9 ft	East: 11.3 ft x 9 ft
		South: 14.6 ft x 9 ft	North: 19.2 ft x 9 ft	South: 7.1 ft x 8 ft
		West: 11.0 ft x 9 ft	South: 3.1 ft x 9 ft	
Glazing Dimensions & Orientations	South: 14.8 ft x 9 ft	North: 14.8 ft x 9 ft	East: 3 ft x 7 ft & 4.5 ft x 1.5 ft, 6 ft overhang	East: 11 ft x 1.5 ft
			North: 1.5 ft x 7 ft, 12.5 ft x 1.5 ft	
Infiltration	0.4 cfm/sq ft of wall	0.25 cfm/sq ft of wall	0.15 cfm/sq ft of wall	0.15 cfm/sq ft of wall
Room mass	Light (2-hour lag)	Light (2-hour lag)	Light (2-hour lag)	Light (2-hour lag)

INTERNAL HEAT GAINS OF EQUIPMENT - All electrical appliances within the home are expected to create sensible heat. ASHRAE Fundamentals Chapter 18.7 was used to calculate the amount of heat gained through each of these sources. In this calculation, the power requirement (wattage) of each appliance was multiplied by the usage factor ($F_{u)}$ and radiation factor ($F_{r)}$ to calculate the heat dissipated by each piece of equipment. The heat dissipated by the TV and the computer was simply calculated by multiplying the power requirement by the percentage of load estimated to dissipate into the space and divided by 100. The heat dissipated by all equipment is illustrated in the following table. The numbers were inputted into TRACE along with a schedule designating the time that each appliance was to be used.

HEAT DISSIPATION OF EQUIPMENT					
Zone	**Equipment Type**	**Power Requirement (W)**	**F_u**	**F_r**	**Heat Dissipated (W)**
Bedroom	Dryer	5600	0.5	1	2800
	Washer	1400	0.5	1	700
	Computer	25	0.5	1	12.5
Kitchen	Cooktop	5800	0.3	0.41	713
	Dishwasher	875	0.27	0.34	80
	Oven	2600	0.2	0.14	73
	Vent Hood	0	0	0	0
	Refrigerator	50	1	1	50
Living Room	TV	50	0.4	1	20

The wattage and lighting type of all fixtures within in each zone were added to the load model. Since LEDs comprise the majority of the home's lighting and the remaining lights are fluorescents, the sensible heat dissipated from all lighting is negligible compared to the sensible heat dissipated from appliances and people.

People inside the home will additionally add both sensible and latent heat to the space. For this section, it was important for the competition load models to include schedules that would consider the vast number of people entering the home during tasks such as the tours, dinner party, and movie night.

SYSTEM TYPE AND THERMOSTAT - The final elements of the load model were the selection of the system type and thermostat. The system type for the HVAC system is under-floor distribution through a ducted under-floor plenum. Air is exhausted through the ceiling along a ducted return air path. According to competition rules, all zones in the home are to remain between 71°F and 76°F and under 60% relative humidity. Cool supply air was designed to remain between 60°F and 65°F while warm supply air was designed to remain between 80°F and 85°F.

LOAD MODEL OUTPUTS - Once all of these parameters were added to the load model, results were obtained. The key outputs that were used to determine HVAC system sizing were the total cooling and heating loads in Btu/hour. The cooling and heating loads include both envelope loads and internal loads. Envelope cooling loads are the amount of heat that enters the home through the thermal envelope when the home is in cooling mode for instance, roof conduction, glass solar and infiltration. Internal heat gains from lights, people, and equipment additionally add undesired heat to the space when the home is in cooling mode. On the other hand, envelope heating loads are the amount of undesired heat that leaks from inside to outside the home when the home is in heating mode such as roof conduction, glass/door conduction, wall conduction, floor conduction, and infiltration.

5.3 – COMPETITION LOAD AND HVAC ANALYSIS

Load models were created within TRACE to determine the peak loads experienced by HARVEST HOME and to insure that the HVAC system would be sized to handle these loads. Since cooling loads were expected to be greater than heating loads, TRACE was used to pinpoint the times of the competition with the greatest cooling load. The Individual load models created for Day 11 to Day 19 of the competition account for varying people, lighting and equipment schedules.

Each day was modeled with specific tasks as follows:

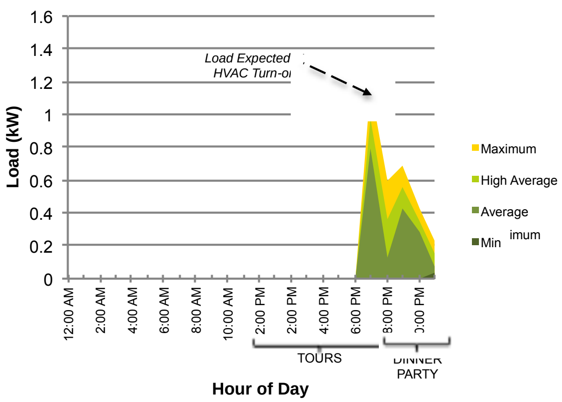
- Day 11: Tours (11am – 7pm), Lighting (7pm – 11pm), Dinner Party (7pm – 11pm)
- Day 12: Tours (11am – 7pm), Dishwasher (8am – 10:30am), Movie Night (8pm – 10:30pm)
- Day 13: Tours (11am – 7pm), Cooking (8am – 9:30am), Lighting (7pm – 11pm), Dinner Party (7pm – 11pm)
- Day 14: Dishwasher (8am – 10:30am), Cooking (8:30am – 10:30 am), Lighting (7pm – 11pm)
- Day 15: Lighting (7pm – 11pm)
- Day 16: Dishwasher (2pm – 4:30pm), Cooking (5pm – 7pm), Lighting (7pm – 11pm)
- Day 17: Cooking (11:30pm – 1:30pm, 4:30pm – 6:30pm)
- Day 18: Dishwasher (8am – 10:30am), Lighting (7pm – 11pm)
- Day 19: Dishwasher (8am – 10:30am), Cooking (8:30am – 10:30am)

The following assumptions were made for each task within the load model:

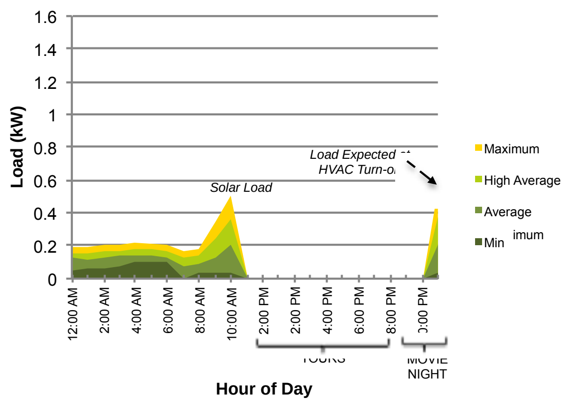
- Home electronics are assumed to provide negligible internal loads
- Clothes washer and dryer are assumed to provide negligible internal loads due to the vent in the laundry room
- During each cooking contest, 14,583 Btu/hr of latent loads are calculated to enter the space
- During the movie night, there will be 8 people in the room emitting a total of 1960 Btu/h of sensible heat plus 840 Btu/h of latent heat
- The dinner party consists of cooking from 7pm to 9pm, where 500 Btu/h of latent heat is emitted. From 9pm to 11pm, 2000 Btu/h of sensible heat and 1200 Btu/h of latent heat is emitted from 8 people and 1200 Btu/hr of latent heat is emitted from the 8 meals
- The dishwasher is assumed to run for one hour during each dishwasher task, emitting 2500 Btu/h of sensible heat
- The home's lighting was entered as 1 Watt per square foot.
- Tours are modeled with 100% infiltration due to the constant opening and closing of doors. 8 people will be in the home during all tours, emitting a total of 2000 Btu/h of sensible heat and 1200 Btu/h of latent heat

The following graphs are cooling equipment load profiles for Day 11 through Day 19 of the competition illustrating the amount of cooling required for all hours of the competition. The peaks in each graph represent the times of day where the greatest amount of energy will be required from the HVAC system. The graphs indicate that tours, solar loads due to solar heat gain and boiling water all add heat to the home and cause a peak in cooling loads.

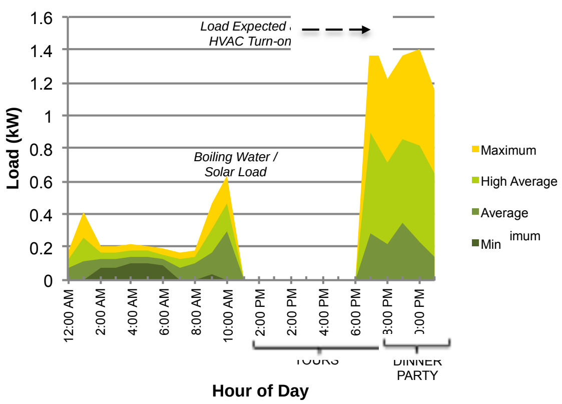
DAY 11 COOLING EQUIPMENT LOAD PROFILE



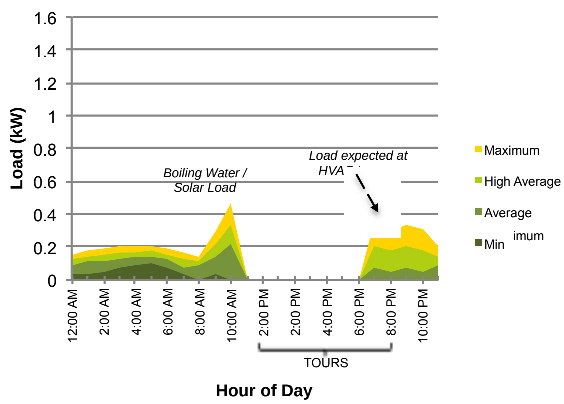
DAY 12 COOLING EQUIPMENT LOAD PROFILE



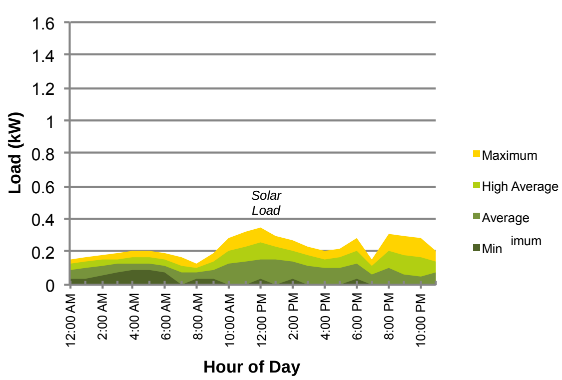
DAY 13 COOLING EQUIPMENT LOAD PROFILE



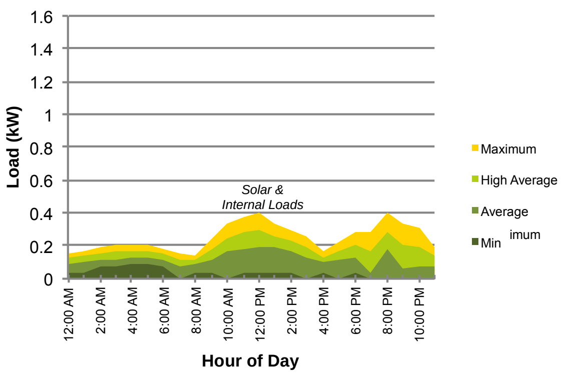
DAY 14 COOLING EQUIPMENT LOAD PROFILE



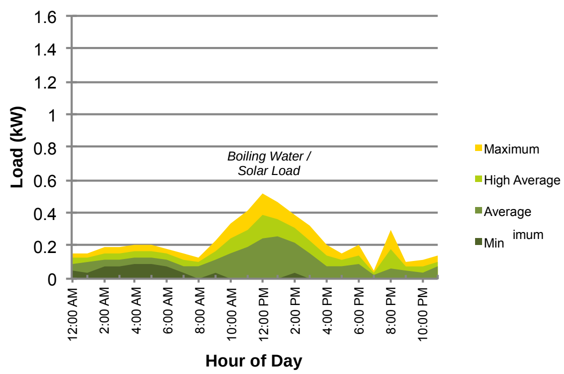
DAY 15 COOLING EQUIPMENT LOAD PROFILE



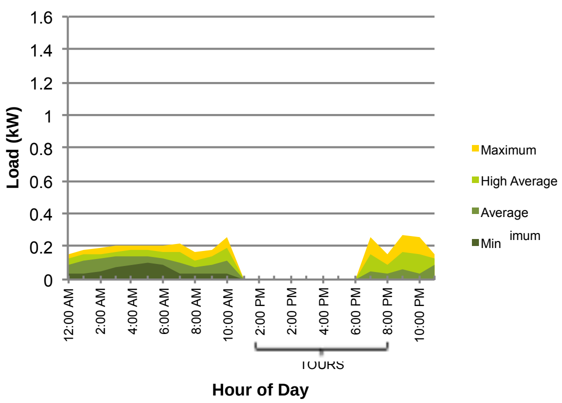
DAY 16 COOLING EQUIPMENT LOAD PROFILE



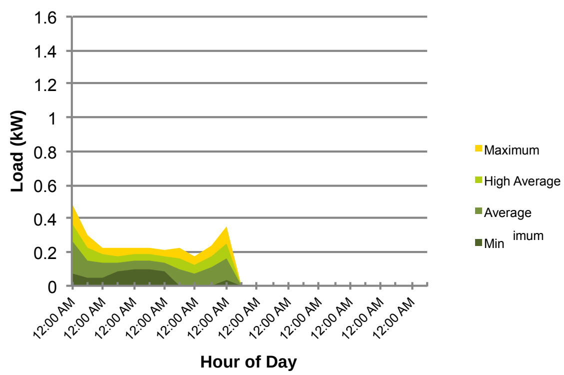
DAY 17 COOLING EQUIPMENT LOAD PROFILE



DAY 18 COOLING EQUIPMENT LOAD PROFILE



DAY 19 COOLING EQUIPMENT LOAD PROFILE



The daily energy consumption of the HVAC system ranges from 2.78 kWh to 8.55 kWh depending upon the daily cooling and heating loads. Day 13 exhibits the greatest cooling load due to the cooking contest in the morning with tours during the day. The cooling load expected as the HVAC system turns on at 8pm is just over 1.4 kW. The load will remain in this range during the dinner party, where people, equipment and food will contribute even more heat to the space. During this peak, 2.5 tons of cooling would be required to ensure that cooling and dehumidification will maintain desired temperature and humidity levels. Therefore, a 3-ton heat pump was specified to provide enough cooling and heating during the competition and year-round.

Using the load model results, the HVAC energy consumption was estimated by adding the cooling loads to the expected heating loads. All hourly loads, in kW, were converted into hourly energy consumption, in kilowatt-hours (kWh), by taking the efficiency and energy consumption of the HVAC equipment into consideration. The following table shows the estimated HVAC energy consumption, in kWh, for each day of the competition.

DAILY COMPETITION HVAC ENERGY CONSUMPTION, kWh								
Day 11	**Day 12**	**Day 13**	**Day 14**	**Day 15**	**Day 16**	**Day 17**	**Day 18**	**Day 19**
3.01	3.01	8.55	3.50	5.13	5.16	5.16	3.03	2.78

COMPETITION HVAC ENERGY CONSUMPTION, kWh = 39.3kWh

5.4 – ANNUAL LOAD ANALYSIS

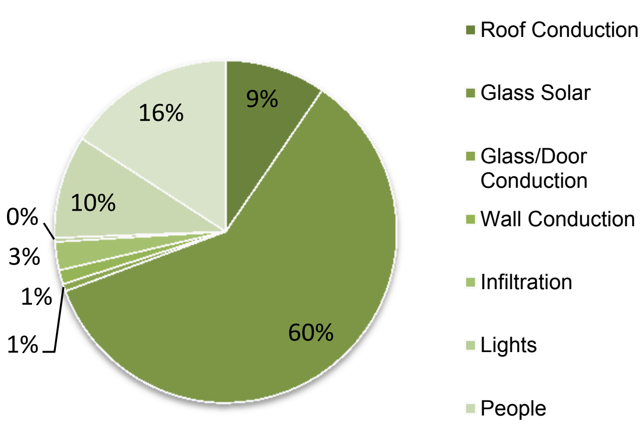
Once the loads during the competition were calculated, it was then necessary to create an energy model on TRACE for an entire year of operation for two main reasons: 1) To ensure that the 3-ton heat pump will provide adequate heating and cooling throughout the year; and 2) To estimate the estimated monthly HVAC consumption throughout an entire year of operation.

For the annual energy model, the inputted envelope data will remain the same as the competition load models. The schedules for people, equipment, and lighting were adjusted between the competition model and the annual model. Heat loads from the TV and computer will be considered negligible. The following assumptions were made for the energy modeling schedules, keeping in mind that the home will be a 2-occupant residence:

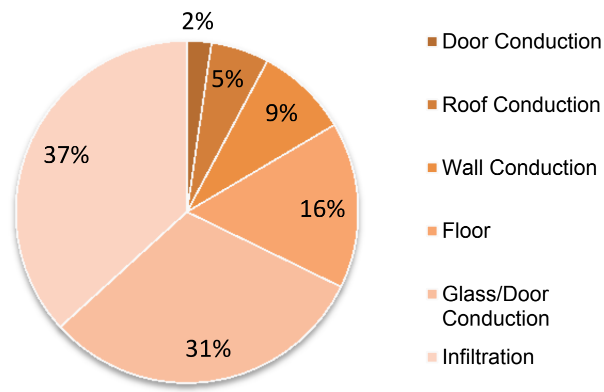
- Weekday: 2 people in the home for 24 hours, lights on from 6pm-10pm, dishwasher runs from 2pm to 3pm, oven is on from 1pm to 2pm, and refrigerator is on for 24 hours
- Weekend: 2 people in the home for 24 hours and 2 people in the home from 11am to 10pm, lights on from 6pm to 10pm, oven on from 1pm to 2pm, cooktop on from 2pm to 3pm, washer on from 1pm to 2pm, dryer on from 2pm to 3pm, refrigerator on for 24 hours

The following charts breakdown of the home's heating and cooling loads.

TOTAL PEAK COOLING LOAD = 8449 kWh



TOTAL PEAK HEATING LOAD = 9769 kWh



As shown above, the peak heating loads are greater than the peak cooling loads, which indicate that the home may consume more annual energy for heating than cooling spaces. The estimated monthly energy HVAC consumption in kWh, also outputted from the TRACE energy model, is shown below.

ESTIMATED MONTHLY HVAC ENERGY CONSUMPTION, kWh											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
198	173	204	188	203	214	263	261	264	208	185	199

ESTIMATED ANNUAL HVAC ENERGY CONSUMPTION = 2560kWh

6.0 – ENERGY CONSUMPTION

6.1 TOTAL COMPETITION ENERGY CONSUMPTION

A breakdown of the total energy consumption during the competition is shown below. The daily energy consumption ranges from 13.0 kWh to 28.8 kWh. During each dinner party, it was assumed that the cooktop, oven, and vent hood would all be on for one hour. For each cooking contest, it was assumed that the cooktop and vent hood would be on for one hour. The electricity consumption of the clothes washer and dryer is two times greater on Day 17 and Day 19 than on Day 12, Day 13, Day 14, and Day 15 because two laundry loads are required on these days. The "Lighting" task includes not only lighting from the Lighting contest but also all lighting required throughout each day of the competition.

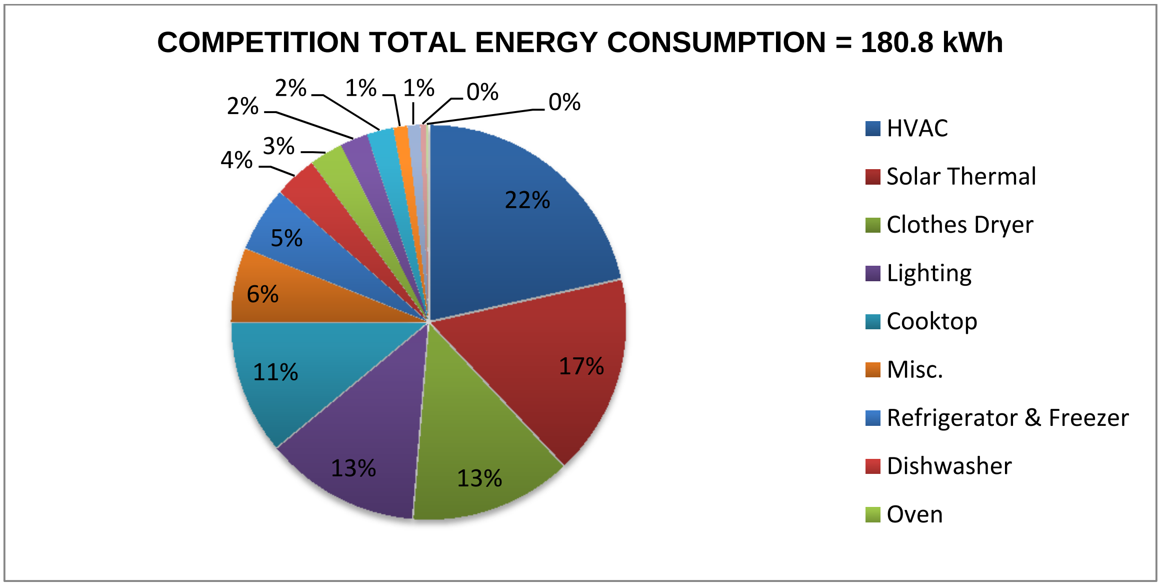
COMPETITION ENERGY CONSUMPTION (kWh)

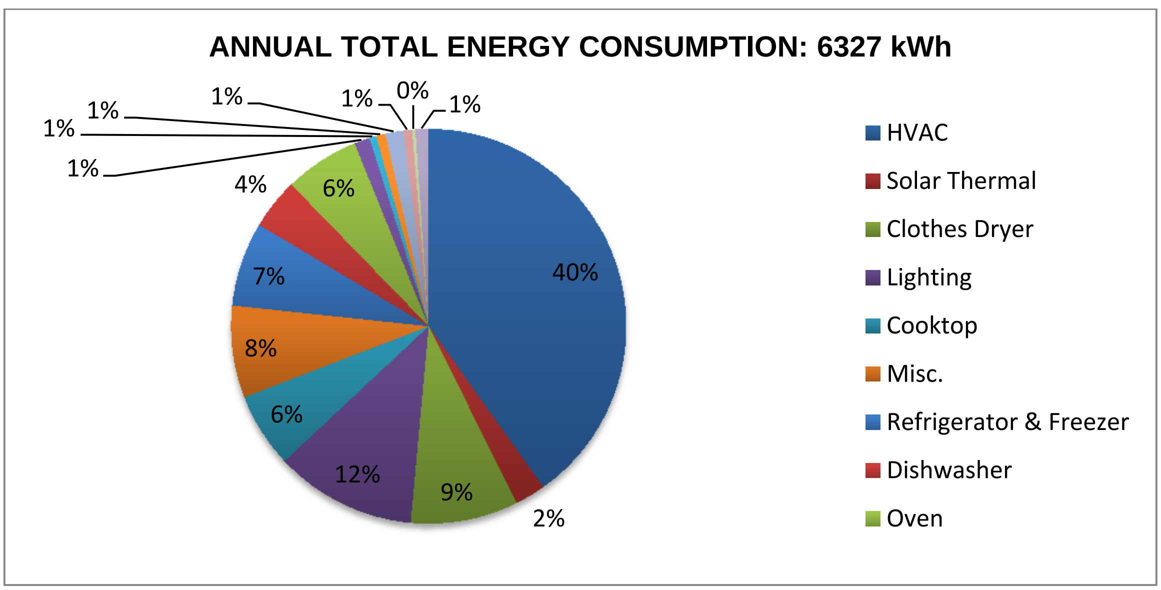
Day #	Task	kWh/contest	kWh/day
Day 11	Refrigerator & Freezer	0.8	
3-Oct	Lighting	3.1	
Public Exhibit	Dinner Party	5.6	**13.3**
	Temperature & Humidity	3.0	
	Other (Landscaping)	0.8	
Day 12	Refrigerator & Freezer	1.2	
4-Oct	Lighting	1.7	
Public Exhibit	Clothes Washer	0.2	
	Clothes Dryer	2.7	
	Home Electronics	0.3	
	Dishwasher	1.3	**15.2**
	Hot Water	3.8	
	Movie Night	0.2	
	Temperature & Humidity	3.0	
	Other (Landscaping)	0.8	
Day 13	Refrigerator & Freezer	1.2	
5-Oct	Clothes Washer	0.2	
Public Exhibit	Clothes Dryer	2.7	
	Home Electronics	0.2	
	Cooking	3.0	**28.8**
	Hot Water	3.8	
	Lighting	2.7	
	Dinner Party	5.6	
	Temperature & Humidity	8.6	
	Other (Landscaping)	0.8	
Day 14	Refrigerator & Freezer	1.2	
6-Oct	Clothes Washer	0.2	
Public Exhibit	Clothes Dryer	2.7	**19.5**
	Home Electronics	0.2	
	Dishwasher	1.3	

	Cooking	3.0	
	Hot Water	3.8	
	Lighting	2.7	
	Temperature & Humidity	3.5	
	Other (Landscaping)	0.8	
Day 15	Refrigerator & Freezer	1.2	
7-Oct	Clothes Washer	0.5	
Jury Walkthroughs	Clothes Dryer	5.4	
	Home Electronics	0.4	**19.6**
	Hot Water	3.8	
	Lighting	3.3	
	Temperature & Humidity	5.1	
Day 16	Refrigerator & Freezer	1.2	
8-Oct	Home Electronics	0.5	
Jury Walkthroughs	Dishwasher	1.3	
	Hot Water	3.8	**18.4**
	Cooking	3.0	
	Lighting	3.5	
	Temperature & Humidity	5.2	
Day 17	Refrigerator & Freezer	1.2	
9-Oct	Clothes Washer	0.5	
Jury Walkthroughs	Clothes Dryer	5.4	
	Home Electronics	0.6	
	Cooking	6.0	**26.1**
	Hot Water	3.8	
	Lighting	3.5	
	Temperature & Humidity	5.2	
Day 18	Refrigerator & Freezer	1.2	
10-Oct	Home Electronics	0.2	
Public Exhibit	Dishwasher	1.3	
	Hot Water	3.8	**13.0**
	Lighting	2.7	
	Temperature & Humidity	3.0	
	Other (Landscaping)	0.8	
Day 19	Refrigerator & Freezer	0.6	
11-Oct	Clothes Washer	0.5	
Public Exhibit	Clothes Dryer	5.4	
	Home Electronics	0.2	
	Dishwasher	1.3	**17.5**
	Cooking	3.0	
	Hot Water	3.8	
	Lighting	0.0	
	Temperature & Humidity	2.8	
COMPETITION ENERGY CONSUMPTION (kWh)			**171.4**

6.2 TOTAL ANNUAL ENERGY CONSUMPTION

The following charts compare the total breakdown of energy consumption by appliance/equipment for the competition and the entire year. Throughout the year, the HVAC system is expected to comprise a greater percentage of the total energy consumption caused by the small electrical loads of the two-person residence. The miscellaneous category was added to both the competition and annual energy consumption charts to and account for electrical loads from equipment that is either plugged in and not in use or unaccounted electronics within the home.

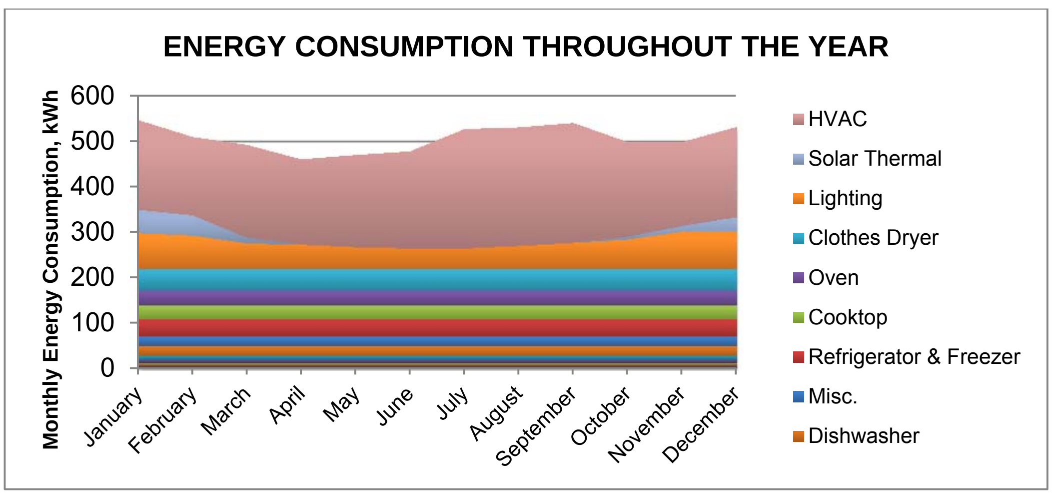




The following table depicts a side-by-side comparison of the energy consumption of each appliance during the competition and year-round.

EQUIPMENT/APPLIANCE ENERGY CONSUMPTION, kWh		
Equipment/Appliance	**Competition Consumption**	**Annual Consumption**
HVAC	39.3	2560.0
Solar Thermal	30.2	159.1
Clothes Dryer	24.3	561.6
Lighting	23.2	737.6
Cooktop	20.0	390.0
Misc.	11.2	480.4
Refrigerator & Freezer	9.8	440.0
Dishwasher	6.4	266.0
Oven	5.0	390.0
Vent Hood	4.2	81.1
Landscaping	4.0	36.5
Clothes Washer	2.1	48.0
Large TV	1.9	93.0
Computer	0.9	45.6
Speakers	0.4	18.3
Small TV	0.0	68.2
TOTAL	**182.8**	**6375.4**

Finally, the monthly energy consumption was determined by combining the monthly HVAC, hot water and lighting energy consumptions with the average equipment loads per month. As shown below, the monthly energy consumption ranges from 458 kWh in April to 544.2 kWh in January. Overall, the home's monthly energy consumption remains fairly constant throughout the year.



6.3 – PHOTOVOLTAIC MODULES

Team Capitol dc has selected Yingli modules based on many factors both technical and non-technical, including competitive pricing, company financial strength, establishment in the PV industry, proven technology, strong warranty backing, and reliability. Yingli provides optimum value as one of the largest vertically integrated PV module suppliers with the entire PV value chain handled in-house, from poly-silicon manufacturing to module assembly. Fully automated production of ingots, wafers, solar cells and modules ensures tight control of their material and production quality, while providing a significant cost advantage. This instills confidence in investors because Yingli manufactures their own silicon wafers for the PV modules, which comprise nearly a third of system cost. This is especially taken into account when evaluating the value of the 25 year module power production warranty. Yingli was the world's first vertically integrated PV module manufacturer and with over 6 GW of modules installed globally, Yingli has been proven to deliver reliable, durable modules. In 2012 Yingli shipped more PV modules than any other manufacturer worldwide with a grand total of 2,300 MW of PV modules, 500 MW more than the second highest volume manufacturer in the same period.

The selected module for this project is Yingli's YL245P-29b, which is Yingli's work horse universal 60 cell polycrystalline module used for all types of grid-tied applications. The modules are certified to UL 1703 and have a UL Fire Safety Class C rating. The module is comprised of an assembly of solar cells encapsulated within an insulating material with a rigid glass front surface that is rated to withstand the impact of a 51 MPH 1" hailstone and 113 psf of static load due to snow and wind. The PV cells and inter-cell connections are all encapsulated in a water-proof EVA laminate and weather-proof back sheet to prevent corrosion of electrical connections and ensure long operating life.

6.4 - METHODOLOGY FOR SELECTION OF ENPHASE MICROINVERTERS

Team Capitol dc decided early on in our design process that a microinverter solution would be the best technology for the U.S. Department of Energy Solar Decathlon application for several reasons such as design flexibility, enhanced system performance, and system reliability and safety. The Enphase product was selected primarily due to their dominance in the residential microinverter market, proven product performance and willingness to provide support in the form of sponsorship.

DESIGN FLEXIBILITY - At the beginning of concept development for the HARVEST HOME, there was significant uncertainty about how much total energy would be needed from the PV system, how many PV modules would neatly fit on the building, and how much space would be available for PV inverters and other equipment in the mechanical room. The selection of Enphase's M215 microinverter allowed for nearly limitless PV array design flexibility without performance trade-offs. Due to the module level electronics employed with the microinverter approach any odd number of modules could be integrated into the home's design. No string size uniformity is required and multiple array orientations are easily accommodated. As is evident in the final design, the team took advantage of this feature, with the North sub-array at a tilt angle of 25° and the South sub-array at a tilt angle of 15°. This allowed for a cleaner integration of the solar PV and solar thermal systems because the solar thermal system requires a higher tilt angle for proper performance. If the same 25° tilt were to be used on the South sub-array the rear-most row of modules would be 5'9" above the roof, which would result in shading onto the North sub-array and would not look as good. Another key design feature that allows for a smoother system integration is the fact that the microinverters require no space in the mechanical closet. As is evident, space inside the home comes at a premium and the ability to avoid adding another component in the mechanical room was crucial. Lastly, the monitoring system integrates seamlessly and straight forward due to data communications over the power line.

SYSTEM PERFORMANCE - Total energy yield from the solar PV system was one of our key design criteria for the development of the PV array configuration. The Enphase microinverters provide many valuable system performance features. Module level control eliminates mismatch losses between PV modules, optimizes the output of each PV module, and limits the impact of any shading, soiling or component failure. The Enphase microinverters also have a very wide MPPT range, allowing the PV system to operate as low as 16V and as high as 36V. This enables the system to turn on earlier in the day and produce energy in lower light conditions than other inverters. Individual module level performance monitoring has many advantages, which enable the system to easily be maintained to operate a peak performance. For example, module level monitoring provides for easy and fast identification of individual module under performance or failure without the need to perform string level IV curve traces. The Enlighten web-based software also has a great time lapse module power graphing tool that enables comparative analysis of each module to the others, identification of shading issues, and early detection of sub-optimal performance.

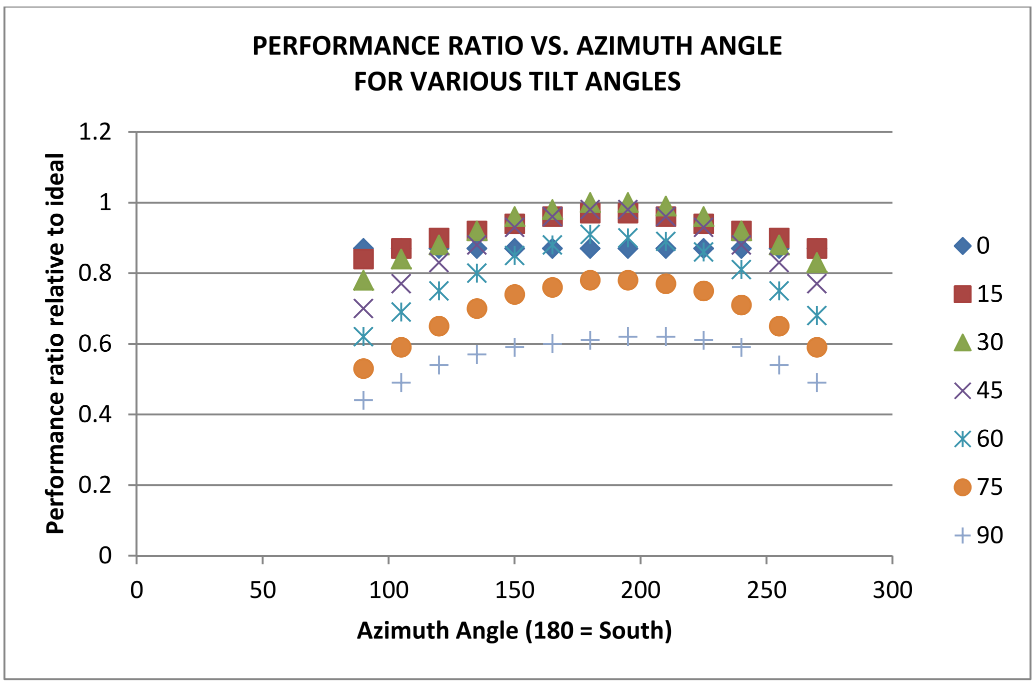
SAFETY AND RELIABILITY - There are many valuable safety benefits as a result of distributed module level electronics as well as system reliability advantages. The distributed inverter architecture allows for system resiliency in the case of a single failure. Only a single PV module is affected if an inverter fails, the rest of the system continues to operate at full power. There is no single point of failure that can bring down the entire PV system as is possible with a single string inverter. The main safety benefits of this type of system design are low DC circuit voltage, system shut down and isolation at the module level, and redundant ground fault detection. In the case of an emergency, when power to the home is disconnected there are no live conductors on the PV system except for the PV module wires between the PV modules and the microinverters. Additionally, since each module is connected to its own inverter all strings are only one module, which limits the maximum DC side voltage to 40.26V at the minimum expected temperature. This allows the roof and all PV conductors running from the roof to the main electrical panel to be safe and pose no risk to emergency personnel. Lastly, Each inverter has its own ground fault detection and interruption mechanism. If there is a ground fault picked up by any one inverter the Enlighten monitoring system will immediately sent an automated email alert as well as indicate the problem on the monitoring unit.

6.5 - PV ARRAY CONFIGURATION AND MOUNTING

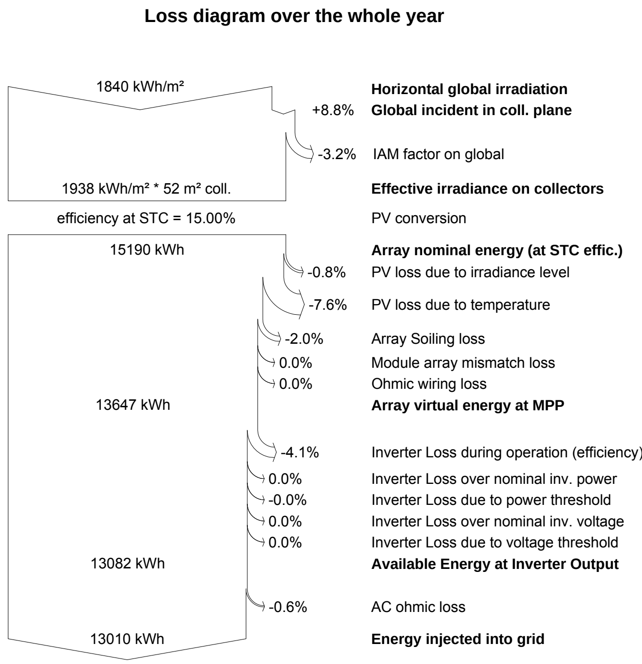
The design of the PV array mounting system and configuration on the Harvest rooftop was carefully considered, balancing trade-offs between system performance, aesthetics, and practically of integration into the rooftop. The team ultimately decided to employ an extruded aluminum rail module mounting system connected on top of a custom steel super structure bolted directly to the main structural members of the building.

SINGLE INCLINE PLANE VS. MULTIPLE ROWS OF TILTED PV MODULES - A single inclined plane of PV modules was the selected configuration for each building section for many reasons. Primarily, the single inclined plane allows for a higher density layout, superior aesthetics and better performance. The expected electricity yield is higher with the single inclined plane due to no inter-row shading issues and better air flow around the modules due to higher roof clearance. This approach allowed the team to meet the target electricity production and fit the desired number of PV modules on the roof, where the multiple row approach fell short.

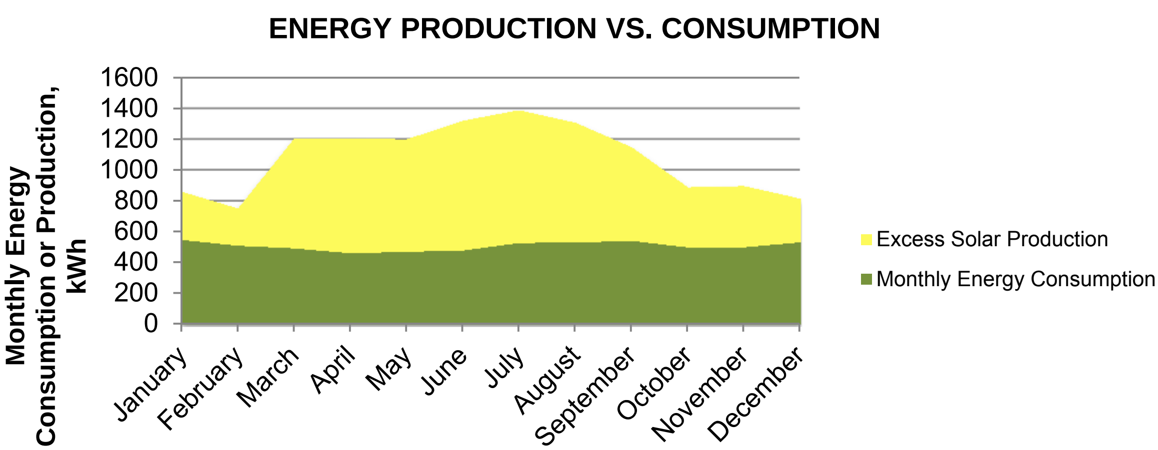
SELECTED TILT ANGLES - The team performed an exhaustive analysis of the PV system electricity production using PVsyst to determine the ideal tilt angles for maximum annual yield and maximum electricity yield during the competition. The results of this analysis were used to identify the tilt angles that would produce the most electricity and integrate well into the aesthetic of the home. For maximum annual yield the ideal tilt angle is between 25 and 30 degrees. However, for maximum production during the Solar Decathlon competition the ideal tilt angle is closer to 40 degrees. A 40 degree tilt angle was simply not practical for our home due to the resulting height of the North side of each inclined plane and potential shading that would be cast by the South sub-array onto the North sub-array. The team decided to trade-off some of the production on the South sub-array, about 2% annually, and elected to use a 15° tilt angle. This prevented any shading concern and matched up better with the original architectural design intent. Because microinverters were used, the team was able to select the ideal tilt angle of 25° for the North sub-array, which also allowed it to match the tilt angle of the adjacent solar thermal system. Refer to Climate Analysis Chapter for initial Insolation analysis.



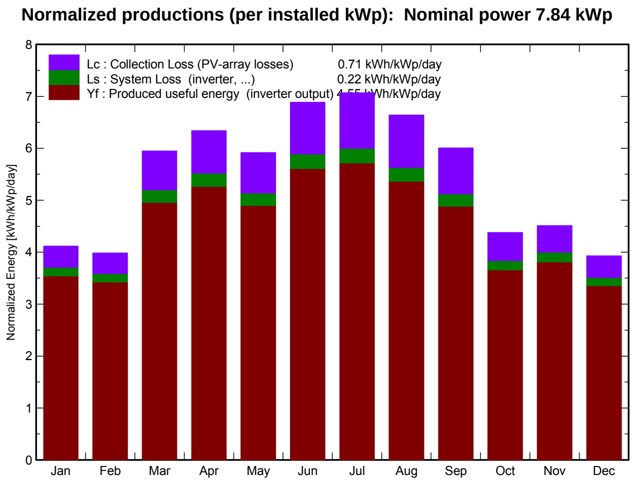
EXPECTED ENERGY LOSSES - The following diagram illustrates all expected energy losses associated with the PV system's conversion of sunlight into energy.

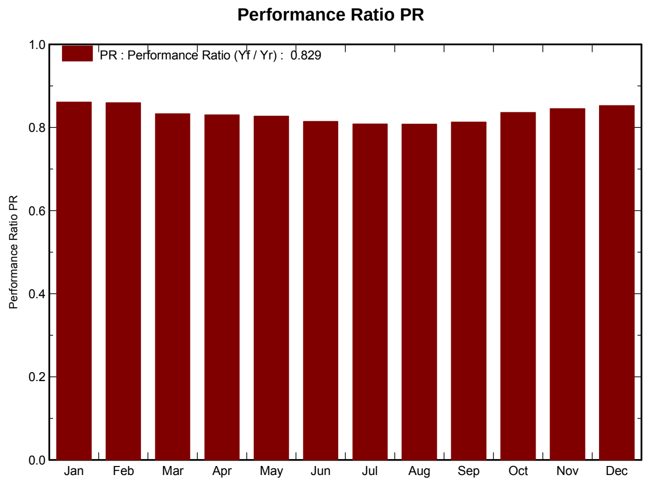


MONTHLY ENERGY CONSUMPTION - When sizing the home's photovoltaic array, the goal was to provide enough energy to the home during the competition and during the year in its final location. The PV array selected for the home, rated at 7.84 kW, is expected to generate a total of 229 kWh during the competition, exceeding our expected energy consumption by 28%. Throughout an entire year, the PV array is expected to generate 13,010 kWh, exceeding the estimated annual household consumption by 106%. This ensures that the home will be net positive over the course of a year and will generate about twice as much energy as it consumes. This is demonstrated visually in the following graph.



As shown above, HARVEST HOME will produce more energy than it consumes, allowing the homeowner the opportunity to sell electricity back to the grid.





7.0 - CERTIFYING HARVEST HOME

7.1 - LEED

Residential construction in the U.S. represents the largest amount of square footage, as well as the most inefficient building type in the built environment. Single-family homes built between 2000 and 2005 are 29% larger on average than those built in the 1980s and 38% larger than those built before 1950[1]. Homes are also consuming more energy; from 1990 to 2009 residential building energy consumption increased 24%[1]. In today's market , homes tend to be large, poorly insulated and high consumers of energy and water.

However for the first time in decades home sizes are getting smaller and energy consumption is decreasing relative to growth. The Department of Energy's 2012 Annual Energy Outlook estimates that due to improvements in building and appliance efficiency, energy usage is predicted to increase only 13% from 2009 to 2035. Among the reasons for this turn around, is the proliferation of green building rating systems such as Energy Star, Earthcraft, Build it Green (California), and LEED for Homes which provide design and construction guidance and tools for building towards reduced environmental impact. Decreased energy and water usage green labels on homes increases the value. A study of 1.6 million homes sold from 2007 to 2012 finds that green labeled homes sell for 9% more than non-labeled homes[2].

Due to label recognition and proven performance HARVEST HOME is utilizing LEED for Homes to demonstrate the environmental benefits of the design and construction. Major systems for energy, indoor air quality, water and materials selection have been optimized using LEED requirements as a decision making tool and framework to prioritize performance goals. The requirements were applied at both the entire home and specific detail scale during every phase of development, from schematic design through construction details. Because this home is a living laboratory of green building technology HARVEST HOME is pursuing the newest LEED for Homes rating system. LEED v4. The higher stringency of this new standard posed many challenges, but dedication to what this home could be saw the team through.

For the energy systems of HARVEST HOME, the ultimate goal is to be "net zero" which means the home produces as much energy as it consumes. With this goal in mind, the passive systems of the envelope are harmonized with the active systems of heating, cooling and solar equipment to reach net zero. In utilizing LEED v4 the energy systems had to meet not only the code requirements for the state of California, but also the Energy Star for Qualified Homes version 3 (rev.03). In referencing the requirements of Energy Star 3 prescriptive paths the envelope was made air and water tight by designing and installing a roof, wall, and floor system with high R values and low SHGC (solar Heat gain coefficient). The performance path for energy benchmarking and the HERS (Home Energy Rating) index, modeling results from both EnergyPlus and RESNET were used to compare, test, and re-design envelope and equipment systems for efficient energy performance.

A a component of the heating and cooling equipment, is the ventilation. Indoor air quality is a major component to occupant comfort, because this home has been designed to align the ethos of a healing environment, the goals of the team, and the goals of the LEED rating system. LEED for Homes v4 advocates for contaminant control thought the installation of shoe storage, non-chemical pest control, and low VOC (volatile organic compounds) material selection. Each of these prescriptive strategies have been deployed in the home design. LEED for Homes also advocates for meeting ASHREA 62.2-2010 voluntary standard for ventilation as well as performance testing for air duct seal, and quality testing prior to occupancy, all these procedures can be utilized during design and construction, and these were performed.

From the beginning, the goals of HARVEST HOME have been in sync with the credit intent of the Sustainable Sites portion on LEED for Homes v4. Water consumption inside the home is minimized using low flow and flush fixtures. After potable water is used in the home, it goes to a "gray" water reclaiming system for landscaping water, where exterior water use is further reduced by the installation of native plant species. The system has also been designed to be metered, a credit in LEED but outside code and competition requirements.

Aside from materials that were selected for installation based on efficiency and performance, many materials installed in the home have been selected because of reduced environmental impact. Using the LEED requirements as a framework priority for non-tropical wood, durable construction, salvaged materials and recycled content were applied to material selection where possible. The durable construction requirements focus on controlling and mitigating the effects of water infiltration within the home in the bath, kitchen and laundry facilities. Techniques such as drain pans, non-paper backed wallboard and water resistant flooring were utilized to ensure the home functions for a long time without the need for extensive repair. In selection of environmentally preferable materials, salvaged wood was used for wall framing, finish flooring, decking and the exterior rain screen. The use of these materials was extremely challenging given the added processing needed and extra installation time required. The use of salvage materials was a major focus for the team to showcase the highest value for reused materials and that these materials can be up-cycled to a higher use without compromising on the modern design aesthetic. Another consideration for materials selection was recycled content, many interior elements including counters, paint, cabinets, and furniture have high recycled content, reducing the need for virgin materials to be extracted and processed.

For as many LEED credits and prerequisites that were used in the decision making process of HARVEST HOME, many other credit were not feasible, either because there was no one able to provide a particular service in the area, such as finding Energy Star qualified contractors, or because our tight timeline did not allow for long lead times for delivery, such as windows, in other cases the team's first choice technology was not able to be installed due to lack of product available, such as the HVAC equipment, which was planned initially to be water to water, but because water tanks don't come in the required size it had to be modified to an air-to-air system. Using LEED requirements as a framework allowed a large team to organize priorities quickly and carry them through the project. It also taught the team the challenges involved in advocating for "green building" even for a project as unique and sustainably driven as this one.

[1]DOE Buildings Energy Data Book http://buildingsdatabook.eren.doe.gov/ChapterIntro2.aspx
[2]Kok, Nils, and Mathew E. Kahn. The Value of Green Labels in the California Housing Market: An economic analysis on the sales price of a home. July 2012. http://new.usgbc.org/sites/default/files/ValueofGreenHomeLabelsStudy_July2012.pdf. May 26 2013.

7.2 – ENERGY STAR V3 FOR HOMES

A significant portion of LEED for Homes v4 is meeting the Energy Star Qualified Homes version 3 Requirements. This program included performance aspects of the enclosure, HVAC system installation, and water management. As part of both Energy Star and LEED documentation Everyday Green, a DC based residential sustainability consultant, was the LEED for Homes Provider and Energy Star Rater. The residential experts at Everyday Green provided performance and modeling testing for HARVEST HOME. The performance testing for the home related to enclosure performance that included infiltration and heat resistance testing while HVAC installation performance tested for duct leakage.

To test air infiltration, a blower door test was performed by Everyday near construction completion, recommendations to improve infiltration performance were then provided. To improve infiltration performance additional air tight insulation was added to floor penetrations around ducts and between gaps in the metal decking at the ceiling and floor. The test was repeated after construction completion to measure improvement.

To examine heat resistance Everyday Green used an infrared imaging device to detect locations in the home where the R-value of the assembly was not performing to high standards. In this test it was found that the windows needed to be adjusted for a tight fit when in the closed position and the floor needed additional insulation.

Because the HVAC design of this home calls for air delivery through ducts, Everyday Green performed a duct leakage test during construction to determine if there was air loss through under floor ducting and if the velocity of delivered air met the performance specification. When leaks were detected those locations received extra sealing.

In addition to these performance tests a major portion of energy efficiency performance is determined through the homes HERS score (Home Energy Rating System). A home energy rating is calculated based on the U.S. Department of Energy HERS guidelines. Everyday Green used this program to identify annual energy consumption and percent improvement over the ENERGY STAR Reference Home. LEED uses the HERS score to determine annual energy use reduction percentage resulting in points awarded. The HERS score is determined using REM/Rate energy modeling software, which is required to calculate heating, cooling, hot water, lighting, and appliance energy loads, consumption and costs for new and existing single and multi-family homes. The results of the Harvest home model are shown in the following chart.

ENERGY MODEL UPDATE REPORT		
Parameter	Projected Improvements	ENERGY STAR Reference Home
Mechanical Ventilation	100 CFM supply-side ventilation for 6 hrs/day. Air handler fan uses 100 watts	24 CFM continuous supply via dedicated 11 watt fan
Infiltration	3 ACH50	5 ACH50
Windows	0.33-0.45 U-value, 0.18-0.24 SHGC	0.35 U-value, 0.30 SHGC
Glass Doors	0.41-0.53 U-value, 0.18-0.23 SGHC	0.32 U-value, 0.30 SHGC
Cooling Equipment	York YZH03911/MV12D 17.35 SEER	14.5 SEER
Heating Equipment	10 HSPF	8.2 HSPF
Duct Tightness	35 CFM leakage to outside, 50 CFM total	Same
Water heating	50 gallon tank+22 sgft solar collector	.92 EF electric tank
Duct Leakage	4% duct leakage to outdoors	Same
Ceiling/Roof Insulation	6” SIP, R-25-R-12.5 Tapered insulation, Gypsum = R-40	R-30
Wall Insulation	4.5” SIP wall = R-16	R-13
Frame Floor Insulation	R-20 cavity, Steel studs = R-10	R-13
Lighting	100% ENERGY STAR	80% ENERGY STAR
Appliances	Frigidaire FFBF285SS: 400 kWh/Yr	ENERGY STAR
	Fisher&Paykel DD36SFTX2: 266 kWh/year, 0.83 EF, 9 place settings	ENERGY STAR
	Frigidaire FAF4073NW: 3.8 cu.ft., 96 kWh/year, 3/41 MEF	ENERGY STAR
	Frigidaire FASE7073N: 3.10 EF, moisture sensing	Standard

In conclusion, the areas of deficit include the floor insulation and the air changes per hour. For the floor insulation additional plywood and batt insulation were added, for air changes per hour the team will be testing on site to see if passive strategies will increase the air changes. For the overall score, without including the PV, the home has a HERS Index of 54 (meaning the home is 46% more energy efficient than a code home), but this number changes dramatically to a HERS -99 (199% more energy efficient than a code home) with solar due to the net positive energy use.

8.0 COURSEWORK & SOFTWARE

8.1 – COURSEWORK

A significant portion of the design decisions that impact building performance are made in the early stages of project development. As a result, the entire process of design is affected. How is building performance analysis implemented into the design process and in a designer's formative years is important in understanding how our design thinking must evolve. Students should be educated in these trends to meet the market demand and improve sustainable potential of their designs. Each of the contributing universities of Team Capitol dc have developed coursework since the Spring of 2010 that has either directly or indirectly supported the development of a net-zero home for the U.S. Department of Energy Solar Decathlon 2013. Refer to the Coursework section of the Project Manual.

8.2 – SOFTWARE

Digital technologies now offer building designers a wide array of tools that can be integrated into the conceptual design stages by rapidly assessing and optimizing a building's performance. Software is informing building shape, structure, materials and orientation and fulfilling benchmarking requirements. Various types of approaches have evolved, each requiring different levels of efforts and results for performance analysis.

DIVA FOR RHINO - is a highly optimized daylighting and energy modeling plug-in for Rhinoceros, a NURBS modeling software. The plug-in was initially developed at the Graduate School of Design at Harvard University and is distributed by Solemma LLC. The software allows users to carry out a series of environmental performance evaluations of individual buildings and urban landscapes including Radiation Maps, Photorealistic Renderings, Climate-Based Daylighting Metrics, Annual and Individual Time Step Glare Analysis, LEED and CHPS Daylighting (Collaborative for High Performance Schools) Compliance, and Single Thermal Zone

Energy and Load Calculations. We have used this program for analyzing the interior daylighting (see Daylighting).

ECOTECT – is an building performance and environmental analysis tool that allows architects to simulate the performance of a building from the earliest stage of conceptual design through design development. It combines a wide array of detailed analysis functions with a highly visual and dynamic displays that presents analytical results directly within the context of the building model, enabling it to communicate complex concepts and datasets in surprisingly intuitive and effective ways. The software contains CIBSE steady state heat loss calculations and admittance-method based heat gain calculations. We have used this program for insolation (see Solar Incident Radiation) and Climate Analysis.

ENERGY PLUS - is a whole building energy simulation program that designers use to model energy and water use in buildings over time. In was created by the U.S. Department of energy as a stand-alone simulation program. The program takes into account for building heating, cooling, lighting, ventilating, and other energy flows. Modeling the performance of a building with EnergyPlus enables building professionals to optimize the building design to use less energy and water.

OPEN STUDIO - Is a plug-in program to Google's Sketch-Up that brings the Energy Plus program into the 3-D modeling program. I allows Sketch-up to include energy modeling in a user friendly interface. We have used this program for preliminary energy modeling.

REM/RATE - REM/Rate calculates heating, cooling, hot water, lighting, and appliance energy loads, consumption and costs for new and existing single and multi-family homes. The tool is for residential energy analysis, code compliance and rating software developed specifically for the needs of Home Energy Rating System (HERS) providers. A home energy rating is calculated based on U.S. Department of Energy HERS guidelines. We have used this program to identify residential energy consumption and LEED compliance.

THERM - THERM is a windows based program developed at Lawrence Berkley National Laboratory (LBNL) to detect and visually show heat transfer in objects. It is used to model in two dimensions any abject or assembly from a building to an appliance. THERM allows those interested in heat transfer to evaluate a products energy efficiency and local temperature patterns, which relate directly to problems with condensation, moisture damage, and structural integrity. We have used this program in the envelope analysis (see Building Envelope Analysis).

TRANE TRACE - TRACE is a Windows-based program used to construct a virtual building, calculate air conditioning loads, and simulate its hourly operation, over the course of 1 year. It can also perform a life cycle cost analysis. The program simulates a virtual building, but it does not display a visual image of the building. The software can be used in both the Design phase of a project, and the analysis phase. We have used this program as our main energy modeling engine.

VASARI - Project Vasari is an expressive design tool for creating building concepts using environmental factors. Vasari goes further, with integrated analysis for energy and carbon, providing design insight where the most important design decisions are made. Vasari is focused on conceptual building design using both geometric and parametric modeling. It supports performance-based design via integrated energy modeling and analysis features. The technology preview has graduated from Autodesk Labs and has been implemented into Revit and used mainstream. The software provides whole building energy simulation using DOE2 and is a platform for Green Building Studio – a cloud-based simulation program. We have used this program to analyze ventilation and design potential (see Wind Analysis), and Climate Analysis.

WUFI - A windows based modeling program developed by Oak Ridge National Laboratory and Fraunhofer IBP as a program that allows realistic calculation of the transient coupled one-dimensional heat and moisture transfer in multi-layer building components exposed to natural weather. It is based on the physics of vapor diffusion and liquid transport in building materials, which have been validated by laboratory and outdoor material testing. We have used this program in analyzing envelope materiality (see Building Envelope Analysis).

9.0 – CONSULTANTS

The following consultants were critical to the energy efficient design of HARVEST HOME. Working in tandem with Team Capitol dc, the consultants analyzed, tested and collaborated on decisions that ultimately evolved into the current home design.

ARUP

Arup, an engineering consulting firm in Washington, DC, provided professional consulting in structural engineering, mechanical engineering, electrical engineering, and fire protection to Team Capitol dc. They assisted with relevant technical drawings and ensured that all systems in the home are up to code.

EVERYDAY GREEN

PERFORMANCE TESTING FOR ENERGY STAR - Using the modeling program RemRate, Elliot Seibert at Everyday Green tested the performance of the home design against Energy Star requirements.

INFILTRATION TEST - Using a blower door test Everyday Green checked the air tightness of the home at near construction completion and provided recommendations to improve infiltration performance. They also performed the same test after construction completion to measure improvement.

HEAT RESISTANCE TEST - Using an infrared imaging device Everyday Green was able to detect locations in the home where the R-value of the assembly was not performing to high standards. They provided recommendations for improvement.

DUCT LEAKAGE TEST - Because the HVAC design of this home calls for air delivery through ducts, Everyday Green performed a duct leakage test during construction to determine if there was air loss through under floor ducting and if the velocity of delivered air met the performance specification. One leaks were detected those location received extra sealing.

STANDARD SOLAR

Standard Solar worked with Team Capitol dc to design the photovoltaic panel system that would produce energy for the net-zero home. Tests were completed to insure the appropriate balance of energy consumption to production was maintained based upon orientation, tilt angle, product type and microinverter type. Standard Solar donated the (32) photovoltaic panels and assisted with the roof installation to their corresponding microinverter.

QUANTITY TAKEOFF OF COMPETITION PROTOTYPE HOUSE

Specification Number	Brief Description	Detailed Description	Qty	Unit
Division 01	General Requirements			
01 XX XX	Crawler Mounted, lattice boom, 100 ton capacity, 60' boom		1.00	Daily
01 XX XX	Decking Support System - Scaffold Screws		175.00	EA
Division 05	Metals			
05 XX XX	C-Channel C8x11.5		10.00	LF
05 XX XX	L-Angle L3x3x1/4		5.47	EA
05 XX XX	L-Angle L4x4x5/16		11.97	EA
05 XX XX	Plate PL 3"x1/4"		176.38	SF
05 XX XX	Plate PL 3x3/8		24.00	SF
05 XX XX	Steel Angle Bracket 6"x6" .25"thick		38.00	SF
6 XX XX	Plate PL 8x1/2"		-	0
05 XX XX	Plate PL 9"x1/4"		12.33	SF
05 XX XX	W-Wide Flange W8x10 Coped		44.00	LF
05 XX XX	W-Wide Flange W8x10		142.01	LF
05 XX XX	W-Wide Flange W8x13 with openings		78.00	LF
05 XX XX	W-Wide Flange W8x13		5.19	LF
05 XX XX	W-Wide Flange W10x12 Coped		64.00	LF
05 XX XX	W-Wide Flange W10x12		139.53	LF
05 XX XX	W-Wide Flange W10x15		9.39	LF
05 XX XX	W-Wide Flange W10x15 with 1 rectangular openings		22.00	LF
05 XX XX	W-Wide Flange W10x15 with 2 rectangular openings		34.00	LF
05 XX XX	W-Wide Flange W10x15 with 8 rectangular openings		12.00	LF
05 XX XX	Column Cap Plate		15.00	LF
6 XX XX	HSS 3x2x.25		47.26	LF
7 XX XX	HSS 6x4x.25		161.25	LF
05 XX XX	HSS 4x4x.25 Columns 12' Tall		172.94	LF
05 XX XX	Miscellaneous Metals		1.00	LS
05 XX XX	Whole Building Foundation System		16.00	EA
05 XX XX	Living Module_Deck, Steel, 3" Floor		455.04	SF
05 XX XX	Resting Module_Deck, Steel, 3" Floor		266.70	SF
05 XX XX	Living Module_Deck, Steel, 1 1/2" Roof		523.41	SF
05 XX XX	Resting Module_Deck, Steel, 1 1/2" Roof		316.64	SF
05 XX XX	Railings		92.00	LF
05 XX XX	Safety Edging		300.00	LF
05 XX XX	Rain Barrel		1.00	EA
05 XX XX	Rill		28.00	LF
05 XX XX	Decorative Pots		6.00	EA
Division 06	Wood, Plastics and Composites			
06 XX XX	Structural Insulated Panels (SIP) - 4 1/2" Thick		1,947.00	SF
06 XX XX	Structural Insulated Panels (SIP) - 6 1/2" Thick		1,780.00	SF
06 XX XX	Milk Crates		700.00	EA
06 XX XX	Southern Deck		244.00	SF
06 XX XX	Morning Deck		104.00	SF
06 XX XX	Bridge Deck		93.00	SF
06 XX XX	Harvest Table Deck		380.00	SF
06 XX XX	Ramps/Landings		507.00	SF
06 XX XX	Tree of Life Garden Sub-floor		462.00	SF
06 XX XX	Harvest Table Deck Sub-floor		380.00	SF
06 XX XX	Bridge Lawn Sub-floor		88.00	SF
7 XX XX	Light Fixtures, Solar, Exterior		2.00	EA
8 XX XX	Plant Material		1.00	EA
9 XX XX	Soil		250.00	CU.FT

10 XX XX	Water Cart for Irrigation	1.00	EA
11 XX XX	Containter Liners	2.00	EA
12 XX XX	Straw Bales	100.00	EA
13 XX XX	Vertical Gardens	2.00	EA
14 XX XX	Water Pump	1.00	EA
15 XX XX	Compost Bin	1.00	EA
16 XX XX	Beehive	1.00	EA
17 XX XX	Planter	30.00	EA
06 XX XX	Decking Support System - 2x6 Wood	2,420.83	LF
06 XX XX	Framing, 2' X 2" wood studs	50.83	LF
06 XX XX	Framing, 2' X 4" wood studs	1,524.62	LF
06 XX XX	Framing, 2' X 4" wood studs Split Stud	48.13	LF
06 XX XX	Framing, 2' X 5 1/16" wood studs	8.18	LF
06 XX XX	Framing, 2' X 6" wood studs	16.18	LF
06 XX XX	Framing, 2' X 6" wood studs Ripped Down	15.49	LF
06 XX XX	Framing, 2' X 10" wood studs	41.55	LF
06 XX XX	Sheathing, 7/16" Plywood	99.23	SF
06 XX XX	Sheathing, 1/2" Plywood	96.41	SF
06 XX XX	Sheathing, 5/8" Plywood	5.32	SF
06 XX XX	Sheathing, 3/4" Plywood	174.69	SF
06 XX XX	Gypsum Board 1/2" Thick	-	SF
06 XX XX	Gypsum Board 5/8" Thick	1,350.00	SF
06 XX XX	Gypsum Board 3/4" Thick	-	SF
06 XX XX	Rain Screens Harvested Wood - Red Pine	1,336.54	LF
06 XX XX	Rain Screens Cambia Wood - Yellow Poplar	3,410.00	LF

Division 07	Thermal and Moisture Protection		
07 XX XX	Downspout, metal	41.00	LF
07 XX XX	Flashing	395.00	SF
07 XX XX	Insulation Spray	-	SF
07 XX XX	Exterior Walls Waterproofing	1,947.00	SF
07 XX XX	Roofing Waterproofing / Underhouse Waterproofing	1,780.00	SF

Division 08	Openings		
08 XX XX	Glass Quote Total	1.00	EA
08 XX XX	Customized Wood Double Doors Mechanical	1.00	EA
08 XX XX	Pocket Door Bathroom	1.00	EA
08 XX XX	Sliding Closet Door Bedroom	1.00	EA
08 XX XX	Living Module_Louvers, exterior, sunscreen_South	99.17	SF

Division 09	Finishes		
09 XX XX	Living Space - Wallcover, North	81.83	SF
09 XX XX	Living Space - Wallcover, South	57.33	SF
09 XX XX	Living Space - Wallcover, West	66.91	SF
09 XX XX	Living Space - Wallcover, East	81.00	SF
09 XX XX	Bedroom - Wallcover, West	76.00	SF
09 XX XX	Bedroom - Wallcover, East	48.25	SF
09 XX XX	Bedroom - Wallcover, North	112.42	SF
09 XX XX	Bedroom - Wallcover, South	119.50	SF
09 XX XX	Mechanical Room - Wallcover, North	41.33	SF
09 XX XX	Mechanical Room - Wallcover, South	41.33	SF
09 XX XX	Mechanical Room - Wallcover, West	76.00	SF
09 XX XX	Mechanical Room - Wallcover, East	76.00	SF
09 XX XX	Bathroom - Wallcover, North	53.28	SF
09 XX XX	Bathroom - Wallcover, South	53.28	SF
09 XX XX	Bathroom - Wallcover, West	76.25	SF
09 XX XX	Bathroom - Wallcover, East	71.00	SF
09 XX XX	Living Area_flooring	392.38	SF

09 XX XX	Living Area_flooring carpet	60.00	SF
09 XX XX	Bathroom Area_Tile flooring	81.39	SF
09 XX XX	Mechanical Area_Linoleum flooring	56.60	SF
09 XX XX	Resting Area_Wood flooring	193.15	SF
09 XX XX	Living Area_Ceiling	392.38	SF
09 XX XX	Resting Area_Ceiling	193.15	SF
09 XX XX	Bathroom Area_Ceiling	81.39	SF
09 XX XX	Living Space - Wallcover, North Backsplash	25.82	SF
09 XX XX	Bathroom Countertop	6.71	SF
09 XX XX	Kitchen Countertop	30.00	SF
Division 10	Specialties		
10 XX XX	Fire Extinguishers UL rating 2A-10BC	2.00	EA
Division 11	Equipment		
11 XX XX	Dryer vent	1.00	EA
11 XX XX	Refrigerator	1.00	EA
11 XX XX	Dishwasher	1.00	EA
11 XX XX	Oven	1.00	EA
11 XX XX	Washer	1.00	EA
11 XX XX	Induction Cooking Top	1.00	EA
11 XX XX	Vent Hood	1.00	EA
11 XX XX	Dryer	1.00	EA
Division 12	Furnishings		
12 XX XX	Bench, Shower	1.00	EA
12 XX XX	Cabinets -Wood	1.00	LS
Division 21	Fire Suppression		
21 XX XX	Heads, Sprinkler, Fire	10.00	EA
21 XX XX	Pump, jockey, fire	1.00	EA
Division 22	Plumbing		
22 XX XX	Lavatory - Kitchen	1.00	EA
22 XX XX	Lavatory Hardware - Kitchen	1.00	EA
22 XX XX	Toilet - Bathroom	1.00	EA
22 XX XX	Toilet Paper Holder - Bathroom	1.00	EA
22 XX XX	Towel Bar - Bathroom	1.00	EA
22 XX XX	Lavatory - Bathroom	1.00	EA
22 XX XX	Lavatory Hardware - Bathroom	1.00	EA
22 XX XX	Grab Bar 42" - Bathroom	1.00	EA
22 XX XX	Grab Bar 36" - Bathroom	1.00	EA
22 XX XX	Shower Hardware - Handshower Set	1.00	EA
22 XX XX	Shower Hardware - Rain Showerhead 8"	1.00	EA
22 XX XX	Shower Hardware - Thermostatic Mixing Valve Trim	1.00	EA
22 XX XX	1/2" PVC	419.50	LF
22 XX XX	3/4" PVC	75.04	LF
22 XX XX	1" PVC	17.49	LF
22 XX XX	1 1/4" PVC	15.25	LF
22 XX XX	1 1/2" PVC	36.40	LF
22 XX XX	2" PVC	8.80	LF
22 XX XX	2 1/2" PVC	0.27	LF
22 XX XX	3" PVC	14.36	LF
22 XX XX	4" PVC	17.40	LF

22 XX XX	Drains, floor	7.00	EA
22 XX XX	3" PVC Tee	2.00	EA
22 XX XX	Pipe, Steel, Fire Sprinkler System	100.00	LF
22 XX XX	Pipe, Steel, Hangars, Fire Sprinkler System	20.00	EA
22 XX XX	Other (Piping, etc.)	1.00	EA
Division 23	Heating, Ventilating, and Air-Conditioning		
23 XX XX	Bathroom Exhaust fan	1.00	EA
23 XX XX	HVAC, flex ducts, 5"	4.00	LF
23 XX XX	Energy Recovery Ventilator	1.00	EA
23 XX XX	Solar Thermal System	1.00	EA
23 XX XX	Heat Pump	1.00	EA
23 XX XX	Air Handling Unit	1.00	EA
23 XX XX	Heat Exchanger	1.00	EA
23 XX XX	Chilled Ceiling Panels	10.00	EA
23 XX XX	Ducts, Piping and Dampers	1.00	EA
23 XX XX	Floor Swirl Diffusers	12.00	EA
23 XX XX	Thermostats	2.00	EA
Division 25	Integrated Automation		
25 XX XX	Control 4 Home Automation System	1.00	EA
Division 26	Electrical		
26 XX XX	Panel, Electric, 150 A, 225A Bus, 42 slot	1.00	EA
26 XX XX	Breakers, Panel 15 A, 2 pole	1.00	EA
26 XX XX	Breakers, Panel 20 A, 1 pole	15.00	EA
26 XX XX	Breakers, Panel 30 , 2 pole	3.00	EA
26 XX XX	Breaker, Panel, 150 A, 2 pole	1.00	EA
26 XX XX	Disconnects, electrical	4.00	EA
26 XX XX	Breakers, Panel 40 A, 2 pole	1.00	EA
26 XX XX	Breakers, Panel 60 A, 2 pole	1.00	EA
26 XX XX	#10 THHN with GND	600.00	LF
26 XX XX	#8 THHN with GND	100.00	LF
26 XX XX	#12 THHN with GND	900.00	LF
26 XX XX	#1 THHN with #6 GND	75.00	LF
26 XX XX	Receptacles, Duplex, 15A	7.00	EA
26 XX XX	Receptacles, Duplex, 20A	5.00	EA
26 XX XX	Receptacles, Duplex, GFI, 20A	7.00	EA
26 XX XX	Dryer outlet	1.00	EA
26 XX XX	Range outlet	1.00	EA
26 XX XX	Lighting Total Estimate	1.00	EA
26 XX XX	CAT 6 Cable System	400.00	LF
26 XX XX	Switches, Lights	5.00	EA
26 XX XX	Switches, Lights, 3-way	2.00	EA
26 XX XX	Boxes, Junction, exterior	6.00	EA
26 XX XX	Boxes, Junction, interior	4.00	EA
Division 27	Communications		
27 XX XX	Communications	-	0
Division 28	Electronic Safety and Security		
28 XX XX	Smoke detectors	2.00	EA

Division 33	Utilities		
33 XX XX	Water Tank, Blackwater, 500 gallon	1.00	EA
33 XX XX	Water Tank, Competition Deliverable 1500 gallon	1.00	EA
33 XX XX	Water Tank, Domestic Hot Water, 120 gallon	1.00	EA
33 XX XX	Water Tank, HVAC Hot Tank, 70 gallon	1.00	EA
33 XX XX	Water Tank, Chilled Water, 200 gallon	1.00	EA
33 XX XX	Water Tank, Rainwater, 200 gallon	1.00	EA
33 XX XX	Water Tank, Greywater, 500 gallon	1.00	EA

Division 48	Electrical Power Generation		
48 XX XX	Solar Collector Panels	33.00	EA

CONSTRUCTION SPECIFICATIONS

Division 00 – Procurement and Contracting Requirements

00 01 15	List of Drawing Sheets
00 31 00	Available Project Information

Division 01 - General Requirements

01 10 00	Summary
01 29 00	Payment Procedures
01 31 00	Project Management Coordination
01 32 13	Project Coordination
01 33 00	Submittal Procedures
01 41 00	Regulatory Requirements
01 50 00	Temporary Facilities and Controls
01 54 19	Temporary Cranes
01 54 23	Temporary Scaffolding and Platforms

Division 05 – Metals

05 12 23	Structural Steel for Buildings
05 31 00	Steel Decking

Division 06 – Wood, Plastics, and Composites

06 10 00	Rough Carpentry
06 12 00	Structural Insulated Panels
06 15 13	Wood Floor Decking
06 16 00	Sheathing
06 20 13	Exterior Finish Carpentry

Division 07 – Thermal and Moisture Protection

07 10 00	Dampproofing and Waterproofing
07 21 00	Thermal Insulation
07 21 19	Foamed-In-Place Insulation
07 53 23	Ethylene-Propylene-Diene-Monomer Roofing
07 62 00	Sheet Metal Flashing and Trim
07 71 00	Roof Specialties
07 92 00	Joint Sealants

Division 08 – Openings

08 11 16	Aluminum Doors and Frames
08 14 16	Flush Wood Doors
08 32 13	Sliding Glass Doors
08 50 00	Windows
08 50 13	Aluminum Windows
08 71 00	Door Hardware
08 80 00	Glazing
08 83 00	Mirrors

Division 09 – Finishes

00 00 00
PROCUREMENT AND CONTRACTING REQUIREMENTS

00 00 00 - DIVISION CONTENTS

SECTION 00 01 15

LIST OF DRAWING SHEETS

PART 1 – GENERAL INFORMATION

1.01 LIST OF DRAWING SHEETS

CS-001	S-106	A-314	A-525	A-731
G-001	S-107	A-315	A-526	A-732
G-101	S-201	A-316	A-527	A-733
G-102	S-301	A-317	A-528	A-734
G-103	S-401	A-318	A-531	A-735
G-104	S-411	A-319	A-532	A-736
G-901	S-501	A-320	A-533	A-901
H-101	S-511	A-401	A-541	F-101
C-101	S-512	A-402	A-551	P-001
C-102	S-601	A-411	A-601	P-101
C-103	S-701	A-501	A-602	P-102
C-201	S-901	A-502	A-603	P-103
C-202	S-902	A-503	A-604	P-501
L-001	A-101	A-504	A-605	P-502
L-101	A-102	A-505	A-701	P-503
L-102	A-111	A-506	A-711	M-001
L-103	A-112	A-507	A-712	M-101
L-202	A-121	A-508	A-713	M-102
L-301	A-201	A-511	A-714	M-201
L-302	A-202	A-512	A-715	M-501
L-303	A-301	A-513	A-716	E-001
L-501	A-302	A-514	A-717	E-101
S-001	A-303	A-515	A-718	E-102
S-101	A-304	A-516	A-719	E-601
S-102	A-305	A-521	A-720	E-602
S-103	A-311	A-522	A-721	E-603
S-104	A-312	A-523	A-722	O-101
S-105	A-313	A-524	A-723	O-102
				O-103

1.02 STRUCTURAL SUBMISSION

A. The following is a list of all drawings and specifications sections that have been or will be stamped by the qualified, licensed design professional in the stamped structural submission.

S-001	S-106	S-501	S-601
S-101	S-107	S-511	S-701
S-102	S-201	S-512	S-901
S-103	S-301	S-521	S-902
S-104	S-401	S-522	
S-105	S-411	S-531	

END OF SECTION 00 01 15

SECTION 00 31 00

AVAILABLE PROJECT INFORMATION

PART 1 – GENERAL INFORMATION

1.01 PRELIMINARY SCHEDULE BY PHASE

A. Schematic Design Phase — January 2012 – April 2012

B. Design Development Phase — May 2012 – October 2012

C. Construction Documents Phase — August 2012 - February 2013

D. Construction Phase — November 2012 – July 2013

E. System and Building Testing Phase — July 2013 – August 2013

F. Competition Phase — September 2013 – October 2013

1.02 PROJECT BUDGET INFORMATION

A. Construction Budget: $300,000

B. Total Project Budget: $950,000

1.03 CONSTRUCTION FACILITY

A. The Team Capitol dc Solar Decathlon 2013 House will be constructed on the Campus of the Catholic University of America on a site provided by the Catholic University of America.
1. 620 Michigan Ave., NE Washington, DC 20064

END OF SECTION 00 31 00

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01 00 00
GENERAL REQUIREMENTS

01 00 00 - DIVISION CONTENTS

SECTION 01 10 00

SUMMARY

PART 1 – GENERAL INFORMATION

1.01 PROJECT INFORMATION

A. Project: Harvest, Team Capitol DC Solar Decathlon 2013
   1. Construction Location: 620 Michigan Ave., NE Washington, DC 20064
   2. Competition Location: Orange County Great Park, Irvine, CA

B. Owner: Team Capitol DC

C. Architect: The Catholic University of America, School of Architecture and Planning

D. Contractor: *Clark Construction*

E. The Work consists of Design, Construction, Transportation and assembly of an 800 sq. ft. house.

F. Owner Furnished Items: The following products will be furnished by Owner and shall be installed by Contractor as part of the work:
   1. Harvest Table
   2. Kitchen Table
   3. Bedroom Cabinetry
   4. Bedroom Barn Door
   5. Kitchen Millwork

1.02 WORK RESTRICTIONS

A. Contractor's Use of Premises: During construction, Contractor will have use of are indicated. Contractor's use of premises is limited only by Owner's right to perform work or employ other contractors on portions of Project.
   1. Owner will occupy premises during construction. Perform construction only during normal working hours (8 AM to 5 PM Monday thru Friday, other than holidays), unless otherwise agreed to in advance by Owner. Cleanup work areas and return to usable condition at the end of each work period.
   2. Limits: Limit site disturbance, including earthwork and clearing of vegetation, to 40 feet beyond building perimeter; 10 feet beyond surface walkways, patios, surface parking, and utilities less than 12 inches in diameter; 15 feet beyond primary roadway curbs and main utility branch trenches; and 25 feet beyond constructed areas with permeable surfaces (such as pervious paving areas, storm water

detention facilities, and playing fields) that require additional staging areas to limit compaction in the constructed area.

3. Driveways, Walkways, and Entrances: Keep driveways and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.

B. Nonsmoking Building: smoking is not permitted within the building or within 25 feet of entrances, operable windows, or outdoor-air intakes.

END OF SECTION 01 10 00

SECTION 01 29 00

PAYMENT PROCEDURES

PART 1 – GENERAL INFORMATION

1.01 APPLICATIONS FOR PAYMENT

A. Submit to Designers

B. Format
1. Payment Application forms shall be a similar format to AIA G702 – Application and Certificate for Payment and AIA G703 – Continuation Sheet, shall be itemized with line items, scheduled values, authorized change orders, percentage of completion, balance to finish and retainage.
2. Four (4) copies shall be submitted with original notarized signature.
3. Each copy shall include all necessary attachments.

C. Attachments for Applications for Payment:
1. Continuation sheets as described above

D. Attachments for FINAL Application for Payment:

E. Design Development Phase	May 2012 – October 2012
F. Construction Documents Phase	August 2012 - February 2013
G. Construction Phase	November 2012 – May 2013
H. System and Building Testing Phase	June 2013 – August 2013
I. Competition Phase	September 2013 – October 2013

1.02 PROJECT BUDGET INFORMATION

A. Construction Budget: $300,000

B. Total Project Budget: $950,000

1.03 CONSTRUCTION FACILITY

A. The Team Capitol dc Solar Decathlon 2013 House will be constructed on the Campus of the Catholic University of America on a site provided by the Catholic University of America.
    1. 620 Michigan Ave., NE Washington, DC 20064

END OF SECTION 01 29 00

SECTION 01 31 00

PROJECT MANAGEMENT AND COORDINATION

PART 1 – GENERAL INFORMATION

1.01 PROJECT COORDINATION

A. The University Partners (The Catholic University of America, The George Washington University and American University), General Contractor and Subcontractors shall review other sections of work applicable to their work and ascertain requirements in other section applicable to their own work. Each shall be held responsible for coordination and inclusion of the work indicated as if it were in the particular subcontractor's section. The Architects shall be advised of any discrepancies or conflicts at the earliest possible time.

B. All partners, general contractors, subcontractors, suppliers, etc. shall be held responsible for knowing and understanding what information is given on all drawing sheets and specifications concerning their required work. All items or work shown on drawings shall be included in the contract. The reverse condition shall also apply.

1.02 PROJECT MEETINGS

A. Pre-Construction Meetings
   1. A pre-construction conference will be scheduled immediately following the award of contract.
   2. The contractor shall be required to be present in addition to the project coordinator, job superintendent, and all major subcontractors specified within the contract.

B. Progress Meetings
   1. The partners, owner, general contractor, all subcontractors, material suppliers, and vendors who's presence is required, must attend all scheduled meetings called by the architects or other members of the team for the purpose of discussing the
   2. Progress meetings shall be held bi-weekly or as required, at the time and place designated by the owner and architect.
   3. Decisions, instructions, and interpretations given by the architects at these meetings shall be binding and conclusive on the contractor.
   4. Proceedings of the meetings shall be recorded and the contractor shall be issued a necessary amount of copies for use and distribution to the necessary subcontractors, vendors, material suppliers, etc.
   5. Prior to each meeting, the contractor shall have prepared a construction progress report, schedule updates, and reports on upcoming work.

END OF SECTION 01 31 00

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 – GENERAL INFORMATION

1.01 SUBMITTALS

A. Contractors shall submit shop drawings, product data, samples, and all other items required for review in accordance with this section and related requirements in the general conditions and paragraph 1.2 with reasonable promptness.

B. Subcontractors shall make submittals promptly so as to cause no delay in the work of the project or in the work of any other subcontractor.

C. Submittals shall contain:
1. The date of submission and the dates of any previous submissions
2. The project title and number
3. Contractor Identification
4. The names of:
a. The contractor
b. The supplier
c. The manufacturer
5. Identification of the project, with the specification section number, and locations at which materials and/or equipment are to be installed.
6. Details shall be identified by reference to sheet and detail, schedule or room numbers shown on contract drawings.
7. Field dimensions, clearly identified as such, made by the contractor or subcontractor.
8. Relation to adjacent or critical features of the work of materials.
9. Applicable standards, such as ASTM or federal specification numbers.
10. Identification of deviation from contract documents.
11. Identification of revisions on re-submittals
12. An 8” by 8” blank space for Contractor and Architect/Engineer Stamps
13. Four complete copies
14. Contractor’s approval stamp

1.02 STANDARDS OF PRODUCT APPROVAL

A. The naming of products and/or materials is done for the explicit purpose of establishing a basis of durability, efficiency, appearance, and simplification of maintenance, and not for the purpose of limiting competition. Other manufacturer’s materials or articles may be used providing the material or article is presented to and approved by the owner and design team, and is subject to the conditions described hereafter.

B. Approved Equal: Wherever products are specified describing proprietary items, model numbers, catalog numbers, or “as approved equal” to a specific manufacturer, establishing proof of the equality of the products to that specified shall be the responsibility of the contractor. Equality of all products is vested in the design team, whose decision shall be final and binding upon all concerned. Should use of a product be denied by the design team as not being equal to that specified, the contractor shall use either the product specified or one of equal quality as approved by the design team at no additional cost to the owner.

C. Agency or Association: when products are specified in accordance with Federal Specifications, American Standards or other recognized association standards, the contractor shall present proof from the manufacturer certifying that the product complies with the particular referenced standard where requested or specified, supporting test data shall be submitted to substantiate compliance.

1.03 CONTRACTOR’S RESPONSIBILITIES

A. Review shop drawings, product data and samples prior to submission of submittals.

B. Verify:
   1. Field measurements
   2. Field construction criteria
   3. Catalog numbers and similar data
   4. Conformance with specifications and construction drawings
   5. All dimensions and quantities

C. Coordinate each submittal with requirements of the work and of the contract documents

D. Notify the Architect/Engineer in writing, at the time of submission, of any deviations in the submittals from requirements of the contract documents

E. Stamp “Approved” or “Approved as Noted”, sign and date submission

F. Begin no fabrication or work which require submittals until the return of submittals with Architect/Engineer approval

G. Failure of the contractor to fulfill these responsibilities will result in the submittal(s) being returned to the contractor, unchecked by the architect for proper handling.

1.04 QUALITY ASSURANCE

A. Product literature shall permit the architect and engineers to determine which materials, equipment, and systems will be accepted in the project and shall consist of brochures, catalog cuts, or other data sufficient to clearly identify subject items; optional features to be utilized; performance characteristics, limitations; physical dimension; conformance with standards, codes, fire ratings, acoustical ratings, appearance, characteristic, and any other pertinent data to identify it as either item specified or as equal to that specified. Statements such as “as specified” will not suffice.

B. Shop Drawings
1. Shop drawings facilitate integration, coordination, and progress of the work and are not to be considered contract documents.
2. The architect and engineers will review shop drawings for general design requirements only.
3. Variations from the contract documents so minor as to involve no change in contract amount may be accepted if acceptance is in the owner’s interest, as determined by the architect. Do not construe the architect’s review as allowing the following:
   a. Variation from contract documents, except as specifically authorized or requested by the architect.
   b. Relieving the contractor of responsibility for errors in details or dimensions.
   c. Departures from additional details or instruction previously furnished by the architect.
   d. Relieving the contractor of responsibility for integrating and coordinating various trades and separate contracts.

C. Samples: Review of samples shall permit the architect and engineers to physically verify conformance of materials, products, fixtures, or devices with contract documents either by inspection or testing.
1. Review of samples will be only for characteristics or uses named in such review and shall not be taken to change or modify any contract requirement, except as specifically authorized or requested by the architect.
2. Samples shall set standards for items or characteristics of which samples are representative and after sample has been reviewed, no further change in brand, make or quality will be permitted.

END OF SECTION 01 33 00

SECTION 01 41 00

REGULATORY REQUIREMENTS

PART 1 – GENERAL INFORMATION

1.01 CODE REQUIREMENTS

A. U.S. Department of Energy Solar Decathlon 2013
   1. U.S. Department of Energy Solar Decathlon 2013 Building Code
   2. 2012 International Residential Code (IRC) of the International Code Council with Amendments
   3. 2012 International Energy Conservation Code
   4. 2011 National Electric Code (NEC) of National Fire Protection Agency (NFPA)
   5. 2009 ADA

B. District of Columbia

C. In cases of conflict, the most stringent requirements shall apply.

1.02 LAWS

A. All activities associated with the design, construction, transportation, and exhibition of the Team Capitol DC Solar Decathlon 2013 project are required to abide by applicable Federal, State, and Local Laws and Regulations.

1.03 RULES

A. U.S. Department of Energy Solar Decathlon 2013
   1. This project is designed to abide by the rules set forth by the U.S. Department of Energy Solar Decathlon 2013 Rules.

1.04 PERMITS

A. District of Columbia
   1. The Team Capitol dc Solar Decathlon 2013 Project will undergo review and inspections by the District of Columbia Fire Marshall's Office for Buildings. Team Capitol dc will be responsible for submitting all documentation for approval. Team Capitol dc will also work with a General Contractor to schedule onsite inspections as necessary for the permitting process as dictated by the District of Columbia Fire Marshall's Office.

END OF SECTION 01 41 00

SECTION 01 50 00

TEMPORARY FACILITIES AND CONTROLS

PART 1 – GENERAL INFORMATION

1.01 SECTION REQUIREMENTS

A. Electric Power: Available from a portable generator provided by the team. Provide connections and extensions of services as required for construction operations.

B. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.

PART 2 – PRODUCTS

2.01 OWNER PROVIDED EQUIPMENT

A. Generators
   1. Generator:
   2. AC Output:
   3. Full GFCI Protection
   4. Noise:
      a. Engine generators shall not exceed 60dB (A) at 50ft under full load per the manufacture's listed sound rating. Operation and refueling of generators are limited to times approved by the organizers.

PART 3 – EXECUTION

3.01 TEMPORARY UTILITY INSTALLATION

A. Team Capitol dc is to provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, inspections, and traffic conditions.

3.02 SECURITY AND PROTECTION FACILITIES INSTALLATION

A. Supervision: Enforce strict discipline in the use of temporary facilities. To minimize waste and abuse, limit the availability of temporary facilities to essential and intended uses.

B. Remove each temporary facility when need for its use has ended when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion.

END OF SECTION 01 50 00

SECTION 01 53 00

TEMPORARY FOUNDATIONS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. Section Includes:
   1. Temporary Building Foundations
   2. Temporary Deck Foundations

B. Related Sections:
   1. Division 05 12 00 “Structural Steel Framing”
   2. Division 05 50 00 “Metal Fabrications”
   3. Division 06 10 00 “Rough Carpentry”
   4. Division 06 15 00 “Wood Decking”

PART 2 – PRODUCTS

2.01 BUILDING FOUNDATIONS

A. Building Footings
   1. Fabricated Steel

2.02 DECK FOUNDATIONS

A. Deck Footings
   1. Fabricated Steel

B. Connection plate

C. 4”x4” Wood Riser

D. Plywood Base

PART 3 – EXECUTION

3.01 INSTALLATION, BUILDING FOUNDATIONS

A. Neoprene pad placed on tarmac.

B. Steel bottom place placed onto of neoprene pad.

C. Steel Rod, bolted into steel bottom plate.

D. Module lowered onto building foundation, and bolted to z clip.

3.02 ASSEMBLY DECK FOUNDATIONS

A. Screw base plate to plywood base.

B. Screw 4x4 wood riser to plywood base.

C. Screw footing lever to top of 4x4 wood riser.

D. Connect to decking frame with connector plate.

END OF SECTION 01 53 00

SECTION 01 54 19

TEMPORARY CRANES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Temporary Cranes

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufactures
   1. To be determined

2.02 TEMPORARY CRANES

A. Type: 100 ton, All Terrain Crane,
   1. Boom Extension: 164 feet

PART 3 – EXECUTION

1.01 INSTALLATION

A. Prepare gound by cleaning, removing projections, clearing obstructions, and cording off safe work zone, and as otherwise recommended in temporary crane manufacture's written instructions.

B. Ground crane securely in place, per operational specifications.

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

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

E. Coordinate operations with structural requirements per specifications of structural engineer and crane operator.

F. Correct deficiencies in or remover and reinstall temporary cranes that do not comply with requirements.

END OF SECTION 01 54 19

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05 00 00
METALS

05 00 00 - DIVISION CONTENTS

SECTION 05 12 23

STRUCTURAL STEEL FRAMING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Structural steel
   2. Bolts, washers, and other steel accessories
   3. Welded steel connections

B. Related Sections:
   1. Division 01 Section “Quality Requirements”
   2. Division 09 Section “Paintings and Coatings” for surface-preparation and priming requirements.

1.02 SUBMITTALS

A. Submit complete Product Data for each product specified

B. Shop Drawings included all products specified
   1. Submit shop drawings to Engineer for review and obtain Engineer’s acceptance prior to start of fabrication.
   2. Include layout, member size, and weights, materials used, and beam marks as well as orientation and relation of members to appropriate fired lines.
   3. Include details of cuts, connections, splices, camber, holes, openings, doubler plates, stiffeners and other pertinent data, including bolt hole sizes, connections materials, and welded joint designations.
   4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts.

C. Connection Design:
   1. The Engineer shall be licensed in the state in which the project is constructed.
   2. Submit calculations of all connections. Calculations and details shall be clearly keyed to the appropriate members on the construction documents. Calculations shall bear the seal of the Engineer supervising design of the steel connections.

1.03 QUALITY ASSURANCE

A. Shop and field testing and inspection of steelwork specified in this document or otherwise required will be performed by an independent agency.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Do not handle structural steelwork until paint has thoroughly dried. Care shall be exercised to avoid abrasions and other damage.

B. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Materials shall be kept free from dirt, grease, and other foreign matter.

C. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.

PART 2 – PRODUCTS

2.01 MATERIAL

A. Wide Flanges: ASTM A992.

B. Channels: ASTM A572 Grade 50.

C. Plates: ASTM A36.

D. Cold-Formed Hollow Structural Sections: ASTM A500, Grade B, seamless structural tubing.

E. Steel Pipe: ASTM A53, Type E, Grade B.

2.02 FABRICATION

A. Fabricate structural steel in accordance with AISC 360 and AISC 303.

B. Fabricate and assemble in shop to the greatest extent possible.

C. High strength bolts: install according to RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts" for type of bolt and type of joint specified.

D. Weld connections: comply with AWS D1.1 for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work. Welding shall be accomplished by certified welders.

E. Priming
1. Shop prime steel surfaces.
2. Surface preparation: clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to SSPC-SP2 "Hand Tool Cleaning" and SSPC-SP3 "Power Tool Cleaning."
3. Immediately after surface preparation, apply primer according to manufacturer's written instructions and at a rate recommended by SSPC to provide a minimum dry film

thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Prepare ground surface by cleaning, removing projections, filling voids, and as otherwise recommended in steel manufacturer's instructions.

B. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place using appropriate fastening methods.

C. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360. Check plumbness after erection.

D. Where erection requires performing work of fabrication on site, comply with the applicable standards of Part 2 of this specification.

E. Correct deficiencies or remove and reinstall any steel framing that does not comply with requirements.

F. Repair, refinish, or replace aluminum extrusions and connecting hardware damaged during installation, as directed by Architect.

END OF SECTION 05 12 23

SECTION 05 31 00

STEEL DECKING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Steel Roof Deck
2. Steel Floor Deck

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.3, “Structural Welding Code – Sheet Steel.”

PART 2 – PRODCUTS

2.01 DECKING

A. Comply with SDI Publication No. 31.

B. Steel Roof Deck: fabricate panels from galvanized steel sheet with raised pattern ribs and interlocking side laps, to comply with the following:
1. Profile Depth: 1-1/2 inches (38 mm)
2. Gauge: 18
3. Manufacturer: New Millennium

C. Steel Floor Deck: fabricate panels from galvanized steel sheet with raised pattern ribs and interlocking side laps, to comply with the following:
1. Profile Depth: 3 inches (76 mm)
2. Gauge: 18
3. Manufacturer: New Millennium

PART 3 – EXECUTION

3.01 INSTALLATION

A. Place, adjust, align, and bear deck panels on structure. Do not stretch or contract side-lap interlocks.

B. Place deck panels flat and square and fasten using powder actuated tool or weld to structure without warp or deflection.

C. Cut, reinforce, and fit deck panels and accessories around openings and projections.

D. Prepare and repair damaged galvanized coatings on both surfaces with galvanized repair paint according to ASTM A 780.

END OF SECTION 05 31 00

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06 00 00
WOOD, PLASTICS, AND COMPOSITES

06 00 00 - DIVISION CONTENTS

SECTION 06 10 00

ROUGH CARPENTRY

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Framing

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings

PART 2 – PRODUCTS

2.01 FRAMING

A. Certified Wood: Wood framing shall be certified as “FSC Pure” or “FSC Mixed Credit” according to FSC STD-01-001, “FSC Principles and Criteria for Forest Stewardship,” and to FSC STD-40-004, “FSC Standard for Chain of Custody Certification.”

B. Reclaimed materials: shall be de-nailed and re-planned to have consistent finish clean finish from excess materials.

C. Dimension Lumber:
   1. Maximum Moisture Content: 15 percent for 2-inch nominal (38-mm actual) thickness or less, 19 percent for more than 2-inch nominal (38-mm actual) thickness.
   2. Non-Load-Bearing Interior Partitions: Construction or No. 2
   3. Framing Other Than Non-Load-Bearing Interior Partitions: No. 2
      4. Exposed Framing: Provide material hand-selected for uniformity of appearance and freedom from characteristics, on exposed surfaces and edges, that would impair finish appearance, including decay, honeycomb, knot-holes, shake, splits, torn grain, and wane.
         a. Species: As specified for framing other than non-load-bearing interior partitions.
         b. Grade: No. 2

C. Timbers 5-Inch Nominal (117 –mm Actual) Size and Thicker: No. 1
      1. Maximum Moisture Content: 20 percent

PART 3 – EXECUTION

3.01 INSTALLATION

A. Set rough carpentry to require levels and lines, with members' plumb, true to line, cut and fitted. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.

B. Framing Standard: Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.

C. Do not splice structural members between supports unless otherwise indicated.

D. Securely attach rough carpentry to substrates, complying with the following:
1. CABO NER-272 for power driven fasteners.
2. Published requirements of metal framing anchor manufacturer.
3. [Table 2304.9.1, "Fastening Schedule," in the IBC] [Table R602.3(1), "Fastener Schedule for Structural Members, " and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two- Family Dwellings].

END OF SECTION 06 10 00

SECTION 06 12 00

STRUCTURAL INSULATED PANELS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Structural Insulated Panels

1.02 SUBMITTALS

A. Submit complete specifications, shop drawings, and EPS Code Compliance.
B. Provide Structural Calculation prepared by a design professional registered in the state where work is being performed.

1.03 REFERENCES

A. American Society of Civil Engineers (ASCE) Publications
   1. ASCE 7 – Minimum Loads for Buildings and Other Structures.

B. ASTM International Publications:
   1. ASTM C578 – Standard Specifications for Rigid, Cellular Polystyrene Thermal Insulation.
   2. ASTM E72 – Standard Test Methods of Conducting Strength Tests of Panels for Building Construction
   3. ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials
   4. ASTM E1803 – Standard Test Method for Determining Structural Capacities of Insulated Panels.

C. APA The Engineered Wood Association Publications:
   1. DOC PS2 – Performance Standard for Wood-Based Structural-Use Panels.
   2. APA PRP-108 – Performance Standards and Qualification Policy for Structural-Use Panels

1.04 WARRANTY

A. All SIPs will meet the specification set out in the Insulspan Sales Order, associated project drawings and the Insulspan Design Manual, as applicable; and be free from any defect in materials and workmanship on the date of final delivery to the Owner.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. ACME

Panel Thickness	Insulation Thickness	Panel to Panel Connection Type	Roof Overall R-Value	Wall Overall R-Value
4-1/2"	3-5/8"	OSB Spline	16.3	16.5
		Single 2x Lumber	15.7	15.5
6-1/2"	5-5/8"	OSB Spline	23.8	23.3
		Single 2x Lumber	23.4	22.3
8-1/4"	7-3/8"	OSB Spline	30.3	29.2
		Single 2x Lumber	29.2	28.0

2.02 MATERIALS

A. Expanded Polystyrene (EPS) core – EPS insulation complying with ASTM C578, Type 1

B. Oriented Strand Board (OSB)

C. Adhesives shall be in conformance with ICC ES AC05

2.03 ACCESSORIES

A. Splines:
1. OSB, dimensional lumber, engineered wood or I-beam for use in joining SIPs shall be supplied by the SIP manufacturer as specified on approved SIP shop drawings

B. Fasteners:
1. Nails as per SIP manufacturer design requirements shall be used for spline and plate attachments following fastening requirements specified on approved SIP shop drawings. Nails for field installation of spline and plated to be supplied by the SIP installer.
2. Panel screws as per SIP manufacturer design requirements shall be used following fastening requirements specified on approved SIP shop drawings. Panel screws are to be supplied by the SIP manufacturer or approved equal supplied by the SIP installer.

C. SIP Sealant
1. Sealants shall be specifically designed for use with SIPs. Sealant must be compatible with all components of the SIP. Sealant is to be supplied by the SIP manufacturer or approved equal supplied by the SIP installer.

D. SIP Panel Seal Tape

1. Tape with an adhesive suitable for indoor use, minimum 6” wide for use on flat SIP joints and minimum 12” wide for use on opposing angled surfaces including ridge and roof-to-wall connections. SIP tape shall be supplied by the manufacturer.

2.04 FABRICATION

A. Panel sizes shall be fabricated in accordance with approved shop drawings. Maximum panel size shall be 2440 mm x 7320 mm (8’ X 24’). Fabrication tolerances shall comply with values in manufacturer product specification.

B. Manufacturing Standards: SIPs shall be manufactured under a third party certification program monitored by an accredited agency and manufacturer shall maintain a quality management system in accordance with ISO 9001: 2000.

C. SIP Thermal Resistance at a Mean Temperature of 75° F (24º C) for SIP only consisting of 7/16” (11 mm) OSB structurally laminated to both faces of EPS insulation core.
NOTE**:** SIP effective thermal resistance values are for Insulspan SIPs with OSB surface spline or Insulspline panel to panel connection type. Thermal resistance value does not include interior/exterior cladding or finish materials and air films. R-value (Inch-pound) units of measure are (ft^2•hr•°F)/BTU. RSI-Value (SI System) units of measure are (m^2•°C)/W.
1. 4 ½” (114 mm) thick SIP with R-14.5 (RSI-2.56).
2. 6 ½” (165 mm) thick SIP with R-22.1 (RSI-3.88).
3. 8 ¼” (210 mm) thick SIP with R-28.6 (RSI-5.03).
4. 10 ¼” (260 mm) thick SIP with R-36.1 (RSI-6.35).
5. 12 ¼” (311 mm) thick SIP with R-43.6 (RSI-7.68).

D. Fire Performance Rating: Intertek Testing Services or equal assembly listing for testing per ASTM E119/CAN/CSA-S101 to required fire resistance rating

2.05 PRODUCT SUBSTITUTIONS

A. Substitutions: No substitutions permitted without fourteen day (14) prior approval.

2.06 RELATED MATERIALS

A. Related Material: refer to other sections for related materials as follows:
1. Dimensional Lumber: SPF # 2 or better or pre-engineered equivalent: Refer to Division 06 carpentry Section.

2.07 SOURCE QUALITY

A. Source Quality Assurance: Each SIP component required shall be supplied by SIP manufacturer and shall be obtained from the selected SIP manufacturer of its approved supplier.

B. Each SIP shall be labeled indicating Third Party Certification.
1. Provide evidence of Third Party Certification and labeling of all insulation used in the manufacturing of SIPs.

2. SIP manufacturer shall provide lamination, R-value (RSI-value) and warranty document for building owner acceptance and execution.
3. Dimensional Tolerance – shall comply with values listed in the SIP manufacturer Quality Control Manual.

C. Source Quality: Obtain SIPs from a single manufacturer.

PART 3 - INSTALLATION

3.01 MANUFACTURER INSTRUCTIONS

A. Compliance: Comply with SIP manufacturer {ICC-ES} {CCMC} evaluation reports, published Load Design Charts, Construction Assembly Drawings, Approved Shop Drawings and product data including Technical Bulletins and Product Information Bulletins for design and installation.

B. Construction Documents and Shop drawings shall be reviewed by a qualified architect/engineer and shall be signed and sealed. Deviations from standard details or load design values shall be calculated for the specific use and the calculations and details shall be signed and sealed by a registered design professional and provided to the manufacturer.

3.02 EXAMINATION

A. Site Verification of Conditions: Verify substrate conditions (which have been previously installed under other related sections) are acceptable for product installation in accordance with SIP manufacturer instructions and guidelines.
   1. Verify conditions of foundation/structural system/substrate and other conditions which affect installation of SIPs. Any adverse conditions shall be reported in writing to the SIP manufacturer and the lead design professional. Do not proceed with installation until adverse conditions are corrected and documented.

3.03 INSTALLATION

A. SIP Installation:
   1. SIP Support: Provide level and square foundation/structural system/substrate that support wall and/or roof SIPs. For wall SIPs hold sill plate back from edge of deck ½" to provide full bearing of both OSB skins. Provide adequate bracing of SIPs during panel erection. Remove debris from plate area prior to application of sealant and SIP placement.
   2. Electrical: If requested, provide 1 ½" diameter access holes in top and bottom plating to align with electrical wire chases in SIPs. Align all horizontal electrical chases in SIPs and maintain debris free electrical chases.
   3. SIP Fastening: Connect SIPs using screws or nails as shown on approved shop drawings. Where manufacturer supplied SIP Screws are used, a minimum of 1 ½" of penetration is required into wood support.
   4. SIP Sealant: Sealant must be installed in a continuous bead at all connections.

5. SIP Tape: Apply SIP tape at joints between roof SIPs, at the roof-to-wall connection and at the ridge. Tape shall only be installed after all spline connections are completed as per Manufacturer installation instructions.
6. Vapor Retarders: Provide vapor retarders as required by applicable building code.
7. Thermal Barriers: Interior surface of SIPs shall be finished with a minimum 15-minute thermal barrier, such as ½" gypsum wall board, nominal 1" (25 mm) solid wood paneling, or other approved materials. Apply approved thermal barrier according to requirements of applicable building code.
8. Restrictions: Do not install SIPs directly or in contact with concrete/dirt. Do not install plumbing in a SIP without consulting SIP manufacturer. Do not over-cut panel skins for approved field-cut openings. Do not cut skins to install electrical chases. Do not expose EPS core of SIPs to any solvents or solvent-based adhesives.
9. Remove and replace any SIP wall or roof panels which have become wet or damaged before proceeding with the installation of additional SIPs or other work that may cover a compromised SIP.

3.04 PROTECTION

A. Protection: Protect installed product from exposure and damage during construction.
   1. Wall or Roof SIP Temporary Protection: Protect SIPs from weather with temporary protection at the end of each day or when rain or snow is imminent. Apply wall or roof sheathing membrane to exposed panel faces as soon as practical after installation.
   2. After installation is complete, cover SIPs to prevent contact with excessive water on all exposed SIP edges and faces.
   3. Wall or Roof SIP Cladding: Cladding design must include a second line of defense based upon the anticipated wind-driven rain, snow and ice condition for the geographical location, building code requirements and cladding manufacturer requirements.
   4. Roof SIP: Roofing material must only be installed on a dry SIP roof with a moisture content of 17% or less.

END OF SECTION 06 12 00

SECTION 06 15 33

WOOD PATIO DECKING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Exterior Wood Decking

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings

B. Submit ICC-ES evaluation reports for wood-preservative treated wood, expansion anchors, metal framing anchors, and decking fasteners.

1.03 QUALITY ASSURANCE

A. List of Attachments

PART 2 – PRODCUTS

2.01 WOOD PRODUCTS

A. Lumber: Provide dressed lumber, S4S, marked with grade tamp of inspection agency.

B. Reclaimed Wood: Shall be de-nailed and re-planned to have consistent finish clean finish from excess materials.

C. Certified Wood: Wood-based materials shall be certified as “FSC Pure” or “FSC Mixed Credit” according to FSC STS-01-001.

2.02 TREATED MATERIALS

A. Preservative-Treated Boards and Dimension Lumber: AWPA U1; Use Category UC3b

1. Use treatment containing no arsenic or chromium.

B. Preservative-Treated Timber and Poles: AWPA U1; Use Category UC4a, waterborne preservative.
   1. Use treatment containing no arsenic or chromium.
   2. Treatment with CCA shall include post-treatment fixation process.

C. After treatment, redry boards, dimension lumber, timber, and poles to 19 percent maximum moisture content.

D. Mark treated wood with treatment quality mark of an inspection agency approved by ALSC’s Board of Review.

E. Provide preservative-treated materials for all exterior rough carpentry unless otherwise indicated.

2.03 LUMBER

A. Dimension Lumber
   1. Maximum Moisture Content: 15 percent for 2-inch nominal thickness or less
   2. Deck and Stair Framing:
   3. Dimension Lumber Posts:
   4. Dimension Lumber Decking:
   5. Dimension Lumber Railing Members or Benches:

B. Boards:
   1. Maximum Moisture Content: 15 percent
   2. Board Decking and Stair Treads: 1-¼ inch thick, radius-edged decking of the following species and grades:

2.04 MISCELLANEOUS PRODUCTS

A. Fasteners: Stainless steel

   1. Provide nails or screws, in sufficient length, to penetrate not less than 1-½ inches into wood substrate.
   2. Power driven Fasteners: CABO NER-272
   3. Carbon Steel Bolts: ASTM A 307 with ASTM A 563 hex nuts and, where indicated, flat washers all hot-dip zinc coated.

B. Postinstalled Anchors: Stainless steel anchors with capability to sustain, without failure, a load equal to six times the load imposed as determined by testing per ASTM E 488.

C. Metal Framing Anchors: Stainless steel complying with ASTM A 666, Type 304.

D. Deck Clips: Black-oxide-coated stainless-steel clips designed to be fastened to deck framing with screws, and to secure decking material with teeth.

E. Deck Tracks: Formed metal strips designed to be fastened to deck framing and to secure decking material from underside with screws. Made from stainless steel.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Set work to required levels and lines, with members plumb, true to line, cut and fitted. Locate nailers, blocking, and similar supports to comply with requirements for attaching other constructions.

B. Framing Standard: Comply with AF&PA's "Details for Conventional Wood Frame Construction" unless otherwise indicated.

C. Securely attach work to substrates, complying with the following:
1. CAB O NER-272 for power driven fasteners
2. Published requirements of metal framing anchor manufacturer

D. Secure decking to framing with concealed decking fasteners.

E. Secure stair treads and risers by gluing and screwing to carriages. Countersink fastener heads, fill flush, and sand filler. Extend treads over carriages.

END OF SECTION 06 15 33

SECTION 06 16 00

SHEATHING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Plywood
2. Oriented Strand Board

1.02 SUBMITTALS

C. Submit complete specifications and shop drawings

PART 2 – PRODUCTS

2.01 WALL SHEATHING

A. Plywood Wall Sheathing: Exterior sheathing.

B. Oriented-Strand-Board Wall Sheathing: Exposure 1 sheathing

C. Paper-Surfaced Gypsum Wall Sheathing: ASTM C 1396/C 1396M, gypsum sheathing; with water-resistant-treated core.

2.02 ROOF SHEATHING

F. Plywood Roof Sheathing: Exterior sheathing.

G. Oriented-Strand-Board Roof Sheathing: Exposure 1 sheathing.

2.03 SUBFLOORING AND UNDERLAYMENT

A. Combination Subfloor-Underlayment:
1. Plywood Combination Subfloor-Underlayment: DOC PS 1, Exposure 1, Underlayment single-floor panels.

2. Oriented-Strand-Board Combination Subfloor-Underlayment: Exposure 1 single-floor panels.

B. Subflooring:
1. Plywood Subflooring: Exposure 1 single-floor panels or sheathing.
2. Oriented-Strand-Board Subflooring: Exposure 1, single-floor panels or sheathing.

2.04 MISCELLANEOUS PRODUCTS

A. Fasteners: Size and type indicated.
1. For roof and wall sheathing, provide fasteners of Type 304 stainless steel.
2. Power-Driven Fasteners: CABO NER-272.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Securely attach to substrates, complying with the following:
1. CABO NER-272 for power-driven fasteners.
2. Table R602.3(1), “Fastener Schedule for Structural Members,” and Table R602.3(2), “Alternate Attachments,” in ICC’s International Residential Code for One- and two-Family Dwellings.

B. Fastening Methods:
1. Combination Subfloor-Underlayment
   a. Screw to wood framing.
   b. Screw to cold-formed metal framing.
2. Subflooring:
   a. Screw to wood framing.
   b. Screw to cold-formed metal framing.
3. Wall and Roof Sheathing:
   a. Screw to wood framing.
   b. Screw to cold-formed metal framing.

C. Glass-Mat Gypsum Sheathing Joint-and-Penetration Treatment: Seal sheathing joints and penetrations according to sheathing manufacture’s written instructions.

D. Install cementitious backer units and treat joints according to ANSI A 108.11 and manufacture’s written instructions for type of application indicated.

END OF SECTION 06 16 00

SECTION 06 20 13

EXTERIOR FINISH CARPENTRY

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Exterior Rainscreen

B. Related Sections:
   1. Division 09 93 13 “Exterior Staining and Finishing”

1.02 SUBMITTALS

A. Submit labeled sample of siding materials for approval, with complete specifications and shop drawings

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics

1.04 WARRANTY

A. Manufacturer’s Product Warranty: Northland Forest Products
   1. Warranty period: Twenty-Five (25) year warranty against decay.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Reclaimed Wood

2.02 WOOD SPECIES

A. Yellow Poplar
B. Red Oak
C. White Oak

D. Cherry
E. Chestnut
F. Mahogany
G. Yellow Pine
H. Spruce
I. Other unspecified species

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Install siding system in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

A. Field Tests: Northland Forestry Products to perform testing on all wood in the NFP test facilities. Tests not meeting specified performance requirements and units having deficiencies shall be corrected.

3.03 PROTECTION AND CLEANING

A. Protection: Protect installed product's finished surfaces from damage during construction.

B. Cleaning: Repair or replace damaged installed products. Clean installed products in accordance with manufacturer's instructions prior to owner's acceptance. Remove construction debris from project site and legally dispose of debris.

END OF SECTION 06 20 13

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07 00 00
THERMAL AND MOISTURE PROTECTION

07 00 00 - DIVISION CONTENTS

SECTION 07 21 00

THERMAL INSULATION

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Extruded-Polystyrene Board Insulation
   2. Open-Cell Polyurethane Foam Insulation

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Surface-Burning Characteristics: According to ASTM 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

PART 2 – PRODCUTS

2.01 INSULATION PRODUCTS

A. Extruded-Polystyrene Board Insulation: ASTM C 578, Type TBD, with flame –spread and smoke-developed indexes of 75 and 450, respectively.
   1. Manufacturer: TBD

B. Open-Cell Polyurethane Foam Insulation: Spray-applied polyurethane foam using water as a blowing agent, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, and minimum density of 0.4 lb/cu. Ft. (6.4 kg/cu. m.)
   1. Manufacturer: TBD

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install insulation in areas in thicknesses indicated or required to produce R-values indicated. Cut and fit tightly around obstructions and fill voids with insulation.

B. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.

C. Install eave ventilation troughs between roof framing members in insulated attic spaces at vented eaves.

D. Except for loose-fill insulation and insulation that is friction fitted in stud cavities, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.

E. Spray-Applied Insulation: Apply insulation according to manufacturer’s written instructions. Do not apply insulation until installation of pipes, duct, conduits, wiring, and electrical outlets in walls is completed and items not indicated to receive insulation are masked. After insulation is applied, make flush with face of studs.

END OF SECTION 07 21 00

SECTION 07 53 23

ETHYLENE-PROPYLENE-DIENE-MONOMER (EPDM) ROOFING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. EPDM Sheet

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 WARRANTY

A. Manufacturer’s standard form or customizes, without monetary limitation, signed by roofing manufacturer agreeing to repair leaks due to defects in materials or workmanship for period of TBD years.

PART 2 – PRODCUTS

2.01 PERFORMANCE REQUIREMENTS

A. Energy Performance: Initial Solar Reflectance not less than 0.70 and Thermal Emittance not less than 0.75 when tested according to CRRC-1.

B. Solar Reflectance Index: Not less than 78 when calculated according to ASTM E 1980.

C. Exterior Fire-Test Exposure: ASTM E 108, Class TBD

2.02 ROOFING MATERIALS

A. EPDM Sheet: ASTM D 4637, Type TBD, thickness TBD
1. Manufacturer: TBD

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install EPDM sheet according to roofing system manufacturer's written instructions and as follows:
   1. Adhered Sheet Installation: Apply bonding adhesive to substrate and underside of sheet and allow to partially dry. Do not apply bonding adhesive to splice area of sheet.
   2. Mechanically Fastened Sheet Installation: Secure one edge of sheet using fasting plates or battens centered within the membrane splice and mechanically fasten sheet to roof deck.

END OF SECTION 07 53 23

SECTION 07 62 00

SHEET METAL FLASHING AND TRIM

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Sheet Metal

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

PART 2 – PRODCUTS

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.
   1. Finish: Manufacturer’s Standard
   2. Concealed Finish: Manufacturer’s standard white or light-colored acrylic or polyester backer finish.

2.02 ACCESSORIES

A. Fasteners: Wood screws, annular-threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners.
   1. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with SMACNA's "Architectural Sheet Metal Manual." 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 a bituminous coating or polymer-modified, bituminous sheet underlayment.

END OF SECTION 07 62 00

SECTION 07 71 00

ROOF SPECIALTIES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Gutters and Downspouts

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 WARRANTY

A. Provide manufacturer's standard written warranty, signed by manufacturer agreeing to promptly repair or replace roof specialties that show evidence of deterioration of factory-applied finishes within TBD years from date of Substantial Completion.

PART 2 – PRODCUTS

2.01 ROOF SPECIALTIES

A. Gutters and Downspouts:
   1. Manufacturers:
   2. Gutters: Manufactured in uniform section lengths, with matching corner units, ends, outlet tubes, and other accessories. Elevate back edge at least 1 inch (25 mm) above front edge. Furnish expansion joints, and expansion-joint covers.
      a. Gutter Style: TBD
      b. Aluminum: TBD Thickness
      c. Gutter Supports: TBD with finish matching the gutters
   3. Downspouts: Plain rectangular with mitered elbows. Furnish wall brackets of same material and finish as downspouts, with anchors.
      a. Formed Aluminum: TBD thickness
      b. Extruded Aluminum: TBD thickness

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Install roof specialties according to manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement.

B. Coat back side of [aluminum] [stainless-steel] roof specialties with bituminous coating where they will contact wood, ferrous metal, or cementitious construction.

C. Separate dissimilar metals with a bituminous coating or polymer-modified, bituminous sheet underlayment.

D. Fastener Sizes: Use fasteners of sizes that will penetrate wood blocking or sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws.

E. Gutters: Join and seal gutter lengths. Allow for thermal expansion. Attach gutters to firmly anchored gutter supports spaced not more than 12 inches (305 mm) apart. Attach ends with rivets and solder to make watertight. Slope to downspouts.

F. Downspouts: Join sections with manufacturer's standard telescoping joints. Provide hangers with fasteners designed to hold downspouts securely to walls and 1 inch (25 mm) away from walls; locate fasteners at top and bottom and at approximately 60 inches (1500 mm) o.c.

END OF SECTION 07 71 00

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08 00 00
OPENINGS

08 00 00 - DIVISION CONTENTS

SECTION 08 11 16

ALUMINUM DOORS AND FRAMES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Aluminum doors and frames

B. Related Sections:
   1. Division 08 80 00 “Glazing”

1.02 SUBMITTALS

A. Submit labeled sample of glazing materials for approval, with complete specifications and shop drawings

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics

1.04 WARRANTY

A. Manufacturer’s Product Warranty: Western Window Systems
   1. Warranty period: Two (2) years from the Date of Manufacture and the warranty on the replacement parts will extend only for the balance of the warranty period of the original product.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Exterior Doors shall be provided from the following manufacturer:
   1. Western Windows
   2. www.westernwindowsystems.com
   3. Point of Contact: Brian Flavin

2.02 DOORS

A. Mechanical Closet
   1. HM Double Door
   2. Dimensions:
      a. Rough Opening:
      b. Frame Size (Width x Height): 96” x 84”
      c. Jamb Width: 4.5”
   3. Hardware:
      a. Stainless Steel
   4. Frame Finish:
      a. Black Anodized
      5. Basis of Design: CECO: 01 18 CRS 60 70 f

A. Entry Bedroom
   1. Swing In Direction, Medium Stile, Thermally Broken
   2. Dimensions:
      a. Rough Opening:
      b. Frame Size (Width x Height): 39” x 84”
      c. Jamb Width: 4.5”
   3. Glazing:
      a. Insulated Low E, SolarBan 70, Argon Gas
      b. Tempered Glass, 1” OA (5mm/.62”/5mm)
      c. U-Value: .53
      d. SHGC (Solar Heat Gain Coefficient): .18
      e. VT (Visible Transmittance):
      f. Water Penetration: 3.00 PSF
      g. Aluminum Box Spacer, Black
   4. Hardware:
      a. Coastal Stainless Package
   5. Frame Finish:
      a. Bronze Anodized
   6. Basis of Design:
      a. Western Window Series 900 Entry Door Right

B. Entry Living Room
   1. Swing In Direction, Medium Stile, Thermally Broken
   2. Dimensions:
      a. Rough Opening:
      b. Frame Size (Width x Height): 42” x 84”
      c. Jamb Width: 4.5”
   3. Glazing:
      a. Insulated Low E, SolarBan 70, Argon Gas
      b. Tempered Glass, 1” OA (5mm/.62”/5mm)
      c. U-Value: .53

   d. SHGC: .18
   e. VT:
   f. Water Penetration: 3.00 PSF
   g. Aluminum Box Spacer, Black
4. Hardware:
   a. Coastal Stainless Package
5. Frame Finish:
   a. Bronze Anodized
6. Basis of Design:
   a. Western Window Series 900 Entry Door Right

C. Entry Kitchen
1. Swing In Direction, Medium Stile, Thermally Broken
2. Dimensions:
   a. Rough Opening:
   b. Frame Size (Width x Height): 85” x 84”
   c. Jamb Width: 4.5”
3. Glazing:
   a. Insulated Low E, SolarBan 70, Argon Gas
   b. Tempered Glass, 1” OA (5mm/.62”/5mm)
   c. U-Value: .53
   d. SHGC: .18
   e. VT:
   f. Water Penetration: 3.00 PSF
   g. Aluminum Box Spacer, Black
4. Hardware:
   a. Coastal Stainless Package
5. Frame Finish:
   a. Bronze Anodized
6. Basis of Design:
   a. Western Window Series 900 Entry Door Right

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Install door system in accordance with manufacturer’s instructions.

3.02 FIELD QUALITY CONTROL

A. Field Tests: Western Window Systems to perform testing on all doors in the Western Window test facilities. Tests not meeting specified performance requirements and units having deficiencies shall be corrected.

3.03 PROTECTION AND CLEANING

A. Protection: Protect installed product’s finished surfaces from damage during construction. Protect aluminum door system from damage from grinding and polishing compounds, plaster, lime, acid, cement, or other harmful contaminants.

B. Cleaning: Repair or replace damaged installed products. Clean installed products in accordance with manufacturer’s instructions prior to owner’s acceptance. Remove construction debris from project site and legally dispose of debris.

END OF SECTION 08 11 16

SECTION 08 14 16

FLUSH WOOD DOORS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. Section Includes:
1. Interior Bi-Fold Door
2. Interior Sliding Door

B. Related Sections:
1. Division 08 71 00 "Door Hardware"
2. Division 09 91 23 "Interior Paint"

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Interior Doors shall be provided from the following manufacturer:
1. TW Perry
2. http://www.twperry.com/MainSite/Store1/Content/SiteContent/1/main/home/main.aspx

2.02 DOORS

A. Washer/Dryer Closet
1. Barn Door
2. Custom Fabricated by Team Capitol dc

B. Bathroom
1. Solid Core Doors – Pocket
   a. Dimensions: Door width = 36 in., Door height = 84 in.
   b. Finish: Paint
   c. Door Thickness: 1 3/4 in.

C. Bedroom
1. Solid Core Doors – Pocket
   a. Dimensions: Door width = 36 in., Door height = 84 in.
   b. Finish: Paint
   c. Door Thickness: 1 3/4 in.

PART 3 – EXECUTION

3.01 INSTALLATION, FRAME, MANUFACTURER SPECIFICATIONS

A. Verify that doorframe openings are constructed plumb, true and level before beginning installation process. Select fasteners of adequate type, number and quality to perform the intended functions.

B. Remove protective packaging just prior to installation. Comply with manufacturer' product data, including product technical bulletins, product catalog installation instructions and product packaging instructions for installation.

C. Finishes: See Masonite – How to Paint or How to stain instructions for complete finishing details. Varioius types of materials are used in the construction of the door system; each shall be sealed in accordance with manufacturer's specifications to protect against various environmental conditions. Make sure to completely seal and inspect all six surfaces (top, hinge side, bottom, lock side, front face and back face) with two coats minimum on operable panels. Finishing and/or re-finishing must be completed immediately after door has acclimated to the environment where it is to be installed and within a maximum of 7 days. Avoid finishing after a rain or damp and during periods of higher than average humidity.

END OF SECTION 08 14 16

SECTION 08 32 00

SLIDING GLASS DOORS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. Section Includes:
   1. Exterior Sliding Door and Track
   2. Exterior Sliding Door Hardware

B. Related Sections:
   1. Division 08 80 00 “Glazing”

PART 2 – PRODUCTS

2.01 SLIDING DOOR AND TRACK

A. Western Window: Series 600 Multi-Slide Door
   1. 4 Panel complete unit
   2. Dimensions: Frame width = 170 in., Frame height = 84 in.
   3. Finish: Bronze Anodized
   4. Maximum Door Weight:
   5. Glass Thickness: 7/8 in. OA (5mm / .50 in. / 5mm)

2.02 SLIDING DOOR HARDWARE

A. Western Window: Coastal Stainless Package
   1. Standard Flush Handle
   2. Finish: Brush Nickel Hardware
   3. Rollers: 1.81 in.

PART 3 – EXECUTION

3.01 INSTALLATION, FRAME, MANUFACTURER SPECIFICATIONS

A. Refer to the drawings supplied and inspect the rough opening carefully to ensure it has been prepared correctly to accept the configuration and size being installed.

B. If the floor condition is wood, it must be protected with an appropriate flashing or waterproofing material prior to doorframe installation.

C. Check the floor to see that it is flat and level. If the floor varies more than .0625” (1/16”) per foot or a total of .25” (1/4”) over the entire width of the opening, it must be corrected before proceeding with installation.

D. Determine the top inside of the threshold assembly by holes in the weather strip panel. Position the threshold on the floor in the approximate location and make sure the inside edge of the threshold is properly aligned with the structure.

E. Inspect the threshold assembly where it meets the surface of the floor. Check for, and mark, any gaps that will need to be filed or shimmed prior to final anchoring. The final installation must result in the threshold being level and supported continuously for proper operation.

F. Once satisfied that the threshold assembly is in the correct location, carefully inspect the header above to confirm that the head assembly can be installed directly above it at the proper height. Mark the inside edge full length, and across each end sufficient to locate the inside corners. There are installation holes in the weather-stripped channel of each additional track that align with the countersunk holes. Beginning with the holes in the inside track, mark the floor through each hole. Remove the threshold assembly from the opening.

G. If the floor condition is concrete, drill .25” (1/4”) installation holes at each marked location approximately 2” deep and insert one of the green anchor plugs supplied. NOTE: If you choose to drill the installation holes through the threshold assembly in lieu of drilling them after it is removed, it is important to vacuum all of the debris from the weather-stripped channel to avoid contamination of the weather-stripping and roller assemblies.

H. If the floor is wood with flashing or waterproofing, apply a generous amount of the appropriate sealant at each mark where the installation screws will penetrate the flashing.

I. Apply a .50” (1/2”) wide by .50” (1/2”) high bed of sealant on the floor along the exterior side of the mark, from jamb to jamb and from the inside corners across the end to the outside edge of where the threshold assembly will be. Inspect the sealant carefully to ensure that a complete water barrier has been accomplished across the full width of the opening.

J. Using the marks on the floor set the threshold assembly back in place. Shim as required and proceed with anchoring. Use #10 X 2.5” flathead countersunk screws, finished to match the frame color, to anchor the inside track, and #10 X 2.5” zinc plated flathead screws in the weather-stripped channels.

K. Inspect the opening header to confirm that it is ready to receive the door head assembly and that there is sufficient backing for anchoring. Based on the net frame height shown on the shop drawings, determine if additional material needs to be added to the header to minimize shimming.

L. Using a plumb bob, project a sufficient number of points onto the structure above to locate the head assembly directly above the threshold assembly. Carefully raise the head assembly into position and temporarily anchor using a #10 X 2.5” flat head screws, finished to match the frame color, through the predrilled holes, sufficient to hold it safely.

M. Seal the pre-drilled hole(s) in the threshold end plates using Dow Corning 795 silicone, or equal. Raise or lower the head to align the holes in the jamb with the holes in the end plates and anchor using #12 X ¾” and #12 x 11/4”flat head countersunk screws. Shim the lock jambs as required to ensure they will be plumb and anchor to the structure through the additional holes using #10 X 2.5 flat head screws.

N. Complete the jamb assembly by placing the jamb filler into the jamb and with a non-marring mallet and lightly tap it into place.

O. Complete the anchoring of the head assembly to ensure that it is flat, level and parallel with the threshold.

3.02 INSTALLATION, PANELS, MANUFACTURER SPECIFICATIONS

A. Locate and remove the black foam blocks form the head channels. The blocks are approximately 1” X 1” X 1.75”, and there will be one in each channel. Set them aside temporarily, they will be reinstalled when the panel installation is complete.

B. Each panel will be marked with the unit number, and a panel letter, lettered from left to right as viewed from the outside.

C. Locate the lead panel. IF you are installing a door that is bi-parting, there will be two led panels. The active panel, the one that contains the lock mechanism, will be installed first on the left side of the extreme inside track. If the door has only one lead panel, it will be installed on the extreme inside track on the appropriate side depending on the configuration of the door you are installing. From the outside of the building, with the bottom rail vinyl to the outside, lean the top of the panel in and insert it into the extreme interior head track and lower it onto the threshold. Using a medium size Phillips screwdriver through the middle hole at the bottom of each stile adjust the rollers to achieve a dimension of approximately .375” (3/8”) from the bottom of the stile to the top surface of the threshold. Roll the panel towards the lock jamb to view the vertical gap between the panel and jamb. Make final roller adjustments so the gap is consistent from top to bottom.

D. Locate the lettered panel that is to be installed directly adjacent to the lead panel. From the outside of the building, with a portion of the panel overlapping the interlocker of the lead panel, insert the top into the next head track and lower onto the threshold. Repeat the same process with the remaining panels. Temporarily adjust the rollers on the active panels so that they roll freely.

E. If the door has fixed panels, they will go in last. As shown on the drawings, attach the Security L-clip to the fixed jamb using a #10 X 2.5” flat head screw through the pre-punched installation hole located at the same height as the strike on the lock jamb. Position the adjacent rolling panel to allow the fixed panel to overlap it when the jamb stile of the fixed panel is within a few inches of the fixed jamb. Insert the top of the fixed panel.

F. Make final adjustments to the panel rollers to achieve the optimum alignment throughout the entire door.

G. Adjust the strike plate on the lock jamb by loosening the two machine screws and moving it up or down until the lock engages fully when actuated. To remove excessive slack, open the sliding panel and adjust the lock using the slotted adjusting screw in the center of the lock.

H. With the door in the fully closed position, from the exterior of the building, reinstall the black foam blocks (from instruction A) up into the head channels against the small rubber bumper to close the head channel gap above the panel.

I. Seal the bottom of the fixed panel to the threshold on the exterior side. Seal the interior side of the threshold to the floor from jamb to jamb. Seal the exterior of the doorframe at the head and jambs. Do not seal the exterior of the threshold. The weep slots on the exterior of the threshold must remain open.

J. The door installation is complete.

END OF SECTION 08 32 00

SECTION 08 50 00

WINDOWS

PART 1 – GENERAL INFORMATION

1.01 REQUIREMENTS

A. Structural Performance: Provide aluminum windows engineered, fabricated, and installed to withstand normal thermal movement, wind loading, and impact loading without failure, as demonstrated by testing manufacturer's standard window and door assemblies representing types, grades, and sizes required for this project according to test methods indicated.

1.02 SUBMITTALS

A. Submit labeled sample of glazing materials for approval, with complete specifications and shop drawings

1.03 QUALITY ASSURANCE

A. Performance requirements for operating force, air infiltration, water penetration, structural performance, and forced-entry resistance for aluminum windows are those specified in AAMA Standards.

B. Testing shall be performed by a qualified independent testing agency based on the following criteria:
1. Design wind velocity at project site is 60 mph
2. Window units shall be tested according to ASTM E 283 for air infiltration, ASTM E 547 for water penetration, and ASTM E 330 for structural performance

C. Performance requirements: Testing shall demonstrate compliance with requirements indicated in AAMA for water penetration, and structural performance for the type and performance grade of window units required. Where required design pressure exceed the minimum for the specified window grade, comply with requirements of AAMA for higher than minimum performance grade

PART 2 – PRODUCTS

2.01 ALUMINUM WINDOWS

A. Western Windows

PART 3 – EXECUTION

3.01 STANDARDS AND PERFORMANCE

A. Skilled glaziers shall set all glass in strict accordance with glass and frame manufacturers' printed instructions.

B. Watertight and airtight installation of each piece of glass is required, except as otherwise shown. Each installation must withstand normal temperature changes, wind loading, impact loading (for operating sash and doors) without failure of any kind, including loss or breakage of glass, failure of sealants of gaskets to remain watertight and airtight, deterioration of glazing materials and other defects in the work.

C. Protect glass from edge damage at all times during handling, installation and operation of the building.

D. Glazing channel dimensions s shown are intended to provide for necessary minimum bite on the glass, minimum edge clearance and adequate sealant thicknesses, with reasonable tolerances. The glazier is responsible for providing correct glass size for each opening, within the tolerances and necessary dimensions established.

E. Comply with combined recommendations of glass manufacturer and manufacturer of sealants and other materials used in glazing, except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

F. Comply with "glazing manual" by flat glass marketing association except as shown and specified otherwise, and except as specifically recommended otherwise by the manufacturers of the glass and glazing materials.

G. Inspect each piece of glass immediately before installation, and eliminate any, which have observable edge damage or face imperfections.

H. Unify appearance of each series of lights by setting each piece to match others as nearly as possible. Inspect each piece and set with pattern, draw and bow oriented in the same direction as other pieces.

I. Install insulating glass units to comply with recommendations by sealed insulating glass manufacturer's association, except as otherwise specifically indicated or recommended by glass and sealant manufacturers.

3.02 PREPARATION FOR GLAZING

A. Verify that site conditions are acceptable for installation of glass

B. Verify openings for glazing are correctly sized and within tolerance

C. Verify that a functioning weep system is present

D. Verify that the minimum required face and edge clearances are being followed

E. Clean the glazing channel, or other framing members to receive glass, immediately before glazing. Remove coatings that are not firmly bonded to the substrate. Remove lacquer from metal surfaces wherever elastomeric sealants are used.

F. Apply primer or sealer to joint surfaces wherever recommended by sealant manufacturer

G. Do not proceed with glazing until unsatisfactory conditions have been corrected.

3.03 GLAZING

A. Install products using the recommendations of manufacturers of glass, sealants, gaskets and other glazing materials, except where more stringent requirements are indicated, including those in the “Western Window Installation Manual”

B. Verify that insulating glass (IG) unit secondary seal is compatible with glazing sealants

C. Install glass in prepared glazing channels and other framing members

D. Install setting blocks in rabbets as recommended by referenced glazing standards

E. Provide bite on glass, minimum edge and face clearances and glazing material tolerances recommended

F. Proved weep system as recommended
G. Set glass lites in each series with uniform pattern, draw, bow and similar characteristics

H. Distribute the weight of the glass unit along the edge rather than at the corner

I. Comply with manufacturer’s and referenced industry recommendations on expansion joints and anchors, accommodating thermal movement, glass openings, use of setting blocks, edge, face and bite clearances, use of glass spaces, edge blocks and installation of weep systems

J. Do not attempt to cut, seam, nip or abrade glass that is tempered, heat strengthened or coated

K. Clean and trim excess materials from the glass and stops or frames promptly after installation, and eliminate stains and discolorations.

L. Gasket glazing. Miter cut and bond ends together at corners where gaskets are used for channel glazing, so that gaskets will not pull away from corners and result in voids or leaks in the glazing system

M. Provide bite, face clearance and edge clearance as recommended by glass and framing manufacturers

N. Protect glass from edge damage during handling and installation

O. Prevent glass from contract with contaminating substances that result from construction operations, such as weld spatter, fireproofing or plaster

3.04 CURE, PROTECTION AND CLEANING

A. Protect exterior glass from breakage immediately upon installation, by attachment of crossed streamers to framing held away from glass. Do not apply markers of any type to surface of glass

B. Remove and replace glass which is broken, chipped, cracked, scratched, marred, pitted, obscured, abraded or damaged in other ways during the construction period, including natural causes, accidents and vandalism.

C. Maintain glass in a reasonably clean condition during construction, so that it will not be damaged by corrosive action and will not contribute to the deterioration of glazing materials and other work

D. Clean excess sealant or compound from glass and framing members immediately after application, using solvents or cleaners recommended by manufacturers

E. Glass to be cleaned according to:
   1. Manufacturer specification
   2. AGC

F. Do not use scrapers or other metal tools to clean glass

END OF SECTION 08 50 00

SECTION 08 51 13

ALUMINUM WINDOWS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Aluminum doors and frames
   2. Aluminum windows and frames

B. Related Sections:
   1. Division 08 80 00 "Glazing"

1.02 SUBMITTALS

A. Submit labeled sample of glazing materials for approval, with complete specifications and shop drawings

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics

1.04 WARRANTY

A. Manufacturer's Product Warranty: Western Window Systems
   1. Warranty period: Two (2) years from the Date of Manufacture and the warranty on the replacement parts will extend only for the balance of the warranty period of the original product.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Windows shall be provided from the following manufacturer:
   1. Western Window Systems
   2. www.westernwindowsystems.com
   3. Point of Contact: Brian Flavin

2.02 WINDOWS

A. West Main Module Vertical Window
   1. Direct set, Double Pane, Vertical Window
   2. Dimensions:
      a. Rough Opening:
      b. Frame Size (Width x Height): 18” x 84”
      c. Jamb Width: 4.5”
   3. Glazing:
      a. Insulated Low E, SolarBan 70, Argon Gas
      b. Tempered Glass, 1” OA (3mm/.75”/3mm)
      c. U-Value: .35
      d. SHGC (Solar Heat Gain Coefficient): .25
      e. VT (Visible Transmittance):
      f. CR (Condensation Resistance)
      g. Aluminum Box Spacer, Black
   4. Hardware:
      a. Coastal Stainless Package
   5. Frame Finish:
      a. Bronze Anodized
   6. Basis of Design:
      a. Western Window Series 600 Direct Set

B. West Main Module Horizontal Awning Window
   1. Awning Vent, Double Pane, Horizontal Window
   2. Dimensions:
      a. Rough Opening:
      b. Frame Size (Width x Height): 58” x 18” (x2)
      c. Jamb Width: 4.5”
   3. Glazing:
      a. Insulated Low E, SolarBan 70, Argon Gas
      b. Tempered Glass, 7/8” OA (5mm/.5”/5mm)
      c. U-Value: .45
      d. SHGC: .18
      e. VT:
      f. CR:
      g. Aluminum Box Spacer, Black
   4. Hardware:
      a. Coastal Stainless Package
      b. Operator Type = Roto Operator, Folding Handle, Hardware Matches Frame
   5. Frame Finish:
      a. Bronze Anodized
   6. Basis of Design:
      a. Western Window Series 700 Awning

C. East Bedroom Horizontal Window

1. Direct Set, Double Pane, Horizontal Window
2. Dimensions:
    a. Rough Opening:
    b. Frame Size (Width x Height): 54.5” x 18”
    c. Jamb Width: 4.5”
3. Glazing:
    a. Insulated Low E, SolarBan70, Argon Gas
    b. Tempered Glass, 1”OA (3mm/.75”/3mm)
    c. U-Value: .35
    d. SHGC: .25
    e. VT:
    f. CR:
    g. Aluminum Box Spacer, Black
4. Hardware:
    a. N/A
5. Frame Finish:
    a. Bronze Anodized
6. Basis of Design:
    a. Western Window Series 600 Direct Set

D. North Vertical Window
1. Direct Set, Double Pane, Vertical Window
2. Dimensions:
    a. Rough Opening
    b. Frame Size (Width x Height): 18” x 84”
    c. Jamb Width: 4.5”
3. Glazing:
    a. Insulated Low E, SolarBan70, Argon Gas
    b. Tempered Glass, 1”OA (3mm/.75”/3mm)
    c. U-Value: .35
    d. SHGC: .25
    e. VT:
    f. CR:
    g. Aluminum Box Spacer, Black
4. Hardware:
    a. N/A
5. Frame Finish:
    a. Bronze Anodized
6. Basis of Design:
    a. Western Window Series 600 Direct Set

E. North Clerestory Awning Windows
1. Awning Vent, Double Pane, Horizontal Window
2. Dimensions:
    a. Rough Opening
    b. Frame Size (Width x Height): 30.4” x 18” (x5)
    c. Jamb Width: 4.5”

3. Glazing:
    a. Insulated Low E, SolarBan 70, Argon Gas
    b. Annealed Glass, 7/8" OA (5mm/.50"/5mm)
    c. U-Value: .45
    d. SHGC: .18
    e. VT:
    f. CR:
    g. Aluminum Box Spacer, Black
4. Hardware:
    a. Coastal Stainless Package
    b. Operator Type = Roto Operator, Folding Handle, Hardware Matches Frame
5. Frame Finish:
    a. Bronze Anodized
6. Screen:
    a. Black Fiberglass Mesh
7. Basis of Design:
    a. Western Window Series 700 Awning Vent

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Install window system in accordance with manufacturer's instructions and AAMA window guide specifications manual.

3.02 FIELD QUALITY CONTROL

A. Field Tests: Western Window Systems to perform testing on all windows in the Western Window test facilities. Tests not meeting specified performance requirements and units having deficiencies shall be corrected.

3.03 PROTECTION AND CLEANING

A. Protection: Protect installed product's finished surfaces from damage during construction. Protect aluminum window system from damage from grinding and polishing compounds, plaster, lime, acid, cement, or other harmful contaminants.

B. Cleaning: Repair or replace damaged installed products. Clean installed products in accordance with manufacturer's instructions prior to owner's acceptance. Remove construction debris from project site and legally dispose of debris.

END OF SECTION 08 51 13

SECTION 08 71 00

DOOR HARDWARE

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. Section Includes:
1. Interior Door Hardware – Bi-Fold
2. Interior Door Hardware – Sliding

B. Related Sections:
1. Division 08 14 16 “Flush Wood Doors”
2. Division 09 91 23 “Interior Paint”

PART 2 – PRODUCTS

2.01 DOOR HARDWARE

A. Pocket Door
1. Top hung aluminum track system
2. Two high-density nylon wheel trolleys, floor guide

B. Barn Door
1. Top hung aluminum track system
2. Two high-density nylon wheel trolleys, floor guide

PART 3 – EXECUTION

3.01 INSTALLATION, FRAME, MANUFACTURER SPECIFICATIONS

A. Install in accordance with the manufacturer’s recommendations

END OF SECTION 08 71 00

SECTION 08 80 00

GLAZING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. Section includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:
1. Windows
2. Doors
3. Partition
4. Backsplash

1.02 SUBMITTALS

A. Submit labeled sample of glazing materials for approval, with complete specifications.

1.03 QUALITY ASSURANCE

A. Comply with provisions of the consumer product safety standard for architectural glazing materials (16 CFT 1201)

B. The glazier must examine the framing and glazing channel surfaces, backing, removable stop design, and the conditions under which the glazing is to be performed, and notify the contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the glazing until unsatisfactory conditions have been corrected in a manner acceptable to the glazer.

C. Environmental requirements: installation of glass products at ambient air temperature below 40 degrees F is prohibited. Do not proceed with installation of liquid sealants under adverse weather conditions, or when temperatures are below or above manufacturer's recommended limitations for installations.

D. Glazing contractor shall obtain compatibility and adhesions test reports from sealant manufacturer, indicating that glazing materials were tested for compatibility and adhesions with glazing sealant, as well as other glazing materials including insulating units.

1.04 WARRANTY

A. Provide manufacturer’s standard warranty for each glass product specified.

PART 2 – PRODUCTS

2.01 GLASS PRODUCTS

A. Glass at Exterior Doors

PART 3 – EXECUTION

3.01 STANDARDS AND PERFORMANCE

A. Skilled glaziers shall set all glass in strict accordance with glass and frame manufacturers’ printed instructions.

B. Watertight and airtight installation of each piece of glass is required, except as otherwise shown. Each installation must withstand normal temperature changes, wind loading, impact loading (for operating sash and doors) without failure of any kind, including loss or breakage of glass, failure of sealants of gaskets to remain watertight and airtight, deterioration of glazing materials and other defects in the work.

C. Protect glass from edge damage at all times during handling, installation and operation of the building.

D. Glazing channel dimensions s shown are intended to provide for necessary minimum bite on the glass, minimum edge clearance and adequate sealant thicknesses, with reasonable tolerances. The glazier is responsible for providing correct glass size for each opening, within the tolerances and necessary dimensions established.

E. Comply with combined recommendations of glass manufacturer and manufacturer of sealants and other materials used in glazing, except where more stringent requirements are shown or specified and except where manufacturer’s technical representative directs otherwise.

F. Comply with “glazing manual” by flat glass marketing association except as shown and specified otherwise, and except as specifically recommended otherwise by the manufacturers of the glass and glazing materials.

G. Inspect each piece of glass immediately before installation, and eliminate any, which have observable edge damage or face imperfections.

H. Unify appearance of each series of lights by setting each piece to match others as nearly as possible. Inspect each piece and set with pattern, draw and bow oriented in the same direction as other pieces.

I. Install insulating glass units to comply with recommendations by sealed insulating glass manufacturer's association, except as otherwise specifically indicated or recommended by glass and sealant manufacturers.

3.02 PREPARATION FOR GLAZING

A. Verify that site conditions are acceptable for installation of glass

B. Verify openings for glazing are correctly sized and within tolerance

C. Verify that a functioning weep system is present

D. Verify that the minimum required face and edge clearances are being followed

E. Clean the glazing channel, or other framing members to receive glass, immediately before glazing. Remove coatings that are not firmly bonded to the substrate. Remove lacquer from metal surfaces wherever elastomeric sealants are used.

F. Apply primer or sealer to joint surfaces wherever recommended by sealant manufacturer

G. Do not proceed with glazing until unsatisfactory conditions have been corrected.

3.03 GLAZING

A. Install products using the recommendations of manufacturers of glass, sealants, gaskets and other glazing materials, except where more stringent requirements are indicated, including those in the "Western Window Installation Manual"

B. Verify that insulating glass (IG) unit secondary seal is compatible with glazing sealants

C. Install glass in prepared glazing channels and other framing members

D. Install setting blocks in rabbets as recommended by referenced glazing standards

E. Provide bite on glass, minimum edge and face clearances and glazing material tolerances recommended

F. Proved weep system as recommended
G. Set glass lites in each series with uniform pattern, draw, bow and similar characteristics

H. Distribute the weight of the glass unit along the edge rather than at the corner

I. Comply with manufacturer's and referenced industry recommendations on expansion joints and anchors, accommodating thermal movement, glass openings, use of setting blocks, edge, face and bite clearances, use of glass spaces, edge blocks and installation of weep systems

J. Do not attempt to cut, seam, nip or abrade glass that is tempered, heat strengthened or coated

K. Clean and trim excess materials from the glass and stops or frames promptly after installation, and eliminate stains and discolorations.

L. Gasket glazing. Miter cut and bond ends together at corners where gaskets are used for channel glazing, so that gaskets will not pull away from corners and result in voids or leaks in the glazing system

M. Provide bite, face clearance and edge clearance as recommended by glass and framing manufacturers

N. Protect glass from edge damage during handling and installation

O. Prevent glass from contract with contaminating substances that result from construction operations, such as weld spatter, fireproofing or plaster

3.04 CURE, PROTECTION AND CLEANING

A. Protect exterior glass from breakage immediately upon installation, by attachment of crossed streamers to framing held away from glass. Do not apply markers of any type to surface of glass

B. Remove and replace glass which is broken, chipped, cracked, scratched, marred, pitted, obscured, abraded or damaged in other ways during the construction period, including natural causes, accidents and vandalism.

C. Maintain glass in a reasonably clean condition during construction, so that it will not be damaged by corrosive action and will not contribute to the deterioration of glazing materials and other work

D. Clean excess sealant or compound from glass and framing members immediately after application, using solvents or cleaners recommended by manufacturers

E. Glass to be cleaned according to:
   1. Manufacturer specification
   2. AGC

F. Do not use scrapers or other metal tools to clean glass

END OF SECTION 08 80 00

SECTION 08 83 00

MIRRORS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the custom mirror used in the Bathroom and Bedroom of Harvest home.

PART 2 – PRODUCTS

2.01 MANUFACTURER

A. Available at national chain hardware stores such as Home Depot or Lowes.

2.02 PRODUCTS

A. Custom Mirrors
1. Dimensions for Bathroom mirror: 24” wide x 36” high
2. Dimensions for Bedroom mirror: 60” wide x 30” high

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install mirror plumb, square, and true to line

END OF SECTION 08 83 00

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09 00 00
FINISHES

09 00 00 - DIVISION CONTENTS

SECTION 09 29 00

GYPSUM BOARD

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes:
   1. Gypsum board and accessories
      a. 1/2-inch
      b. 5/8-inch

1.02 SUBMITTALS

A. Submit complete specifications

B. Product Certificate for GREENGUARD Indoor Air Quality for products and materials required to comply with requirements for minimum chemical emission.

C. ASTM C 1396 standards applicable

1.03 WARRANTY

A. Manufacturer – USG
   1. Manufacturer's warranty
      a. Abide by manufacturer product warranty

PART 2 – PRODUCTS

2.01 GYPSUM BOARD

A. Standard Gypsum Board
   1. Core: Regular
   2. Surface Paper: 100% recycled content paper on front, back, and long edges.
   3. Edges: Tapered

B. Mold and Moisture Resistant Gypsum Board
   1. Core: Mold and moisture resistant gypsum core
   2. Surface paper: 100% recycled content moisture/mold/mildew resistant paper on front, back, long edges.
   3. Edges: Tapered

4. Mold/Mildew Resistance: 10 when tested in accordance with ASTM D 3273 Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber.
5. Environmental Requirements: Provide products that comply with testing and product requirements for low emitting materials.
6. Locations:
   a. Partitions in Bathroom; Kitchen

2.02 TILE BACKER BOARD

A. Acceptable Manufacturers
   1. Schluter
      a. Kerdi-Board
      b. 1/2”, 5/8”, 2” Thicknesses

B. Cementitious Backer Board
   1. Panel of lightweight concrete core with coated glass fiber mesh reinforcement and high-density Portland cement surface.
   2. ASTM C 1325 or ANSI A118.9 compliant
   3. Edges: Square

C. Accessory Products
   1. Tape:
      a. Paper Tape: 2-1/16 inches wide
      b. Paper Tape: 2 inches wide with metal strips laminated along the center crease to form inside and outside corners
      c. Fiberglass Tape: Nominal 2 inches wide self-adhering tape.

   2. Trims and Beads
      a. Zinc-coated steel, 26 gauge minimum, ASTM C10472
         1. Control Bead: Use at outside corners
         2. Control Joint: Use where indicated and specified
         3. J-Bead: Use where indicated and specified

   3. Drying Type Compound
      a. Ready Mix vinyl base compound
      b. Ready Mix vinyl base compound formulated for enhanced mold and mildew resistance.
      c. Ready Mix vinyl base compound formulated to reduce airborne dust during sanding.
      d. Ready Mix vinyl base topping compound for finish coating.
      e. Ready Mix vinyl base compound for embedding joint tape, cornerbeads or other accessories.
      f. Field Mix vinyl base compound.

   4. Setting Compound
      a. Field mixed hardening compound.

b. Field mixed hardening compound for fire resistance rated construction and penetrations.
c. Field mixed hardening compound for fire resistance rated construction and penetrations.

5. Gypsum Board Screws; Steel Screws
   a. Comply with ASTM C1002

6. Attachment Hardware
   a. Schluter Kerdi-Board-ZT
   b. Galvanized Steel Attachment Washer

7. Profiles
   a. Schluter Quadec

8. Shower Systems
   a. Schluter Kerdi-Board-SN
   b. Model: KB 12 SN 305 508 A1
   c. Size: 12” x 20” x 3-1/2”

PART 3 – EXECUTION

3.01 INSTALLATION: GYPSUM BOARD

A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in gypsum board manufacturer’s written instructions

3.02 INSTALLATION: TILE BACKER BOARD

A. Cementitious backer board shall be used as a base on walls for thin set application of ceramic tile, plastic tile, and natural stone tiles in areas defined as wet area.

B. Fasten backer boards to framing members with screw 8” o.c. Perimeter fasters to be at least 3/8” and less than 5/8” from ends and edges.

END OF SECTION 09 29 00

SECTION 09 30 00

TILING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Porcelain Tile

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

PART 2 – PRODCUTS

2.01 PORCELAIN TILE

A. Ceramic tile that complies with Standard grade requirements in ANSI A137.1, "Specifications for Ceramic Tile."

B. Tile type porcelain: Factory-mounted unglazed cushion-edged porcelain tile.
   1. Manufacturers: Florida Tile
   2. Module Size: 12 inch by 12 inch
   3. Surface: Slip resistant, with abrasive admixture.
   4. Finish: Mat opaque glaze
   5. Color and Pattern: Dune 25004; Progetto Casa
   6. Grout color: Cream

C. Tile type porcelain: Factory-mounted unglazed cushion-edged ceramic mosaic tile.
   1. Manufacturers: Florida Tile
   2. Module Size: 12 inch by 12 inch, Blend pattern consisting of tiles 1/2 inch by 3 inch
   3. Surface: Slip resistant, with abrasive admixture.
   4. Finish: Mat opaque glaze
   5. Color and Pattern: Dune 25004/I; Progetto Casa
   6. Grout color: Cream

D. Tile type porcelain: Factory-mounted unglazed cushion-edged ceramic cove base and corner tile.
   1. Manufacturers: Florida Tile

2. Module Size: 6 inch by 12 inch cove base; 6 inch by 1 inch cove base corner
3. Surface: Slip resistant, with abrasive admixture.
4. Finish: Mat opaque glaze
5. Color and Pattern: Dune 25004; Progetto Casa; P36C9 cove base; PB3169 cove base corner
6. Grout color: Cream

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in tile installation schedules. Comply with parts of ANSI A108 Series "Specifications for Installation of Ceramic Tile" that are referenced in TCA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.
   1. For installation indicated below, follow procedures in ANSI’s “Specifications for the Installation of Ceramic Tile” for providing 95 percent mortar coverage.
      a. Tile floors in wet areas
      b. Tile floors composed of tiles 8 by 8 inches (200 by 200 mm) or larger.

B. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

C. Lay tile in grid pattern unless otherwise indicated. Align joints where adjoining tiles on floor, base, walls, and trim are the same size.

D. Install cementitious backer units and treat joints according to ANSI A108.11.

E. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot (1:50) toward drains.

F. Install waterproofing to comply with ANSI A108.13.

G. Do not install tile over waterproofing until waterproofing has cured and been tested to determine that it is watertight.

H. Install stone thresholds in same type of setting bed as adjacent floor unless otherwise indicated. At locations where mortar bed (thickset) would otherwise be exposed above adjacent floor finishes, set thresholds in latex-portland cement mortar (thin set).

I. Interior Floor Tile Installation Method:
   1. Over Waterproof Membranes on Wood Subfloors: TCA F121 (cement mortar bed).

J. Interior Wall Tile Installation Method:
   1. Shower Wall Installations, Wood Studs: TCA B412 thin-set mortar on cementitious backer units or fiber cement underlayment.

END OF SECTION 09 30 00

SECTION 09 64 29

WOOD FLOORING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Plank flooring

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

PART 2 – PRODCUTS

2.01 WOOD FLOORING, GENERAL

A. Hardwood Flooring: Comply with NOFMA grading rules for species, grade, and cut.
1. Certification: Provide flooring that carries NOFMA grade stamp on each bundle or piece.

2.02 FIELD-FINISHED WOOD FLOORING

A. Solid –Wood Strip and Plank Flooring: Kiln dried and as follows:
1. Manufactures: Reclaimed Flooring
2. Species and Grade: Oak
3. Cut: Reclaimed
4. Thickness: ¾ inch (19-mm)
5. Face Width: 2 inches
6. Lengths: Random-length strips complying with applicable grading rules.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with flooring manufacturer's written installation instructions, but not less than applicable recommendations in NWFA's "Installation Guidelines: Wood Flooring."

B. Provide expansion space at walls and other obstructions and terminations of flooring of not less than 3/4 inch (19 mm).

C. Solid-Wood, Plank Flooring: Blind nail or staple flooring to substrate.

END OF SECTION 09 64 29

SECTION 09 77 23

FABRIC-WRAPPED PANELS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes: IPS Pre-assembled Panels.

B. Related Work: 1. Section [09 77 13 – Stretched-Fabric Wall System.]

1.02 REFERENCES

A. ASTM E84 – Surface Burning Characteristics of Building Materials.

B. ASTM C208 – Cellulosic Fiber Insulating Board.

C. ASTM C423 – Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

D. ASTM C612 – Mineral Fiber Block and Board Thermal Insulation.

E. NFPA 255 – Surface Burning Characteristics of Building Materials.

F. NFPA 701 – Fire Tests for Flame Propagation of Textiles and Films.

1.03 SYSTEM DESCRIPTION

A. System shall consist of pre-assembled panels. Panels consist of an acoustical, tackable, or magnetic (or combination thereof) backing framed completely in high-impact plastic to secure the fabric covering and to prevent edge damage. The specified fabric covering will free-float above the backing eliminating most visible surface damage. The system shall allow for removal and replacement of fabric with the panel mounted in-place (beveled edge profile).

1.04 SUBMITTALS

A. Comply with Division 01 submittal requirements.

B. Product Data:
1. Manufacturer’s Technical Data: Submit for [track], [backing material,] and fabric showing compliance with Specifications.
2. Installation Instructions: Submit track manufacturer’s installation instructions.
3. Cleaning Instructions: Submit fabric manufacturer’s cleaning and instructions for fabric.

C. Shop Drawings:
1. [If necessary to supplement information shown on Drawings,] show types and locations of panels and fabric direction [pattern matching or repeats].
2. Show special installation instructions not included in product data.

D. Samples:
1. Submit two (2) sets of fabric standards showing full range of colors, textures, and pattern available.
2. Submit one (1) of each type of accessory.

E. Installer Qualification Statement: Submit certification of installer qualifications.

F. QUALITY ASSURANCE
1. In accordance with panel manufacturer’s quality assurance program.
2. Mock-Up: Install panel on wall selected by Architect. Notify Architect and allow Architect to review mock-up. Make modifications to mock-up as required by Architect. Accepted mock-up establishes quality for remaining work and may remain as part of Project.

1.05 DELIVERIES, STORAGE, AND HANDLING

A. Comply with instructions of manufacturer. Protect from moisture in shipment, storage, and handling. Deliver in unopened bundles and store in a dry place with adequate air circulation. Do not deliver [backing materials or] fabrics until wet work such as concrete and plaster has been completed.

1.06 PROJECT CONDITIONS

A. Do not install panels until building is enclosed and temperature and humidity are maintained at approximate conditions planned for occupancy and in accordance with instructions of manufacturer.
B. Install panels under lighting conditions similar to permanent lighting.

1.07 WARRANTY

A. Provide panel manufacturer’s five-year limited warranty against defects and workmanship.

1.08 EXTRA MATERIALS

A. Fabric: Furnish two (2) additional panels for each color, pattern, and type of fabric used. Pack for storage with protective covering and label.

B. Accessories: Furnish ten (10) additional of each accessory.

1.09 NO-COST FABRIC REPLACEMENT PROGRAM

A. Provide fabric replacement agreement signed by Fabricmate Systems. Owner will not be liable for additional payments for work performed under agreement.

B. Agreement shall have a 3-year term and include replacement of up to ten percent or 15-year term and include replacement of up to fifteen percent of fabric on Project.

C. Provide materials and labor to replace fabric damaged for any reason. Replacement fabric may not exceed cost of original fabric.

D. If fabric in excess of specified percent requires replacement during term of agreement, Fabricmate Systems shall provide fabric at standard prices plus labor at the installer's standard rates.

E. Fabricmate shall make reasonable efforts to respond to Owner's service requests within 48 hours.

F. Agreement will not cover removal or replacement of items not specified in this section.

G. If Owner chooses to install or maintain the IPS Pre-assembled Panels, Fabricmate shall sell Owner additional panels, fabric and installation tools at standard terms and prices.

PART 2 – PRODUCTS

2.01 "OWNER'S STANDARD" PRODUCTS

A. Products in this Section are designated "Owner's Standard" products and Owner will accept no substitutes.

2.02 PANELS

A. Manufacturer: Fabricmate Systems Inc. (www.fabricmate.com); (866)622-2996 or (805)642- 7470 (from outside the United States), info@fabricmate.com.

B. Fabrication: Pre-assembled panels. Panels consist of an acoustical, tackable, or magnetic (or combination thereof) backing framed completely in high-impact plastic to secure the fabric covering and to prevent edge damage. The specified fabric covering will free-float above the backing eliminating most visible surface damage. The system shall allow for removal and replacement of fabric with the panel mounted in-place. PRE-WRAPPED PANELS WHERE FABRIC IS GLUED DIRECTLY TO THE BACKING MATERIAL WILL NOT BE ACCEPTED.

C. Performance: Panel frame shall be able to securely hold fabric without sagging, allow fabric to be easily removed, and permit repeated cycles of fabric attachment and removal.

D. Depth: 1”

E. Color: Natural

F. Edge Profile:
1. Profile: Square
2. Type: [Fabric inserts from front. Side of frame is exposed.] [Fabric inserts from rear and wraps frame.]

G. Fasteners: Provide double-sided tape, hook & loop tape, impaling clips, z-clips, or other fasteners suitable for use on different surfaces as recommended by the panel manufacturer.

2.03 BACKING MATERIALS

A. Tackable/Acoustical Backing Material:
1. Type: Fabricmate ReCore® Single-Solution Substrate – 65% post consumer product content, lightweight, tackable, high-impact.
2. Density: 6.8 pcf minimum
3. Thickness: 1 inch
4. Noise Reduction Coefficient (NRC): 0.25 – 0.45, ASTM C423, Type A mounting.
5. Surface Burning Characteristics: ASTM E84 Class A.
6. Recycled Content: up to 65%, Post-Industrial Content: up to 100%.

B. Acoustical Backing Material:

1. Types: Fabricmate ReCore® Single-Solution Substrate – 65% post consumer product content, lightweight, tackable, high-impact.
2. Thickness: 1 inch
3. Density: 6.8 pcf
4. NRC: 0.80, Type A mounting.
5. Surface Burning Characteristics: ASTM-E84, Class A.
6. Thermal Insulation: 4.5 R-Value .
7. Recycled Content: 100% post-industrial.

C. Recycled Acoustical Backing Material:

1. Types: Fabricmate ReCore® Single-Solution Substrate – 65% post consumer product
2. Thickness: 1”
3. Density: 6.8 pcf
4. NRC: 0.75, Type A mounting.
5. Surface Burning Characteristics: ASTM-E84, Class A.
6. Recycled Content: 65% post-consumer, 80% post-industrial.

D. Magnetic Surfaces: To add magnetic properties to a backing material specify Mag-tack® .040” magnetic receptive layer. The tackability of tackable backing materials is maintained.

E. Adhesive: Provide construction-grade adhesive suitable for conditions of use.

F. Low-VOC, Low-Odor Adhesive: DYNAMITE 111 Heavy-Duty Clay Non-Strippable Wall covering Adhesive by Gardner-Gibson.

G. Fasteners: Provide types suitable for conditions of use.

2.04 FABRIC

A. Each type of fabric shall be from a single run or lot.

B. Fabric:
1. Product: Transmission; Color: Bluberry; No. FTR-5173, by Luna Textiles.
2. Fiber: 100% Eco-Intellegent Polyester
3. Weight: 16 +/- 0.5 oz./lin. yd.
4. Usable Width: 66”.
5. Repeat: 14 2/5” horizontal repeat x 10 4/5” vertical repeat.
6. Flammability: Passes NFPA 701 large scale test.
7. Surface Burning Characteristics: ASTM E84 is Class 1 or Class A.
8. Environmental Solutions: MBCD Cradle to Cradle Certified Gold

C. Fabric Backing: Acoustically transparent, spunbonded polypropylene scrim complying with. ASTM E84 Class A. Backing shall be factory applied to fabric or installed on wall system tracks.

2.05 ACCESSORIES

A. Stapler Kit: Provide one light-duty stapler, a box of 3/8” staples for each room with tackable wall system, and user instructions.

B. “Pintainer” Accessory Kit:
1. “Pintainer”: In each room with tackable and magnetic wall system, provide a clear plastic tube with colored, spill-resistant end cap that opens when squeezed.
2. Graphic: Container shall have imprint or decal with 2-color artwork as supplied by

Architect.

3. Contents: Fill container with approximately 100 push pins in rooms with tackable wall system and an assortment of magnets in rooms with magnetic wall system.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions under which the wall system is to be applied and notify Architect in writing of conditions detrimental to proper and timely completion. Do not proceed until unsatisfactory conditions have been corrected.

B. Install IPS Pre-assembled Panels in accordance with the manufacturer's instructions.

C. Layout: Panels shall be installed tiled vertically per drawing.

D. Fabric:

1. Install fabric plumb, level, and in proper relation to panel edges.
2. Direction of fabric shall be consistent on panel and on adjacent panels, except where otherwise shown on Drawings. Install fabric with consideration for pattern matching and repeats.
3. Stretch over backing material and tucked into the panel frame’s locking jaws using panel manufacturer’s professional installation tool.
4. Fabric shall “float” above backing; do not fix in place with adhesives, fasteners, sewn seams or tape.
5. Fabric shall be sufficiently taut to avoid sagging under seasonal temperature and humidity variations; shall maintain its shape after being touched or leaned against without leaving any indentations or blisters; and shall be free from ripples, waviness or "hourglass" effects.

3.02 CLEANING AND PROTECTION

A. Clean exposed surfaces and repair minor damage in accordance with the panel manufacturer's instructions.

B. Protect finished installation against damage by other work.

END OF SECTION 09 77 23

SECTION 09 91 23

INTERIOR PAINTING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes:
   1. Interior Painting and Finishing

1.02 SUBMITTALS

A. Submit complete specifications

1.03 WARRANTY

A. Sherwin-Williams - Emerald Interior Acrylic Latex Paint
   1. Manufacturer's warranty
      a. Lifetime warranty

PART 2 – PRODUCTS

2.01 INTERIOR PAINTING

A. Sherwin-Williams - Emerald Interior Acrylic Latex Paint
B. Matte Finish
   1. Zero VOCs
   2. Self-priming paint
C. Satin Finish
   1. Zero VOCs
   2. Self-priming paint
   3. Resin type: 100% Acrylic Latex

PART 3 – EXECUTION

3.01 PREPARATION OF SURFACES

A. Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

3.02 APPLICATION

A. Paint exposed surfaces, new and existing, unless otherwise indicated
   1. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces.
   2. Paint the back side of access panels.
   3. Do not paint prefinished items, items with an integral finish, operating parts, and labels unless otherwise indicated.

B. Apply paints according to manufacturer's written instructions.
   1. Use rollers for finish coat on interior walls and ceilings except where impractical.

C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, run, sags, ropiness, or other surface imperfections.

END OF SECTION 09 91 23

SECTION 09 97 13.13

INTERIOR STEEL COATINGS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes:
1. 05 12 13 Architecturally-Exposed Structural Steel Framing

1.02 SUBMITTALS

A. Submit complete specifications; color to match control sample

PART 2 – PRODUCTS

2.01 INTERIOR PAINTING

A. Enviro-Glaze Series 297 by Tnemec Co., Inc.
1. Low VOCs, waterborne polyurethane
2. Color: TBD
3. Finish: Gloss

PART 3 – EXECUTION

3.01 PREPARATION OF SURFACES

A. Prepare surfaces by method suitable for exposure and service. Refer to the appropriate primer data sheet for specific recommendations. Surface must be clean, dry and free of oil, grease and other contaminants.

3.02 APPLICATION

A. Coverage Rates

1. Allow for overspray and surface irregularities and waste. Film thickness is rounded to nearest 0.5 mil or 5 microns.
2. Suggested Coverage: 366 sq. ft. / gal.

B. Apply paints according to manufacturer's written instructions.

C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, run, sags, ropiness, or other surface imperfections.

END OF SECTION 09 97 13.13

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SPECIALTIES

10 00 00 - DIVISION CONTENTS

SECTION 10 28 16

RESIDENTIAL BATH ACCESSORIES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes:
1. Toilet Paper Holder
2. Towel Bar
3. ADA Grab Bar

1.02 SUBMITTALS

A. Product Data, Cut Sheets

1.03 WARRANTY

A. American Standard
1. Products to be free from defects in materials or workmanship for as long as the original consumer purchaser owns this product.

PART 2 – PRODUCTS

2.01 TOILET PAPER HOLDER

A. Kohler
1. Single roll holder, solid metal construction
2. Surface mounted with concealed anchorage
3. Polished Chrome finish
4. Model #: K-14444-CP

2.02 GRAB BAR

A. Kohler
1. 1.25-inch diameter heavy-gauge bar, solid brass construction
2. Surface mounted with concealed anchorage
3. Polished Chrome finish

4. Model: K-11895-S 36”
5. Model: K-11896-S 42”
6. Compliance Certifications
   a. ASTM F 466, ANSI A 117.1, CSA

2.03 Towel Bar

A. Kohler
   1. 1.25-inch diameter heavy-gauge bar, solid brass construction
   2. Surface mounted with concealed anchorage
   3. Polished Chrome finish
   4. Model: K-14436-CP 24”

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 location and at heights indicated in drawings.

   1. Install grab bars to withstand a downward load of at leadt 250 lbf (1112 N), when tested according to method in ASTM F 466.

B. Adjust accessories for unencumbered smooth operation and verify that mechanisms function properly. Replace damaged or defective items. Remove temporary labels and protective coatings.

C. Repair, refinish, or replace units damaged during installation or transit, as directed by Architect.

END OF SECTION 10 28 16

SECTION 10 71 13

ROLLING EXTERIOR SHUTTERS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. Section includes specifications for the following:
  1. Custom fabricated rolling exterior shutters.
  2. Custom fabricated Nitinol wire.
  3. Support Rail for rolling exterior shutters

1.02 ADMINISTRATIVE REQUIREMENTS

A. Coordination with manufacturer.
  1. Clarification for possible assemblies and potential design limits.
    a. Pre-installation meetings.
  2. Conduct pre-installation meeting to verify project requirements, manufacturer's installation instructions, and manufacturer's warranty requirements.

1.03 SUBMITTALS

A. Product data

B. Shop drawings
  1. Submit shop drawings for rolling exterior shutters showing layout, elevations, product components, and accessories.

C. Samples

D. Manufacturer's instructions
  1. Comply with manufacturer's detail book, shop drawings, and product data, including product technical bulletins, for installation.
  2. Deviations from standard detail and load design values shall be calculated by a qualified architect/engineer.

1.04 QUALITY ASSURANCE

A. Qualifications
  1. All accessories are to be as furnished or recommended by the manufacturer.
  2. Installer should be experienced in performing work of this section and should have specialized in installation of work similar to that required for this project.

PART 2 - PRODUCTS

2.01 PRODUCT TYPE

A. 6061 multipurpose aluminum sheet in extruded section

B. Nitinol Wire

C. Galvanized Steel Barn Door Track Box Style Trolley Rail

2.02 MANUFACTURERS

A. Posner Industries

B. Dynalloy Inc.

C. Stanley

2.03 PERFORMANCE/DESIGN CRITERIA

A. Capacities for 6061 multipurpose aluminum sheet in extruded section
1. A custom designed and fabricated CNC milled shutter system.
2. High pliability and resilience.
3. Low non-directional, reflectivity.

B. Capacities for Nitinol Wire
1. A custom designed, low austenite temperature phase change wire, using manufacturer recommended 705 ring crimp.
2. 5-7% length reduction during austenite phase.
3. 400gram pull force during austenite phase.

C. Capacities for Galvanized Steel Barn Door Track Box Style Trolley Rail
1. Finish: Galvanized Steel.
2. 600 pounds load capacity.
3. Bottom load-free rolling stay

2.04 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surface without blemishes.

B. Ferrous Metals:
1. Steel plates, shapes, and angles: ASTM A 36/A 36M

2.05 FASTENERS

A. General: Stainless –steel fasteners for exterior use. Select fasteners for type, grade, and class required.

2.06 FABRICATION

A. General: Preassemble items in the shop to the greatest extent possible. Use connections that maintain structural value of joined pieces.
   1. Cut and punch metals cleanly and accurately. Remove burrs and ease edges. Remove sharp or rough areas on exposed surfaces.
   2. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Locate joints where least conspicuous.
   3. Fabricate seams and other connections that will be exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

2.07 FINISHES

Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Finish metal fabrications after assembly.

PART 3 - EXECUTION

3.01 INSTALLERS

A. Team Capital DC team

3.02 INSTALLATION

A. Capacities for 6061 multipurpose aluminum sheet in extruded section

   1. General: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, with edges and surfaces level, plumb, and true.
      a. Fit exposed connections accurately together.
      b. Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction.

B. Nitinol Wire
   1. General: Follow manufacturer provided installation guidelines.

C. Galvanized Steel Barn Door Track Box Style Trolley Rail
   1. General: Follow manufacturer provided installation guidelines.

END OF SECTION 10 73 13

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11 00 00
EQUIPMENT

11 00 00 - DIVISION CONTENTS

SECTION 11 31 13

RESIDENTIAL KITCHEN APPLIANCES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Electric Cooktop
2. Electric Wall Oven
3. Exhaust Hood
4. Refrigerator-Freezer
5. Dishwasher

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics.

1.04 WARRANTY

A. Manufacturer's Product Warranty: Coverings Etc.
1. Warranty period: Ten (10) year warranty from date of purchase for material defects.

PART 2 – PRODUCTS

2.01 ELECTRIC COOKTOP

A. Frigidaire
1. 30-inch Induction Cooktop
2. ADA Compliant
3. Stainless Steel finish
4. Approved for Electric Single Wall Oven combined installation
5. Part # FPIC3095MS
6. Frigidaire Built-in Electric Cooktop
7. Dimensions:
a. Exterior Dimensions: 30-3/4" x 21-1/2" x 4-3/8"

2.02 ELECTRIC WALL OVEN

A. Frigidaire
1. 30-inch Single Electric Wall Oven
2. ADA Compliant, UL, Star-K Certified
3. Stainless Steel finish
4. Approved for Electric Cooktop combined installation
5. Part # FFEW3025LS
6. Frigidaire Single Electric Wall Oven
7. Dimensions:
   a. Exterior Dimensions: 30” x 24-1/2” x 29”

2.03 EXHUAST HOOD

A. Frigidaire
1. 36” Island Exhaust Hood
2. cULus approved
3. Stainless Steel finish
4. Part # FHPC3660LS
5. Frigidaire Island Exhaust Hood
6. Dimensions:
   a. Exterior Dimensions: 35-11/32” x 23-5/8” x 42”

2.04 REFRIGERATOR-FREEZER

A. Summit
1. Refrigerator with bottom freezer
2. Energy Star
3. Stainless Steel finish
4. Part # FFBF285SS
5. Summit Refrigerator-Freezer
6. Dimensions:
   a. Exterior Dimensions: 27.63” x 23.5” x 75.25”

2.05 DISHWASHER

A. Fisher & Paykel
1. Dishwasher Drawer
2. Energy Star
3. Stainless Steel finish
4. Part # DD36SFTX2
5. Fisher & Paykel Dishwasher Drawer
6. Dimensions:
   a. Exterior Dimensions: 35-1/4” x 22-1/2” x 18-13/16”

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Install appliances according to manufactures instructions.

3.02 PROTECTION AND CLEANING

A. Protection: Protect installed product's finished surfaces from damage during construction.

B. Cleaning: Repair or replace damaged installed products. Clean installed products in accordance with manufacturer's instructions prior to owner's acceptance. Remove construction debris from project site and legally dispose of debris.

END OF SECTION 11 31 13

SECTION 11 31 23

RESIDENTIAL LAUNDRY APPLIANCES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Frontload Washer
   2. Electric Dryer

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics.

1.04 WARRANTY

A. Manufacturer's Product Warranty: Coverings Etc.
   1. Warranty period: Ten (10) year warranty from date of purchase for material defects.

PART 2 – PRODUCTS

2.01 FRONTLOAD WASHER

A. Frigidaire
   1. 3.8 Cu. Ft. Frontload Washer with Ready Steam
   2. Energy Star, NSF Certified, ADA Compliant, 1200 RPM Spin Speed
   3. Classic White finish
   4. Part # FAFS4073NW
   5. Frigidaire Affinity Frontload Washer
   6. Dimensions:
      a. Exterior Dimensions: 27" x 31-1/10" x 36"

2.02 ELECTRIC DRYER

A. Frigidaire
1. 7.0 Cu. Ft. Electric Dryer
2. ADA Compliant, SilentDesign™, Stainless steel drum, 50 RPM Spin Speed
3. Classic White finish
4. Dryer Ratings:
   a. 240V: 30A, 60Hz
5. Part # FASE7073NW
6. Frigidaire Affinity Frontload Electric Dryer
7. Dimensions:
   a. Exterior Dimensions: 27” x 31-3/10” x 36”

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Install appliances according to manufactures instructions.

3.02 PROTECTION AND CLEANING

A. Protection: Protect installed product’s finished surfaces from damage during construction.

B. Cleaning: Repair or replace damaged installed products. Clean installed products in accordance with manufacturer’s instructions prior to owner’s acceptance. Remove construction debris from project site and legally dispose of debris.

END OF SECTION 11 31 23

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12 00 00
FURNISHINGS

12 00 00 - DIVISION CONTENTS

SECTION 12 35 30

KITCHEN CASEWORK

PART 1 - GENERAL INFORMATION

1.01 SUMMARY

A. Fixed modular casework furniture with finished interiors.

1.02 RELATED SECTIONS

A. Section 06 10 00 - Rough Carpentry: Framing and blocking in walls, floors and ceiling to support equipment.

1.03 REFERENCES

A. ADA (ATBCB ADAAG): Americans with Disabilities Act Accessibility Guidelines.

B. Architectural Woodwork Institute (AWI): Quality Standards.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until project conditions are ready for installation.

1.05 WARRANTY

A. Casework manufacturer shall be notified immediately of defective products, and be given a reasonable opportunity to inspect the goods prior to return. Casework manufacturer will not assume responsibility, or compensation, for unauthorized repairs or labor. Casework manufacturer makes no other warranty, expressed or implied, to the merchantability, fitness for a particular purpose, design, sale, installation, or use, of casework; and, shall not be liable for incidental or consequential damages, losses of or expenses, resulting from the use of their products.

B. The warranty with respect to products from another company sold by the casework manufacturer is limited to the warranty extended by that other company.

C. Casework manufacturer shall provide, with close-out documents, a Certificate of Warranty for products provided.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturer:
   1. Smart Cabinetry; http://www.smartcabinetry.com
   2. Custom CNC Fabricated by Team Capitol DC

B. Contact: Collin Parker (collin.parker@c1pcabinetsupply.com)

C. Substitutions: Not permitted.

D. Product Designations: Drawings indicate sizes and configurations of laboratory casework by referencing designated manufacturer's catalog numbers.

2.02 CONSTRUCTION

A. Wood veneer on plywood core or plyboo

B. Drawer and Door Styles:
   1. Sommerset

2.03 MATERIALS

A. Plyboo

B. Maple veneer with Coffee stain
   1. Wood Moisture Content: 8 to 13 percent.
   2. Medium-Density Fiberboard: ANSI A208.2, Grade 130, made with binder containing no urea formaldehyde.
   3. Particleboard: ANSI A208.1, Grade M-2, made with binder containing no urea formaldehyde.
   4. Veneer-Faced Panel Products (Hardwood Plywood): HPVA HP-1, made with adhesive containing no urea formaldehyde.
   5. High-Pressure Decorative Laminate: NEMA LD 3.

PART 3 EXECUTION

3.01 INSTALLATION

A. Before insallation, condition cabinets to average prevailing humidity conditions in installation areas.

B. Install cabinets to comply with reference quality standard for grade specified.

C. Install cabinet’s level, plumb, true, and straight. Shim as required with concealed shims, Install level and plumb (including tops) to a tolerance of 1/8 inch in 96 inches (3mm in 2400mm).

D. Scribe and cut cabinets to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.

E. Anchor cabinets to anchors or blocking built in or directly attached to substrates. Fasten with countersunk concealed fasteners and blind nailing. Use finishing nails or finishing screws for exposed nailing, countersunk and filled flush.

F. Cabinets: Install so doors and drawers are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation.
   1. Fasten wall cabinets through back, near top and bottom, at ends and not more than 16 inches (400 mm) o.c. with No. 10 wafer-head screws sized for 1=-inch (25-mm) penetration into wood framing, blocking, or hanging strips.

END OF SECTION 12 35 13

SECTION 12 36 40

STONE COUNTERTOPS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Stone Countertops

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Verify dimensions of stone countertops by field measurements and indicate on Shop Drawings

PART 2 – PRODCUTS

2.01 RECYCLED STONE AGGREGATE

A. Caesarstone
   1. http://www.caesarstoneus.com/
   2. Description: Color: Eggshell
   3. Thickness: 2 cm

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install countertops by adhering to supports with water-cleanable epoxy adhesive.

B. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts while cutting.

C. Install backsplash and end splashed by adhering to wall with water-cleanable epoxy adhesive. Leave 1/16-inch (1.5m-mm) gap between countertop and splash for filling with sealant. Use temporary shims to ensure uniform spacing.

D. Grout seams to comply with ANSI A108.10. Tool grout uniformly and smoothly with plastic tool.

E. Apply sealant to gap between countertops and splashes.

3.02 CLEANING

A. Clean countertops as work progresses. Remove adhesive, grout, mortar, and sealant smears immediately.

B. Clean stone countertops not less than six days after completion of sealant installation, using clean water and soft rags. Do not use materials or methods that could damage stone.

C. Apply stone sealer to comply with stone producer’s and sealer manufacture’s written instructions.

END OF SECTION 12 36 40

SECTION 12 93 00

SITE FURNISHINGS / ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Harvest Table/Benches

B. Lighting

C. Plant Containers

D. Liners

E. Vertical Gardens

F. Decorative Pots

G. Deck Furniture

H. Stainless Steel Rill

I. Beehive

J. Composting Bin

K. Milk Crates

PART 2 – PRODUCTS

2.01 Harvest Table/Benches

A. Harvest Table:
1. Provide Basis of Design product: CUA wood fabricators.
a. Size: 8' x 4'
b. Top and seats: Reclaimed wood, FSC certified
c. Rill: Galvanized steel or zinc 4" insert
d. 4" pockets for planting with waterproof membrane.
e. Installation: Free standing
f. Quantity: 1

2.02 Lighting

A. Up Lighting for Tree

1. FL05 Solar 'Multi-Purpose' 108 LED Floodlight
2. http://www.solarilluminations.com/
3. Quantity: 1

B. Pedestrian Level
1. Lighting Style and Manufacturer still TBD

2.03 Plant Containers

A. Milk Crates
1. Supplier – Reclaimed from salvage/recycled materials
2. Size – 16 quart black milk crates measuring 13”x13”x11”
3. Quantity: 610-660

2.04 Liners

A. Supplier – Ethan Brooks, BSA Troop 1853

B. Materials - Nonwoven Geotextile Filter Fabric (3 oz./sq. yd. minimum)

C. Amount: 2-3’x600’ rolls

D. http://www.geotechsouth.com/

E. Quantity: 136

2.05 Vertical Gardens

A. Supplier: Juice Plus+ basic towers with 2 add-on pieces to attain 6’ in height with submersible pump

B. http://www.towergardens.com

C. Quantity - 2

2.06 Decorative Pots

A. Galvanized Steel Pots for containers on deck

B. www.ikea.com

C. Quantity: 10

2.07 Deck Furniture (Chairs)

A. Nelson Coconut Chair

B. Quantity: 4

2.08 Fountain Pump

A. SCS Submersible Pump (Model TBD)

B. Quantity: 1

2.09 Stainless Steel Rill

A.Supplier: SAR Metals

B. www.SARmetals.com

C.Quantity: 33 feet of rill with pool (24”x24”x11”D)

2.10 Bee Hive

A. Steidel Woodworking Bee hive on site

B. Quantity: 1

2.11 Composting Bin

A. Used to create compost for the fertilization of the soil.

B. Quantity - 1

2.12 Milk Crates

A. Used for planters

B. Quantity - 900

END OF SECTION 12 93 00

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21 00 00
FIRE SUPPRESSION

21 00 00 - DIVISION CONTENTS

SECTION 21 13 13

WET-PIPE SPRINKLER SYSTEMS

PART 1 – GENERAL INFORMATION

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Sprinklers.
4. Alarm devices.
5. Pressure gages.

1.3 DEFINITIONS

A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig (1200 kPa), but not higher than 250 psig (1725 kPa)

B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig (1200 kPa) maximum.

1.4 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

1.5 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

B. High-Pressure Piping System Component: Listed for 250-psig (1725-kPa) minimum working pressure.

C. Sprinkler system design shall be approved by authorities having jurisdiction.
   1. Maximum Protection Area per Sprinkler: Per UL listing.
   2. Maximum Protection Area per Sprinkler: Per NFPA 13D

1.6 SUBMITTALS

A. Product Data: For each type of product indicated

B. LEED Submittal:
   1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content and chemical components.

C. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.

D. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Domestic water piping.
   2. HVAC hydronic piping.
   3. Items penetrating finished ceiling include the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
   4. Heat Sources

E. Qualification Data: For qualified Installer

F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

G. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

H. Field quality-control reports.

I. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13R, "Installation of Sprinkler Systems in One and Two Family Dwellings and Manufactured Homes

1.8 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.2 CPVC PIPE AND FITTINGS

A. CPVC Pipe: ASTM F 442/F 442M and UL 1821, SDR 13.5, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), with plain ends. Include "LISTED" and "CPVC SPRINKLER PIPE" markings.

B. CPVC Fittings: UL listed or FM approved, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), socket type. Include "LISTED" and "CPVC SPRINKLER FITTING" markings.
   1. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): ASTM F 438 and UL 1821, Schedule 40, socket type.
   2. NPS 2 to NPS 3 (DN 50 to DN 80): ASTM F 439 and UL 1821, Schedule 80, socket type.
   3. CPVC-to-Metal Transition Fittings: CPVC, one piece, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
   4. CPVC-to-Metal Transition Unions: CPVC, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
   5. Flanges: CPVC, one or two pieces.

2.3 PIPING JOINING MATERIALS

A. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493, solvent cement recommended by pipe and fitting manufacturer, and made for joining CPVC sprinkler pipe and fittings. Include cleaner or primer recommended by pipe and fitting manufacturer.
   1. Use solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 650 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 COVER SYSTEM FOR SPRINKLER PIPING

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
   1. DecoShield Systems, Inc.
   2. <Insert manufacturer's name>.

B. Description: System of support brackets and covers made to protect sprinkler piping.

C. Brackets: Glass-reinforced nylon.

D. Covers: Extruded PVC sections of length, shape, and size required for size and routing of CPVC piping.

2.5 LISTED FIRE-PROTECTION VALVES

A. General Requirements:
   1. Valves shall be UL listed or FM approved.
   2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
   3. Minimum Pressure Rating for High-Pressure Piping: [250 psig (1725 kPa)] [300 psig (2070 kPa)].

B. Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

   2. Standard: UL 1091 except with ball instead of disc.
   3. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
   4. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
   5. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.

2.6 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
   1. AFAC Inc.
   2. Globe Fire Sprinkler Corporation.
   3. Reliable Automatic Sprinkler Co., Inc.
   4. Tyco Fire & Building Products LP.
   5. Venus Fire Protection Ltd.
   6. Victaulic Company.
   7. Viking Corporation.
   8. <Insert manufacturer's name>.

B. General Requirements:
1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.
3. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
4. Pressure Rating for High-Pressure Automatic Sprinklers: [250 psig (1725 kPa) minimum] [300 psig (2070 kPa)].

C. Automatic Sprinklers with Heat-Responsive Element:
1. Residential Applications: [UL 1626]
2. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Sprinkler Finishes:
1. Chrome plated.
2. Bronze.
3. Painted.

2.7 PRESSURE GAGES

A. <u>Manufacturers</u>: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. <u>AMETEK; U.S. Gauge Division</u>.
2. <u>Ashcroft, Inc</u>.
3. <u>Brecco Corporation</u>.
4. <u>WIKA Instrument Corporation</u>.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

D. Pressure Gage Range: [0 to 250 psig (0 to 1725 kPa) minimum]

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 221116 "Domestic Water Piping."

B. Install shutoff valve,[backflow preventer,] pressure gage, drain, and other accessories indicated at connection to water-distribution piping.[Comply with requirements for backflow preventers in Section 221119 "Domestic Water Piping Specialties."]

3.2 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

G. Install sprinkler piping with drains for complete system drainage.

H. Install hangers and supports for sprinkler system piping according to NFPA 13 D. Comply with requirements for hanger materials in NFPA 13 D.

I. Install pressure gages on riser or feed main. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

J. Fill sprinkler system piping with water.

K. Install sleeves for piping penetrations of walls, ceilings, and floors.

L. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Ream ends of pipes and tubes and remove burrs.

D. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

E. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

F. Plastic-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
   2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

3.4 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and with NFPA 13 or NFPA 13R for supports.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 D and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

3.7 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13D.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Flush, test, and inspect sprinkler systems according to NFPA 13 D.

C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain system.

3.11 PIPING SCHEDULE

A. CPVC pipe; [Schedule 40] [Schedule 80] CPVC fittings; and solvent-cemented joints may be used for light-hazard and residential occupancies.

3.12 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: [Upright sprinklers] <Insert type>.
2. Rooms with Suspended Ceilings: Concealed sprinklers

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Upright Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view.

END OF SECTION 21 13 13

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22 00 00
PLUMBING

22 00 00 - DIVISION CONTENTS

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Mechanical sleeve seals.
   5. Sleeves.
   6. Escutcheons.
   7. Grout.
   8. Equipment installation requirements common to equipment sections.
   9. Painting and finishing.
   10. Concrete bases.
   11. Supports and anchorages.

1.02 SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

B. Welding certificates.

C. LEED Submittals:
   1. A completed LEED Reporting Form (LRF) with a separate line item completed for each LEED Focus Materials (LFM).
   2. Product cut sheets for each LFM confirming that the submitted products are the products installed as part of the Work.
   3. Validation for each LFM according to the Action Submittals requirements of Section 01 8113 (Sustainable Design Requirements).
      a. VOC Content.

1.03 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

D. LEED Quality Assurance
   1. VOC content limitations defined in Section 01 8123 “Volatile Organic Compound Limits”.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.03 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:
   1. ABS Piping: ASTM D 2235.
   2. CPVC Piping: ASTM F 493.
   3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   4. PVC to ABS Piping Transition: ASTM D 3138.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.04 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
   1. Manufacturers:
      a. Dresser Industries, Inc.; DMD Div.

    b. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
    c. JCM Industries.
    d. Smith-Blair, Inc.
    e. Viking Johnson.
2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
1. Manufacturers:
    a. Eslon Thermoplastics.

C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
1. Manufacturers:
    a. Thompson Plastics, Inc.

D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
1. Manufacturers:
    a. NIBCO INC.
    b. NIBCO, Inc.; Chemtrol Div.

E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
1. Manufacturers:
    a. Cascade Waterworks Mfg. Co.
    b. Fernco, Inc.
    c. Mission Rubber Company.

2.05 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
   1. Manufacturers:
      a. Eclipse, Inc.
      b. Epco Sales, Inc.
      c. Hart Industries, International, Inc.
      d. Watts Industries, Inc.; Water Products Div.
      e. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Epco Sales, Inc.
      c. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Pipeline Seal and Insulator, Inc.
   2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and non-corrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg.
   1. Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and non-corrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
   1. Manufacturers:
      a. Precision Plumbing Products, Inc.
      b. Sioux Chief Manufacturing Co., Inc.
      c. Victaulic Co. of America.

2.06 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
   2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Carbon steel Include two for each sealing element.
   4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.07 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Under-deck Clamp: Clamping ring with set screws.

2.08 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated.

D. One-Piece, Stamped-Steel Type: With set screw and chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

2.09 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

PART 3 – EXECUTION

3.01 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends, provide additional supports as required.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   1. New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
      g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
      h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
      c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1. Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire-stop materials. Refer to Division 07 Section "Penetration Fire-stopping" for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.02 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   5. PVC Non-pressure Piping: Join according to ASTM D 2855.
   6. PVC to ABS Non-pressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.03 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
   4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.04 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.05 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.06 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.
   6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Miscellaneous Cast-in-Place Concrete."

3.07 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.08 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.09 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 22 05 00

SECTION 22 05 13

COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

PART 2 – PRODCUTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:
1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multi-speed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.05 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

B. Multi-speed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 – EXECUTION (Not Applicable)

END OF SECTION 22 05 13

SECTION 22 05 19

METERS AND GAGES FOR PLUMBING PIPING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Liquid-in-glass thermometers.
   2. Thermowells.
   3. Dial-type pressure gages.
   4. Gage attachments.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Product Certificates: For each type of meter and gage, from manufacturer.

C. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 – PRODCUTS

2.01 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flo Fab Inc.
      b. Palmer Wahl Instrumentation Group.
      c. Trerice, H. O. Co.
      d. Weiss Instruments, Inc.
   2. Standard: ASME B40.200.
   3. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.

4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue[or red] organic liquid.
6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass
8. Stem: Aluminum and of length to suit installation.
   a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Thermowells:
1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

C. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.02 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Ernst Flow Industries.
   d. Palmer Wahl Instrumentation Group.
   e. Tel-Tru Manufacturing Company.
   f. Trerice, H. O. Co.
   g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   h. Weiss Instruments, Inc.
2. Standard: ASME B40.100.

3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.03 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install valve and snubber in piping for each pressure gage for fluids.

H. Install test plugs in piping tees.

I. Install thermometers in the following locations:
   1. Inlet and outlet of each water heater.
   2. Inlet and outlet of each domestic hot-water storage tank.

J. Install pressure gages in the following locations:
   1. Building water service entrance into building.
   2. Inlet and outlet of each pressure-reducing valve.
   3. Suction and discharge of each domestic water pump.

3.02 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.03 ADJUSTING

A. Adjust faces of meters and gages to proper angle for best visibility.

3.04 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
   1. Liquid-filled, bimetallic-actuated type.
   2. Direct-mounted, metal-case, vapor-actuated type.

B. Thermometer stems shall be of length to match thermowell insertion length.

3.05 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F and minus 20 to plus 50 deg C.

B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F and 0 to 150 deg C.

3.06 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be one of the following:
   1. Liquid-filled, Open-front, pressure-relief direct-mounted, metal case.
   2. Sealed direct-mounted, metal case.

B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be one of the following:
   1. Liquid-filled Open-front, pressure-relief direct-mounted, metal case.
   2. Sealed direct-mounted, plastic case.

C. Pressure gages at suction and discharge of each domestic water pump shall be one of the following:
   1. Liquid-filled Open-front, pressure-relief direct-mounted, metal case.
   2. Sealed direct-mounted, plastic case.

3.07 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 160 psi and 0 to 1100 kPa.

B. Scale Range for Domestic Water Piping: 0 to 160 psi and 0 to 1100 kPa.

END OF SECTION 22 05 19

SECTION 22 05 23

GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Bronze angle valves.
2. Brass ball valves.
3. Bronze ball valves.
4. Iron ball valves.
5. Iron, single-flange butterfly valves.
6. Iron, grooved-end butterfly valves.
7. Bronze lift check valves.
8. Bronze swing check valves.
9. Iron swing check valves.
10. Iron swing check valves with closure control.
11. Iron, grooved-end swing check valves.
12. Iron, center-guided check valves.
13. Iron, plate-type check valves.
14. Bronze gate valves.
15. Iron gate valves.
16. Bronze globe valves.
17. Iron globe valves.
18. Lubricated plug valves.
19. Chainwheels.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

PART 2 – PRODCUTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

B. Valve Sizes: Same as upstream piping unless otherwise indicated.

2.02 SPECIALTY VALVES

A. CPVC Union Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc.
      b. Asahi/America, Inc.
      c. Fischer, George Inc.
      d. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
      e. IPEX Inc.
      f. NIBCO INC.
      g. Sloane, George Fischer, Inc.
      h. Spears Manufacturing Company.
      i. Thermoplastic Valves Inc.
   2. Description:
      a. Standard: MSS SP-122.
      b. Pressure Rating: 150 psig at 73 deg F.
      c. Body Material: CPVC.
      d. Body Design: Union type.
      e. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
      f. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded.

g. Ball: CPVC; full port.
h. Seals: PTFE or EPDM-rubber O-rings.
i. Handle: Tee shaped.

B. CPVC Non-Union Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. American Valve, Inc.
b. Asahi/America, Inc.
c. Legend Valve.
d. NIBCO INC.
e. Thermoplastic Valves Inc.
2. Description:
a. Standard: MSS SP-122.
b. Pressure Rating: 150 psig at 73 deg F.
c. Body Material: CPVC.
d. Body Design: Non-union type.
e. End Connections: Socket or threaded.
f. Ball: CPVC; full or reduced port.
g. Seals: PTFE or EPDM-rubber O-rings.
h. Handle: Tee shaped.

C. CPVC Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Fischer, George Inc.
b. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
c. NIBCO INC.
d. Sloane, George Fischer, Inc.
e. Thermoplastic Valves Inc.
2. Description:
a. Pressure Rating: 150 psig at 73 deg F.
b. Body Material: CPVC.
c. Body Design: Lug or wafer type.
d. Seat: EPDM rubber.
e. Seals: PTFE or EPDM-rubber O-rings.
f. Disc: CPVC.
g. Stem: Stainless steel.
h. Handle: Lever.
i. Handle: Lever.

D. CPVC Ball Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. American Valve, Inc.
    b. Asahi/America, Inc.
    c. Fischer, George Inc.
    d. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
    e. IPEX Inc.
    f. NIBCO INC.
    g. Sloane, George Fischer, Inc.
    h. Thermoplastic Valves Inc.
2. Description:
    a. Pressure Rating: 150 psig at 73 deg F.
    b. Body Material: CPVC.
    c. Body Design: Union-type ball check.
    d. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
    e. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded.
    f. Ball: CPVC.
    g. Seals: EPDM- or FKM-rubber O-rings.
3. Description:
    a. Pressure Rating: 150 psig at 73 deg F.
    b. Body Material: PVC.
    c. Body Design: Union-type ball check.
    d. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
    e. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket or threaded.
    f. Ball: PVC.
    g. Seals: EPDM- or FKM-rubber O-rings.

E. CPVC Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Sloane, George Fischer, Inc.
    b. Spears Manufacturing Company.
2. Description:
    a. Pressure Rating: 150 psig at 73 deg F
    b. Body Material: CPVC.
    c. Body Design: Non-rising stem.
    d. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or Threaded.
    e. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket or threaded.
    f. Gate and Stem: Plastic.

g. Seals: EPDM rubber.
h. Handle: Wheel.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.
   1. Install chain-wheels on operators for ball butterfly gate globe and plug valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

E. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

3.03 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
1. Shutoff Service: Ball, butterfly, or gate valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service: Globe or ball valves.
4. Pump-Discharge Check Valves:
5. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
6. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.
7. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

END OF SECTION 22 05 23

SECTION 22 07 00

PLUMBING INSULATION

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Insulation Materials:
      a. Mineral fiber.
   2. Insulating cements.
   3. Adhesives.
   4. Lagging adhesives.
   5. Sealants.
   6. Factory-applied jackets.
   7. Tapes.
   8. Securements.
   9. Corner angles.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

PART 2 – PRODCUTS

2.01 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Mineral-Fiber Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. 3M
      b. CertainTeed Corp.; Duct Wrap.
      c. Johns Manville; Microlite.
      d. Knauf Insulation; Duct Wrap.
      e. Owens Corning; All-Service Duct Wrap.

2.02 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-96.
      b. Foster Products Corporation, H. B. Fuller Company; 81-33.
   2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.03 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Products, Division of ITW; CP-52.
      b. Foster Products Corporation, H. B. Fuller Company; 81-42.
      c. Marathon Industries, Inc.; 130.
      d. Mon-Eco Industries, Inc.; 11-30.

e. Vimasco Corporation; 136.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
3. Service Temperature Range: Minus 50 to plus 180 deg F.
4. Color: White.

2.04 SEALANTS

A. Joint Sealants:
1. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
2. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Products, Division of ITW; CP-76.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Fire- and water-resistant, flexible, elastomeric sealant.
5. Service Temperature Range: Minus 40 to plus 250 deg F.
6. Color: White.
7. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.05 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
   b. Compac Corp.; 104 and 105.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.06 SECUREMENTS

A. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

B. Wire: 0.062-inch soft-annealed, stainless steel.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. C & F Wire.
2. Childers Products.
3. PABCO Metals Corporation.
4. RPR Products, Inc.

2.07 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use de-mineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing. Any insulation materials contaminated by moisture or mildew will be replaced at the contractors expense.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
   1. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

N. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.

2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Handholes.
5. Cleanouts.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Fire-stopping."

3.05 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. Label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

3.06 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective work if sample inspection reveals noncompliance with requirements.

3.08 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.09 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot and Re-circulated Hot Water:
1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
3. NPS 1-1/2 and Larger: Insulation shall be one of the following:
4. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
5. Where plastic piping is installed in return air plenum ceilings use insulation approved for installation within plenum ceilings.

END OF SECTION 22 07 00

SECTION 22 11 16

DOMESTIC WATER PIPING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Specialty valves.
   3. Flexible connectors.
   4. Escutcheons.
   5. Sleeves and sleeve seals.
   6. Wall penetration systems.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping.

C. Comply with NSF 61 for potable domestic water piping and components.

PART 2 – PRODCUTS

2.01 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.02 CPVC PIPING

A. CPVC Pipe: ASTM F 441/F 441M, Schedule 40, plenum rated.
   1. CPVC Socket Fittings: ASTM F 438 for Schedule 40.

B. CPVC Piping System: ASTM D 2846/D 2846M, SDR 11, pipe and socket fittings.

C. CPVC Tubing System: ASTM D 2846/D 2846M, SDR 11, tube and socket fittings.

D. Use only CPVC in plenum ceilings.

2.03 PIPING JOINING MATERIALS

A. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
   1. Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.04 TRANSITION FITTINGS

A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cascade Waterworks Manufacturing.
      b. Dresser, Inc.; Dresser Piping Specialties.
      c. Ford Meter Box Company, Inc. (The).
      d. JCM Industries.
      e. Romac Industries, Inc.
      f. Smith-Blair, Inc; a Sensus company.
      g. Viking Johnson; c/o Mueller Co.

D. Plastic-to-Metal Transition Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Charlotte Pipe and Foundry Company.
b. Harvel Plastics, Inc.
c. Spears Manufacturing Company.

2. Description: CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket or threaded end.

E. Plastic-to-Metal Transition Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
   b. Spears Manufacturing Company.
2. Description: CPVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

2.05 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Central Plastics Company.
   b. EPCO Sales, Inc.
   c. Hart Industries International, Inc.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; Wilkins Water Control Products.
2. Description:
   a. Pressure Rating: 150 psig.
   b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Central Plastics Company.
   b. EPCO Sales, Inc.
   c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Factory-fabricated, bolted, companion-flange assembly.
   b. Pressure Rating: 150 psig.
   c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.
2. Description:
   a. Non-conducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Calpico, Inc.
   b. Lochinvar Corporation.
2. Description:
   a. Galvanized-steel coupling.
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Female threaded.
   d. Lining: Inert and noncorrosive, thermoplastic.

F. Dielectric Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Perfection Corporation; a subsidiary of American Meter Company.
   b. Precision Plumbing Products, Inc.
   c. Victaulic Company.
2. Description:
   a. Electroplated steel nipple complying with ASTM F 1545.
   b. Pressure Rating: 300 psig (2070 kPa) at 225 deg F.
   c. End Connections: Male threaded or grooved.
   d. Lining: Inert and noncorrosive, propylene.

2.06 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Hyspan Precision Products, Inc.
4. Metraflex, Inc.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

2.07 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated or rough-brass finish with setscrews.

C. One Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.

D. Split Casting, Cast Brass: Polished, chrome-plated or rough-brass finish with concealed hinge and setscrew.

E. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

2.08 SLEEVES

A. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

B. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

2.09 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex, Inc.
   4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   1. Sealing Elements: NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.

3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.10 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 – EXECUTION

3.01 EARTHWORK

A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install domestic water piping level and plumb.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping adjacent to equipment and specialties to allow service and maintenance.

F. Install piping to permit valve servicing.

G. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install unions in copper tubing at final connection to each piece of equipment.

3.03 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

E. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

F. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.04 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

3.05 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples or unions.

3.06 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.07 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1 and Smaller: 36 inches with 3/8-inch rod.
   2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.

F. Install supports for vertical CPVC piping every 60 inches for NPS 1 and smaller, and every 72 inches for NPS 1-1/4 and larger.

1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.

3.08 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
   4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.09 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish.
   5. Bare Piping in Equipment Rooms: One piece, stamped steel with set screw.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Label pressure piping with system operating pressure.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:
1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 ADJUSTING

A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.

6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.12 CLEANING

A. Clean and disinfect potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:

         1. Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.

         2. Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      d. Remove all faucet aerators and screens during flushing operation.
      e. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.13 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
   1. CPVC, Schedule 40 pipe; CPVC, Schedule 40 socket fittings; and solvent-cemented joints.

3.14 VALVE SCHEDULE

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller.
   2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller.
   3. Drain Duty: Hose-end drain valves.

C. Use check valves to maintain correct direction of domestic water flow to and from equipment.

D. CPVC valves matching piping materials may be used.

END OF SECTION 22 11 16

SECTION 22 11 19

DOMESTIC WATER PIPING SPECIALTIES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Vacuum breakers
   2. Hose bibbs
   3. Wall Hydrants
   4. Drain valves

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. 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.
B. NSF Compliance:
   1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 – PRODCUTS

2.01 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme.

b. Conbraco Industries, Inc.
c. Legend Valve.
d. MIFAB, Inc.
e. Watts Industries, Inc.; Water Products Div.
f. Woodford Manufacturing Company.
g. Zurn Plumbing Products Group; Light Commercial Operation.
h. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

2.02 HOSE BIBBS

A. Hose Bibbs:
1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Operation: Wheel Handle.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig.
8. Vacuum Breaker: Integral non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Equipment Rooms: Rough bronze.

2.03 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate-Valve-Type, Hose-End Drain Valves:
1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.

6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves:
1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.03 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:
1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

END OF SECTION 22 11 19

SECTION 22 11 23

DOMESTIC WATER PUMPS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Residential Booster Pump
   2. Motors

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

PART 2 – PRODCUTS

2.01 RESIDENTIAL BOOSTER PUMP

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Goulds JRS5K
   2. Or approved equal.

B. Capacities and Characteristics:
   1. Capacity: 14.6 GPM
   2. Total Dynamic Head: 40 PSI
   3. Total Suction Lift: 10 FEET
   4. Inlet and Outlet Size: 1-1/4” inlet, 1” outlet
   5. Pump Speed: 3500 rpm

6. Pump Control: Continuous
7. Motor Horsepower: ½ hp
8. Electrical Characteristics:
   a. Volts: 120.
   b. Phases: Single.
   c. Hertz: 60.
   d. Built on over-load with automatic reset
9. Stainless steel shaft.

2.02 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "Common Motor Requirements for Plumbing Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.02 PUMP INSTALLATION

A. Install booster pump package in accordance with manufacturer’s requirements.

3.03 CONNECTIONS

A. Comply with requirements for piping specified in Division 22 Section "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps to allow service and maintenance.

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
   1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
      a. Horizontally mounted, in-line, separately coupled centrifugal pumps.

b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
c. Vertically mounted, in-line, close-coupled centrifugal pumps.
d. Comply with requirements for flexible connectors specified in Division 22 Section "Domestic Water Piping."

2. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Division 22 Section "General-Duty Valves for Plumbing Piping" and comply with requirements for strainers specified in Division 22 Section "Domestic Water Piping Specialties."
3. Install pressure gage at suction of each pump and pressure gage at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages specified in Division 22 Section "Meters and Gages for Plumbing Piping."

D. Comply with Division 26 Sections for electrical connections, and wiring methods.

E. Connect all control components to pumps that they control.

3.04 STARTUP SERVICE

A. Perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set control components for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:
   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in the correct direction.
6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.05 ADJUSTING

A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 22 11 23

SECTION 22 12 00

FACILITY POTABLE-WATER STORAGE TANKS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Water supply tanks

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings

PART 2 – PRODUCTS

2.01 WATER SUPPLY TANKS

A. Fol-Da-Tank
   1. Three 525-gallon pillow tanks. Potable water fabric NSF/ANSI 61 standard, 4” FNPT PVC opening
   2. Part # PW-525
   3. Will provide the necessary 300 gallons of water to the fire suppression system

PART 3 – EXECUTION

3.01 INSTALLATION

A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

B. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

C. Correct deficiencies in or remove and reinstall products that do not comply with requirements.

D. Repair, refinish, or replace products damaged during installation as directed by Architect.

E. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 22 12 00

SECTION 22 13 16

SANITARY WASTE AND VENT PIPING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Piping materials.
   2. PVC pipe and fittings.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.03 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
   1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

B. Solvent Cement and Adhesive Primer:
   1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 – EXECUTION

3.01 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   2. Dissimilar Pipe-Material Couplings: Flexible, Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
   1. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   2. Dissimilar Pipe-Material Couplings: Flexible, Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3.03 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

C. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

D. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

E. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
   1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

F. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.

G. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.04 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. PVC Non-pressure Piping Joints: Join piping according to ASTM D 2665.

3.05 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.
   2. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   2. Backwater valve are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.06 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Install individual, straight, horizontal piping runs according to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
   2. NPS 3: 48 inches with 1/2-inch rod.
   3. NPS 4: 48 inches with 5/8-inch rod.

F. Install supports for vertical PVC piping every 48 inches.

G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.07 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
  1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
  2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
  3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
  4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.08 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
  1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
  2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
  1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
  2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
  3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
  4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.09 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.10 PROTECTION

A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 22 13 16

SECTION 22 13 19

SANITARY WASTE PIPING SPECIALTIES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Backwater valves.
   2. Cleanouts.
   3. Roof flashing assemblies.
   4. Miscellaneous sanitary drainage piping specialties.
   5. Flashing materials.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
B. 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.
C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

PART 2 – PRODCUTS

2.01 BACKWATER VALVES

A. Horizontal, Plastic Backwater Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Canplas LLC.
      b. IPS Corporation.

c. NDS Inc.
d. Oatey.
e. Plastic Oddities; a division of Diverse Corporate Technologies.
f. Sioux Chief Manufacturing Company, Inc.
g. Zurn Plumbing Products Group; Light Commercial Operation.
2. Size: Same as connected piping.
3. Body: PVC.
4. Cover: Same material as body with threaded access to check valve.
5. Check Valve: Removable swing check.
6. End Connections: Socket type.

2.02 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Acorn Engineering Company; Elmdor/Stoneman Div.
b. Thaler Metal Industries Ltd.

B. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch- thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
1. Low-Silhouette Vent Cap: With vandal-proof vent cap.

2.03 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Sleeve Flashing Device:
1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

B. Stack Flashing Fittings:
1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

C. Vent Caps:
1. Size: Same as connected stack vent or vent stack.

D. Expansion Joints:
1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.04 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
   3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

   Fasteners: Metal compatible with material and substrate being fastened.

B. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

C. Solder: ASTM B 32, lead-free alloy.

D. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.

C. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

D. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

E. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

F. Install vent caps on each vent pipe passing through roof.

G. Install wood-blocking reinforcement for wall-mounting-type specialties.

H. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

I. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.03 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.

C. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

D. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.04 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 13 19

SECTION 22 13 53

FACILITY SEPTIC TANKS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Septic Tanks
   2. Pipes and Fittings

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings

PART 2 – PRODUCTS

2.01 SEPTIC TANKS

A. Fol-Da-Tank
   1. Two 525-gallon pillow tanks. Fabric NSF/ANSI 61 standard, 4” FNPT PVC opening
   2. Part # GW-525

2.02 DISTRIBUTION PIPES AND FITTINGS

A. PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, non-perforated, for solvent-cement or elastomeric gasket joint.
   1. Solvent Cement: ASTM D 2564
   2. Gaskets: ASTM F 477, elastomeric seal

PART 3 – EXECUTION

3.02 INSTALLATION

A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

B. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

C. Correct deficiencies in or remove and reinstall products that do not comply with requirements.

D. Repair, refinish, or replace products damaged during installation as directed by Architect.

E. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 22 13 53

SECTION 22 33 00

ELECTRIC DOMESTIC WATER HEATERS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Household, collector-to-tank, heat-exchanger-coil, solar-electric water heater.

1.02 SUBMITTALS

A. Product Data:
   1. Manufacturer: SunMaxx Solar
   2. Model number: 80 ETC
   3. Capacity: 80 gallon water heater tank
   4. Electrical Data: 4.5 kW, 120V, 1 Ph
   5. Operating conditions: 180 ℉ and 8 GPM, 89 MBH

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Maintenance: Disconnect and flush tank as needed so as to remove debris build-up

D. Warranty:
   1. 7 years limited warranty – on tank and coil heat exchanger

1.03 QUALITY ASSURANCE

A. Source Limitations: Electric water heater is provided with tank

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of electric water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. 4500 W Electric back-up Element – UL listed.

D. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

E. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

F. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

1.04 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including storage tank and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period(s): From date of Substantial Completion:
      a. Household Electric Water Heaters:
         1. Storage Tank and Coil Heat Exchanger: Seven years.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. Household, Collector-to-Tank, Heat-Exchanger-Coil, Solar-Electric Water Heaters: Comply with UL 174 with integral coil-type heat exchanger.
   1. Manufacturers:
      a. StorMaxx SE
   2. Storage-Tank Construction: Steel.
      a. Tappings: ASME B1.20.1 pipe thread.
      b. Pressure Rating: 150 psig.
      c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
   3. Factory-Installed Storage-Tank Appurtenances:
      a. Anode Rod: Replaceable magnesium.
      b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      c. Drain Valve: ASSE 1005.
      d. Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
      e. Heat Exchanger: Corrosion-resistant-metal immersion coil.
      f. Heating Element: One; electric, screw-in immersion type with 6 kW or less.
      g. Temperature Control: Adjustable thermostat for each element.
      h. Safety Control: High-temperature-limit cutoff device or system.
      i. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater

working-pressure rating. Select relief valve with sensing element that extends into storage tank.

4. Capacity and Characteristics:
   a. Capacity: 50 GPM
   b. Recovery: 180 GPH at 180 °F, 100°F temperature rise.
   c. Heating Element:
      1. Quantity: One.
      2. Power Demand: 4.5 kW
   d. Heat-Exchanger Coil Surface: 30 sq. ft.
   e. Temperature Setting: 120 °F.
   f. Electrical Characteristics:
      1. Total Power Demand: 4.5 kW
      2. Volts: 120
      3. Phases: 1
      4. Hertz: 60

2.02 WATER HEATER ACCESSORIES

A. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than water heater working-pressure rating.

C. Water Heater Stand and Drain-Pan Units: High-density-polyethylene-plastic, 2” high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS drain outlet with ASME B1.20.1 pipe thread.

D. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 1.

2.03 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 – EXECUTION

3.01 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.
   1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
   2. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains.

E. Fill water heaters with water.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

END OF SECTION 22 33 00

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. General information applicable to all Plumbing Fixtures.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. 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.

C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

D. NSF Standard: Comply with NSF 61, "Drinking Water System Components-Health Effects," for fixture materials that will be in contact with potable water.

E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

F. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   1. Stainless-Steel Residential Sinks: ASME A112.19.3.

2. Vitreous-China Fixtures: ASME A112.19.2M.
3. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.

G. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
4. Faucets: ASME A112.18.1.
5. Hose-Connection Vacuum Breakers: ASSE 1011.
6. Hose-Coupling Threads: ASME B1.20.7.
7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
8. NSF Potable-Water Materials: NSF 61.
9. Pipe Threads: ASME B1.20.1.
10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
11. Supply Fittings: ASME A112.18.1.
12. Brass Waste Fittings: ASME A112.18.2.

H. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Plastic Tubular Fittings: ASTM F 409.
4. Brass Waste Fittings: ASME A112.18.2.
5. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

I. Comply with the following applicable standards and other requirements specified for miscellaneous components:
1. Flexible Water Connectors: ASME A112.18.6.
2. Floor Drains: ASME A112.6.3.
3. Hose-Coupling Threads: ASME B1.20.7.
4. Off-Floor Fixture Supports: ASME A112.6.1M.
5. Pipe Threads: ASME B1.20.1.
6. Plastic Toilet Seats: ANSI Z124.5.
7. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.04 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
   a. Structural failures of unit shell.
   b. Faulty operation of controls, blowers, pumps, heaters, and timers.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Commercial Applications: Three year(s) from date of Substantial Completion.
3. Warranty Period for Residential Applications of Shells: Five years from date of Substantial Completion.
4. Warranty Period for Residential Applications of Electronic Controls: Five years from date of Substantial Completion.

PART 2 – PRODCUTS

2.01 REFER TO PLUMBING FIXTURE SCHEDULE ON THE CONTRACT DRAWINGS AND SECTIONS 22 41 16, 22 41 23, 22 41 39 FOR ADDITIONAL INFORMATION.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

C. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

D. Install wall-mounting fixtures with tubular waste piping attached to supports.

E. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

F. Install counter-mounting fixtures in and attached to casework.

G. Install fixtures level and plumb according to roughing-in drawings.

H. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 15 Section "General-Duty Valves for Plumbing Piping."

I. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

J. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

K. Install toilet seats on water closets.

L. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

M. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

N. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

O. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

P. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 15 Section "Common Work Results for Plumbing."

Q. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.05 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Replace washers and seals of leaking and dripping faucets and stops.

3.06 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.07 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 40 00

SECTION 22 41 16

RESIDENTIAL LAVATORIES AND SINKS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Above counter rectangular sink
   2. Stainless steel kitchen sink
   3. Toilet

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 WARRANTY

A. American Standard
   1. Products to be free from defects in materials or workmanship for as long as the original consumer purchaser owns this product.

PART 2 – PRODUCTS

2.01 ABOVE-COUNTER RECTANGULAR SINK

A. Kohler
   1. 1.75-inch standard drain opening
   2. Vitreous china interior and exterior, smooth
   3. Integral faucet deck for single hole faucet
   4. Compliance Certifications
      a. ASME A112.19.2-2008, CSA B45.1-08
   5. Model: K-2314-0

2.02 STAINLESS STEEL KITCHEN SINK

A. Kohler
   1. 18 gauge stainless steel
   2. 29-inch undermount 10mm radius covered corners
      a. 9-inch deep
   3. Waste fittings included
   4. Model: K3821-1-NA

2.03 TOILET

A. Kohler
   1. Model K-3654-0
      a. K-4322 (Bowl)
      b. K-4419 (Tank and Cover)
   2. 1.6GPF/0.8GPF
   3. Dual-Max flushing system, Extended skirt, Universal height
   4. Meets or exceeds ASME A112.19.2/CSA B45.1, ASME A112.19.14
   5. California AB715, California Green Building Code

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install per manufacturer's installation guide.

B. Set units level, plumb, and true to line, and anchor securely in place.

C. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasters, unless otherwise indicated.

D. Repair, refinish, or replace products damaged during installation, as directed by Architect.

E. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 22 41 16

SECTION 22 41 23

RESIDENTIAL SHOWERS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes:
   1. Residential Shower
   2. Linear Shower Drain

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.02 WARRANTY

PART 2 – PRODUCTS

2.01 Kohler
A. Model: K-T14422-4E-CP
B. Chrome Finish

2.02 Schluter-Kerdi-Line Drain

A. 36" KLV 60 E 90
   1. Stainless Steel
   2. Drain cover: KLAR 19 EB 90
   3. Internally pitched channel drain body
   4. ASME A112.18.2-2005, CSA B125.2-2005, PMG 1042, CUPC 6181

END OF SECTION 22 41 23

SECTION 22 41 39

RESIDENTIAL FAUCETS, SUPPLIES, AND TRIM

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes:
   1. Lavatory Faucet
   2. Kitchen Faucet
   3. Shower Head
   4. Valve Trim

1.02 SUBMITTALS

A. Submit complete specifications.

1.03 WARRANTY

A. TOTO
   1. Product to be free from defects in materials and workmanship during normal use when properly installed and serviced, for a period of one (1) year from date of purchase. This limited warranty is extended only to the original purchaser of the product.

B. American Standard
   1. Products to be free from defects in materials or workmanship for as long as the original consumer purchaser owns this product.

PART 2 – PRODUCTS

2.01 LAVATORY FAUCET

A. Kohler
   1. Low-flow 2.0 gpm faucet, cross or lever handles, solid brass construction
   2. Metal pop-up drain assembly included
   3. Polished Chrome finish
   4. Compliance Certifications

a. ASME A112.18.1/CSA B125.1, NSF 61 Section 9, UPC, IPC, NSPC, California Green Building Code
b. ADA Compliant
5. Model: K-T14419-4-CP

2.02 KITCHEN FAUCET

A. Kohler
1. Hi-flow spout, memory position valving, metal construction
2. Polished Chrome finish
3. Compliance Certifications
a. ANSI A117.1, ASME A112.18.1, NSF 61 Section 9 & Annex G, CSA B125, Lead Free
4. Model: K-7505-CP

2.03 SHOWER HEAD

A. Kohler
1. Polished Chrome finish
2. Compliance Certifications
a. ASME A112.18.1, CSA B125.1, UPC, IPC, NSPC
3. Model: K-T14422-4E-CP

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install showerhead 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 22 41 39

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23 00 00

HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

23 00 00 - DIVISION CONTENTS

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Performance Requirements
2. Sleeves and Sleeve Seals
3. Grout
4. Escutcheons and Floor Plates
5. Pressure Gages and Test Plugs
6. Hangers and Supports For HVAC

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

PART 2 – PRODCUTS

2.01 PERFORMANCE REQUIREMENTS

A. Hangers and Supports for Plumbing Piping Equipment:
1. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
a. Design supports for multiple pipes capable of supporting combined weight of supported systems, and system contents.
b. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
c. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.02 SLEEVES AND SLEEVE SEALS

A. Galvanized-Steel Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

B. PVC Pipe: ASTM D 1785, Schedule 40.

C. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

D. Modular rubber sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
  1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  2. Pressure Plates: Carbon steel.
  3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

E. Stack-Seal Fitting: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
  1. Underdeck Clamp: Clamping ring with setscrews.

2.03 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

2.04 ESCUTCHEONS AND FLOOR PLATES

A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

B. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

C. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

2.05 PRESSURE GAGES AND TEST PLUGS

A. Direct-Mounted, Metal-Case or Plastic-Case, Dial-Type Pressure Gages:
  1. Standard: ASME B40.100.
  2. Case: Sealed Open-front, pressure relief type(s); nominal diameter.
  3. Movement: Mechanical, with link to pressure element and connection to pointer.
  4. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa).
  5. Pointer: Dark-colored metal.
  6. Window: Plastic.
  7. Ring: Metal.
  8. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Test Plug: Corrosion-resistant brass or stainless-steel body with two self-sealing rubber core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping. Minimum pressure and temperature rating of 500 psig at 200 deg F (3450 kPa at 93 deg C).

2.05 HANGERS AND SUPPORTS FOR HVAC

A. Carbon-Steel Pipe Hangers and Supports:
1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:
1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

C. Fastener Systems:
1. Verify suitability of fasteners in this article for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick.
2. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
3. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated/stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

D. Miscellaneous Materials:
1. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
2. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   a. Properties: Nonstaining, noncorrosive, and nongaseous.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 – EXECUTION

3.01 GENERAL PIPING INSTALLATIONS

A. Install piping free of sags and bends.

B. Install fittings for changes in direction and branch connections.

C. Sleeves:
1. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

2. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
    a. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

3. Install stack-sleeve fittings in new slabs as slabs are constructed.
4. Exterior Wall, Pipe Penetrations: Mechanical sleeve seals installed in steel or cast-iron pipes for wall sleeves.
5. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078446 "Penetration Firestopping."

D. Sleeve-Seal-System Installation:
1. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
2. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

E. Escutcheons & Floor Plates:
1. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
2. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
3. Install floor plates for piping penetrations of equipment-room floors.
4. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

F. Install unions at final connection to each piece of equipment.

G. Install dielectric unions and flanges to connect piping materials of dissimilar metals in gas piping.

H. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in water piping.

3.02 HANGERS AND SUPPORTS

A. Comply with MSS SP-69 and MSS SP-89. Install building attachments within concrete or to structural steel.

B. Install hangers and supports to allow controlled thermal and seismic movement of piping systems.

C. Install powder-actuated fasteners and mechanical-expansion anchors in concrete after concrete is cured. Do not use in lightweight concrete or in slabs less than 4 inches (100 mm) thick.

D. Load Distribution: Install hangers and supports so piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

E. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
   1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
   2. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.

F. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).

3.03 GENERAL EQUIPMENT INSTALLATIONS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

E. Mix and install grout for pump and other equipment base plates, and anchors. Place grout, completely filling equipment bases.

END OF SECTION 23 05 00

SECTION 23 05 19

METERS AND GAGES FOR HVAC

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Thermometers
   2. Gages
   3. Test Plugs

1.02 SUBMITTALS

A. Section 01 33 00 – Submittal Procedures: Submittal procedures and Section 23 05 00 – Common Work Results for HVAC. Where conflicts occur between divisions, the more stringent requirement shall apply.

B. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. American Society of Mechanical Engineers:
   1. ASME B-40.1 – Gauges – Pressure Indicating Dial Type – Elastic Element
   2. ASME Section VIII – Boiler and Pressure Vessel Code- Pressure Vessels

B. American Society for Testing and Materials:
   1. ASTM E1 – Standard Specification for ASTM Thermometers
   2. ASTM E77 – Standard Test Method for Inspection and Verification of Thermometers.

C. Underwriters Laboratories Inc.:
   1. UL 393 – Indicating Pressure Gauges for Fire-Protection Service.
   2. UL 404 – Gauges, Indicating Pressure, for Compressed Gas Service

1.04 WARRANTY

A. Section 01 70 00 – Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer warranty for items covered under this section.

PART 2 – PRODCUTS

2.01 In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

A. Manufacturers: Subject to compliance with requirements and manufactures offerings, products that may be incorporated into the Work include, but are not limited to, manufacturers specified. The first manufacture listed represents the basis of design as schedule and drawn in the Construction Documents.

2.02 VAPOR-ACTUATED DIAL THERMOMETERS

A. Manufacturers:
   1. Trerice, H.O. Co.
   2. Ashcroft Commercial Instrumentation Operations; Dresser Industries; Instrument Div.
   3. Weiss Instruments, Inc.

B. Provide direct-mounting or remote mounting as needed.

C. Construction:
   1. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2 inch (114mm) Diameter.
   2. Element: Bourdon tube or other type of pressure element.
   3. Movement: Mechanical, connecting element and pointer.
   4. Dial: Satin-faced, non-reflective aluminum with permanently etch scale markings
   5. Pointer: Red metal.
   6. Window: Glass or plastic (if indoors).
   7. Ring: Metal or plastic
   8. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
   9. Thermal System: Organic liquid filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation. Stem material to match piping material to prevent contact between dissimilar metals.

D. For thermometer and wells through insulation, provide extensions to compensate for insulation thickness

E. Accuracy: Plus or minus 1 percent of range or plus or minus 1 sclae division to maximum of 1.5 percent of range

2.03 BIMETALLIC-ACTUATED LIQUID DIAL THERMOMETERS

A. Manufacturers:
   1. Trerice, H.O. Co.
   2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   3. Weiss Instruments, Inc.

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40-3.

C. Scale: Dual scale Fahrenheit and Celsius.

D. Construction:
   1. Case: Liquid-filled type, stainless stell with 5-inch (127 mm) diameter.
   2. Element: Bimetal coil
   3. Dial: Satin-face, non-reflective aluminum with permanently etch scale markings.
   4. Pointer: Black metal
   5. Window: Glass
   6. Ring: Stainless steel
   7. Connector: Adjustable angle type.
   8. Stem: Metal, or thermowell installation and of length to suit installation. Stem material to match piping material to prevent contact between dissimilar metals.

E. For thermometers and wells through insulation, provide extensions to compensate for insulation thickness.

F. Accuracy: Plus or minus 1 percent of full range.

G. Select dial range of each gauge for normal operation point at mid-span and full range not to exceed 50% of maximum design.

H. Connection: 1.2 inch union with bulb for hydronic service. Select bulb length to extend into 2/3 of pipe diameter. Material to match piping material to prevent contact between dissimilar metals.

2.04 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions, and with cap and chain.

B. Flange: 3 inch (76mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.05 THERMOWELLS

A. Manufactuers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer. With cap and chain. Material to match piping material to prevent contact between dissimilar metals.

2.06 PRESSURE GAGES

A. Manufacturers:
   1. Ashcroft Commercial Instrument Operations; Dresser Indstries; Instrument Div.
   2. Trerice, H.O. Co.
   3. Weiss Instruments, Inc.

B. Direct-Mounted or Remote-Mounted, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type
   1. Case: Dry or liquid filled type, drawn steel or cast aluminum, 4-1/2 inch (114mm) diameter (where remoted mounted provide with holes for panel mounting).
   2. Scale: both psi and kPa
   3. Pressure-Element Asssembly: Bourdon tube, 316 Stainless Steel.
   4. Pressure Connection: Metal, ¼-inch, bottom-outlet type. Material to match piping material to prevent contact between dissimilar metals.
   5. Movement: Mechanical, stainless steel, with link to pressure element and connection to pointer.
   6. Dial: Stain-face, non-reflective aluminum with permanently etch scale markings.
   7. Pointer: Micro adjustable,black finished, front adjustable.
   8. Window: Glass
   9. Ring: Threaded fiberglass reinforced polypropylene.
   10. Accuracy: ASME B40,100 Grade 2A, plus or minus 0.5 percent of scale range.
   11. Options Required: Red Set Hand.
   12. Vacuum-Pressure Range: 15-in Hg of vacuum to 15 psig of pressure (50 kPa of vacuum to 103 kPa of pressure)
   13. Snubber screw: Provide on all gauges on suction and discharge sides of pumps.
   14. Select dial range of each gauge for normal operating point at mid-span and full range not to exceed 50% of test pressure.

C. Pressure-Gage Fittings:
   1. Valves: ¼-inch brass or stainless-steel needle type.
   2. Syphons: ¼-inch coil of brass tubing with threaded ends.
   3. Snubbers: ASME B40.5. 1/4-inch brass bushing with corrosion-resistant porus-metal disc or material suitable for system fluid and working pressure.

2.07 PRESSURE GAGE TAPS

A. Manufacturers:
   1. H.O. Trerice Co.

B. Needle Valve: 1/4inch NPT for minimum 300psi.

C. Ball Valve: Brass 1/4inch NPT for 250 psi

D. Pressure Snubber:
   1. Series 872 Brass.
   2. 1/4inch NPT connections.

E. Coil Siphon

1. Series 885.
2. 40 Brass.
3. 1/4inch NPT.

2.08 TEST PLUGS

A. Manufacturers:
   1. Peterson Equipment Co., Inc.
   2. Trerice, H.O. Co.
   3. Flow Design, Inc.
   4. MG Piping Products Co.
   5. National Meter, Inc.
   6. Sisco Manufacturing Co.
   7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping. Provided stainless steel for steel piping and brass for copper piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C)

D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for air or water service at minus 30 to plus 275 deg f (minums 35 to plus 136 deg C) shall be EPDM.

E. Locate where required for balancing and where indicated on Drawings. Coordinate with balancing firm.

2.09 TEST KIT

A. Furnish one test kit containing one pressure gage and adaptor, one thermometer, and carrying case. Pressure gage, adapter probers, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

B. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch (51-76 mm) diameter dial and probe. Dial range shall be 0 to 200 psig (0 to 1380 kPa).

C. Low –Range Thermometer: Small bimetallic insertion type with 1- to 2-inch (25-to 51-mm) diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F (minus 4 to plus 52 deg C).

D. Carrying case shall have formed instrument padding.

2.10 DUCT TEST HOLES

A. Manufacturers:
   1. Hardcast PTP-1.

B. Permanent Test Holes: Factory fabricated, air tight flanged fitting with screw cap. Furnish extended neck fittings to clear insulation.

2.11 DUCT DIAL THERMOMETERS

A. Manufacturers:
   1. Trerice, H.O. Co.

B. Thermometer: ASTM E1, stainless steel case, adjustable angle with front calibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless tell stem.
   1. Size: 3 inch (76 mm) diameter dial.
   2. Lens: Clear Lexan.
   3. Accuracy: q percent.
   4. Calibration: Both °F and °C, -30°F to 130°F.

2.12 DUCT STATIC PRESSURE GAGES

A. Manufacturers:
   1. Trerice, H.O. Co.

B. Dial Gages: 3-1/2 inch (89 mm) diameter dial in metal case, diaphragm actuated, black figures on white background, front calibration adjustment, 2 percent of full scale accuracy.

C. Accessories: Static pressure tips with compression fittings for bulkhead mounting, ¼ inch (6mm) diameter tubing.

PART 3 – EXECUTION

3.01 THERMOMETER APPLICATIONS

A. Provide thermometer types listed in the following locations:

Application	Thermometer Type
Inlet and outlet of each hydronic zone	Vapor-actuated dial or Bi-metallic actuated dial
Inlet and outlest of each hydronic coil in air-handling units and built-up central systems larger that 2,000 cfm	Vapor-actuated dial or Bi-metallic actuated dial
Inlet and outlet of each hydronic heat exchanger	Vapor-actuated dial or Bi-metallic actuated dial
Inlet and outlet of each thermal storage	Vapor-actuated dial or

tank	Bi-metallic actuated dial
Suction and discharge or each pump	Vapor-actuated dial or Bi-metallic actuated dial
Outside air, return air, and supply air at each floors riser connection and at the furthest branch on the most remote floor	Duct thermometer
Air handler outside air, supply, and return duct connections	Duct thermometer

B. Provide the following temperature ranges for thermometers:

Application	Range
Heating Hot Water	30 to 240 deg F, with 2-degree scale divisions (Minus 1 to plus 115 deg C, with 1-degree scale divisions)
Chilled Water	0 to 100 deg F, with 2-degree scale divisions (Minus 18 to plus 38 deg C, with 1-degree scale divisions)
Air Ducts	Minus 40 to 110 deg F, with 2-degree scale divisions (Minus 40 to plus 43 deg C, with 2-degree scale divisions)

3.02 PRESSURE GAGE APPLICATIONS

Application	Pressure Gage Type
Discharge of pressure reducing valve	Dry type dial gage
Discharge of differential pressure control valve	Dry type dial gage
Suction and Discharge of Pumps	Liquid filled type dial gage
Fan discharge	Duct pressure gage
At every system duct static pressure sensor that is monitored by the direct digital control system.	Duct pressure gage
Across duct mounted filters and filter banks, (inlet to outlet). On multiple banks in series, provide manifold and single gage with switching capability or else provide independent gages to monitor each individual bank.	Duct pressure gage

3.03 INSTALLATION - PIPE

A. Install thermometers and gauges for easy readability (height distance, view angle) from floor or maintenance platform, except thermometer and gauges at ceiling coils.

B. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines and equipment.

C. Dial Thermometers
1. Install thermometes in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches (65 mm) for installation of thermometer sockets. Allow clearance from insulation.
2. Install thermowellls with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.
3. Install direct-mounting pressure gages in piping tess with pressure gage located on pipe at most readable position. Install direct-mounting thermometers and adjust vertical and tilted positions for readability.
4. Use remote mounted dial thermometers when fluid thermometers are not easily readable due to distance or position in piping. Install remote=mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length. Install gauges on non-vibrating backing. Install related gauges (e.g. pump suction, discharge) on common supports and at same height.
5. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated on drawings and as specified. Attach to duct with screws and caulk to seal.

D. Pressure Gage
1. Install pressure gages with pulsation dampeners. Provide ball valve to isolate each gage. Extend nipples to allow clearance from insulation.
2. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam). Install needle-valve and syphon fitting in piping for each pressure gage for steam.

E. Test Plugs
1. Provide pressure/temperature test plugs at suction and discharge of all pumps, inlets and outlets of boiler, coils, pressure reducing valves, heat exchangers, riser take-offs, etc and where indicated on drawings.
2. Provide instrument cocks at pressure gauges.
3. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets and where indicated on drawings.

3.04 INSTALLATION - DUCT

A. Install permanent duct test holes as listed below and as required for testing and balancing purposes.

B. Install thermometers in air duct systems on flanges.

C. Were thermometers are provided on local panels, duct mounted thermometers are not required.

D. Locate duct-mounted thermometers minimum 10 feet (3m) downstream of mixing-dampers, coils, or other devices causing air turbulence.

E. Provide instruments with scale ranges selected according to service with largest appropriate scale.

F. Install thermometers in locations where they are easily read from normal operating level. Install vertical to 45° off vertical.

G. Adjust thermometers to final angle, clean windows and lenses, and calibrate to zero.

H. Duct test holes shall be provided as follows:
   1. Upstream and downstream of coils (including at air handling devices)
   2. At each riser exit/entrance.
   3. Within the furthest-away branch of each system.
   4. Next to each duct mounted sensor connected to the building automation system.
   5. Across each flow measurement station.

3.05 PROTECTION OF INSTALLED CONSTRUCTION

A. Section 01 70 00 – Execution and Closeout Requirements: Requirements for protecting installed construction.

B. Do not install hydronic pressure gauges until after systems are pressure tested.

3.06 ADJUSTING

A. Calibrate meters according to manufacturer’s written instructions, after installation.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.07 TESTING

A. Prior to testing thermometers and gages, test air vent points to insure all air has been vented.

B. Test thermometers and pressure gauges for accurate indication with known calibrated master.

END OF SECTION 23 05 19

SECTION 23 05 23

GENERAL-DUTY VALVES FOR HVAC

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Ball valves.
   2. Gate valves.
   3. Globe valves.
   4. Check valves.
   5. Calibrated balancing valves.
   6. Air vents.
   7. Drain valves.

1.02 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittal procedures and Section 23 05 00 – Common Work Results for HVAC. Where conflicts occur between divisions, the more stringent requirement shall apply.

B. Furnish shop drawings and product data.

C. Product Data: For each type of valve indicated include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating each valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

D. Manufacturer's Installation Instructions: Submit hanging and support methods, joining procedures.

E. Valve Chart
   1. Submit a valve schedule listing a unique valve reference number, service, location, valve type, size, flow rate and model number for each valve. Cross reference to supporting product data. Refer to Section 23 05 53.

F. Balancing Valves
   1. Provide a summary chart tabulating:
      a. Balancing valve reference code (as agreed by testing adjusting and balancing contractor).

b. Required flow rate.
c. Selection procedure including required balancing pressure drop (provided by the testing adjusting and balancing contractor).

G. The submittal shall include all manufacturers' literature detailing the selection procedure.

H. Shop Drawings
1. Submit shop drawings for all piping installation in the project. Indicate all valves on the pipework shop drawings including reference code on the valve chart.

1.03 QUALITY ASSURANCE

A. American Society for Testing and Materials:
1. ASTM A216/A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
2. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
3. ASTM D4101 - Standard Specification for Propylene Injection and Extrusion Materials.

B. Manufacturers Standardization Society of the Valve and Fittings Industry:
1. MSS SP 67 - Butterfly Valves.
2. MSS SP 70 - Cast Iron Gate Valves, Flanged and Threaded Ends.
3. MSS SP 71 - Cast Iron Swing Check Valves, Flanged and Threaded Ends.
4. MSS SP 78 - Cast Iron Plug Valves, Flanged and Threaded Ends.
5. MSS SP 80 - Bronze Gate, Globe, Angle and Check Valves.
6. MSS SP 85 - Cast Iron Globe & Angle Valves, Flanged and Threaded.
7. MSS SP 110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

C. Source Limitations for Valves: Obtain each type of valve from single manufacturer.

D. ASME Compliance:
1. ASME B31.9 for building services piping valves up to 125psig (860 kPa). ASME B31.1 for higher pressure systems.
2. Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

1.04 WARRANTY

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for warranties.

B. Furnish five year manufacturer warranty for valves excluding packing.

PART 2 – PRODCUTS

2.01 In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

A. Manufacturers: Subject to compliance with requirements and manufacturer's offerings, products that may be incorporated into the Work include, but are not limited to, manufacturers specified. The first manufacturer listed represents the basis of design as scheduled and drawn in the Construction Documents.

2.02 VALVES, GENERAL

A. Provide valve materials suitable for service and temperature of respective systems, especially with respect to discs, plugs, balls, linings, gaskets, and lubricants of globes valves, plug cocks, ball valves, etc.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

D. Valve Flange: Same pressure rating as valve.

E. Valve Actuators:
1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
2. Gear Drive: For quarter-turn valves 8 Inches and larger.
3. Handwheel: For valves other than quarter-turn types.
4. Lever Handle: For quarter-turn valves 6 Inches and smaller, except plug valves.
5. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

F. Valves in Insulated Piping: With minimum 2-inch (50-mm) stem extensions and the following features:
1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

G. Valve-End Connections:
   1. Flanged: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.
   2. Grooved: With grooves according to AWWA C606.
   3. Solder Joint: With sockets according to ASME B16.18.
   4. Threaded: With threads according to ASME B1.20.1.

H. Valve Bypass and Drain Connections: MSS SP-45.

I. Contractor shall provide similar metals and, if not available, provide for proper connections between dissimilar metals.

J. Wheel handles to be non-heating style cast from malleable iron ASTM A197.

K. Mark each valve at the factory with the following minimum information, engraved, stamped or cast on each valve or metal tag permanently attached to the valve.
   1. Manufacturer's name.
   2. Catalog or Figure number.
   3. Size and pressure class.
   4. Arrows shall indicate direction of flow on check, globe, angle, non-return and eccentric plug valves.
   5. UL approved valves and shall bear the UL label.

2.03 BALL VALVES

A. Manufacturers:
   1. NIBCO, Inc.
   2. Crane Valve, North America.
   3. Conbraco.
   4. Apollo.

B. 3 inches and Smaller: MSS SP 110, 600 psi WOG, three piece bronze body, stainless steel ball, full port, Teflon seats, blow-out proof stainless steel stem, solder or threaded ends, lever handle. Provide stem extension for insulated applications.

2.04 GATE VALVES

A. Manufacturers:
   1. NIBCO, Inc.
   2. Crane Valve, North America.
   3. Stockham Valves & Fittings.
   4. Milwaukee Valve Company.

B. 2 Inches and Smaller:
   1. MSS SP 80, Class 125, bronze body, bronze trim, union bonnet, non-rising stem, hand-wheel, inside screw solid wedge disc, alloy seat rings, solder ends.

C. 2-1/2 Inches and Larger:
   1. MSS SP 70, Class 125, cast iron body, bronze trim, bolted bonnet, non-rising stem, hand-wheel, outside screw and yoke, solid wedge disc with bronze seat rings, flanged ends.
   2. Furnish chain-wheel operators for valves 6 inches and larger mounted over 8 feet above finished floor.

2.05 GLOBE VALVES

A. Manufacturers:
   1. NIBCO, Inc.
   2. Crane Valve, North America.
   3. Stockham Valves & Fittings.
   4. Milwaukee Valve Company.

B. 2 Inches and Smaller:
   1. MSS SP 80, Class 125, bronze body, bronze trim, union bonnet, hand wheel, Teflon composition disc, solder ends.

C. 2-1/2 Inches and Larger:
   1. MSS SP 85, Class 125, cast iron body, bronze trim, hand wheel, outside screw and yoke, flanged ends.
   2. Furnish chain-wheel operators for valves 6 inches and larger mounted over 8 feet above finished floor.

2.06 CHECK VALVES

A. Manufacturers:
   1. NIBCO, Inc
   2. Crane Valve, North America.
   3. Hammond Valve.
   4. Milwaukee Valve Company.

B. Horizontal Swing Check Valves
   1. 2 Inches and Smaller:
      a. MSS SP 80, Class 150, bronze body and cap, bronze seat, teflon disc, solder ends.
   2. 2-1/2 Inches and Larger:
      a. MSS SP 71, Class 125, cast iron body, bolted cap, bronze or cast iron disc, renewable disc seal and seat, flanged ends.

C. Spring Loaded Check Valves
   1. 2 Inches and Smaller:

a. MSS SP 80, Class 125, bronze body, in-line spring lift check, silent closing, Teflon disc, integral seat, solder ends.
2. 2-1/2 Inches and Larger:
   a. MSS SP 71, Class 125, globe style, cast iron body, bronze seat, center guided bronze disc, stainless steel spring and screws, flanged ends.

D. Non-Slam Check Valves
   1. Mount non-slam silent closing check valves on the discharge side of the pumps.

2.07 CALIBRATED BALANCING VALVES

A. Manufacturers:
   1. TA Hydronics.
   2. Bell & Gossett.

B. Up to 2 Inches: Nonferrous, pressure die cast, nonporous copper alloy body. EPDM seat and probe seals. TA Hydronics Series 786 or 787.

C. Over 2 Inches: Ductile Iron body conforming to ASTM Grade A535. All other metal parts shall be of nonferrous copper alloy. EPDM seat and probe seals. TA Hydronics Series 788.

D. All balancing valves shall include a concealed memory with a locking tamperproof setting.

E. All balancing valves shall be furnished with valve manufacturer’s preformed rigid polyurethane thermal insulation and extended level stem.

2.08 AIR VENTS

A. Manufacturers
   1. Bell and Gossett.
   2. Taco.
   3. Hoffman.
   4. Armstrong.

B. Manual Type: 3 inch tall vertical sections of 2 inch diameter pipe to form air chamber, with 1/4 inch ball valve at top of chamber with hose bibb and cap.

C. Automatic Float Type:
   1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve piped to approved plumbing receptor.

2.09 DRAIN VALVES

A. Manufacturers:
   1. NIBCO, Inc.

2. Crane Valve, North America.
3. Red Valve Company.

B. 3/4 inch, MSS SP 110, 600 psi WOG, two piece bronze body, chrome plated brass ball, full port, Teflon seats, blow-out proof stem, solder or threaded ends, lever handle, hose cap and chain. Provide stem extension for insulated applications.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

D. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

E. Examine threads on valve and mating pipe for form and cleanliness.

F. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

G. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. Use the following types of valves:

System	Application	Valve
Chilled Water and Cold Condensate	Shutoff	2” (DN 50) and smaller - ball valves

Heating Hot Water	Shutoff	2” (DN 50) and smaller - ball valves
Pump Discharge	Check valve	2” (DN 50) and smaller –swing check valves

3.03 AIR VENT AND DRAIN VALVE APPLICATION

Equipment type	Required locations	Comments
Automatic air vents	Tops of risers	Pipe to the nearest approved receptor drain with ¼” copper tubing
Manual air vents	On each side of each heat-transfer device Each high point in the piping system on the floor layout	Provided threaded hose end connection
Manual drain valves	Bottoms of risers	Size for 2” with threaded hose end connection. Coordinate with plumbing for nearby approved receptor drain.
Manual drain valves	On each side of each heat-transfer device Each low point in the piping system on the floor layout At each mains shut-off	Provided threaded hose end connection

3.04 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Provide all equipment with shutoff valves. Provide all valves, strainers and check valves, except control valves and unless specifically sized, of same size as the pipes in which they are installed unless otherwise indicated. Provide fixture stops.

C. Provide shut-off valves for shut-off at each riser connection.

D. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

E. All hand-controlled line valves are to be gate, ball or butterfly valves, except where throttling control or frequent operation is required, provide globe, butterfly or angle valves, unless otherwise shown or specified. Install all globe and angle valves to close against system pressure.

F. Position gate valves so that stems are in any suitable angle from horizontal to upright position, not inverted. Install valves only in accessible locations. Provide access doors where valves and fittings are not accessible. Coordinate size and location of access doors with Section 08 31 13.

G. Support line valves at the valve in addition to regularly spaced pipe supports shown and specified.

H. Provide extended level handle to accommodate insulation.

I. Provide ball blow-down valves and hose adaptors at strainers, air separators, tanks, pipe traps, equipment drains, etc. of same size as strainer blow-off connection.

J. Install 3/4 inch (20 mm) ball valves with cap for drains at main shut-off valves, low points of piping, and at equipment. Provide 2 inch (50 mm) ball valve with cap at bases of vertical risers. When located above ceilings, locate drain valves 6 inches from access panels for fixed ceilings and 6 inches above ceiling for accessible ceilings.

K. Provide ball valves to isolate expansion devices.

L. Provide open-ended line valves with plugs or blind flanges.

M. Provide valves at points shown and as required for complete isolation of equipment, risers, branches off mains, automatic valves and tanks arranged so as to give complete and regulation control of piping systems throughout the building. Install valves, with neat appearance and grouping, so that all parts are easily accessible for maintenance. Not all isolation valves are indicated on drawings.

N. Install check valves for proper direction of flow and per manufacturer’s directions.

3.05 JOINT CONSTRUCTION

A. Refer to Section 23 21 23 for basic piping joint construction.

B. Grooved Joints (where explicitly allowed): Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.06 TESTING

A. Test valve bonnets for tightness. Operate valves from closed-to-open-to-closed position while valve is under test pressure.

B. Test automatic valves including solenoid valves, expansion valves, water regulating valves, pressure reducing valves, pressure relief valves, safety valves and temperature and pressure relief valves for proper operation at settings indicated.

C. Insure that valves are field checked for packing and lubricant and that disc is for service intended. Replace leaking packing. Service valves which do not operate smoothly and properly with suitable lubricant before placing in operation.

D. Test relief valves, safety relief valves, safety valves and temperature and pressure relief valves three times.

3.07 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 23 05 23

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Pip hangers and supports
2. Insulated pipework supports.
3. Pipe guides
4. Hanger rods
5. Inserts
6. Flashing

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Section 01 33 00 - Submittal Procedures: Submittal procedures and Section 23 05 00 – Common Work Results for HVAC. Where conflicts occur between divisions, the more stringent requirement shall apply.

C. Note compliance with all regulatory agencies and seismic regulations on submittals. Hangers and Supports shall be designed by a professional structural engineer.

D. Shop Drawings:
1. Hangers and Supports:
   a. Indicate system layout with location of all hangers and supports cross referenced by type and point load. Locations shall include dimensions from gridlines, walls or floors. Provide a detail for each hanger type proposed. Include manufacturer's model number or equipment reference on each detail. Provide a reference code for each hanger type that cross-refers to system shop drawings. Provide the point load on the structure in each support location.
   b. Provide details showing hangar configuration, anchorage and modifications to existing structure (as necessary).
2. Firestopping: Indicate through cross-reference to UL or WH approved details the firestopping application that maintains integrity at the services penetrations at each fire-related construction.
3. Wherever hangers and supports impose a point load greater than 300 lbs. the shop drawings shall include details of support and anchorage spacing off of known building reference gridlines.

E. Product Data:
1. Hangers and Supports: Submit manufacturers catalog data including hanger load capacity, stamped detail drawings, bracing/load tables or individual hanger calculations to establish loads at each point.
2. Anchorage: Based on the anticipated hangar loads, provide catalog data in concrete on the anchor support of the hangar accessories. If inserts are used, provide evidence of load capacity, installation instructions, and proof of compatibility with structural elements.
3. Anchorage to structural steel: Based on anticipated hangar loads, provide catalog data on the anchor support of the hanger, including load capacity local loading of steel, method of attachment, and proof of available strength in the structural system.
4. Firestopping: Submit data on product characteristics, performance and limitation criteria.
5. Firestopping Schedule: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance rating of adjacent assembly.
6. Engineering Judgments: For firestopping conditions not covered by UL or WH listed designs, submit judgments by licensed professional engineer suitable for presentation to authority having jurisdiction for acceptance as meeting code fire protection requirements.

F. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers. Indicate calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers. Submit calculations stamped by a registered California professional structural engineer.

G. Manufacturer's Installation Instructions:
1. Hangers and Supports: Submit special procedures and assembly of components.
2. Firestopping: Submit preparation and installation instructions.

1.03 QUALITY ASSURANCE

A. American Society of Mechanical Engineers:
1. ASME B31.1 - Power Piping.
2. ASME B31.9 - Building Services Piping.

B. American Society for Testing and Materials:
1. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.
2. ASTM E119 - Method for Fire Tests of Building Construction and Materials.
3. ASTM E814 - Test Method of Fire Tests of Through Penetration Firestops.
4. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
5. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.

C. American Welding Society:
1. AWS D1.1 - Structural Welding Code – Steel.

D. FM Global:
1. FM - Approval Guide, A Guide to Equipment, Materials & Services Approved By Factory Mutual Research For Property Conservation.

E. Manufacturers Standardization Society of the Valve and Fittings Industry:
1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.

2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
3. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

F. Underwriters Laboratories Inc.:
1. UL 263 - Fire Tests of Building Construction and Materials.
2. UL 723 - Tests for Surface Burning Characteristics of Building Materials.
3. UL 1479 - Fire Tests of Through-Penetration Firestops.
4. UL 2079 - Tests for Fire Resistance of Building Joint Systems.
5. UL - Fire Resistance Directory.

G. Through Penetration Firestopping of Fire Rated Assemblies: ASTM E814 with 0.10 inch water gage (24.9 Pa) minimum positive pressure differential to achieve fire F-Ratings and temperature T-Ratings as indicated on Drawings, but not less than 1-hour.
1. Wall Penetrations: Fire F-Ratings as indicated on architectural Drawings, but not less than 1-hour.
2. Floor and Roof Penetrations: Fire F-Ratings and temperature T-Ratings as indicated on architectural Drawings, but not less than 1-hour.
   a. Floor Penetrations within Wall Cavities: T-Rating is not required.

H. Surface Burning Characteristics: 25/50 flame spread/smoke developed index when tested in accordance with ASTM E84.

I. Perform Work in accordance with AWS D1.1 for welding hanger and support attachments to building structure.

1.04 WARRANTY

A. Section 01 70 00 - Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer warranty for pipe hangers and supports.

PART 2 – PRODCUTS

2.01 In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

A. Manufacturers: Subject to compliance with requirements and manufacturer’s offerings, products that may be incorporated into the Work include, but are not limited to, manufacturers specified. The first manufacturer listed represents the basis of design as scheduled and drawn in the Construction Documents.

2.02 PIPE HANGERS AND SUPPORTS

A. Manufacturers:
   1. Unistrut.
   2. Fee & Mason.
   3. B-Line.
   4. Anvil.

B. Pipe hanger and support listed in the following sections are Superstrut unless otherwise noted.

C. Conform to ASME B31.1 and ASME B31.9, ASTM F708, MSS SP58, MSS SP69, and MSS SP89.

D. Corrosion Protection
   1. The base material for all hangers and supports shall be as detailed below. Each base material shall be electro galvanized. Products with other final finishes shall not be acceptable.
   2. All pipe supports shall be painted with zinc-based paint where the original plating has been removed due to welding, threading or scraping.

E. Individual Horizontal Piping: Series C-711 hangers 3 inches and smaller. C710 hangers 4 inches and larger.

F. Individual Grouped Piping: Horizontal channel Superstrut A1200 with Series 702 straps.

G. Copper Pipe Support: Copper-plated carbon-steel ring.

H. Risers: Series C-720 at each floor.

I. Beam Clamps: No. U501, U520, with restraining clamp.

J. Install pipe rollers on trapeze supported pipe that is subject to expansion and contraction.
   1. No. C728 for trapeze supported pipe.
   2. No. C729 on individually supported piping that is seismically braced.

K. Dielectric Isolators: All uninsulated copper tubing systems. Use Superstrut isolators, Cush-A-Strip or Cush-A-Clamp on all pipe clamps. For individual hangers, use felt lined hangers.

L. Miscellaneous Steel: Provide miscellaneous steel members, beams, brackets, etc., for support of Work of this Division unless specifically included in other Divisions.

M. Pipe and Equipment Wrapping and Coating:
   1. The Manville Company No. 22 primer adhesive.
   2. The Manville Company V10-20, 20-mil thick polyvinyl tape.
   3. Standard X-Tru-Coat and Thermofit 25-mil extruded polyethylene.
   4. Koppers Bitumastic 70-B enamel.
   5. Permacell UG pipe tape.

2.03 INSULATED PIPEWORK SUPPORTS

A. Manufacturers:
   1. Unistrut.
   2. Fee & Mason.
   3. B-Line.
   4. Anvil.

B. Insulated pipe supports shall be supplied and installed on all insulated pipe and tubing. Hangers and supports shall fit outside of all pipe insulation and insulation inserts. Provide pre-insulated pipe supports as specified and install per manufacturer's installation instructions.

C. Insulation Shields: 360-degree insert of high density, 100 psi, waterproofed calcium silicate, asbestos-free, K=0.38, encased in a 360-degree galvanized sheet metal shield, ASTM A-527.
   1. Pipe supported on rod hangers: Use Models A1000, A2000, A3000, A4000 and A9000.
   2. Pipe supported on flat surfaces: Use Models A1000, A2000, A5000, A6000 and A7000.
   3. Pipe supported on pipe rolls: Use Models A3000, A4000, A5000, A6000 and A8000.
   4. Model designations are by Pipe Shields.

D. All insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of the following codes: ASME B31.9, MSS SP-58, MSS SP-69 and MSS SP-89.

E. Insulation Saddles: 20-gage galvanized sheet metal with felt lining. Saddle length not less than three times the insulation outside diameter; 12 inch minimum length at each hanger.

2.04 PIPE GUIDES

A. Manufacturers:
   1. Anvil.
   2. B-line.
   3. Tolco.

B. Sizes suitable to receive insulation.

2.05 HANGER RODS

A. Mild steel threaded both ends, threaded on one end, or continuous threaded.

2.06 SAFETY HANGER WIRES

A. For air diffusers and other mechanical units to be mounted on suspended-grid ceiling systems and weighing less than 56 pounds per unit, furnish and install safety hanger wires, but not connect, as work under Division 09, and to meet requirements as referenced.

B. In advance of ceiling hanger-wire work, provide to jobsite layouts or instructions necessary for proper installation of safety wires.

C. As part of Work under this Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC):
1. Connect safety wires to mechanical diffusers and equipment.
2. For diffusers and equipment units weighing 56 pounds or more, provide approved hangers as required by UBC Section 47.1814.

2.07 ESCUTCHEONS

A. Provide at all piping penetrations of walls, floors and ceilings in occupied spaces. Occupied spaces include rooms with finished ceilings and where penetration occurs below finished ceiling. Where piping is insulated provide escutcheons to fit insulation outside diameter.

B. Escutcheons shall be of sufficient outside diameter to cover sleeve opening and fit snugly around pipe. Provide special deep escutcheons where necessary to cover heads of fittings or sleeves extending through floors.

C. Spring clips are not acceptable.

D. Escutcheon plates shall be polished chrome plated. Plated steel escutcheon plates are not acceptable. Where piping requires special escutcheon sizes, manufacture from stainless steel.

2.08 FLASHING

A. Make penetrations through any dampproofed/waterproofed surfaces dampproof/waterproof by appropriate means to maintain integrity of system penetrated. Includes penetrations caused by hangers suspended off such surfaces.

B. Flash and counterflash watertight all pipe and duct penetrations of roofs and exterior walls.

C. Metal Flashing: 26 gage (0.5 mm) thick galvanized steel.

D. Metal Counterflashing: 22 gage (0.8 mm) thick galvanized steel.

E. Lead Flashing:
1. Waterproofing: 5 lb./sq. ft (24.5 kg/sq m) sheet lead.
2. Soundproofing: 1 lb./sq. ft (5 kg/sq m) sheet lead.

F. Flexible Flashing: 47 mil (1.2 mm) thick sheet butyl; compatible with roofing.

G. Caps: Steel, 22 gage (0.8 mm) minimum; 16 gage (1.5 mm) at fire resistant elements.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify openings are ready to receive sleeves.

C. Verify openings are ready to receive firestopping.

3.02 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.

B. Remove incompatible materials affecting bond.

C. Install backing damming materials to arrest liquid material leakage.

D. Do not use powder-actuated anchors.

E. Obtain permission from Architect/Engineer before drilling or cutting structural members.

3.03 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Install in accordance with ASME 31.9, ASTM F708, MSS SP 58, MSS SP 69 and MSS SP 89.

B. Use properly manufactured supports throughout. Do not use make-shift materials such as wire, tape, wood blocks, etc.

C. Do not cut or weld to any structural steel without permission of structural engineer.

D. Design hangers for pipe movement and removal or equipment without disengagement of supported pipe.

E. Install pipe rollers for trapeze supported pipe that is subject to expansion and contraction.

F. Insulated pipe supports shall be supplied and installed on all insulated pipe and tubing.

G. On hot pipe, apply three-inch wide vapor barrier tape or band over the butt joint.

H. All insulated pipe supports shall be load rated. Load ratings shall be established by the pipe support manufacturer based upon testing and analysis in accordance with the latest edition of the following codes: ASME B31.9, MSS SP-58, MSS SP-69 and MSS SP-89.

I. All insulated supports and anchors shall be installed according to the manufacturer's installation instructions. All insulated supports shall be from the same manufacturer.

J. Prime coat exposed steel hangers and supports. Refer to Section 09 90 00. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

K. Provide clearance in hangers and from structure and other equipment for installation of insulation. Refer to Section 22 07 00.

L. Adjust each hanger to carry its proper share of load.

M. Install additional supports or braces if, during test or normal operation, piping should sway, crawl or vibrate. Piping shall be immobile.

N. Support piping below any ductwork from wall or trapeze with hanger rods outside of ductwork.

O. Support piping including valves, etc., independently of equipment; no piping weight or stress due to expansion, construction to be transmitted to equipment. Contractor is responsible for proper alignment of piping at equipment in all conditions (maximum hot to minimum cold); install anchors, guides, bracing and spring supports as required. Flexible connections, expansion joints' deflections shall be always within allowable limits. Do not install piping at equipment until inspected for alignment at extreme temperature conditions.

P. Pre-insulated pipe supports shall be installed while the pipe is being erected.

Q. Trapeze suspension (trapeze hangers may be used for parallel lines if pipes pitch same direction): Size channel assembly in accordance with manufacturer's published load ratings. Deflections not to exceed 1/360 of a span.

R. Supports from wall shall be steel brackets, hooks, clamps attached to wall structure with anchor bolts. Isolate pipe supported by clamps or hooks from supports and building construction with felt. Clamps shall not anchor piping, unless anchoring is required.

S. Install riser clamps at each floor. Install metal channel intermediate supports midway between riser clamps.

T. Where piping is installed in parallel and at same elevation, provide multiple pipe or trapeze hangers.

U. Support riser piping independently of connected horizontal piping.

V. Provide felt-lined copper plated hangers and supports for bare copper piping.

W. Pipe Hanger Spacing:
1. Install hangers with minimum 1/2 inch (13 mm) space between finished covering and adjacent work.
2. Place hangers within 12 inches (300 mm) of each horizontal elbow.
3. Use hangers with 1-1/2 inch (38 mm) minimum vertical adjustment.
4. Support vertical risers at their bases and at each floor minimum. Copper piping less than 1-1/2 inch diameter and steel piping less than 3/4-inch diameter shall have one intermediate support between floors.
5. Support every pipe branch over three feet long.
6. Support any cast-iron piping with no fewer than two supports each section and within 18 inches from both sides of each joint. Maximum 5 foot intervals except for pipe exceeding five foot length, provide supports at intervals equal to pipe length but not exceeding ten feet.
7. Install hanger within 12 inches of each change of direction and for each branch 5 feet and longer.
8. Support horizontal metal piping as follows:

Pipe Size Inches (mm)	Copper		Schedule 40		Cast Iron	
	Maximum Hanger Spacing Feet (m)	Hanger Rod Diameter Inches (mm)	Maximum Hanger Spacing Feet (m)	Hanger Rod Diameter Inches (mm)	Maximum Hanger Spacing Feet (m)	Hanger Rod Diameter Inches (mm)
1/2 (12)	5 (1.5)	3/8 (9)	7 (2.1)	3/8 (9)	10 (3)	3/8 (9)
3/4 (20)	5 (1.5)	3/8 (9)	7 (2.1)	3/8 (9)	10 (3)	3/8 (9)
1 (25)	6 (1.8)	3/8 (9)	7 (2.1)	3/8 (9)	10 (3)	3/8 (9)
1-1/4 (32)	7 (2.1)	3/8 (9)	7 (2.1)	3/8 (9)	10 (3)	3/8 (9)
1-1/2 (38)	8 (2.4)	3/8 (9)	9 (2.7)	3/8 (9)	10 (3)	3/8 (9)

Note 1: Support grooved piping per manufacturer's recommendations.

9. Support plastic piping as follows:

PIPE MATERIAL	MAXIMUM HANGER SPACING Feet (m)	HANGER ROD DIAMETER Inches (mm)
ABS (All sizes)	4 (1.2)	3/8 (9)
FRP (All Sizes)	4 (1.2)	3/8 (9)
PVC (All Sizes)	4 (1.2)	3/8 (9)

Note 1: Refer to manufacturer's recommendations for grooved end piping systems.

X. Thrust Blocks:

1. All buried pressure piping with friction type joints (bell and spigot, Tyton, etc.) shall have adequate concrete thrust blocks installed at each change of direction (horizontal, vertical), at each tee and dead end. Anchor pipe at entrance to building.

3.04 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements and 01 70 00 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect installed firestopping for compliance with specifications and submitted schedule.

3.05 CLEANING

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for cleaning.

B. Clean adjacent surfaces of firestopping materials.

C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

D. Clean all surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

3.06 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protecting finished Work.

B. Protect adjacent surfaces from damage by material installation.

END OF SECTION 23 05 29

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. General information

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.
   1. Certified TAB reports.
   2. Documentation of work performed per ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
   3. Documentation of work performed per ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

B. TAB Firm Qualifications: NEBB or TABB certified.

C. TAB Report Forms: Standard TAB contractor's forms approved by Architect.

D. Perform TAB after leakage and pressure tests on [air] [and] [water] distribution systems have been satisfactorily completed.

PART 2 – PRODCUTS (Not Used)

PART 3 – EXECUTION

3.01 INSTALLATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine the approved submittals for HVAC systems and equipment.

C. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

D. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

E. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

F. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

G. Examine automatic temperature system components to verify the following:
1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of dampers and valves for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

H. Report deficiencies discovered before and during performance of test and balance procedures.

3.02 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.03 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare schematic diagrams of systems' "as-built" duct layouts.

B. For variable-air-volume systems, develop a plan to simulate diversity.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Verify that motor starters are equipped with properly sized thermal protection.

E. Check for airflow blockages.

F. Check condensate drains for proper connections and functioning.

G. Check for proper sealing of air-handling unit components.

H. Check for proper sealing of air duct system.

3.04 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data; number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
   1. Open all manual valves for maximum flow.
   2. Check liquid level in expansion tank.
   3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
   4. Set system controls so automatic valves are wide open to heat exchangers.
   5. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

3.05 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent.
   2. Air Outlets and Inlets: Plus 10 percent.
   3. Heating-Water Flow Rate: Plus 5 percent.
   4. Cooling-Water Flow Rate: Plus 5 percent.

END OF SECTION 23 05 93

SECTION 23 07 00

HVAC INSULATION

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Insulation Materials

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. For adhesives and sealants, documentation including printed statement of VOC content.

1.03 QUALITY ASSURANCE

A. Quality Assurance: Labeled with maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to ASTM E 84.

PART 2 – PRODCUTS

2.01 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics:
   1. Indoor Insulation and related materials: To be factory labeled designating maximum flame-spread index of 25 or less, and smoke-developed index of 50 or less according to ASTM E 84.
   2. Outdoor Insulation and related materials: To be factory labeled designating maximum flame-spread index of 75 or less, and smoke-developed index of 150 or less according to ASTM E 84.

2.02 INSULATION MATERIALS

A. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

C. Mineral-Fiber Blanket Insulation: Comply with ASTM C 553, Type II and ASTM C 1290, Type I.

D. Mineral-Fiber Board Insulation: Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ.

E. Mineral-Fiber, Preformed Pipe Insulation: Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ.

F. Mineral-Fiber, Pipe and Tank Insulation: Complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB; and having factory-applied [ASJ] [FSK jacket]. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less.

G. Polyolefin Insulation: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

H. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

I. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

J. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

K. Factory-Applied Jackets: When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

L. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

M. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

PART 3 – EXECUTION

3.01 INSULATION INSTALLATION

A. Comply with requirements of the Midwest Insulation Contractors Association's "National Commercial & Industrial Insulation Standards" for insulation installation on pipes and equipment.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall, Partition, and Floor Penetrations: Install insulation continuously through penetrations. Seal penetrations. Comply with requirements in Section 078413 "Penetration Firestopping."

D. Flexible Elastomeric Insulation Installation:
   1. Seal longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
   2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

E. Mineral-Fiber Insulation Installation:
   1. Insulation Installation on Straight Pipes and Tubes: Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   2. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
   3. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
   4. Blanket and Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   5. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier.

F. Polyolefin Insulation Installation:
   1. Seal split-tube longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
   2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of polyolefin pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

G. Plenums and Ducts Requiring Insulation:
   1. Concealed and exposed supply and outdoor air.
   2. Concealed and exposed return air located in nonconditioned space.

3. Concealed and exposed exhaust between isolation damper and penetration of building exterior.

H. Plenums and Ducts Not Insulated:
1. Metal ducts with duct liner.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

I. Piping Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawlspaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.02 DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed duct insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch (25 mm).
2. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. M) nominal density.
3. Mineral-Fiber Board: 1-1/2 inches (38 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
4. Polyolefin: 1 inch (25 mm) thick.

B. Exposed duct insulation shall be one of the following:
1. Flexible Elastomeric: 2 inch (25 mm) thick.
2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m), 1.5-lb/cu. ft. (24-kg/cu. m), 3-lb/cu. ft. (48-kg/cu. m) nominal density.
3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density.
4. Polyolefin: 1 inch (25 mm) thick.

3. 03 HVAC PIPING INSULATION SCHEDULE

A. Chilled Water: Insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
2. Polyolefin: 1 inch (25 mm) thick.

B. Heating-Hot-Water Supply and Return: Insulation shall be the following:
1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) thick.

C. Refrigerant Suction and Hot-Gas Piping: Insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
3. Polyolefin: 1 inch (25 mm) thick.

D. Refrigerant Suction and Hot-Gas Flexible Tubing: Insulation shall be the following:
   1. Polyolefin: 1 inch (25 mm) thick.

E. Dual-Service Heating and Cooling: Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches (38 mm) thick

END OF SECTION 23 07 00

SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes control equipment for HVAC systems and components.

B. Related Sections include the following:
1. Division 15 Section “Air Duct Accessories”
2. Division 15 Section “Testing, Adjusting and Balancing”

1.02 DEFINITIONS

A. DDC: Direct-Digital Controls.

B. BMS: Building Management System

C. BLN: Building Level Network.

D. FLN: Field Level Network.

E. PID: Proportional Integral and Derivative

F. RTD: Resistance Temperature Detector

G. VFD: Variable Frequency Drive

1.03 SYSTEM DESCRIPTION

A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems.

B. Control system includes the following:
1. Air Handling Units (Type 1 and 2)
2. Miscellaneous Exhaust Fans
3. Domestic Water Pump Monitoring
4. Domestic Hot Water Recirculation Pump Monitoring

C. The building management system shall consist of the following:

1. Stand-alone peer to peer DDC Controllers for all main equipment (air handling units, etc.). The intent of this specification is that the loss of any one DDC controller shall not affect the operation of other HVAC systems.
2. Stand-alone networked Terminal Equipment Controllers (TEC) shall only be used for terminal equipment.

D. The system shall be modular in nature and permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.

E. The DDC system shall operate with an input voltage rated at 120 Volts, 60 Hertz. All units shall be grounded in accordance with the local Electrical Code and the NEC. All units shall be supplied with filtered power, if required, to preclude noise generation. Signal range shall be 4-20 mA or 0-10 VDC.

F. All control products provided for this project shall be comprised of a BACnet network. Communications involving control components (all types of controllers and operator interfaces) shall conform to ANSI/ASHRAE Standard 135-1995 BACnet.

1.04 SYSTEM PERFORMANCE

A. Comply with the following response times and performance requirements:
1. Graphic Display: Display graphic with minimum 20 dynamic points with current dynamic data within 20 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current dynamic data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within 5 seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as 5 seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control:
   a. Water Temperature: +/- 0.5degF
   b. Water Flow: +/- 5% of full scale
   c. Water Pressure: +/- 2% of full scale
   d. Space Temperature: +/- 0.5degF
   e. Ducted Air Temperature: +/- 5degF
   f. Outside Air Temperature: +/- 1 degF
   g. Dew Point Temperature: +/- 1.5 degF
   h. Temperature Differential: +/- 0.15 degF
   i. Relative Humidity: +/- 5%RH
   j. Airflow (Pressurized Spaces): +/- 3% of full scale
   k. Airflow (Measuring Stations): +/- 5% of full scale
   l. Airflow (Terminal): +/- 10% of full scale

1.05 SHOP DRAWING SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials and installation and start-up instructions for each type of product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection.

1. Schematic flow diagrams, showing AHU's, fans, pumps coils, dampers, valves, and control devices.
2. 2.Written description of sequence of operations.
3. Building DDC system architecture diagram showing all networked control components and locations. Include reference to future tenant fit-out.
4. .Schedule of dampers, including size, leakage, and flow characteristics.
5. Schedule of valves including size, leakage, sizing and flow characteristics.
6. Trunk cable schematic showing programmable control unit (DDC panel) locations and trunk data conductors.
7. Listing of connected data points, including connected control unit and input device.
8. System GUI colorgraphic's indicating monitored and controlled systems, data (connected and calculated), point addresses, and operator notations.
9. System configuration showing peripheral devices, batteries, power supplies, diagrams, and interconnections.
10. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, model number. Indicate technical data for operating system software, operator workstation, interface equipment, control units, transducer/transmitter, sensor, actuators, relays, switches, etc.
11. Control System Software: Include technical data for operating system software, operator workstation upgrade and any third party applications.
12. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data.
13. Bill of materials of equipment indicating quantity, manufacturer, and model number.
14. Wiring Diagrams: Power, signal and control wiring. Differentiate between manufacturer installed and field installed wiring.
15. Details of control panel faces, including controls and wiring diagram, instrumentation and labeling.
16. Samples: For each color required, of each type of thermostat cover. Coordinate space temperature cover appearance with Architect.
17. DDC System Hardware:
    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication and power wiring showing trunk data conductors and wiring between operator workstation and control unit locations.
18. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
19. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:

a. Maintenance instructions and lists of spare parts for each type of control device.
b. Interconnection wiring diagrams with identified and numbered system components and devices.
c. Keyboard illustrations and GUI colorgraphics and step-by-step procedures indexed for each operator function.
d. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
e. Calibration records and list of set points.

20. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
21. Project As-built Record Documents: Record actual installation and locations of control components (one-lines and floor plans), including control units, thermostats, and sensors. Revise shop drawings to reflect actual point to point wiring installation and operating sequences after all testing and commissioning is complete and approved.

1.02 QUALITY ASSURANCE

A. Single source responsibility of manufacturer shall be the complete installation and proper operation of DDC System and shall include debugging and proper calibration of each component in the entire system.

B. All work shall conform to the following Codes and Standards, where applicable:
1. National Fire Protection Association (NFPA) Standards, as specified.
2. National Electrical Code (NEC) and applicable local Electrical Code.
3. Underwriters' Laboratories (UL) listing and labels, as specified.
4. Owners Insurance Carrier.
5. American National Standards Institute (ANSI).
6. National Electric Manufacturers' Association (NEMA).
7. American Society of Mechanical Engineers (ASME).
8. American Society of Heating, Refrigerating and Air Conditioning (ASHRAE).
9. Air Movement and Control Association (AMCA).
10. Institute of Electrical and Electronic Engineers (IEEE).
11. American Standard Code for Information Interchange (ASCII).
12. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS).
13. Electronics Industries Association (EIA).
14. Occupational Safety and Health Administration (OSHA).
15. American Society for Testing and Materials (ASTM).
16. NFPA 92A and 92B
17. ASHRAE standard 135-2001: BACnet – A Data Communications Protocol for Building Automation and Control Networks.
18. Applicable Local Codes

1.03 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. Coordinate factory mounted component requirements with the manufacturer.

1.04 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.05 WARRANTY

A. The system including all hardware, software and workmanship shall be guaranteed for a period of one year from the date of final acceptance. Any manufacturing or installation defects arising during the warranty period shall be corrected at no cost to the owner. . BMS contractor shall respond to owner request for warranty service within 4 hours of warranty service call.

B. All applicable software, as detailed in this specification, shall be updated by the BMS contractor free of charge during the warranty period to insure that the system software is the most up to date software available for the system hardware installed, at the end of the warranty.

C. All corrective software modifications made during the warranty service period shall be updated on all user documentation and on user and manufacturer archived software disks.

1.06 TRAINING

A. Provide one (1) day of training on site.

B. The BMS contractor shall provide instructors to give full instructions to designated owner personnel in the adjustment, operation and maintenance of the system installed. Instructors shall be thoroughly familiar with all the aspects of the subject matter they are to teach. All training shall be held during the normal work hours with the exception of training of staff working other shifts. Training schedule for all shifts to be coordinated with owner.

C. Training shall include but not limited to:
1. Explanation of drawings and operations and maintenance manuals.
2. Walk thru of the job to locate control components.
3. DDC, Network controller and TEC operation.
4. Operator workstation and peripherals.
5. Operator control functions including graphic generation and field panel programming.
6. Explanation of adjustment, calibration and replacement procedures.

D. Provide competent, factory, authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Construction Manager and owner after submission and approval of formal training plans. All training sessions shall be videotaped by the BMS contractor and submitted as part of the operations and maintenance documentation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Siemens Technology
      b. Johnson Controls

2.02 ENVIRONMENT

A. All equipment detailed in this specification or other equipment associated with the DDC shall be capable of operation in environmental conditions were equipment is located.

2.03 SYSTEM ARCHITECTURE

A. Building Level Network (BLN)
   1. All DDC Controllers located in the same MER or specific area shall directly reside on a BLN such that peer communications may be executed directly between DDC Controllers.

2.04 DDC CONTROLLER AND NETWORK CONTROLLER

A. Stand-alone controllers with 32 bit processors shall be complete with power supplies, a real time clock, input and output modules, memory, processors and all other items necessary for proper and correct interfacing and operation of the control functions described in this Specification. All controllers shall have peer-to-peer communications.

B. In the event of transmission failure in the controller network, the controllers shall continue to operate with all sequence interlocks and control strategies operating normally excepting those, which require global information. Either user adjustable default values or the last sensed value (user selectable) shall then be assumed for these global parameters.

C. Controllers shall be able to provide the operator’s station with status information concerning their internal diagnostic operations.

D. All necessary interfacing equipment shall be provided so that the controllers are fully compatible with controlled HVAC equipment.

E. The controller shall be capable of accepting binary, analog, pulsed inputs and providing binary and analog outputs.
   1. Binary Input
   2. Pulsed Input
   3. Binary Output
   4. Analog Inputs
   5. Analog Outputs

6. Universal Inputs – Shall be configurable to either binary or analog input and shall have the features defined above.

F. Each controller or controller location shall be provided with spare hardware capacity for future additions of at least 15 percent of each type of point. Memory shall also be sufficient to allow all programs associated with these points to be run in the controller.

G. The controllers shall be provided with their own internal battery back up power supply, capable of maintaining all memory including the real time clock for not less than 72 hours.

H. The controllers shall be mounted in control panels, which shall meet project environmental requirements.

2.05 TERMINAL EQUIPMENT CONTROLLERS (TEC-FUTURE)

A. When a controller is used to monitor and control terminal equipment (example VAV or CAV etc) they shall be classified as terminal equipment controllers (TEC's).

B. TEC's shall be either small freely programmable controllers or firmware application specific controllers, which shall be selected to meet the performance requirements of the specification. TEC shall be mounted in enclosure acceptable to environmental conditions as required.

C. Each TEC shall be networked, integrated and adjusted by an operator's station or portable terminal, which may plug into the network at any point.

2.06 ALARM PROCESSING

A. Alarms shall be classified by their alarm type. The facility shall be provided for enabling and disabling each individual alarm on the system.

B. Once generated, the alarm shall be processed by its associated alarm type as defined in the I/O Point Schedules. The alarm types shall be as follows:
1. General Mismatch
2. Critical Mismatch
3. General Binary
4. Critical Binary
5. General Analog
6. Critical Analog

2.07 CONFIGURATION

A. Configuration data shall be stored in the DDC Controllers or the Terminal Unit Controllers. Configuration data shall include but not be limited to the following:
1. The unit applicable (deg F, gpm, cfm, inches of water, etc.)
2. The point identifier (minimum of 12 characters).
3. The point alarm message if applicable (minimum of 80 characters).
4. The point descriptor (minimum of 32 characters).

2.08 DDC STANDARD PROGRAMS

A. The device schedules included in this Specification provide details of inputs monitored and outputs controlled by the DDC System. All point types are described under Controllers elsewhere in this Specification. The DDC System shall allow for the following point functionality and standard programs to be available:
   1. Point Override
   2. Manual Start/Stop
   3. Fixed Time Program
   4. Optimum Start/Stop
   5. Control Loops (Proportional-Integral and Derivative control algorithms)
   6. Rotational Point
   7. Run Time Totalization
   8. Anti-Short Cycling
   9. Staggered Start
   10. User Definable Software
   11. General Control Requirements

2.09 INTEGRATION

A. General
   1. The BMS shall utilize and be compatible with standard integration protocols (Lonworks, BACnet, and Modbus) for subsystem integration. Coordinate integration protocols with VFD manufacturer.

2.10 BMS WORKSTATION COLORGRAPHICS

A. General
   1. The new workstation graphic user interface (GUI) shall be upgraded to minimize operator training through the use of English language prompting and point identification with on-line help and industry standard PC application software.
   2. The software shall provide a multi-tasking Microsoft Windows environment that allows the user to run several applications simultaneously.
   3. Provide a GUI which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and “point and click” approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or a similar pointing device.
   4. The software shall provide a multi-tasking Microsoft Windows environment that allows the user to run several applications simultaneously. Other Windows applications shall run simultaneously with the BMS software including Word and Excel. The operator shall be able to drag and drop information between applications (e.g. click on any point in the alarm screen and drag it into the dynamic trend graph screen to initiate a dynamic trend).
   5. Operator specific password access protection shall allow the user to limit workstation control, display, and data base manipulation capabilities for each object in the system. An object shall be defined as any input or output point, setpoint, system program, etc. Operators shall only be able to perform only those commands on the objects available based on their respective passwords.

6. An audit trail report to track system object changes, accounting for operator initiated actions, changes made by a particular person or change made to a specific piece of equipment.
7. Software shall allow the operator to perform commands including, but not limited to start-up or shutdown of equipment, adjust setpoints, time programming, enable/disable process execution, lock/unlock alarm reporting, enable/disable totalization, enable/disable trending, override PID setpoints, enter temporary override schedules, define holiday schedule, change time/date, enter/modify analog warning and alarm limits, view limits.
8. Provide trending capabilities that allow the operator to easily monitor and preserve records of system activity over an extended period of time. All BMS and integrated system points may be trended automatically (at the same time) at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on new workstation for future diagnostics and reporting. BMS server shall be capable of storing all temperature, humidity, and pressure historical trend values simultaneously, recording in 15 minute intervals. Data trend report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 15 points. Provide additional functionality that allows any trended data to be transferred to an off the shelf spreadsheet package such as Excel.

2.11 FIELD DEVICES

A. Input/Output sensors and devices shall be closely matched to the requirements of the DDC for accurate, responsive, noise-free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control. Thermistors are acceptable for all temperature sensor applications.

B. Temperature Sensors
   1. Provide the following instrumentation as required by the monitoring, control and optimization functions.
   2. Outdoor Air Temperature and Humidity Transmitter Assembly: Provide outdoor air temperature and humidity sensors located in suitable weatherproof-water proof enclosure (with sunshield) Manufacturer: Vaisala
      a. Temperature Transmitter Assembly – airstream averaging type
         1. The assembly shall consist of a capillary type sensor housed in a flexible sheath contained in housing suitable for duct mounting.
         2. Accuracy: +/- .25degF.
      b. Temperature Transmitter Assembly – air stream non-averaging type.
         1. The assembly shall consist of an insertion type sensor mounted on a 12 inch probe (or ½ duct diameter) contained in a housing suitable for duct mounting.
         2. Accuracy: +/- .25degF.
      c. Temperature Transmitter Assembly – space
         1. The assembly shall consist of a 1000 ohm platinum RTD contained in a decorative ventilated enclosure similar in appearance to room thermostats. Space temperature sensors shall include options for temperature display (LCD), setpoint adjustment (+/-3degF), unoccupied override pushbutton for after hour

operation, blank face plate, color, etc. Coordinate temperature sensor options and features with owner and architect.
2. Accuracy: +/- .25degF.

C. Pressure Sensors

1.	Water Differential Pressure Switch	
	Range	8 to 70 psi
	Differential	3 psi
	Maximum differential pressure	200 psi
	Maximum pressure	325 psi
2.	Air Differential Pressure Switch	
	Differential pressure switches shall be diaphragm type, with die-cast aluminum housing and adjustable set point. Switch rating shall be minimum 5 amps at 120 VAC. Switches shall be SPDT and be used for fan status as specified in the point schedule. Switch pressure range shall be suited for application. (e.g. filter 0-2.0", fan status 0-5.0", etc.)	
3.	Air Static Pressure Sensor	
	Sensors shall be suitable for low pressures likely to be encountered and be selected for approximately 50% over range and have 4-20ma outputs. Connect to measuring points with valve lines for testing and calibration. Sensors shall be adjustable for zero and span. Manufacturer: Setra	

D. Damper Operators
1. Damper operators shall be electronic. Operators shall be sufficiently sized to ensure smooth, positive, operation and tight shut-off against system pressure.
2. BMS contractor shall furnish and install damper actuators on all factory and field installed automatic control dampers (modulating and two position type) .

E. Automatic Control Valves;
1. All automatic control valve shall be fully proportioning with modulating plug valve or characterized V port ball valves (Flow characterizing disk). The valve shall be quiet in operation and fail safe in either a normally open or closed position. The BMS contractor shall ensure that the valves selected will perform at all load conditions without cavitation. All control valves shall be suitable for pressure conditions and shall close off against differential pressure involved. All control valves shall be sized for a 3-5psi pressure drop. Body pressure rating and connection type construction shall conform to fitting and valve schedule.

F. Electric Thermostats
1. Furnish and install all line voltage thermostats. Thermostats contacts shall be rated for maximum heater amperage and shall be snap acting, SPDT. Thermostat cover shall provide exposed set point and key adjust.

G. Current Sensors
1. Provide and install current sensing relays for all fan and pump motor status points in remote starter enclosures. Each sensor shall be split core, two wire, loop powered and sized for expected amperage and capable of detecting the monitored equipment operating at minimum speed. Units shall be UL listed.

H. Field Equipment Cabinets
1. All electric relays, transformers, power supplies, pressure transducers, override switches, etc., shall be mounted in a suitable NEMA enclosure and factory wired to terminal strips.
2. All components mounted outdoors including roof shall be installed in a NEMA 4X enclosure. Wiring shall be installed rigid conduit.

I. Component Tags
1. Sensor Tags
   a. All sensors shall be identified with 1” x 3” black lamicoid labels with engraved white lettering. Lettering shall be 1/4” high. Provide sensor number, HVAC Unit number, part number and sensor range on tag. Submit tag schedule and sample for approval.

J. Relays
1. All relays shall be plug in or rib style.
2. Start/stop relay modules shall provide either momentary or maintained switching action as appropriate for the motor being started.
3. Provide a required interposing relays and wiring for 120 Volt (fractional horse power) HVAC equipment without starters and for interfacing with new and existing equipment or devices as required for “turnkey installation”.

K. Fuel Oil Level Switch (High and Low level indication):
1. Provide UL listed fuel oil level transmitter for monitoring fuel oil level in the main fuel oil tank and the day tank. Coordinate installation with existing site conditions.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

3.02 INSTALLATION

A. Install equipment level and plumb.

B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Verify location of thermostats and other exposed control sensors with plans and room details before installation.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install damper motors on outside of duct.

3.03 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 16 Section “Raceways and Boxes for Electrical Systems”.

B. Install building wire and cable according to Division 16 Section “Low-Voltage Electrical Power Conductors and Cables”.
   1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceways.
   3. Install concealed cable in raceways.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cable.
   7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all line voltage wiring, concealed or exposed in EMT in accordance with Division 16 specifications, local electric code and the NEC.

D. Provide extensions of 120 volt, 20 amp circuit and circuit breakers from emergency or normal power panel boards or existing junction box locations for all DDC panels, terminal box controls and devices that require power as required. Coordinate with Division 16.

3.04 FIELD QUALITY CONTROL SYSTEM START-UP AND TESTING

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test and adjust field-assembled components and equipment installation, including connections and assistance in field testing. Report results in writing.

B. Prepare the following field tests and inspections and prepare test report:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Test each point through its full operating range to verify that safety and operating control setpoints are as required.

4. Test each control loop to verify stable mode of operation and compliance with sequence of operations. Adjust PID control algorithms.
5. Test each system for compliance with sequence of operations.
6. Test hardware and software interlocks.

C. DDC Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed properly.
5. Check pressure instruments, piping slope, installation of valve manifold and self contained pressure regulators.
6. Check temperature instruments and material and length of sensing element.
7. Check control valves. Verify that they are in correct direction.
8. Check DDC system as follows: Verify that the DDC controller power supply is from emergency power if applicable. Verify that the wires at control panels are tagged with their service designation and approved tagging. Verify that spare I/O capacity has been provided. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

E. After completion of the installation, adjust and calibrate thermostats, control valves, sensors, actuators, and similar equipment provided as work of this section. Final adjustment shall be performed by specially trained personnel in the direct employ of the manufacturer of the primary temperature control system. Provide complete commissioning assistance as needed to test and verify performance of all systems controlled under this contract, at all design conditions.

F. Point to Point Check-out: Each I/O device (both field mounted and those mounted in field interface panels) shall be inspected and verified for proper installation and functionality.

G. Controller and BMS Workstation Checkout: A field checkout of all controllers and front-end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software.

H. System Acceptance Testing
1. All application software shall be verified and compared against the sequence of operations. Control PID loops shall be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variables to setpoint. Record all test results and attach to the Test Result Sheet.
2. Test each alarm in the system and validate that the system that the system generates the appropriate alarm message, that the alarm appears at all prescribed destinations (workstations and printers), and that the any other related actions occur as defined (i.e. reports generated). Submit a test results sheet to the government representative and the commissioning agent.
3. Perform an operational test of each unique colorgraphic display and report to verify that the items exist, that the appearance and content are correct, and that any special

features work as intended. Submit a test results sheet to the government representative and the commissioning agent.

4. Trend logs shall be compiled to show compliance with all setpoints, scheduling, setbacks, etc.

3.05 ADJUSTMENT

A. Calibrating and Adjusting
   1. Calibrate instruments.
   2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
   3. Calibrate equipment and procedures using manufacturer’s written recommendations and instrument manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
   4. Control System Inputs and Outputs:
      a. Check analog inputs at 0, 50 and 100 percent.
      b. Check analog outputs using milliampere meter at 0. 50, and 100% output.
      c. Check digital inputs using a jumper cable.
      d. Check digital outputs using ohmmeter to test for contact making or breaking.
      e. Check resistance temperature inputs at 0, 50, and 100 percent of span using precision resistant source.

B. Occupancy Adjustment: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 3 visits to project during other than normal occupancy hours for this purpose.

3.06 DEMONSTRATION

A. Engage a factory-authorized systems and service representative to train Owners maintenance personnel to adjust, operate, and maintain HVAC instruments and controls.

3.07 COMMISSIONING (TO BE DETERMINED)

END OF SECTION 23 09 00

SECTION 23 21 13

HYDRONIC PIPING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. General Information

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. For solvent cements and adhesive primers, documentation including printed statement of VOC content.

PART 2 – PRODCUTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
   1. Hot-Water Heating Piping: <Insert psig (kPa)> at 200 deg F (93 deg C).
   2. Chilled-Water Piping: <Insert psig (kPa)> at 200 deg F (93 deg C).
   3. Condensate-Drain Piping: 150 deg F (66 deg C).
   4. Air-Vent Piping: 200 deg F (93 deg C).

2.02 PIPES, TUBES, AND FITTINGS

A. Hard Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B) with ASME B16.22 wrought-copper solder fittings and ASTM B 32, 95-5 tin antimony solder.

B. Soft Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A) with ASME B16.22 wrought-copper solder fittings.

C. CPVC Pipe: ASTM F 441/F 441M, Schedule 40, plain ends with ASTM F 438, socket-type solvent welding fittings.

1. CPVC solvent cement shall have a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. PVC Pipe: ASTM D 1785, Schedule 40, plain ends with ASTM F 438, socket-type solvent welding fittings.
1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Steel Pipe: ASTM A 53, Schedule 40, plain ends with cast malleable-iron threaded fittings, Class 125.

F. Unions: ASME B16.39, malleable-iron, Class 150, hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.

G. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig (1035-kPa) minimum working pressure, 250 deg F (121 deg C) maximum operating temperature.

H. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, ends.

2.03 SPECIAL-DUTY VALVES

A. Calibrated Plug Valves: 125-psig (860-kPa) water working pressure, 250 deg F (121 deg C) maximum operating temperature; bronze body with calibrated orifice. Provide with connections for portable differential pressure meter with integral check valves and seals. Valve shall have integral pointer and calibrated scale to register degree of valve opening.

2.04 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig (1035-kPa) working pressure, 225 deg F (107 deg C) operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 (DN 6) discharge connection and NPS 1/2 (DN 15) inlet connection.

B. Diaphragm-Type Expansion Tanks: Welded carbon steel, 125-psig (860-kPa) working pressure, 375 deg F (190 deg C) maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by means of a flexible diaphragm securely sealed into tank. Provide taps for pressure gage and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled according to ASME Pressure Vessel Code: Section VIII.

C. Y-Pattern Strainers: 125-psig (860-kPa) working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 (DN 65) and larger, threaded connections for NPS 2 (DN 50) and smaller, bolted cover, perforated Type 304 stainless-steel basket, and bottom drain connection.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with requirements in Section 230500 "Common Work Results for HVAC" for basic piping installation requirements.

B. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Comply with requirements in Section 230500 "Common Work Results for HVAC" for wall penetration systems.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping free of sags and bends and install fittings for changes in direction and branch connections.

E. Use the fewest number of joints belowground and within floor slabs.

F. Install piping at a uniform slope of 0.2 percent upward in the direction of flow.

G. Make reductions in pipe sizes using eccentric reducer fitting installed with level side up.

H. Install branch connections to mains using tee fittings in main with takeoff out the bottom of the main, except for up-feed risers, which shall have swing joint and takeoff out the top of the main line.

I. Install unions in pipes adjacent to each valve, at final connections with each piece of equipment, and elsewhere as indicated.

J. Install flexible connectors at inlet and discharge connections to pumps (except in-line pumps) and other vibration-producing equipment.

K. Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before soldering or brazing.

3.02 VALVE INSTALLATIONS

A. Shutoff Duty: Use gate or ball valves.

B. Throttling Duty: Use globe or ball valves.

C. Install shutoff-duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.

D. Install throttling-duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

E. Install calibrated plug valves on the outlet of each heating or cooling element and elsewhere as required to facilitate system balancing.

F. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple and cap.

G. Install check valves on each pump discharge and elsewhere as required to control flow direction.

H. Install safety relief valves on hot-water generators and elsewhere as required by authorities having jurisdiction. Pipe discharge to floor drain without valves.

I. Install manual air vents at high points in the system, at heat-transfer coils, and elsewhere as required for system air venting.

J. Install valves with stem up. Allow clearance above stem for check mechanism removal.

3.03 SPECIALTIES INSTALLATIONS

A. Install diaphragm-type compression tanks on floor. Vent and purge air from hydronic system; charge tank with proper air charge to suit system design requirements.

B. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated.

3.04 TESTING, ADJUSTING, AND BALANCING

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens.

B. Hydrostatically test completed piping at a pressure one and one-half times operating pressure. Isolate equipment before testing piping. Repair leaks and retest piping until there are no leaks.

C. Balance water flow as required by Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.05 PIPING SCHEDULE

A. Hot and Chilled Water, NPS 2 (DN 50) and Smaller:

1. Aboveground: Drawn-temper copper tubing with soldered joints, or steel pipe with threaded joints.
2. Aboveground: Steel pipe with threaded joints.
3. Aboveground: CPVC pipe and fittings with solvent welded joints.
4. Belowground or within Slabs: Annealed-temper copper tubing with soldered joints.

B. Condensate Drain Lines: Drawn-temper copper tubing with soldered joints or PVC pipe with solvent-welded joints.

END OF SECTION 23 21 13

SECTION 23 21 23

HYDRONIC PUMPS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Hydronic Pumps

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Comply with UL 778 for motor-operated water pumps.

PART 2 – PRODCUTS

2.01 HYDRONIC PUMPS

A. Permanently Lubricated Iron & Lead-Free Bronze Booster Pump
   1. Manufacturer: Bell & Gossett
   2. Model Number: PL-30B
   3. Part Number: 1BL013LF
   4. Maximum Working Pressure: 150 psi (10 Bar)
   5. Maximum Operating Temperature: 225°F
   6. Booster Body: Bronze
   7. Face Plate: Stainless Steel
   8. Motor Type: ODP
   9. Elastomers: EPDM
   10. Standard 60 Cycle Single Phase Motor Characteristics: HP 1/12, Voltage 115, F.L. AMPS 1.4, RPM 2650
   11. Flange Size Inches – NPT: ¾, 1, 1-1/4, 1-1/2
   12. Motor HP: 1/12
   13. Dimensions (H x W x D): 6-3/8” x 4-3/8” x 8-5/8”
   14. Weight: 11.6 lbs.

B. Close-Coupled, In-Line Centrifugal Pumps: Factory-assembled and -tested, overhung impeller, designed for installation with pump and motor shafts mounted horizontally or vertically. Rated for 125-psig (860-kPa) minimum working pressure and minimum continuous water temperature of 225 deg F (107 deg C).
1. Manufacturers: One of the following:
2. Armstrong Pumps Inc.
3. Crane Pumps & Systems.
4. Flowserve Corporation.
5. ITT Corporation; Bell & Gossett.
6. TACO Incorporated.
7. Casing: Radially split, cast iron, threaded gage tappings at inlet and outlet, and threaded union end connections.
8. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
9. Pump Shaft: Steel, with copper-alloy shaft sleeve.
10. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.

C. Separately Coupled, Vertical, In-Line Centrifugal Pumps: Factory-assembled and -tested, overhung impeller, designed for installation with pump and motor shafts mounted vertically. Rated for 175-psig (1200-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C).
1. Manufacturers: One of the following:
2. Armstrong Pumps Inc.
3. Crane Pumps & Systems.
4. Flowserve Corporation.
5. ITT Corporation; Bell & Gossett.
6. TACO Incorporated.
7. Casing: Radially split, cast iron, withthreaded gage tappings at inlet and outlet, and threaded union end connections.
8. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
9. Pump Shaft: Steel, with copper-alloy shaft sleeve.
10. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
11. Pump Bearings: Permanently lubricated ball bearings.

2.02 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Less Than 1/2 HP (373 W): Built-in thermal-overload protection.

C. 1/2 to 3 HP (373 to 2238 W): Permanently lubricated ball bearings.

D. Motor shall be non-overloading within full range of pump performance.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install pumps with access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

B. Support pumps and piping so weight of piping is not supported by pump volute.

C. Install electrical connections for power, controls, and devices.

D. Suspend in-line pumps independent from piping. Use continuous-thread hanger rods and vibration isolation hangers. Fabricate brackets or supports as required for pumps.

E. Retain paragraph above or first paragraph below, or both. If both types of pumps are required, indicate location of each on Drawings, in schedules, or by inserts.

F. Install vertical in-line pumps on concrete bases.

G. Connect piping with valves that are at least the same size as piping connecting to pumps.

H. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

I. Install shutoff valve and strainer on suction side of pumps.

J. Install nonslam check valve and throttling valve on discharge side of pumps.

3.02 SPECIAL INSTALLATION

A. The pumps shall be of the horizontal, permanently lubricated type, specifically designed and guaranteed for quiet operation.
B. The pumps shall have a steel shaft supported by permanently lubricated, sealed precision ball bearings. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on silicon carbide. The motor shall be non-overloading at any point on the pump performance curve.
C. The motor shall be of the drip=-proof, sealed precision ball-bearing, quiet-operating construction. The permanent split-capacitor motor shall be equipped with thermal overload protection.
D. Pumps to be suitable for 225°F operating temperature at 150psig working pressure.

END OF SECTION 23 21 23

SECTION 23 31 00

HVAC DUCTS AND CASINGS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Performance Requirements
   2. Ducts
   3. Accessories

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Documentation indicating that duct systems and accessories comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning." and Section 6.4.4 - "HVAC System Construction and Insulation."

D. Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."

E. For adhesives and sealants, documentation including printed statement of VOC content.

PART 2 – PRODCUTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

E. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

G. Comply with NFPA 96 for ducts connected to commercial kitchen hoods.

H. Comply with UL 181 for ducts and closures.

2.02 DUCTS

A. Galvanized-Steel Sheet: ASTM A 653/A 653M, with G60 hot-dip galvanized coating.
   1. Galvanized Coating Designation: G60.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

B. Carbon-Steel Sheets: ASTM A 1008/A 1008M; with oiled, matte finish for exposed ducts.

C. Stainless Steel: ASTM A 480/A 480M, [Type 316] [Type 304], with a No. 2D finish for concealed ducts and No. 4 finish for exposed ducts.

D. Fibrous-Glass Duct Board: Comply with UL 181, Class 1, 1-inch- (25-mm-) thick, fibrous glass with fire-resistant, reinforced foil-scrim-kraft barrier, and having the air-side surface treated to prevent erosion.

E. Joint and Seam Tape, and Sealant: Comply with UL 181A.

F. Rectangular Metal Duct Fabrication: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

G. Fibrous-Glass Duct Fabrication: Comply with SMACNA's "Fibrous Glass Duct Construction Standard."

H. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
   1. Thickness: 1 inch (25 mm).
   2. Antimicrobial coating in first subparagraph below is an optional feature for duct liner.
   3. Airstream surface coated with an antimicrobial erosion-resistant coating.
   4. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
   5. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment.

2.03 ACCESSORIES

A. Volume Dampers and Control Dampers: Single-blade and multiple opposed-blade dampers, standard leakage rating, and suitable for horizontal or vertical applications; factory fabricated and complete with required hardware and accessories.

B. Flexible Connectors: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Flexible Ducts: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-inch- (25-mm-) thick, glass-fiber insulation around a continuous inner liner complying with UL 181, Class 1.

D. Floor Boot: For round “Swirl” diffusers, underfloor air distribution systems ducted connection
1. Manufacturer: Nailor
2. Model: NFB-D
3. Dimensions (H x W x D): 9” x 10” x 10”
4. Material: 22 ga. Corrosion resistant steel, mechanically sealed

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
1. Outdoor, Supply-Air Ducts: Seal Class A.
2. Outdoor, Exhaust Ducts: Seal Class C.
3. Outdoor, Return-Air Ducts: Seal Class C.
4. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa)and Lower: Seal Class B.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
6. Unconditioned Space, Exhaust Ducts: Seal Class C.
7. Unconditioned Space, Return-Air Ducts: Seal Class B.
8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa)and Lower: Seal Class C.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
10. Conditioned Space, Exhaust Ducts: Seal Class B.
11. Conditioned Space, Return-Air Ducts: Seal Class C.

C. Conceal ducts from view in finished and occupied spaces.

D. Avoid passing through electrical equipment spaces and enclosures.

E. Support ducts to comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Hangers and Supports."

F. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

G. Install volume and control dampers in lined duct with methods to avoid damage to liner and to avoid erosion of duct liner.

H. Clean new duct system(s) before testing, adjusting, and balancing.

3.02 TESTING, ADJUSTING, AND BALANCING

A. Balance airflow within distribution systems, including submains, branches, and terminals to indicated quantities.

END OF SECTION 23 31 00

SECTION 23 34 40

HVAC FANS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Ceiling Fan
   2. Inline ceiling fans.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Section 01 33 00 - Submittal Procedures: Submittal procedures and Section 23 05 00 – Common Work Results for HVAC. Where conflicts occur between divisions, the more stringent requirement shall apply.

C. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, where applicable, including housings, linkages, and operators.
   6. Fan speed controllers, where applicable.

D. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Provide updated pressure drop calculations for each system based on ductwork shop drawings.
   2. Wiring Diagrams: Power, signal, and control wiring.
   3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   4. Vibration Isolation Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

E. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Show fan room layout and relationships between components and adjacent structural and mechanical elements.
   6. Show support locations, type of support, and weight on each support.
   7. Indicate and certify field measurements.

F. Field quality-control test reports.

G. Manufacturer's Installation Instructions: Submit fan manufacturer’s instructions.

1.03 QUALITY ASSURANCE

A. American Bearing Manufacturers Association:
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc.:
   1. AMCA 99 - Standards Handbook.
   2. AMCA 204 - Balance Quality and Vibration Levels for Fans.
   3. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
   4. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
   5. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

C. American Refrigeration Institute:
   1. ARI 1060 - Air-to-Air Energy Recovery Ventilation Equipment Certification Equipment Program.

D. National Electrical Manufacturers Association:
   1. NEMA MG 1 - Motors and Generators.
   2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

E. Underwriters Laboratories Inc.:
   1. UL 705 - Power Ventilators.

F. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

G. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

H. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.

I. Fan impeller balancing: balance fan impellers in accordance with AMCA Standard 204-96.

J. 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.
K. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.04 WARRANTY

A. Section 01 70 00 - Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer's warranty for fans.

PART 2 – PRODCUTS

2.01 Ceiling Fan

A. Manufacturer: Greenheck

B. Model number SP-B90

C. Profile min. Height: 7 inches

D. Sound min. Sones: 1.2

E. Air Volume (maximum): 200 cfm

F. UL Listing: UL/cUL Listed for above bathtub/shower with GFCI branch protected circuit

G. Energy Star: Yes

H. RPM: 700

I. Amps: 0.65

J. Watts: 49.7

2.02 In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

A. Manufacturers: Subject to compliance with requirements and manufacturer's offerings, products that may be incorporated into the Work include, but are not limited to, manufacturers specified. The first manufacturer listed represents the basis of design as scheduled and drawn in the Construction Documents.

2.03 GENERAL FAN REQUIREMENTS

A. Performance Base: Sea level conditions.
B. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

C. Motors: In accordance with Section 23 05 13.

D. Disconnect Switch: Factory mount non-fusible on fan housing for thermal overload-protected motor, NEMA 250 Type as applicable in installation, with minimum enclosure rating as follows:
   1. Indoors: NEMA 1, lockable.
   2. Indoors (mechanical rooms with no water-filled piping): NEMA 12, lockable.
   3. Indoors (mechanical rooms with water-filled piping): NEMA 3R, lockable.
   4. Outdoors (Protected by overhang): NEMA 3R, lockable.
   5. Outdoors (exposed to windblown dust or water): NEMA 4, lockable.

2.03 CEILING FANS AND INLINE CEILING FANS

A. Manufacturers:
   1. Greenheck Corp.
   2. Loren Cook Company.
   3. Penn Ventilation.
   4. Acme Engineering and Manufacturing Corp.

B. Configuration: Inline within ceiling void.

C. Centrifugal Fan Unit: Direct driven with galvanized steel housing [lined with 1/2 inch (13 mm) acoustic insulation], resilient mounted motor, gravity backdraft damper in discharge opening, integral outlet duct collar.

D. Disconnect Switch: Fan mounted toggle switch for thermal overload protected motor.

E. Wheel: DWDI Centrifugal forward curved type constructed of injection molded or polypropylene resin.

F. Motor: Open drip proof type with permanently lubricated sealed bearings and thermal overload protection.

G. Accessories:
   1. Wall cap with damper, round duct inlet.
   2. Wall cap with rectangular duct inlet.
   3. Eave elbow.
   4. Roof jack constructed of corrosion resistant, galvanized steel with baked enamel finish.

5. Filter box.
6. Rubber-in-shear vibration isolator.
7. Ceiling radiation damper.
8. Fan speed controller.
9. Time delay relay.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Coordinate to verify roof curbs are installed and dimensions are as instructed by manufacturer.

3.02 INSTALLATION

A. Install units with clearances for service and maintenance.

B. Install fans level and plumb.

C. Install flexible connections, specified in Section 233300, between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

D. Install fans as indicated. Install with resilient or vibration isolation mountings specified in Section 230548 and with flexible electrical leads.

E. Install fan restraining snubbers. Flexible connectors shall not be in tension while running.

F. Install backdraft dampers on exhaust fans, outside air makeup fans, and gravity ventilators if not already provided as a fan accessory. Refer to Section 23 33 00.

G. Install safety screen where inlet or outlet is exposed.

H. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.

I. Provide sheaves as required for final air balance. Coordinate with air balance contractor.

J. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for manufacturer's field services.

B. Furnish services of factory trained representative for minimum of one days to start-up, calibrate controls, and instruct Owner's Representative on operation and maintenance.

C. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
2. Verify that units are secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position prior to startup.
9. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.
11. Disable automatic control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Refer to "Owner's Commissioning Requirements" for additional requirements.

3.05 DEMONSTRATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for demonstration and training.

B. Demonstrate fan operation and maintenance procedures.

C. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans. Refer to Division 01 Section "Demonstration and Training" and “Owner’s Commissioning Requirements” for additional requirements.

3.06 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protecting finished Work.

B. Vacuum clean inside of fan cabinet.

C. Do not operate fans until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

END OF SECTION 23 34 40

SECTION 23 37 00

AIR OUTLETS AND INLETS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Floor "Swirl" Diffusers
   2. Grilles and registers.
   3. Ceiling diffuser outlets.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Section 01 33 00 – Submittal Procedures: Submittal procedures and Section 23 05 00 – Common Work Results for HVAC. Where conflicts occur between divisions, the more stringent requirement shall apply.

C. Product Data: For each product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings at design conditions.
   2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

E. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes. Submit one of each required air outlet and inlet type. Maintain on site for review by Owner's Representative at next site meeting. Do not ship or mail.

F. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

G. Test Reports: Rating of air outlet and inlet performance.

1.03 QUALITY ASSURANCE

A. Air Movement and Control Association International, Inc.:
   1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:
   1. ASHRAE 70 - Method of Testing for Rating the Performance of Air Outlets and Inlets.

C. Sheet Metal and Air Conditioning Contractors:
   1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

D. Air Diffusion Council:
   1. Equipment Test Code 1062-GRD Test Codes for Grilles, Registers and Diffusers.

E. National Fire Protection Association:
   1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

F. Test and rate diffuser, register, and grille performance in accordance with ASHRAE 70.

G. Test and rate louver performance in accordance with AMCA 500.

PART 2 – PRODCUTS

2.01 FLOOR SWIRL DIFFUSERS

A. Manufacturer: Nailor

B. Model Number: NFD-VAV

C. Airflow: 60 CFM

D. Plenum Pressure: 0.036 inches w.g.

E. Vertical Projection: 1.0-1.5-2.0 ft. @ 150, 100, 50 fpm

F. Horizontal Spread: 1.8-2.1-4.6 ft. @ 150, 100, 50 fpm

G. Dimensions (H x W): 6” x 9-5/16”

H. Include PFG Press Fit Gasket

2.02 In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

A. Manufacturers: Subject to compliance with requirements and manufacturer's offerings, products that may be incorporated into the Work include, but are not limited to, manufacturers specified. The first manufacturer listed represents the basis of design as scheduled and drawn in the Construction Documents.

2.02 GENERAL DIFFUSER AND GRILLE REQUIREMENTS

A. Units shall have been tested in accordance with Air Diffuser Council (ADC) Code and ASHRAE Standard 36-72, with ratings certified by the ADC.

B. Provide all diffusers, registers and grilles to match the performance, noise criteria and size requirements as scheduled on Drawings.

C. Units shall have a factory applied finished, color as selected by the Owner's Representative.

D. Diffuser, register and grille frames shall be compatible with the ceiling suspension systems. For types of ceiling suspension systems refer to the Architectural Drawings.

E. Provide factory plenum box for linear diffusers.

F. Provide factory round duct neck transition for diffusers with square neck connections.

G. Furnish frames complete with felt or sponge rubber gaskets, except when they are used as plaster stops on all four sides.

2.03 GRILLES AND REGISTERS

A. Wall Grilles
   1. Manufacturers:
      a. Titus.
      b. Krueger.
      c. Price Industries.
      d. Nailor
   2. Fabrication: Steel, unless otherwise scheduled, with 20 gage minimum frames and 22 gage minimum blades
   3. Frame: Countersunk screw mounting and gasket.
   4. Exhaust or return grilles:
      a. Provide 40-degree or 45-degree fixed single deflection type, consisting of a heavy formed face with horizontal face bars spaced 3/4 inch (19 mm) apart.

B. Underfloor Swirl Diffuser
   1. Manufacturers:
      a. Titus.

b. Krueger.
c. Price Industries.
d. Nailor.

2. Type: Round, perforated steel (unless otherwise scheduled) return register, baked enamel finish, for plenum return applications.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Section 01 30 00 – Adminstrative Requirements: Verification of existing conditions before starting work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Verify inlet and outlet locations.

D. Verify ceiling, roof and wall systems are ready for installation

3.02 INSTALLATION

A. Locate grilles, registers, and diffusers indicated on the reflected ceiling plan drawings and submit Shop Drawings before installation in suspended ceiling systems or surface mounted in gypsum ceilings as scheduled. Locate all ceiling grilles and diffusers symmetrically, in accordance with the requirements of Section 09 50 00 – Ceilings. Provide inactive segments and blank-offs as required for linear diffuser installations.

B. For aesthetic quality, provide continuous diffusers and locate active plenum boxes above ceiling as noted on the Drawings. Provide “dummy” diffuser blank-off caps where plenums do not exist.

C. Provide all branch ducts to grilles and diffusers complete with volume dampers.

D. Install diffusers, registers, and grilles level and plumb.

E. Install diffusers to ductwork with airtight connection.

F. Install balancing dampers on duct take-off to diffusers, grilles, and registers, whether or not dampers are furnished as part of diffuser, grille, and register assembly. Refer to Section 23 33 00

G. Paint visible portion of ductwork behind air outlets and inlets matte black. Refer to Section 09 90 00

H. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

I. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

J. Registers and Grilles Installed in Exposed Ductwork:
   1. Frames are not required for registers and grilles installed directly in exposed ductwork.
   2. Cut and form openings in ducts, so that there shall be a double thickness of metal, to attach the registers or grilles to the ductwork, with sheet metal screws. Bend back edges of the openings into the duct, on all four sides, a minimum of 1 inch to provide the thickness of metal stated above. Provide felt or sponge rubber gasketing, all four sides of duct openings, for supply grilles and supply registers.

K. Air Diffusers Installed in Exposed Ductwork:
   1. Frames are not required for registers and grilles installed directly in exposed ductwork.
   2. Cut and form openings in ducts, to accommodate the specified volume control damper and adjustable equalizing grid assembly. Reinforce opening as required. Provide felt or sponge rubber gasketing, around duct opening, for supply diffuser assemblies.

L. Install inclined blade return and exhaust grilles and registers so that blades obstruct vision by inclining blades as follows:
   1. Ceiling outlets: Incline toward nearest wall.
   2. Wall outlets near ceiling: Incline toward ceiling.
   3. Wall outlets near floor: Incline toward floor.

M. Adjust throw-patterns of all supply air outlets to result in uniform, draft free room air distribution at minimum and maximum air flows. Coordinate throw patterns with drawings where throw patterns are indicated.

3.03 INTERFACE WITH OTHER PRODUCTS

A. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3.04 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.05 SPECIAL INSTALLATION

A. Furnish and install Nailor Model NFD-VAV Floor “Swirl” Diffusers with Actuators of the size and type shown on the plans and air distribution schedules. Units shall be complete with all connecting cables and power supply modules as shown, the diffuser shall be constructed entirely of high impact polycarbonate plastic which complies with UL Standard 94-5V for flammability. The core design shall produce a low velocity helical “swirl” discharge air pattern maximizing induction and comfort in the occupied zone. A variable volume flow regulator damper shall be provided with an integral 24 VAC direct drive actuator which operates from a 2 – 10 VDC control signal for precise airflow control. The actuator shall incorporate two RJ12 ports for simple interconnection using modular plenum rated cables and allowing multiple units to be daisy chained together. Each diffuser shall include a standard 12 ft. modular plenum rated cable, for interconnection between diffusers, allowing diffusers to be space on 10 ft. intervals. The damper shall have visual open/closed indication and include an adjustable minimum volume stop. The diffusers shall incorporate a removable dust/dirt collection basket to catch anything that might fall through the diffuser face. Three universally adjustable mounting clamps shall be provided for each diffuser to permit installation from above the floor without removal of the floor panel or carpet.

END OF SECTION 23 37 00

SECTION 23 56 13

HEATING SOLAR FLAT-PLATE COLLECTORS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Heating Solar Flat-Plate Collectors

1.02 SUBMITTALS

A. Approved Drawings and Data

B. Commercial Products Data with Performance Charts and Curves: Annotate descriptive data to show the specific model, type, and size of the item.

C. Solar System Design: Submit a complete description of the design of the system, including drawings, specifications, flow calculations, and written narrative. Submit calculations of solar system performance leading to the proposed design.

D. Statements: Prior to installation, submit data showing that the Contractor has successfully designed and installed systems of the same type and design as specified herein and proposed by the contractor or original collector manufacturer supports him during all phases of the project.

E. Drawings: Provide drawings for the system type and size containing a system schematic; a collector layout and roof plan noting reverse-return piping for the collector array; a system evaluation; a schedule of operation and installation instructions; and a schedule of design information including collector height and width, recommended collector flow rate and pressure drop at that flow rate, number of collectors, number of manifolds to be grouped per bank (not to exceed 8 collectors per bank), gross area and net aperture area of collectors, collector fluid volume, collector filled weight of support structure, and tilt angle of collectors from horizontal. Include in the drawings, complete wiring and schematic diagrams, proposed pipe pitch and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work, including clearance for maintenance and operation.

Provide a detail of the joint connection between the solar collector mounting brackets and the roof membrane.

F. Final Drawings and Data

G. Instructions: Submit proposed diagrams, instructions and other sheets, including a system schematic, wiring and control diagrams, and a complete layout of the entire system for the system type to be installed. Include with the instructions, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system, methods of balancing and testing flow in the system, and methods of testing for control failure and proper system operation.

H. Operating and Maintenance Manuals: Submit manuals that detail the step-by-step procedures required for system filling, startup, operation, and shutdown. Include in the manuals the manufacturer's name, model number service manual, parts list, and brief descriptions of all equipment and their basic operating features. List routine maintenance procedures, possible breakdowns and repairs, recommended spare parts, troubleshooting guides, piping and equipment layout, balanced fluid flow rates, and simplified wiring and control diagrams ofthe system as installed.

I. Field Test Reports
   1. Submit reports of piping hydraulic pressure test and commissioning.
   2. Submit results of system performance testing.

1.03 QUALITY ASSURANCE

A. Solar Rating Certification Corporation:
   1. SRCC OG100
B. American Society of Mechanical Engineers:
   A. ASME B 16.22- Wrought Copper and Copper Alloy Solder Joint Pressure Fittings\
   B. ASME Section IX- Boiler and Pressure Vessel Code- Welding and Brazing Qualifications
C. ASTM International:
   1. ASTM B32- Standard Specification for Solder Metal
   2. ASTM B88- Standard Specification for Seamless Copper Water Tube
   3. ASTM B584- Standard Specification for Copper Alloy Sand Castings for General
   4. Applications
   5. ASTM F708- Standard Practice for Design and Installation of Rigid Pipe Hangers

AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS, INC. (ASHRAE)

ASHRAE 93	Methods of Testing to Determine the Thermal Performance of Solar Collectors
NFPA 70	National Electrical Code
ISO 9001	ISO 9001 Certified Manufacturer
ISO 9002	ISO 9002 Certified Manufacturer

PART 2 – PRODCUTS

2.01 GENERAL EQUIPMENT REQUIREMENTS

A. Standard of Pre-approved Products: Furnish materials and equipment that are the standard products of a manufacturer regularly engaged in the manufacture of such products and which essentially duplicate items that have been in satisfactory use for at least ten years prior to proposal due date.

B. Nameplates: Secure to the major item of equipment the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate.

2.02 PIPING SYSTEM

Provide a piping system complete with pipe, pipe fittings, valves, strainers, expansion loops hangers, inserts, supports, anchors, guides, sleeves, and accessories with this specification and the drawings. Provide, install, and test the piping. Piping shall be Type L copper tubing, ASTM B-88, with 95/5 tin-antimony soldered joints.

A. Pipe Installation: Furnish interior pipe insulation and coverings such as Armaflex, Insul-Tube, Rubatex, and approved equivalent. Provide outside array piping insulation with a capability of withstanding 250 degrees F, except that piping insulation within 1.5 feet of collector shall be capable of withstanding 300 degrees F. Protect outside piping insulation from water damage and ultraviolet degradation with a suitable outer coating.

B. Balancing Valves (if required): If systems are proposed with multiple collector banks, provide balancing valves suitable for 125 psig and 250 degrees F service. Furnish balancing valves with bronze body/brass ball construction with seat rings compatible with system fluid and differential readout ports across valve scat area. Provide readout ports fitted with internal insert of compatible material and check valve. Provide calibrated balancing valves with a memory stop feature to allow valve to be closed for service and reopened to set point without disturbing balance position, and with a calibrated nameplate to assure specific valve settings. Provide calibrated balancing valves and ball valves at the outlet of the collector bank. The balancing valves are specified to allow the array to be flow balanced. The ball valves are required to enable the array to be disconnected for maintenance or repair. This section is not applicable to systems of only one collector bank, where balance of flow is not an issue.

C. Pressure Gauges: Provide pressure gauges with throttling type needle valve or a pulsation dampener and shutoff valve. Furnish a 3Y2 inch minimum dial size.

D. Thermometers: Supply thermometers with wells and separable bronze sockets.

E. Pipe Hangers and Supports: Support and hang piping so that the weight of the piping is not supported by drywall, siding, or other building members not designed to bear load. Support piping so that thermal expansion and contraction of the pipe length is accommodated.

F. Valves: Provide valves compatible with the piping. Ball valves shall be used for shutoff, with full port, bronze body, bronze ball and Teflon seat. Bronze hose-end gate valves shall be used for draining low points of piping.

2.03 COLLECTOR SUBSYSTEM

A. Solar Collector Construction: The type of solar collector proposed shall be compatible with the proposed system type:
   1. Absorber plate shall be coated with high-efficient selective coating which ensures maximum radiation absorption and minimize thermal radiation losses.
   2. Heat pipe's heat transfer fluid shall be water based.

B. Collector Warranty: Flat plat collectors must be fully warranted to be free from defects in both material and workmanship for a total period often (10) years from date of installation acceptance.

C. Delivery, Storage and Handling: Accept collectors on site securely packed with labeling in place. Inspect for damage. Provide individual drilled wooden blocks, strapped to the panel to protect the copper header and union, if so equipped. Provide temporary end caps and closures on the piping and fittings. Maintain temporary caps in place until installation. Protect piping systems from entry of foreign materials with temporary covers.

D. Solar Collector Performance: Plot thermal performance on the thermal efficiency curve in accordance with ASHRAE93. Show manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate. Indicate the manufacturer's recommendations or the number of collectors to be joined per bank while providing for balanced flow and for thermal expansion considerations.

E. Heating Solar Flat Plate Collectors: SunMaxx Solar
   1. TitanPowerPlus SU-2

a. 79.4 in x 38.78 in x 3.03 in
b. Collector Area: 21.42 ft
c. Tilt Angle: 35°
d. Stainless Steel, AISI: 304, 0.7 mm guage, 3.2 mm toughened glass
e. Maximum Operating Pressure (psi): 87
f. Recommended Operating Pressure: 36.3 – 43.5 psi
g. Minimum Flow Rate: 0.13 gpm
h. Nominal Flow Rate: 0.44 gpm
i. Maximum Flow Rate: 0.79 gpm
j. Recommended Flow Rate: 0.176 – 0.617 gpm

2. Fasteners: All screws 18-8 stainless steel with black oxide coating. Corners fastened using structural high strength, protruding head aluminum blind rivets with a retained aluminum mandrel meeting BS 1473 standards. Shear strength is 6.0 kN with a tensile strength of 4.2 kN typical. Back sheet is fastened using domed head, 5056 aluminum rivets with a steel mandrel. Shear strength is 930 Nand tensile strength is 1450 N typical.
3. Collector frame must be Certified tested to withstand up to 181 mph
4. Collector must include factory installed stainless steel 1OK inside collector box.
5. No penetrations are allowed to the collector box.
6. Collectors must come with factory pre-installed and factory pressure tested unions.
7. Instantaneous efficiency: Minimum Y Intercept of.706 with a slope of no less than 0.865 BTU/hr•ft2•°F and lJ 2: 0.691 per SRCC test data.
8. Thermal Performance Rating: Clear Day performance, Category Cas documented by SRCC certification data to be not less than [sckct appropriate number Cor pand used]

2.04 SOLAR COLLECTOR ARRAY

A. Net Absorber Area and Array Layout: Collector array shall be oriented so that all collectors face the same direction. Space collectors arranged in multiple rows so that no shading from other collectors is evident between 1000 hours and 1400 hours solar time on December 21. Indicate minimum spacing between rows. Roof plan shows locations where panels would fit best at other roof equipment.

B. Piping: Connect interconnecting array piping between solar collectors, in a reverse-return configuration with approximately equal pipe length for any possible flow path. Indicate flow rate through the collector array. Provide the collector bank isolated by valves, with a pressure relief valve and with the capability of being drained. Locate manually-operated air vents at systems high points, and pitch array piping a minimum of 0.25 inch per foot so that piping can be drained by gravity. Install balancing valves at the outlet of the collector bank as indicated.

C. Supports for Solar Collector Array: Provide support structure for the collector array of aluminum. Furnish a support stfucture, which secures the collector array at the proper tilt angle with respect to horizontal and orientation with respect to true south. The collector tilt angle shall vary by not more than ±25 degrees from the angle of the local latitude, and the azimuth angle may vary by not more than ±45% from due true south. Provide a support structure that will withstand the static weight of filled collectors and piping, wind, seismic, and other anticipated loads without damage. Show wood backing to be designed by others and installed by framing contractors. Provide a support structure, which allows access to all equipment for maintenance, repair, and replacement. Neoprene or EPDM washers shall separate all dissimilar metals.

2.05 SOLAR PREHEAT STORAGE TANK

A. Provide a thermal energy storage solar tank with a storage capacity specified in design drawings. Provide the interior of the tank with stainless steel, glass lining, epoxy or cement for potable service.

2.06 HEAT TRANSPORT SUBSYSTEM

A. Heat Exchanger: Use solar tanks with single wall heat exchangers, either immersion in the tank or of flat plate design. If using single wall exchangers, make sure the solar relief valves are set below city water pressures, only non-toxic propylene glycol is used and the tank and exchanger clearly mark that no chemicals may be added to the solar system. Or use double wall heat exchangers per local jurisdiction.

B. Pumps: Provide electrically driven circulating pump such as those manufactured by Taco or approved equivalent. Support pumps on a concrete foundation or by the piping on which installed. Construct the pump shaft of corrosion-resistant alloy steel with a mechanical seal. Control motors with switches that can be activated by the variable speed differential temperature controller.

C. Gauges: Provide Miljoco Stainless steel temperature gauges on the cold water supply, the domestic solar hot water outlet, the solar supply and the solar hot water return. Also provide a pressure gauge on the solar closed loop and the cold water inlet.

D. Make up water/glycol solution to closed loop solar system must Axiom SF or MF series make up water kits with optional alarm.

E. Heat Transfer Fluid: Heat transfer fluid shall be compatible with all materials in the system. The nature and amount of heat transfer fluid will depend on the type of system proposed. Any conditioners or corrosion inhibitors added to the heat transfer fluid must be non-toxic rated as Class I.

2.07 CONTROL AND INSTRUMENTATION SUBSYSTEM

A. Differential Temperature Control Equipment: As required by the approved system design, furnish the control equipment as a system from a single manufacturer. Furnish a solid-state electronic type controller complete with an integral transformer to supply low voltage. Provide differential controls with direct digital temperature readings of all temperatures sensed. Supply controls with a visual indicator when pumps are energized and recording capabilities. Provide a controller that will identify open and short circuits on both the solar collector temperature sensor circuit and the storage tank sensor circuit. BTU metering with data logging is required.

B. Thermistor Temperature Sensors: Provide temperature sensors that are compatible with the differential temperature controller, with an accuracy of plus or minus 1 percent. CSA approved. Must be capable of operating up to 350F. Provide immersion wells or watertight threaded fittings for temperature sensors on solar tanks greater than 120 gallons.

C. Tempering Valve: Systems must have a tempering or mixing valve to limit the temperature of the hot water supplied to the plumbing fixtures.

2.08 ELECTRICAL WORK

A. Provide electric motor-driven equipment complete with motor, motor starters, and controls. Provide electrical equipment and wiring in accordance with local codes. Furnish motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified capacity without exceeding the nameplate rating of the motor. There must be a dedicated circuit for the solar system, one for single phase power and one for three phase if three phase is being used.

2.09 PAINTING AND FINISHING

A. Furnish equipment and component items, with the factory-applied manufacturer's standard finish.

PART 3 – EXECUTION

3.01 INSPECTION

A. Inspect substrate to ensure mount connection is compatible with conditions.

B. Notify architect or engineer of unsatisfactory conditions, do not proceed until condition has been satisfactorily corrected.

3.02 PREPARATION

A. Clean and prepare substrate according to manufacturer's instructions.

B. Prepare piping connections to equipment with couplers or unions.

C. Keep open ends of pipe free from scale and dirt.

D. Protect open ends with temporary plugs or caps.

3.03 INSTALLATION

A. Install piping straight and true to bear evenly on hangers and supports. Do not hang piping from sheetrock or suspended ceilings. Keep interior and ends of new piping thoroughly cleaned of foreign matter. Keep piping systems clean during installation by means of plugs or other approved methods. Discharge storage tank pressure and temperature relief valves into floor drains. Provide air vents with threaded plugs or caps. Install control and sensor wiring conduit. Or install within the pipe insulation jacket, but not against the copper tubing.

B. System Flushing and Disinfection: Flush the piping system.

C. Collector Subsystem
1. Collector Array: Install solar collector array at the proper tilt angle, orientation, and elevation above roof. Install the solar collectors with the ability to be removed from maintenance repair, or replacement. The array may be level to the roof.
2. Array Piping: Install collector array piping in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length. Install%" air vents in the high points of the collector array piping with shut off valves. Provide proper pitch at *W'* per foot for draining of collector array piping.
3. Array Support: Install array support in accordance with the recommendations of the collector manufacturer.
4. Pipe Expansion: Provide for the expansion and contraction of supply and return piping with changes in the direction ofthe run off pipe or by expansion loops. Do not use expansion joints in the system piping.
5. Valves: Install full port ball valves at the inlet and outlet of the bank of manifolded collectors when there are multiple arrays. Install balancing valves at the outlet of the collector bank, and mark final settings on the valve. Install a union adjacent to the ball valve. Balance flow through the collector piping with at least one balancing valve left in the open position. Locate tempering mixing valve downstream of auxiliary water heater to control hot water delivery temperature. Roof mounted relief valves

must be piped directly to a metal roof drain, never relieved to a tar or a foam based roof.

6. Sensors: Solar collector sensor must be mounted inside the solar collector box inside a well which is welded to the hot out absorber header.
7. Labeling: Install flow indicators and description of solar supply, solar return, cold water supply, solar domestic hot water, heat exchanger supply and return. Arrows to the collectors should be in blue, and from the collectors should be red.
8. Roof Penetrations: All roof penetrations shall be made permanently waterproof. Contractor shall coordinate work with the current warranty of the existing new roof. For flat roofs, lag bolt a 6" x 8" doug fir runner to roof rafters, roof in with cant strips, and aluminum cap flash the runner that includes an I" overhang and I" drip edge. Secure collector rack footings to runner with 4" minimum stainless steel lag bolt. Waterproof the penetrations. Supply and return tubing must be installed within a roof jack. For pitched roofs, use Fastjack stanchions bolted to roof rafters then water proof with roof jacks and roof sealant. Stanchions should not be located more than 4' from each other on the top collector runner or on the bottom collector runner. Each runner is running horizontally along the roof and is roughly on center to the length of the collectors. Consult with engineer for details.
9. Securely attach all panel brackets using stainless steel hardware as provided by the manufacturer.
10. Install panels at angle specified by Architect or Engineer based on latitude and site conditions.
11. Support adjacent panels such that no weight is carried by the header pipe.
12. Follow manufacturer' guidelines for assembly of panel arrays. Array must not exceed 8 collectors per array.
13. Insulate all exposed pipe runs and unions.
14. Where there are more than one piping material is specified, use compatible components and joints. Use non-conducting brass when joining dissimilar metals.
15. Install spring loaded check valves on the solar return of closed loop pressurized solar arrays.
16. Install %" ball valves with hose bib and cap for drains at low points in the piping.
17. Install fill, block and purge system to adequately purge air out of each array and at the mechanical room.

3.04 INSPECTION AND TESTING

A. Instructions: Provide instructions for the system type. Include in these instructions a system schematic and wiring and control diagrams showing the complete layout of the solar system. Prepare condensed operating instructions explaining preventative maintenance procedures, balanced flow rates, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system, in typed form, framed as specified above, and posted beside the diagrams. Post the framed instructions before acceptance testing of the system.

B. Acceptance Testing and Final Inspection: Maintain a written record of the results of all acceptance tests, to be submitted in booklet for. Provide following tests:
   1. Hydrostatic Test: Hydrostatically test the system to a minimum of 125 psi. Isolate instrumentation, expansion tank, relief valves not suitable for the intended test pressure.
   2. Operational Test: Operationally test the system over a period of 48 consecutive hours with sufficient solar insulation to cause activation of the solar energy.

END OF SECTION 23 56 13

SECTION 23 57 00

HEAT EXCHANGERS FOR HVAC

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Heat Exchanger

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Ensure all fittings are properly installed and sealed.
B. Pressure test before filling with liquid.

1.04 WARRANTY

A. Warranty specified by the manufacture.

PART 2 – PRODCUTS

2.01 HEAT EXCHANGER

A. Manufacturer: Hydronic Heating Supplies

B. Model: WA19x20

C. Number of Tubes: 20

D. Fin Height x Fin Length: 20.0 in x 19.0 in

E. Rows Deep x Fins / Inch: 3.0 Rows x 12.0 Fin Per Inch

F. Tube O.D. and Thickness: 3/8in. x 0.014 Wall – Smooth Tubing

G. Fin Thickness and Material: 0.0060 Corrugated Aluminum Fins

H. Face Area: 2.64 Square Feet

I. Weight: 15.26 lbs

J. Number of Circuits: 10

K. BTU: 150,000

L. CFM: 2500

M. Pressure Drop Air: 1.49

N. Pressure Drop Water: 0.388

O. GPM: 15

P. Website: http://www.northlanddistrib.com/Water-To-Air-Heat-Exchangers_c_423.html

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install equipment per manufacturer's installation guidelines.

B. Ensure all piping is secured, and properly sealed.

END OF SECTION 23 57 00

SECTION 23 73 13

AIR HANDLING UNITS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Air Handling Unit
   2. Heating Coil
   3. Modular factory fabricated air-handling units and accessories.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Section 01 33 00 - Submittal Procedures: Submittal procedures and Section 23 05 00 – Common Work Results for HVAC. Where conflicts occur between divisions, the more stringent requirement shall apply.

C. Calculations:
   1. Provide updated fan pressure drop calculations for each system as laid out in the ductwork shop drawings.
   2. Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

D. Product Data, Submit the following:
   1. Dimensioned plan and elevation view drawings, and control cabinets, required clearances, and location of all field connections.
   2. Indicate split points on the drawings for units that will not be shipped completely assembled. Sectionalized sections/structure shall be coordinated prior to ordering.
   3. Summary of all auxiliary utility requirements such as: electricity, water, etc. Summary shall indicate quality and quantity of each required utility.
   4. Ladder type schematic drawing of the power and ancillary utility field hookup requirements, indicating all items which are furnished.
   5. Manufacturer’s performance of each unit. Selection shall indicate, as a minimum, the following.
      a. All data listed in the Drawing Schedules.
      b. Air flow rates
      c. Static pressure summary including component pressure drops, total static pressure, and external static pressure

   d. Cooling coils capacities, entering air temperatures (dry bulb and wet bulb), leaving air temperatures (dry bulb and wet bulb), entering and leaving water temperatures, maximum pressure loss (air side water side)
   e. Heating coils capacities, entering and leaving air temperatures, entering and leaving water temperatures, maximum pressure loss (air side and water side).
6. Velocities through coils, louvers and dampers.
7. ASTM B-117 and D-2247 documentation of painting system for exterior panels meeting 500 hour scrub test and 1000 hour unscrubed test.
8. Identify materials, gauges and finishes for base frame, floor plate, drain pans, unit housing (inner and outer), thermal insulation, louvers, fan supports, coils, and dampers.
9. Filters: Include information on filter media, performance data (including clean and dirty pressure drops), filter assembly, filter frames, filter gauge (including scale range).
10. Fans: Performance and fan curves with specified operating point plotted, power, RPM.
11. Sound Power Level Data: Units outlets, inlets, exhaust, and casing radiation at rated capacity. Sound power levels shall be at each octave band from 63Hz to 8000Hz.
12. Sound Performance Test Methodology, including letter confirming payment of time and materials cost for acoustical engineer’s time in reviewing all proposed test procedures that are submitted as substitutions to the required certified laboratory tests.
13. Electrical Requirements: rated load amp draw of each electrical device, electrical ratings and characteristics, power supply wiring, electrical wiring diagrams for interlock and control wiring, indication of what is factory installed and field installed wiring.
14. Approximate unit shipping weight.
15. Air flow and temperature measure system probes and processor.
16. A copy of the balance test data showing calculations for deflection of the shaft and wheel assembly.
17. Where noise performance tests are specified, submit results for the air handling units tested for review prior to any air handling unit shipment to the jobsite.
18. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   c. devices on which the certification is based and their installation requirements.
19. Controls Coordination:
   a. Submit a list of controls devices to be provided from the controls contractor and installed by the air handler manufacturer. Provide a letter from the controls contractor confirming this list and confirming a list of all field installed devices to be installed by the controls contractor.
   b. Submit a diagram of the required control panel size and internal content to prove that the recess is correctly sized. Provide a letter from the controls contractor confirming acceptance of the size.
   c. Submit a diagram co-signed by the controls contractor and the air handling unit manufacturer confirming that all controls devices, as specified and any intended substitutions, will fit in the unit and that controls devices will not be installed until

controls submittals are returned with no exception taken. State that the air handler manufacturer and the controls contractor bear the risk of installing devices that remain in a “revise and resubmit” status.

20. Submit manufacturer's installation instructions.
21. Submit manufacturer’s quality assurance and quality control procedures.
22. Submit test procedures for performance tests.
23. Submit performance test results.

E. Shop Drawings:
   1. The Contractor shall submit certified scale plan and elevation drawings of the units. The drawings shall include:
      a. Unit components, equipment and accessories.
      b. Dimensioned locations and sizes of field connections (piping, electrical, ductwork, controls wiring) including manufacturing tolerances for locations.
      c. Unit dimensions.
      d. Weight loading.
      e. Identify minimum clearances for access (including clear height) referencing all items requiring access. Access clearance requirements may be described in notes or dimensioned areas identified on the plan and elevation drawings. Where notes are used the description shall include dimensions.
      f. Identify dimensioned location of assembled center of gravity.
      g. Provide support details with point loading.
   2. Provide construction details including unit base, panel jointing and insulation application.
   3. Provide field connection details.
   4. Electrical connection locations.

1.03 QUALITY ASSURANCE

A. American Bearing Manufacturers Association:
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc.:
   1. AMCA 99 - Standards Handbook.
   2. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
   3. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
   4. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
   5. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

C. Air-Conditioning and Refrigeration Institute:
   1. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
   2. ARI 430 - Central-Station Air-Handling Units.
   3. ARI Guideline D - Application and Installation of Central Station Air-Handling Units.

D. American Society of Heating Refrigerating and Air-Conditioning Engineers:
   1. ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2. ASHRAE/IESNA 90.1: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. National Electrical Manufacturers Association:
   1. NEMA MG 1 - Motors and Generators.

F. National Fire Protection Association:
   1. NFPA 70 - National Electrical Code
   2. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

G. Sheet Metal and Air Conditioning Contractors:
   1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

H. Underwriters Laboratories Inc.:
   1. UL - Fire Resistance Directory.
   2. UL 181 - UL Standard for Safety Factory-Made Air Ducts and Connectors
   3. UL 723 - UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
   4. UL 900 - Air Filter Units.

I. Damper Leakage: Test in accordance with AMCA 500.

1.04 WARRANTY

A. Section 01 70 00 - Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish one year manufacturer warranty for air handling units. All work required on the unit as part of the warranty shall be performed by Factory Certified Technicians.

C. The air handler manufacturer shall ensure that coordination with the internal component manufacturers has taken place and will not affect single-point of responsibility warranty, which resides solely with the air handling unit manufacturer.

D. Liebert limited warranty
   1. As provided herein, the Liebert product is warranted to be free of defects in material and workmanship for a period of one year from the start-up date provided the product Warranty Inspection sheet is returned to Liebert, start-up occurs within six (6) months of the Liebert shipping date, and the product has been stored in a suitable environment prior to start-up. The start-up date will be determined only from the completed inspection and start-up sheet received with the product. If the product start-up sheet is not returned to Liebert, the Liebert product is warranted to be free of defects in material and workmanship for a period of thirteen (13) months from date of product shipment by Liebert. The shipment date will be determined only from the Liebert bill of lading.
   2. In addition, for products installed in the United States or Canada, the drive package contained in the Liebert DS product and Liebert InteleCool2® Compressor is warranted to be free of defects in material and workmanship for a period of five (5) years from the

above referenced dates, as applicable. The drive package contained in the Liebert DS product consists of blower belts, a blower shaft, blower bearings, a blower pulley, and motor sheave.

PART 2 – PRODCUTS

2.02 Air Handling Units

A. Manufacturers: Liebert

B. Model: BF102C-TMHI Challenger 3000 Environmental Control System

C. Nominal 5 ton Downflow System, MBH at 72°, 50% RH, 230 voltage, 1 Phase, 60 Hz

D. Chilled Water Unit: Insulated Chilled Water Piping, 3 way Modulating Control Valve

E. System Accessories:
1. Liebert iCOM microprocessor with Small Graphic Display
2. Display Language is English
3. Factory Balanced Evaporator Motor & Blower Package
4. Hot Water Reheat 5 ton
5. Infrared W/ Autoflush Humidifier
6. Locking Disconnect Switch
7. Qty-1 LT410 Point Leak Detection Sensor
8. Condensate Pump – Dual Float
9. 2” Merv 8 Filter Package
10. 1.5 HP Motor
11. Smoke Sensor
12. 24” High Floorstand
13. Unit color: Z-0420

2.03 HEATING COIL

A. Manufacturer: Alpine

B. Model: AHAEHBCC05CSA

C. Kilowatt Rating: 5kW

D. Amperage Requirement (Circuit 1/Circuit 2): 30 / 0 amps

E. Voltage: 208 / 230 Volts

F. Frequency: 60 Hz

G. Voltage Phase: 1

H. Website: http://www.alpinehomeair.com/viewproduct.cfm?productID=453064972

2.04 MODULAR AIR HANDLING UNITS

A. Manufacturers:
   1. Carrier.
   2. Trane.
   3. York.
   4. McQuay.

B. Configuration and Dimensions: The manufacturer shall fabricate the unit following the dimensions shown on the plans. Reduced or increased sizes shall only be acceptable where access provision or unit performance is not affected. Proposals to change unit dimensions shall be clearly identified through a substitution request.

C. Performance Base: Sea level.

D. Fabrication: Conform to AMCA 99 and ARI 430.

E. Frame:
   1. Fabricate mounting base and attachment to air-handling unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when air-handling unit frame is anchored to building structure.

F. Construction:
   1. Channel base and drain pan of welded steel. Assemble sections with gaskets and bolts.
   2. Formed and reinforced wall panels, 2" thick, with at least two breaks at each joint. Fabricated to allow removal for access to internal parts and components, with joints between sections sealed with water-resistant sealant. Casing joints secured with sheet metal screws or pop rivets.
   3. Strength: Furnish structure to brace casings for suction pressure to match 1.5 times return/relief fan pressure, with maximum deflection of 1 in 200.
   4. Outside Casing:
      a. 16 gauge G90 galvanized thick with double die-formed panel secured with ¼-inch hex head, and zinc plated fasteners.
      b. For indoor units, manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
   5. Inside Casing:
      a. The inside liner shall incorporate a 5 degree bend on all exposed surfaces to eliminate any waving. Liner shall be secured with sheet metal screws to outside casing every 8-inches.
      b. 20 gauge thick galvanized steel. Solid except in fan sections where perforated shall be used.
      c. Cooling Coil Drain Pan Access Section: 304 Stainless Steel: Solid, minimum 20 gauge.
   6. Floor Plate:

a. Floor seams shall be seamed to create leak free joints. The perimeter of the unit shall have a 1.5-inch upturned perimeter lip to create a drainable floor.
b. 10 gauge galvanized steel.

7. Insulation:
   a. Location and Application: Encased between outside and inside casing.
   b. Materials: ASTM C 1071, Type I.
   c. Insulation shall meet the requirements of UL-181 facing the air stream and fire hazard classification of 25/50 per ASTM-84 and UL 723.
   d. 'K' ('Ksi') factor at 75°F (42°C): Maximum 0.26 Btuh inch/ sq ft/ °F (0.037 W/m/Degree K).
   e. Effective thermal conductivity (C) of 0.24 (btu-in/hr-sqft-deg F)
   f. Density: 2 inch (50 mm) thick, 1-1/2lbs/cu ft (24 kg/cu m).
   g. Noise reduction coefficient (NRC) of 0.7 per inch (based on type "A" mounting)

8. Access Doors:
   a. Provide access doors to the following unit sections: fan, coil, filter.
   b. Locate all access doors on the side of unit dedicated for access.
   c. Neoprene gasket, applied around entire perimeters of panel frames.
   d. Arrange doors to be opened against air-pressure differential. Where this is not feasible due to site constraints, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement. Also provide interlocking mechanism for each fan access door that will de-energize the fan when the door is opened.

G. Fans
1. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.
2. Sound Ratings: AMCA 301, tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
3. Mounting:
   a. The frame and/or sub-base which supports the fan housing and the motor and drive package shall be of heavy gauge structural steel channel all welded construction adequately reinforced as required to assure permanent motor, drive and fan shaft alignment and to hold vibration to an absolute minimum. A two bolt adjustable motor base shall be provided to allow for easy alignment and adjustment of belt tension.
4. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
5. Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Prior to shipment, all fans shall receive a final test balance at the specified operating speed and shall ship fully assembled.
   a. Fans shall be selected not to exceed an RPM rating higher than 90% of the maximum class RPM.
   b. Thrust restraints shall be provided on all fans with 100 lbs of thrust or more.

H. Motors
1. Refer to Section 23 05 13 for motor requirements.

I. Bearings, Shaft, and Drives

1. Bearings:
   a. Pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9 L-10 life at 20,000 hours. Lubrication fittings extended to exterior of casing with copper tube and grease fitting rigidly attached to casing.
2. Shafts:
   a. Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
   b. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
3. Drive:
   a. Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
   b. V-belt, cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of motor.
   c. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   d. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
   e. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
   f. Belt Guard: Fabricate to SMACNA Standard; 0.106 inch (2.6 mm) thick, 3/4 inch (20 mm) diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

J. Coils
1. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
2. For multi-zone units, provide air deflectors and air baffles to balance airflow across coils.
3. Coils shall not act as structural component of unit.
4. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.
5. All water coil assemblies are leak tested under water at 315 PSIG. Standard construction is suitable for 250 PSIG operating pressure up to 300° F.
6. Casing with access to both sides of coils. Enclose coils with headers and return bends fully contained within casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.
7. Drain Pans: Stainless steel, double sloped IAQ type 24 inch (600 mm) downstream of coil and down spouts for cooling coil banks more than one coil high.
8. Eliminators: Three break of Type 304 stainless steel, mounted over drain pan.
9. Fabrication:
   a. Casings for chilled water coils and humidifiers shall be minimum 16 gauge 304SS with 1-1/2” die-formed flanges to permit easy stacking and mounting. Intermediate

tube supports are supplied on coils over 44-inches fin lengths with additional supports every 42-inch multiples thereafter.

b. Primary Tube Surface: Round seamless 5/8" O.D. copper tubes with 0.025" wall thickness mechanically expanded into fin collars of the secondary surface. Tubes shall be mechanically expanded to provide a permanent metal-to-metal bond for efficient heat transfer. Manufacturer may only use staggered tubes in direction of airflow and only return bends - reduced tube wall hairpin bends are not acceptable. 10 rows maximum.

c. Secondary Fin Surface: Die-formed, corrugated plate-type 0.01" Aluminum fins with full drawing fin collars to provide accurate fin spacing control and maximum tube contact. 10 fins per inch maximum.

d. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.

K. Condensate Drain Pans:

1. Furnish drain pans under cooling coil section.
2. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils, including coil piping connections, coil headers, and return bends. Provide a minimum depth of 2 inches (50 mm). Extend drain pan downstream from leaving face to the end of the section.
3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan. Connections shall be on the same side as the access.
4. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

L. Filters

1. Filters shall be arranged for upstream loading.
2. Filter Gauges: The filters shall be installed to allow pressure measurement across each filter bank. Factory install at each filter bank, see Section 23 40 00 for gage requirements. Recess body of gauge into air handling unit casing so that the face of the gauge is flush with the outside of the cabinet. Provide hinged access cover for gauges on outdoor units to reduce effect of UV light on plastic face.

M. Louvers (Outdoor Units):

1. Intake Louvers: Louvers shall be stationary drainable blade type entirely contained within a 6.5" G90 galvanized frame. Leading edge of the damper blade shall be rounded to smooth air flow and minimize pressure drop. Framing shall be no less than 20 gauge G90 galvanized steel channel with box flanges. Louver blades shall be fabricated from G90 galvanized steel. A 1/2" mesh bird-screen shall be provided on all louvers.

N. Controls

1. Provide stand-alone factory mounted controls.
2. Unit Mounted Controls :

a. All controls shall be factory mounted by the Air Handling Unit manufacturer. These controls shall include all damper actuators, temperature sensors, pressure sensors, airflow measuring sensors, filter switches, smoke and fire detectors as indicated on the controls drawings and in the specification.

b. Electric and electronic controls shall be wired to a terminal block in a sheet metal enclosure located at a common location mounted on the air handling unit. All wiring shall run in a minimum of 1/2 inch conduit.
c. All pressure sensing controls shall be piped to a common point on the unit with 1/4 inch compression fittings.
d. All sensors shall have rubber escutcheon fittings where they penetrate unit walls.
e. Unless otherwise specified in this section, control devices shall be supplied by the controls contractor and shipped to the Air Handling Unit manufacturer for installation.

O. Electrical Characteristics and Components
1. Electrical Characteristics: In accordance with Section 26 05 03 and schedules on the Drawings.
2. Disconnect Switch: Provided by Division 26, except where VFDs are provided or disconnect at MCCs not visible at unit. Coordinate with field installers.
3. Provide independent 120V external junction box and internal wiring to receptacles and maintenance lights.
4. If an electric humidifier or heating coil is incorporated within the AH unit, it shall be wired on the single supply power panel.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install in strict accordance with manufacturer’s requirements, shop drawings, and Contract Documents.

B. Install assembled units with vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as required. Adjust snubbers to prevent tension in flexible connectors when fan is operating. Refer to Section 23 05 48.

C. Install in accordance with ARI 430.

D. Provide all items required to ensure a fully operational and functional system.

E. Arrange installation of units to provide access space around air-handling units for service and maintenance.

F. Coordinate AHU electrical installation with Division 26 - Electrical.

G. Coordinate AHU controls with control contractor.

H. Install flexible connections between unit and inlet and discharge ductwork. Refer to Section 23 33 00.

I. Provide fixed sheaves required for final air balance.

J. Install condensate piping with trap and route from drain pan to nearest floor drain. Refer to Section 23 21 13.

3.03 INSTALLATION WATER COILS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Make connections to coils with unions or flanges.

E. Connect water supply to leaving airside of coil (counter flow arrangement). Locate water supply at bottom of supply header and return water connection at top.

F. Install water coils to allow draining and install drain connection at low points.

G. Install the following piping accessories on chilled water piping connections.
  1. On supply:
     a. Thermometer well and thermometer.
     b. Well for control system temperature sensor.
     c. Shutoff valve.
     d. Strainer.
     e. Control valve.
     f. Pressure gage.
  2. On return:
     a. Thermometer well and thermometer.
     b. Well for control system temperature sensor.
     c. Pressure gage.
     d. Shutoff valve.
     e. Balancing valve.

H. Install automatic air vents at high points complete with shutoff valve. Refer to Section 23 05 23.

3.04 SOUND PERFORMANCE TEST:

A. A sound performance test shall be made on air handlers in schedule below prior to shipment of any air handler. These units are representative of the air handlers on the job as follows:

B. The octave band sound power levels shall be determined via the reverberant room method in accordance with the latest version of ARI 260 standard in an AMCA certified laboratory. An alternate procedure approved by and details agreed to by the project acoustical consultant is also acceptable when based according and traceable to national or international standards. When submitting an alternate procedure, the alternate procedure shall be submitted with the first air handler submittal to allow for extra time in review by the project acoustical consultant. In addition, the manufacturer who is proposing the alternate procedure shall simultaneously submit a letter that agrees to pay for the project acoustical consultant's time and material fee up to a maximum of two manweeks of time to cover that amount of time related to the evaluation of the alternate procedure. Evaluation of the alternate procedure is no guarantee that it will be accepted. The decision resides solely with the project acoustical engineer as to whether the alternate procedure will be allowed. If the alternate procedure is rejected, then the AMCA certified laboratory testing specified above must be done.

C. All performance tests (including retests) shall be witnessed by the project mechanical engineer, the project's acoustic consultant, and Owner's Representative. The costs incurred for these individuals (including the time and expenses for both parties) to witness the tests shall be borne by the equipment manufacturer. The scheduling of the test shall be coordinated with all parties attending a minimum 15 days in advance.

D. During the test, the data shall be taken from completed 'ready to ship' units; all sensors, gauges, dampers, etc shall be in place. This shall be verified in writing prior to travel to test site.

E. Data shall be taken at the unit's full flow CFM and static pressure to verify the unit's sound power levels.

F. Each fan or AHU tested shall have its operating characteristics (CFM, SP, RPM, HP) evaluated in general accordance with AMCA 210 "Laboratory Methods of Testing Fans for Rating."

G. Test results shall be submitted for approval prior to shipment of any equipment. If the result of the sound test indicates the AHU noise levels exceed project specified levels, the contractor shall take corrective measures to reduce the sound levels. No tolerances are permitted when evaluating measured sound levels – measured sound levels must be below the Maximum Allowable sound levels within the Construction Documents. The manufacturer and contractor shall be responsible for recommending corrective action and submitting a proposal for modification along with supporting acoustical calculations to demonstrate that the modification will be successful at bringing the sound levels below the requirements in the Construction Documents. Project acoustical consultant will review the calaculations and proposals – time for this review of corrective work will be backcharged to the manufacturer on a time and materials basis. A retest shall be conducted to verify that the modified unit meets project requirements. All costs associated with the witnessing of the retesting shall be borne by the manufacturer. Any modifications made to correct the test unit shall also be applied to all AHUs represented by the test unit, as noted above.

3.05 MANUFACTURER'S FIELD SERVICES

A. Section 01 40 00 - Quality Requirements: Requirements for manufacturer’s field services.

B. Field Quality Control
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
   2. Tests and Inspections:
      a. Leak Test: After installation, test coils and connections for leaks.
      b. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
      c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
   4. Prepare test and inspection reports.

C. Start-Up Services
   1. Start-up is to be supervised by the unit manufacturer or a manufacturer certified service organization.
   2. Physical connections and start-up are provided by the installing contractor. Provide for as long a period of time as is necessary to ensure proper operation of the unit but in no case for less than 2 full working days.
   3. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made.
   4. Engage a factory-authorized service representative to perform startup service.
      a. Complete installation and startup checks according to manufacturer's written instructions.
      b. Verify that shipping, blocking, and bracing are removed.
      c. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
      d. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
      e. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
      f. Verify that zone dampers fully open and close for each zone.
      g. Verify that face-and-bypass dampers provide full face flow.
      h. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
      i. Comb coil fins for parallel orientation.
      j. Verify that proper thermal-overload protection is installed for electric coils.

k. Install new, clean filters.
l. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
m. Verify that the humidifiers have been installed correctly and absorption/non-wetting distance is as specified.

5. Starting procedures for air-handling units include the following:
   a. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
   b. Measure and record motor electrical values for voltage and amperage.
   c. Manually operate dampers from fully closed to fully open position and record fan performance.
6. The start-up engineer shall submit a written report to the Owner's Representative and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.
7. Refer to "Owner's Commissioning Requirements" for additional requirements.

3.06 AIR LEAKAGE TEST:

A. Each unit shall be leakage tested on site after wiring installation in complete.

B. Leakage test shall be performed on installed units after controls wiring and conduit has been installed. Factory tests alone shall not be acceptable.

C. An Air Handling Unit shall be considered acceptable if it leaks at a rate of not more than one percent of the unit's design volume at the test pressure.

D. Apparatus:
   1. A U-Tube manometer shall be used to measure the static pressure exerted on the unit cabinet. The manometer must have graduations no larger than 0.2" (inches of water gauge).
   2. A pressure blower that is capable of producing the required pressure without operating at a stall shall be used to perform the test. The pressurizing fan shall be attached to a flow metering station that shall measure the volume flow rate by pressure drop through one or more ASME long radius nozzles. The test apparatus shall have a means of dampering such that the required pressure may be exerted without over-pressurizing the cabinet.

E. Procedure:
   1. The fan unit shall have all duct, damper, and louver openings sealed with plywood or sheet metal and caulked or taped.
   2. The static pressure tap shall be arranged with one leg open to atmosphere and one leg tapped to the cabinet interior.
   3. A static pressure load of 1.25 times the maximum calculated internal unit static pressure or 12" whichever is less shall be exerted on the cabinet.
   4. The leakage rate shall be recorded at the flow measuring apparatus. The air density at which the test was performed shall be determined. The test results will be corrected to standard air.

5. Air density shall be determined with wet and dry bulb thermometers and a mercury barometer or equivalent.

3.07 CLEANING

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for cleaning.

B. Vacuum clean coils and inside of unit cabinet.

C. Install temporary filters on all ducted openings during construction period to protect internal surfaces while the unit sits in place, non-operational, but with completed ductwork connections. Provide new filters prior to TAB work. Replace with permanent filters at Substantial Completion, unless the Owner’s Representative has inspected the TAB filter status and wishes to accept the second set of filters as stock.

3.08 DEMONSTRATION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for demonstration and training.

B. Demonstrate unit operation and maintenance.

C. Furnish services of manufacturer's technical representative for one 8 hour day to instruct Owner's personnel in operation and maintenance of units. Schedule training with Owner, provide at least 7 days notice to Owner’s Representative of training date.

3.09 PROTECTION OF FINISHED WORK

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protecting finished Work.

B. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

END OF SECTION 23 73 13

SECTION 23 81 46

WATER-SOURCE UNITARY HEAT PUMPS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Heat Pump
   2. Concealed horizontal or vertical units, 6 tons (21 kW) and smaller.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Product Data: Include rated capacities, furnished specialties, and accessories for each model.

C. LEED Submittals:
   1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
   2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

D. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Wiring Diagrams: Power, signal, and control wiring.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of unit indicated.

1.03 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water-source heat pumps and are based on the specific system indicated. Refer to Section 016000 "Product Requirements."

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

B. 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.

C. ASHRAE Compliance:
   1. ASHRAE 15.
   2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Comply with NFPA 70.

F. Comply with safety requirements in UL 484 for assembly of free-delivery water-source heat pumps.

G. Comply with safety requirements in UL 1995 for duct-system connections.

1.04 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, refrigeration components.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 – PRODCUTS

2.01 HEAT PUMP

A. Manufacturer: Miami Heat Pump

B. Model Number: HPHWW041SS

C. Cooling Performance
   1. Leaving Load Water : 46°F
      a. Entering Source Water 75°F
      b. Total Capacity 32.10 MBTuH
      c. EER 15.40
   2. Leaving Load Water: 50°F

a. Entering Source Water 90°F
b. Total Capacity 31.60 MBTuH
c. EER 12.60

D. Weight: 210 lbs

2.02 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.03 CONCEALED WATER-SOURCE HEAT PUMPS, 6 TONS (21 kW) AND SMALLER

A. Manufacturers:
1. Addison Products Company.
2. Bard Manufacturing Company.
3. Carrier Corporation.
4. FHP Manufacturing Inc.
5. Mammoth Inc.
6. McQuay International.
7. Trane.

B. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ARI-ISO-13256-1.

C. Cabinet and Chassis: Stainless-steel casing with the following features:
1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Flanged duct connections.
4. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch (13 mm) thick, complying with UL 181.
5. Condensate Drainage: Plastic or stainless-steel drain pan with condensate drain piping projecting through unit cabinet.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Water Circuit:
1. Water-to-Water Heat Exchangers:
a. Coaxial heat exchangers with cupronickel water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.

b. Stainless-steel, brazed-plate heat exchanger leak tested to 450 psig (3102 kPa) for refrigerant side and 400 psig (2758 kPa) for water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.

E. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig (3102 kPa).

F. Refrigerant Circuit Components:
1. Sealed Refrigerant Circuit: Charge with R-22, R-407C, R-410A refrigerant.
2. Sealed Refrigerant Circuit: Charge with R-407C or R-410A refrigerant.
3. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
4. Charging Connections: Service fittings on suction and liquid for charging and testing.
5. Compressor: Hermetic [rotary] [reciprocating] [scroll] compressor installed on vibration isolators and housed in an acoustically treated enclosure with factory-installed safeties as follows:
   a. High-pressure cutout.
   b. Low-pressure cutout or loss of charge switch.
   c. Internal thermal-overload protection.
   d. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.

6. Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch- (10-mm-) thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-development indexes according to ASTM E 84.
8. Refrigerant Metering Device: Thermal expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F (minus 4 to plus 52 deg C).
9. Hot-Gas Reheat Valve: Pilot-operated sliding-type valve with replaceable magnetic coil.

G. Control equipment and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls."

H. Controls:
1. Basic Unit Controls:
   a. Low- and high-voltage protection.
   b. Overcurrent protection for compressor and fan motor.
   c. Random time delay, three to ten seconds, start on power up.
   d. Time delay override for servicing.
   e. Control voltage transformer.
2. Thermostat:
   a. Wall-Mounted Thermostat:
      1. Heat-cool-off switch.
      2. Fan on-auto switch.
      3. Automatic changeover.
      4. Exposed temperature set point.
      5. Exposed temperature indication.

6. Deg F indication.

b. Wall-Mounted Humidistat: Exposed.
   1. Temperature set point.
   2. Temperature indication.
c. Wall-mounted temperature sensor.
d. Unoccupied period override push button.
e. LED to indicate fault condition at heat pump.
f. Data entry and access port.
   1. Input data include room temperature and humidity set points for occupied and unoccupied periods.
   2. Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:
   a. Scheduled operation for occupied and unoccupied periods on 7-day clock with minimum 4 programmable periods per day.
   b. [Two] <Insert number>-hour unoccupied period override period.
   c. Remote control panel to contain programmable timer and LED for fault condition.
   d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
   e. Return-air temperature high-limit (firestat). Stop unit on high temperature.
   f. Differential pressure switch to indicate fan status. Fan failure alarm.
   g. Differential pressure switch to indicate filter status. Dirty filter alarm.

4. BAS interface requirements as further described in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls."
   a. Interface relay for scheduled operation.
   b. Provide BAC-net interface for central BAS workstation for the following functions:
      1. Set-point adjustment for set points identified in this Section.
      2. Start/stop and operating status of heat-pump unit.
      3. Data inquiry to include supply air, room air temperature and humidity, and entering-water temperature.
      4. Occupied and unoccupied schedules.

I. Electrical Connection: Single electrical connection[with fused disconnect].

2.04 PUMP MODULE

A. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.

B. Three-way brass shut-off/flushing/purging valve.

C. Include controls to operate pump as required to maintain room temperature and ventilation set points.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of water-source heat pumps.

B. Examine roughing-in for piping and electric installations for water-source heat pumps to verify actual locations of piping connections and electrical conduit before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Connect supply and return hydronic piping to heat pump with hose kits.
   2. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

C. Install piping adjacent to machine to allow service and maintenance.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect[, test, and adjust] field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:
1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Verify that filters are installed.
8. Adjust vibration isolators.
9. Start unit according to manufacturer's written instructions.
10. Complete startup sheets and attach copy with Contractor's startup report.
11. Inspect and record performance of interlocks and protective devices; verify sequences.
12. Operate unit for an initial period as recommended or required by manufacturer.
13. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.

3.05 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.06 CLEANING

A. Replace filters used during construction prior to air balance or substantial completion.

B. After completing installation of exposed, factory-finished water-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water-source heat pumps. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 23 81 46

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25 00 00
INTEGRATED AUTOMATION

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SECTION 25 10 00

INTEGRATED AUTOMATION NETWORK EQUIPMENT

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Wireless Dimmers and Switches
2. Wireless Keypads
3. Wireless Thermostat
4. 7” In-Wall Touch Screen with Camera
5. 7” Portable Touch Screen with Camera
6. Door Station – Exterior
7. WallStation

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics.

1.04 WARRANTY

A. Manufacture’s Product Warranty: Schnider
1. Hardware Warranty: Control4 Corporation (“Control4”) warrants Hardware against defects in materials and workmanship under normal use for a period of two (2) years from the date that the applicable Hardware was shipped by Control4 (“Hardware Warranty Period”). If a hardware defect arises in the Hardware and You submit a valid claim to Control4 within the Hardware Warranty Period, Control4 will, at its option and to the extent permitted by law, either (1) repair the hardware defect at no charge using new or refurbished replacement parts, (2) exchange the Hardware with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the Hardware, or (3) refund the Hardware purchase price paid by You. A replacement product or part that has been installed by Control4 assumes the remaining warranty of the original Hardware or ninety (90) days from the date of replacement or repair, whichever provides longer coverage to You. When a product or part is exchanged, any replacement item becomes your property and the replaced item

becomes Control4's property. When a refund is given, the product for which the refund is provided must be returned to Control4 and it becomes Control4's property.

PART 2 – PRODCUTS

2.01 Outside Air Sensor

A. Viconics Technologies
   1. Model Number: S2020E1000

2.02 Discharge Air Sensor

A. Viconics Technologies
   1. Model Number: S200D1000

2.03 Return Air Sensor

A. Viconics Technologies
   1. Model Number: S200D1000

2.04 Outside Air Humidity Sensor

A. VERIS
   1. Model Number: HD3XMSTH

2.05 Daylight Sensor

A. Leviton
   1. Model Number: WSCPC-00W

2.06 Occupancy Sensor

A. Leviton
   1. Model Number: WSC04-10W

2.08 Light Switches

A. Illumra
   1. Model Number: E3T-S1AWH

2.09 Dimming Module

A. Leviton
   1. Model Number: WSD01-001

2.10 Power Pack

A. Leviton
   1. Model Number: OSP20-RD0

2.11 Line Voltage Dimming

A. Carlo Gavazzi
   1. Model Number: RM1E23V25

2.12 Branch Circuit Monitoring

B. VERIS
   1. Model Number: H923

2.13 Space Humidity, CO2 and Temperature Sensors

B. Thermokon
   1. Model Number: SR04 CO2_315-rH

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with Manufactures installation instructions.

B. Make sure all camera lenses have been cleaned after installation.

C. Make sure all wall mounts are flush.

END OF SECTION 25 10 00

SECTION 25 11 00

HOME AUTOMATION AND CONTROL SYSTEMS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
  1. HC-250 Controller
  2. HC-800 Controller

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. List of Attachments

1.04 WARRANTY

A. Manufacture’s Product Warranty: Control 4
  1. Hardware Warranty: Control4 Corporation (“Control4”) warrants Hardware against defects in materials and workmanship under normal use for a period of two (2) years from the date that the applicable Hardware was shipped by Control4 (“Hardware Warranty Period”). If a hardware defect arises in the Hardware and You submit a valid claim to Control4 within the Hardware Warranty Period, Control4 will, at its option and to the extent permitted by law, either (1) repair the hardware defect at no charge using new or refurbished replacement parts, (2) exchange the Hardware with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the Hardware, or (3) refund the Hardware purchase price paid by You. A replacement product or part that has been installed by Control4 assumes the remaining warranty of the original Hardware or ninety (90) days from the date of replacement or repair, whichever provides longer coverage to You. When a product or part is exchanged, any replacement item becomes your property and the replaced item becomes Control4’s property. When a refund is given, the product for which the refund is provided must be returned to Control4 and it becomes Control4’s property.

PART 2 – PRODCUTS

2.01 HC-250 Controller

A. Control4 HC-250 Controller
1. Model: C4-HC250-BL
2. Power Over Ethernet/Power Consumption: 802.3af / 12.95W
3. Rack Mount: IRU
4. Shelf (with A/V gear): Y
5. Wall/TV Mount: Y
6. Dimensions (H x W x D): 1.23” x 8.59” x 4.92”
7. Weight: 1.8 lbs
8. Power Supply: Internal
9. Power Supply: 100 – 240V, 50-60Hz
10. Website: http://www.control4.com/files/products/data-sheets/Control4-HC-250-DS.PDF

2.02 HC-800 Controller

A. Control4 HC-800 Controller
1. Model: C4-HC800-BL
2. Rack Ear Kit: IRU with optional ears
3. Shelf (with A/V gear): Y
4. Wall/TV Mount: N
5. Dimensions (H x W x D): 11.98” x 17.32” x 9.15”
6. Weight: 6.1 lbs
7. Power Supply (external): Input-100-240VAC, 50-60Hz; Output-19V, 3.43A (65 watts)
8. Website: http://www.control4.com/files/products/data-sheets/Control4-HC-800-DS.PDF

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with Manufactures installation instructions.

B. Ensure installed into rack mount correctly and completely.

END OF SECTION 25 11 00

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26 00 00
ELECTRICAL

26 00 00 - DIVISION CONTENTS

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting raceways, cables, wireways, and cable trays will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 – PRODCUTS

2.01 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

2.02 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.
2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.03 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 – EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 6 inches (150 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.03 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve.

Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.04 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 26 05 00

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Field quality-control test reports.

1.03 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

1.04 COORDINATION

A. Set sleeves in structural components as they are constructed.

PART 2 – PRODCUTS

2.01 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.

B. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.

C. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.

2.02 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.03 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.04 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Plastic. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 – EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

C. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway; Metal-clad cable, Type MC.

E. Class 1 Control Circuits: Type THHN-THWN, in raceway.

F. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.04 CONNECTIONS

A. 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.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.05 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Fire Rated Assemblies: Install sleeves for penetrations of rated-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

C. Cut sleeves to length for mounting flush with both wall surfaces.

D. Extend sleeves installed in floors 6 inches (150 mm) above finished floor level.

E. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed.

F. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

G. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

H. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

3.06 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
1. After installing conductors and cables and before electrical circuitry has been energized, test feeders for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.02 SUBMITTALS

A. Product Data: For steel slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
   3. Equipment supports.

C. Welding certificates.

1.03 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.04 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

PART 2 – PRODCUTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.; a division of Cooper Industries.
    c. Thomas & Betts Corporation.
    d. Unistrut; Tyco International, Ltd.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Hilti Inc.
    b. ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
    c. MKT Fastening, LLC.
    d. Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1. Cooper B-Line, Inc.; a division of Cooper Industries.
        2. Empire Tool and Manufacturing Co., Inc.

3. Hilti Inc.
4. ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5. MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 – EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

PART 2 – PRODCUTS

2.01 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. EMT: ANSI C80.3.

C. LFMC: Flexible steel conduit with PVC jacket.

D. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
   1. Fittings for EMT: Set-screw type.

2.02 METAL WIREWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 [3R], unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Finish: Manufacturer's standard enamel finish.

2.03 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

B. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

C. Metal Floor Boxes: Cast metal, rectangular.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

2.04 METAL WIREWAYS

A. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

C. Wireway Covers: Hinged type.

D. Finish: Manufacturer's standard enamel finish.

PART 3 – EXECUTION

3.01 RACEWAY APPLICATION

A. Comply with the following indoor applications, unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: Rigid steel conduit.
   2. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   4. Damp or Wet Locations: Rigid steel conduit.
   5. Raceways for Optical Fiber or Communications Cable: EMT.
   6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

B. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.02 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

I. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.

J. Raceways for Optical Fiber and Communications Cable: Install as follows:

1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

K. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where otherwise required by NFPA 70.

L. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC in damp or wet locations not subject to severe physical damage.

M. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

N. Set metal floor boxes level and flush with finished floor surface.

3.03 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 26 05 33

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Identification for conductors and communication and control cable.
2. Warning labels and signs.
3. Equipment identification labels.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

1.04 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

PART 2 – PRODCUTS

2.01 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Marker Tape: Vinyl or vinyl -cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.02 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Fasteners for Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

F. Warning label and sign shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 mm)."

2.03 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

PART 3 – EXECUTION

3.01 APPLICATION

A. Auxiliary Electrical Systems Conductor and Cable Identification: Use marker tape to identify field-installed alarm, control, signal, sound, intercommunications, voice, and data wiring connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and cable pull points. Identify by system and circuit designation.
2. Use system of designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

B. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.
2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

C. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:
   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.
   b. Elevated Components: Increase sizes of labels and legend to those appropriate for viewing from the floor.
2. Equipment to Be Labeled:
   a. Identification labeling of some items listed below may be required by individual Sections or by NFPA 70.
   b. Panelboards, electrical cabinets, and enclosures.
   c. Access doors and panels for concealed electrical items.
   d. Emergency system boxes and enclosures.
   e. Transformers.
   f. Motor starters.
   g. Push-button stations.
   h. Battery inverter units.
   i. Fire Alarm system equipment
   j. Uninterruptible power supply equipment.
   k. Disconnect switches.
   l. Enclosed circuit breakers.

3.02 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded feeder, and branch-circuit conductors.
1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
    a. Phase A: Black.
    b. Phase B: Red.
    c. Phase C: Blue.
3. Colors for 480/277-V Circuits:
    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.

END OF SECTION 26 05 53

SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Indoor occupancy sensors.
2. Lighting contactors.
3. Emergency shunt relay

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

B. Field quality-control test reports.

C. Operation and maintenance data.

1.03 QUALITY ASSURANCE

A. 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.

PART 2 – PRODCUTS

2.01 INDOOR OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Novitas, Inc.
2. TORK.
3. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
   c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.

2.02 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allen-Bradley/Rockwell Automation.
2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
3. Square D; Schneider Electric.
4. TORK.
5. Watt Stopper (The).

B. Description: Electrically operated and mechanically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.

2.03 EMERGENCY SHUNT RELAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Lighting Control and Design, Inc.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
   1. Coil Rating: 277 V.

2.04 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 – EXECUTION

3.01 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.02 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.03 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.04 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label contactors with a unique designation.

3.05 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
   2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 26 09 23

SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 100 kVA:
   1. Distribution transformers

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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.

D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. Siemens Energy & Automation, Inc.
3. Square D; Schneider Electric.

2.02 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Usually retain aluminum option in subparagraph below. See Evaluations for discussion of copper vs. aluminum winding material.
   3. Coil Material: Copper.

2.03 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Delete first paragraph below if seismic bracing is not required. Coordinate with Parts 1 and 3.

C. Cores: One leg per phase.

D. If all transformers have same enclosure, retain one of two paragraphs and associated subparagraphs below. Retain first paragraph for indoor transformers; second, for outdoor transformers. If several types of enclosures are required for Project, delete paragraphs and indicate enclosure type on Drawings.

E. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

F. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: Gray.

G. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
   1. Complying with NEMA TP 1, Class 1 efficiency levels.
   2. Tested according to NEMA TP 2.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.
   3. Shield Effectiveness:
      a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
      b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
      c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

M. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.04 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.05 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions and seismic codes applicable to Project.

3.03 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 00

SECTION 26 24 16

PANELBOARDS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

D. 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.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
   a. Eaton Corporation; Cutler-Hammer Products.
   b. Siemens Energy & Automation, Inc.
   c. Square D.

2.02 MANUFACTURED UNITS

A. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1.
1. Rated for environmental conditions at installed location.
2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
3. Retain subparagraph above or below.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
5. First three subparagraphs below are optional features. Coordinate with Drawings.
6. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
7. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.

B. Phase and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
2. Subparagraphs below are optional features. Coordinate with Drawings.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
4. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.
5. Split Bus: Vertical buses divided into individual vertical sections.

C. Conductor Connectors: Suitable for use with conductor material.
1. Main and Neutral Lugs: Mechanical type.
2. Ground Lugs and Bus Configured Terminators: Compression type.
3. First two subparagraphs below are optional features. Coordinate with Drawings.
4. Feed-Through Lugs: Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

D. Retain paragraph below for panelboards incorporating one or more main service disconnect switches.

E. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.

F. Retain paragraph below if future provisions are required.

G. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

2.03 PANELBOARD SHORT-CIRCUIT RATING

A. UL label indicating series-connected rating with integral or remote upstream overcurrent protective devices. Include size and type of upstream device allowable, branch devices allowable, and UL series-connected short-circuit rating.

B. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.04 DISTRIBUTION PANELBOARDS

A. Coordinate this Article with Drawings.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike. Omit for fused-switch panelboards.

C. Main Overcurrent Protective Devices: Circuit breaker.

D. Branch Overcurrent Protective Devices:
1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.05 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Coordinate paragraph below with Drawings.

C. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.07 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip-unit circuit breakers shall have RMS sensing; field-replaceable rating plug; and with the following field-adjustable settings:
    a. Instantaneous trip.

b. Long- and short-time pickup levels.
c. Long- and short-time time adjustments.
d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and two-pole configurations with 30-mA trip sensitivity.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
9. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.

2.08 ACCESSORY COMPONENTS AND FEATURES

A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Furnish portable test set to test functions of solid-state trip devices without removal from panelboard.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mount top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated.

C. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

D. Install overcurrent protective devices and controllers.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

E. Install filler plates in unused spaces.

3.02 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.03 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 24 16

SECTION 26 27 26

WIRING DEVICES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Snap switches and wall-box dimmers.
4. Wall-switch and exterior occupancy sensors.
5. Floor service outlets.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.02 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper; 5351 (single), 5352 (duplex).
      b. Hubbell; HBL5351 (single), CR5352 (duplex).
      c. Leviton; 5891 (single), 5352 (duplex).
      d. Pass & Seymour; 5381 (single), 5352 (duplex).

2.03 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. Catalog numbers in subparagraphs below are for feed-through types, arranged to protect receptacles downstream on the same circuit; revise catalog numbers if non-feed-through types are required.
      b. Cooper; GF20.
      c. Pass & Seymour; 2084.

2.04 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper; L520R.
      b. Hubbell; HBL2310.
      c. Leviton; 2310.
      d. Pass & Seymour; L520-R.

2.05 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Catalog numbers in subparagraphs below are for 20-A devices; revise catalog numbers if 15-A devices are desired.
      b. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).

c. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
d. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
e. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

2.06 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Four-way switching may be added to first paragraph below after verifying availability with manufacturers.

C. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

D. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
   1. 600 W; dimmers shall require no derating when ganged with other devices.

E. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.07 OCCUPANCY SENSORS

A. Wall-Switch Sensors:
   1. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. Retain one of first two subparagraphs and list of manufacturers below. See Division 01 Section "Product Requirements."
   2. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   3. Products: Subject to compliance with requirements, provide one of the following:
      a. Leviton; ODS 10-ID.
      b. Pass & Seymour; WS3000.
      c. Watt Stopper (The); WS-200.
   4. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

B. Long-Range Wall-Switch Sensors:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Hubbell; ATD1600WRP.
      b. Leviton; ODW12-MRW.
      c. Watt Stopper (The); DT-200.

2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft. (111 sq. m).

C. Wide-Range Wall-Switch Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Leviton; ODWHB-IRW.
   b. Pass & Seymour; HS1001.
   c. Watt Stopper (The); CX-100-3.
2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).

2.08 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."

2.09 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Coordinate with Architect prior to installation.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Blank cover with bushed cable opening.

2.10 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.
1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:
1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.02 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."
1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

END OF SECTION 26 27 26

SECTION 26 28 13

FUSES

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Cartridge fuses rated 600 V and less for use in switches.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. 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.

B. Comply with NEMA FU 1.

C. Comply with NFPA 70.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Bussman, Inc.
   2. Ferraz Shawmut, Inc.
   3. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 – EXECUTION

3.01 FUSE APPLICATIONS

A. Motor Branch Circuits: Class RK1, time delay.

B. Other Branch Circuits: Class RK1, time delay.

3.02 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.03 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 26 28 13

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following individually mounted, enclosed switches and circuit breakers:
1. Fusible switches.
2. Enclosures.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.
2. Siemens Energy & Automation, Inc.
3. Square D/Group Schneider.

B. Fusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.03 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
1. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

C. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

D. Mount individual wall-mounting switches with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

3.02 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:
   1. Inspect mechanical and electrical connections.
   2. Verify switch and relay type and labeling verification.
   3. Verify rating of installed fuses.

B. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

END OF SECTION 26 28 16

SECTION 26 29 13

ENCLOSED CONTROLERS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes ac general-puepose contollers rated 600 V and less that are supplied as enclosed units.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent testing agency with the experience and capability to satisfactorily conduct the testing indicated, as documented according to ASTM E 548.

C. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.

D. 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.

E. Comply with NFPA 70.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, including clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Manual and Magnetic Enclosed Controllers:
   a. Eaton Corp.; Cutler-Hammer Products.
   b. Siemens/Furnas Controls.
   c. Square D Co.
2. Variable-Frequency Controllers:
   a. Eaton Corp.; Cutler-Hammer Products.
   b. Siemens/Furnas Controls.
   c. Square D Co.

2.02 MANUAL ENCLOSED CONTROLLERS

A. Description: NEMA ICS 2, general purpose, Class A, with toggle action and overload element.

2.03 MAGNETIC ENCLOSED CONTROLLERS

A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

B. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

D. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 10 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

E. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
1. Compelling relay to ensure motor will start only at low speed.
2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
3. Decelerating relay to ensure automatically timed deceleration through each speed.

2.04 VARIABLE-FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, pulse-width-modulated, variable-frequency controller; listed and labeled as a complete unit and arranged to provide variable speed of a NEMA MG 1, Design B, 3-phase, induction motor by adjusting output voltage and frequency.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Isolation Transformer: Match transformer voltage ratings and capacity to system and motor voltages; and controller, motor, drive, and load characteristics.

D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

E. Starting Torque: 100 percent of rated torque or as indicated.

F. Speed Regulation: Plus or minus 1 percent.

G. Ambient Temperature: 0 to 40 deg C.

H. Efficiency: 95 percent minimum at full load and 60 Hz.

I. Minimum Displacement Power Factor at Input Terminals: 95 percent.

J. Isolated control interface allows controller to follow control signal over an 11:1 speed range.
   1. Electrical Signal: 4 to 20 mA at 24 V.

K. Internal Adjustability: Include the following internal adjustment capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 2 to 22 seconds.
   4. Deceleration: 2 to 22 seconds.
   5. Current Limit: 50 to 110 percent of maximum rating.

L. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

M. Self-protection and reliability features shall include the following:
   1. Delete items below if not required.
   2. Input transient protection by means of surge suppressors.
   3. Snubber networks to protect against malfunction due to system voltage transients.
   4. Motor Overload Relay: Adjustable and capable of NEMA 250, Class 10 performance.
   5. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
   6. Instantaneous overcurrent trip.
   7. Loss-of-phase protection.
   8. Reverse-phase protection.
   9. Under- and overvoltage trips.

10. Overtemperature trip.
11. Short-circuit protection.

N. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.

O. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

P. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

Q. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate controller output current, voltage, and frequency.

R. Manual Bypass: Magnetic contactor shall be arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass, selector-switch indicator lights set and indicate mode selection.

S. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.

T. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

U. Isolating Switch: Non-load-break switch arranged to isolate variable-frequency controller and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

V. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.05 ENCLOSURES

A. Description: Flush- or surface-mounted cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
1. Delete items below if not applicable. Add other Project-specific requirements.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2.06 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Elapsed Time Meters: Heavy duty with digital readout in hours.

F. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
   1. Ammeter: Output current, with current sensors rated to suit application.
   2. Voltmeter: Output voltage.
   3. Frequency Meter: Output frequency.

G. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
   2. Switch-selectable digital display of the following:
      a. Phase Currents, Each Phase: Plus or minus 1 percent.
      b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      d. Three-Phase Real Power: Plus or minus 2 percent.
      e. Three-Phase Reactive Power: Plus or minus 2 percent.
      f. Power Factor: Plus or minus 2 percent.
      g. Frequency: Plus or minus 0.5 percent.
      h. Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
      i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
   3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

H. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

I. Use below with three external current transformers.

J. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.07 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

3.03 INSTALLATION

A. See Division 26 Section "Common Work Results For Electrical" for general installation requirements.

B. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Common Work Results For Electrical."

C. Install freestanding equipment on concrete bases complying with Division 3 Section "Cast-in-Place Concrete."

D. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.04 IDENTIFICATION

A. Identify enclosed controller components and control wiring according to Division 26 Section "Electrical Identification."

3.05 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.06 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment.

C. 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.

3.07 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
1. Test insulation resistance for each enclosed controller bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing: Perform the following field quality-control testing:
1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16.
2. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting solid-state controllers.

D. Test Reports: Prepare a written report to record the following:
1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.08 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.09 CLEANING

A. Clean enclosed controllers internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that enclosed controllers are installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 16 Sections.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers and variable-frequency drives.
1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 26 29 13

SECTION 26 51 00

INTERIOR LIGHTING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
  1. Interior lighting fixtures, lamps, and ballasts.
  2. Exit signs.
  3. Lighting fixture supports.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

PART 2 – PRODCUTS

2.01 MANUFACTURERS

A. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

E. Metal Parts: Free of burrs and sharp corners and edges.

F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallized Film: 90 percent.

I. Plastic Diffusers, Covers, and Globes:
1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
    a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is indicated.
    b. UV stabilized.
2. Glass: Annealed crystal glass, unless otherwise indicated.

J. Air-Handling Fluorescent Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 23 Section "Diffusers, Registers, and Grilles."
1. Air Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.
2. Heat Removal Units: Air path leads through lamp cavity.
3. Combination Heat Removal and Air Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air supply units.
4. Dampers: Operable from outside fixture for control of return-air volume.
5. Static Fixture: Air supply slots are blanked off, and fixture appearance matches active units.

2.03 BALLASTS

A. Electronic Ballasts for Linear Fluorescent Lamps: Comply with ANSI C82.11; programmed-start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.
1. Sound Rating: A, except B for T12/HO and T12/Slimline lamp ballasts.
2. Total Harmonic Distortion Rating: Less than 10 percent.
3. Transient Voltage Protection: IEEE C62.41, Category A or better.
4. Operating Frequency: 20 kHz or higher.
5. Lamp Current Crest Factor: 1.7 or less.
6. BF: 0.85 or higher.
7. Power Factor: 0.95 or higher.

B. Electromagnetic Ballasts for Linear Fluorescent Lamps: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
1. Ballast Manufacturer Certification: Indicated by label.

C. Ballasts for Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher for Linear Fluorescent Lamps: Electromagnetic type designed for use with indicated lamp types.

D. Ballasts for Dimmer-Controlled Lighting Fixtures with Linear Fluorescent Lamps: Electronic type.
1. Dimming Range: 100 to 5 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

E. Ballasts for Bi-Level Controlled Lighting Fixtures with Linear Fluorescent Lamps: Electronic type.
1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
   a. High-Level Operation: 100 percent of rated lamp lumens.
   b. Low-Level Operation: 30 percent of rated lamp lumens.
2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

F. Ballasts for Compact Fluorescent Lamps: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
1. Lamp end-of-life detection and shutdown circuit.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher, unless otherwise indicated.
9. Power Factor: 0.95 or higher.

10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
11. Ballast Case Temperature: 75 deg C, maximum.

G. Ballasts for Dimmer-Controlled Lighting Fixtures with Compact Fluorescent Lamps: Electronic type.
   1. Dimming Range: 100 to 5 percent of rated lamp lumens.
   2. Ballast Input Watts: Can be reduced to 20 percent of normal.
   3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

H. Internal-Type Emergency Fluorescent Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
   1. Emergency Connection: Operate 1 fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
   2. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
      a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
      b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
   3. Battery: Sealed, maintenance-free, nickel-cadmium type.
   4. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

I. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features, unless otherwise indicated:
   1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
   2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
   3. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
   4. Open-circuit operation that will not reduce average life.
   5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.

J. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
   1. Lamp end-of-life detection and shutdown circuit.
   2. Sound Rating: A.
   3. Total Harmonic Distortion Rating: Less than 15 percent.
   4. Transient Voltage Protection: IEEE C62.41, Category A or better.
   5. Lamp Current Crest Factor: 1.5 or less.
   6. Power Factor: .90 or higher.
   7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
   8. Protection: Class P thermal cutout.

2.04 EXIT SIGNS

A. Internally Lighted Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
   1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.

2.05 LAMPS

A. Low-Mercury Fluorescent Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

B. T8 Rapid-Start low-mercury Fluorescent Lamps: Rated 32 W maximum, nominal length 48 inches (1220 mm), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours, unless otherwise indicated.

C. T8 Rapid-Start low-mercury Fluorescent Lamps: Rated 17 W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

D. Compact Fluorescent Lamps: 4-Pin, low mercury, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.
   1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
   2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
   3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
   4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
   5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
   6. 55 W: T4, triple tube, rated 4300 initial lumens (minimum).

E. Metal-Halide Lamps: ANSI C78.1372, with a minimum CRI 65, and color temperature 4000 K unless otherwise indicated.

F. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.

G. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000 K.

2.06 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

E. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Comply with NFPA 70 for minimum fixture supports.

C. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

E. Adjust aimable lighting fixtures to provide required light intensities.

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.02 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 26 51 00

SECTION 26 56 00

EXTERIOR LIGHTING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Exterior Light Fixtures

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

PART 2 – PRODCUTS

2.01 HESS AMERICA

A. RESIDENZA RS 200
   1. LED light
   2. Stainless steel casing

2.02 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Coordinate this Article with Drawings. See Editing Instruction No. 2 in the Evaluations for discussion of seismic considerations.

B. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Comply with NFPA 70 for minimum fixture supports.

C. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.02 FIELD QUALITY CONTROL

A. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 26 56 00

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28 00 00
ELECTRICAL SAFETY AND SECURITY

28 00 00 - DIVISION CONTENTS

SECTION 28 31 11

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Nonsystem smoke detectors

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 QUALITY ASSURANCE

A. Tests and Inspections:
   1. Visual Inspections: Conduct visual inspection prior to testing.
      a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its “Completion Documents, Preparation” Table in the “Documentation Section of the “Fundamentals of Fire Alarm Systems” Chapter
      b. Comply with “Visual Inspection Frequencies” Table in the “Inspection” Section of the “Inspection, Testing and Maintenance” Chapter in NFPA 72; retain the “Initial/Reacceptance” column and list only the installed components.

   2. System Testing: Comply with “Test Methods” Table in the “Testing” Section of the “Inspection, Testing and Maintenance” Chapter in NFPA 72.

PART 2 – PRODCUTS

2.01 NONSYSTEM SMOKE DETECTORS

A. Single-Station Smoke Detectors: Comply with UL 217 and UL 464; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with “low” or “missing” battery chirping-sound device.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.
   1. Comply with requirements for seismic-restraint devices specified in Section 280500 “Common Work Results for Electronic Safety and Security”

END OF SECTION 28 31 11

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32 00 00
EXTERIOR IMPROVEMENTS

32 00 00 - DIVISION CONTENTS

SECTION 32 80 00

IRRIGATION

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:

1. Water Storage Tanks

B. Irrigation will be supplied by the water allocated by the DOE at the beginning of the competition. Additional water will be available from the grey water recycled from the house. A small amount may also be available from the rain-water collection system harvesting run off from the house during a rain event.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics

1.04 WARRANTY

A. Fol-Da-Tank has a lifetime warranty.

PART 2 – PRODUCTS

2.01 GREY WATER PILLOW

A. Manufacturer: Fol-Da-Tank
B. Size: 525 gal. pillow tank.
C. Materials: Potable water fabric NSF/ANSI 61 standard, 4” FNPT PVC opening. Part # PW-525
D. http://www.fol-da-tank.com

2.02 CISTERN (Rain water collection)

A. Manufactured in-house by GWU students
B. Size : 500 gals
C. Material: Galvanized steel

END OF SECTION 32 80 00

SECTION 32 84 00

PLANTING IRRIGATION

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Wheeled Irrigation

B. All plants on the property will be hand watered on a daily basis. Vegetables grown in vertical towers will be irrigated with a self-circulating submergible pump.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics

1.04 WARRANTY

A. Lifetime warranty on framework
B. 5-year warranty on tubs

PART 2 – PRODUCTS

2.01 WHEELED IRRIGATION

A. Manufacturer: SmartCarts
B. Holds 20 gallons
C. Output: 5 gallons in 15 seconds
D. http://www.mullerscarts.com

END OF SECTION 32 80 00

32 91 00

PLANTING

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Trees, Shrubs, and Grasses
   2. Perennials, Annuals, Vegetables, and Ground Covers
   3. Planting soil mix
   4. Mulch

B. All plants on the property will be hand watered on a daily basis. Vegetables grown in vertical towers will be irrigated with a self-circulating submergible pump.

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings

1.03 QUALITY ASSURANCE

A. Submit certified test reports showing compliance with specified performance characteristics

1.04 WARRANTY

A. Lifetime warranty on framework
B. 5-year warranty on tubs

PART 2 – PRODUCTS

2.01 TREES

A. General: Furnish nursery-grown tree complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, full branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sunscald, injuries, abrasions, and disfigurement.
B. Root-Ball Depth: Furnish tree with root ball measured from top of root ball, which shall begin at root flare according to ANSI Z60.1-2004. Root Flare shall be visible before planting.
C. Grade: Proovide tree of size and grade complying with ANSI Z60.1. A tree of a larger size may be used if acceptable to architect, with a proportionate increase in size of roots or

balls.

D. Specifics: Supplier – Rancho Santa Anna Botanical Garden
1. Type: Manzanita or other with similar characteristics
2. Age: 20-30 years old
3. Height: starting at approximately 14-18 feet
4. Trunk: approximately 15-18" diameter or multi-stemmed

2.02 SHRUBS AND GRASSES

A. Various shrubs and grasses provided balled and burlapped or container-grown shrubs. Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigis enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1.

2.03 GROUND COVERS

A. Strawberry (Fragaria chiloensis) ground cover from plugs provided in plastic flats

2.04 ANNUALS/EDIBLES

A. Vegetables provided in 1 quart, 4", or 2" plastic containers or transplanted to supplied miles crates prior to delivery. Some vegetables will be started from seed in milk crates off-site.

B. Flowers provided in 1 gallon or 6" plastic containers or transplanted to supplied milk crates prior to delivery.

2.05 SOIL

A. Milk Crate Soil Mix to be 40% Sand, 30% Peat Moss, 20% Pummice and 10% Perlite per Laguna Hills Nursery

B. Quantity: 136 cubic feet

2.06 MULCH

A. Used for top dressing in containers where specified.

END OF SECTION 32 91 00

32 94 19

LANDSCAPE SURFACING

PART 1 – GENERAL

1.1 SUMMARY

A. Provide labor, materials and equipment necessary for complete installation of the following items as shown on Drawings and as specified herein.
   1. Rubber Tile Grid System
   2. Ramps, Landings, Handrails
   3. Decks
   4. Cover for Rill (ADA compliance)

PART 2 – PRODUCTS

A. RUBBER TILE GRID SYSTEM
   1. Supplier: Softile
   2. 2' square tiles manufactured from recycled tires
   3. Custom color blends available

B. DECKS, RAMPS, LANDINGS
   1. All materials to coordinate with exterior of the home
   2. Materials sourced from recycled products
   3. See Section 05 52 00 for Handrail specifications.
      a. Railings and decks must be structurally analyzed and stamped by a P.E.

C. Cover for Rill (ADA compliance)
   1. Material: Stainless Steel grate custom fabricated by SAR Metals

END OF SECTION 32 94 19

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48 00 00
ELECTRICAL POWER GENERATION

48 00 00 - DIVISION CONTENTS

SECTION 48 14 00

SOLAR ENERGY ELECTRICAL POWER GENERATION EQUIPMENT

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
1. Photovoltaic Panel

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 Warranty

A. Manufactures product warranty of 10 years.
B. Manufactures linear power warranty of 10 years at 91.2% of the minimal rated power output, 25 years at 80.7% of the minimal rated power output.

PART 2 – PRODUCTS

2.01 Photovoltaic Panel

A. Yingli Solar
1. Model Number: YL245P-29b
2. Module Efficiency (%): 15.0
3. Solar Cells: Multicrystalline 156 x 156mm (6 inches)
4. Module Dimensions: 1650 x 990 x 40mm (64.95 x 38.97 x 1.57 inches)
5. Weight: 19.1kg (42.1lb)
6. Glass: Low-iron tempered glass 3.2mm (0.13 inches)
7. Frame: Anodized aluminum alloy
8. J-Box: IP 65 rated
9. Cables: Photovoltaic Technology cable 4.0mm^2 (0.006 inches^2), 1000mm (39.4 inches)
10. Connector: MC4
11. Nominal Operating Cell Temperature (NOCT): 46°C (±2°C)
12. Operational Temperature: -40 ~+85°C
13. Maximum System Voltage: 1000V DC(IEC)/600V DC(UL)
14. Max Series Fuse Rating: 15A

15. Website:
    http://www.yinglisolar.com/assets/uploads/products/downloads/YGE_60_Cell_Series_EN.pdf

PART 3 – EXECUTION

3.01 INSTALLATION

A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

B. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

C. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

D. Correct deficiencies in or remove and reinstall products that do not comply with requirements.

E. Repair, refinish, or replace products damaged during installation as directed by Architect.

F. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 48 14 00

SECTION 48 19 16

ELECTRICAL POWER GENERATION INVERTERS

PART 1 – GENERAL INFORMATION

1.01 SUMMARY

A. This section includes the following:
   1. Microinverters

1.02 SUBMITTALS

A. Submit complete specifications and shop drawings.

1.03 Warranty

A. Manufactures limited warranty of 25 years.
B. Monitoring: Free lifetime monitoring via Enlighten software.

PART 2 – PRODUCTS

2.01 Microinverter

A. Enphase
   1. Model Number: M215 Microinverter
   2. Recommended Input Power (STC) : 190 – 270W
   3. Maximum Input DC Voltage: 45V
   4. CEC Weighted Efficiency: 96.0%
   5. Peak Inverter Efficiency: 96.3%
   6. Static MPPT Efficiency (weighted, reference EN50530): 99.6%
   7. Dynamic MPPT Efficiency (fast irradiation changes, reference EN50530): 99.3%
   8. Night Time Power Consumption: 46mW
   9. Operating Temperature Range (Internal): -40°C to +85°C
   10. Dimensions (W x H x D): 17.3 cm x 16.4 cm x 2.5 cm (6.8” x 6.45” x 1.0”) without mounting bracket
   11. Weight: 1.6 kg(3.5 lbs)

12. Cooling: Natural Convection – No Fans
13. Enclosure Environmental Rating: Outdoor – NEMA 6
14. Compatibility: Pairs with most 60-cell PV modules
15. Communication: Power Line
16. Website: http://enphase.com/wp-uploads/enphase.com/2011/10/Enphase-Datasheet-M215-Microinverter.pdf

PART 3 – EXECUTION

3.01 INSTALLATION

A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.

B. Fasten securely in place, with provisions for thermal and structural movement. Install with concealed fasteners, unless otherwise indicated.

C. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.

D. Correct deficiencies in or remove and reinstall products that do not comply with requirements.

E. Repair, refinish, or replace products damaged during installation as directed by Architect.

F. Adjust operating parts and hardware for smooth, quiet operation.

END OF SECTION 48 19 16

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APPENDIX A: STRUCTURAL CALCULATIONS

	Uniform Load (lb/ft^2)	Linear Load (lb/ft)	Module 1			Module 2		
			Area (ft^2)	Length (ft)	Weight (lbs)	Area (ft^2)	Length (ft)	Weight (lbs)
Floor								
Wood or tile floors	6	-	450	-	2700	265	-	1590
Subflooring	3	-	450	-	1350	265	-	795
Insulation	2	-	450	-	900	265	-	530
Metal deck	4	-	450	-	1800	265	-	1060
Concrete	25	-	450	-	11250	265	-	6625
Floor dead load subtotal (psf)	**40**							
Roof								
Solar panels	4	-	450	-	1800	315	-	1260
Wood sheathing	3	-	450	-	1350	315	-	945
Capillary Mat	2	-	450	-	900	315	-	630
Metal deck	4	-	450	-	1800	315	-	1260
Insulation	2	-	450	-	900	315	-	630
Roof dead load subtotal (psf)	**15**							
Wall								
Glass	18	-	211	-	3798	52.5	-	945
Non-Glass	12	-	779	-	9353	653	-	7835
South Façade Screen	2.5	-	285	-	713	-	-	-
Mechanical								
ERV	-	-	-	-	-	-	-	71
DHW Tank	-	-	-	-	-	-	-	831
Heat Pump	-	-	-	-	-	-	-	191
AHU	-	-	-	-	-	-	-	252.37
HVAC Hot Tank	-	-	-	-	-	-	-	695
Chilled Water Tank	-	-	-	-	-	-	-	1930
Structure								
Frame	-	-	-	-	7739	-	-	5338
Footing	-	-	-	-	874	-	-	874
PV Rack	-	-	-	-	1517	-	-	1314
Transportation								
Total allowable additional load during transport	20	-	450	-	9000	250	-	5000
TOTAL WEIGHT - TRANSPORTATION								
			Module 1 (lbs)			**57,743**		
			Module 2 (lbs)			**40,601**		
TOTAL WEIGHT - CRANED								
			Module 1 (lbs)			**48,743**		
			Module 2 (lbs)			**31,631**		
TOTAL WEIGHT - PERMANENT								
			Module 1 (lbs)			**48,743**		
			Module 2 (lbs)			**35,601**		

APPENDIX B: STRUCTURAL CALCULATIONS

ARUP	Job No.	Sheet No.	Rev.
Job Title	Member/Location		
	Drg. Ref.		
Calculation **Seismic Load per ASCE 7-05**	Made by	Date	Chd.

Static Seismic Base Shear and Lateral Force Distribution

Building Information

Lateral System Type	Ordinary braced frame		
Number of Stories	1		
Building Height (h_n)	10.167	ft	
Total Weight (W)	48743	lbs	
Response Modification Factor (R)	3		[ASCE 7-05 Table 12.2-1]
Occupancy Category	I		[I to IV per ASCE 7-05 Table 1-1]
Importance Factor (I)	1		[ASCE 7-05 Table 11.5-1]
Seismic Design Category	D		[A to D per ASCE 7-05 Table 11.6-1, 11.6-2]

Site Spectral Data

Mapped MCE spectral response acceleration (S_s)	1.5	g	
Mapped MCE spectral respone acceleration at T = 1s (S_1)	0.56	g	
Site Class	D		[A to F]
Site Coefficient F_a	1		[ASCE 7-05 Table 11.4-1]
Site Coefficient F_v	1.5		[ASCE 7-05 Table 11.4-2]
MCE spectral response acceleration for short periods (S_{MS}) = F_a*S_s	1.500	g	
MCE spectral response acceleration for 1s (S_{M1}) = F_v*S_1	0.840	g	
Design EQ SRA at short periods (S_{DS}) = 2/3*S_{MS}	1.000	g	
Design EQ SRA at short periods (S_{D1}) = 2/3*S_{M1}	0.560	g	

Building Period

Period parameter C_t	0.02		[ASCE 7-05 Table 12.8-2]
Period parameter x	0.75		[ASCE 7-05 Table 12.8-2]
Period (T_a) = C_t*h_n^x	0.11	sec	[ASEC 7-05 EQ12.8-7]
Long period transition period (T_L)	8	sec	[ASEC 7-05 Figure 22-15 and 22-16]

Base Shear

Seismic Response Factor (C_S) = S_{DS}/(R/I)	0.333	g	
C_{smax} = S_{D1}/(T*R/I) if T<T_L	1.639	g	
C_{smax} = S_{D1}*T_L/(T^2*R/I) if T>T_L	N/A	g	
C_{smin} = .044*S_{DS}*I >= 0.01g	0.044	g	[ASCE 7-05 Supplement 2, EQ12.8-5]
C_{smin} = 0.5*S_1/(R/I) if S_1>=0.6g	N/A	g	
Governing C_s Factor	0.333	g	
Base Shear (V) = C_s * W	16248	lbs	

Vertical Distribution of Lateral Force

Floor Level	Story Weight	Height (ft)	k[1]	w_x*h_x^k	C_{vx} w_x*h_x^k / Σw_i*h_i^k	F_x = C_{vx}*V
Roof	18562	10.2	1.00	188714.9738	0.7676	12472
Attic	0	0.0	1.00	0	0.0000	0
2nd Floor	0	0.0	1.00	0	0.0000	0
1st Floor	29812	1.9	1.00	57139.74038	0.2324	3776

[1] if T<0.5 k=1, if T>2.5 k=2, otherwise k is linearly interpolated between 1 and 2 based on T

APPENDIX C: STRUCTURAL CALCULATIONS

ARUP	Job No.	Sheet No.	Rev.
	Member/Location		
Job Title	Drg. Ref.		
Calculation **Seismic Load per ASCE 7-05**	Made by	Date	Chd.

Static Seismic Base Shear and Lateral Force Distribution

Building Information

Lateral System Type	Ordinary braced frame		
Number of Stories	1		
Building Height (h_n)	10.167	ft	
Total Weight (W)	35601	lbs	
Response Modification Factor (R)	3		[ASCE 7-05 Table 12.2-1]
Occupancy Category	I		[I to IV per ASCE 7-05 Table 1-1]
Importance Factor (I)	1		[ASCE 7-05 Table 11.5-1]
Seismic Design Category	D		[A to D per ASCE 7-05 Table 11.6-1, 11.6-2]

Site Spectral Data

Mapped MCE spectral response acceleration (S_s)	1.5	g	
Mapped MCE spectral respone acceleration at T = 1s (S_1)	0.56	g	
Site Class	D		[A to F]
Site Coefficient F_a	1		[ASCE 7-05 Table 11.4-1]
Site Coefficient F_v	1.5		[ASCE 7-05 Table 11.4-2]
MCE spectral response acceleration for short periods (S_{MS}) = F_a*S_s	1.500	g	
MCE spectral response acceleration for 1s (S_{M1}) = F_v*S_1	0.840	g	
Design EQ SRA at short periods (S_{DS}) = 2/3*S_{MS}	1.000	g	
Design EQ SRA at short periods (S_{D1}) = 2/3*S_{M1}	0.560	g	

Building Period

Period parameter C_t	0.02		[ASCE 7-05 Table 12.8-2]
Period parameter x	0.75		[ASCE 7-05 Table 12.8-2]
Period (T_a) = C_t*h_n^x	0.11	sec	[ASEC 7-05 EQ12.8-7]
Long period transition period (T_L)	8	sec	[ASEC 7-05 Figure 22-15 and 22-16]

Base Shear

Seismic Response Factor (C_S) = S_{DS}/(R/I)	0.333	g	
C_{smax} = S_{D1}/(T*R/I) if T<T_L	1.639	g	
C_{smax} = S_{D1}*T_L/(T^2*R/I) if T>T_L	N/A	g	
C_{smin} = .044*S_{DS}*I >= 0.01g	0.044	g	[ASCE 7-05 Supplement 2, EQ12.8-5]
C_{smin} = 0.5*S_1/(R/I) if S_1>=0.6g	N/A	g	
Governing C_s Factor	0.333	g	
Base Shear (V) = C_s * W	11867	lbs	

Vertical Distribution of Lateral Force

Floor Level	Story Weight	Height (ft)	k[1]	w_x*h_x^k	C_{vx} w_x*h_x^k / Σw_i*h_i^k	F_x = C_{vx}*V
Roof	11560	10.2	1.00	117526.504	0.7446	8836
Attic	0	0.0	1.00	0	0.0000	0
2nd Floor	0	0.0	1.00	0	0.0000	0
1st Floor	21030	1.9	1.00	40308.15308	0.2554	3031

[1] if T<0.5 k=1, if T>2.5 k=2, otherwise k is linearly interpolated between 1 and 2 based on T