



TEAM BOSTON
SOLAR DECATHLON 2009

PROJECT MANUAL



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TEAM BOSTON
2009 SOLAR DECATHLON

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PROJECT INFORMATION

Project Name:	Curio House
Mailing Address:	Team Boston Solar Decathlon Boston Architectural College 320 Newbury Street Boston, MA 02116
Site Address:	Solar Decathlon Build Site Tufts University Next to 62 Talbot Ave. Somerville, MA 02144
Date Created:	June 1, 2009
Owner/Tenant:	Team Boston - The BAC Tufts Consortium
Estimated Construction Cost:	\$325,000
Summary:	To respond to the 2009 Solar Decathlon Challenge, the Boston Architectural College (BAC) and Tufts University have formed a Consortium, combining resources and expertise to meet and exceed the Solar Decathlon Project goals. The Consortium considers the Solar Decathlon competition to be an organizational catalyst to address issues of energy consumption, as well as larger challenges of sustainability on the local, regional and international levels.
Project Principal Investigator:	Greg Demchak, Boston Architectural College William Moomaw, Tufts University
Structural Engineer:	Aaron A. Ford, PE L.A. Fuess Partners 101 Federal Street, Suite 502 Boston, MA 02110
Student Project Directors:	Colin Booth, Boston Architectural College Kevin Horne, Boston Architectural College Sarah Howard-McHugh, Boston Architectural College Stephen Messinger, Boston Architectural College Michelle Stadelman, Boston Architectural College Benjamin Steinberg, Tufts University Matthew Thoms, Tufts University
Student Architecture Lead:	Damian Liddiard, Boston Architectural College
Student Engineering Leads:	Dante DeMeo, Tufts University, Electrical Ross Trethewey, Tufts University, Mechanical
Contributing Authors:	Colin Booth, Dante DeMeo, Kevin Horne, Sarah Howard-McHugh, Damian Liddiard, Stephen Messinger, Michelle Stadelman, Benjamin Steinberg, Matthew Thoms, Ross Trethewey
Supporting Advisors:	Rob Darnell, Jenn Dougherty, Aaron Ford, Nicholas Gayeski, Christopher Kilfoyle, Amir Mesgar
Contribution Sponsors:	MIT Internet Zero (i0)



TEAM BOSTON
SOLAR DECATHLON 2009

SUMMARY OF CHANGES



SUMMARY OF CHANGES

<u>ITEM</u>	<u>SHEET/SECTION</u>	<u>DATE</u>	<u>DESCRIPTION</u>
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This section is a place holder for detailed information about changes and revisions to the construction specifications and drawings after the June 2, 2009 NREL submittal deadline.



APPROVED SUBSTITUTION

Aaron Ford, L.A. Fuess Partners, our structural engineer of record has approved the alternate framing material for the Curio House. The team has chosen to use engineered lumber rather than dimensional for several advantages for to the construction and shipment of the house. The engineered joists used in lieu of the dimensional lumber is considerably lighter for shipping the house modules and the recycled content of the material is an added benefit.

The following is the approved submittal from L.A. Fuess Partners.

Michelle Stadelman

From: Jeff Olitch [jolitch@lafp.com]
Sent: Thursday, April 23, 2009 3:23 PM
To: Damian Liddiard; Michelle Stadelman
Cc: Aaron Ford (Aaron Ford)
Subject: A8189 Submittal 002 - Alternate floor and roof framing Submittal
Attachments: A8189_SUBM_04-23-09_[02 - I-Joists].pdf

Damian and Michelle,

See attached copy of the reviewed and approved submittal from Boise proposing the use of I-joists for floor and roof members.

Date : Apr 23, 2009
 To : Boston Architectural College
 Boston
 320 Newbury Street
 Boston, Massachusetts 02115

 Attn : **Michelle Stadelman & Damian Liddiard**
 Sent Via : Electronic Mail

Job Name : **BAC Solar Decathlon** File **A8189-B.1**
 Reference : **CONSTRUCTION SUBMITTAL**

***L.A. Fuess Partners Inc.** transmits herewith the items described below. Please contact us at once if the items received are not as described.*

LAFP Submittal Number : 002
 Client Reference Number : 002-6100
 Submittal Type : Fabrication/Erection Drawings
 Specification Section : 6100 Structural Timber
 Submittal Status : Corrections Noted
 Reviewer : AF
 Vendor : Boise
 Description : Adjusted framing plans of floor and roof
 Sheet Numbers : 1 - 36"x24" sheet
 Date Received : 04/22/2009
 Date Returned : 04/23/2009
 Comments :

The following are included in this transmittal:

Number of Copies : 1
 Number of Reproducibles : 0

Copy of Transmittal Sent To :

features are intended for use by the public, they shall be accessible in accordance with 2006 IBC Chapter 11 and ICC/ANSI A117.1-2003.

4-2. Accessibility – Habitable Roof Deck and Interior Second Floor/Loft Levels

Solar Decathlon competition houses are intended to demonstrate single-family dwellings that would not normally be regulated by any federal accessibility standard. However, these buildings are open to the public for educational purposes and must be accessible in all primary function areas. Therefore, any portion of the building where the public is permitted must be on an accessible route. The Americans with Disabilities Act (ADA) requires an elevator to be installed in buildings (funded pursuant to Title II) where an accessible route is required to stories above the first floor (such as the roof deck, second floor, or loft). The 3,000 ft² (278.7 m²) exception located in IBC Section 1104.4 Exc. 1 is superseded by Federal regulation.

The ADA Assistance Center indicates that it is acceptable to “demonstrate” a roof deck, loft, or upper level accessed via stairs, or other means of inaccessible access, as long as no member of the public, organizers, or competing teams is allowed to access the space during public exhibit periods. Any provided means of access shall be fully gated or cordoned off to inhibit entry. Adherence to these guidelines should remove any perception that the upper level is being used as a primary function and therefore subject to the accessibility provisions of the ADA.

4-3. Accessibility – Ramps

The following are the most important regulations regarding ramps.

- a. A “ramp” is any sloping surface used as part of the circulation path that has a slope in excess of 1:20.
- b. The slope of a ramp cannot exceed 1:12.
- c. At the top and bottom of any ramp, a landing 60 in. (152.4 cm) long is required.
- d. A 60-in. by 60-in. (152.4-cm by 152.4-cm) landing is required at any point where a ramp changes directions.
- e. Handrails are required if the ramp’s rise exceeds 6 in. (15.2 cm) (Americans with Disabilities Act Accessibility Guidelines [ADAAG] Sec. 4.8 and ANSI A117.1-2003 Section 405).

4-4. Changes in Elevation

All changes in elevation (including even minor changes in areas such as door thresholds) must be considered along an accessible route. Changes not exceeding 0.25 in. (0.64 cm) are acceptable. Elevation changes between 0.25 in. and 0.5 in. (0.64 cm and 1.3 cm) shall be beveled at a maximum of 1:2. Any higher change in elevation exceeding 0.5 in. (1.3 cm) shall be by a ramp with a maximum slope of 1:12 (ADAAG, Sec. 4.5.2).

4-5. Doors and Door Approaches

All doors shall comply with ADAAG Section 4.13 (ANSI A117.1-2003 Section 404). Doors that can be fixed in an open position may be accepted as part of the accessible route if 32-in. (81.3-cm) minimum clearance is provided through the door opening with the door secured in the fully open position. Doors without required clearances intended to remain open must be clearly identified on the plans and approved by the Solar Decathlon Building Official.

Section 5. Structural

The structural drawings and calculations included in the Construction Documents shall be stamped by a qualified, licensed design professional. Obtaining the stamp is the responsibility of the teams, not the organizers. The organizers will submit stamped structural drawings and calculations to the National Park Service for final approval. It is strongly recommended that teams involve a qualified, licensed professional throughout the design process, because he or she could require structural design changes that could affect other aspects of the house. In addition to meeting applicable IRC requirements, special attention must be given to the structural design challenges unique to the Solar Decathlon. These challenges include, but are not limited to, the following:

- a. Increased live loads because of public access to houses

- b. Necessity for tie-downs because of the lack of a permanent foundation (tie-downs must not penetrate more than 18 in. [45.7 cm] into the competition site topsoil)
- c. Use of low-impact footings to protect the competition site grass
- d. Unique wind-loading conditions because of roof-mounted solar systems
- e. Increased dead loads because of unusual mechanical and electrical components equipment.

5-1. Prescriptive Requirements

Structural systems shall be designed in accordance with the appropriate prescriptive provisions of the IRC (see alternate materials provisions in IRC, Sec. CC2.6). For structural framing, a one-line structural plan view drawing is required at a minimum. Successive plan sheets shall be provided and shall include foundation footings, floor framing, wall locations, and roof framing. All structural components shall be listed including sizes, species and grade, and repetitive spacing (on-center distances). Include details on connections between joists and beams, floor systems and foundations, walls and floors, rafters and beams, etc. Specify proprietary hangers or other mechanical connections (IRC, Sec. R301.1).

5-2. Design Loads

The following minimum loads must be used in the structural design:

- a. Wind: 60 mph (26.8 m/s) (3-second gust), exposure category C (if tie-downs are not used, you must show that there is no overturning or uplifting with a safety factor of 2)
- b. Railings: 200-lb (890-N) concentrated load applied in any direction at any point at the top of the rail
- c. Interior floor, decks, ramps: 50 psf (2.39 kPa) live load
- d. Roof: 20-psf (0.958-kPa) live load
- e. Soil: 1,500-psf (71.8-kPa) load-bearing pressure on top of the soil
- f. Additional structural design requirements at the post-event house location (to be determined by the licensed professional of record).

Structural plans shall indicate the design loads (e.g., 50 psf [2.39 kPa] floors, 100 psf [4.78 kPa] means of egress components, 20 psf [0.958 kPa] snow roof live load) and the location, size, and weight of special loads such as liquid storage tanks and mass or trombe walls.

5-3. Exterior Construction

Structural plans shall include design details for any exterior appurtenances such as decks, stairs, ramps, awnings, canopies, and roof projections (IRC, Sec. R301.1).

5-4. Specific Point Loads

Provide wind-analysis calculations for point-load connections demonstrating the components' abilities to withstand 60-mph (26.8-m/s), exposure category C wind conditions. Provide point-load connection details for all solar panel connections to demonstrate that the connections will resist uplift (IRC, Sec. R301.1).

5-5. Foundation

Provide a foundation plan for temporary setup on the competition site. Plans shall include location and size of all pad footings and required tie-down anchors (e.g., type, number, and installation configuration) to prevent wind uplift or overturning (IRC, Sec. R401.1 and R401.2). Please provide consideration for sloping or variable site conditions. The surface of each assigned site on the competition site may vary up to 18 in. (45.7 cm) depending upon location.

a. General Requirements

All houses, decks and other structures shall be provided with foundations sufficient to safely transmit gravity, lateral, and uplift loads. For purposes of design, the presumptive soil bearing capacity shall be 1,500 psf (7,323.6 kg/m²). Design wind speed shall be 60 mph (26.8 m/s) (3-second gust) with a C exposure. The design winds have

been reduced to accommodate the season and short duration of the Washington, D.C., event and to acknowledge mandatory evacuation when anticipated winds are expected to exceed 50 mph (22.4 m/s).

b. Pad and Spread Footing Leveling

The surface of Solar Decathlon lots may vary up to 18 in. (45.7 cm) across the lot. Foundations should be designed to accommodate site variations without relying on imported fill materials for anything other than leveling the surface for complete pad contact. Any imported fill materials must be demonstrated to transmit all required loads. The surface of the National Mall must be protected from contamination by fill materials via geotextile fabric or other approved barriers. All fill materials shall be retained by approved methods to prevent displacement by water or wind erosion.

c. Uplift Design

Uplift design may employ uplift anchorage, dead-load analysis, or a combination of both. Anchorage embedment in the National Mall is limited to an 18 in. (45.7 cm) depth. Teams are encouraged to configure their structures to take advantage of dead loads to resist uplift, overturning, and sliding. All designs shall be supported by calculations demonstrating the efficacy of the system. Foundation designs and calculations shall be APPROVED prior to placement of the structure on the National Mall.

5-6. Alternate Materials

Alternate materials are permitted as follows.

- a. Engineered lumber (e.g., TJIs, LPIs, and BCIs) pursuant to specific manufacturer's design data. The product selected must carry a current International Code Council (ICC) Evaluation Services report. See <http://www.icc-es.org/>.
- b. Structurally insulated panel systems pursuant to specific manufacturer's design data. The product selected must carry a current ICC Evaluation Services report. Also be advised that foam plastics must be thermally isolated from the interior of the dwelling (see Section 3-6 for more details).
- c. Engineered trusses (floor or roof) must be designed in accordance with IRC Sections R502.11 or R802.10 as appropriate. Individual truss reports shall be provided for review and shall bear the seal of a registered design professional (IRC, Sec. R104.11).
- d. Other alternate materials may be permitted if approved pursuant to IRC Section 104.11. It is the responsibility of the applicant to provide adequate proof to document the alternate as meeting the intent of the prescriptive code requirements. The organizers reserve the right to deny any alternate for failure to clearly demonstrate code equivalence.
- e. Phase-change materials included within building components must be identified on the plans. Specifications for the material composition must be provided with any available fire-performance testing data. Be advised that phase-change embedment in gypsum board or interior wall or ceiling finishes may affect the ability of these materials to pass required fire tests.

5-7. Structural Steel

Provide structural details for load-carrying structural steel assemblies. Include welded or bolted connections within the assembly and where attached to other structures (IRC, Sec. R301.1.3).

Section 6. Electrical

6-1. Governing Code

The provisions of the NEC supersede the limited prescriptive electrical requirements contained in Chapters 33-42 of the IRC.

6-2. Drawing Requirements

- a. Electrical plan(s) must include layouts of proposed receptacles, switches, light fixtures, smoke alarms, ceiling fans, etc.



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SOLAR DECATHLON 2009

RULE COMPLIANCE CHECKLIST

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)	Coordinates
4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site		
4-2	Construction Equipment	Specs for heavy machinery	Specifications 01 50 00	
4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	A101 – Site Plan	
4-4	Impact on the Turf	Drawing(s) showing the location, contact area, and soil bearing pressure of every component resting directly on the turf	S1.1 – Mall Footing Plan Structural calculations	
4-5	Generators	Specifications for generators	Specifications 01 50 00	
4-6	Spill Containment	Drawing(s) showing the locations of all equipment, tanks, and pipes that will contain fluids at any point during the event	P101 – Plumbing Supply & Removal Plan	
4-6	Spill Containment	Specifications for all equipment, tanks, and pipes that will contain fluids at any point during the event		
4-7	Lot Conditions	Calculations showing that structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists	S1.1 – Mall Footing Plan	
4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot	S1.1 – Mall Footing Plan	
5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	A101 – Site Plan	
5-2	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references		
6-1	Structural Design Approval	List of, or marking on, all sheets in the complete electronic Construction Documents that have been or will be stamped by the structural engineer in the hard-copy, stamped structural submission; the stamped submission shall consist entirely of sheets or pages that also appear in the complete electronic construction document set	See December submittal for signed and sealed drawings. Structural calculations are included in the specifications.	
6-2	Maximum Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to measure the architectural footprint electronically	A115 – Building Footprint	
6-2	Maximum Architectural Footprint	Drawing(s) showing all movable components that may increase the footprint if operated during contest week	I509-I511 with Description in Project Manual	
6-2	Maximum Architectural Footprint	Shading calculations and/or diagrams for components that DO NOT shade the building above its finished floor height between 9 a.m. and 5 p.m. EDT on October 1 (shading calculations and/or diagrams are not necessary for components that are either shorter than finished floor height or obviously do not shade the building)		
6-3	Minimum Conditioned Space	Drawing(s) showing space conditioning means in primary living spaces	A116 – Conditioned Space Plan	

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)	Coordinates
6-4	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route and the ground surface area that will be covered by organizer-provided walkway material	X101 – Accessible Route Plan	
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		
7-2	Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems	C101 – Drainage Plan	
8-1	PV Technology Limitations	Specifications for photovoltaic components	Included in Specifications	
8-1	PV Technology Limitations	Retail price quote for photovoltaic components	Included in Specifications	
8-3	Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components	M101 – Mechanical Plan	
8-3	Thermal Energy Storage	Specifications for thermal energy storage components	Included in Specifications	
8-3	Thermal Energy Storage	Shading calculations and/or diagrams for thermal energy storage components (if necessary)	Included in Energy Analysis at back of project manual	
8-4	Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices		
8-4	Batteries	Specifications for all stand-alone, PV-powered devices		
8-5	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	N/A	
8-5	Desiccant Systems	Specifications for desiccant system components	N/A	
8-6	Village Grid	Completed Interconnection Application form.		
8-6	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E601 – One-Line Diagram E602 – Three-Line Diagram	
8-6	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means		
8-6	Village Grid	One-line electrical diagram	E601	
8-6	Village Grid	Calculation of service/feeder net computed load per NEC 220	Included in Specifications	
8-6	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	A101 – Site Plan X102 – Tour Route Plan	
8-6	Village Grid	Elevation(s) showing the terminal box, meter housing, main utility disconnect, and other service equipment	E201 – Electrical Elevation	
9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems		

Rule #	Rule Description	Content Requirement(s)	Drawing Sheet(s)	Coordinates
9-6	Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems		
9-6	Thermal Mass	Specifications for components of water-based thermal mass systems		
10-2	Event Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	To be issued at a later date.	
10-3	Team Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	To be issued at a later date.	
11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	X102 – Tour RoutePlan	
11-4	Public Exhibit	Drawing(s) showing the dimensions, materials, artwork, and content of the handout	To be issued at a later date.	
11-4	Public Exhibit	Drawing(s) showing the artwork and content of the team uniform	To be issued at a later date.	



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CODE COMPLIANCE CHECKLIST



CODE COMPLIANCE CHECKLIST

This section is a place holder for materials and a checklist yet to be fully developed.



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COMPETITION SCHEDULE & SCORE CARDS



	FRIDAY DAY 9				SATURDAY DAY 10				MONDAY DAY 12			TUESDAY DAY 13					
8:00 AM	A115	M116	C117	A107	M108	C109	<div>IMPORTANT NOTE: The jury schedule on any or all of these four days may be modified if either of the following occurs: 1) One or more teams withdraw from the competition 2) There is a significant unforeseen event, such as a Presidential visit, that disrupts the published schedule.</div>										
8:05 AM																	
8:10 AM																	
8:15 AM																	
8:20 AM																	
8:25 AM																	
8:30 AM	TRAVEL			TRAVEL													
8:35 AM																	
8:40 AM	A116	M117	C115	A108	M109	C107											
8:45 AM																	
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9:05 AM																	
9:10 AM	TRAVEL			TRAVEL			L110	E109		L120	E119						
9:15 AM																	
9:20 AM	A117	M115	C116	A109	M107	C108		TRAVEL			TRAVEL						
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5:05 PM																	
	Contest Abbreviations					7:30 PM	L110			L120							
	A = Architecture Jury					7:35 PM	TRAVEL			TRAVEL							
	M = Market Viability Jury					7:40 PM											
	C = Communications Jury					7:45 PM	L109			L119							
	E = Engineering Jury					7:50 PM	TRAVEL			TRAVEL							
	L = Lighting Design Jury					7:55 PM											
						8:00 PM	L108			L118							
						8:05 PM	TRAVEL			TRAVEL							
						8:10 PM											
						8:15 PM	L107			L117							
						8:20 PM	TRAVEL			TRAVEL							
						8:25 PM											
						8:30 PM	L106			L116							
						8:35 PM	TRAVEL			TRAVEL							
						8:40 PM											
						8:45 PM	L105			L115							
						8:50 PM	TRAVEL			TRAVEL							
						8:55 PM											
						9:00 PM	L114			L104							
						9:05 PM	TRAVEL			TRAVEL							
						9:10 PM											
						9:15 PM	L113			L103							
						9:20 PM	TRAVEL			TRAVEL							
						9:25 PM											
						9:30 PM	L112			L102							
						9:35 PM	TRAVEL			TRAVEL							
						9:40 PM											
						9:45 PM	L111			L101							
						9:50 PM											

**Official Score Sheet for 2009 Solar Decathlon
Contest 9: Home Entertainment – Dining**

[Insert team name here]	[Insert Decathlete name here]	[Insert Decathlete name here]	Dinner Party #	
Name of Team and Decathletes Evaluating Dinner Party Note – This form is to be completed by the two Decathletes who attended the dinner party. Complete this form in your house and submit it to your observer before impound.				
[Insert Host Team name here]				
Name of Team Hosting the Dinner Party				
			Points Awarded (to be completed by Scoring Official only)	
Did the Host Team follow their approved meal plan? (See approved Team meal plan attached).	Yes	No	Don't Know	
	(Circle one) If you circled "No" or "Don't Know," then explain in the comment section below.			
Did the Host Team serve their meal within the required time frame?	Yes	No	Don't Know	
		Write time meal served here		
(Circle one) If you circled "Don't Know," then explain in the comment section below.				
Did the Host Team prepare the required 8 servings?	Yes	No	Don't Know	
	(Circle one) If you circled "Don't Know," then explain in the comment section below.			
If you circled "No," how many servings did they prepare?	Zero	1-7	More than 8	
	(Circle one)			
Score – rate each criterion from 0 to 100, with 100 being the highest ranking.	Quality of the Meal	Ambience	Overall Experience	
Total points awarded for this task.				

Dinner Guest Comments – provide justification for your score:

**Official Score Sheet for 2009 Solar Decathlon
Contest 9: Home Entertainment – Home Theater**

[Insert name of team evaluating movie night here]		# of your team members who attended		Movie Night	
Note – This form is to be completed by the Decathletes who attended the movie night. Complete this form in your house and submit it to your observer before impound.					
[Insert name of team hosting movie night here]					
Points Awarded (to be completed by Scoring Official only)					
Note the Host Team's target market. (This information is on the Solar Decathlon Web page describing each team's target market.)					
Location of permanent site					
Housing Type		# of occupants	# of bedrooms		
Occupant demographic			Homeowner annual income		
Did the Host Team show only the approved movie?	Yes	No	Don't Know (provide an explanation)		
Did your group stay for at least the required 15 minutes?	Yes	No (If no, note how long you stayed and provide an explanation)			
Score – rate each criterion from 0 to 100, with 100 being the highest ranking.	Quality of the home theater system and design	Ambience	Overall Experience		
Total points awarded for this task.					

Movie Night Comments – provide justification for your score:



TEAM BOSTON
SOLAR DECATHLON 2009

CONSTRUCTION SPECIFICATIONS



SPECIFICATIONS AT A GLANCE

DIVISION	DIVISION TITLE	PRODUCT DESCRIPTION	MANUFACTURER	PRODUCT WEBSITE
01 00 00	GENERAL REQUIREMENTS			
01 00 00	General Requirements			
01 11 00	Summary of Work			
01 30 00	Administrative Requirements			
01 35 15	LEED Certification Requirements	LEED for Homes	USGBC	www.usgbc.org
01 50 00	Temporary Facilities			
01 51 13	Temporary Electricity	Diesel Light Tower	Ingersoll-Rand	www.sunbeltrentals.com
01 51 16	Temporary Fire Protection			
01 51 26	Temporary Lighting	Diesel Light Tower	Ingersoll-Rand	www.sunbeltrentals.com
01 54 16	Temporary Hoists			
01 57 19	Construction Indoor Air Quality			
01 60 00	Product Requirements			
01 67 00	Environmental Product Requirements			
01 70 00	Execution and Closeout Requirements			
01 74 00	Construction Waste Management Plan			
01 90 00	Life Cycle Activities			
01 91 13	General Commissioning Requirements			
01 91 14	Commissioning Authority Responsibilities			
02 00 00	EXISTING CONDITIONS			
02 40 00	Demolition and Structure Moving			
02 43 13	Structure Relocation			
03 00 00	CONCRETE			
03 30 00	Cast-in-Place Concrete			
04 00 00	MASONRY			
05 00 00	METALS			

05 20 00	Metal Joists			
05 40 00	Cold-Formed Metal Framing			
05 50 00	Metal Fabrications			
05 51 33	Vertical Metal Ladders			
05 70 00	Decorative Metal			
05 73 16	Wire Rope Decorative Metal Railings			
06 00 00	WOODS, PLASTICS AND COMPOSITES			
06 10 00	Rough Carpentry			
06 11 13	Engineered Wood Products			
06 15 33	Wood Patio Decking			
06 16 23	Subflooring			
06 16 53	Moisture-Resistant Sheathing Board			
06 17 13	Laminated Veneer Lumber			
06 17 33	Wood I-Joists			
06 20 00	Finish Carpentry			
06 22 13	Standard Pattern Wood Trim			
06 40 00	Architectural Woodwork			
06 40 13	Exterior Architectural Woodwork			
06 40 23	Interior Architectural Woodwork			
06 46 13	Wood Door and Window Casings			
06 46 29	Wood Fascia and Soffits			
06 48 13	Exterior Wood Door Frames			
06 48 16	Interior Wood Door Frames			
06 48 23	Stick-Built Wood Windows			
06 70 00	Structural Composites			
06 73 00	Composite Decking			
07 00 00	THERMAL AND MOISTURE PROTECTION			
07 10 00	Dampproofing and Waterproofing			
07 13 00	Sheet Waterproofing			
07 15 00	Sheet Metal Waterproofing			
07 20 00	Thermal Protection			
07 21 13	Board Insulation			
07 21 16	Blanket Insulation			
07 21 26	Blown Insulation	Cel-Pak Cellulose Insulat	National Fiber	www.nationalfiber.com/cel-pak
07 22 16	Roof Board Insulation			
07 50 00	Membrane Roofing			
07 54 23	Thermoplastic-Polyolefin Roofing			
07 60 00	Flashing and Sheet Metal			

07 62 00	Sheet Metal Flashing and Trim			
08 00 00	OPENINGS			
08 10 00	Doors and Frames			
08 14 00	Wood Doors			
08 30 00	Specialty Doors and Frames			
08 32 00	Sliding Glass Doors			
08 50 00	Windows			
08 52 00	Wood Windows			
08 80 00	Glazing			
08 81 00	Glass Glazing			
08 85 00	Glazing Accessories			
08 87 13	Solar Control Films			
		Polycarbonate Wall Systems	Exterior Technologies, Inc	http://www.extech-voegele.com/3100standard.htm
08 90 00	Louvers and Vents			
08 95 13	Soffit Vents			
09 00 00	FINISHES			
09 20 00	Plaster and Gypsum Board			
09 21 16	Gypsum Board Assemblies			
09 28 00	Backing Boards and Underlayments			
09 30 00	Tiling			
09 31 00	Thin-Set Tiling			
09 34 00	Waterproofing-Membrane Tiling			
09 50 00	Ceilings			
09 54 00	Specialty Ceilings	Techstyle Classic Ceiling	Hunter Douglas	www.hunterdouglascontract.com
09 60 00	Flooring			
09 64 00	Wood Block Flooring			
09 90 00	Painting and Coating			
09 91 00	Painting			
09 93 00	Staining and Transparent Finishing			
09 97 13	Steel Coatings			
10 00 00	SPECIALTIES			
10 10 00	Information Specialties			
10 11 00	Visual Display Surfaces			
10 14 00	Signage			
10 20 00	Interior Specialties			
10 28 16	Bath Accessories			
10 28 23	Laundry Accessories			

10 40 00	Safety Specialties			
10 44 16	Fire Extinguishers			
10 50 00	Storage Specialties			
10 55 23	Mail Boxes			
10 57 23	Closet and Utility Shelving			
10 70 00	Exterior Specialties			
10 71 13	Exterior Sun Control Devices			
11 00 00	EQUIPMENT			
11 30 00	Residential Equipment			
11 31 13	Residential Kitchen Appliances			
11 31 23	Residential Laundry Appliances			
11 80 00	Collection and Disposal Equipment			
11 82 23	Recycling Equipment			
11 82 29	Composting Equipment			
12 00 00	FURNISHINGS			
12 10 00	Art			
12 20 00	Window Treatments			
12 24 00	Window Shades			
12 30 00	Casework			
12 35 30	Residential Casework			
12 36 00	Countertops	PaperStone		www.paperstoneproducts.com
12 40 00	Furnishings and Accessories			
12 41 00	Office Accessories			
12 42 00	Table Accessories			
12 43 00	Portable Lamps			
12 44 00	Bath Furnishings			
12 45 00	Bedroom Furnishings			
12 46 00	Furnishings Accessories			
12 48 00	Rugs and Mats			
12 50 00	Furniture			
12 58 13	Couches and Loveseats			
12 58 16	Residential Chairs			
12 58 19	Dining Tables and Chairs			
12 58 29	Beds			
12 58 83	Custom Residential Furniture			
12 90 00	Other Furnishings			
12 93 13	Bicycle Racks	6-Bike Rack	Stadium Racks	www.bikerackshops.com
12 93 43	Site Seating and Tables			

13 00 00	SPECIAL CONSTRUCTION		
13 50 00	Special Instrumentation		
13 53 00	Meteorological Instrumentation		
22 00 00	PLUMBING		
22 10 00	Plumbing Piping and Pumps		
22 11 16	Domestic Water Piping		
22 11 19	Domestic Water Piping Specialties		
22 11 23	Domestic Water Pumps		
22 12 19	Facility Ground-Mounted, Potable Water ≤ 750-Gallon water tank	Go-To Tanks	www.gototanks.com
22 13 16	Sanitary Waste and Vent Piping		
22 13 19	Sanitary Waste Piping Specialties		
22 30 00	Plumbing Equipment		
22 33 30	Residential, Electric Domestic Water Heaters		
22 40 00	Plumbing Fixtures		
22 41 13	Residential Water Closets, Urinals and BirAquia Dual Flush	TOTO	www.totousa.com
22 41 16	Residential Lavatories and Sinks		
22 41 23	Residential Shower Receptors and Basins		
22 41 26	Residential Disposers		
22 41 36	Residential Laundry Trays		
22 41 39	Residential Faucets, Supplies and Trim		
23 00 00	HEATING, VENTILATING AND AIR-CONDITIONING		
23 30 00	HVAC Air Distribution		
23 31 13	Metal Ducts		
23 37 13	Diffusers, Registers and Grilles		
23 50 00	Central Heating Equipment		
23 56 00	Solar Energy Heating Collectors		
23 70 00	Central HVAC Equipment		
23 72 19	Fixed-Plate Air-to-Air Energy-Recovery Equipment		
23 80 00	Decentralized HVAC Equipment		
23 81 26	Split-System Air-Conditioners		
23 83 00	Radiant Heating Units		
23 84 16	Dehumidifiers		
25 00 00	INTEGRATED AUTOMATION		
25 50 00	Integrated Automation Facility Controls		
25 51 00	Integrated Automation Control of Facility Equipment		

26 00 00	ELECTRICAL			
26 20 00	Low-Voltage Electrical Distribution			
26 24 16	Panelboards	200 Amp Load Center	General Electric	http://products.geindustrial.com
26 30 00	Facility Electrical Power Generating and Storing Equipment			
26 31 00	Photovoltaic Collectors			
26 50 00	Lighting			
26 51 00	Interior Lighting			
26 56 00	Exterior Lighting			
28 00 00	ELECTRONIC SAFETY AND SECURITY			
28 30 00	Electronic Detection and Alarm			
28 31 46	Smoke Detection Sensors			
28 31 49	Carbon-Monoxide Detection Sensors			
31 00 00	EARTHWORK			
32 80 00	Irrigation			
32 84 00	Planting Irrigation			
32 90 00	Planting			
32 93 00	Plants			
32 94 00	Planting Accessories			
33 00 00	UTILITIES			
33 70 00	Electrical Utilities			
33 71 73	Electrical Utility Services			
48 00 00	ELECTRICAL POWER GENERATION			
48 10 00	Electrical Power Generation Equipment			
48 14 13	Solar Energy Electrical Power Generation Equipment			
48 19 16	Electrical Power Generation Inverters			



SECTION 01 00 00

GENERAL REQUIREMENTS

SECTION TABLE OF CONTENTS

1.01 Related Documents	1.08 Procedures and Controls
1.02 Project Requirements	1.09 Warranties
1.03 Specification Information	1.10 Temporary Facilities and Utilities
1.04 Definitions	1.11 Delivery, Storage and Handling
1.05 Industry Standards	1.12 Labels
1.06 Codes and Regulations	1.13 Record Documents
1.07 Progress Schedule	1.14 Final Cleaning and Repair

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents apply to this Section. This Section applies to all Work performed under the Contract.

1.02 PROJECT REQUIREMENTS

- A. Project Identification: Team Boston 2009 Solar Decathlon House, Somerville, MA.
Project Owner: Boston Architectural College and Tufts University Consortium – “Team Boston”
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).
- C. Project Requirements for Temporary Utilities and Facilities:
1. Utility Costs: The Contractor shall meter and pay for cost of utility services consumed, including electricity, water, gas and temporary heat.
- D. Permits and Fees: Apply for, obtain, and pay for permits, fees, and utility company backcharges required to perform the work.
- E. Codes for Somerville, MA: Comply with applicable codes and regulations of authorities having jurisdiction. Submit copies of inspection reports, notices and similar communications to Architect.
Codes for Washington, D.C.: Comply with applicable codes and regulations outlined by the DOE & NREL. Post all inspection reports, notice and similar on Mall construction site for reference and keep copy for project closeout.
- G. Dimensions: Verify dimensions indicated on drawings with field dimensions before fabrication or ordering of materials. Do not scale drawings.
- H. Existing Conditions: Notify Architect of existing conditions differing from those indicated on the drawings.
- I. Contractor's Conduct on Premises: The Contractor and his employees shall behave in a respectful, courteous and safe manner. Abusive, harassing, and lewd behavior is prohibited. Alcohol, tobacco and drug use is prohibited.

1.03 SPECIFICATION INFORMATION

- A. These specifications are a specialized form of technical writing edited from master specifications and contain deviations from traditional writing formats. Capitalization, underlining and bold print is only used to assist reader in finding information and no other meaning is implied.
 - B. Except where specifically indicated otherwise, the subject of all imperative statements is the Contractor.
 - C. Sections are generally numbered in conformance with Construction Specifications Institute Masterformat System. Numbering sequence is not consecutive. Refer to the table of contents for names and numbers of sections included in this Project.
 - D. Pages are numbered separately for each section. Each section is noted with "End of Section" to indicate the last page of a section.
- 1.04 DEFINITIONS
- A. General: Basic Contract definitions are included in the Conditions of the Contract.
 - B. "Approved": When used to convey Architect's action on Contractor's submittals, applications, and requests, "approved" is limited to Architect's duties and responsibilities as stated in the Conditions of the Contract.
 - C. "Directed": A command or instruction by Architect. Other terms including "requested," "authorized," "selected," "approved," "required," and "permitted" have the same meaning as "directed."
 - D. "Indicated": Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown," "noted," "scheduled," and "specified" have the same meaning as "indicated."
 - E. "Regulations": Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work and within the guidelines of the Solar Decathlon Competition.
 - F. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
 - G. "Install": Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.
 - H. "Provide": Furnish and install, complete and ready for the intended use.
 - I. "Project Site": Space available for performing construction activities. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built. Project site includes the Somerville, MA building site and the competition site on the National Mall in Washington, DC.
 - J. "Jurisdiction": The local building authority and representatives for Somerville, MA as well as the ruling body and authority from the DOE and NREL overseeing the Solar Decathlon Competition.
 - K. "Owner": The Boston Architectural College and Tufts University Consortium – "Team Boston". The Governing Board and Student Project Directors are the decision making body acting as the owner.
 - L. "Contractor"/"Subcontractor": The students, in-kind sponsors and other associated volunteers working on Team Boston's construction crew.

- 1.05 INDUSTRY STANDARDS
- A. Referenced standards are part of the Contract Documents and have the same force and effect as if bound with these specifications.
 - B. Except where specifically indicated otherwise, comply with the current standard in effect as of the date of the Owner/Contractor Agreement. Obtain copies of industry standards directly from publisher.
 - C. The titles of industry standard organizations are commonly abbreviated; full titles may be found in Encyclopedia of Associations or consult Architect.
- 1.06 CODES AND REGULATIONS
- A. Comply with all applicable codes, ordinances, regulations and requirements of authorities having jurisdiction.
 - B. Submit copies of all permits, licenses, certifications, inspection reports, releases, notices, judgments, and communications from authorities having jurisdiction to the Architect. All documentation will be retained for final house placement after the Solar Decathlon Competition.
 - C. All drawings and documents are to be submitted and approved by NREL prior to any construction beginning on the National Mall. The Event overseers must sign-off and approve all construction prior to the house being open for exhibit or participation in the Solar Decathlon Competition.
- 1.07 PROGRESS SCHEDULE
- A. Provide comprehensive bar chart schedule showing all major and critical minor portions of the work, sequence of work and duration of each activity. Update and reissue regularly, but not less than weekly.
- 1.08 PROCEDURES AND CONTROLS
- A. Project Meetings: Arrange for and attend meetings with the Architect and such other persons as the Architect requests to have present. The Contractor shall be represented by a principal, project manager, general superintendent or other authorized main office representative, as well as by the Contractor's field superintendent.
 - B. Emergency Addresses: Furnish the Owner and Architect, in writing, the names addresses and telephone numbers of individuals to be contacted in the event of an out-of-hours emergency at the building site. Post a similar list readily visible from the outside of the field office or a location acceptable to the Architect.
 - C. Layout: Layout work and be responsible for all lines, elevations, and measurements of the building, grading, utilities and other work executed under the contract.
 - D. Field Measurements: Verify measurements at the building prior to ordering materials or commencing work. No extra charge or compensation will be allowed because of differences between actual dimensions and measurements indicated on the Drawings. Differences which may be found shall be submitted to the Architect for decision before proceeding with the work.
 - E. Observation: Notify the Architect and authorities having jurisdiction at least thirty-six hours in advance of concealing any work.
 - F. Utilities: Prior to interrupting utilities, services or facilities, notify the utility owner and the Owner and obtain their written approval a minimum 48 hours in advance.
 - G. Furnishings, Fixtures, and Equipment: Cooperate and permit the Owner to install his furnishings and equipment during the progress of the work. Owner's installation of furnishings or equipment does not signify Owner's acceptance of any portion of the work.

- K. Clean-Up: Frequently clean-up all waste, remove from site regularly, and legally dispose of offsite. Comply with requirements of Section 01 74 00, Construction Waste Management.
- L. Installer's Acceptance of Conditions: All installers shall inspect substrates and conditions under which work is to be executed and shall report in writing to the Contractor all conditions detrimental to the proper execution and completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means installer accepts previous work and conditions.
- M. Coordination : The Contractor shall be fully responsible for coordinating all trades, coordinating construction sequences and schedules, and coordinating the actual installed location and interface of all work.
1. Prior to beginning mechanical, electrical and fire protection work, the Contractor shall prepare coordination drawings showing the exact alignment, physical location and configuration of the mechanical, electrical and fire protection installations and demonstrating to the Contractor's satisfaction that the installations will clear all obstructions, permit proper clearances for the Work of other trades, and present an orderly appearance where exposed. The Contractor shall be solely liable and responsible for any costs and delays resulting from the Contractor's failure to prepare such coordination drawings or from the negligent preparation of such coordination drawings.
 2. Exact locations and groupings of mechanical, electrical and fire protection fixtures, switches, heads and outlets shall be obtained from the Architect before the Work is roughed in. Work installed without such information from the Architect shall be relocated at the Contractor's expense if the Architect so requests.
- 1.09 WARRANTIES
- A. Warranties Required: Refer to individual trade sections for specific product warranty requirements.
- B. Procurement: Where a warranty is required, do not purchase or subcontract for materials or work until it has been determined that parties required to countersign warranties are willing to do so.
- C. Warranty Forms: Submit written warranty to Owner through Architect for approval prior to execution. Furnish two copies of executed warranty to Owner for his records; furnish two additional conformed copies where required for maintenance manual.
- D. Work Covered: Contractor shall remove and replace other work of project which has been damaged as a result of failure of warranted work or equipment, or which must be removed and replaced to provide access to work under warranty. Unless otherwise specified, warranty shall cover full cost of replacement or repair, and shall not be pro-rated on basis of useful service life.
- E. Warranty Extensions: Work repaired or replaced under warranty shall be warranted until the original warranty expiration date or for ninety days whichever is later in time.
- F. Warranty Effective Starting Date: Guarantee period for all work, material and equipment shall begin on the date of substantial completion, not when subcontractor has completed his work nor when equipment is turned on. In addition to the one year guarantees for the entire work covered by these Contract Documents, refer to the various sections of the specifications for extended guarantee or maintenance requirements for various material and equipment.
- 1.10 TEMPORARY FACILITIES AND UTILITIES
- A. Scope of Temporary Work: This article is not intended to limit the scope of temporary work required under the Contract. Provide all temporary facilities and utilities needed.
- B. Permits and Fees: Obtain and pay for all permits, fees and charges related to temporary work.
- C. Codes and Authorities Having Jurisdiction for Temporary Facilities and Utilities: Comply with all requirements of authorities having jurisdiction, codes, utility companies, OSHA, and industry standards

including, but not limited to the following:

1. Solar Decathlon Building Code
2. NFPA Code 241, Building Construction and Demolition Operations.
3. ANSI-A10 Series, Safety Requirements for Construction and Demolition.
4. NECA National Joint Guideline NJG-6, Temporary Job Utilities and Services.
- 5 Electrical Service: NEMA, NECA, and UL.

- D. Equipment and Tools: Provide all equipment including, but not limited to, hoists, lifts, scaffolding, machines, tools and the like, as needed for execution of the work. Provide safe access to all parts of the work.
- E. Temporary Enclosures: Provide temporary enclosures to maintain proper temperatures and to prevent weather damage. Always maintain legal means of egress.
- F. Streets, Walks and Grounds: Maintain public and private roads and walks clear of debris caused by construction operations. Repair all damage caused to streets, drives, curbs, sidewalks, fences, poles and similar items where disturbed or damaged by building construction and leave them in as good condition after completion of the work as before operations started.
- G. Protection: Protect nearby property and the public from construction activities. Provide and maintain barricades, warning signs and lights, railings, walkways and similar items. Immediately repair damaged property to its condition before being damaged.
- H. Construction Fencing: Provide construction fencing and barriers as applicable to the project and as required by code to protect personnel, the public, and to control access on the Somerville, MA building site.
- I. Fire Prevention: Take every precaution to prevent fire. Provide and maintain in good operating condition suitable and adequate fire protection equipment and services, and comply with recommendations regarding fire protection made by the representative of the fire insurance company carrying insurance on the Work or by the local fire chief or fire marshal. The area within the site limits shall be kept orderly and clean, and all combustible rubbish shall be promptly removed from the site.
- J. Egress: Maintain safe and legal means of egress at all times. At all times, provide at least two separate means of egress.

1.11 DELIVERY, STORAGE AND HANDLING

- A. Manufacturer's Instructions: Strictly comply with manufacturer's instructions and recommendations and prevent damage, deterioration and loss, including theft. Minimize long term storage at the site. Maintain environmental conditions, temperature, ventilation, and humidity within range permitted by manufacturers of materials and products used.

1.12 LABELS

- A. Labels, Trademarks, & Tradenames: Locate required labels on inconspicuous surfaces. Do not provide labels, nameplates, or trademarks which are not required. Provide permanent data plate on each item of equipment stating manufacturer, model, serial number, capacity, ratings and all other essential data.
 1. All labels, trademarks, & tradenames must comply to the Solar Decathlon Building Code and Rules. Recognition of sponsors on the Mall are to be strictly adhered too.

1.13 RECORD DOCUMENTS

- A. General: Keep record documents neatly and accurately. Record information as the work progresses and deliver to Architect at time of final acceptance. Include in record documents all field changes made, all relevant dimensions, and all relevant details of the work. Keep record documents up to date with all field orders and change orders clearly indicated.

GENERAL REQUIREMENTS

01 00 00-5

- B. Drawings: One set of current, complete construction documents shall be kept and submitted to NREL for competition purposes. Neatly and accurately note all deviations from the Contract Documents and the exact actual location of the work as installed. Marked-up and colored prints will be used as a guide to determine the progress of the work installed. Requisitions for payment will not be approved until the record documents are accurate and up-to-date.
 - 1. At completion of the work, submit one complete set of marked-up prints for review. After acceptance these marked-up prints shall be used in the preparation of the record drawings.
 - 2. A record set shall be submitted to each school, the Boston Architectural College and Tufts University.
- C. Operating and Maintenance Manuals: Manuals shall be submitted which contain the following:
 - 1. Description of the system provided; mark each copy to show which choices and options are applicable to project.
 - 2. Handling, storage, and installation instructions.
 - 3. Detailed description of the function of each principal component of the systems or equipment.
 - 4. Operating procedures, including prestartup, startup, normal operation, emergency shutdown, normal shutdown and troubleshooting.
 - 5. Maintenance procedures including lubrication requirements, intervals between lubrication, preventative and repair procedures, and complete spare parts list with cross reference to original equipment manufacturer's part numbers.
 - 6. Control and alarm features including schematic of control systems, control loop electric ladder diagrams, controller operating set points, settings for alarms and shutdown systems, pump curves and fan curves.
 - 7. Safety and environmental considerations.

1.14 FINAL CLEANING AND REPAIR

- A. Clean Up: Immediately prior to the Architect's inspection for Substantial Completion, the Contractor shall completely clean the premises and clean and prepare the completed work in order for it to be used for its intended purpose in accordance with the Contract Documents. Such work shall include, but not be limited to the following:
 - 1. Concrete and ceramic surfaces shall be cleaned and washed.
 - 2. Resilient coverings shall be cleaned, waxed and buffed as applicable.
 - 3. Woodwork shall be dusted and cleaned.
 - 4. Sash, fixtures and equipment shall be thoroughly cleaned.
 - 5. Stains, spots, dust, marks and smears shall be removed from all surfaces.
 - 6. Hardware and metal surfaces shall be cleaned and polished.
 - 7. Glass and plastic surfaces shall be thoroughly cleaned by professional window cleaners.
 - 8. Damaged, broken or scratched glass or plastic shall be replaced by the Contractor at the Contractor's expense.
 - 9. Vacuum carpeted and soft surfaces with high efficiency particulate arrestor (HEPA) vacuum.
 - 10. Use low-emitting, environmentally friendly cleaning agents and procedures.
- B. Repairs: Repair and touch-up all damaged and deteriorated products and surfaces.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

END OF SECTION



SECTION 01 35 15

LEED CERTIFICATION PROCEDURES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 LEED CERTIFICATION / PROJECT GOAL

- A. The proposed project, as described in Section 01000, General Requirements, is designed to be a sustainable or "green" building, and as a result the requirements of this Section are made a part of the Contract Requirements for this Project.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).
 - 1. Comply with LEED (Leadership in Energy and Environmental Design) Green Building Rating System, LEED for Homes.
 - 2. Refer to LEED Checklist/Scorecard attached at the end of this Section.
 - 3. Refer to individual Specification Sections for additional requirements.
- C. Additional requirement information is available from:
The U.S. Green Building Council (USGBC)
1800 Massachusetts Avenue, NW
Suite 300
Washington, DC 20036
Phone (202) 828-7422
Fax (202) 828-5110
Email: leedinfo@usgbc.org
Website: www.usgbc.org

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect the work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 01 31 15, LEED Submittals; including Materials Credits Documentation Sheet.
 - 2. Section 01 57 19, Construction Indoor Air Quality (IAQ) Management.
 - 3. Section 01 74 00, Construction Waste Management.
 - 4. Section 01 91 13, Commissioning.
 - 5. Individual Specifications Sections identifying sustainable requirements.

1.04 DEFINITIONS

- A. Certificates of Chain-of-Custody: Certificates signed by manufacturers certifying that wood used to make products was obtained from forests certified by an Forest Stewardship Council (FSC)-accredited certification body to comply with FSC 1.2, "Principles and Criteria." Certificates shall include evidence that mill is certified for chain-of-custody by an FSC accredited certification body.
- B. LEED: Leadership in Energy & Environmental Design.
- C. Regionally Manufactured Materials: Materials that are manufactured within a radius of 500 miles (800 km) from the Project location. Manufacturing refers to the final assembly of components into the building product that is installed at the Project site.

LEED CERTIFICATION PROCEDURES

- D. Regionally Extracted, Harvested, or Recovered Materials: Materials that are extracted, harvested, or recovered and manufactured within a radius of 500 miles (800 km) from the Project site.
- E. Recycled Content: The percentage by weight of constituents that have been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process (preconsumer), or after consumer use (post-consumer).
 - 1. Spills and scraps from the original manufacturing process that are combined with other constituents after a minimal amount of reprocessing for use in further production of the same product are not recycled materials.
 - 2. Discarded materials from one manufacturing process that are used as constituents in another manufacturing process are pre-consumer recycled materials.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION



LEED-Homes Checklist

Curio House

Boston, MA

Yes	?+	?(-)	No		
2	4	1		Innovation and Design Process (ID)	11 Points

Y				Prereq 1	Preliminary Rating	Required
1				Credit 1.2	Integrated Project Team	1
		1		Credit 1.3	Professional Credentialed with Respect to LEED for Homes	1
	1			Credit 1.4	Design Charrette	1
1				Credit 1.5	Building Orientation for Solar Design	1
Y				Credit 2.1	Durability Planning	Required
Y				Credit 2.2	Durability Management	Required
	3			Credit 2.3	Third-Party Durability Management Verification	3
				Credit 3.1	Innovation #1	1
				Credit 3.2	Innovation #2	1
				Credit 3.3	Innovation #3	1
				Credit 3.4	Innovation #4	1

Yes	?+	?(-)	No		
				Location and Linkages (LL)	10 Points

				Credit 1	LEED for Neighborhood Development	10
				Credit 2	Site Selection	2
				Credit 3.1	Preferred Locations	1
				Credit 3.2	Infill	1
				Credit 3.3	Previously Developed	1
				Credit 4	Existing Infrastructure	1
				Credit 5.1	Basic Community Resources	1
				Credit 5.2	Extensive Community Resources	2
				Credit 5.3	Outstanding Community Resources	3
				Credit 6	Access to Open Space	1

Yes	?+	?(-)	No		
	3			Sustainable Sites (SS)	22 Points

Y				Prereq 1.1	Erosion	Required
				Credit 1.2	Minimize Disturbed Area of Site	1
Y				Prereq 2.1	No Invasive Plants	Required
				Credit 2.2	Basic Landscape Design	2
				Credit 2.3	Limit Conventional Tuft	3
				Credit 2.4	Drought Tolerant Plants	2
				Credit 2.5	Reduce Overall Irrigation Demand by at Least 20%	6
	1			Credit 3	Reduce Local Heat Island Effects	1
				Credit 4.1	Permeable Lot	4
				Credit 4.2	Permanent Erosion Control	1
				Credit 4.3	Management of Run-off from Roof	2
				Credit 5	Pest Control Alternatives	2
	2			Credit 6.1	Moderate Density	2
				Credit 6.2	High Density	3
				Credit 6.3	Very High Density	4

Yes	?+	?(-)	No		
	7	4		Water Efficiency (WE)	15 Points

	4			Credit 1.1	Rainwater Harvesting System	4
		1		Credit 1.2	Graywater Reuse System	1
				Credit 1.3	Use of Municipal Recycled Water System	3
				Credit 2.1	High Efficiency Irrigation System	3
				Credit 2.2	Third Party Inspection	1
				Credit 2.3	Reduce Overall Irrigation Demand by at Least 45%	4
	3			Credit 3.1	High-Efficiency Fixtures & Fittings	3

		3	
Yes	?+	?(-)	No

Credit 3.2 **Very High Efficiency Fixtures & Fittings**

6

2	35		
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Energy & Atmosphere (EA)

38 Points

Y			
	34		
2			
	1		
Y			
Yes	?+	?(-)	No

Prereq 1.1	Performance of ENERGY STAR for Homes	Required
Credit 1.2	Exceptional Energy Performance	34
Credit 7.1	Efficient Hot Water Distribution	2
Credit 7.2	Pipe Insulation	1
Prereq 11.1	Refrigerant Charge Test	Required
Credit 11.2	Appropriate HVAC Refrigerants	1

8	8	4	
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Materials & Resources (MR)

16 Points

Y			
	1		
	1		
	3		
		4	
Y			
8			
Y			
	3		
Yes	?+	?(-)	No

Prereq 1.1	Framing Order Waste Factor Limit	Required
Credit 1.2	Detailed Framing Documents	1
Credit 1.3	Detailed Cut List and Lumber Order	1
Credit 1.4	Framing Efficiencies	3
Credit 1.5	Off-site Fabrication	4
Prereq 2.1	FSC Certified Tropical Wood	Required
Credit 2.2	Environmentally Preferable Products	8
Prereq 3.1	Construction Waste Management Planning	Required
Credit 3.2	Construction Waste Reduction	3

1	23		
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Indoor Environmental Quality (EQ)

21 Points

	13		
Y			
	2		
Y			
	2		
Y			
	1		
Y			
Y			
	1		
1			
Y			
	1		
Y			
	3		
Yes	?+	?(-)	No

Credit 1	ENERGY STAR with Indoor Air Package	13
Prereq 2.1	Basic Combustion Venting Measures	Required
Credit 2.2	Enhanced Combustion Venting Measures	2
Credit 3	Moisture Load Control	1
Prereq 4.1	Basic Outdoor Air Ventilation	Required
Credit 4.2	Enhanced Outdoor Air Ventilation	2
Credit 4.3	Third-Party Performance Testing	1
Prereq 5.1	Basic Local Exhaust	Required
Credit 5.2	Enhanced Local Exhaust	1
Credit 5.3	Third-Party Performance Testing	1
Prereq 6.1	Room-by-Room Load Calculations	Required
Credit 6.2	Return Air Flow/Room by Room Controls	1
Credit 6.3	Third-Party Performance Testing/Multiple Zones	2
Prereq 7.1	Good Filters	Required
Credit 7.2	Better Filters	1
Credit 7.3	Best Filters	2
Credit 8.1	Indoor Contaminant Control during Construction	1
Credit 8.2	Indoor Contaminant Control	2
Credit 8.3	Preoccupancy Flush	1
Prereq 9.1	Radon-Resistant Construction in High-Risk Areas	Required
Credit 9.2	Radon-Resistant Construction in Moderate-Risk Areas	1
Prereq 10.1	No HVAC in Garage	Required
Credit 10.2	Minimize Pollutants from Garage	2
Credit 10.3	Exhaust Fan in Garage	1
Credit 10.4	Detached Garage or No Garage	3

3			
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Awareness & Education (AE)

3 Points

Y			
1			
1			
1			
Yes	?+	?(-)	No

Prereq 1.1	Basic Operations Training	Required
Credit 1.2	Enhanced Training	1
Credit 1.3	Public Awareness	1
Credit 2	Education of Building Manager	1

16	80	9	
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105 Project Totals (pre-certification estimates)

136 Points

Certified 45-59 points Silver 60-74 points Gold 75-89 points Platinum 90-136 points



SECTION 01 50 00

TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 DESCRIPTION

- A. Section includes general requirements relating to responsibilities for temporary construction facilities, controls, and environmental protection, except temporary erosion and sediment control included in Section 01 74 00.

1.02 CONSTRUCTION FACILITIES

- A. General: Temporary facilities and protective devices include, but are not necessarily limited to, temporary barricades, fences, bridges, guards, temporary utilities, steel plates over trenches, maintenance of traffic, project identification signs, and construction of haul roads.
 - 1. Use materials in construction of above-mentioned items of work of size, shape, and strength suitable for use intended.
 - 2. Conduct construction operations to cause least inconvenience possible to general public, the Commission, and its employees.
 - 3. Wherever required, erect and maintain signs, fences, barricades, and pedestrian bridges, and supply guards and flagmen for protection of public.
 - 4. Take positive measures to prevent entry of children, animals, and unauthorized adults to work site and storage areas at all times.
 - 5. Obtain Engineer's approval before transporting or locating temporary facilities within construction site.
- B. Furnish and construct temporary fencing required to fence off excavation, storage, and operating areas.
 - 1. Erect suitably constructed temporary fences, neat in appearance, and meeting Engineer's approval.
 - 2. Unless otherwise indicated, erect fences 6 feet high.
- C. Barricade or close all openings in roadways, floors, walls, or other parts of structures or walkways while openings are not in regular use.
 - 1. Use barricades substantial in character, neat in appearance, and of size and arrangement with Engineer's approval.
- D. In areas where removal of existing sidewalk is necessary, construct pedestrian bridges of suitable materials, with handrails or sides tightly boarded, following local or State requirements.
 - 1. Construct bridges with minimum width of 6 feet, or greater width to accommodate normal traffic flow at the particular location.

1.03 TEMPORARY UTILITIES

- A. Water.
 - 1. Unless otherwise specified, the Commission will furnish water required during construction period at no cost to Contractor.
 - 2. Make arrangements for, piping, backflow devices, appurtenances, and hookup required.
 - 3. Assure availability of drinking water for work force.
 - 4. Install temporary pumps, tanks, and compressors to produce required pressures.
- B. Electricity.
 - 1. Make necessary arrangements and pay for all temporary electric service and lighting required during construction period.
 - 2. Pay costs for permanent power authorized by Engineer and used during construction period through date of Contract substantial completion

TEMPORARY FACILITIES

01 50 00-1

3. Ensure electric service of sufficient capacity and characteristics to supply proper current for various types of construction tools, motors, welding machines, light, heating plant, pumps, testing, and other work required.
4. Install necessary temporary wiring, panelboards, outlets, switches, lamps, fuses, controls and accessories.

1.04 ENVIRONMENTAL PROTECTION

- A. Furnish necessary items for fulfilling work described herein for environmental protection that results directly or indirectly from Work. For erosion and sediment control see Section 01570.

1. Prevention of Water Pollution:
 - a. Take precautions in conduct of operations necessary to avoid contaminating water in adjacent watercourses or water storage areas, including wells, whether natural or man-made.
2. Conduct earthwork, moving of equipment, water control of excavations, and other operations likely to create silting to eliminate pollution of watercourses or water storage areas.
 - a. Dispose of water contaminated with oil, bitumens, harmful or objectionable chemicals, sewage, or other pollutants offsite: Federal Clean Water Act and Resource Conservation and Recovery Act.
 - b. Discharge of pollutants into any watercourse or water storage area prohibited: State of Maryland National Pollutant Discharge Elimination System.
 - c. When water from adjacent natural sources is needed, use intake methods, which avoid contaminating source of supply or becoming source of erosion or sedimentation.
3. Noise and Air Pollution Control: As to not violate following applicable ordinances, regulations, rules and laws pertaining to noise and air pollution in effect.
 - a. Rules and Regulations Governing the Control of Air Quality in the State of Maryland, COMAR 26.11., Maryland Department of the Environment.
 - b. Chapter 3, Montgomery County Code, 1972, Bill No. 42-73, Air Quality Control.
 - c. Subtitle 19, Prince George's County Code, 1999 Edition, Pollution.
 - d. Rules and Regulations Governing the Control of Noise Pollution in the State of Maryland COMAR 26.02.03, Maryland Department of the Environment.
 - e. Chapter 31B, Montgomery County Code, 1972, Bill No. 64-73, Noise Control.
4. Plant Pest Control: By soil moving or handling equipment that has operated in or will operate in regulated areas following plant quarantine regulations.
 - a. In general, these regulations require thorough cleaning of soil from equipment before it is moved from regulated areas to uninfested areas.
 - b. Obtain complete information from regional office of Plant Pest Control Division of United States Department of Agriculture.
5. Preservation of Natural Resources: In construction operations for Work, clean-up, and condition of adjacent terrain upon completion of Work, fully comply with all applicable regulations and laws concerning preservation of natural resources.
6. Dust Control: Throughout construction period, maintain dust control using water sprinklers or chemical dust control binder with Engineer's approval.

PART 2 PRODUCTS
NOT USED

PART 3 EXECUTION
NOT USED

END OF SECTION



SECTION 01 57 19

CONSTRUCTION INDOOR AIR QUALITY (IAQ) MANAGEMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Requirements for minimum indoor air quality (IAQ) performance standards during the construction period and before occupancy.
- B. With regard to these goals the Contractor shall develop, for Owner and Architect review, a Construction Indoor Air Quality Management Plan for this Project.
- C. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED REQUIREMENTS

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
 - 1. Section 01 00 00, General Requirements; Submittal requirements.
 - 2. Section 01 60 00, Product Requirements.
 - 3. Section 01 74 00, Construction Waste Management and Disposal
 - 4. Section 09 90 00, Painting.
 - 5. Division 23 – Mechanical.
 - 6. Divisions 2 through 14 & 21 through 28 Specification Sections; Specific requirements relating to indoor air quality for each Section.

1.04 PERFORMANCE REQUIREMENTS

- A. Prevent exposure of building systems to environmental tobacco smoke during construction. At a minimum, take the following measures:
 - 1. Do not allow smoking in enclosed portions of the project site.
 - 2. Locate exterior designated smoking areas at least 25 feet away from entries, outdoor air intakes and operable windows.
- B. During construction meet or exceed the minimum requirements of the recommended Control Measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 1995, Chapter 3.
- C. Protect absorptive materials from moisture damage when stored on-site and after installation.
- D. After construction ends but before occupancy, comply with one of the following requirements, per LEED EQ Cr. 3.2:
 - 1. Perform a building flush-out with outside air.
 - 2. Conduct IAQ testing for air contaminant levels in the building.

1.05 SUBMITTALS

- A. Construction Indoor Air Quality Management Plan: The Contractor shall submit a preliminary Construction IAQ Management Plan.

1. The proposed Plan shall comply with Division 15 – MECHANICAL requirements.
2. The proposed Plan shall include, but not be limited to, the following:
 - a. Protection of ventilation system components during construction.
 - b. Cleaning and replacing contaminated ventilation system components after construction, including filtration media.
 - c. Temporary ventilation.
 - d. Protection of absorptive materials from moisture damage when stored on-site and after installation, including exterior wall rain protection.
 - e. Sequence of finish installation plan.
 - f. Selection of cleaning products and procedures to be used during construction and final cleaning.
 - g. Other items as required by SMACNA IAQ Guidelines for Occupied Buildings under Construction, 1995, Chapter 3.
3. Coordinate Construction IAQ Management Plan with Owner's current IAQ management plans and procedures.
4. Comply with the requirements of LEED EQ Credits 3.1 and 3.2.

- B. Indoor Air Quality (IAQ) Data: Submit emission test data as required, with testing laboratory and date clearly identified.
- C. Material Safety Data Sheets (MSDS): Submit for materials as required, with date clearly identified. MSDS must contain specific chemical content data identifying the percent of the total product mass represented by each listed chemical.
- D. Product Data: Submit for each type of filtration media used during construction and installed immediately prior to occupancy, with MERV values clearly identified.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Take special care to prevent accumulation of moisture on materials and within packaging during delivery, storage, and handling to prevent development of mold and mildew inside packaging and on products.
- B. Immediately remove from site and properly dispose of materials showing signs of mold and mildew, including materials with moisture stains.

PART 2 PRODUCTS

2.01 FILTRATION MEDIA

- A. Filtration Media: Comply with ASHRAE 52.2-1999 and provide MERV as required.

PART 3 EXECUTION

3.01 CONSTRUCTION IAQ MANAGEMENT PLAN IMPLEMENTATION

- A. IAQ Manager: The Contractor shall designate an on-site person responsible for instructing workers and overseeing and documenting results of the Construction IAQ Management Plan for the Project.
- B. Distribution: The Contractor shall distribute copies of the Construction IAQ Management Plan to the Job Site Foreman, each subcontractor, the Owner, and the Architect.
- C. Instruction: The Contractor shall provide on-site instruction of appropriate procedures and methods to be used by all parties at the appropriate stages of the Project.

- D. Preconditioning: Allow products, which have odors and significant VOC emissions, to off-gas in a dry, well-ventilated space for sufficient period to dissipate odors and emissions prior to delivery to Project.
 - 1. Remove containers and packaging from materials prior to conditioning to maximize offgassing of VOCs.
 - 2. Condition products in ventilated warehouse or other building.
- E. Coordinate Construction IAQ Management Plan with final cleaning as indicated in Section 01 00 00, General Requirements.

END OF SECTION



SECTION 01 67 00

ENVIRONMENTAL PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. This Section includes:
 - 1. Environmental requirements for products.

1.02 DEFINITIONS

- A. Definitions pertaining to sustainable development: As defined in ASTM E2114.
- B. Biobased Materials: As defined in the Farm Security and Rural Investment Act, for purposes of Federal procurement of biobased products, "biobased" means a "commercial or industrial product (other than food or feed) that is composed, in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials." Biobased materials also include fuels, chemicals, building materials, or electric power or heat produced from biomass as defined by The Biomass Research and Development Act of 2000.
 - 1. Biobased content: The amount of biobased carbon in the material or product as a percentage of weight (mass) of the total organic carbon in the material or product.
- C. Chain-of-Custody: Process whereby a product or material is maintained under the physical possession or control during its entire life cycle.
- D. Environmentally preferable products: Products and services that have a lesser or reduced effect on the environment in comparison to conventional products and services. Refer to EPA's Final Guidance on Environmentally Preferable Purchasing for more information
www.epa.gov/epp/pubs/guidance/finalguidancetoc.htm.
- E. Stewardship: Responsible use and management of resources in support of sustainability.
- F. Sustainability: The maintenance of ecosystem components and functions for future generations.

1.03 SUBMITTAL

- A. With Record Submittals as specified in Section 01 78 53 (01780) - Sustainable Design Close-Out Documentation, submit the following:
 - 1. Affirmative Procurement Reporting Form. Submit on form in Appendix A of this Section, or similar form as approved by Owner.
 - 2. Submit environmental data in accordance with Table 1 of ASTM E2129 for the following products:
 - a. Masonry
 - b. Finish Carpentry
 - c. Plastic Fabrications
 - d. Building Insulation
 - e. Roofing
 - f. Joint Sealers
 - g. Wood & Plastic Doors
 - h. Windows
 - i. Skylights
 - j. Glazed Curtain Wall

ENVIRONMENTAL PRODUCT REQUIREMENTS

01 67 00-1

- k. Gypsum Board
 - l. Tile
 - m. Acoustical Ceilings
 - n. Resilient Flooring
 - o. Carpet
 - p. Wall Coverings
 - q. Paints & Coatings
 - r. Toilet Compartments
 - s. Furnishings & Accessories
 - t. Renewable Energy Equipment
 - u. Plumbing fixtures and equipment
 - v. HVAC equipment
 - w. Lighting equipment
3. Material Safety Data Sheets (MSDS): For each product required by OSHA to have a MSDS, submit an MSDS. MSDS shall be prepared within the last five years. Include information for MSDS Sections 1 - 16 in accordance with ANSI Z400.1 and as follows:
- a. Section 1: Chemical Product and Company Identification.
 - b. Section 2: Composition/Information on Ingredients.
 - c. Section 3: Hazards Identification.
 - d. Section 4: First Aid Measures.
 - e. Section 5: Fire Fighting Measures.
 - f. Section 6: Accidental Release Measures.
 - g. Section 7: Handling and Storage.
 - h. Section 8: Exposure Controls/Person Protection.
 - i. Section 9: Physical and Chemical Properties.
 - j. Section 10: Stability and Reactivity Data.
 - k. Section 11: Toxicological Information. Include data used to determine the hazards cited in Section 3. Identify acute data, carcinogenicity, reproductive effects, and target organ effects.
 - l. Section 12: Ecological Information. Include data regarding environmental impacts during raw materials acquisition, manufacture, and use. Include data regarding environmental impacts in the event of an accidental release.
 - m. Section 13: Disposal Considerations. Include data regarding the proper disposal of the chemical. Include information regarding recycling and reuse. Indicate whether or not the product is considered to be "hazardous waste" according to the US EPA Hazardous Waste Regulations 40 CFR 261.
 - n. Section 14: Transportation Information. Identify hazard class for shipping.
 - o. Section 15: Regulatory Information. Identify federal, state, and local regulations applicable to the material.
 - p. Section 16: Other Information. Include additional information relative to recycled content, biobased content, and other information regarding environmental and health impacts.
4. Chain Of Custody: Submit chain-of-custody documentation for sustainable forestry for the following products:
- a. Rough Carpentry
 - b. Finish Carpentry
 - c. Wood Doors
 - d. Windows
 - e. Wood Flooring
 - f. Furnishings & Accessories

1.04 SUBSTITUTIONS

- A. Notify Owner when Contractor is aware of materials, equipment, or products that meet the aesthetic and programmatic intent of Contract Documents, but which are more environmentally responsible than materials, equipment, or products specified or indicated in the Contract Documents.
1. Requirements of Section 01 60 00 (01600), Product Requirements apply except prior to submitting detailed information required under Section 01 60 00 (01600), submit the following for initial review by Owner and Architect:
- a. Product data including manufacturer's name, address, and phone number.
 - b. Description of environmental advantages of proposed substitution over specified product.

1.05 PACKAGING

- A. Where Contractor has the option to provide one of the listed products or equal, preference shall be given to products with minimal packaging and easily recyclable packaging as defined in ASTM D5834.
- B. Maximize use of source reduction and recycling procedures outlined in ASTM D5834.
- C. Provide minimum 50% post-consumer recycled content and minimum 100% recovered fiber content of industrial paperboard in accordance with EPA's Comprehensive Procurement Guidelines and ASTM D5663.
- D. Provide minimum 25 % post-consumer recycled content and minimum 100% recovered fiber content of carrier board accordance with EPA's Comprehensive Procurement Guidelines and ASTM D5663.
- E. Provide minimum 25% post-consumer recycled content and minimum 100% recovered fiber content of brown papers (e.g. wrapping papers and bags) in accordance with EPA's Comprehensive Procurement Guidelines and ASTM D5663.

1.06 ENVIRONMENTALLY PREFERABLE PRODUCTS

- A. Provide environmentally preferable products to the greatest extent possible.
1. To the greatest extent possible, provide products and materials that have a lesser reduced effect on the environment considering raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, and/or disposal of the product.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION



SECTION 01 74 00

CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 SUMMARY

- A. This Section specifies requirements for the Contractor's implementation of waste management controls and systems for the duration of the Work.
- B. The intent of this Section is to develop and implement a waste management plan, quantifying material diversion by weight to recycle and/or salvage at least 75 percent (LEED Certification MR 2.2) (by weight) of construction, demolition, and land clearing waste.
 - 1. Innovation in Design Credit Requirement: Material diversion of at least 95 percent.

1.03 INTENT

- A. The Owner and Architect have established that this Project shall generate the least amount of waste practical and that processes that ensure the generation of as little waste as possible due to error, poor planning, breakage, mishandling, contamination, or other factors shall be employed.
- B. Of the waste that is generated, as many of the waste materials as economically feasible shall be reused, salvaged, or recycled. Waste disposal in landfills shall be minimized to the greatest extent practical.
- C. With regard to these goals the Contractor shall develop, for the Architect's review, a Waste Management Plan for this Project.
- D. Each Subcontractor shall be responsible for segregating his own waste into different dumpsters as directed by the Contractor.
- E. Contractor shall be responsible for ensuring that debris will be disposed of at appropriately designated licensed solid waste disposal facilities, as defined by local authorities having jurisdiction.

1.04 SUBMITTALS

- A. Waste Management Plan: the Contractor shall provide a plan containing the following:
 - 1. Analysis of the proposed jobsite waste to be generated, including types and rough quantities.
 - 2. Landfill Options: The name of the landfills where trash and building debris will be disposed of, the applicable landfill tipping fees, and the projected cost of disposing of all Project waste in the landfills.
 - 3. Landfill Certification: Contractor's statement of verification that landfills proposed for use are licensed for types of waste to be deposited and have sufficient capacity to receive waste from this project.
 - 4. Alternatives to Landfilling: A list of each material proposed to be salvaged or recycled during the course of the Project. Include the following and any additional items proposed:
 - a. Cardboard.
 - b. Clean dimensional wood.
 - c. Beverage containers.
 - d. Concrete.
 - e. Bricks and masonry.
 - f. Asphalt.
 - g. Metals from framing, banding, stud trim, ductwork, piping, rebar, roofing, other trim, steel, iron, galvanized sheet steel, stainless steel, aluminum, copper, zinc, lead, brass, and bronze.

CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

- h. Glass.
 - i. Mechanical and electrical equipment.
 - j. Building components which can be removed relatively intact from existing construction.
 - k. Packaging materials.
 - l. Scraps from new gypsum wall board.
 - m. Carpet and pad.
 - n. Acoustical ceiling panels.
 - o. Plastics.
 - 5. Meetings: A description of the regular meetings to be held to address waste management.
 - 6. Materials Handling Procedures: A description of the means by which any waste materials identified above will be protected from contamination, and a description of the means to be employed in recycling the above materials consistent with requirements for acceptance by designated facilities.
 - 7. Transportation: A description of the means of transportation of the recyclable materials (whether materials will be site-separated and self-hauled to designated centers, or whether mixed materials will be collected by a waste hauler and removed from the site) and destination of materials.
 - 8. Waste Management Plan per the Document following this Section.
- B. Waste Management Progress Report: Concurrent with each Application for Payment, submit a written Waste Management Progress Report in the same format as required for Final Report.
- C. Waste Management Final Report: Prior to Substantial Completion, submit a written Waste Management Final Report summarizing the types and quantities of materials recycled and disposed of under the Waste Management Plan. Include the name and location of disposal facilities. Quantity may be measured by either weight or volume; be consistent in calculations. Include the following:
- 1. Material category.
 - 2. Generation point of waste.
 - 3. Total quantity of waste, by weight.
 - 4. Quantity of waste salvaged, both estimated and actual.
 - 5. Quantity of waste recycled, both estimated and actual.
 - 6. Total quantity of waste recovered (salvaged plus recycled).
 - 7. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.
- D. Other Submittals:
- 1. Records of Donations: Indicate receipt and acceptance of salvageable waste donated to individuals and organizations. Indicate whether organization is tax exempt.
 - 2. Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals and organizations. Indicate whether organization is tax exempt.
 - 3. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
 - 4. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
 - 5. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.
- 1.06 CONTRACTOR
- A. Contractor may subcontract work of this Section to a sub-contractor specializing in recycling and salvaging of construction waste.
- B. Acoustical Ceiling Panel Recycling: Demolition and construction waste pulpable mineral fiber ceiling panels may be recycled by Armstrong World Industries. Contact Armstrong at 1-877-ARMSTRONG (1-877-

276-7876) or visit www.armstrong.com to coordinate recycling efforts, apply for product approvals, and receive reclamation procedure requirements.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 RECYCLING

- A. Metal, including but not limited to aluminum stairs, structural beams and sections, and reinforcing steel shall be recycled.
- B. Wood that is not painted and does not contain preservatives (i.e. creosote, arsenic, and chromium-containing preservatives) shall be segregated and recycled.

3.02 WASTE MANAGEMENT PLAN IMPLEMENTATION

- A. Manager: The Contractor shall designate an on-site person responsible for instructing workers and overseeing and documenting results of the Waste Management Plan for the Project.
- B. Distribution: The Contractor shall distribute copies of the Waste Management Plan to the Job Site Foreman, each Subcontractor, the Owner and the Architect.
- C. Instruction: The Contractor shall provide on-site instruction of appropriate separation, handling, and recycling, salvage, reuse, and return methods to be used by all parties at the appropriate stages of the Project.
- D. Separation Facilities: The Contractor shall lay out and label a specific area to facilitate separation of materials for recycling, salvage, reuse, and return. Recycling and waste bin areas are to be kept neat and clean and clearly marked in order to avoid contamination of materials. Location shall be acceptable to the Architect.
- E. Hazardous Wastes: Any unforeseen hazardous wastes shall be separated, stored, and disposed of according to local regulations and as directed by the Owner.

END OF SECTION



SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. General Notes, Sections, Plans, Typical Details, and other notes indicated on the structural drawings. In cases of conflict, information indicated on the structural drawings shall govern.

1.02 SUMMARY

- A. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:
 - 1. Footings.
 - 2. Foundation walls.
 - 3. Slabs-on-grade.
 - 4. Concrete toppings.
- B. Related Sections include the following:
 - 1. Division 2 Section "Earthwork" for drainage fill under slabs-on-grade.

1.03 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Indicate amounts of mixing water to be withheld for later addition at Project site.
- C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.
- D. Qualification Data: For Installer, manufacturers, and testing agency.
- E. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
 - 1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
- F. Material Certificates: For each of the following, signed by manufacturers:
 - 1. Cementitious materials.
 - 2. Admixtures.

CAST-IN-PLACE CONCRETE

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3. Form materials and form-release agents.
4. Steel reinforcement and accessories.
5. Waterstops.
6. Curing compounds.
7. Floor and slab treatments.
8. Bonding agents.
9. Adhesives.
10. Vapor retarders.
11. Semirigid joint filler.
12. Repair materials.

G. Floor surface flatness and levelness measurements to determine compliance with specified tolerances.

H. Field quality-control test and inspection reports.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

C. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures through one source from a single manufacturer.

E. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301, "Specification for Structural Concrete," Sections 1 through 5 and Section 7, "Lightweight Concrete."
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

F. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

G. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:
 - a. Contractor's superintendent.

- b. Independent testing agency responsible for concrete design mixtures.
 - c. Ready-mix concrete manufacturer.
 - d. Concrete subcontractor.
 - 2. Review special inspection and testing and inspecting agency procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, and joint-filler strips, semirigid joint fillers, forms and form removal limitations, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.
- 1.06 DELIVERY, STORAGE, AND HANDLING
- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.
 - B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 PRODUCTS

2.01 FORM-FACING MATERIALS

- A. Smooth-Formed Finished Concrete: Form-facing panels that will provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
 - 1. Plywood, metal, or other approved panel materials.
 - 2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
 - a. High-density overlay, Class 1 or better.
 - b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
 - c. Structural 1, B-B or better; mill oiled and edge sealed.
 - d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.
- B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.
- D. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.
- E. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
 - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
- F. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
 - 1. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.
 - 2. Furnish ties that, when removed, will leave holes no larger than 1 inch in diameter in concrete surface.
 - 3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.02 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Weldable reinforcing bars: A706/A706M-05a Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

- C. Plain-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from as-drawn steel wire into flat sheets.
- 2.03 REINFORCEMENT ACCESSORIES
- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 - 1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
- 2.04 CONCRETE MATERIALS
- A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
 - 1. Portland Cement: ASTM C 150, Type I/II, gray.
 - B. Normal-Weight Aggregates: ASTM C 33, Class 3S coarse aggregate or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.
 - 1. Maximum Coarse-Aggregate Size: 3/4 inch nominal.
 - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
 - C. Lightweight Aggregate: ASTM C 330, 1/2-inch nominal maximum aggregate size.
 - D. Water: ASTM C 94/C 94M and potable.
- 2.05 ADMIXTURES
- A. Air-Entraining Admixture: ASTM C 260.
 - B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
 - 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - 2. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
- 2.06 WATERSTOPS
- A. Flexible PVC Waterstops: CE CRD-C 572, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
- 2.07 VAPOR RETARDERS
- A. Plastic Vapor Retarder: ASTM E 1745, Class A. Include manufacturer's recommended adhesive or pressure-sensitive tape.
 - B. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448, Size 57, with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.
- 2.08 CURING MATERIALS
- A. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.
 - B. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

2.09 RELATED MATERIALS

- A. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 aromatic polyurea with a Type A shore durometer hardness range of 90 to 95 per ASTM D 2240.
- B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
 - 1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- D. Dovetail Anchor Slots: Hot-dip galvanized steel sheet, not less than 0.0336 inch thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.10 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
 - 2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by underlayment manufacturer.
 - 4. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C 109/C 109M.
- B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C 150, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
 - 2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
 - 4. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C 109/C 109M.

2.11 CONCRETE MIXTURES, GENERAL

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.
- B. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- C. Admixtures: Use admixtures according to manufacturer's written instructions.
 - 1. Use water-reducing or high-range water-reducing admixture in concrete, as required, for placement and workability.
 - 2. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.

2.12 CONCRETE MIXTURES FOR BUILDING ELEMENTS

- A. Footings, Foundation Walls, Slabs on Grade: Proportion normal-weight concrete mixture as follows:

1. Minimum Compressive Strength: 4000 psi at 28 days.
2. Maximum Water-Cementitious Materials Ratio: 0.45.
3. Slump Limit: 4 inches, plus or minus 1 inch.
4. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery for 3/4-inch nominal maximum aggregate size (applies to footings and foundation walls, and all other concrete exposed to freeze/thaw action).

B. Topping Slabs: Proportion structural lightweight concrete mixture as follows:

1. Minimum Compressive Strength: 4000 psi at 28 days.
2. Calculated Equilibrium Unit Weight: 110 lb/cu. ft., plus or minus 3 lb/cu. ft. as determined by ASTM C 567.
3. Slump Limit: 4 inches, plus or minus 1 inch.
4. Air Content: 6 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size greater than 3/8 inch.
5. Air Content: 7 percent, plus or minus 2 percent at point of delivery for nominal maximum aggregate size 3/8 inch or less.
6. Air Content: Do not allow air content of troweled finished floors to exceed 3 percent.

2.13 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.14 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 EXECUTION

3.01 FORMWORK

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.
- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
1. Class A, 1/8 inch for smooth-formed finished surfaces.
 2. Class B, 1/4 inch for rough-formed finished surfaces.
- D. Construct forms tight enough to prevent loss of concrete mortar.
- E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
1. Install keyways, reglets, recesses, and the like, for easy removal.
 2. Do not use rust-stained steel form-facing material.
- F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
- G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

- H. Chamfer exterior corners and edges of permanently exposed concrete.
 - I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
 - J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
 - K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
 - L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.
- 3.02 EMBEDDED ITEMS
- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."
 - 2. Install dovetail anchor slots in concrete structures as indicated.
- 3.03 REMOVING AND REUSING FORMS
- A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
 - 1. Leave formwork for beam soffits, joists, slabs, and other structural elements that supports weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
 - 2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
 - B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.
 - C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.
- 3.04 VAPOR RETARDERS
- A. Plastic Vapor Retarders: Place, protect, and repair vapor retarders according to ASTM E 1643 and manufacturer's written instructions.
 - 1. Lap joints 6 inches and seal with manufacturer's recommended tape.
 - B. Granular Course: Cover vapor retarder with granular fill, moisten, and compact with mechanical equipment to elevation tolerances of plus 0 inch or minus 3/4 inch.
- 3.05 STEEL REINFORCEMENT
- A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.
 - 1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.
 - C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
 - D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
 - E. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.
- 3.06 JOINTS
- A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.
 - B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
 2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
 3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
 6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 7. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:
 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
- 3.07 WATERSTOPS
- A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.
- 3.08 CONCRETE PLACEMENT
- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

- B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.
 - C. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
 - 1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
 - 2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
 - 3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.
 - D. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
 - 1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 - 2. Maintain reinforcement in position on chairs during concrete placement.
 - 3. Screed slab surfaces with a straightedge and strike off to correct elevations.
 - 4. Slope surfaces uniformly to drains where required.
 - 5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.
 - E. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 1. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
 - 2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
 - F. Hot-Weather Placement: Comply with ACI 301 and as follows:
 - 1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 - 2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.
- 3.09 FINISHING FORMED SURFACES
- A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.
 - 1. Apply to concrete surfaces not exposed to public view.
 - B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to public view,.

- C. Rubbed Finish: Apply the following to smooth-formed finished as-cast concrete where indicated:
 - 1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
- D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.10 FINISHING FLOORS AND SLABS

- A. General: Comply with ACI 302.1R recommendations for screeding, restraighening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture.
 - 1. Apply float finish to surfaces indicated by architect.
- C. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 - 1. Apply a trowel finish to surfaces indicated by architect.
 - 2. Finish surfaces to the following tolerances, according to ASTM E 1155, for a randomly trafficked floor surface:
 - a. Specified overall values of flatness, F(F) 25; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and of levelness, F(L) 15.

3.11 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures, unless otherwise indicated, after work of other trades is in place. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.
- D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel-finish concrete surfaces.

3.12 CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

- B. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.
 - C. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
 - D. Cure concrete according to ACI 308.1, by one or a combination of the following methods:
 - 1. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.
- 3.13 JOINT FILLING
- A. Prepare, clean, and install joint filler according to manufacturer's written instructions.
 - 1. Defer joint filling until concrete has aged at least one month(s). Do not fill joints until construction traffic has permanently ceased.
 - B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joint clean and dry.
 - C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.
- 3.14 CONCRETE SURFACE REPAIRS
- A. Defective Concrete: Repair and patch defective areas when approved by Architect. Remove and replace concrete that cannot be repaired and patched to Architect's approval.
 - B. Patching Mortar: Mix dry-pack patching mortar, consisting of one part portland cement to two and one-half parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.
 - C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
 - 1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension in solid concrete, but not less than 1 inch in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
 - 2. Repair defects on surfaces exposed to view by blending white portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 - 3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Architect.
 - D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
 - 1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
 - 2. After concrete has cured at least 14 days, correct high areas by grinding.
 - 3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent

concrete.

4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
6. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
7. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.15 FIELD QUALITY CONTROL

A. Testing and Inspecting: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.

B. Inspections:

1. Steel reinforcement placement.
2. Headed bolts and studs.
3. Verification of use of required design mixture.
4. Concrete placement, including conveying and depositing.
5. Curing procedures and maintenance of curing temperature.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
 - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; ASTM C 173/C 173M, volumetric method, for structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
5. Unit Weight: ASTM C 567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.

6. Compression Test Specimens: ASTM C 31/C 31M.
 - a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
 7. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.
 - a. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
 8. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
 9. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
 10. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
 11. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Architect.
 12. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 13. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- D. Measure floor and slab flatness and levelness according to ASTM E 1155 within 24 hours of finishing.

END OF SECTION



SECTION 05 12 00

STRUCTURAL STEEL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Structural steel.
 - 2. Grout.
- B. Related Sections include the following:
 - 1. Division 1 Section "Quality Requirements" for independent testing agency procedures and administrative requirements.
 - 2. Division 5 Section "Metal Fabrications" for steel lintels or shelf angles not attached to structural-steel frame miscellaneous steel fabrications and other metal items not defined as structural steel.
 - 4. Division 9 painting Sections and Division 9 Section "High-Performance Coatings" for surface preparation and priming requirements.
 - 5. Division Section "Metal Building Systems" for structural steel.

1.03 DEFINITIONS

- A. Structural Steel: Elements of structural-steel frame, as classified by AISC's "Code of Standard Practice for Steel Buildings and Bridges," that support design loads.

1.04 PERFORMANCE REQUIREMENTS

- A. Connections: Provide details of simple shear connections required by the Contract Documents to be selected or completed by structural-steel fabricator to withstand ASD-service loads indicated and comply with other information and restrictions indicated.
 - 1. Select and complete connections using schematic details indicated and AISC's "Manual of Steel Construction, Allowable Stress Design," Part 4.
 - 2. Engineering Responsibility: Fabricator's responsibilities include using a qualified professional engineer to prepare structural analysis data for structural-steel connections.

1.05 SUBMITTALS

- A. Shop Drawings: Show fabrication of structural-steel components.
 - 1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
 - 2. Include embedment drawings.
 - 3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
 - 4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical high-strength bolted connections.
 - 5. For structural-steel connections indicated to comply with design loads, include structural analysis data prepared by the qualified professional engineer responsible for their preparation.

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- B. Welding certificates:
 - 1. Qualification Data: For Installer and fabricator.
- 1.06 QUALITY ASSURANCE
- A. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category CSE.
 - B. Fabricator Qualifications: A qualified fabricator who participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category Sbd.
 - C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."
 - D. Comply with applicable provisions of the following specifications and documents:
 - 1. AISC's "Code of Standard Practice for Steel Buildings and Bridges."
 - 2. AISC's "Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design."
 - 3. AISC's "Specification for the Design of Steel Hollow Structural Sections."
 - 4. AISC's "Specification for Allowable Stress Design of Single-Angle Members."
 - 5. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- 1.07 DELIVERY, STORAGE, AND HANDLING
- A. 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. Protect steel members and packaged materials from erosion and deterioration.
 - 1. Store fasteners in a protected place. Clean and relubricate bolts and nuts that become dry or rusty before use.
 - 2. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
- 1.08 COORDINATION
- A. Furnish anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

PART 2 PRODUCTS

2.01 STRUCTURAL-STEEL MATERIALS

- A. W-Shapes: ASTM A 992/A 992M.
- B. Channels, Angles, M , S-Shapes: ASTM A 572/A 572M, Grade 50.
- C. Plate and Bar: ASTM A 36/A 36M.
- D. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B C, structural tubing.
- E. Welding Electrodes: Comply with AWS requirements.

2.02 BOLTS, CONNECTORS, AND ANCHORS

- A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy hex steel structural bolts; ASTM A 563 heavy hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers.
- B. Headed Anchor Rods: ASTM F 1554, Grade 55, weldable, straight.
 - 1. Nuts: ASTM A 563 heavy hex carbon steel.
 - 2. Plate Washers: ASTM A 36/A 36M carbon steel.
 - 3. Washers: ASTM F 436 hardened carbon steel.

2.03 PRIMER

- A. Primer: Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer.
 - B. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20 ASTM A 780.
- 2.04 GROUT
- A. Cement Grout: Portland cement, ASTM C 150, Type I; and clean, natural sand, ASTM C 404, Size No. 2. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- 2.05 FABRICATION
- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC's "Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design."
 - 1. Camber structural-steel members where indicated.
 - 2. Identify high-strength structural steel according to ASTM A 6/ A 6M and maintain markings until structural steel has been erected.
 - 3. Mark and match-mark materials for field assembly.
 - 4. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
 - B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
 - 1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1.
 - C. Bolt Holes: Cut, drill, mechanically thermal cut, or punch standard bolt holes perpendicular to metal surfaces.
 - D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
 - E. Holes: Provide holes required for securing other work to structural steel and for passage of other work through steel framing members.
 - 1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
 - 2. Base-Plate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
 - 3. Weld threaded nuts to framing and other specialty items indicated to receive other work.
- 2.06 SHOP CONNECTIONS
- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
 - 1. Joint Type: Snug tightened.
 - B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.
- 2.07 SHOP PRIMING
- A. Shop prime steel surfaces except the following:
 - 1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
 - 2. Surfaces to be field welded.
 - 3. Surfaces to receive sprayed fire-resistive materials.
 - 4. Galvanized surfaces.
 - B. Painting: Apply a 1-coat, nonasphaltic primer complying with SSPC-PS Guide 7.00, "Painting System Guide 7.00: Guide for Selecting One-Coat Shop Painting Systems," to provide a dry film thickness of not less than 1.5 mils.

- 2.08 GALVANIZING
- A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A 123/ A 123M.
1. Fill vent holes and grind smooth after galvanizing.
 2. Galvanize lintels attached to structural-steel frame and located in exterior walls.
- 2.09 SOURCE QUALITY CONTROL
- A. Owner will engage an independent testing and inspecting agency to perform shop tests and inspections and prepare test reports.
1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
- B. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
- C. Bolted Connections: Shop-bolted connections will be inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- D. Welded Connections: In addition to visual inspection, shop-welded connections will be tested and inspected according to AWS D1.1 and the following inspection procedures, at testing agency's option:
1. Liquid Penetrant Inspection: ASTM E 165.
 2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 3. Ultrasonic Inspection: ASTM E 164.
 4. Radiographic Inspection: ASTM E 94.

PART 3 EXECUTION

- 3.01 EXAMINATION
- A. Verify elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments, with steel erector present, for compliance with requirements.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- 3.02 PREPARATION
- A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place, unless otherwise indicated.
- 3.03 ERECTION
- A. Set structural steel accurately in locations and to elevations indicated and according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and "Specification for Structural Steel Buildings-- Allowable Stress Design and Plastic Design."
- B. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting base and bearing plates. Clean bottom surface of base and bearing plates.
1. Set base and bearing plates for structural members on wedges, shims, or setting nuts as required.
 2. Weld plate washers to top of base plate.
 3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of base or bearing plate before packing with grout.

4. Promptly pack grout solidly between bearing surfaces and base or bearing plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure.
 - C. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."
 - D. Align and adjust various members forming part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
 1. Level and plumb individual members of structure.
 - E. Do not use thermal cutting during erection.
 - F. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
- 3.04 FIELD CONNECTIONS
- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
 1. Joint Type: Snug tightened.
 - B. Weld Connections: Comply with AWS D1.1 for welding procedure specifications, tolerances, appearance, and quality of welds and for methods used in correcting welding work.
 1. Comply with AISC's "Code of Standard Practice for Steel Buildings and Bridges" and "Specification for Structural Steel Buildings--Allowable Stress Design and Plastic Design" for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.
- 3.05 FIELD QUALITY CONTROL
- A. Testing Agency: Engage a qualified independent testing and inspecting agency to inspect field welds and high-strength bolted connections.
 - B. Bolted Connections: Shop-bolted connections will be inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
 - C. Welded Connections: Field welds will be visually inspected according to AWS D1.1.
 1. In addition to visual inspection, field welds will be tested according to AWS D1.1 and the following inspection procedures, at testing agency's option:
 - a. Liquid Penetrant Inspection: ASTM E 165.
 - b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - c. Ultrasonic Inspection: ASTM E 164.
 - d. Radiographic Inspection: ASTM E 94.
 - D. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
- 3.06 REPAIRS AND PROTECTION
- A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
 - B. Touchup Painting: After installation, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted joists and accessories, bearing plates, and abutting structural steel.

1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.
2. Apply a compatible primer of same type as shop primer used on adjacent surfaces.

C. Touchup Painting: Cleaning and touchup painting are specified in Division 9 painting Sections.

END OF SECTION



SECTION 05 20 00

STEEL JOISTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Open-web K-series steel joists.
 - 2. Joist accessories.
- B. Related Sections include the following:
 - 1. Division 3 Section "Cast-in-Place Concrete" for installing bearing plates in concrete.
 - 2. Division 9 Section "Painting" for prime painting.

1.03 SUBMITTALS

- A. Product Data: For each type of joist, accessory, and product indicated.
- B. Shop Drawings: Show layout, mark, number, type, location, and spacings of joists. Include joining and anchorage details, bracing, bridging, accessories; splice and connection locations and details; and attachments to other construction.
 - 1. Indicate locations and details of anchorage devices and bearing plates to be embedded in other construction.
- C. Welding Certificates: Copies of certificates for welding procedures and personnel.
- D. Mill certificates signed by manufacturers of bolts certifying that their products comply with specified requirements.
- E. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- F. Research/Evaluation Reports: Evidence of steel joists' compliance with building code in effect for Project, from a model code organization acceptable to authorities having jurisdiction.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in manufacturing joists similar to those indicated for this Project and with a record of successful in-service performance.
 - 1. Manufacturer must be certified by SJI to manufacture joists complying with SJI standard specifications and load tables.

STEEL JOISTS

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- B. SJI Specifications: Comply with SJI's "Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders" (hereafter, "Specifications"), applicable to types of joists indicated.
- C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel"; and AWS D1.3 "Structural Welding Code--Sheet Steel."
- 1.05 DELIVERY, STORAGE, AND HANDLING
 - A. Deliver, store, and handle joists as recommended in SJI's "Specifications."
 - B. Protect joists from corrosion, deformation, and other damage during delivery, storage, and handling.
- 1.06 SEQUENCING
 - A. Deliver steel bearing plates and other devices to be built into concrete and masonry construction.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Steel: Comply with SJI's "Specifications" for chord and web members.
- B. Steel Bearing Plates: ASTM A 36/A 36M.
- C. Welding Electrodes: Comply with AWS standards.
- D. Galvanizing Repair Paint: SSPC-Paint 20

2.02 PRIMERS

- A. Primer: SSPC-Paint 15, Type I, red oxide; FS TT-P-636, red oxide; or manufacturer's standard shop primer complying with performance requirements of either of these red-oxide primers.

2.03 OPEN-WEB K-SERIES STEEL JOISTS

- A. Manufacture steel joists according to "Standard Specifications for Open Web Steel Joists, K-Series," in SJI's "Specifications," with steel-angle top- and bottom-chord members, underslung ends, and parallel top chord; of joist type indicated.
 - 1. Joist Type: K-series steel joists.
- B. Comply with AWS requirements and procedures for shop welding, appearance, quality of welds, and methods used in correcting welding work.
- C. Provide holes in chord members for connecting and securing other construction to joists.
- D. Do not camber joists.
- E. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches.

2.04 JOIST ACCESSORIES

- A. Bridging: Schematically indicated. Detail and fabricate according to SJI's "Specifications."
 - 1. Furnish additional erection bridging if required.
- B. Fabricate steel bearing plates with integral anchorages of sizes and thicknesses indicated. Shop prime paint.
- C. Supply ceiling extensions, either extended bottom-chord elements or a separate extension unit of enough strength to support ceiling construction. Extend ends to within 1/2 inch of finished wall surface, unless otherwise indicated.

- D. Supply miscellaneous accessories, including splice plates and bolts required by joist manufacturer to complete joist installation.
- 2.05 CLEANING AND SHOP PAINTING
- A. Clean and remove loose scale, heavy rust, and other foreign materials from fabricated joists and accessories to be primed by hand-tool cleaning, SSPC-SP 2 or power-tool cleaning, SSPC-SP 3.
 - B. Do not prime paint joists and accessories to receive sprayed fire-resistive materials.
 - C. Apply one shop coat of primer to joists and joist accessories to be primed to provide a continuous, dry paint film not less than 1 mil thick.
 - D. Painting of joists and joist accessories is specified in Division 9 Section "Painting."

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine supporting substrates, embedded bearing plates, and abutting structural framing, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Do not install joists until supporting construction is in place and secured.
- B. Install joists and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Specifications," joist manufacturer's written recommendations, and requirements in this Section.
 - 1. Before installation, splice joists delivered to Project site in more than one piece.
 - 2. Space, adjust, and align joists accurately in location before permanently fastening.
 - 3. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.
 - 4. Delay rigidly connecting bottom-chord extensions to columns or supports until dead loads have been applied.
- C. Field weld joists to supporting steel bearing plates. Coordinate welding sequence and procedure with placement of joists. Comply with AWS requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
- D. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.

3.03 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to inspect field welds.
- B. Field welds will be visually inspected according to AWS D1.1.
- C. In addition to visual inspection, field welds will be tested according to AWS D1.1 and the following procedures, as applicable:
 - 1. Radiographic Testing: ASTM E 94 and ASTM E 142.
 - 2. Magnetic Particle Inspection: ASTM E 709.
 - 3. Ultrasonic Testing: ASTM E 164.

- D. Correct deficiencies in Work that inspections and test reports have indicated are not in compliance with specified requirements.
 - E. Additional testing will be performed to determine compliance of corrected Work with specified requirements.
- 3.04 REPAIRS AND PROTECTION
- A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
 - B. Touchup Painting: After installation, promptly clean, prepare, and prime or reprime field connections, rust spots, and abraded surfaces of prime-painted joists and accessories, bearing plates and abutting structural steel.
 - 1. Clean and prepare surfaces by hand-tool cleaning, SSPC-SP 2, or power-tool cleaning, SSPC-SP 3.
 - 2. Apply a compatible primer of the same type as the shop primer used on adjacent surfaces.
 - C. Touchup Painting: Cleaning and touchup painting are specified in Division 9 Section "Painting."
 - D. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure joists and accessories are without damage or deterioration at time of Substantial Completion.

END OF SECTION



SECTION 05 40 00

COLD-FORMED METAL FRAMING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Metal framing for lateral support of raised platforms, where indicated. Include incidental blocking, bridging and related accessories for items supported in or by framing as required by project conditions.
- B. Refer to Structural Drawings for additional requirements for cold formed metal framing.
- C. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; framing for support of platforms.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations, and recommendations for each material used. Provide certifications stating that materials comply with requirements.
- B. Shop Drawings: Provide large scale shop drawings for fabrication, installation and erection of all parts of the work. Provide plans, elevations, and details of anchorages, connections and accessory items. Provide installation templates for work installed by others.
 - 1. Shop drawings shall illustrate materials, shop coatings, steel thicknesses, details of fabrication, details of attachment to adjoining work, size, location, and spacing fasteners for attaching framing to itself, details of attachment to the structure, accessories and their installation, and critical installation procedures.
- C. Field Measurements: Take accurate field measurements before preparation of shop drawings and fabrication. Do not delay job progress; allow for field cutting and fitting where taking field measurements before fabrication is not possible. Do not field cut or fit items which have been hot-dip galvanized after fabrication.
- D. Calculations: Provide professionally prepared calculations and certification of the performance of this work. Show how design load requirements and other performance criteria have been satisfied.
- E. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

COLD-FORMED METAL FRAMING

05 40 00-1

- A. Engineering: Provide the services of a Professional Engineer, who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated, to design and certify that the work of this section meets or exceeds the performance requirements specified in this section. Calculate structural properties of studs and assemblies in accordance with American Iron and Steel Institute (AISI) "Specification for Design of Cold-Formed Steel Structural Members."
 - 1. All connections including member to member, and member to structure shall be designed.
 - 2. Wall bridging shall be designed to provide resistance to minor axis bending and rotation of wall studs.
 - B. Shop fabricate work to the greatest extent possible. Clearly label pieces in shop to facilitate field assembly.
 - C. Use qualified welders and comply with American Welding Society (AWS) D1.3, "Structural Welding Code - Sheet Steel."
 - D. Materials which are rusted, dented, bent or twisted shall be removed from the job site immediately.
- 1.06 ENVIRONMENTAL REQUIREMENTS
- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
 - 1. Steel Framing: 22.6% of 20% post-consumer and 8.4% of 40% post-industrial; total 32% recycled content.
 - B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
- 1.07 DELIVERY, STORAGE AND HANDLING
- A. Store work off of the ground and under cover. Protect from damage. Sequence deliveries to avoid delays, but minimize on-site storage.
 - B. Store materials on a flat plane.
- PART 2 - PRODUCTS
- 2.01 MATERIALS
- A. Provide cold formed metal framing manufactured by Dietrich, Marino Ware, Dale/Incor, or Architect approved equal.
 - B. System Components: Manufacturer's standard load-bearing steel studs, joists, and furring of type, size, shape, and gage as indicated. With each type of metal framing required, provide manufacturer's standard steel runners (tracks), blocking, lintels, clip angles, shoes, reinforcements, fasteners, and accessories for applications indicated, as needed to provide a complete metal framing system.
 - C. Materials and Finishes: As required for design criteria.
 - 1. For 16-gage and heavier units, fabricate metal framing components of structural quality steel sheet with a minimum yield point of 40,000 psi; ASTM A 446, A 570, or A 611.
 - 2. For 18-gage units, fabricate metal framing components of commercial quality steel sheet with a minimum yield point of 33,000 psi; ASTM A 446, A 570, or A 611. Members lighter than 20-gage are not permitted.
 - 3. Fasteners: Provide nuts, bolts, washers, screws, and other fasteners with corrosion resistant plated finish equivalent to cadmium plating, ASTM A165, Type NS.
 - 4. Electrodes for Welding: Comply with AWS Code and as recommended by stud manufacturer.
 - D. Galvanizing: Hot-dip galvanize all metalwork, inserts, and accessories in strict compliance with ASTM A123, A143, A153, A384, A385, and A386.

2.02 FABRICATION

- A. General: Framing components may be prefabricated into assemblies before erection. Fabricate panels plumb, square, true to line, and braced against racking with joints welded. Perform lifting of prefabricated units to prevent damage or distortion.
- B. Fabricate units in jig templates to hold members in proper alignment and position and to assure consistent component placement.
- C. Fastenings: Attach similar components by welding. Attach dissimilar components by welding, bolting, or screw fasteners, as standard with manufacturer.
- D. Wire tying of framing components is not permitted.
- E. Fabrication Tolerances: Fabricate units to a maximum allowable tolerance variation from plumb, level, and true to line of 1/8 inch in 20 feet.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. General: Install metal framing systems in accordance with manufacturer's printed or written instructions and recommendations.
- B. Runner Tracks: Install continuous tracks sized to match studs. Align tracks accurately to layout at base and tops of studs. Secure tracks as recommended by stud manufacturer for type of construction involved, except do not exceed 24 inches o.c. spacing for nail or power-driven fasteners or 16 inches o.c. for other types of attachment. Provide fasteners at corners and ends of tracks.
- C. Installation of Wall Studs: Secure studs to top and bottom runner tracks by either welding or screw fastening at both inside and outside flanges unless vertical slip joint is required.
- D. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.
- E. Where stud system abuts structural columns or walls, including masonry walls, anchor ends of stiffeners to supporting structure.
- F. Install supplementary framing, blocking, and bracing in metal framing system wherever walls or partitions are indicated to support fixtures, equipment, services, casework, heavy trim and furnishings, and similar work requiring attachment to the wall or partition. Where type of supplementary support is not otherwise indicated, comply with stud manufacturer's recommendations and industry standards in each case, considering weight or loading resulting from item supported.
- G. Frame wall openings larger than 2 feet square with double stud at each jamb of frame except where more than two are either shown or indicated in manufacturer's instructions. Install runner tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with stud shoes or by welding, and space jack studs same as full-height studs of wall. Secure stud system wall opening frame in manner indicated.
- H. Frame both sides of expansion and control joints with separate studs; do not bridge the joint with components of stud system.
- I. Install horizontal stiffeners in stud system, spaced (vertical distance) at not more than 54 inches o.c. Weld at each intersection.
- J. Erection Tolerances: Bolt or weld wall panels (at both horizontal and vertical junctures) to produce flush, even, true-to-line joints.

1. Maximum variation in plane and true position between prefabricated assemblies should not exceed 1/16 inch.

- K. Reinforce ends with end clips, steel hangers, steel angle clips, steel stud section, or as otherwise recommended by joist manufacturer.
- L. Holes that are field cut into steel framing members shall be within limitations of the product and its design. Provide reinforcement where holes are cut through load-bearing members in accordance with manufacturer's recommendations.
- M. Purlins shall be installed with their web area perpendicular to the bearing surface. Bridging, either steel strap or solid, shall be provided as indicated on the shop drawings.
- N. Provide additional framing around all roof openings as noted on the shop drawings.
- O. End blocking shall be provided where purlin ends are not otherwise restrained from rotation. All bridging, bracing, blocking, strapping, web reinforcement shall be in place prior to further loading.
- P. Steel drill screws shall be of the minimum diameter indicated by the design of that particular attachment detail on the shop drawings. Penetration through joined materials shall not be less than 3 exposed threads.
- Q. Field Painting: Touch-up damaged shop-applied protective coatings. Use galvanizing repair system for galvanized surfaces.

3.02 TOLERANCES

- A. Provide alignment of within 1/8 in. in 10 ft of proper location.
- B. Spacing of purlins shall not be more than plus or minus 1/8 in. from the designed spacing providing that the cumulative error does not exceed the requirements of the finishing materials.

3.03 INSPECTIONS

- A. Inspections shall be performed to assure strict conformance to the shop drawings. All members shall be checked for proper alignment, bearing, completeness of attachments, proper alignment and reinforcement. Inspections where and as required by local codes shall be controlled inspections.

3.04 REPAIRING, CLEANING, AND PROTECTION

- A. Touch-up damaged coatings and finishes to eliminate evidence of repair.
- B. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired.

3.05 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 05 50 00

METAL FABRICATIONS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section includes, but is not limited to:
 - 1. Metal stair systems and railings.
 - 2. Handrails and guardrails.
 - 3. Miscellaneous framing and supports.
 - 4. Installation of Owner-furnished bicycle rack.
 - 5. Rough hardware, including specialty joist hangers.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 01 00 00, General Requirements.
 - 2. Section 03 30 00, Cast-In-Place Concrete.
 - 3. Division 26 - ELECTRICAL.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations, and recommendations for each material used. Provide certifications stating that materials comply with requirements.
- B. Shop Drawings: Provide large scale shop drawings for fabrication, installation and erection of all parts of the work. Provide plans, elevations, and details of anchorages, connections and accessory items. Provide installation templates for work installed by others.
 - 1. Include wiring diagrams for motorized equipment.
- C. Field Measurements: Take accurate field measurements before preparation of shop drawings and fabrication. Do not delay job progress; allow for field cutting and fitting where taking field measurements before fabrication is not possible. Do not field cut or fit items which have been hot-dip galvanized after fabrication.
- D. Calculations: Provide professionally prepared calculations and certification of the performance of this work. Show how design load requirements and other performance criteria have been satisfied.
- E. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

METAL FABRICATIONS

05 50 00-1

- A. Engineering: Provide the services of a Professional Engineer, who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated, to design and certify that the work of this section meets or exceeds the performance requirements specified in this section.
 - B. Shop fabricate work to the greatest extent possible. Clearly label pieces in shop to facilitate field assembly.
 - C. Perform welding in compliance with American Welding Society Code. Shop weld and grind connections to the greatest extent possible.
- 1.06 ENVIRONMENTAL REQUIREMENTS
- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
 - 1. Steel: 25% recycled content.
 - 2. Aluminum: 50% recycled content.
 - B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
 - C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option B, Paints and Coatings: Comply with the following criteria:
 - a. Architectural Paints, Coatings and Primers: Green Seal GS-11, Paints, First Edition May 20, 1993. For applications on interior walls and ceilings.
 - b. Anti-Corrosive and Anti-Rust Paints: Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997. For applications on interior ferrous metal substrates.
 - c. Clear Wood Finishes, Floor Coatings, Stains, and Shellacs: South Coast Air Quality Management District (SCAQMD) Rule #1113, Architectural Coatings, rules in effect on January 1, 2004. For applications on interior elements.
- 1.07 DELIVERY, STORAGE AND HANDLING
- A. Store work off of the ground and under cover. Protect from damage. Maintain shop applied primer coatings until finish painting is complete. Sequence deliveries to avoid delays, but minimize on-site storage.
- 1.08 PROJECT CONDITIONS
- A. Do not permit use of stairs, ladders, handrails, guardrails or other work until work is completely and fully installed and ready to assume its intended design loads. Do not permit overloading of any miscellaneous metal system. Do not permit use of concrete filled metal pan stair systems before concrete is placed and cured.
- PART 2 - PRODUCTS
- 2.01 MATERIALS AND PRODUCTS
- A. Steel Shapes: ASTM A36.
 - B. Steel Tubing: ASTM A500, cold-formed.
 - C. Steel Sheet: ASTM A366, A570 or A611, of grade required for design loading.
 - D. Steel Pipe: ASTM A53, black schedule 40, unless indicated otherwise. Type and grade as required for design loading.
 - E. Aluminum Plate and Sheet: ASTM B209, Alloy 6061-T6.

- F. Aluminum Extrusions: ASTM B 221, alloy 6063-T6, extrusions suitable for service intended.
 - 1. Aluminum Magnesium Alloy: ASTM B 26 and B 179, alloy 535.
 - G. Iron Castings: ASTM A47 or A48, grade and class are manufacturer's option.
 - H. Grout: Pre-mixed, non-staining, non-corrosive, non-shrink, non-metallic complying with CE CRD-C588, type D.
 - I. Bolts and Fasteners: ASTM A307 and other types as appropriate and approved by Architect.
 - J. Concrete: Comply with requirements of Section 03 30 00, Cast-In-Place Concrete.
 - K. Comply with the latest edition of the following standards:
 - 1. AISI Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.
 - 2. AISC Code of Standard Practice for Steel Buildings and Bridges.
 - 3. AWS Code for Welding in Building Construction.
 - 4. Specifications for Structural Joints using ASTM A325 or A490 Bolts, Research Council on Riveted and Bolted Structural Joints of Engineering Foundation.
 - 5. SSPC Painting Manual, Vol. 1 - Good Painting Practice and Vol. 2 - Systems and Specifications.
 - 6. Fed. Specs QQ-I-652A, Iron Gray Castings: QQ-S-741A, Steel Plates, Shapes and Bars, Carbon, Structural; WW-P-521, Malleable Iron.
- 2.02 FABRICATION
- A. General Fabrication: Fabricate work to be truly straight, plumb, level and square and to sizes, shapes, and profiles indicated on approved shop drawings. Ease exposed edges. Cut, reinforce, drill and tap metalwork as necessary for proper assembly and use.
 - 1. Fabricate all miscellaneous metal supports, brackets, braces and the like required to fully complete the work of this project.
 - 2. Coordinate miscellaneous metal requirements with other specification sections to ensure proper interface of various parts of the work.
 - 3. Obtain loading requirements from suppliers of work to be supported and design and fabricate support systems with factor of safety of at least 6.
 - B. Work Exposed To View: Take special care in choosing materials that are smooth and free of blemishes such as pits, roller marks, trade names, scale and roughness. Fabricate work with uniform, tight joints. Form welded joints and seams continuously, but do not grind flush and smooth. Welded joints and seams shall be visible after painting. Fillet welds will not be accepted; plug welds and flush welds are required. For exposed fasteners, use hex head bolts or Phillips head machine screws.
 - C. Galvanizing: Hot-dip galvanize all exterior miscellaneous metalwork, all items located in exterior wall and roof assemblies, and all items indicated to be galvanized in strict compliance with ASTM A123, A143, A153, A384, A385, and A386. Any item that is cut, welded, or is otherwise damaged must be repainted with an acceptable zinc-rich coating product. Any item that is cut, welded, or is otherwise damaged must be repainted with an acceptable zinc-rich coating product.
 - 1. Nickel Zinc: Comply with ASTM B6.
 - 2. Coverage: Provide at least 2.0 oz./sq. ft. nickel zinc coverage, but not less than the coverage required by referenced standards.
 - 3. Fabrication: To the greatest extent possible, galvanize after fabrication is completed.
 - 4. Touch Up: Touch-up damaged or abraded galvanized surfaces with ZRC Cold Galvanizing Compound, Duncan ZiRP or Architect approved equal in compliance with ASTM A780.
 - D. Painting & Preparation, Exposed Steel: Prime paint all work not indicated to be galvanized. Prepare work for shop priming in compliance with Steel Structures Painting Council SP-6 Commercial Blast Cleaning.

Provide 1 mil dry film thickness of rust inhibitive primer specified in Section 09910 - Painting. Provide two coats with two mils total dry film thickness for surfaces which are inaccessible after assembly or erection.

- E. Painting & Preparation, Egress Stairs and Miscellaneous Metals Concealed From View: Prime paint all work not indicated to be galvanized. Prepare work for shop priming by power tool cleaning. Provide 1 mil dry film thickness of rust inhibitive primer specified in Section 09 90 00, Painting. Provide two coats with two mils total dry film thickness for surfaces which are inaccessible after assembly or erection.
- F. Stair Fabrication: Design and fabricate stair systems to conform to size and arrangements shown and required. Comply with applicable codes and ordinances related to fire exit stairs. Architect shall be final judge in matters relating to final appearance of units. Bolted connections shall not be acceptable at monumental stair.
 - 1. Design stair system to support code required loading. Design anchors, connections, support brackets and all other interfaces with the supporting structure.
 - 2. Take field measurements to accurately determine actual floor to floor heights and fabricate stairs so that all risers in each run are of equal height within $\pm 1/16"$ and so that the average height of risers in two adjacent runs do not vary by more than $3/16"$.
 - 3. Fabricate stringers from steel channels or plates. Form metal tread and landing pans from 12 gage minimum steel sheet to the shape shown on approved shop drawings. Weld tread and landing pans to supporting frames.
 - 4. Shop weld and assemble stair system to the greatest extent possible. Locate bolted connections in inconspicuous areas. Take care to be sure that welds exposed to view are ground flush and smooth so as to be not visible after painting.
- G. Metal Railings and Guardrails: Design and fabricate handrails, guardrails, railings and balusters to provide load capacity as required by code or authorities having jurisdiction. Architect shall be final judge in matters relating to final appearance of units.
 - 1. Provide members of type, style and profile indicated and provide metal handrails in patterns indicated designed to meet all applicable building codes.
 - 2. Typical Railings: Cold-rolled steel construction.
 - a. Provide fully welded construction, using internal slip connectors. Grind all joints flush and smooth so that joints are invisible after painting.
 - b. Provide mitered joints or sweeps at square turns as indicated on the drawings.
 - c. Provide smooth radiuses at bends and maintain uniform cross-section throughout with no kinks, buckling or twisting.
 - d. Joint construction for steel railings shall comply with NOMMA standards for Type 3 Railing System Joint Construction , as directed by the Architect.
 - e. Joint construction for ornamental railing, at monumental stair, shall comply with NOMMA standards for Type 1 Railing System Joint Construction , as directed by the Architect.
 - 3. Return all ends to walls with fully concealed anchors, except where detailed not to return to wall.
 - 4. Provide brackets, flanges, fittings and anchors for connecting railing to railing and railing to floors, landings, stringers and walls.
 - 5. Provide infill panels as indicated.
- H. Miscellaneous Framing and Supports: Fabricate all miscellaneous metal supports, brackets, braces and the like required to fully complete the work of this project, including but not limited to store fixtures. Examine all shop drawings for other work of the Contract and provide all miscellaneous steel items as noted thereon. Coordinate requirements with work of other specification sections to ensure proper interface of various parts of the work. Obtain loading requirements from manufacturers and suppliers of work to be supported and design and fabricate support systems with safety factor of at least 6.
- I. Bicycle Rack: Saris Stadium Rack, 6-Bike Rack, Model SAR2136.
 - 1. <http://www.bikerackshops.com/SARSTADIUMRACK.html>

- J. Rough Hardware: Provide standard and custom fabricated bolts, anchors, hangers, dowels and other miscellaneous metal items as needed to properly complete the work of the project.
 - 1. Specialty Joist Hangers: Provide heavy duty, 12 ga. steel, load-rated joist hangers, equal to OHU Specialty Joist Hanger, by Simpson StrongTie. Provide manufacturer's standard textured powder coated flat black paint finish. Provide sizes as indicated.
 - a. http://www.strongtie.com/products/connectors/LBV-BA-B-HB_SCL.asp
 - b. http://www.strongtie.com/products/connectors/HUS-HHUS-HGUS_SCL.asp
 - c. <http://www.strongtie.com/products/connectors/LUS-HUS.asp>
 - d. <http://www.strongtie.com/products/connectors/IUS-IUT-MIU.asp>
 - e. <http://www.strongtie.com/products/connectors/J-JP.asp#codes>

2.03 FINISHING

- A. General: Shop prime work to greatest extent possible, except those items indicated to be embedded in concrete, and those items indicated to receive fireproofing. Field touch-up shop applied coatings after installation.
- B. Prepare work for shop priming in compliance with SSPC SP6.
- C. Provide 1 mil dry film thickness of rust inhibitive primer over properly prepared, non-galvanized and/or non-fireproofed surfaces. Provide two coats with 2 mils total dry film thickness for surfaces which are inaccessible after assembly or erection.
- D. Primer for Non-Galvanized Ferrous Surfaces (except interior handrail and railing assemblies and interior steel stairs): Provide high-quality, lead-free, rust-inhibitive primer, equal to one of the following:
 - 1. Series 10 Metal Primer, Tnemec.
 - 2. Bar-ox Quick Dry Universal Primer; Devoe and Raynolds.
 - 3. Ironclad Retardo; Benjamin Moore.
- E. Shop Primer for Galvanized Fabrications: Exterior galvanized handrails, lintels, shelf angles, pipe bollards, and other items as indicated or directed by Architect to be painted, shall be primed with one of the following shop primers within 12 hours of the galvanizing process. Provide one coat of the following at 3.0 to 4.0 mils DFT for galvanized items indicated to be painted:
 - 1. No. 69 Hi-Build Epoxoline; Tnemec.
 - 2. International Protective Coatings equal.
 - 3. Valspar equal.
- F. Bituminous-based paint for electrolytic isolation shall be cold applied black asphaltic mastic conforming to SSPC Paint 12, with no asbestos fibers
- G. Special Finish at Handrails and Elsewhere As Indicated: Match Architect's sample. Refer to Section 09 90 00, Painting.

PART 3 - EXECUTION

3.01 INSTALLATION/ERECTION

- A. Provide suitable anchors and fasteners to connect miscellaneous metal items to other construction. Provide setting templates and diagrams and coordinate with other work so that adequate anchor bolts, blocking and bracing is in place and accurately located. Beginning work means Installer accepts substrates and conditions.
- B. Set work accurately and truly plumb, level and aligned. Make field assembly and connections with the same level of quality as shop fabricated work.

- C. Stairs: Fill stair system tread and landing pans with concrete, and cure and finish in strict compliance with the requirements of Section 03 30 00, Cast-In-Place Concrete. Provide very light non-slip broomed surface where no finish material is indicated. Obtain Architect's approval of finish texture before beginning work.
 - D. Handrails: Adjust handrails prior to final anchoring and grouting. Plumb posts in both directions. Provide 1-1/2" clearance from inside of handrails to face of walls. Provide wall brackets at spacing shown, or if not shown, at not more than 6'-0" on center. Securely anchor wall brackets into structure or very secure blocking. Connections shall withstand loading specified for handrails.
 - E. Miscellaneous Framing and Supports: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings. Anchor supports securely to and rigidly brace from building structure.
- 3.02 TOLERANCES
- A. The following allowable installed tolerances are allowable variations from locations and dimensions indicated by the Contract Document and shall not be added to allowable tolerances indicated for other work.
 - 1. Allowable Variation from True Plumb, Level and Line: $\pm 1/8"$ in 20'-0".
- 3.03 REPAIRING, CLEANING, & PROTECTION
- A. Touch-up damaged coatings and finishes to eliminate evidence of repair.
 - B. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired.
- 3.04 CONSTRUCTION WASTE MANAGEMENT
- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 06 10 00

ROUGH CARPENTRY

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Provide all rough carpentry work, as indicated on the Drawings and as specified herein. Rough carpentry shall include but not be limited to:
 - 1. Rough hardware, inserts, and related metal components, for work of this Section, except those items specifically specified to be provided by other trades.
 - 2. Plywood backing panels for electrical and telephone work.
 - 3. Rough carpentry framing, sleepers, blockings, curbs, cants, edgings, grounds, nailers, furring, strapping, sheathing.
 - 4. Blocking for items hanging from or supported by walls, blocking for signage, and similar items, required for all trades.
 - 5. Wood preservative treatments and applications.
 - 6. Other usual items of normal rough carpentry work indicated on the Drawings or necessary for the proper completion of the Project, even though not specifically mentioned herein.
 - 7. All other rough carpentry indicated.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
 - 1. Section 06 40 00, Architectural Woodwork; interior carpentry and millwork.
 - 2. Section 09 64 00, Wood Flooring.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's printed product data, specifications, standard details, installation instructions, use limitations and recommendations for each material used. Provide certifications that materials and systems comply with specified requirements.
- B. Shop Drawings: Provide large scale shop drawings for fabrication, installation and erection of all parts of the work. Provide plans, elevations, and details of anchorage, connections and accessory items. Provide installation templates for work installed by others. Show all interfaces and relationships to work of other trades.
- C. Field Measurements: Take field measurements before preparation of shop drawings and fabrication. Do not delay progress of the job. If field measurements are not possible prior to fabrication, allow for field cutting and fitting.
- D. Initial Selection Samples: Submit samples showing complete range of colors, textures, and finishes available for each material used.

ROUGH CARPENTRY

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- E. Verification Samples: Submit representative samples of each material that is to be exposed in the completed work. Show full color ranges and finish variations expected. Provide samples having minimum size of 144 sq. in.
 - F. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.
- 1.05 QUALITY ASSURANCE
- A. Materials and workmanship shall conform to governing laws and applicable building code.
 - B. Provide lumber and plywood bearing the grade-trademark of the association under the rules or standards of which it was produced. Grade-trademarks shall conform to the rule or standard under which the material is produced, including requirements for qualifications and authority of the inspection organization, usage of authorized identification, and information included in the identification.
 - 1. Grades specified are the minimum acceptable. Lumber grades shall be determined in accordance with ASTM D 245.
 - 2. Lumber shall bear the grade mark of an American Lumber Standards Committee, Board of Review-approved agency. Lumber shall conform to USDC PS 20.
 - 3. Lumber shall bear a mark of mill identification.
 - 4. Plywood shall comply with APA Design/Construction Guide, Residential and Commercial, grading requirements, USDC PS 1, and ANSI A199.1.
 - 5. Non-plywood type performance-rated construction panels shall conform to APA PRP-108.
 - 6. Fasteners shall comply with CABO NER-272.
- 1.06 ENVIRONMENTAL REQUIREMENTS
- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
 - 1. Steel: 25% recycled content.
 - 2. Plywood: 50% recycled content.
 - B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
 - C. Certified Wood Components: Provide a minimum of 50 percent of the wood -based materials and products certified in accordance with the Forest Stewardship Council's Principles and Criteria.
 - D. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.
- 1.07 COORDINATION
- A. Coordinate the work of this Section with the work of other Sections to assure the steady progress of all the work of the Contract.
- 1.08 PRODUCT DELIVERY AND STORAGE
- A. Materials when delivered to site shall be stacked and stored above the ground under protective coverings or indoors in such manner as to insure proper drainage, ventilation, and protection. No kiln dried materials

shall be placed in the building until concrete and masonry work have been completed, and are sufficiently dry.

- B. Rough carpentry materials shall be stored on elevated piles to allow for air circulation below and tipped in one direction to effectively drain moisture. Lumber shall be wrapped completely, including bottoms, in waterproof tarps. Tarps shall be tied down to protect against wind blowoff. Should delays in Project be anticipated, lumber shall be stored in covered storage trailers.
- C. Do not leave any newly installed wood blocking exposed. Cover and protect all new wood daily with the new roof systems or other suitable covering approved by the Architect.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Lumber shall be of sound stock, new, straight, of consistent size, free of stains and mildew, and kiln dried to a moisture content of not more than 19%, by weight. Where exposed or semiexposed, wood members shall be selected for best possible appearance from the grade of stock specified.
 - 1. Lumber shall be surfaced four sides (S4S) and shall bear the grade and trademark of the association under whose rules it is produced, and a mark of mill identification.
 - 2. Lumber shall be furnished in longest practical lengths with respect to each intended use, and single length pieces shall be used wherever possible.

- B. Plywood shall conform to the requirements of APA Design/Construction Guide, Residential and Commercial, and be Structural 1 rated sheathing.

- C. General Carpentry Material Schedule shall be as follows:

<u>Item</u>	<u>Grade</u>	<u>Species</u>
Lumber 2 in. nominal thickness or greater:	No. 2 Structural or better	Hem-Fir or Southern Pine or Doug Fir
Lumber less than 2 in. nominal thickness	No. 2 Common	Hem-Fir or Spruce or Doug Fir
Treated wood	CCA 0.25 pcf Treated, SPC Select and No. 1 Grade, kiln-dried	Pressure Southern Pine or Doug Fir
Exposed wood	As required	Hem-Fir or Douglas Fir

- D. Pressure-Treated Wood, Arsenic and Chromium Free: Provide pressure treated wood produced in accordance with AWP standards as applicable, C1, C2, C4, C5, C9, C15, C17, C22, P5 and the following:
 - 1. Standard Product: Preserve Brand treated wood products with ACQ treatment.
 - 2. Water-Repellent Product: Preserve Plus, water repellent retention of 0.31 pounds per cubic foot.
 - 3. Manufacturer: CSI Chemical Products; 704-522-0825; www.treatedwood.com.
 - 4. Retention Rate:
 - a. Above Ground Deck Support: 0.40 pounds per cubic foot for decking, fence boards, handrails and similar items.
 - b. Ground Contact Fresh Water: 0.40 pounds per cubic foot for fence posts, landscaping, piers, docks, and similar items.
 - c. Permanent Wood Foundations: 0.60 pounds per cubic foot for wood foundations and crawl spaces.
 - d. Poles: 0.60 pounds per cubic foot for building and distribution poles.

- E. Fire-Retardant Treated Wood for Exterior and Interior Use: Provide water based, low voc content, with no polybrominated diphenyl ethers (PBDE), UL fire retardant penetrating treatment, which yields a flame spread of not more than 25 when tested in conformance with ASTM E 84.
 - 1. Acceptable Product: Wood Seal Fire Retardant, by Flame Seal Products, Inc., Houston, TX; www.flameseal.com.
 - 2. Plywood conforms to AWWA C 27 for Exterior Type, and has successfully passed a rain test conforming to ASTM D 2898. Kiln dry after treatment to a maximum moisture content of 19%.
 - 3. Lumber conforms to AWWA C20, Type A. Kiln dry after treatment to a maximum moisture content of 19%.
 - 4. Fire retardant treatment shall not affect the coloration and pigment of the wood, where exposed in final work.
 - F. Adhesive for glued construction shall conform to APA Performance Specification AFG-01.
- 2.02 ROUGH HARDWARE AND FASTENERS
- A. Comply with CABO NER-272 and the requirements of the applicable building code.
 - B. Provide all rough hardware required to complete this work and to attach this work in a secure and rigid manner to work of this and other trades, including all inserts, anchors, anchor bolts, lag bolts, screws, washers, nuts, nails, and other rough hardware. Assist other trades as necessary in the placement of inserts and anchor bolts in concrete and masonry and furnish full instructions regarding locations, sizes, and other requirements of the items in order that they may properly prepare their work to receive same. Rough hardware shall comply in all respects with requirements of the governing laws and codes.
 - C. Rough hardware items for use at framing, blocking, nailers, etc., and other exterior uses, and to be exposed in the finished interior work, shall be hot-dip galvanized zinc or cadmium-plated steel, or stainless steel in accordance with ASTM A 153, or non-ferrous, as indicated or as approved by Engineer. Galvanizing shall conform to ASTM A 153. Concealed interior nails shall be bright. Other concealed items shall be cadmium plated or zinc chromate plated. Rough hardware items shall be of appropriate type and of proper capacity and size as required for each specific application.
 - D. Unless otherwise called out, wood framing, blockings, nailers, etc., of 2 in. nominal thickness or greater shall be bolted to back-up material with 1/2 in. bolts (galvanized at exterior locations and at roofs) located 4 in. from ends and splices, and spaced not greater than 32 in. on center along lengths of the members, to develop positive and secure anchorage to the back-up material. Nails shall be of sufficient length to penetrate the receiving member a minimum of 1-1/2 in.
 - E. Fasteners for securing wood framing, blocking or plywood into concrete if required, shall be non-impact drilled anchors of sufficient length to penetrate the receiving member a minimum of 1-1/2 in.
 - F. Unless otherwise called out, wood framing, nailers, furring, etc., less than 2 in. nominal thickness shall be secured to back-up material by use of appropriate fasteners located 4 in. from ends and spaced not greater than 16 in. on center along lengths of the members. Type and length of fastening devices shall be such as to develop positive and secure anchorage to the back-up material.
- 2.03 CONSTRUCTION PANELS
- A. Scope: Construction panels required to complete the work of this Section include, but is not limited to the following:
 - 1. Pressure treated plywood.
 - 2. Plywood.
 - B. Factory mark each panel with APA trademark showing compliance with requirements.
 - 1. Plywood: Comply with USDC PS 1 and APA Design/Construction Guide, Residential and Commercial as applicable.

- C. Plywood: Provide APA trademarked, Performance-Rated sheathing, UL fire-retardant treated, Exposure 1 panels, not less than 3/4 in. thick. Provide fire-retardant treatment which yields a flame spread rating of not more than 25 when tested in conformance with ASTM E 84, and conforms to AWWA C 27, Interior Type A. Kiln dry after treatment to a maximum moisture content of 15%.
 - 1. Concealed (i.e. blocking): C-D Plugged.
 - 2. Exposed: A-C Sanded, and free from markings, stamps and stickers.
- 2.04 MISCELLANEOUS MATERIALS
 - A. Inserts, Anchors, and Fasteners: Provide inserts, anchors, anchor bolts, lag bolts, screws, washers, nuts, nails, and other rough hardware. Assist other trades as necessary in the placement of inserts and anchor bolts in concrete and masonry. Furnish full instructions regarding locations, sizes, and other requirements to ensure proper preparation. Provide rough hardware which complies with requirements of the governing laws and codes.
 - B. Rough Hardware: Provide hot-dip galvanized steel finish or stainless steel finish for rough hardware items for use at exterior. Hot dip galvanizing shall be in accordance with ASTM A 153. Provide other concealed items cadmium plated or zinc chromate plated.
 - C. Provide non-impact drilled anchors and fasteners for securing wood framing, blocking or plywood into masonry of sufficient length to penetrate the receiving member a minimum of 1-1/2 in.

PART 3 - EXECUTION

- 3.01 ROUGH CARPENTRY WORK, GENERAL
 - A. No attempt is made in this Specification to list the various elements of rough carpentry work, as the major part of the work to be done is clearly shown on or reasonably inferred from the Drawings. The rough carpentry work required shall include all such work, regardless of whether or not each and every item is specifically called for. Refer to Drawings to determine the major extent of the rough carpentry work required.
 - B. The Contractor shall be responsible for structural integrity, connections, and anchorage of rough carpentry work. All nailing shall be in accordance with the applicable building code.
 - C. Discard units of material which are unsound, warped, bowed, twisted, improperly treated, not adequately seasoned, or too small to fabricate with minimum number of joint or optimum jointing arrangements, or which are of defective quality with respect to surfaces or sizes.
 - D. All anchors and fasteners that attach wood blocking to the structure at roofs shall have their spacing halved for an 8 ft. length away from all exterior corners of the perimeter.
 - E. Butt joints in wood shall be flush to provide a smooth, uniform line with no irregularities. Built-up blocking shall have butt joints staggered 4 in. minimum layer to layer. The minimum length of any individual piece of woodwork shall be 12 in. All lengths of woodwork shall have a minimum of four fasteners.
 - F. Construct all rough carpentry work plumb, level, and true with tight, close fitting joints, securely attached and braced to surrounding construction, all in a first class workmanlike manner. Counterbore for bolt heads, nuts, and washers where required to avoid interference with other materials.
 - G. Structural members shall be full-length without splices, and spaced not farther than 16 in. on center, except as may be otherwise specifically indicated on the Drawings.
 - H. Wood framing members shall be one-piece full length for maximum strength.

- I. Wood blockings, nailers, edgings, etc., shall be installed as indicated or specified and shall be furnished in lengths not less than 12 ft., except where shorter lengths are required.
 - J. All connections, nailing, and fastening of rough carpentry work shall conform to requirements of the governing laws and codes.
 - K. Install all wood grounds required at stucco, plaster, and gypsum wallboard work, including those required by other trades to properly attach their work, such as grounds to assure proper lines and levels and for attachment of fixtures, louvers, grilles, registers, diffusers, etc. Do not, however, include fixture support blockings at steel stud framed or furred gypsum wallboard finished walls or partitions as work of this Section.
 - L. If nailing, drilling, or powder-driving into concrete or masonry causes puncturing of conduits, pipes, ducts, etc., embedded in such work, repair all damage so caused.
- 3.02 AIR INFILTRATION BARRIER
- A. Install air infiltration barrier over all exterior wall areas, in accordance with air infiltration barrier manufacturer's recommendations.
 - B. Fasten air infiltration barrier using acceptable fasteners in accordance with manufacturer's approved methods.
 - C. Install barrier in largest sizes practical minimizing joints in barrier.
 - D. Lap barrier and tape seams with approved sheathing tape in accordance with barrier manufacturer's recommendations.
- 3.03 FASTENING OF EXTERIOR CARPENTRY FRAMING AND SHEATHING
- A. Wood shall be secured to wood substrates and other wood to wood connection with nails spaced 12 in. on center maximum staggered along the centerline of the member being installed. All nail heads must be flush with the top surface.
 - B. Wood to masonry connections shall be completed using non-impact drilled anchors through predrilled holes spaced 8 in. on center maximum. Predrill the hole, insert fastener sleeve, and secure in place with nail.
 - C. Installation and nailing of performance-rated construction panels and sheathing shall be in strict accordance with the published specifications and recommendations of the American Plywood Association (APA), including APA Design/Construction Guide, Residential and Commercial. Unless otherwise indicated on the Drawings, all sheathing shall be nailed at 3 in. o.c. at edges and 12 in. o.c. for panel field nailing, with 10d galvanized steel nails.
- 3.04 CLEANING
- A. Upon completion of rough carpentry work in any given area, remove all rubbish and debris from the work area and leave in broom clean condition.
- 3.05 CONSTRUCTION WASTE MANAGEMENT
- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 06 11 13

ENGINEERED WOOD PRODUCTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Provide all rough carpentry work, as indicated on the Drawings and as specified herein. Engineered Wood Products shall include but not be limited to:
 - 1. Rough hardware, inserts, and related metal components, for work of this Section, except those items specifically specified to be provided by other trades.
 - 2. Plywood backing panels for electrical and telephone work.
 - 3. Rough carpentry framing, sleepers, blockings, curbs, cants, edgings, grounds, nailers, furring, strapping, sheathing.
 - 4. Blocking for items hanging from or supported by walls, blocking for signage, and similar items, required for all trades.
 - 5. Wood preservative treatments and applications.
 - 6. Other usual items of normal rough carpentry work indicated on the Drawings or necessary for the proper completion of the Project, even though not specifically mentioned herein.
 - 7. All other rough carpentry indicated.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry.
 - 2. Section 06 40 00, Architectural Woodwork; interior carpentry and millwork.
 - 3. Section 09 64 00, Wood Flooring.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's printed product data, specifications, standard details, installation instructions, use limitations and recommendations for each material used. Provide certifications that materials and systems comply with specified requirements.
- B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Materials and workmanship shall conform to governing laws and applicable building code.
- B. Provide lumber and plywood bearing the grade-trademark of the association under the rules or standards of which it was produced. Grade-trademarks shall conform to the rule or standard under which the material is produced, including requirements for qualifications and authority of the inspection organization, usage of authorized identification, and information included in the identification.

ENGINEERED WOOD PRODUCTS

1. Grades specified are the minimum acceptable. Lumber grades shall be determined in accordance with ASTM D 245.
2. Lumber shall bear the grade mark of an American Lumber Standards Committee, Board of Review-approved agency. Lumber shall conform to USDC PS 20.
3. Lumber shall bear a mark of mill identification.
4. Plywood shall comply with APA Design/Construction Guide, Residential and Commercial, grading requirements, USDC PS 1, and ANSI A199.1.
5. Non-plywood type performance-rated construction panels shall conform to APA PRP-108.
6. Fasteners shall comply with CABO NER-272.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
 1. Steel: 25% recycled content.
 2. Plywood: 50% recycled content.
- B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
- C. Certified Wood Components: Provide a minimum of 50 percent of the wood-based materials and products certified in accordance with the Forest Stewardship Council's Principles and Criteria.
- D. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 PRODUCT DELIVERY AND STORAGE

- A. Materials when delivered to site shall be stacked and stored above the ground under protective coverings or indoors in such manner as to insure proper drainage, ventilation, and protection. No kiln dried materials shall be placed in the building until concrete and masonry work have been completed, and are sufficiently dry.
- B. Rough carpentry materials shall be stored on elevated piles to allow for air circulation below and tipped in one direction to effectively drain moisture. Lumber shall be wrapped completely, including bottoms, in waterproof tarps. Tarps shall be tied down to protect against wind blowoff. Should delays in Project be anticipated, lumber shall be stored in covered storage trailers.
- C. Do not leave any newly installed wood blocking exposed. Cover and protect all new wood daily with the new roof systems or other suitable covering approved by the Architect.

PART 2 - PRODUCTS

2.01 Manufacturers

- A. Boise Cascade
Properties Evaluated: Structural.
 1. Uses: The AJS® Series prefabricated wood
 2. I-joists are used as floor joists and blocking panels to support floor design loads.

2.02 Description:

- A. General: The AJS Series prefabricated wood:

1. I-joists have solid-sawn lumber or composite lumber flanges and oriented strand board (OSB) webs. The top and bottom flanges are parallel, creating constant-depth joists. The web-to-web joints of the I-joists are square butt joints and conform to the specifications in the approved quality control manuals. The web-to-flange connection is a proprietary grooved connection, also conforming to the approved quality control manuals. The I-joists are available in various lengths and depths. See *ESR-1144 Table 1 for full description of the AJS I-Joist*.

2.03 Material Specifications:

- A. Flanges: The flanges of the I-joists are sawn lumber or composite lumber conforming to the specifications in the approved quality control manuals. The sawn lumber flange material, grade, width and depth are noted in ESR-1144, Table 1.
- B. Web: Web material for the I-Joists is $\frac{3}{8}$ -inch thick (10mm) OSB conforming to Exposure 1 requirements of PS-2, with further requirements set forth in the approved quality control manuals and manufacturing standards.
- C. Adhesive: Adhesives used in the fabrication of the I-joists comply with ASTM D 2559, and are specified in the quality control manuals and the manufacturing standards.

2.04 Design and Installation

- A. Design of the prefabricated wood I-joists described in this report shall be in accordance with the applicable code. Additionally, the design and installation of the prefabricated wood I-joists shall comply with Sections 4.1 through 4.12 listed in ESR-1144 which include 4.1 Allowable Structural Capacity, 4.2 Fasteners, 4.3 Web Stiffeners, 4.4 Lateral Support, 4.5 Holes in I-Joist Web, 4.6 Duration of Load, 4.7 In-Service Moisture Conditions, 4.8 Repetitive- Member Use, 4.9 Member Spans, 4.10 Deflection, 4.11 Blocking Panels, & 4.12 Cantilevered Joists, and the manufacturer's installation instructions.

2.05 Conditions of Use

- A. The AJS Series I-joists described in this report comply with, or are suitable alternatives to what is specified in, those codes listed under Evaluation Scope of these specifications, subject to the following conditions:
 - 1. For applications based on ESR-1144 Table 2, Allowable Design Properties for Alljoist I-Joists, design calculations and details for specific applications shall be furnished to the code official. Calculations and drawings shall be prepared, signed and sealed by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.
 - 2. Flanges of the I-joists shall not be cut or notched.
 - 3. The I-joists are produced by Boise Cascade Alljoist Ltd at their plant in St. Jacques, New Brunswick, Canada. Quality control inspections are conducted by PFS Corporation.

PART 3 - EXECUTION

3.01 ENGINEERED WOOD PRODUCTS

- A. No attempt is made in this Specification to list the various elements of rough carpentry work, as the major part of the work to be done is clearly shown on or reasonably inferred from the Drawings. The rough carpentry work required shall include all such work, regardless of whether or not each and every item is specifically called for. Refer to Drawings to determine the major extent of the rough carpentry work required.
- B. The Contractor shall be responsible for structural integrity, connections, and anchorage of rough carpentry work. All nailing shall be in accordance with the applicable building code.
- C. Discard units of material which are unsound, warped, bowed, twisted, improperly treated, not adequately seasoned, or too small to fabricate with minimum number of joint or optimum jointing arrangements, or which are of defective quality with respect to surfaces or sizes.

- D. All anchors and fasteners that attach wood blocking to the structure at roofs shall have their spacing halved for an 8 ft. length away from all exterior corners of the perimeter.
 - E. Butt joints in wood shall be flush to provide a smooth, uniform line with no irregularities. Built-up blocking shall have butt joints staggered 4 in. minimum layer to layer. The minimum length of any individual piece of woodwork shall be 12 in. All lengths of woodwork shall have a minimum of four fasteners.
 - F. Structural members shall be full-length without splices, and spaced not farther than 16 in. on center, except as may be otherwise specifically indicated on the Drawings.
 - H. Wood framing members shall be one-piece full length for maximum strength.
 - I. Wood blockings, nailers, edgings, etc., shall be installed as indicated or specified and shall be furnished in lengths not less than 12 ft., except where shorter lengths are required.
 - J. All connections, nailing, and fastening of rough carpentry work shall conform to requirements of the governing laws and codes.
 - K. Install all wood grounds required at stucco, plaster, and gypsum wallboard work, including those required by other trades to properly attach their work, such as grounds to assure proper lines and levels and for attachment of fixtures, louvers, grilles, registers, diffusers, etc. Do not, however, include fixture support blockings at steel stud framed or furred gypsum wallboard finished walls or partitions as work of this Section.
 - L. If nailing, drilling, or powder-driving into concrete or masonry causes puncturing of conduits, pipes, ducts, etc., embedded in such work, repair all damage so caused.
- 3.02 AIR INFILTRATION BARRIER
- A. Install air infiltration barrier over all exterior wall areas, in accordance with air infiltration barrier manufacturer's recommendations.
 - B. Fasten air infiltration barrier using acceptable fasteners in accordance with manufacturer's approved methods.
 - C. Install barrier in largest sizes practical minimizing joints in barrier.
 - D. Lap barrier and tape seams with approved sheathing tape in accordance with barrier manufacturer's recommendations.
- 3.03 FASTENING OF EXTERIOR CARPENTRY FRAMING AND SHEATHING
- A. Wood shall be secured to wood substrates and other wood to wood connection with nails spaced 12 in. on center maximum staggered along the centerline of the member being installed. All nail heads must be flush with the top surface.
 - B. Wood to masonry connections shall be completed using non-impact drilled anchors through predrilled holes spaced 8 in. on center maximum. Predrill the hole, insert fastener sleeve, and secure in place with nail.
 - C. Installation and nailing of performance-rated construction panels and sheathing shall be in strict accordance with the published specifications and recommendations of the American Plywood Association (APA), including APA Design/Construction Guide, Residential and Commercial. Unless otherwise indicated on the Drawings, all sheathing shall be nailed at 3 in. o.c. at edges and 12 in. o.c. for panel field nailing, with 10d galvanized steel nails.

- 3.04 CLEANING
 - A. Upon completion of rough carpentry work in any given area, remove all rubbish and debris from the work area and leave in broom clean condition.
- 3.05 CONSTRUCTION WASTE MANAGEMENT
 - A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 06 16 53

MOISTURE-RESISTANT SHEATHING BOARD

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.02 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. Plywood wall sheathing.
 - 2. Plywood roof sheathing.
 - 3. Subflooring.
 - 4. Underlayment.
 - 5. Weather-resistant sheathing paper.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Section 04200 - UNIT MASONRY for masonry-veneer anchors and insulation in cavity wall construction.
 - 2. Section 06100 - ROUGH CARPENTRY for framing at exterior wall.
 - 3. Section 07620 - SHEET METAL FLASHING AND TRIM for flashing applied to gypsum sheathing.
- C. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 DEFINITIONS

- A. Gypsum Board Construction Terminology Standard: Refer to ASTM C 11 and GA-505 for definitions of terms for gypsum sheathing board construction not defined in this Section or in other referenced standards.

1.04 SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used, net amount of preservative retained, and chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material.
 - 2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials, both before and after exposure to elevated temperatures when tested according to ASTM D 5516 and ASTM D 5664.
 - 3. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
 - 4. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain each gypsum sheathing product through one source from a single manufacturer.

MOISTURE-RESISTANT SHEATHING BOARD

- B. Fire-Resistance-Rated Assemblies: Where gypsum sheathing boards are part of fire-resistance-rated assemblies, provide assemblies as follows:
 - 1. Assemblies comply with requirements of fire-response-tested assemblies indicated by GA File Numbers in GA-600, "Fire Resistance Design Manual"; or by design designations in UL's "Fire Resistance Directory" or in certification listings of another testing and inspecting agency acceptable to authorities having jurisdiction.
 - 2. Fire-resistance ratings were determined by fire-response testing assemblies according to ASTM E 119.
- 1.06 DELIVERY, STORAGE, AND HANDLING
- A. Deliver materials in original packages, containers, or bundles, each bearing brand name and identification of manufacturer.
 - B. Store materials protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, or other causes.
 - 1. Neatly stack gypsum sheathing board flat on leveled supports off the ground, under cover, and fully protected from weather.
 - 2. Neatly stack lumber, plywood, and other panels; place spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.
- 1.07 SEQUENCING AND SCHEDULING
- A. Sequence installing sheathing with installing exterior cladding to comply with requirements indicated below:
 - 1. Do not leave glass-mat gypsum sheathing board exposed to weather for more than 180 days.

PART 2 - PRODUCTS

2.01 WOOD PANEL PRODUCTS, GENERAL

- A. Plywood: Either DOC PS 1 or DOC PS 2, unless otherwise indicated.
- B. Thickness: As needed to comply with requirements specified, but not less than thickness indicated.
- C. Factory mark panels to indicate compliance with applicable standard.

2.02 PRESERVATIVE-TREATED PLYWOOD

- A. Preservative Treatment by Pressure Process: AWPA C9.
 - 1. Preservative Chemicals: Acceptable to authorities having jurisdiction and not containing arsenate.
- B. Mark plywood with appropriate classification marking of an inspection agency acceptable to authorities having jurisdiction.
- C. Application: Treat items indicated on Drawings and plywood in contact with masonry or concrete or used with roofing, flashing, vapor barriers, and waterproofing.

2.03 FIRE-RETARDANT-TREATED PLYWOOD

- A. General: Comply with performance requirements in AWPA C27.
 - 1. Use treatment that does not promote corrosion of metal fasteners.
 - 2. Use Exterior type for exterior locations and where indicated.
 - 3. Use Interior Type A, unless otherwise indicated.
- B. Kiln-dry material after treatment to a maximum moisture content of 15 percent. Do not use material that is warped or does not comply with requirements for untreated material.
- C. Identify fire-retardant-treated plywood with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.

- D. Application: Treat plywood indicated on Drawings, and as required by local authorities having jurisdiction.
- 2.04 WALL SHEATHING
- A. Plywood Wall Sheathing: Exterior, Structural I sheathing.
 - 1. Span Rating: As indicated.
 - 2. Nominal Thickness: Not less than 1/2 inch.
- 2.05 ROOF SHEATHING
- A. Plywood Roof Sheathing: Exterior, Structural I sheathing.
 - 1. Span Rating: As indicated.
 - 2. Nominal Thickness: Match existing, Not less than 3/4 inch.
- 2.06 SUBFLOORING AND UNDERLAYMENT
- A. Plywood Subflooring: Exterior, Structural I single-floor panels or sheathing.
 - 1. Span Rating: Not less than 16 o.c.
 - 2. Nominal Thickness: Not less than 23/32 inch
 - 3. Edge Detail: Tongue and groove.
 - 4. Composite wood for interior use shall be made with adhesive and binder containing no urea formaldehyde.
 - B. Underlayment, General: Provide underlayment in nominal thicknesses indicated or, if not indicated, not less than 1/4 inch over smooth subfloors and not less than 3/8 inch over board or uneven subfloors.
 - 1. Edge Detail: Tongue and groove.
 - 2. Composite wood for interior use shall be made with adhesive and binder containing no urea formaldehyde.
 - C. Plywood Underlayment for Resilient Flooring: DOC PS 1, Exterior C-C Plugged, with fully sanded face.
- 2.07 FASTENERS
- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.
 - 1. For roof and wall sheathing, provide fasteners of stainless steel, Type 304.
 - B. Nails, Brads, and Staples: ASTM F 1667.
 - C. Power-Driven Fasteners: NES NER-272.
 - D. Screws for Fastening Wood Structural Panels to Cold-Formed Metal Framing: ASTM C 954, except with wafer heads and reamer wings, length as recommended by screw manufacturer for material being fastened.
 - 1. For wall and roof sheathing panels, provide screws with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours according to ASTM B 117.
- 2.08 WEATHER-RESISTANT SHEATHING PAPER
- A. Building Wrap: ASTM E 1677, Type I air retarder; with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested according to ASTM E 84; UV stabilized; and acceptable to authorities having jurisdiction.
 - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Chemical Company (The); Styrofoam Weathermate Plus Brand Housewrap.
 - b. DuPont (E. I. du Pont de Nemours and Company); Tyvek Home Wrap.
 - c. Reemay, Inc.; Tytar HouseWrap.
 - 2. Allowable UV Exposure Time: Not less than three months.

- B. Building-Wrap Tape: Pressure-sensitive plastic tape recommended by building-wrap manufacturer for sealing joints and penetrations in building wrap.

PART 3 - EXECUTION

3.01 INSTALLATION, GENERAL

- A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction, unless otherwise indicated.
- C. Securely attach to substrate by fastening as indicated, complying with the following:
 - 1. NES NER-272 for power-driven fasteners.
- D. Cut boards at penetrations, edges, and other obstructions of the work; fit tightly against abutting construction, except provide a 3/8-inch setback where non-load-bearing construction abuts structural elements.
- E. Coordinate sheathing installation with flashing and joint sealant installation so these materials are installed in the sequence and manner that prevent exterior moisture from passing through completed exterior wall assembly.
 - 1. Gypsum Sheathing: Install gypsum sheathing to comply with GA-253 and manufacturer's written instructions.
 - 2. Wood Sheathing and Underlayment: Comply with applicable recommendations in APA Form No. E30S, "Engineered Wood Construction Guide," for types of structural-use panels and applications indicated.
- F. Apply fasteners so screw heads bear tightly against face of sheathing boards but do not cut into facing.
- G. Do not bridge building expansion joints with sheathing; cut and space edges to match spacing of structural support elements.
- H. Wood Sheathing and Underlayment, Fastening Methods:
 - 1. Nail to wood framing and wood subflooring.
 - 2. Screw to cold-formed metal framing.
 - 3. Space panels 1/8 inch apart at edges and ends.

3.02 WEATHER-RESISTANT SHEATHING-PAPER INSTALLATION

- A. General: Cover sheathing with weather-resistant sheathing paper as follows:
 - 1. Cut back barrier 1/2 inch on each side of the break in supporting members at expansion or control-joint locations.
 - 2. Apply barrier to cover vertical flashing with a minimum 4-inch overlap, unless otherwise indicated.
- B. Building Wrap: Comply with manufacturer's written instructions.
 - 1. Seal seams, edges, fasteners, and penetrations with tape.
 - 2. Extend into jambs of openings and seal corners with tape.

END OF SECTION



SECTION 06 20 13

EXTERIOR FINISH CARPENTRY

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Provide all exterior finish carpentry work as indicated on the Drawings and as specified herein. Include, but do not limit to:
 - 1. Exterior wood standing and running trim and accessories.
 - 2. All other exterior finish carpentry work indicated.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; Wood sheathing, underlayment, and fasteners.
 - 2. Section 09 91 00, Painting; Field finishing of work of this Section.
 - 3. Division 22 - Plumbing.
 - 4. Division 23 - Mechanical.
 - 5. Division 26 - Electrical.

1.04 DEFINITIONS

- A. Exterior architectural woodwork includes wood blocking, shims, and nailers for installing woodwork items unless concealed within other construction prior to woodwork installation.

1.05 SUBMITTALS

- A. Product data for each type of product and process specified and incorporated into items of architectural woodwork during fabrication, finishing, and installation.
- B. Shop drawings showing location of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components.
 - 1. Show details full size.
 - 2. Show locations and sizes of blocking and nailers, including concealed blocking and reinforcing specified in other Sections.
- C. Mock-Up: Mock-up of exterior wall siding is required. Provide 4' X 6' full-size mock-up as approved by Architect, including backup to support mock-up. Include siding, insulation, vapor barriers, sheathing, sealants and flashings. Locate on-site at location approved by Architect. Coordinate with work of other sections to ensure that mock-up construction is coordinated. Remove mock-up at end of project as acceptable to Architect.
- D. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED Submittals.

EXTERIOR FINISH CARPENTRY

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- 1.06 QUALITY ASSURANCE
- A. Fabricator Qualifications: Firm experienced in producing architectural woodwork similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units without delaying the Work.
 - B. Installer Qualifications: Arrange for exterior architectural woodwork installation by a firm that can demonstrate successful experience in installing architectural woodwork items similar in type and quality to those required for this Project.
- 1.07 ENVIRONMENTAL REQUIREMENTS
- A. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
 - B. Certified Wood Components: Provide a minimum of 50 percent of the wood-based materials and products certified in accordance with the Forest Stewardship Council's Principles and Criteria.
- 1.08 DELIVERY, STORAGE, AND HANDLING
- A. Protect woodwork during transit, delivery, storage, and handling to prevent damage, soilage, and deterioration.
- 1.09 PROJECT CONDITIONS
- A. Environmental Limitations: Obtain and comply with woodwork manufacturer's and Installer's coordinated advice for optimum temperature and humidity conditions for woodwork during its storage.
 - B. Weather Limitations: Proceed with installation of exterior woodwork only when existing and forecasted weather conditions will permit work to be performed and at least one coat of specified finish to be applied without exposure to rain, snow, or dampness.
 - C. Field Measurements: Where woodwork is indicated to be fitted to other construction, check actual dimensions of other construction by accurate field measurements before fabrication, and show recorded measurements on final shop drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
 - 1. Verify locations of concealed framing, blocking, and reinforcements that support woodwork by accurate field measurements before being enclosed. Record measurements on final shop drawings.
 - 2. Where field measurements cannot be made without delaying the Work, guarantee dimensions and proceed with fabricating woodwork without field measurements. Provide allowance for trimming at site and coordinate construction to ensure that actual dimensions correspond to guaranteed dimensions.
- 1.10 COORDINATION
- A. Coordinate sizes and locations of framing, blocking, reinforcements, and other related units of Work specified in other Sections to ensure that exterior architectural woodwork can be supported and installed as indicated.

PART 2 - PRODUCTS

- 2.01 MATERIALS, GENERAL
- A. Lumber Standards: Comply with DOC PS 20, "American Softwood Lumber Standard," for lumber and with applicable grading rules of inspection agencies certified by American Lumber Standards Committee Board of Review.
 - B. Softwood Plywood: Comply with DOC PS 1, "U.S. Product Standard for Construction and Industrial Plywood."
 - C. Hardwood Plywood: Comply with HPVA HP-1, "Interim Voluntary Standard for Hardwood and Decorative Plywood."

- D. Inspection Agencies: Inspection agencies, and the abbreviations used to reference them, include the following:
 - 1. APA - American Plywood Association.
 - 2. NELMA - Northeastern Lumber Manufacturers Association.
 - 3. NLGA - National Lumber Grades Authority.
 - 4. WCLIB - West Coast Lumber Inspection Bureau.
 - 5. WWPA - Western Wood Products Association.
 - E. Grade Stamps: Provide lumber with each piece factory marked with grade stamp of inspection agency evidencing compliance with grading rule requirements and identifying grading agency, grade, species, moisture content at time of surfacing, and mill.
 - 1. For exposed lumber, furnish pieces with grade stamps applied to ends or back of each piece, or omit grade stamps entirely and provide certificates of grade compliance issued by inspection agency.
- 2.02 WOOD-PRESERVATIVE-TREATED MATERIALS
- A. Preservative Treatment by Nonpressure Process: Comply with NWWDA I.S.4 and the following for woodwork items indicated to receive water-repellent preservative treatment.
 - 1. Water-Repellant Preservative: NWWDA-tested and -accepted formulation containing 3-iodo-2-propynyl butyl carbonate (IPBC) as its active ingredient.
 - B. Preservative Treatment by Pressure Process: Comply with AWWPA C2 (lumber) and AWWPA C9 (plywood) and the following for woodwork items indicated to receive pressure preservative treatment. Mark each treated item with the AWPB or SPIB Quality Mark Requirements.
 - 1. Preservative Chemicals: Pressure-impregnate woodwork with preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants in solution to distinguish treated material from untreated material.
 - 2. Pressure-treat aboveground items with preservatives to a minimum retention of 0.25 lb/cu. ft. (4.0 kg/cu. m). Kiln-dry lumber and plywood to a maximum moisture content, respectively, of 19 and 15 percent.
 - C. Extent of Treatment: Treat each item of exterior woodwork regardless of species from which it is fabricated.
- 2.03 INSTALLATION MATERIALS
- A. Blocking, Shims, and Nailers: Fire-retardant-treated softwood lumber, kiln dried to less than 15 percent moisture content.
 - B. Screws: Select material, type, size, and finish required for each use, nonferrous metal or hotdip galvanized, unless otherwise indicated. Comply with ASME B18.6.1 for applicable requirements.
 - 1. For metal framing supports, provide screws as recommended by metal-framing manufacturer.
 - C. Nails: Select material, type, size, and finish required for each use. Comply with FS FF-N-105 for applicable requirements.
 - 1. Stainless-steel nails.
 - D. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide nonferrous metal or hot-dip galvanized anchors and inserts, unless otherwise indicated. Provide toothed steel or lead expansion bolt devices for drilled-in-place anchors.
 - E. Fasteners for Use with Pressure Preservative Treatment: Stainless steel, Type 304 or better.
- 2.04 FABRICATION, GENERAL

- A. Wood Moisture Content: Comply with requirements of referenced quality standard for wood moisture content in relation to relative humidity conditions existing during time of fabrication and in installation areas.
 - B. Fabricate woodwork to dimensions, profiles, and details indicated. Ease edges to radius indicated for the following:
 - 1. Edges of solid-wood (lumber) members 3/4 inch thick or less: 1/16 inch .
 - 2. Edges of rails and similar members more than 3/4 inch thick: 1/8 inch.
 - C. Complete fabrication, including assembly, finishing, and hardware application, before shipment to Project site to maximum extent possible. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
 - D. Shop-cut openings, to maximum extent possible, to receive hardware, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Smooth edges of cutouts and seal edges with a water-resistant coating suitable for exterior applications.
- 2.05 EXTERIOR STANDING AND RUNNING TRIM AND SOFFITS
- A. Scope: Work shall include but not be limited to the following:
 - 1. Trim and fascia.
 - 2. Soffits.
 - 3. Ornamental items.
 - B. Wood: Provide finished lumber and moldings complying with the following requirements including those of the grading agency listed with species:
 - 1. Species: Clear Western Red Cedar.
 - 2. Texture: Rough sawn.
 - 3. Lumber for Transparent Finish (Stained or Clear): Solid lumber stock.
 - 4. Lumber for Painted Finish: Glued-up lumber or solid lumber stock.
- 2.06 SHOP FINISHING
- A. Wood Items: Shop finishing work includes, but is not limited to, the following:
 - 1. Painted Work: Provide prime coat to all sides, complying with Section 09 90 00, PAINTING.
 - 2. Transparent Finished Work: Provide sealer coat to all sides, complying with Section 09 90 00, PAINTING.

PART 3 EXECUTION

3.01 WORKMANSHIP AND INSTALLATION REQUIREMENTS

- A. Dressed and sand finish carpentry work free from machine and tool marks, abrasions, raised grain, or other defects on surfaces exposed to view.
- B. Provide tight joints formed to conceal shrinkage. Fit butt joints with concealed spline. Glue and dowel shop miters which are four inches or greater. Glue and spline miters less than 4 in., with spline concealed.
- C. Blind nail finish work to the greatest extent possible. Where surface nailing is used, set and fill nails to match adjacent wood.
- D. Wherever nailing into concrete is done, care shall be taken to protect pipes or conduits embedded in the slab. No puncturing of pipes or conduits will be allowed. Damage to embedded work shall be corrected without further cost to Owner. Inserts and anchor bolts shall be placed before the pouring of concrete.
- E. Secure work to prevent checks or warps. Finish carpentry work shall be properly framed, closely fitted, and accurately set to the required lines and levels and shall be rigidly secured in place.

3.02 PAINTING AND FINISHING

- A. Field painting and finishing is specified under Section 09 90 00, PAINTING. All finish carpentry items shall be primed or sealed on all sides, as work of this Section, before installation. Paint or seal coats must be dry before items are installed.

3.03 SPECIFIC INSTRUCTIONS

- A. Important Note: No attempt is made in the following specific instructions to list all elements of exterior finish carpentry required on this project. It is the responsibility of the Contractor to determine for himself from the Drawings the scope and nature of the work required. These specific instructions are intended only to provide additional instructions regarding those portions of the exterior finished carpentry for which information beyond that given on the Drawings or covered in the AWI Quality Standards seems needed to properly describe the work. Where the scope of a category is listed it is done in a general manner to assist the Contractor in determining the general nature of work he shall look for as being required in said category, and not to limit the work.

3.04 FINISH CARPENTRY WORK

- A. Fabricate and install finish carpentry work in accordance with manufacturer's recommendations, the Drawings, the specifications, and AWI Quality Standards applicable or referenced to this work.
- B. Miscellaneous Items: Install all required standing and running trim and other miscellaneous items throughout, as indicated on the Drawings and as required to satisfactorily complete the entire work, whether or not each and every required piece is specifically indicated on the Drawings. Trim shall be of same material and finish as the larger member to which applied.

3.05 COMPLETION

- A. Just prior to completion of work of this Section, inspect work in the company of Architect and make adjustments and corrections to work leaving operating parts in perfect operating condition, all jointing to adjacent material tight, all surfaces without blemishes or stains, all work properly executed and complete, and all defects and damaged work replaced or corrected.

3.06 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 74 00, Construction Waste Management, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 06 20 23

INTERIOR FINISH CARPENTRY

PART 1 GENERAL

1.01 SUMMARY

- A. This Section includes the following:
 - 1. Interior standing and running trim.
 - 2. Shelving and clothes rods.
- B. See Division 06 Section "Interior Architectural Woodwork" for interior woodwork not specified in this Section.

1.02 SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product.
- B. Samples: For each type of paneling indicated.
- C. LEED Submittals:
 - 1. Credit EQ 4.1: Manufacturers' product data for adhesives and glues, including printed statement of VOC content.
 - 2. Credit EQ 4.4: Composite wood manufacturer's product data for each composite wood product used indicating that the bonding agent contains no urea formaldehyde.

PART 2 PRODUCTS

2.01 MATERIALS, GENERAL

- A. Lumber: DOC PS 20 and applicable grading rules of inspection agencies certified by ALSC's Board of Review.
- B. Softwood Plywood: DOC PS 1.
- C. Hardboard: AHA A135.4.
- D. MDF: ANSI A208.2, Grade 130, made with binder containing no urea-formaldehyde resin.
- E. Particleboard: ANSI A208.1, Grade M-2, made with binder containing no urea-formaldehyde resin.
- F. Melamine-Faced Particleboard: Particleboard complying with ANSI A208.1, Grade M-2, finished on both faces with thermally fused, melamine-impregnated decorative paper complying with LMA SAT-1.

2.02 FIRE-RETARDANT-TREATED MATERIALS

- A. Lumber: Comply with performance requirements in AWPA C20, Interior Type A. Kiln dry after treatment to a maximum moisture content of 19 percent.
- B. Plywood: Comply with performance requirements in AWPA C27, Interior Type A. Kiln dry after treatment to a maximum moisture content of 15 percent.
- C. Application: All interior lumber and plywood.

2.03 STANDING AND RUNNING TRIM

- A. Softwood Lumber Trim:

INTERIOR FINISH CARPENTRY

1. Species and Grade: Douglas fir-larch or Douglas fir south, Superior or C & Btr finish; NLGA, WCLIB, or WWPA.
 2. Maximum Moisture Content: 15 percent.
- B. Hardwood Moldings for Transparent Finish (Stain or Clear Finish): WMMPA HWM 2, N-grade wood moldings made to patterns included in WMMPA WM 12.
1. Species: Poplar.
 2. Maximum Moisture Content: 9 percent.
- C. Moldings for painted trim:
1. Hardwood moldings as above
 2. Optional Material: Primed MDF.
- 2.04 SHELVING AND CLOTHES RODS
- A. Shelving: Made from one of the following materials, 3/4 inch thick. Do not use particleboard or MDF that contains urea formaldehyde.
1. Particleboard with solid-wood front edge.
 2. MDF with solid-wood front edge.
 3. Melamine-faced particleboard with applied PVC front edge.
 4. Softwood Boards: Douglas fir-larch, Douglas fir south, or hem-fir; NLGA, WCLIB, or WWPA; or southern pine; SPIB; kiln dried.
- B. Shelf Cleats: 3/4-by-5-1/2-inch boards with hole and notch to receive clothes rods, as specified above for shelving.
- C. Shelf Brackets with Rod Support: BHMA A156.16, B04051; prime-painted formed steel.
- D. Shelf Brackets without Rod Support: BHMA A156.16, B04041; prime-painted formed steel.
- E. Clothes Rods: 1-1/2-inch- diameter, clear, kiln-dried hardwood.
- 2.05 MISCELLANEOUS MATERIALS
- A. Glue: Aliphatic-resin, polyurethane, or resorcinol wood glue.
1. Use wood glue that has a VOC content of 30 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 EXECUTION

- 3.01 PREPARATION
- A. Before installing interior finish carpentry, condition materials to average prevailing humidity in installation areas for a minimum of 24 hours.
- 3.02 INSTALLATION, GENERAL
- A. Install interior finish carpentry level, plumb, true, and aligned with adjacent materials. Use concealed shims where necessary for alignment.
1. Scribe and cut interior finish carpentry to fit adjoining work.
 2. Countersink fasteners, fill surface flush, and sand where face fastening is unavoidable.
 3. Install to tolerance of 1/8 inch in 96 inches for level and plumb. Install adjoining interior finish carpentry with 1/32-inch maximum offset.
 4. Install stairs with no more than 3/16-inch variation between adjacent treads and risers and with no more than 3/8-inch variation between largest and smallest treads and risers within each flight.
- 3.03 STANDING AND RUNNING TRIM INSTALLATION

- A. Install with minimum number of joints practical, using full-length pieces from maximum lengths of lumber available. Cope at returns and miter at corners to produce tight-fitting joints. Use scarf joints for end-to-end joints.

3.04 SHELVING AND CLOTHES ROD INSTALLATION

- A. Cut shelf cleats at ends of shelves about 1/2 inch less than width of shelves and sand exposed ends smooth.
- B. Install shelf cleats by fastening to framing or backing with finish nails or trim screws, set below face and filled. Space fasteners not more than 16 inches o.c.
- C. Install shelf brackets according to manufacturer's written instructions, spaced not more than 36 inches o.c. Fasten to framing members, blocking, or metal backing, or use toggle bolts or hollow wall anchors.
- D. Cut shelves to neatly fit openings with only enough gap to allow shelves to be removed and reinstalled. Install shelves, fully seated on cleats, brackets, and supports.

END OF SECTION



SECTION 06 40 23

INTERIOR ARCHITECTURAL WOODWORK

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, interior architectural woodwork including the following:
 - 1. Scheduling and coordination of Owner-furnished Owner-installed casework.
 - 2. Standing and running trim and rails.
 - 3. Custom wood casework.
 - 4. Plastic laminate casework.
 - 5. Plastic laminate countertops.
 - 6. Wood countertops.
 - 7. Solid surfacing countertops.
 - 8. Wood paneling and interior siding.
 - 9. Additional items as specified and indicated on the Drawings.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 05 50 00, Metal Fabrications; counter supports.
 - 2. Section 06 10 00, Rough Carpentry; blocking, grounds and nailers.
 - 3. Section 09 90 00, Painting; Field painting work of this Section.
 - 4. Division 23 - Mechanical; coordination with mechanical requirements.
 - 5. Division 26 - Electrical; coordination with electrical requirements.

1.04 SUBMITTALS

- A. Certifications: Provide certifications stating that materials and fabrication complies with specification requirements.
- B. Shop Drawings: Provide large scale shop drawings for fabrication, installation and erection of all parts of the work. Provide large scale detailed plans, elevations, and details of anchorages, connections and accessory items.
- C. Field Measurements: Take accurate field measurements before preparation of shop drawings and fabrication. Do not delay job progress; allow for field cutting and fitting where taking field measurements before fabrication is not possible.
- D. Verification Samples: Submit at least two fully finished representative samples minimum 12 by 12 inches in size of each material that is to be exposed in the finished work, showing the full range of color and finish variations expected.
 - 1. Do not place orders for products prior to approval by Architect.

INTERIOR ARCHITECTURAL WOODWORK

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- E. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.
- 1.05 QUALITY ASSURANCE
- A. Source: For each material type required for work of this Section, provide primary materials which are product of one manufacturer. Provide secondary or accessory materials which are acceptable to manufacturers of primary materials.
 - B. Installer: A firm with a minimum of three years experience in type of work required by this Section.
 - C. Quality Standard: Provide work complying with applicable requirements of AWI Quality Standards. Where not otherwise indicated, fabricator may choose among options permitted by AWI for grade of work specified.
 - 1. Panel Products: Provide minimum 45 pounds per cubic foot medium density particleboard. Do not use hardboard.
- 1.06 ENVIRONMENTAL REQUIREMENTS
- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
 - 1. Plywood: 50% recycled content (or FSC).
 - 2. MDF: 50% recycled content.
 - B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
 - C. Certified Wood Components: Provide a minimum of 50 percent of the wood-based materials and products certified in accordance with the Forest Stewardship Council's Principles and Criteria.
 - D. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.
 - 2. Option D, Composite Wood and Agrifiber Products: Composite wood and agrifiber products, include particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores. Comply with one of the following criteria for each product:
 - a. Composite wood and agrifiber products must contain no added urea-formaldehyde resins. Laminate adhesives used to fabricate on-site and shop applied assemblies must contain no added urea formaldehyde.
 - b. Composite wood and agrifiber products must meet the testing and product requirements of the California Department of Health Services (CDHS) Standard Practice for the Testing of Volatile Organic Emissions From Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.
 - E. Resource Reuse: Provide salvaged, refurbished or reused materials for the following items:
 - 1. Wood panels, as indicated.
- 1.07 PROJECT CONDITIONS
- A. Substrates: Proceed with work only when substrate construction and penetration work is complete.

- B. Wet Work: Proceed with work of this Section after wet work has been complete and fully dry or cured. Wet work is defined as plaster, gypsum drywall, paint, concrete, etc.
- C. Conditioning: Advise Contractor of temperature and humidity requirements for woodwork installation. Do not install work of this Section until required temperature and relative humidity in areas of installation has been stabilized and will be maintained.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Do not deliver materials to site until building has been closed in, wet work is completed and sufficiently dry, and building is continuously maintained at a temperature above 65oF. Obtain Architect's approval before delivering materials or fabricated items. Store materials off the floor, fully protected from damage.
- B. Provide fasteners and hardware required to complete the work. Use concealed fastenings wherever possible. Provide cadmium plated or zinc chromate plated fasteners at concealed locations; stainless steel or chrome plated at exposed interior locations.
- C. Provide materials and products which meet or exceed the requirements of the indicated AWI Quality Standards specified for each type of work.
- D. Provide solid lumber, kiln-dried to moisture content of 5% to 10% by weight, with average not to exceed 8%.
- E. Furnish lumber in longest practical lengths. Use single-length pieces wherever possible.
- F. Take necessary field measurements before starting fabrication of built-in work.

2.02 VENEERS AND LUMBER

- A. Quality Standard: Provide AWI Premium Grade materials and workmanship.
- B. Veneers and Lumber: Kiln dry to 6-8 percent moisture content. Components shall be free of defects and sapwood. Match adjacent pieces for color and grain pattern.
 1. Species and Cuts: Refer to Finish Schedule.
 2. Paneling: Provide reclaimed beadboard and T1-11 paneling, refer to Finish Schedule.
 3. Reclaimed Wood Panels: Refer to Section 06403, Specialty Wood Specification.
 4. Trim, Transparent Finish: Provide Douglas Fir, face grain, as approved by the Architect.
 5. Trim, Opaque Painted Finish: Provide Poplar, plain sawn.
- C. Single-Source Requirement for Wood Veneers and Solids: Intent is to provide wood which matches as closely as possible throughout the project. Provide wood veneers and solids from the same distributor, and from the same flitches and solids sources to the greatest extent possible. Requirement shall apply to all wood with transparent finish specified in Section 06 20 00 and 08 14 00.
- D. Fire-Retardant Treated Wood for Exterior and Interior Use: Provide water based, low voc content, with no polybrominated diphenyl ethers (PBDE), UL fire retardant penetrating treatment, which yields a flame spread of not more than 25 when tested in conformance with ASTM E 84.
 1. Acceptable Product: Wood Seal Fire Retardant, by Flame Seal Products, Inc., Houston, TX; www.flameseal.com.
 2. Plywood conforms to AWPAC 27 for Exterior Type, and has successfully passed a rain test conforming to ASTM D 2898. Kiln dry after treatment to a maximum moisture content of 19%.
 3. Lumber conforms to AWPAC20, Type A. Kiln dry after treatment to a maximum moisture content of 19%.
 4. Fire retardant treatment shall not affect the coloration and pigment of the wood, where exposed in final work.

- E. Medium Density Fiberboard (MDF): ANSI A208.2, Grade MD, exterior glue with no added ureaformaldehyde resins. Acceptable products are as follows:
1. Arreis SDF, by SierraPine Ltd, Medford, OR; telephone 800-676-3339; www.sierrapine.com.
 - a. Wood Fiber: 100% recycled content.
 2. Medite II for interior applications, Medex for use in high moisture applications, and Medite FR for Class 1 fire-rated applications as applicable, by SierraPine Ltd, Moncure, NC. Telephone 800-334-2250; www.sierrapine.com.
 3. Premier Plus fiberboard, by Willamette Industries.
 4. PurKor MDF Plus, by Panel Source International, St. Albert, Alberta, Canada T8N 5C1; Telephone 780-458-1007; www.panelsource.net.
 - a. Wood Fiber: 100% recycled content.
 5. PurKor Platinum MDF, by Panel Source International, St. Albert, Alberta, Canada T8N 5C1; Telephone 780-458-1007; www.panelsource.net.
 - a. Wood Fiber: 100% recycled content.
 - b. Wood Fiber: FSC certified.
- F. Particle Board: ANSI A208.1, Grade M2, exterior glue with no added urea-formaldehyde resins. Acceptable products are as follows:
1. Encore SDP, by SierraPine Ltd, Adel, GA; telephone 800-676-3339; www.sierrapine.com.
 2. PurKor Particleboard Plus, by Panel Source International, St. Albert, Alberta, Canada T8N 5C1; Telephone 780-458-1007; www.panelsource.net.
 - a. Wood Fiber: 100% recycled content.
 3. Resincore I, as manufactured by Rodman Industries, Oconomowoc, WI 53066, Telephone 262-569-5820; www.rodmanindustries.com.
 4. SkyBlend, as manufactured by Roseburg Forest Products Co., Roseburg, OR 97470; Telephone 541-679-3311; www.rfpco.com.
- G. Plywood: DOC PS 1, exterior grade, exterior glue with no added urea-formaldehyde resins. Acceptable products are as follows:
1. Purebond, by Columbia Forest Products. Portland, OR 97201; telephone 800-547-4261; www.cfpwood.com. Local manufacturing location for hardwood veneer is Newport, VT and Presque Isle, ME, and hardwood plywood is St. Casimir, QC, Canada.
 2. PurKor Platinum, by Panel Source International, St. Albert, Alberta, Canada T8N 5C1; telephone 780-458-1007; www.panelsource.net.
 3. SkyPly, as manufactured by Roseburg Forest Products Co., Roseburg, OR 97470; telephone 541-679-3311; www.rfpco.com.

2.03 PLASTIC LAMINATE

- A. Plastic Laminate Manufacturers: Provide plastic laminate materials that meet or exceed specified requirements from one of the following manufacturers, or Architect approved equals:
1. Formica Decorative Laminates; Formica Corporation, Cincinnati, OH 45241.
 2. Laminart Decorative Laminate; Laminart, Elk Grove, IL.
 3. Nevamar Decorative Laminates; Nevamar Corporation; Odenton, MD 21113.
 4. Pionite Decorative Laminates; Pioneer Plastics Corporation, Auburn, ME 04210.
 5. Wilsonart Decorative Laminates., Ralph Wilson Plastics Co.; Temple, TX 76501.
 6. Avonite; Belen, NM 87002.
- B. Provide laminate complying with NEMA LD 3, and the following:
1. Horizontal and Vertical Surfaces (Except Postformed Surfaces): General Purpose Standard Grade, GP-50 (0.050 in. nominal thickness).
 2. Postformed Surfaces: Postforming Type, PF-42 (0.042 in. nominal thickness).
 3. Balance Sheet: Backer Type, BK-20 (0.020 in. nominal thickness).

4. Color/Texture/Pattern: Provide laminates in colors, textures and patterns selected by Architect from industry-wide available choices.
 - C. Core: Provide medium density, phenolic resin, particleboard (Type 1-M-1) core for all plastic laminate work. Provide minimum 45 pcf medium density particleboard. Do not use hardboard.
- 2.04 SOLID SURFACING
- A. Solid Surfacing Material: Provide the following:
 1. Corian; Du Pont Company, Wilmington, DE 19898
 - B. Provide material in sizes, profiles, and configurations indicated on Drawings. Color shall be as indicated on the Finish Schedule. Thickness shall be 1/2 in.
- 2.05 INTERIOR STANDING AND RUNNING TRIM
- A. Scope: Standing and running trim work includes, but is not limited to, the following:
 1. Wood wall elements.
 2. Stairwork and rails.
 3. Battens.
 4. Miscellaneous molding and trim.
 - B. Quality Standard: Provide AWI Premium Grade materials and workmanship.
 - C. Wood Species and Cuts: Provide as follows:
 1. Transparent Work: Refer to Finish Schedule and conforming to AWI Quality Standards Premium Grade.
 2. Opaque Work: Poplar, plain sawn.
 - D. Shop Assembly: Shop assemble casings and frames with accurately mitered joints, pressure glued with lemon shaped splines.
- 2.06 CASEWORK
- A. Scope: Standing and running trim work includes, but is not limited to, the following:
 1. Wood casework
 2. Plastic laminate casework.
 - B. Quality Standard: Provide AWI Custom Grade materials and workmanship.
 - C. Wood Species and Cuts: As specified hereinabove conforming to AWI Quality Standards Custom Grade.
 - D. Plastic Laminate: Provide as specified above and complying with the following:
 1. Color/Texture/Pattern: Provide laminates in colors, textures and patterns selected by Architect from industry available choices.
 2. Construction: Provide balancing sheets for work. Fabricate work for use in wet environments. All surfaces of core shall be covered with laminate. Provide loose splashes with six sides covered with laminate. All exposed surfaces shall be covered with "face" laminate.
 - E. Door Frames: Reveal overlay, to profiles indicated on the Drawings. Coordinate with hardware requirements.
 - F. Dust Panels: Provide plywood dust panels in work.
 - G. Preparation for Related Work: Prepare casework for related electrical, telephone, mechanical, and plumbing work. Cut holes to fit templates of appliances and fixtures. Trim openings so that core materials are covered with laminate.

- H. Hardware: Provide following or Architect approved equal unless different hardware is indicated on the Drawings:
 - 1. Hinges: Stanley 1560 series, self-closing.
 - 2. Drawer and Door Pulls: Stanley 4484.
 - 3. Drawer Slides: Accuride C3800.
 - 4. Adjustable Shelf Hardware: Recessed Knap and Vogt 233 with 237 shelf clips.
 - 5. Door Silencers: Glynn Johnson GJ-65.
 - 6. Locks: pin tumbler types to suit thickness of material in which installed, Corbin cabinet locks or approved equal; use at locations noted on Drawings.
 - 7. Countertop Support Brackets: Extra heavy duty RAKKS EH-1818.
 - I. Drawer Construction: Provide multiple dovetail construction with applied drawer fronts.
 - J. Casework Joinery: Fabricate countertops to have fewest possible seams. Locate seams where shown on shop Drawings as approved by Architect. Do not use any exposed fasteners or connectors. Use concealed bolts to hold seams and joints hairline, lightproof tight.
- 2.07 COUNTERTOPS
- A. Quality Standard: Provide AWI Custom Grade materials and workmanship.
 - B. Plastic Laminate: Provide as specified above and complying with the following:
 - 1. Color/Texture/Pattern: Provide colors, textures and patterns selected by Architect from industry available choices.
 - 2. Construction: Provide balancing sheets for work. Fabricate work for use in wet environments. All surfaces of core shall be covered with laminate. Provide loose splashes with six sides covered with laminate. All exposed surfaces shall be covered with "face" laminate.
 - C. Wood Species and Cuts: As specified hereinabove conforming to AWI Quality Standards Custom Grade.
 - D. Solid Surfacing: Provide as specified above and complying with the following:
 - 1. Color/Texture/Pattern: Provide colors, textures and patterns selected by Architect from industry available choices.
 - 2. Fabrication: Fabricate tops in one piece with shop-applied backsplashes and edges, unless otherwise indicated. Comply with material manufacturer's recommendations for adhesives, sealers, fabrication, and finishing.
 - a. Install integral sink bowls in countertops in the shop.
 - E. Preparation for Related Work: Prepare countertops for all related appliances and plumbing work. Cut holes to fit templates of appliances and fixtures. Trim openings so that all core materials are covered with laminate.
 - F. Fabricate countertops with fewest possible seams. Conceal fasteners.
- 2.08 PANELWORK FABRICATION
- A. Scope: Wood panelwork includes, but is not limited to, the following:
 - 1. Plywood and T1-11 paneling.
 - 2. Reclaimed wood panels as indicated on the Finish Schedule.
 - B. Panelwork Grade: Provide panelwork complying with the referenced quality standard, Premium grade.
 - C. Wood Moisture Content: Comply with requirements of referenced quality standard for wood moisture content in relation to relative humidity conditions existing during time of fabrication and in installation areas.

- D. Sand fire-retardant-treated wood lightly to remove raised grain on exposed surfaces before fabrication.
 - E. Fabricate panelwork to dimensions, profiles, and details indicated.
 - F. Grade stamps and mill markings shall be removed from exposed face of panels, prior to installation.
 - G. Complete fabrication, including assembly, finishing, and other construction, before shipment to Project site to maximum extent possible. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
 - 1. Trial fit assemblies at the fabrication shop that cannot be shipped completely assembled. Install dowels, screws, bolted connectors, and other fastening devices that can be removed after trial fitting. Verify that various parts fit as intended and check measurements of assemblies against field measurements indicated on approved shop drawings before disassembling for shipment.
 - H. Shop-cut openings, to maximum extent possible, to receive hardware, appliances, plumbing fixtures, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Smooth edges of cutouts.
- 2.09 FINISHING
- A. Shop Finish, Interior Architectural Woodwork and Doors for Satin Transparent Finish Where Indicated (all hardwoods and hardwood veneers unless indicated otherwise): AWI Premium Grade TR-6, catalyzed polyurethane, with stain and UV protective coating.
 - B. Field Finish, Interior Architectural Woodwork and Doors for Opaque Painted Finish Where Indicated: Refer to Section 09 90 00, Painting.
- 2.10 INSTALLATION MATERIALS
- A. Blocking, Shims, and Nailers: Fire-retardant-treated softwood lumber, kiln dried to less than 15 percent moisture content.
 - B. Screws: Select material, type, size, and finish required for each use, nonferrous metal or hotdip galvanized, unless otherwise indicated. Comply with ASME B18.6.1 for applicable requirements.
 - 1. For metal framing supports, provide screws as recommended by metal-framing manufacturer.
 - C. Nails: Select material, type, size, and finish required for each use. Comply with FS FF-N-105 for applicable requirements.
 - 1. Stainless-steel nails.
 - D. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide nonferrous metal or hot-dip galvanized anchors and inserts, unless otherwise indicated. Provide toothed steel or lead expansion bolt devices for drilled-in-place anchors.
- PART 3 - EXECUTION
- 3.01 WORKMANSHIP - GENERAL
- A. Work of this Section shall conform to design and detail indicated. Where practicable, work shall be finished and assembled at architectural millwork shop.
 - B. Work shall be finished smooth and free from machine or tool marks that will telescope through finish.
- 3.02 INSTALLATION
- A. Preinstallation Meeting: Convene a pre-installation conference to establish procedures to maintain optimum working conditions and coordinate this work with related and adjacent work. Require architectural woodwork manufacturer, Installer, Contractor, and Owner's Project Manager to attend.

- B. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning of installation work means Installer's acceptance of substrates and conditions.
 - C. Condition woodwork to average prevailing humidity conditions in installation areas prior to installation.
 - D. Proceed with installation only when required ambient conditions have been properly maintained, as determined by all attending pre-installation conference.
 - 1. Provide work to sizes, shapes, and profiles indicated on approved shop drawings.
 - 2. Install work to comply with quality standards and tolerances specified for shop work.
 - 3. Color match wood at joints and seams to minimize expression of joints and seams in transparent finished work.
 - E. Install architectural woodwork plumb, level, true and straight. Shim as required using concealed shims. Install work, including tops, to a tolerance of $\pm 1/8$ in. in 8 ft.
 - F. Scribe and cut architectural woodwork to fit adjoining work. Refinish cut surfaces.
 - G. Anchor casework securely in place.
- 3.03 REPAIRING AND PROTECTION
- A. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired.
 - B. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.
- 3.04 CONSTRUCTION WASTE MANAGEMENT
- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 06 73 00

COMPOSITE DECKING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Composite wood decking.
 - 2. Composite wood trim.
- B. Related Sections:
 - 1. Section 06 10 00, Rough Carpentry.
 - 2. Section 06 20 13, Exterior Finish Carpentry.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. C177-04 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
 - 2. D143-94(2000) - Standard Test Methods for Small Clear Specimens of Timber.
 - 3. D198-05 - Standard Test Methods of Static Tests of Lumber in Structural Sizes.
 - 4. D1037-06 - Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials.
 - 5. D1413-05 - Standard Test Method for Wood Preservatives by Laboratory Soil-Block Cultures.
 - 6. D1761-06 - Standard Test Methods for Mechanical Fasteners in Wood.
 - 7. D1929-96(2001) - Standard Test Method for Determining Ignition Temperature of Plastics.
 - 8. D2047-04 - Standard Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine.
 - 9. D2394-05 - Standard Methods for Simulated Service Testing of Wood and Wood-Base Finish Flooring.
 - 10. D2395-06 - Standard Test Methods for Specific Gravity of Wood and Wood-Based Materials.
 - 11. D4761-05 - Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.
 - 12. E84-07 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 13. F1679-04 Standard Test Method for Using a Variable Incidence Tribometer (VIT).
- B. American Wood Preservers Association (AWPA) E1-06 - Standard Method for Laboratory Evaluation to Determine Resistance to Subterranean Termites.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle composite wood in accordance with manufacturer's instructions.
- B. Store composite wood level and flat, off ground or floor, with supports at each end and maximum 24 inches on center.
- C. Do not stack composite wood over 12 feet high.
- D. Cover composite wood with waterproof covering, vented to prevent moisture buildup.

1.04 WARRANTIES

- A. Furnish manufacturer's 25 year warranty providing coverage against checking, splitting, splintering, rotting, structural damage from termites, and fungal decay of composite wood.

PART 2 - PRODUCTS

COMPOSITE DECKING

06 73 00-1

2.01 MANUFACTURERS

- A. Contract Documents are based on products by Trex Company, Inc.

2.02 MATERIALS

- A. Composite Wood:

1. Composition: Reclaimed wood and plastic with integral coloring; free from toxic chemicals and preservatives.
2. Profiles:
 - a. Decking: Nominally 2 x 6 inches x 20 feet long.
 - b. Trim: Nominally 2 x 4 inches x 20 feet long.
3. Surface texture: Brasilia.
4. Color: Burnished
5. Characteristics:
 - a. Abrasion resistance: 0.01 inch wear per 1000 revolutions, tested to ASTM D2394.
 - b. Hardness: 1124 pounds, tested to ASTM D143.
 - c. Self ignition temperature: 743 degrees F, tested to ASTM D1929.
 - d. Flash ignition temperature: 698 degrees F, tested to ASTM D1929.
 - e. Flame spread rating: 80, tested to ASTM E84.
 - f. Water absorption, 24 hour immersion, tested to ASTM D1037:
 - 1) Sanded surface: 4.3 percent.
 - 2) Unsanded surface: 1.7 percent.
 - g. Thermal expansion coefficient, 36 inch long samples:
 - 1) Width: 35.2×10^{-6} to 42.7×10^{-6} .
 - 2) Length: 16.1×10^{-6} to 19.2×10^{-6} .
 - h. Fastener withdrawal, tested to ASTM D1761:
 - 1) Nail: 163 pounds per inch.
 - 2) Screw: 558 pounds per inch.
 - i. Static coefficient of friction:
 - 1) Dry: 0.53 to 0.55, tested to ASTM D2047.
 - 2) Dry: 0.59 to 0.70, tested to ASTM F1679.
 - 3) Wet: 0.70 to 0.75, tested to ASTM F1679.
 - j. Fungus resistance, white and brown rot: No decay, tested to ASTM D1413.
 - k. Termite resistance: 9.6 rating, tested to AWPA E-1.
 - l. Specific gravity: 0.91 to 0.95, tested to ASTM D2395.
 - m. Compression:
 - 1) Parallel: 1806 PSI ultimate, 550 PSI design, tested to ASTM D198.
 - 2) Perpendicular: 1944 PSI ultimate, 625 PSI design, tested to ASTM D143.
 - n. Tensile strength: 854 PSI ultimate, 250 PSI design, tested to ASTM D198.
 - o. Shear strength: 561 PSI ultimate, 200 PSI design, tested to ASTM D143.
 - p. Modulus of rupture: 1423 PSI ultimate, 250 PSI design, tested to ASTM D4761.
 - q. Modulus of elasticity: 175,000 PSI ultimate, 100,000 PSI design, tested to ASTM D4761.
 - r. Thermal conductivity: 1.57 BTU per inch per hour per square foot at 85 degrees F, tested to ASTM C177.

2.03 ACCESSORIES

- A. Fasteners: composite wood screws of length recommended by composite wood manufacturer for profile being fastened.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install composite wood in accordance with manufacturer's instructions.
- B. Cut, drill, and rout composite wood using carbide tipped blades.

- C. Pre-drill fastener holes located closer than 1 inch from edges.
 - D. Cut ends square and true.
 - E. Do not use composite wood products as structural members.
 - F. Do not exceed maximum spans recommended by manufacturer.
 - G. Place boards perpendicular to supports.
 - H. Stagger end joints in adjacent rows at least one support.
 - I. Leave expansion spaces between abutting boards and between boards and adjacent construction:
 - 1. End gaps between boards: 1/8 inch at ambient temperatures of 60 degrees F and above and 3/16 inch at ambient temperatures below 60 degrees F.
 - 2. Side gaps between boards: 1/4 inch at ambient temperatures of 60 degrees F and above and 3/8 inch at ambient temperatures below 60 degrees F.
 - 3. Gaps between boards and adjacent construction: 1/4 inch at ambient temperatures of 60 degrees F and above and 1/2 inch at ambient temperatures below 60 degrees F.
 - J. Place boards to span three or more supports.
 - K. Fasten each board to each support with two fasteners.
- 3.02 CLEANING
- A. Clean composite wood to remove stains:
 - 1. Mold, mildew, and berry and leaf stains: Clean surfaces with conventional deck wash containing detergent or sodium hypochlorite.
 - 2. Rust and ground-in dirt: Clean surfaces with cleaner containing oxalic or phosphoric acid.
 - 3. Oil and grease: Clean surfaces with detergent containing degreasing agent.

END OF SECTION



SECTION 07 21 13

BOARD INSULATION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section includes, but is not limited to:
 - 1. Board-type building insulation at foundation walls, under slabs, and elsewhere as indicated.
 - 2. Board-type building insulation at exterior walls and elsewhere as indicated.
 - 3. Vapor barriers.
 - 4. Other building insulation work as may be called for on Drawings and not indicated or specified to be included under other Sections.

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 03 30 00, Cast-In-Place Concrete.
 - 2. Section 05 40 00, Cold Formed Metal Framing.
 - 3. Section 07 55 54, Single Ply Membrane Roofing; Roof insulation.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements and are intended for use indicated.
 - 1. Compatibility: Submit certification that products selected for use are compatible with adjacent materials.
- B. Test Reports: Submit certified test reports for performance required.

1.05 QUALITY ASSURANCE

- A. Fire Performance: Provide products which meet or exceed flammability ratings indicated and required by authorities having jurisdiction.
 - 1. Except as otherwise indicated, provide insulation with flame spread rating of 25 or less, when tested in accordance with ASTM E 84.
- B. Thicknesses: Where thicknesses are indicated, they are related to the k-values specified. Provide additional thickness, if necessary, to obtain the same level of performance with acceptable substitute materials which have different values of thermal conductivity. Where R-values are indicated, provide thickness required to achieve value specified.

BOARD INSULATION

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from moisture and damage. Protect plastic insulations from sunlight. Take every possible precaution to avoid fire; conceal materials within building assemblies as quickly as possible. Sequence deliveries to avoid delays, but minimize on-site storage.

PART 2 - PRODUCTS

2.01 BOARD-TYPE INSULATION AT EXTERIOR WALLS

- A. Extruded-Polystyrene Board Insulation: ASTM C 578, Type X, 1.60 cu.ft. density, with maximum flame-spread and smoke-developed indices of 75 and 450, respectively:
1. Manufacturer: Styrofoam Cavitymate by Dow Chemical or equal.
 2. Compressive Strength, ASTM D 1621: 15 pounds per square inch, minimum.
 3. Thickness: As indicated on Drawings.
 4. Board Edge: Tongue and groove.
- B. Air Barrier Tape: CCW-705 Air Barrier Tape by Carlisle Coatings and Waterproofing or equal.
- C. Adhesive for Bonding Insulation at Vertical Surfaces: Product recommended by insulation manufacturer with demonstrated capability to bond insulation securely to substrates indicated without damaging insulation or substrates.

2.03 VAPOR BARRIER

- A. Vapor barrier to be installed in wall assemblies as indicated on the Drawings.
- B. Vapor Barrier: Natural color 6-mil polyethylene film sheet complying with ASTM D 4397 with laboratory-tested vapor transmission rating of 0.2 perms.
1. Vapor Barrier Under Slab: Refer to Section 03 30 00, Cast-In-Place Concrete. Provide one of the following or approved equal:
 - a. "15 Mil RMB 400", Carlisle Coatings and Waterproofing Inc., www.carlisleccw.com
 - b. "15 Mil Stego Wrap", Stego Industries
 - c. "Griffolyn 15 Mil Green", Reef Industries Inc.
 - d. "Premolded Membrane Vapor Seal with Plasmatic Core", W. R. Meadows Inc.
- C. Vapor Retarder Tape: Pressure-sensitive tape of type recommended by vapor retarder manufacturer for sealing joints and penetrations in vapor retarder.

PART 3 - EXECUTION

3.01 INSPECTION

- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 INSTALLATION

- A. General Installation Requirements: Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.
1. Clean substrates and remove projections which could puncture vapor barriers.
 2. Extend insulation over entire area indicated to be insulated.
 3. Fit tightly around penetrations and obstructions. Fill all holes, gaps and voids including voids and shim spaces at door and window perimeters.
 4. Do not over compress insulation.
 5. Provide insulation in one layer with tightly butted edges, unless indicated otherwise.

6. Provide continuous installation of vapor barrier with joints and transitions lapped and or sealed and punctures repaired.

B. Wall Insulation: Adhere board-type insulations to clean substrate with spot application of adhesive compatible with adjacent materials and approved by the insulation manufacturer. Extend insulation over the area shown. Foundation insulation shall be continuous to below the frost depth or as indicated.

C. Vapor Barriers: Install polyethylene vapor barriers with taped joints, repaired tears and holes, and seal to adjacent vapor barrier material.

1. Vapor Barrier Under Slab: Install according to Section 03 30 00, Cast-In-Place Concrete. Coordinate with adjacent air and vapor barriers.

3.03 PROTECTION

A. Provide temporary protection to ensure work being without damage or deterioration from weather or physical abuse.

END OF SECTION



SECTION 07 21 16

BLANKET INSULATION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section includes, but is not limited to:
 - 1. Batt or blanket type building insulation at wall studs and other areas, as indicated.
 - 2. Other building insulation work as may be called for on Drawings and not indicated or specified to be included under other Sections.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 0540 00, Cold Formed Metal Framing.
 - 2. Section 09260, Gypsum Board Assemblies; Sound attenuation insulation.
 - 3. Division 23- Mechanical; Pipe and duct insulation.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements and are intended for use indicated.
- B. Test Reports: Submit certified test reports for performance required.
- C. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Fire Performance: Provide products which meet or exceed flammability ratings indicated and required by authorities having jurisdiction.
 - 1. Except as otherwise indicated, provide insulation with flame spread rating of 25 or less, when tested in accordance with ASTM E 84.
- B. Thicknesses: Where thicknesses are indicated, they are related to the k-values specified. Provide additional thickness, if necessary, to obtain the same level of performance with acceptable substitute materials which have different values of thermal conductivity. Where R-values are indicated, provide thickness required to achieve value specified.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
 - 1. Batt Insulation: 25% recycled content min.

BLANKET INSULATION

07 21 16-1

- B. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from moisture and damage. Protect plastic insulations from sunlight. Take every possible precaution to avoid fire; conceal materials within building assemblies as quickly as possible. Sequence deliveries to avoid delays, but minimize on-site storage.

PART 2 - PRODUCTS

2.01 BATT TYPE INSULATION

- A. Provide resilient, flexible batts of inorganic, non-asbestos fibers and binders complying with ASTM C665 and having the following properties and characteristics:
1. Thickness at Walls: 6 in. nominal; to achieve R20 min., and as noted on Drawings.
 2. Density: 0.5 lbs/cu.ft. or greater except 2.5 lbs/cu.ft. at acoustical partitions.
 3. k-Value: 0.27.
 4. Type: Unfaced unless indicated otherwise.
 5. Size: Coordinate widths with spaces to be insulated for friction fit.
- B. Acceptable Batt Insulation Manufacturers: Provide products of one of the following manufacturers if they meet or exceed the requirements of these specifications:
1. CertainTeed Products Corporation;
<http://www.cerainteed.com/products/insulation/fiber-glass-insulation/batts---rolls/317351>.
 2. Manville Building Materials Corporation; <http://www.specjm.com/residential/insulation.asp>.
 3. Owens-Corning Fiberglas Corporation; <http://insulation.owenscorning.com/professionals/insulation-products/r-21-fiberglass-insulation.aspx>.

PART 3 - EXECUTION

3.01 INSPECTION

- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 INSTALLATION

- A. General Installation Requirements: Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.
1. Extend insulation over entire area indicated to be insulated.
 2. Fit tightly around penetrations and obstructions. Fill all holes, gaps and voids including voids and shim spaces at door and window perimeters.
 3. Do not over compress insulation.
 4. Provide insulation in one layer with tightly butted edges, unless indicated otherwise.

3.03 PROTECTION

- A. Provide temporary protection to ensure work being without damage or deterioration from weather or physical abuse.

3.04 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 07 21 26

BLOWN INSULATION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section includes, but is not limited to:
 - 1. Blown type building insulation at wall studs and other areas, as indicated.
 - 2. Other building insulation work as may be called for on Drawings and not indicated or specified to be included under other Sections.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 05 40 00, Cold Formed Metal Framing.
 - 2. Section 06 10 00, Rough Carpentry.
 - 3. Section 09 21 16, Gypsum Board Assemblies.
 - 4. Division 23 - Mechanical; Pipe and duct insulation.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements and are intended for use indicated.
- B. Test Reports: Submit certified test reports for performance required.
- C. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Fire Performance: Provide products which meet or exceed flammability ratings indicated and required by authorities having jurisdiction.
 - 1. Except as otherwise indicated, provide insulation with flame spread rating of 25 or less, when tested in accordance with ASTM E 84.
- B. Thicknesses: Where thicknesses are indicated, they are related to the k-values specified. Provide additional thickness, if necessary, to obtain the same level of performance with acceptable substitute materials which have different values of thermal conductivity. Where R-values are indicated, provide thickness required to achieve value specified.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.

BLOWN INSULATION

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1. Blown Insulation: 75% recycled content min.

B. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):

1. Option A, Adhesives and Sealants: Comply with the following criteria:

a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.

b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from moisture and damage. Protect plastic insulations from sunlight. Take every possible precaution to avoid fire; conceal materials within building assemblies as quickly as possible. Sequence deliveries to avoid delays, but minimize on-site storage.

PART 2 - PRODUCTS

2.01 BLOWN TYPE INSULATION

A. Provide blown cellulose insulation and having the following properties and characteristics:

1. Thickness at Walls: 6 in. nominal; to achieve R20 min., and as noted on Drawings.

2. Meets ASTM C739 Class 1/A Building Material.

3. Size: Coordinate widths with spaces to be insulated for friction fit.

B. Acceptable Cellulose Insulation Manufacturers: Provide products of the following manufacturers if they meet or exceed the requirements of these specifications:

1. National Fiber, Cel-Pack Cellulose Insulation,

http://www.nationalfiber.com/uploads/textWidget/wysiwyg/documents/CelPak_Spec_Sheet.pdf.

PART 3 - EXECUTION

3.01 INSPECTION

A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 INSTALLATION

A. General Installation Requirements: Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.

1. Extend insulation over entire area indicated to be insulated.

2. Fit tightly around penetrations and obstructions. Fill all holes, gaps and voids including voids and shim spaces at door and window perimeters.

3. Do not over compress insulation.

4. Provide insulation in one layer with tightly butted edges, unless indicated otherwise.

3.03 PROTECTION

A. Provide temporary protection to ensure work being without damage or deterioration from weather or physical abuse.

3.04 CONSTRUCTION WASTE MANAGEMENT

A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION

BLOWN INSULATION

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SECTION 07 27 00

VAPOR PERMEABLE AIR BARRIER MEMBRANE

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Provide weather resistant vapor permeable air barriers installed on exterior sheathing, as indicated on Drawings and as specified herein.

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; Exterior plywood sheathing.
 - 2. Section 07 21 13, Board Insulation.
 - 3. Section 07 21 16, Blanket Insulation.
 - 4. Section 07 21 26, Blown Insulation.
 - 5. Section 07 92 00, Joint Sealers.
 - 6. Section 09 21 16, Gypsum Board Assemblies.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data for each material. Include standard details, certified test results, installation instructions, and recommendations for sealing penetrations and perimeter.
- B. Samples: Submit three labeled samples of each product, not less than 6 by 12 inches in size.
- C. Shop Drawings for Air and Vapor Barrier Membrane Mockup: Submit shop drawings for mockup indicating size of mockup, details of construction, and expansion and control joints. Include relationship with adjacent materials, sequence of installation and materials and methods for sealing penetrations. Obtain approval of shop drawings prior to construction of mockup. Revise to show changes necessary to obtain approval of mockup.
- D. Shop Drawings for Air and Vapor Barriers: Submit shop drawings indicating details of construction for continuous air and vapor barrier required by code for each type of exterior wall and roof assembly required for the project. Include relationship with adjacent materials, indication of sequence of installation, and materials and methods for sealing connections and penetrations. At a minimum, shop drawings shall include details of the following connections, as applicable to the project:
 - 1. Foundation and walls.
 - 2. Walls and windows or doors.
 - 3. Different wall systems.
 - 4. Wall and roof.
 - 5. Wall and roof over unconditioned space.
 - 6. Walls, floor and roof across construction, control and expansion joints.
 - 7. Walls, floors and roof to utility, pipe and duct penetrations.
- E. Qualifications of Installer: Submit qualifications of firm installing air and vapor barrier membrane materials, including name and qualifications of supervisor for this project, and including name and location of three projects where similar work was performed by both firm and supervisor.

VAPOR PERMEABLE AIR BARRIER MEMBRANE

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- F. Mockups of Air and Vapor Barrier Membrane Installation: Prior to installation on the building, construct mockup of typical exterior wall assembly, including connection between wall and roof, and connection between wall and glazing to indicate relationship of materials with air and vapor barrier and quality of workmanship. Mockup shall use actual air and vapor barrier membrane, wall, window and roof materials. Provide several mockups if necessary to include the various conditions. Remove mockup assemblies from site at completion of project. Rebuild mockups which are not approved at no additional cost to the Owner.
1. Construct mockup in accordance with details of mockup indicated on the Drawings.

1.05 PERFORMANCE REQUIREMENTS

- A. Air Barriers: The building envelope shall be designed and constructed with a continuous air barrier to control air leakage into, or out of the conditioned space. An air barrier shall also be provided for interior partitions between conditioned space and space designed to maintain temperature or humidity levels which differ from those in the conditioned space by more than 50 percent of the difference between the conditioned space and design ambient conditions. The air barrier shall have the following characteristics:
1. It must be continuous, with all joints made air-tight.
- B. Air Barrier Penetrations: All penetrations of the air barrier and paths of air infiltration/exfiltration shall be made air-tight.

1.06 PROJECT MEETINGS

- A. Pre-Construction Meeting: After approval of mockup shop drawings, but prior to construction of mock-up, convene a meeting with representatives of materials to be incorporated in the mockup and installers of mockup. Agenda shall include sequence and details of construction to ensure continuity of air and vapor barrier.
- B. Pre-Installation Meeting: Convene a pre-installation meeting a minimum of one week prior to commencing work of this section. Attendees shall include representatives of air and vapor barrier manufacturer, exterior wall installers and project superintendent. Agenda shall include the following:
1. Review of approved submittals.
 2. Review of mock-ups.
 3. Coordination with sequence of installation with adjacent materials.
 4. Schedule for subsequent work covering air and vapor barrier.
 5. Procedures for quality assurance.

PART 2 - PRODUCTS

2.01 VAPOR PERMEABLE AIR BARRIERS

- A. Spun Bonded Polypropylene: Provide WallShield HS, by VaproShield LLC, or approved equal, nominal 0.023 inches thick.
- B. Accessories and Auxiliary Materials: Provide compatible joint tape, flashing, formed shapes and sill pans, as recommended by manufacturer.
- C. Fasteners for Exterior Sheathing: Provide corrosion resistant galvanized steel or stainless steel fasteners, sized as recommended by manufacturer for substrate and installation indicated.

PART 3 - EXECUTION

3.01 CONDITION OF SURFACE

- A. Examine substrates, adjoining construction and condition under which Work is to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected.
- B. Pre-Installation Meeting: Prior to installation of air and vapor barrier and at the Architect's direction, meet at Project site to review material selections, installation procedures, and coordination of Work with other trades. Meeting shall include Architect's Project Representative, Trade Contractor, Subcontractor,

manufacturer's representatives, inspection and testing services (if any), and any other subcontractor whose work requires coordination with this work.

- C. Surfaces to receive air and vapor barrier shall be thoroughly dry and free of moisture. Fasteners shall be countersunk.
- D. Surfaces shall not contain any grease, oil, or any other contaminants which could affect the complete bonding of waterproofing membrane to concrete surface.

3.02 GENERAL PREPARATION

- A. Proceed with air and vapor barrier membrane installation only after substrate preparation is complete.
- B. Clean the existing surface prior to installing air and vapor barrier membrane components to remove all dirt and debris. Do not install air and vapor barrier system components over wet substrates.

3.03 PROTECTION

- A. All equipment used on the job shall comply with all applicable municipal and safety regulations including OSHA guidelines.
- B. Protect finished work from damage during subsequent work, such as impact, marring of the surfaces and other damage. Replace or repair at no additional cost to the Owner all damaged work or materials.
- C. Components of the system may be toxic and flammable. Heed all manufacturer's cautions and warnings in regard to their use. Completed membrane is slippery when wet or covered with frost; take proper precautions.

3.04 GENERAL WORKMANSHIP

- A. Coordinate flashing and sealant work to ensure a concurrent membrane and flashing installation.
- B. The completed air and vapor barrier membrane and flashing system shall be protected from damage. All damage to finished portions or the air and vapor barrier membrane shall be either repaired or replaced in a manner acceptable to the Owner, and the cost of such corrective work shall be paid by the trade responsible for damage.

3.05 INSTALLATION

- A. Strictly comply with air and vapor barrier membrane manufacturer's printed instructions, approved submittals and the following:
 - 1. Apply materials within manufacturer's requirements for temperature and weather conditions.
 - 2. Do not apply to wet or frozen substrates.
 - 3. Do not allow contamination with dust or dirt.
 - 4. Seal completely at edges, perimeter and penetrations.
 - 5. Apply primer if recommended by manufacturer.
- B. Protect installed work from damage due to harmful weather exposures, physical abuse, and other causes.
- C. Provide temporary protection over air and vapor barrier membrane if materials covering air and vapor barrier membrane will not be installed within manufacturer's recommended time limit for exposure.
- D. Repair damage to air and vapor barrier membrane caused by construction activities or subsequent work prior to covering.

3.06 FLASHINGS

- A. All flashings shall be installed concurrently with the air and vapor barrier membrane as the job progresses. No temporary flashing shall be allowed without the prior written approval of the Architect and membrane

manufacturer. Approval shall be for specific locations on specific dates. Flashings shall be adhered to compatible, dry, smooth, and solvent-resistant surfaces.

3.07 CLEAN-UP

- A. Upon completion of the system, clean all stains, remove all masking, protections, equipment, material, and debris from the work and storage area, and leave those areas in an undamaged and acceptable condition.

END OF SECTION



SECTION 07 55 54

TPO SINGLE PLY MEMBRANE ROOFING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Provide single ply membrane roofing system as indicated on the Drawings and as specified herein, including, but not limited to the following:
 - 1. Fully adhered TPO membrane.
 - 2. Roof flashings.
 - 3. Vapor retarder.
 - 4. Roof cover board and deck board.
 - 5. Tapered and nontapered roof insulation.
 - 6. Walkway pads.
 - 7. All other roofing work indicated.
- B. Comply with the requirements of the roof manufacturer's Specifications, the technical Project Specifications, and/or Industry Standards; in the case of conflict, the more stringent shall apply. Refer to Construction Drawings for detailed requirements.

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 05 50 00, Metal Fabrications: Miscellaneous supports at roof.
 - 2. Section 06 10 00, Rough Carpentry; Wood blocking, cants and nailers.
 - 3. Section 07 62 00, Flashing and Sheet Metal; Sheet metal work.
 - 5. Division 23 - Mechanical; Roof penetrations and installation of roof-mounted equipment.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's printed product data, specifications, standard details, installation instructions, use limitations and recommendations for each material used. Provide certifications that materials and systems comply with specified requirements.
- B. Shop Drawings: Provide large scale shop drawings for layout, installation, and fabrication of all parts of the work. Provide plans and details of anchorage, connections and accessory items.
 - 1. Show slope-to-drain plan of roof. Indicate slopes, valleys, crickets, and drain details.
 - 2. Submit shop drawings showing tapered and nontapered insulation layout.
 - 3. Submit shop drawings showing complete layout of walkway pads.
 - 4. Show all roof penetrations and flashing details; details shall depict conditions on the Contract Documents and shall not be standard catalog details.
- C. Test Reports: Provide certified reports for all specified tests.
- D. Contractor's Review: Before commencing work, submit signed statement that Contract Documents have been reviewed with a qualified representative of supplier/manufacturer, and that selected materials and construction are proper, compatible, and adequate for application shown.

TPO SINGLE PLY MEMBRANE ROOFING

- E. Certification: Upon completion of work of this Section, submit certification by roof manufacturer acknowledging that all work performed is acceptable and that the roof meets warranty.
- 1.05 QUALITY ASSURANCE
- A. Materials and installation shall conform to the manufacturer's standard specifications as modified herein and the requirements of the applicable local building code.
 - B. Installer: A firm which has a minimum of five years experience in work of the type required by this Section and which is certified and trained by the manufacturer of the primary materials.
 - C. Source: For each type of material required for the work of this Section, provide primary materials which are the products of one manufacturer who has a minimum of five years experience in manufacturing the type of roofing required by this Section. Provide secondary materials which are acceptable to the manufacturer of the primary materials.
 - D. Roofing Conference: Convene a pre-installation roofing conference at the project site to establish schedules and procedures to maintain optimum working conditions, and to coordinate this work with related and adjacent work. Review required inspections and testing and all other requirements to provide warranted roof and as required by the Owner. Review weather conditions and procedures for dealing with unfavorable conditions.
 - 1. Require attendance by roofing installer, installers of adjacent rooftop mounted mechanical equipment and all other equipment, Architect, Owner, Contractor, and roofing system manufacturer's representative.
 - E. Fire Resistance Classifications: Unless otherwise indicated, provide single ply membrane roofing system certified as UL Class A for external fire exposure, and FM Class 1 for Internal fire exposure.
 - F. FM Uplift Criteria: Design and construct roof systems for the FM uplift criteria of 1-90.
 - G. FMRC Approval: Roofing system shall be FMRC Approved.
 - H. Manufacturer's Representative: Make arrangements and pay all costs to have manufacturer's authorized representative on the roof at the beginning of roofing work to advise installer of proper procedures and quality control techniques.
 - I. Assist Owner in preparation and submittal of roof installation acceptance certification as may be necessary in connection with fire and extended insurance coverage on roofing and associated work.
 - J. Owner reserves the right to retain independent testing laboratory to inspect the work specified herein as specified. Neither presence of the testing laboratory, nor any observations and testing performed by the laboratory shall diminish responsibilities for Work of this Section.
- 1.06 DELIVERY, STORAGE, AND HANDLING
- A. Deliver materials and products in unopened, factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from all possible damage.
 - 1. Do not stockpile materials on the roof.
 - B. Sequence deliveries to avoid delays, but minimize on-site storage.
 - C. Adhesives, cements, mastics and sealers shall be stored between 60oF. and 80oF. should they be exposed to lower temperatures, restore to room temperature for three to five days prior to use. Do not use materials damaged in handling or storage.

- D. Store insulation and provide full protection against dampness before laying. Insulation boards shall be dry when applied, and shall be protected from the weather during installation. Any materials damaged by exposure to the elements or other cause shall be rejected and removed promptly from site.
- 1.07 PROJECT CONDITIONS
- A. Weather: Perform work when existing and forecasted weather conditions are within the limits established by the manufacturers of products and materials used.
 - B. Substrates: Proceed with work only when substrate construction and penetrating work is complete. Comply with roof membrane manufacturer's recommendations.
 - C. Conference: Convene a pre-installation conference to establish procedures to maintain optimum working conditions and coordinate this work with related and adjacent work. Require roofing manufacturer, Installer, Contractor, and Architect to attend.
 - D. Flood Test: Upon completion of roofing, provide flood test of roofing, subject to review and approval of Architect and Owner; flood testing shall be done in presence of roof manufacturer's representative.
- 1.08 WARRANTY
- A. Roofing System Warranty: Provide manufacturer's written "Total System Warranty" with No Dollar Limit signed by manufacturer, installer and Contractor, agreeing to repair or replace work which exhibits defects in materials or workmanship for a period of ten (10) years after date of Substantial Completion. "Defects" is defined to include, but not limited to, leakage of water, abnormal aging or deterioration, and failure to perform as required.
 - 1. Include requirement for removal and replacement of connected adjacent work.
 - B. Membrane Warranty: Provide manufacturer's 20 year warranty covering all material defects in roof membrane.

PART 2 PRODUCTS

- 2.01 VAPOR RETARDER
- A. Vapor Barrier: 3-ply Griffolyn TX-1200FR with prefabricated Pipe Boots, mastic-type Fab Tape at seams, and self-adhesive Griff Tape at punctures by Griffolyn, Div. Reef Industries, Inc.
 - B. Adhesive: Adhesive for vapor retarder shall be as recommended by the roof membrane manufacturer.
- 2.02 INSULATION AND BOARDS
- A. Extruded Polystyrene Tapered and Nontapered Insulation at Typical Roof Areas: Styrofoam Deckmate Plus by Dow or approved equal by Tenneco Building Products or Owens Corning Fiberglass Corporation, tapered where required and as indicated on the Drawings, mechanically fastened as recommended by manufacturer.
 - 1. Insulation shall comply with ASTM C 578 Type IV.
 - 2. Compressive Strength: 25 psi per ASTM D 1621.
 - 3. Crickets shall be sizes and profiles required by project conditions, by same manufacturer.
 - 4. Insulation shall be approved by Factory Mutual (FM) for Class 1 Insulated Steel Deck Construction and shall be UL listed Class A.
 - 5. Insulation shall be cut, cleaned, and vacuumed at the factory to form a clean, dry rigid tapered insulation with minimum slope indicated on the Drawings.
 - 6. Tapered panels shall be stenciled with letter code and an arrow to indicate slope.
 - 7. Insulation shall be approved by the roofing membrane manufacturer.
 - 8. Unless otherwise indicated, minimum thickness of insulation board shall be 3 in.
 - 9. Average overall R value for roof insulation shall be as indicated on Drawings.

10. Provide two layers of insulation at roof areas to receive 4 in. thick insulation. Stagger joints in insulation courses in accordance with roof manufacturer's recommendations. Top layer of insulation shall be 2 in. thick, minimum.

- B. Polyisocyanurate Tapered and Nontapered Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2, felt or glass-fiber mat facer on both major surfaces.
1. Compressive Strength: 25 psi per ASTM D 1621.
 2. Crickets shall be sizes and profiles required by project conditions, by same manufacturer.
 3. Insulation shall be approved by Factory Mutual (FM) for Class 1 Insulated Steel Deck Construction and shall be UL listed Class A.
 4. Insulation shall be cut, cleaned, and vacuumed at the factory to form a clean, dry rigid tapered insulation with minimum slope indicated on the Drawings.
 5. Tapered panels shall be stenciled with letter code and an arrow to indicate slope.
 6. Insulation shall be approved by the roofing membrane manufacturer.
 7. Unless otherwise indicated, minimum thickness of insulation board shall be 3 in.
 8. Average overall R value for roof insulation shall be as indicated on Drawings.
 9. Provide two layers of insulation at roof areas to receive 4 in. thick insulation. Stagger joints in insulation courses in accordance with roof manufacturer's recommendations. Top layer of insulation shall be 2 in. thick, minimum.
- C. Protection Board Over Insulation and Over Roof Deck: Provide glass-mat, water-resistant gypsum board, ASTM C 1177, of type and thickness indicated below:
1. Type and Thickness: Type X, 1/2 inch.
 2. Provide "Dens-Deck" primed manufactured by Georgia-Pacific Corp.
 3. Fasteners: As recommended by manufacturer.

2.03 TPO MEMBRANE ROOFING MATERIALS

- A. TPO Roof Membrane: Thermoplastic polyolefin (TPO) sheet membrane shall be 0.060 in. thick, reinforced "Sure-Weld TPO Sheet Membrane", manufactured by Carlisle, ultraviolet and ozone resistant.
1. Exposed Face Color: White or light grey.
 2. At parapet and other high walls, provide reinforced 0.060 in. thick TPO membrane.
 3. Physical Properties: Provide reinforced thermoplastic polyolefin (TPO) sheets with the following properties as determined per ASTM test method indicated:
 - a. Breaking Strength: 225 lbf; ASTM D 751, grab method.
 - b. Elongation at Break: 15 percent; ASTM D 751.
 - c. Tearing Strength: 55 lbf minimum; ASTM D 751, Procedure B.
 - d. Resistance to Heat Aging: No reduction in breaking strength, elongation at break, and tearing strength after 168 hours at 240 deg F; ASTM D 573.
 - e. Ozone Resistance: No cracks after 168 hours' exposure of 50 percent elongated sample at 100 deg F and 100-pphm ozone; ASTM D 1149, Procedure B.
 - f. Water Absorption: Less than 4 percent mass change after 168 hours' immersion at 158 deg F; ASTM D 471.
 - g. Fabricate membrane with scrim at centerline of thickness.

- B. TPO Flashing: Elastomeric TPO sheet flashing shall be "Sure-Weld TPO Flashing", manufactured by Carlisle, ultraviolet and ozone resistant, 0.055 in. minimum thickness where concealed.

2.04 RELATED MATERIALS

- A. Bonding adhesive shall be as recommended by manufacturer. Adhesive shall be compatible with all materials to which the elastomeric membrane is to be bonded. Provide products that meet or exceed the VOC limits of South Coast Air Quality Management District Rule No. 1168.
- B. Splicing cement shall be as recommended by membrane manufacturer.

- C. Lap sealant for sealing the exposed edge of the splices shall be trowel on gun consistency, as recommended by membrane manufacturer.
 - D. Water cutoff mastic shall be as recommended by membrane manufacturer.
 - E. Night sealer shall be as recommended by membrane manufacturer.
 - F. Pourable sealer shall be as recommended by membrane manufacturer.
 - G. Prefabricated elastomeric accessories (pipe seals, inside and outside corners, etc.) shall be as manufactured and recommended by membrane manufacturer.
 - H. Nailing Strips and Fasteners: Nailing strips shall be Carlisle 'Russ' nailing strips manufactured by Carlisle. Fasteners shall be non-corrosible as recommended by the roof manufacturer.
 - I. Roofing Nails: 11 gauge hot-dip galvanized, length to penetrate wood members at least 7/8 in., with 5/8 in. diameter heads, as recommended by membrane manufacturer.
 - J. Mechanical Fasteners: Provide corrosion resistant, FM-approved mechanical screw and plate fasteners as recommended by the roof manufacturer and conforming to FM requirements.
 - K. Miscellaneous Items: Provide all other roofing materials as required to meet specified design and performance requirements.
- 2.06 ROOF WALKWAY PADS
- A. Pads: Provide Carlisle 30 in. wide x 30 ft. long, x 5/16 in. thick heat weldable walkway rolls; or equivalent product by acceptable manufacturers.
 - 1. Color of pads shall match color of adjacent roof.

PART 3 EXECUTION

3.01 INSPECTION OF SURFACES

- A. Carefully check roof deck areas for conditions affecting application and performance. Report defects in writing to Architect. Do not proceed with roofing work until defects have been corrected.
- B. Beginning work shall constitute acceptance of its conditions and any defects in roofing work resulting from such accepted surfaces shall be corrected without further expense to the Owner.

3.02 GENERAL REQUIREMENTS

- A. Surfaces to receive roofing materials shall be rigid, tight, clean, dry, smooth, free of scale, dust, oil, or other foreign matter, and also free of frost or the effects of freezing. Thoroughly clean surfaces to remove loose particles immediately before application of subsequent materials. Do not apply roofing materials over wet subsurfaces.
- B. Where surface joints at roof and wall substrates exceed 1/4 in. width, fill flush with surface with pourable sealer before proceeding with the installation.
- C. Do not leave unfinished roof areas uncovered overnight or during inclement weather.
- D. Work shall conform to manufacturer's published specifications, and the published standards of UL and Factory Mutual. Roof shall be made permanently weatherproof in continuous operation, including connection to flashing and gravel stops provided under Section 07 62 00, Flashing And Sheet Metal.
 - 1. Rated roof system shall be constructed in accordance with UL Design numbers, as indicated.

- E. Provide manufacturer's recommended weatherproofing method at projections, connections to sheet metal gravel stops and flashings and at other special conditions.
 - F. Special Cautions:
 - 1. Do not use oil-based or plastic roof cement.
 - 2. Do not subject elastomeric materials to contact with petroleum, grease, oil, solvents, vegetable or mineral oil, nor animal fat. Prevent contact with hot pipes, and ducts.
 - 3. Cements and bonding adhesive contain petroleum distillates and are extremely volatile and flammable. Avoid breathing vapors and do not use near fire or flame.
 - 4. Ensure that splicing and bonding surfaces are dry during installation.
 - 5. Do not dilute primers, adhesives, coatings or sealers.
 - G. Do not damage or stain surrounding work. Remove stains and repair damage immediately, as work progresses, as part of work of this Section.
- 3.03 VAPOR RETARDER INSTALLATION
- A. Apply vapor retarder over roof deck using acceptable adhesive.
 - 1. Provide a minimum 2 in. lap for all edges and seal with adhesive.
 - 2. Follow manufacturer's printed instructions for adhesive spreading rates and material handling, in accordance with FM requirements, as applicable.
 - 3. Do not install any more vapor retarder material in any given working day than can be covered with underlayment board, insulation board, and roofing membrane on the same working day.
- 3.04 DECK BOARDS, ROOF INSULATION, AND COVER BOARDS
- A. Follow sequence coding. Install only as much deck board, insulation, and cover board daily as can be covered with roofing by close of work. Do not expose materials to rain or snow, nor overnight. Replace material that becomes wet.
 - 1. Stagger joints between layers of deck board, insulation board, and cover boards.
 - B. Deck Board: Apply deck board to roof deck in accordance with roof manufacturer's recommendations and as specified in this Section.
 - C. Roof Insulation: Install tapered and nontapered roof insulation to deck board in accordance with manufacturer's recommendations and as specified in this Section, meeting the requirements for FM approval.
 - 1. Install tapered insulation and crickets as indicated on approved shop drawings to provide required roof slope and pitch to drains.
 - D. Cover Board: Apply cover board over insulation board in accordance with roof manufacturer's recommendations and as specified in this Section.
 - E. Feather or taper insulation and cover board around drains for smooth transition between roof surface and drain clamp ring.
- 3.05 ELASTOMERIC ROOFING
- A. Install fully adhered single ply membrane roofing system in conformance with approved Submittals, including manufacturer's published instructions, and in accordance with FM requirements.
 - B. Seaming: Hot air weld the membrane seams a minimum of 1-1/2 in. wide with manufacturer's recommended welder.
- 3.06 ROOF PENETRATIONS
- A. Coordinate with other trades to seal penetrations for pipes, conduit, lightning protection, flues, equipment supports, etc.

- B. Coordinate and cooperate with plumbing subcontractor for installation of roof drain assemblies.

3.07 ROOFTOP WALKWAY

- A. Install walkway panels over roof membrane in pattern and layout indicated. Heat weld to roof membrane in accordance with roof manufacturer's recommendations. Provide uniform spacing between walkway pads with maximum spacing 1 in. Maintain straight joint lines.
 - 1. Pads shall be located such that no pad edge is within 1 in. of any roof seam.

3.08 CLEANING

- A. Keep surrounding surfaces clean as work progresses.
- B. Remove cartons, debris, emptied containers, and other rubbish as work progresses, and at completion of work of this Section. Legally dispose of rubbish off site.

END OF SECTION



SECTION 07 62 00

FLASHING AND SHEET METAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section includes, but is not limited to:
 - 1. Metal and membrane flashings.
 - 2. Gutters and downspouts.
 - 3. Scuppers.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; Wood blockings, nailers, etc., for work of this Section.
 - 2. Section 07 55 54, Single Ply Membrane Roofing; Roof membrane flashings.
 - 3. Section 07 84 43, Joint Sealers.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each product used.
- B. Shop Drawings: Provide large scale shop drawings for fabrication, installation and erection of all parts of the work. Provide large scale plans, elevations, and details of profiles, joints, seams, anchorages, connections and accessory items. Include statement that materials are physically compatible.
- C. Verification Samples: Submit representative samples of each material that is to be used in the work, showing the full range of color and finish variations expected. Provide samples having minimum area of 144 square inches.

1.05 QUALITY ASSURANCE

- A. Industry Standard: Except as otherwise shown or specified, comply with applicable recommendations and details of the SMACNA Manual. Conform to dimensions and profiles shown.
- B. Mock-Ups: Prior to commencing the primary work of this section, provide mock-ups at locations acceptable to Architect. Obtain Architect's acceptance of visual qualities. Protect and maintain accepted mock-ups throughout the remainder of the work of this section to serve as criteria for acceptance of the work. Approved mock-ups may be incorporated into the finished work.
 - 1. Comply with requirements of Section 01420, Mock-Ups.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store and handle materials and products in strict compliance with manufacturer's instructions and recommendations and industry standards. Protect from damage.
- B. Sequence deliveries to avoid delays, but minimize on-site storage.

FLASHING AND SHEET METAL

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1.07 SEQUENCING AND SCHEDULING

- A. Conference: Convene a pre-installation conference to establish procedures to maintain optimum working conditions and to coordinate this work with related and adjacent work.
- B. Perform work of this section in coordination with other sections to provide the highest quality work which best fulfills the intent requirements of this work.

PART 2 - PRODUCTS

2.01 FLASHING AND SHEET METAL

- A. Membrane Flashing: W. R. Grace Perm-A-Barrier, CCW 705 TWF by Carlisle Coatings & Waterproofing, or ExoAir TWF by Tremco. Primer is required, type as recommended by manufacturer. Use for jamb flashing, cavity wall flashing and as indicated.
- B. Galvalume Plus Sheet Steel: Provide 55% Aluminum and 45% Zinc coated sheet steel, ASTM A 792 and ASTM AZ55 (0.55 ounces/sq.ft.), 24 gauge thick.
- C. Sheet Aluminum: ASTM B 209, alloy 3003-H14, 0.060 inch thickness minimum. Use for copings and brake metal.
 - 1. Painted Finish: AAMA 2605, PPG Duranar, Kawnear Permadiize or Valspar Fluoropon, minimum 70% Kynar resin, 3-coat minimum, color and gloss as selected by the Architect.
- D. Concealed Metal Flashing: Concealed metal flashing shall be brake formed aluminum, conforming to ASTM B 209, alloy 3003 temper H14, AA-C22A41 clear anodized finish; 0.032 in. thick (20 gage) except as otherwise indicated.

2.02 MISCELLANEOUS MATERIALS

- A. Fasteners: Match material being fastened for both type of material and finish.
- B. Bituminous Coating: Cold-applied asphalt mastic, SSPC Paint 12, compounded for 15-mil dry film thickness per coat, except as otherwise indicated. Provide inert-type noncorrosive compound, nominally free of sulfur components and other deleterious impurities.
- C. Slip Sheet: Rosin - sized building paper, 4 lbs. per 100 sq. ft.
- D. Plastic Underlayment: 6 mil carbonated polyethylene film, FS L-P-512.
- E. Reglets: Metal units of type and profile indicated or required which are compatible with flashings used.
- F. Solder for Galvalume: ASTM B 32, as recommended by manufacturer.
 - 1. Flux: Rosin, cut muriatic acid, or commercial preparation suitable for materials to be soldered.
- G. Accessories: Provide all clips, cleats, straps, anchors and similar items necessary to properly complete the work. Provide accessories that are compatible with sheet metal materials used and which are of sufficient size and gage to perform as intended.

2.03 FABRICATION

- A. Shop fabricate work to the greatest extent possible. Fabricate work to be truly straight, plumb, level and square, and to provide the best possible watertight, weatherproof performance with expansion provisions in running work.
- B. Provide work to sizes, shapes, and profiles indicated on approved shop drawings. Comply with referenced standards. Minimize oil-canning, buckling, tool marks and other defects.

- C. Make work with uniform, watertight joints. Make seams as inconspicuous as possible.
- D. Isolate dissimilar materials with isolation coating or other permanent separation acceptable to the Architect.
- E. Gutters: Fabricate to cross section indicated, complete with end pieces, outlet tubes, and other accessories as required. Fabricate in minimum 96 in. long sections. Furnish flat-stock gutter spacers and gutter brackets fabricated from same metal as gutters, of size recommended by SMACNA but not less than twice the gutter thickness. Fabricate expansion joints, expansion joint covers, and gutter accessories from same metal as gutters.
- F. Downspouts: Fabricate to cross section indicated, complete with mitered elbows. Furnish with metal hangers and anchors, from same material as downspouts.
- G. Scuppers: Fabricate scuppers of dimensions required with closure flange trim to exterior, 4 in. wide wall flanges to interior, and base extending 4 in. beyond cant or tapered strip into field of roof. Fasten gravel guard angles to base of scupper.

PART 3 - EXECUTION

3.01 INSPECTION

- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 INSTALLATION

- A. Install flashing in continuous uninterrupted manner to accomplish 'intent' complete with all transitions, laps, splices, folds, seams necessary to ensure the diversion of water to the exterior. Work in close coordination with installation of exterior masonry, roofing, window, joint sealer, and louvers.
 1. Apply materials within manufacturer's requirements for temperature and weather conditions.
 2. Do not apply to wet or frozen substrates.
 3. Do not allow contamination with dust or dirt.
 4. Seal completely at edges, perimeter and penetrations.
- B. Strictly comply with manufacturer's instructions and recommendations and standard details and recommendations of SMACNA, except where more restrictive requirements are specified in this section. Locked and sealant locked joints as indicated on the Drawings.
- C. Securely anchor work, but allow for thermal movement and building movement. Use concealed fasteners to the greatest extent possible. Install work to be permanently weatherproof and watertight. Provide continuous cleats at all edge conditions.
- D. Bed metal flashing work in thick coating of roofing cement for watertight performance. Do not permit roofing cement to run or drip out from under sheet metal work under any conditions.
- E. Provide reglets where indicated and where required. Coordinate installation with related and adjacent work.
- F. Provide through-wall flashing at masonry walls. Overlap adjacent pieces of flashing minimum 2" and roll all overlaps with steel hand roller. Trim bottom edge of flashing minimum of 1/2" back from exposed face of the building. Staple vertical and horizontal joints. Apply a bead of sealant along top edge of flashing membrane and along seams and cuts as necessary and as recommended by manufacturer.
 1. Fasten membrane and install in horizontal strips with 3 feet wide by 10inch long pieces, starting at the bottom of the wall. Fasten top edge 16 to 24 inches on center. Subsequent strips of membrane shall lap

over the fasteners about 2 inches. Corners shall be reinforced with 18 inch wide membrane strips before applying the membrane.

- G. Provide flashing at every obstruction to the downward flow of water. Design and install flashing to control and divert water to the exterior. Form at least 4" high end pans above lintels and similar conditions to extend the entire length of the lintel where possible. Flashing shall extend 4" minimum beyond end of lintel before it is panned (dammed).

3.03 TOLERANCES

- A. For exposed work, the following allowable installed tolerances are allowable variations from locations and dimensions indicated by the Contract Document and shall not be added to allowable tolerances indicated for other work.
 - 1. Allowable Variation from True Plumb, Level, and Line: $\pm 1/8"$ in 20'-0"
 - 2. Allowable Variation from True Plane of Adjacent Surfaces: $\pm 1/16"$

3.04 ADJUSTING, CLEANING, PROTECTION

- A. Adjust work to conform to specified tolerances and appear uniform, straight and correct.
- B. Touch-up damaged coatings and finishes to eliminate evidence of repair.
- C. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired.
- D. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully cleaned.

END OF SECTION



SECTION 07 92 00

JOINT SEALERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the preparation of joints, sealing and filling of joints and curing and protection of completed work.
- B. Provide joint sealers as scheduled in this section and as indicated on the drawings. Before beginning work, obtain Architect's clarification if the extent of each type of sealer and filler is uncertain.
- C. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 08 80 00, Glass and Glazing; glazing sealers and gaskets.
 - 2. Division 22 - Plumbing.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation and curing instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements and are compatible with adjacent materials selected for use including flashings.
- B. Initial Selection Samples: Submit samples showing complete range of colors and finishes available for each material used.
- C. Verification Samples: Submit representative samples of each material that is to be exposed in the finished work, showing the full range of color and finish variations expected. Provide actual samples having minimum length of 4 inches.

1.05 INTENT

- A. Performance and Design Requirements for Sealers: Provide sealers to maintain long term [20 year minimum] air tight and water tight seals. No cohesive or adhesive failures, nor cracking or bubbling of sealer surfaces are permitted. Provide sealers certified by sealer manufacturer to be capable of accommodating the full range of manufacturing tolerances, field erection tolerances, thermal movements, seismic movements, building structure movements [floor sag, beam sag, and column settlement], building deflections, and all other movements. Design sealer joints to accommodate the worst possible combination of effects and to prevent internal sealer stress failure, deterioration, and failure of weather seals.
 - 1. Exterior Work: A major intent of the exterior work of this section is to keep the building dry and permanently establish and maintain airtight and watertight continuous seals within the manufacturers' published limits of normal wear and aging.
 - 2. Interior Work: Interior work is intended to seal and fill all cracks, voids and gaps in the work, usually, but not always, located between dissimilar materials. In interior areas subject to water use and leakage, sealers are intended to control water and prevent leakage.

JOINT SEALERS

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1.06 QUALITY ASSURANCE

- A. Source: For each type of sealer and filler material required for the work of this section, provide primary materials which are the products of one manufacturer. Provide secondary materials which are acceptable to the manufacturers of the primary materials.
- B. Exterior Wall Mock-Up: Mock-up of exterior wall including joint sealers is required. Comply with requirements of Section 01420, Mock-Ups.

1.07 TESTS

- A. Construction Sealer Adhesion Tests: Periodically test sealers in place for adhesion using methods recommended by sealer manufacturer. Promptly replace all sealer which does not adhere or which fails to cure properly.

1.08 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturers' instructions and recommendations. Protect from damage. Sequence deliveries to avoid delays, but minimize on-site storage.

1.09 PROJECT CONDITIONS

- A. Weather: Perform work only when existing and forecasted weather conditions are within the limits established by manufacturers of the materials and products used.
- B. Substrates: Proceed with work only when substrate construction and penetrating work is complete.
- C. Temperature: Comply with manufacturer's requirements and recommendations. Understand that joints to be sealed should not be near their fully closed nor fully open extremes, but in the mid-range of the joint's intended movement. Obtain Architect's written permission to seal joints when ambient temperatures are below 50°F or above 85°F.

1.10 WARRANTY

- A. Provide written warranty signed by manufacturer, agreeing to repair or replace work which exhibits defects in materials or workmanship. "Defects" is defined to include, but is not limited to, leakage of water, abnormal aging or deterioration, and failure to perform as required. Include requirement for removal and replacement of covering and connected adjacent work.
 - 1. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Before installation check each sealer for compatibility with adjacent materials and surfaces and with indicated exposures. Select sealers which are recommended by the manufacturer for each application indicated. Where exposed to pedestrian or vehicular traffic, provide sealers which are non-tracking and are strong enough to withstand the traffic without damage.
- B. Colors: Provide colors as selected by Architect from manufacturer's standard and special colors.

2.02 NON-SAG POLYURETHANE SEALER

- A. Provide multi-part, non-sag, polyurethane based elastomeric sealer, complying with ASTM C 920 Type M, Grade NS, Class 25, having Shore A hardness of 20 to 30, cured modulus of elasticity at 100% elongation of not more than 75 psi, and tear resistance of not less than 50 lb./in. when tested according to ASTM D 624.
- B. Provide one of the following products that meet or exceed specified requirements:
 - 1. Tremco Dymeric.
 - 2. Sika Sikaflex 2c NS.
 - 3. Sonneborn Sonolastic NP 2.

- C. Extent: Provide non-sag polyurethane sealer at exterior joints in vertical surfaces, and other joints not indicated to be sealed with another type of sealer.
- 2.03 SELF-LEVELING POLYURETHANE SEALER
- A. Provide two or more part, self-leveling, polyurethane based elastomeric sealer, complying with ASTM C920 Type M, Grade P, Class 25, having Shore A hardness of not less than 55 when tested according to ASTM D2240, cured modulus of elasticity at 100% elongation of not more than 150 psi when tested according to ASTM D412, and tear resistance of not less than 50 lbs./inch when tested according to ASTM D 624. Provide one of the following products if they meet or exceed the requirements of these specifications:
 - 1. Pecora Urepan NR-200
 - 2. Tremco THC 900/901
 - 3. Sika 1A, SL
 - B. Where joint surfaces contain bituminous materials, provide modified sealers which are compatible with bituminous materials encountered.
 - C. Extent: Provide self-leveling polyurethane sealer for all paving and floor joints not indicated to be sealed with another type of sealer.
- 2.04 SILICONE SEALER (EXTERIOR)
- A. Provide one-part, medium-modulus, high performance, neutral cure silicone sealant, Colors as selected by the Architect. Provide one of the following:
 - 1. Spectrem 2 by Tremco Inc.
 - 2. 795 by Dow Corning.
 - 3. 864 by Pecora.
 - B. Extent: Provide non-sag silicone sealer for all metal panel to metal panel joints, metal panel to precast joints, metal panel to metal window joints, masonry to metal panel joints, masonry to masonry joints, masonry to precast joints, precast-to-precast joints, precast to metal window joints, and other joints not indicated to be sealed with another type of sealer.
 - 1. Double-Sealer Joints: Unless otherwise indicated, provide double-sealed joints at precast-to-precast joints, precast-to-metal joints, and other joints as indicated. Weep from behind outer bead of sealer at regular intervals as approved by Architect.
 - C. Colors: Provide custom colors as selected by the Architect; a maximum of five colors will be used.
- 2.05 SILICONE SEALER (INTERIOR)
- A. Provide one part, mold and mildew resistant, sanitary interior type silicone rubber based elastomeric sealer, complying with ASTM C 920 Type S, Class 25, Grade NS. Provide one of the following products if they meet or exceed the requirements of these specifications:
 - 1. Dow 786
 - 2. General Electric 1702
 - 3. Pecora 863
 - 4. Tremco Proglaze
 - 5. Tremco Tremsil 200.
 - B. Extent: Provide silicone rubber sealer for all interior joints around toilet room fixtures and control joints in ceramic tile work not on walking surfaces.
- 2.06 ACRYLIC LATEX SEALER
- A. Provide permanently flexible, paintable latex rubber modified acrylic emulsion sealer, complying with ASTM C834. Provide one of the following products if they meet or exceed the requirements of these specifications:
 - 1. Pecora AC-20
 - 2. Sonneborne Sonolac

3. Tremco TremFlex 834

- B. Extent: Provide acrylic latex sealer for use for exposed acoustical sealer, access doors before painting, and for all interior joints except where silicone rubber sealer is indicated.
- C. At interior joints greater than 1/2 in. in width or subjected to periodic building movement, substitute exterior type sealer specified above.
- D. Where surrounding wall surfaces are to be left unpainted, substitute exterior type sealer as specified above.

2.07 STRUCTURAL SILICONE SEALER

- A. Provide one of the following structural sealers recommended by curtainwall manufacturer for structural glazing applications and for interior butt glazing applications.
 - 1. Dow Corning 795 Silicone.
 - 2. General Electric Ultraglaze SSG 4000.
 - 3. Pecora 985 Silicone.
 - 4. Tremco Spectrem 2

2.08 METAL SEAM SEALER

- A. Provide metal seam sealer, specifically compounded to seal very thin joints in metal to metal joints and to match adjacent metal colors and finishes.
- B. Provide one of the following products:
 - 1. Protective Treatments, Inc. PTI 200.
- C. Extent: Provide seam sealer for metal to metal joints in aluminum entrance and storefront, window, and curtain wall systems.

2.09 PREFORMED, PRECOMPRESSED, IMPREGNATED FOAM SEALER

- A. Provide manufacturer's standard preformed, precompressed, impregnated open-cell foam sealer manufactured from high-density urethane foam impregnated with a nondrying, waterrepellant agent; factory-produced in precompressed sizes in roll or stick form to fit joint widths indicated. Provide foam sealer permanently elastic, mildew-resistant, nonmigratory, nonstaining, compatible with substrates, and complying with the following requirements:
 - 1. Impregnating Agent: Manufacturer's standard.
 - 2. Density: 8 - 10 lb./cu. ft.
 - 3. Backing: Manufacturer's standard pressure sensitive adhesive, factory applied to one side, with protective wrapping.
- B. Provide one of the following products, or Architect approved equal:
 - 1. Emseal Greyflex; Emseal Corp.
 - 2. Illmod 600; Tremco (formerly Willseal by Illbruck).
 - 3. York-Seal 100; York Manufacturing, Inc.

2.10 JOINT FILLERS

- A. Provide non-extruding, resilient asphalt impregnated fiberboard complying with ASTM D1751, FS HH-F-341 type I, or AASHTO M213.

2.11 MISCELLANEOUS MATERIALS

- A. Primer: Provide as recommended by sealer manufacturer for surfaces to be adhered to.
- B. Bond Breaker Tape: Provide polyethylene or other plastic tape as recommended by sealer manufacturer to prevent three-sided adhesion.

- C. Backer Rod: Provide compressible rod of durable nonabsorptive material as recommended by sealer manufacturer for compatibility with sealer. Provide products of one of the following manufacturers:
 - 1. Backer Rod Manufacturing and Supply Co.
 - 2. Dow Chemical Co.
 - 3. W. R. Meadows, Inc.
 - 4. Williams Products, Inc.
 - 5. Woodmont Products, Inc.

PART 3 - EXECUTION

3.01 INSPECTION

- A. The Installer shall examine substrates and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning of sealer work means Installer's acceptance of joint surfaces and conditions.

3.02 PREPARATION & INSTALLATION

- A. Manufacturer's Instructions and Recommendations: Strictly comply with manufacturers' instructions and recommendations, except where more restrictive requirements are specified in this section. Prime all porous surfaces using primer recommended by manufacturer.
- B. Preparation: Clean joint surfaces immediately before installation of sealers, primers, tapes and fillers. Remove all substances which could interfere with bond. Etch or roughen joint surfaces to improve bond. Tape or mask adjoining surfaces to prevent spillage and migration problems. Provide backer rods for all liquid sealers except where specifically recommended against by sealer manufacturers. Prevent three sided adhesion by use of bond breaker tapes or backer rods.
- C. Sealing: Force sealer into joints to provide uniform, dense, continuous ribbons free from gaps and air pockets. Install sealers so that compressed sealers do not protrude from joints. Dry tool sealers to form a smooth dense surface with joint surfaces adhering equally on opposite sides. At horizontal joints form a slight cove to prevent trapping water. Except in hot weather, make sealer surface slightly concave.
 - 1. Sealer Depth and Joint Size: Refer to Drawings for joint sizes. Provide width to depth ratio as follows
1/4" wide:1/4" deep; 1/2" wide:1/2" deep; 1/2"-1" wide: 1/2 x width.
- D. Acoustical Sealing: Seal tightly and completely around all penetrations into (such as outlet boxes) or through walls and floors, at the entire perimeter of walls, and between dissimilar materials.
 - 1. At penetrations through drywall construction, provide a thin sheet metal sleeve approximately 3/4" larger on each side than the penetration. Fit and seal the sleeve tightly to the surrounding drywall on both sides of the wall. Pack the 3/4" space between the sleeve and the penetrating object solidly with fibrous acoustical insulation. Provide resilient, non-hardening acoustical sealer to seal both sides of wall between penetration and sleeve.
 - 2. At penetrations through solid walls and where opening is irregular and greater than 1" larger on each side than the penetration, wrap penetrating object with 1" thick fibrous material and solidly grout space between fibrous material and opening with grout. Pack all voids with fibrous filler and seal both sides with resilient, non-hardening acoustical sealer.
 - 3. Where fire-stopping sealer is used at penetrations through fire-rated assemblies, additional acoustical sealing is not required.

3.03 EXTENT OF SEALER WORK

- A. General Extent: Seal all joints as noted and all interior and exterior joints, seams, and intersections between dissimilar materials. Provide elastomeric sealer installation with backer rod in all interior and exterior control joints.
- B. Exterior Sealing: Without limitation, the work of this section includes sealing the following:
 - 1. Metal to metal joints; window sealers.
 - 2. Metal to concrete joints.
 - 3. Concrete to concrete at cold joints.

4. All joints and cracks in paving and walks.
5. Masonry control and isolation joints.
6. Above all joint fillers.

- C. Interior Sealing: Without limitation, the work of this section includes sealing the following whether or not shown in detail drawings:
1. Perimeters of all door frames, window frames, and other metal frames set into exterior assemblies.

3.04 CURING

- A. Cure sealers in strict compliance with manufacturers' instructions and recommendations to obtain highest quality surface and maximum adhesion. Make every effort to minimize accelerated aging effects and increase in modulus of elasticity.

3.05 REPAIR & CLEANING

- A. Remove and replace work which is damaged or deteriorated in any respect.
- B. Clean adjacent surfaces using materials and methods recommended by sealer manufacturer. Remove and replace work that cannot be successfully cleaned.

END OF SECTION



SECTION 08 14 00

WOOD DOORS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Solid wood doors.
 - 2. Glazed and unglazed stile and rail wood doors.
 - 3. Prefitting and premachining of wood doors.
 - 4. Factory finishing of wood doors.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 06 40 23, Interior Architectural Woodwork.
 - 2. Section 08 70 00, Finish Hardware
 - 3. Section 08 80 00, Glass and Glazing

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, specifications, installation instructions, use limitations and recommendations for each door type used. Provide certifications stating that doors comply with requirements.
- B. Shop Drawings: Provide large scale shop drawings for fabrication and installation of all doors. Provide schedules, sizes, elevations, and details of construction, hardware blocking, information on prefitting and premachining work, and accessory items.
- C. Finishing Specifications: Provide detailed specifications for all factory applied coatings and finishes.
- D. Verification Samples: Submit representative samples of each door and finish that is to be exposed in the finished work, showing the full range of color and finish variations expected. Provide samples having minimum area of 144 square inches.
- E. Test Reports: Submit certified reports for fire-tests.
- F. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Source: For each type of door required for the work of this section, provide products of one manufacturer to ensure uniformity in quality of appearance and construction.

WOOD DOORS

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- B. Quality Hallmark: Provide doors bearing WDMA Hallmark certifying compliance with ANSI/WDMA I. S. 1-A-97 Architectural Wood Flush Doors and ANSI/WDMA I. S. 6-A-01 Wood Stile and Rail Doors.
 - C. Architectural Woodwork Institute: Provide doors complying with applicable requirements of AWI Architectural Woodwork Quality Standards, Section 1300, for grade, core construction and finish.
- 1.06 TESTS
- A. Provide doors that are labeled and listed by an agency acceptable to authorities having jurisdiction.
- 1.07 ENVIRONMENTAL REQUIREMENTS
- A. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
 - B. Certified Wood Components: Provide a minimum of 50 percent of the wood-based materials and products certified in accordance with the Forest Stewardship Council's Principles and Criteria.
 - C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.
 2. Option D, Composite Wood and Agrifiber Products: Composite wood and agrifiber products, include particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores. Comply with one of the following criteria for each product:
 - a. Composite wood and agrifiber products must contain no added urea-formaldehyde resins. Laminate adhesives used to fabricate on-site and shop applied assemblies must contain no added urea formaldehyde.
 - b. Composite wood and agrifiber products must meet the testing and product requirements of the California Department of Health Services (CDHS) Standard Practice for the Testing of Volatile Organic Emissions From Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.
- 1.08 DELIVERY, STORAGE AND HANDLING
- A. Deliver doors in manufacturer's standard package. Store and handle in strict compliance with manufacturer's instructions and recommendations. Comply with the requirements of on-site care recommendations of WDMA Care and Finishing of Wood Doors. Protect from damage.
 - B. Sequence deliveries to avoid delays, but minimize on-site storage.
- 1.09 PROJECT CONDITIONS
- A. Weather: Unwrap and install doors only when existing and forecasted weather conditions are within the limits established by manufacturers.
 - B. Proceed with work only when wet-work and other potentially damaging construction work is complete.
 - C. Ventilation: Comply with manufacturer's requirements and recommendations.
- 1.10 WARRANTY
- A. Provide written warranty signed by manufacturer agreeing to repair or replace work which exhibits defects in materials or workmanship for the following periods from date of Substantial Completion. "Defects" is defined to include, but is not limited to, warping, bowing, cupping, twisting, telegraphing of core

construction, exceeding tolerance limitations of WDMA and AWI, abnormal aging or deterioration, and failure to perform as required.

1. Interior Doors: Life of Installation

- B. Include requirement for refinishing and reinstalling doors repaired or replaced under warranty. Manufacturer or fabricator shall not defer action on any claim; claims shall be satisfied immediately.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements, provide products of one of the following manufacturers or approved equal:
 - 1. Algoma Hardwoods
 - 2. Eggers Industries
 - 3. Marshfield DoorSystems, Inc.
 - 4. VT Industries
 - 5. Jeld-Wen.
 - 6. Simpson Door Co. www.simpsondoor.com.

2.02 MATERIALS AND PRODUCTS

- A. General: Core, stiles, and rails shall be glued together before sanding. Wood for stiles and rails shall be thoroughly seasoned, kiln-dried stock with 5% to 8% moisture content.
 - 1. Basis of Design: Simpson Door Co., McCleary, WA 98557; www.simpsondoor.com.
- B. Provide same exposed surface on both sides of door, unless indicated otherwise.
- C. Cut and trim openings (if shown), comply with applicable requirements of referenced standards.
- D. All factory-finished doors shall be shipped in individual protective packaging to jobsite.

2.03 DOORS AND COMPONENTS

- A. Solid Doors:
 - 1. Blocking: Provide blocking with screw holding capability for doors to receive surface mounted hardware.
 - 2. Wood species and cuts for painted and transparent finishes shall be as indicated on Finish Schedule.
 - 3. Glass for glazed wood doors shall comply with Section 08800, GLASS AND GLAZING.
- B. Solid Doors - Fire-Rated: Provide manufacturer's standard construction to obtain fire-resistance rating indicated or required.
- C. Stile and Rail Doors: AWI Premium Grade, plain sawn Douglas Fir solid lumber core with face and edges of veneer specified. Glass panels shall be laminated glass as specified in Section 08 80 00, Glass and Glazing.
- D. Glazing: Provide loose glazing stops as required for use under Section 08800, Glass and Glazing.

2.04 PREFITTING AND PREMACHINING

- A. At factory, prefit doors to frames and premachine doors for hardware listed on final schedules.
- B. Comply with tolerance requirements of AWI for non-rated doors and NFPA for fire-rated doors.
- C. Bevel non-rated doors 1/8" in 2" at lock and hinge stiles. Bevel rated doors 1/8" in 2" at lock edge only.

2.05 FINISHES

- A. General: Comply with referenced quality standard's requirements for factory finishing.

1. Quality Standard: Provide AWI Premium Grade for finishing, complying with AWI Quality Standards, Section 1500.
2. Preparation for Finishing: Comply with AWI Quality Standards for sanding, filling, countersinking, sealing of concealed surfaces, and similar preparation requirements for finishing of work of this Section.

B. Transparent Finish: Match finish as specified in Section 06402, Interior Architectural Woodwork.

C. Painted (Opaque) Finish: Factory prime all sides; field finish per Section 09910, Painting.

PART 3 - EXECUTION

3.01 INSPECTION

- A. The Installer shall examine frames and conditions under which this work is to be installed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 PREPARATION

- A. Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.

B. Condition doors to prevailing conditions before installing.

3.03 INSTALLATION

- A. Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.

B. Prefit and premachine doors to the extent not done at factory. Restore factory finishes before installing.

C. For non-rated doors, provide 1/8" clearances at head, jambs and meeting stiles (of pairs of doors). Provide 1/2" clearance at bottom and as required to clear flooring, except at thresholds provide 1/4" clearance. Coordinate with gasketing requirements.

3.04 ADJUSTING, CLEANING, PROTECTION

- A. Adjust doors to work easily, smoothly, and correctly.

B. Touch-up damaged coatings and finishes to eliminate evidence of repair.

C. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired.

D. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully cleaned.

E. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.

3.05 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 08 52 00

WOOD WINDOWS AND CLAD-WOOD WINDOWS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Clad wood windows, glazing, hardware and trim.
 - 2. Wood windows, glazing, hardware and trim.

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect Work of this Section. Other Specification Sections that directly relate to Work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry.
 - 2. Section 06 20 13, Exterior Finish Carpentry.
 - 3. Section 06 20 23, Interior Finish Carpentry.
 - 4. Section 07 92 00, Joint Sealers; General sealant requirements.
 - 5. Section 08 81 00, Glass and Glazing.
 - 6. Section 09 91 00, Painting.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements.
 - 1. Warranties: Submit example copies of manufacturer's warranties before ordering materials.
- B. Schedule: Provide a schedule of what type of glass will be used in each location. Include locations of safety glass.
- C. Calculations: Provide glass manufacturer's windload charts, calculations and certification of the performance of this work. Show how design load requirements and other performance criteria have been satisfied.

1.05 INTENT AND PERFORMANCE REQUIREMENTS

- A. Air infiltration (air leakage) shall not exceed the following when tested at 1.57 psf when tested in accordance with ASTM E283: 0.30 cfm per square foot of frame.
- B. **Water penetration resistance - There shall be no water penetration when tested at the desired/ specified pressure in accordance with ASTM E547.**
- C. **Structural load testing - Product shall meet the damaged and permanent deflection pass/fail criteria as stated in AAMA/NWWDA 101/I.S. 2-97 or AAMA/WDMA/CSA 101 I.S.2/A440-05 when tested in accordance with ASTM E330.**

1.06 QUALITY ASSURANCE

- A. Source: For each type of glass and glazing material required for the work of this section, provide primary materials which are the products of one manufacturer. Provide secondary materials which are acceptable to the manufacturers of the primary materials. All glass of each type shall exactly match.

WOOD WINDOWS AND CLAD-WOOD WINDOWS

- B. Glass Thickness: Determine exact sizes and thicknesses of glass products and certify that the work of this section meets or exceeds the performance requirements specified in this section. Provide proper thicknesses, edge clearances and tolerances to comply with the recommendations of the glass manufacturer. Provide thicknesses required for application indicated.
 - C. General Standards: Comply with recommendations of GANA's "Glazing Manual".
 - D. Safety Glass Standards: Provide safety glass which complies with ANSI Z97.1 and requirements of 16 CFR Part 1201 for Category II materials and is permanently marked with certification label of Safety Glass Certification Council.
 - E. Insulating Glass Standards: Provide insulating glass assemblies which are permanently marked with certification label of either the Insulating Glass Certification Council or Associated Laboratories, Inc. Provide units which comply with ASTM E774, Class A requirements and SIGMA TM-3000, "Glazing Guidelines for Sealed Insulating Glass Units".
- 1.07 DELIVERY, STORAGE AND HANDLING
- A. Deliver materials and products in labeled, protective packages. Store and handle in strict compliance with manufacturer's instructions and recommendations and GANA "Glazing Manual".
 - 1. Protect from all possible damage.
 - 2. Keep shipping containers closed when not in use.
 - 3. Protect materials during storage from moisture, sunlight, excess heat, sparks and flame.
 - 4. Carefully store materials to avoid overloading any building component or structure.
 - 5. Provide adequate ventilation to prevent build-up of dangerous solvent concentrations.
 - 6. Use clean gloves and tools when handling materials. Avoid contamination.
 - 7. Use rolling blocks and suction cups to move glass units not in shipping crates.
 - 8. Sequence deliveries to avoid delays, but minimize on-site storage.
- 1.08 PROJECT CONDITIONS
- A. Weather: Perform work only when existing and forecasted weather conditions are within the limits established by manufacturers of the materials and products used.
 - B. Temperature Limits: Install sealants only when temperatures are within the recommended range established by sealant manufacturer and never below 40°F.
- A.Field Measurements: Verify wood window openings by field measurements before fabrication and indicate measurements on Shop Drawings.**
- B. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.**
- 1.09 WARRANTIES
- A. Provide written warranties signed by manufacturer , agreeing to repair or replace work which exhibits defects in materials or workmanship for the following periods. "Defects" is defined to include, but is not limited to, leakage of water, abnormal aging or deterioration, failure of hermetic seal in insulating units, edge separation or delamination of laminated glass, peeling, cracking, crazing or other failure of metallic coatings in coated glass, and failure to meet requirements of Contract Documents. Provide warranty periods standard with manufacturer, but not less than the following:
 - 1. Insulating Glass: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 GLASS SCHEDULE

A. Insulating Glass: 1 in. insulating units with 1/2 inch air space, and low-e coating on No. 2 surface. At spandrels where glass is concealed at interior, provide insulating spandrel glass assembly with standard color ceramic frit on the No. 4 surface; two colors required. Tempered as required.

B. Entrances: Refer to Section 08 14 00.

2.02 GLASS MATERIALS AND PRODUCTS

A. Clear Float Glass: ASTM C 1036 ,Type I-Transparent, Flat, Class 1-Clear, Quality q3.

B. Clear Heat Strengthened Glass: ASTM C 1048, Condition A-Uncoated, Type I-Transparent, Flat, Class 1-Clear, Quality q3, Kind HS.

C. Clear Tempered Glass: ASTM C 1048, Condition A-Uncoated, Type I-Transparent, Flat, Class 1-Clear, Quality q3, Kind FT.

2.03 GLAZING MATERIALS AND PRODUCTS

A. General Glazing Requirements: Provide sealants and gaskets which have performance characteristics suitable for applications intended. Make sure that glazing sealants are compatible with sealants used in insulated glass fabrication, with laminated glass interlayer, and with surfaces to be in contact.
1. Colors: Provide colors of sealants and gaskets as selected by Architect from manufacturer's standards.

B. General Glazing: Provide sealant compatible with all substrates and materials and having maximum Shore A hardness of 50. Provide one of the following products if they meet or exceed the requirements of these specifications:

1. Dow Corning 795
2. General Electric Silglaze N 2500, Gesil N, or Contractors SCS-1000.
3. Tremco Tremsil 200 or Spectrum 2

D. Setting Blocks: Provide dense extruded neoprene or silicone with a hardness of 85 ± 5 Shore A Durometer hardness, a minimum length of 4" and a minimum width equal to the glass thickness. Provide materials as recommended and approved by glass and sealant manufacturers. Provide products certified by their manufacturers to be "silicone compatible".

1. Shims: Used with setting blocks shall be the same material, hardness, length and width as setting blocks.

E. Side Blocks: Provide dense extruded neoprene or silicone with a hardness of 55 ± 5 Shore A Durometer hardness. Provide block with sufficient length to prevent point loading on the glass. Provide materials as recommended and approved by glass and sealant manufacturers. Provide products certified by their manufacturers to be "silicone compatible". Provide silicone side blocks for insulating units with silicone edge seals. Neoprene side blocks are acceptable only if permitted by the insulating glass fabricator.

F. Sealant Backer Rods: Provide flexible, resilient polyethylene foam, urethane foam, or extruded silicone as recommended and approved by sealant and glass manufacturers.

G. Primers: Provide cleaners, primers and sealers as recommended by glass and sealant manufacturers.

PART 3 EXECUTION

3.01 INSPECTION

A. The Installer/Glazier shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 PREPARATION AND GLAZING

A. Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section. Comply with FGMA Glazing Manual . Do not glaze when ambient temperature is below 40°F.

1. Inspect all glass before installation. Do not install defective glass.
2. Check glass for correct size and squareness. Adjust frame or glass size to correct as necessary.
3. Protect glass from edge damage. Use roller blocks. Replace all damaged or weakened glass.
4. Thoroughly clean glazing channels and pockets immediately before glazing and keep them dry.
5. Remove coatings which are not firmly bonded to substrates. Remove lacquer, if any.
6. Center glass in opening and provide minimum 1/2" glass bite and 1/8" minimum edge clearances.
7. Place setting blocks at quarter points and side blocks at upper half of each side.
8. Securely set setting blocks and side blocks in position to prevent displacement.
9. Keep weeps clear.
10. Remove stops and provide sealants to create a water tight and air tight installation.
11. Glaze in a manner to permit simple replacement of glass without dismantling frames.
12. Place glass with uniform pattern, draw, bow and similar visual characteristics.
13. Install tapes and gaskets to eliminate dirt and moisture pockets. Prepare for exterior cap seal.
14. Miter and seal tapes and gaskets at corners and seal at joints. Do not overlap at corners.
15. Install tapes and gaskets to prevent pulling away from corners.
16. Prevent metal to glass contact. Protect edges of insulating units from solvents and damage.
17. Replace stops and clean and prime stops, framing, and glass on both sides.
18. Clean, prime and mask for liquid sealants immediately before sealant application.
19. Apply wet sealant in continuous motion and tool thoroughly to "wet" contact surfaces uniformly.
20. Slope sealant to promote drainage away from glass and sealant.
21. Defer glazing of openings needed for construction operations until directed.

3.03 CLEANING AND PROTECTION

- A. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully cleaned. Clean frequently, if necessary, to remove build-up of potentially harmful construction contaminants. Re-clean all glass within one week of final acceptance of the project.
- B. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Do not apply markers to surfaces of glass. Remove protections and reclean as necessary immediately before final acceptance.
- C. Remove and replace all broken, chipped, cracked, scratched or otherwise damaged glass from whatever cause.

END OF SECTION



SECTION 08 70 00

DOOR HARDWARE

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. This section specifies finish hardware for interior and exterior doors to provide correct functions for intended use. Provide related items and services, as indicated on Drawings and as specified. Furnish hardware schedules and templates as required for fabrication of doors and frames under other Sections. Provide hardware that complies with applicable codes and requirements of authorities that have jurisdiction.

- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 08 14 00, Wood Doors.

1.04 SUBMITTALS

- A. Installation Templates: Provide installation templates for work installed or prepared for installation by others.
- B. Product Data: Submit manufacturer's product data, catalog cuts, descriptive data, UL listings, and other pertinent technical data for each hardware item used. Submit certifications of fireratings for hardware items located in rated assemblies.
- C. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Source: For each type of hardware required for the work of this Section, provide products of a single manufacturer.
- B. Consultant: Provide the services of a certified hardware consultant, acceptable to the Architect, to prepare hardware and keying schedules and to certify that the work of this Section meets or exceeds requirements of authorities having jurisdiction.
- C. Comply with American With Disabilities Act Accessibility Guidelines (ADAAG) and applicable local requirements.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
 - 1. Steel: 25% recycled content.

DOOR HARDWARE

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- B. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Packaging: Package and label each hardware item separately with all screws, bolts and accessories required for a complete and proper installation. Coordinate the labeling of packages with hardware set numbers.
- B. Store hardware items in locked spaces. Replace all hardware items lost or damaged. Provide copies of supplier receipts for hardware items delivered to the Project.

PART 2 - PRODUCTS

2.01 FINISH HARDWARE - GENERAL REQUIREMENTS

- A. Provide the specified hardware item, or an equal product from one of the other named manufacturers which meet or exceed the standard as judged by the Architect.
- B. Provide the proper hardware which permits the swing and hand of each door as indicated on the Drawings.
- C. Manufacturer's names or trademarks displayed in a visible location will not be permitted on any piece of hardware. All trademarks and logos visible must be in compliance with rules and code outlined for the Solar Decathlon Competition.
- D. Base Metal: Provide plated brass or bronze with the exception of stainless steel and aluminum items.
- E. Fasteners: Provide concealed fasteners to the greatest extent possible. Do not use throughbolts unless otherwise acceptable to the Architect.

2.02 HARDWARE FINISHES

- A. Provide finish as indicated on Hardware Schedule.

2.03 LOCKSETS AND LATCHSETS

- A. Mortise Locksets and Latchsets: ANSI 156.2 Series 4000, Grade 2. Except where scheduled otherwise, provide latchsets and locks with lever and rose as selected by Architect by one of the manufacturers listed below. Cylinders shall be 6 or 7-pin, interchangeable (I/C) cores as acceptable to the Owner.
 - 1. Best.
 - 2. Corbin Russwin.
 - 3. Schlage.

2.04 HINGES AND BUTTS

- A. Provide products of one of the following manufacturers that meet or exceed the requirements of these specifications:
 - 1. Hager
 - 2. Lawrence
 - 3. McKinney
 - 4. Stanley

- B. Provide hinges template produced, full mortise, five knuckle-type, four-ball bearing type, except as otherwise scheduled.
 - C. Hinge Height: 4-1/2 in.
 - D. Hinge Width: Consultant shall determine proper hinge width based upon door thickness and trim conditions. Provide minimum 4-1/2 in. wide hinges.
 - E. Hinge Quantity: Provide three hinges for doors up to 7 ft.-6 in. high, and one additional hinge for each additional 2 ft.-6 in. of height. Provide one additional hinge for doors over 3 ft.-6 in. wide.
 - F. Pins: Provide flat button pins matching hinges in finish and material. Provide non-removable pins on outswinging exterior and corridor doors. Provide non-rising pins for all other hinges.
- 2.05 WEATHERSTRIPPING, SOUNDSTRIPPING, AND THRESHOLDS
- A. Provide products of one of the following manufacturers that meet or exceed the requirements specified:
 - 1. Reese
 - 2. Pemko
 - 3. Zero
 - B. Thresholds for General Applications: As detailed
 - C. Weatherstripping: Provide neoprene concealed gasket-type weatherstripping at exterior doors. Weatherstripped doors are required to provide a continuous seal at the entire perimeter of door with no cracks.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine doors, frames and conditions under which the work of this Section will be performed. Notify Contractor in writing of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Commencing work means Installer accepts substrates and conditions.

3.02 INSTALLATION

- A. Comply with manufacturers' instructions and recommendations, except where more restrictive requirements are specified in this Section.
- B. Install hardware on doors and frames at locations conforming to ANSI and NAHM standards, and DHI mounting heights, except where specifically indicated otherwise or required by authorities having jurisdiction.
- C. Set hardware plumb, level, and in exact alignment and location. Conceal and countersink fasteners wherever possible.
- D. Set exterior thresholds in bed of sealant provided under Section 07 90 00, Joint Sealers.

3.03 ADJUSTING, CLEANING, AND PROTECTION

- A. Adjust hardware items to work smoothly, easily, and correctly.
- B. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer of hardware being cleaned. Remove and replace work which cannot be successfully cleaned, as judged solely by the Architect.

- C. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately prior to final acceptance.
 - 1. Cover knobs, levers, pulls, and push plates with heavy cloth to protect against damage until Final Acceptance of the Project.

3.04 COMPLETION AND CONTINUED MAINTENANCE

- A. Before completion of work of this Section, inspect work with Architect and adjust and correct work to leave operating parts in perfect operating condition, jointing to adjacent material tight, surfaces without blemishes or stains, work properly executed and complete, and defects and damaged work replaced or corrected.
- B. Provide services of hardware supplier's representative to inspect hardware six months after Final Acceptance of Project. Readjust and restore hardware.
- C. Provide (1) copy of keys and entry devices to NREL officials for duration of Solar Decathlon Competition.

3.05 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

3.06 HARDWARE SETS

- A. The Hardware sets listed indicate the items of hardware required for one opening, single door or pair of doors. This information is furnished for use as a guide only. It is the hardware supplier's responsibility to furnish the proper quantities, functions, weights, and sizes as required by the specifications and as recommended by the manufacturer's catalogue information.
 - 1. Refer to Drawings for sets.

END OF SECTION



SECTION 08 81 00

GLASS AND GLAZING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Glass and glazing for aluminum framing systems.
 - 2. Glass and glazing for doors.

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect Work of this Section. Other Specification Sections that directly relate to Work of this Section include, but are not limited to:
 - 1. Section 07 92 00, Joint Sealers; General sealant requirements.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements.
 - 1. Warranties: Submit example copies of manufacturer's warranties before ordering materials.
- B. Schedule: Provide a schedule of what type of glass will be used in each location. Include locations of safety glass.
- C. Calculations: Provide glass manufacturer's windload charts, calculations and certification of the performance of this work. Show how design load requirements and other performance criteria have been satisfied.

1.05 INTENT AND PERFORMANCE REQUIREMENTS

- A. A major intent of the work of this section is to be weathertight and keep the building dry. Work of this section shall withstand normal loads due to wind, temperature and normal impact without failure, breakage of glass or seals, fogging or other defects.
 - 1. Temperature Range: Glass and glazing shall function correctly and normally throughout an ambient temperature range of 100°F above and below installation temperature.
 - 2. Hermetic Seals: Insulated units shall be free from internal dirt, moisture, condensation, fogging, deterioration of protected internal glass coating [if any], and visual evidence of seal failure throughout the warranty period.
 - 3. Laminated Glass: Laminated glass shall be free from delamination, edge separation, visual discoloration, and other damage throughout the warranty period.

1.06 QUALITY ASSURANCE

- A. Source: For each type of glass and glazing material required for the work of this section, provide primary materials which are the products of one manufacturer. Provide secondary materials which are acceptable to the manufacturers of the primary materials. All glass of each type shall exactly match.
- B. Glass Thickness: Determine exact sizes and thicknesses of glass products and certify that the work of this section meets or exceeds the performance requirements specified in this section. Provide proper

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thicknesses, edge clearances and tolerances to comply with the recommendations of the glass manufacturer. Provide thicknesses required for application indicated.

- C. General Standards: Comply with recommendations of GANA's "Glazing Manual".
- D. Safety Glass Standards: Provide safety glass which complies with ANSI Z97.1 and requirements of 16 CFR Part 1201 for Category II materials and is permanently marked with certification label of Safety Glass Certification Council.
- E. Insulating Glass Standards: Provide insulating glass assemblies which are permanently marked with certification label of either the Insulating Glass Certification Council or Associated Laboratories, Inc. Provide units which comply with ASTM E774, Class A requirements and SIGMA TM-3000, "Glazing Guidelines for Sealed Insulating Glass Units".

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products in labeled, protective packages. Store and handle in strict compliance with manufacturer's instructions and recommendations and GANA "Glazing Manual".
 - 1. Protect from all possible damage.
 - 2. Keep shipping containers closed when not in use.
 - 3. Protect materials during storage from moisture, sunlight, excess heat, sparks and flame.
 - 4. Carefully store materials to avoid overloading any building component or structure.
 - 5. Provide adequate ventilation to prevent build-up of dangerous solvent concentrations.
 - 6. Use clean gloves and tools when handling materials. Avoid contamination.
 - 7. Use rolling blocks and suction cups to move glass units not in shipping crates.
 - 8. Sequence deliveries to avoid delays, but minimize on-site storage.

1.08 PROJECT CONDITIONS

- A. Weather: Perform work only when existing and forecasted weather conditions are within the limits established by manufacturers of the materials and products used.
- B. Temperature Limits: Install sealants only when temperatures are within the recommended range established by sealant manufacturer and never below 40°F.

1.09 WARRANTIES

- A. Provide written warranties signed by manufacturer, agreeing to repair or replace work which exhibits defects in materials or workmanship for the following periods. "Defects" is defined to include, but is not limited to, leakage of water, abnormal aging or deterioration, failure of hermetic seal in insulating units, edge separation or delamination of laminated glass, peeling, cracking, crazing or other failure of metallic coatings in coated glass, and failure to meet requirements of Contract Documents. Provide warranty periods standard with manufacturer, but not less than the following:
 - 1. Insulating Glass: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 GLASS SCHEDULE

- A. Insulating Glass: 1 in. insulating units with 1/2 inch air space, and low-e coating on No. 2 surface. At spandrels where glass is concealed at interior, provide insulating spandrel glass assembly with standard color ceramic frit on the No. 4 surface; two colors required. Tempered as required.
- B. Entrances: Refer to Section 08 14 00.

2.02 GLASS MATERIALS AND PRODUCTS

- A. Clear Float Glass: ASTM C 1036, Type I-Transparent, Flat, Class 1-Clear, Quality q3.

- B. Clear Heat Strengthened Glass: ASTM C 1048, Condition A-Uncoated, Type I-Transparent, Flat, Class 1-Clear, Quality q3, Kind HS.
- C. Clear Tempered Glass: ASTM C 1048, Condition A-Uncoated, Type I-Transparent, Flat, Class 1-Clear, Quality q3, Kind FT.

2.03 GLAZING MATERIALS AND PRODUCTS

- A. General Glazing Requirements: Provide sealants and gaskets which have performance characteristics suitable for applications intended. Make sure that glazing sealants are compatible with sealants used in insulated glass fabrication, with laminated glass interlayer, and with surfaces to be in contact.
 - 1. Colors: Provide colors of sealants and gaskets as selected by Architect from manufacturer's standards.
- B. General Glazing: Provide sealant compatible with all substrates and materials and having maximum Shore A hardness of 50. Provide one of the following products if they meet or exceed the requirements of these specifications:
 - 1. Dow Corning 795
 - 2. General Electric Silglaze N 2500, Gesil N, or Contractors SCS-1000.
 - 3. Tremco Tremsil 200 or Spectrum 2
- C. Preformed Glazing Tape: Provide butyl-polyisobutylene rubber with 100% solids content in extruded tape roll form and complying with AAMA 804.1. Provide one of the following products if they meet or exceed the requirements of these specifications:
 - 1. Protective Treatments 303 or 606
 - 2. Tremco Polyshim II
 - 3. Woodmont Chem-Tape 40
- D. Setting Blocks: Provide dense extruded neoprene or silicone with a hardness of 85 ± 5 Shore A Durometer hardness, a minimum length of 4" and a minimum width equal to the glass thickness. Provide materials as recommended and approved by glass and sealant manufacturers. Provide products certified by their manufacturers to be "silicone compatible".
 - 1. Shims: Used with setting blocks shall be the same material, hardness, length and width as setting blocks.
- E. Side Blocks: Provide dense extruded neoprene or silicone with a hardness of 55 ± 5 Shore A Durometer hardness. Provide block with sufficient length to prevent point loading on the glass. Provide materials as recommended and approved by glass and sealant manufacturers. Provide products certified by their manufacturers to be "silicone compatible". Provide silicone side blocks for insulating units with silicone edge seals. Neoprene side blocks are acceptable only if permitted by the insulating glass fabricator.
- F. Sealant Backer Rods: Provide flexible, resilient polyethylene foam, urethane foam, or extruded silicone as recommended and approved by sealant and glass manufacturers.
- G. Primers: Provide cleaners, primers and sealers as recommended by glass and sealant manufacturers.

PART 3 EXECUTION

3.01 INSPECTION

- A. The Installer/Glazier shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 PREPARATION AND GLAZING

- A. Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section. Comply with FGMA Glazing Manual . Do not glaze when ambient temperature is below 40°F.
1. Inspect all glass before installation. Do not install defective glass.
 2. Check glass for correct size and squareness. Adjust frame or glass size to correct as necessary.
 3. Protect glass from edge damage. Use roller blocks. Replace all damaged or weakened glass.
 4. Thoroughly clean glazing channels and pockets immediately before glazing and keep them dry.
 5. Remove coatings which are not firmly bonded to substrates. Remove lacquer, if any.
 6. Center glass in opening and provide minimum 1/2" glass bite and 1/8" minimum edge clearances.
 7. Place setting blocks at quarter points and side blocks at upper half of each side.
 8. Securely set setting blocks and side blocks in position to prevent displacement.
 9. Keep weeps clear.
 10. Remove stops and provide sealants to create a water tight and air tight installation.
 11. Glaze in a manner to permit simple replacement of glass without dismantling frames.
 12. Place glass with uniform pattern, draw, bow and similar visual characteristics.
 13. Install tapes and gaskets to eliminate dirt and moisture pockets. Prepare for exterior cap seal.
 14. Miter and seal tapes and gaskets at corners and seal at joints. Do not overlap at corners.
 15. Install tapes and gaskets to prevent pulling away from corners.
 16. Prevent metal to glass contact. Protect edges of insulating units from solvents and damage.
 17. Replace stops and clean and prime stops, framing, and glass on both sides.
 18. Clean, prime and mask for liquid sealants immediately before sealant application.
 19. Apply wet sealant in continuous motion and tool thoroughly to "wet" contact surfaces uniformly.
 20. Slope sealant to promote drainage away from glass and sealant.
 21. Defer glazing of openings needed for construction operations until directed.

3.03 CLEANING AND PROTECTION

- A. Clean exposed surfaces using materials and methods recommended by manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully cleaned. Clean frequently, if necessary, to remove build-up of potentially harmful construction contaminants. Re-clean all glass within one week of final acceptance of the project.
- B. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Do not apply markers to surfaces of glass. Remove protections and reclean as necessary immediately before final acceptance.
- C. Remove and replace all broken, chipped, cracked, scratched or otherwise damaged glass from whatever cause.

END OF SECTION



SECTION 09 21 16

GYPSUM BOARD ASSEMBLIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Metal framing and trimming systems for drywall systems.
 - 2. Gypsum boards for wall, ceiling and soffit applications.
 - 3. Cementitious tile backer board, interior.
 - 4. Gypsum board finishes.
 - 5. Sound attenuation insulation.
 - 6. Concealed acoustical sealants.
 - 7. Miscellaneous metal framing and blocking.
 - 8. Installation of access panels.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; Blocking and wood studs.
 - 2. Section 07 92 00, Joint Sealers; Exposed acoustical sealant.
 - 3. Section 09 91 00, Painting; Finishing of work of this section.
 - 4. Division 23 - Mechanical and Division 26 - Electrical; Coordination of mechanical, electrical and plumbing requirements.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements.
- B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 00, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Source: For each type of material required for the work of this section, provide primary materials which are the products of one manufacturer. Provide secondary materials which are acceptable to the manufacturers of the primary materials.
- B. Engineering and Structural Performance: Provide the services of a Professional Engineer, who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated, to design and certify that the work of this section meets or exceeds the performance requirements specified in this section.

GYPSUM BOARD ASSEMBLIES

1. Limit deflection to L/240 for non-rigid finishes, L/360 for rigid finishes applied over drywall. Lateral load is 5 p.s.f.

C. Fire-Test-Response Characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by a qualified independent testing agency, acceptable to the Architect and authorities having jurisdiction.

1. Partition Head Conditions: Comply with design designation from UL's Fire Resistance Directory.

D. Sound Transmission Characteristics: For gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency, acceptable to the Architect and authorities having jurisdiction.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.

1. Steel Framing: 22.6% of 20% post-consumer and 8.4% of 40% post-industrial; total 32% recycled content.

2. Gypsum Board: 93.36% post-industrial recycled content and 5.64% post-consumer recycled content.

3. Facing Paper for Gypsum Board: 100% recycled newsprint.

4. Insulation: 25% recycled content, SCS certified.

5. Manufacturer Recycling: Provide gypsum board materials only from manufacturers who accept scrap products for recycling.

B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.

C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):

1. Option A, Adhesives and Sealants: Comply with the following criteria:

a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.

b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturers' instructions and recommendations. Protect from damage. Adequately support stored gypsum panels to avoid sagging. Sequence deliveries to avoid delays, but minimize on-site storage.

1.08 PROJECT CONDITIONS

A. Weather: Perform work only when existing and forecasted weather conditions are within the limits established by manufacturers of the materials and products used. Comply with requirements of Gypsum Association publication 220.

B. Framing Tolerances: Proceed with work only when framing work is complete and within installation tolerances specified in ASTM C754 and this specification section.

C. Ventilation: Comply with manufacturer's requirements and recommendations and Gypsum Association publication 216. Avoid too rapid drying in hot weather.

- D. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written recommendations, whichever are more stringent.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Metal Framing and Support: Provide products of one of the following manufacturers if they meet or exceed the requirements of these specifications:
1. Dale Industries, Inc. - Dale/Incor.
 2. Dietrich Industries, Inc.
 3. MarinoWare; Division of Ware Ind.
 4. National Gypsum Co.
 5. Unimast, Inc.
- B. Gypsum Board and Related Products: Provide products of one of the following manufacturers if they meet or exceed the requirements of these specifications:
1. Georgia-Pacific Corp.
 2. National Gypsum Co.
 3. USG.

2.02 METAL FRAMING AND SUPPORTS

- A. Studs: ASTM C645, 20 gage, unless otherwise recommended by manufacturer for conditions, span and deflection constraints indicated. Provide galvanized steel studs with not less than ASTM A 653, G60, hot-dip galvanized zinc coating.
1. Depth: 3-5/8" and 6", unless otherwise indicated on drawings or by span and deflection constraints.
- B. Runners: Match studs. Provide type as recommended by stud manufacturer.
- C. Furring: ASTM C 645, 25 gage, except 20 gage where span exceeds 4'; hat shaped or Zshaped as indicated or appropriate. Provide galvanized steel furring with not less than ASTM A 653, G60 coating. Where indicated as "resilient", provide special sound transmission reducing type similar to USG RC-1.
- D. Cold Rolled Channels: 16 gage steel with factory applied black asphaltum paint coating.
- E. Hanger Wire: ASTM A 641, soft, class 1 galvanized, 9 gage minimum.
- F. Hanger Rods: Where required for loading or by local authorities, provide mild-steel rods, sized as required, hot-dip galvanized.
- G. Flat Hangers: Where required for loading or by local authorities, provide mild-steel flat hangers, sized as required, hot-dip galvanized.
- H. Angle-Type Hangers: Provide steel angles with legs not less than 7/8 in. wide, formed from 0.0635 in thick galvanized steel sheet conforming to ASTM A 653, G 90, with bolted connections.
- I. Resilient Hangers: USG Interiors RC-1, Dietrich "RCSS" or "RCSN", or approved equal.
- J. Steel Flat Strap and Backing Plate: Steel sheet for blocking and bracing, in length and width as indicated, and with a minimum base metal (uncoated) thickness of 0.0179 inch thick.

2.03 GYPSUM BOARD

- A. Gypsum Wallboard: ASTM C 36 and C 1396.
1. Types: Fire-resistant type X. Refer to Wall Partition Schedule on the Drawings.
 2. Edges: Tapered.
 3. Thicknesses: 5/8", and as indicated.

- B. Tile Backer Units: Provide one of the following:
 - 1. Cementitious: ANSI A118.9 and ASTM C 1325, cement-coated Portland cement, USG Durock or Custom Building Products Wonderboard or approved equal, nominal 5/8 inch thick.
 - 2. Glass-Mat, Water-Resistant Gypsum: ASTM C 1178, equal to Dens-Shield Tile Backer by G-P Gypsum Corp., nominal 5/8 in. thick.
 - C. Moisture and Mold Resistant Gypsum Board: Provide moisture and mold resistant type gypsum board conforming to ASTM C 36, C 1396 and the following:
 - 1. Non-combustible core complying with ASTM E 136.
 - 2. Water absorption not greater the 5% by weight after 2-hour immersion per ASTM C 473.
 - 3. Resistance to mold panel score of 8 per ASTM D 3273.
 - 4. Thicknesses: 5/8" and as indicated.
 - 5. Product/Manufacturer: "Sheetrock Brand Humitek Gypsum Panels" by USG.
- 2.04 METAL TRIMS AND ACCESSORIES
- A. Provide the following USG trim and accessory types or Architect approved equals from specified manufacturer:
 - 1. Corner Bead: USG No. 800.
 - 2. Control Joint: USG No. 093.
 - 3. Edge Trim: USG No. 200-A and 200-B for drywall. Series 400 trim is not acceptable.
 - B. Interior Work: Galvanized steel trim units of types specified.
 - C. Reveals: Factory-primed extruded aluminum reveal by Pittcon or approved equal, sizes as indicated on the Drawings.
 - D. Control Joints: Provide control joints complying with ASTM C 1047 and requirements indicated below:
 - 1. Material: Steel sheet coated with aluminum or rolled zinc.
 - 2. Type: One-piece control joint formed with V-shaped slot and removable strip covering slot opening.
 - E. Accessory for Curved Edges: Cornerbead formed of metal, plastic, or metal combined with plastic, with either notched or flexible flanges that are bendable to curvature radius.
- 2.05 JOINT MATERIALS
- A. General: Comply with ASTM C475.
 - B. Tape: Provide perforated, cross-fiber paper or fiberglass reinforcing.
 - C. Joint Compound: Provide ready mixed vinyl compound, unless indicated otherwise.
 - 1. For Exterior Applications: Provide setting-type taping and setting-type, sandable topping compounds.
- 2.06 MISCELLANEOUS MATERIALS
- A. Concealed Acoustical Sealant: Non-drying, non-hardening, non-bleeding, non-staining sealant complying with ASTM C919. Provide one of the following:
 - 1. Pecora BA-98.
 - 2. Tremco Acoustical Sealant.
 - 3. USG Acoustical Sealant.
 - B. Sound Attenuation Insulation: ASTM C 665, Type I. At acoustical partitions, provide Thermafiber sound attenuating fire blanket or approved equal with 2.5 lbs/cu.ft density meeting fire characteristics of Thermafiber. Provide clips or wires to hold insulation in place as applicable.

- C. Laminating Adhesive: Use joint compound or adhesive that is recommended by gypsum board manufacturer for laminating gypsum boards.
- D. Screws: Comply with ASTM C646 and C514. Type S, bugle head, for attaching gypsum panels to steel framing. Provide other types as recommended by gypsum board manufacture. Provide cadmium plated fasteners for all fasteners in wet or humid areas.
- E. Anchors: Provide screws, bolts, powder actuated fasteners, inserts and other fasteners that are customarily used in standard construction practices and which are proven capable of supporting at least 3 times design load.

PART 3 - EXECUTION

3.01 INSPECTION

- A. The Installer/Erector shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 INSTALLATION

- A. General Requirements: Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.
 - 1. Furniture Layout: Coordinate and guarantee dimensions required for custom millwork items fitting into wall construction.
- B. Framing: Install/erect framing to comply with ASTM C754. Provide framing to comply with published details and recommendations of gypsum board manufacturer, or if not available, comply with U. S. Gypsum, Gypsum Construction Handbook.
 - 1. Do not bridge building joints; frame separately on both sides and allow for movement.
 - 2. Isolate framing system from structural loading both horizontally and vertically.
 - 3. Provide slip or cushioned joints at top of walls. Maintain lateral stability and acoustical performance.
 - 4. Terminate partitions [framing and wallboard] at structural deck above, except as noted otherwise.
 - 5. Where gypsum wallboard is noted to terminate above ceilings, continue framing to deck above.
 - 6. Space framing members at 16"o.c., unless indicated otherwise. Meet deflection requirements.
 - 7. Provide metal blocking at areas to receive rails, cabinets, window treatment, furnishings, shelving, and similar items requiring support unless indicated to receive wood blocking.
 - 8. Ensure maintenance of fire rating and acoustical rating at areas with built-in or recessed items such as fire extinguisher cabinets, furnishings and similar items.
- C. Gypsum Board Installation: Install gypsum board in strict compliance with ASTM C 840 and Gypsum Association publication 216, Recommended Specifications for the Application and Finishing of Gypsum Board. Refer to partition schedule and details on the Drawings. Unless indicated otherwise, between offices one layer of gypsum board shall extend to structure above on each side of metal stud. Unless indicated otherwise, between offices and corridors, one layer of gypsum board shall extend to structure above.
 - 1. Locate joints between boards as far from center of walls and ceilings as possible.
 - 2. Stagger vertical joints on opposite sides of walls and in multiple layer work.
 - 3. Install gypsum boards with face side out and with joints over framing members.
 - 4. Do not butt dissimilar board edges.
 - 5. Provide one-piece boards around door and window frames.
 - 6. Cover both faces of stud partitions.
 - 7. Attach boards to metal framing with self-tapping, bugle head screws.
 - 8. Space fasteners as recommended by gypsum board manufacturer.
 - 9. Install drywall ceilings prior to gypsum board walls, to the greatest extent possible.
 - 10. Do not use water-resistant gypsum board on ceilings.

11. In multiple layer walls, provide backing board or multiple layers of face board.
12. Form control joints by preparing space between edges to receive metal control joint trim.
13. Provide materials to maintain acoustical and fire rating of walls at built-in items such as fire-extinguisher cabinets.

- D. Cementitious Backer Unit Installation: Install cementitious backer boards in strict compliance with ANSI A108.11 and manufacturer's requirements.
- E. Metal Trim: Strictly comply with manufacturer's instructions and recommendations for installation of metal trims and accessories. Meet installation tolerance requirements.
 1. Provide corner bead trim at all external corners. Provide joint reinforcing tape at all internal corners.
 2. Provide control joints where shown and at less than 30' o.c. at locations approved by Architect.
 3. Provide edge trim wherever edge of gypsum board is exposed, revealed, or sealant filled, or as noted on Drawings.
- F. Acoustical Insulation Work: Provide sound attenuation insulation where indicated and where required to obtain STC ratings indicated. Use clips or wires to hold insulation in place. Stuff flutes in metal deck with acoustical insulation, except stuff flutes with firesafing insulation for fire-rated partitions.
- G. Acoustical Sealing Work: Provide continuous bead of concealed acoustical sealant at both faces of top and bottom runner tracks, wall perimeters, openings, expansion and control joints. Close off all sound flanking paths and openings, including those above ceilings.

3.03 JOINT FINISHING

- A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
 1. Extend joint finishing to floor behind wall base to provide a smooth flat surface for installation of wall base.
 2. For water-resistant board applications, use special water-resistant joint compound to seal joints, cover fastener heads, fill surface defects and seal cut edges.
- B. Prefill open joints, rounded or beveled edges, and damaged surface areas.
- C. Apply joint tape over gypsum board joints, except those with trim having flanges not intended for tape.
- D. Gypsum Board Finish Levels: Finish panels to levels indicated below, according to ASTM C 840, for locations indicated:
 1. Level 1: Embed tape at joints in ceiling plenum areas, concealed areas, and where indicated, unless a higher level of finish is required for fire-resistance-rated assemblies and sound-rated assemblies.
 2. Level 2: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges where panels are substrate for tile and where indicated.
 3. Level 3: Embed tape and apply separate first and fill coats of joint compound to tape, fasteners, and trim flanges where indicated.
 4. Level 4: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges at panel surfaces that will be exposed to view, unless otherwise indicated.
 5. Level 5: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges, and apply skim coat of joint compound over entire surface at panel surfaces that will be exposed to view, unless otherwise indicated.
- E. Cementitious Tile Backer Units: Finish according to manufacturer's written instructions.

3.04 TOLERANCES

- A. The following allowable installed tolerances are allowable variations from locations and dimensions indicated by the Contract Documents and shall not be added to allowable tolerances indicated for other work.
 - 1. Allowable Variation from True Plumb, Level, & Line: $\pm 1/8"$ in 20'-0".
 - B. After finishing joints and screw heads shall be flush and not visible. Surfaces shall appear truly flush, smooth, seamless and uniform. Planes shall be truly flat. Corners shall be crisp and at true angles. Where gypsum drywall work butts dissimilar materials, joints shall be tight and shall be accurately scribed to adjacent construction without gaps.
- 3.05 REPAIR
- A. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired. Clean up all joint compound splatters.
- 3.06 CONSTRUCTION WASTE MANAGEMENT
- A. Comply with the requirements of Section 01 75 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 09 29 00

GYPSUM BOARD SHEATHING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Provide gypsum sheathing back-up system at exterior wall systems, as indicated on Drawings and as specified herein.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 05 40 00, Cold Formed Metal Framing; Light gage steel framing.
 - 2. Section 06 10 00, Rough Carpentry.
 - 3. Section 07 27 00, Vapor Permeable Air Barrier Membranes.
 - 4. Section 07 62 00, Flashing and Sheet Metal; Flashing and tape at joints and perimeter of gypsum sheathing.
 - 5. Section 07 92 00, Joint Sealers.

1.04 QUALITY ASSURANCE

- A. Source: For each material type required for the work of this section, provide primary materials which are the product of one manufacturer. Provide secondary or accessory materials which are acceptable to the manufacturers of the primary materials.

1.05 PROJECT CONDITIONS

- A. Weather: Perform work of this Section only when existing or forecasted weather conditions are within the limits established by manufacturers of the materials and products used.
- B. Exposure: Do not expose gypsum sheathing to weather during storage and installation for longer than that recommended by manufacturer prior to coverage with masonry veneer systems.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials and products in unopened, factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Store above ground under cover and protect from weather damage.
- B. Sequence deliveries to avoid delays, but minimize on-site storage.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
 - 1. Georgia-Pacific Corp.
 - 2. United States Gypsum Co.

GYPSUM BOARD SHEATHING

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2.02 SHEATHING

- A. Wall Sheathing: ASTM C 1177 with glass mats both sides and long edges, water-resistant treated core or ASTM C 1278 with water resistant core; face and back surface water resistant coatings:
 - 1. Manufacturer: Dens-Glass Gold Sheathing by G-P Gypsum Corporation or Fiberock Brand Sheathing by USG.
 - 2. Typical thickness: 5/8 inches thick.
 - 3. Fire Resistance: ASTM E 136, non-combustible; ASTM E 84, flame spread 0, smoke developed 0.
 - 4. Fasteners for Metal Framing: Type S, Bugle head, rust-resistant sharp point.
- B. Silicone Sealant: Dow 790 Silicone Sealant or Tremco Spectrum 3 Sealant.

PART 3 EXECUTION

3.01 INSPECTION

- A. The Installer/Erector shall examine substrates, supports, and conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning of installation will be construed as installer accepting substrates and conditions.

3.02 INSTALLATION

- A. General: Install gypsum sheathing to comply with GA-253 and manufacturer's written instructions.
- B. Cut boards at penetrations, edges, and other obstructions of the work; fit tightly against abutting construction, except provide a 3/8-inch setback where non-load-bearing construction abuts structural elements.
- C. Coordinate sheathing installation with flashing and joint sealant installation so these materials are installed in the sequence and manner that prevent exterior moisture from passing through completed exterior wall assembly.
- D. Apply fasteners so screw heads bear tightly against face of sheathing boards but do not cut into facing.
- E. Do not bridge building expansion joints with sheathing; cut and space edges to match spacing of structural support elements.
- F. Horizontal Installation: Install 24-inch-wide gypsum sheathing boards horizontally with Vgrooved edge down and tongue edge up. Interlock tongue with groove to bring long edges in contact with edges of adjacent boards without forcing. Abut ends of boards over centers of stud flanges and stagger end joints of adjacent boards not less than one stud spacing. Screwattach boards at perimeter and within field of board to each steel stud as follows:
- G. Vertical Installation: Install 48-inch-wide gypsum sheathing boards vertically with vertical edges centered over flanges of steel studs. Abut ends and edges of each board with those of adjacent boards. Screw-attach boards at perimeter and within field of board to each steel stud as follows:
 - 1. Fasteners spaced approximately 8 inches o.c. and set back a minimum of 3/8 inch from edges and ends of boards.
- H. Joint Sealants: Install sealants at joints of gypsum sheathing as recommended by manufacturer.

3.03 PROTECTION

- A. Protect gypsum sheathing that will be exposed to weather for more than 30 days by covering exposed exterior surface of sheathing with a securely fastened air-infiltration barrier. Apply covering immediately after sheathing is installed.

3.04 TOLERANCES

- A. The following allowable installed tolerances are allowable variations from locations and dimensions indicated by the Contract Documents. Do not add these tolerances to any allowable tolerances indicated for other work.

1. Allowable Variation from True Plumb: + 1/8 in. in 20 ft.-0 in.
2. Allowable Variation from True Line: + 1/8 in. in 20 ft.-0 in.

3.05 TOUCH-UP, REPAIR, AND PROTECTION

- A. Provide temporary protection at all times during the course of the work, and immediately after completion to ensure the work of this Section is not damaged or deteriorated in any way prior to installation of masonry veneer.

END OF SECTION



SECTION 09 31 00

THIN-SET TILING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Wall tile and floor tile.
 - 2. Stone thresholds.
 - 3. Preparation of floors surfaces for tile work.
- B. Refer to the Finish Schedule on the Drawings for additional requirements and coding system used on the Drawings.
- C. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 07 92 00, Joint Sealers.
 - 2. Section 09 21 16, Gypsum Board Assemblies; gypsum drywall and cementitious backerboard.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements.
- B. Verification Samples: Submit representative samples of each material that is to be exposed in the finished work, showing the full range of color and finish variations expected. Provide samples having minimum area of 144 square inches mounted on hardboard and grouted. Provide full size trim samples and 6" lengths of stone thresholds.
- C. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Source: For each type of tile required for the work of this section, provide products of one manufacturer. Provide secondary materials which are acceptable to the manufacturers of the primary materials.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
- B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.

THIN-SET TILING

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- C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.
 - 2. Option C, Flooring: Comply with the following criteria:
 - a. Tile Floor Systems: Tile setting adhesives and grout must meet or exceed the requirements of Option A (SCAQMD Rule #1168).

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturers' instructions and recommendations. Protect from damage. Sequence deliveries to avoid delays, but minimize on-site storage.

1.08 PROJECT CONDITIONS

- A. Environment: Perform work only when conditions are within the limits established by manufacturers of the materials and products used. Maintain manufacturer's recommended curing/setting temperatures for at least 7 days after installation.
- B. Substrates: Proceed with work only when substrate construction and penetrating work is complete.
- C. Ventilation: Comply with manufacturer's requirements and recommendations.

PART 2 PRODUCTS

2.01 TILE MATERIALS AND PRODUCTS

- A. General Requirements:
 - 1. Quality, Grade and Certificate: Tile shall comply with the requirements of ANSI A137.1. Tile shall be of Standard grade, and all containers shall be grade-sealed in accordance with minimum grade specifications described in above standard specification. If requested by Architect, furnish, in addition to grade seal, master grade certificate stating grade, kind of tile, identification marks for tile packages and the name and location of job, signed by the manufacturer and issued before shipment of tile is made. Deliver containers to site with seals unbroken.
 - 2. Colors of all materials shall be as selected by Architect from the full range of manufacturer's available colors and blends. No limitation is set on numbers of colors or blends that may be used on the work.
- B. Tile: Cushion-edge, impervious porcelain tile and natural stone tiles, in solid or mottled color(s) as selected by Architect.
 - 1. Wall Tile: Sizes and colors as indicated on the Finish Schedule.
 - 2. Floor Tile: With slip resistant finish. Sizes and colors as indicated on the Finish Schedule.
 - 3. Wall Base:
 - a. Ceramic/porcelain tile base shall be cove tile to match floor tile in colors and shapes required, 8 in. x 6 in. Flat cut edges.
 - b. Natural stone tile base shall be straight tile to match floor tile in colors and shapes required, 8 in. x 6 in. Flat cut edges.
 - 4. Water absorption for porcelain units shall not exceed 0.5%.
- C. Include special shapes, including cove bases, bullnose edges, corners, etc., required to complete the work according to best trade practice for each job condition, whether or not such special shapes are specifically indicated or specified.

2.02 MARBLE THRESHOLDS

- A. General: Provide marble which is uniform in color and finish, fabricated to sizes and profiles indicated or required to provide transition between tile surfaces and adjoining finished floor.
- B. Provide marble thresholds complying with ASTM C 503 requirements for exterior use and abrasion resistance.
 - 1. Provide white, bonded marble complying with MIA Group "A" requirements for soundness.

2.03 SETTING MATERIALS

- A. Latex-Portland Cement Mortar: Shall be prepackaged and presanded, conforming to ANSI A118.4, as manufactured by Upco Company; Mapei, Inc.; Laticrete International, Inc.; or approved equal.
- B. Water Resistant Organic Adhesive: Shall conform to ANSI A136.1, as manufactured by Upco Company; L&M-Surco Mfg., Inc.; Mapei, Inc.; or approved equal.
- C. Water: Clean, potable, from public mains. Free of excessive amounts of salts, acids, alkalis, or other deleterious materials.
- D. Joint Grout: Proprietary, factory packaged, precolored latex-Portland cement grout mixes conforming to ANSI A118.7, equal to "Hydroment Ceramic Tile Grout", manufactured by the Upco Company, Laticrete International, Inc. equivalent products manufactured by L&M-Surco Mfg., Inc., or equal product by manufacturer licensed by Tile Council of America, as approved by Architect. A selection of at least fourteen standard colors plus black, white, and natural must be available for Architect's selection, and grout-mixes must be complete as packaged, with only addition of acrylic latex grout additive required.
- E. Stone Cleaner: Provide stone cleaners of proper formulation for kinds of stones, finishes and applications indicated, as recommended by the natural stone tile manufacturer, and, if sealer is specified, by sealer manufacturer. Do not use acid type cleaning compounds containing caustic or harsh fillers, except where expressly approved by stone producer for type of condition involved.
- F. Stone Sealer: Provide matte finish, low VOC type, penetrating sealer approved by natural stone tile manufacturer.

PART 3 EXECUTION

3.01 INSPECTION

- A. The Installer shall examine substrates and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 CRACK SUPPRESSION

- A. Surfaces to be waterproofed shall be smooth, clean and free from dirt, grease, concrete sealers or curing compounds.
- B. Install waterproofing to comply with ANSI A108.13 and waterproofing manufacturer's written instructions to produce waterproof membrane of uniform thickness bonded securely to substrate.
- C. Flash waterproofing paste and fabric up the walls at the coves and into drains.
- D. Trowel apply a 1/16 in. layer of waterproofing paste slightly wider than the width of the fabric.
 - 1. Reinforcing fabric shall be immediately embedded into the paste.
 - 2. A final layer of paste shall be trowel applied over the fabric to bring the entire waterproof membrane to a nominal 1/8 in. thickness.

3.03 INSTALLATION

- A. Install and grout tile in accordance with the provisions of the standard specification and published details hereinbefore listed, generally as follows, in accordance with TCA "Recommended Uses":
1. Wall Tile Applied to Gypsum Board: Organic Adhesive, TCA Method W242, with Proprietary Commercial Grout.
 2. Wall Tile Applied to Glass Mat Backer Board: Organic Adhesive, TCA Method W245, with Proprietary Commercial Grout.
 3. Wall Tile Applied to Cementitious Backer Board: Latex-Portland Cement Mortar, TCA Method W244, with Proprietary Commercial Grout.
 4. Floor Tile over Concrete Slabs, Interior with Waterproof Membrane: Latex-Portland Cement Mortar, TCA Method F122, with Latex-Portland Cement Grout.
 5. Base Tile Applied to Water Resistant Gypsum Drywall: Organic Adhesives, TCA Method W242 with Proprietary Commercial Grout.
- B. Room temperatures where ceramic material are installed shall be maintained at temperatures of not less than 40 degrees F for a period of at least 48 hours prior to commencement of tile work, during the tile work, and from that time until completion of Project.
- C. Where possible, lay out work so that no tiles less than half size occur. Maintain plumb and true finish surfaces. Maintain joints straight, true, level, plumb. All joints shall be straight and continuous in both directions.
- D. Make tile cuts straight and true. Discard improperly cut tile. Maintain consistent joint width, including joints between adjoining sheets and joints at cut tile. Maintain true and proper planes, levels, and slopes. Remove and replace all tile work which does not comply with specification requirements.
1. Joint Width for Ceramic/Porcelain Tiles and Natural Honed Stone Tiles: 1/8 inch.
 2. Joint Width for Natural Cleft Stone Tiles: 3/8 inch.
- E. Set tile firmly into the bed, to achieve full contact, flush with adjoining units. Leave no voids beneath tiles. Avoid lips.
- F. Control Joints: Provide control joints where tile meets restraining surfaces (walls, curbs, columns, pipes, etc.); directly over control or expansion joints in subsurfaces; and not farther than 24 ft. each way, located as indicated on the Drawings or as directed by Architect. Control joints are not required where tile dimension perpendicular to joint is 12 ft. or less. Work shall conform to TCA Method EJ171.
1. Form control joints neat, straight, and uniform in width. Cut tile neatly and to accurate radius at exposed junction with pipes, etc. Control joints shall be full width of control joint in subsurfaces, and full width or normal tile joint at other locations, and full thickness of tile and setting bed.
 2. Keep open joints free of grout and debris. Upon completion of tile work, install noncontaminating temporary joint filler to maintain joints in clean condition until installation of joint backing and sealant under Section 07 92 00, Joint Sealants.

3.03 GROUTING

- A. Grouting Preparation: Before grouting, make sure the tiles are firmly set and the adhesive or mortar is completely dry. Remove spacers, pegs, ropes or strings. Grout joints must be clean and free of standing water, dust, dirt and foreign matter. Remove excess adhesive or mortar from the joint area so the 2/3 of the depth of the tile or stone is left available for grouting.
- B. Completely fill joints with grout. Clean surplus grout off face of tiles, immediately as work proceeds and before grout dries.
1. Natural Stone Tiles: Rinse at least three times, changing water until it stays completely clear and clean. When wiping the top of the tile be sure the sponge/rag is not very wet to corrupt the grout. Do not allow grout film to remain and dry on natural stone tiles.

- a. After a 50 – 100 sq ft portion has been grouted and the faces cleaned, the following extra step will help get grout film from the cleft of the face. With a piece of burlap bag, rub slightly damp sawdust over the face of the tile, being careful not to rub the grouting from the joints. This special trick will help remove any remaining grout film from the crevices of the cleft.

- C. Cure Time: Leave the grouting to cure for at least 36 hours without traffic or per manufacturer's instructions.

3.04 CLEANING AND PROTECTION

- A. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired. Leave work free of broken, chipped and loose tile.
- B. Clean exposed surfaces using materials and methods recommended by manufacturer of tile being cleaned. Remove and replace work that cannot be successfully cleaned. Do not use acid cleaners unless specifically permitted by tile manufacturer and only after completely curing tile and grout. Protect adjacent surfaces from contact with acid cleaners and thoroughly flush with clean water.
- C. Protect work from foot traffic for at least 7 days after grouting.
- D. Seal stone tile floor as recommended by stone fabricator, cleaner manufacturer, and sealer manufacturer.
- E. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.

3.05 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 09 54 00

SPECIALTY CEILINGS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Provide fabric-faced, composite core acoustical panels, suspended metal grid ceiling system and trim and miscellaneous accessories.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 09 50 00, Ceilings.
 - 2. Section 23 37 13, Diffusers, Registers and Grilles.
 - 3. Section 26 51 00, Interior Lighting.

1.04 QUALITY ASSURANCE

- A. ASTM C 423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method; 2000.
- B. ASTM C 423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method; 2000.
- C. ASTM C 635 - Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings; 2000.
- D. ASTM C 636 - Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels; 1996.
- E. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2000a.
- F. ASTM E 580 - Standard Practice for Application of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Requiring Seismic Restraint; 2000.
- G. ASTM E 1477 - Standard Test Method for Luminance Reflectance Factor of Acoustical Materials by Use of Integrating-Sphere Reflectometers; 1998a.

1.05 PROJECT CONDITIONS

- A. Sequence work to ensure that acoustical ceilings are not installed until building is enclosed, permanent heating system is available, dust generating activities have terminated, wet work is complete and dry, and work above ceilings is complete.

SPECIALTY CEILINGS

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- B. Maintain temperature within 15 degrees Fahrenheit (8 degrees C) and relative humidity within 10 percent of design conditions for spaces of installation not less than 48 hours before installation begins and thereafter.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products in manufacturer's unopened packaging and store unopened in fully enclosed space until ready for installation. Protect products from exposure to sunlight, moisture, and mechanical damage. Handle acoustical panels to avoid soiling exposed surfaces or damaging surfaces and edges.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturer of Acoustical Panels: Hunter Douglas Architectural Products; 1 Hunter Douglas Circle, Thornton, CO 80241. ASD. Tel: 866-556-1235; Fax: 720-872-7850; www.hunterdouglascontract.com/ceilings.

2.02 ACOUSTICAL PANELS

- A. Provide panels comprising composite structural fiberglass core with non-woven polyester textile surface wrapped on two opposite edges and matching integral hinged support clip on other two edges; with properties as follows:

1. Panel Thickness: 1.125 inches (28.5 mm).
2. Panel Size: 30 x 60 inches
3. Reveal: Panels configured to maintain reveal of 1/4 in (6 mm) between adjacent panels.
4. Panel Color: White.
5. Noise Reduction Coefficient (NRC): 0.85, measured in accordance with ASTM C 423 with the equal to or better than absorption coefficient reading at the following specified frequencies:

Frequency:	<u>125</u>	<u>250</u>	<u>500</u>	<u>1000</u>	<u>2000</u>	<u>5000</u>
Absorp Co-ef	0.61	0.82	0.65	0.88	1.04	1.03
6. Surface Burning Characteristics: Flame spread less than 25 and smoke developed less than 50, Class A (1), per ASTM E 84 and ASTM E 1264.
7. Light Reflectance (white only): LR-1 (75%), measured in accordance with ASTM E 1477.
8. Moisture Resistance: Resistant to relative humidity up to 95 percent at 105 degrees F (40.5 degrees C) for 30 days.
9. Mold and Mildew Resistant: In accordance with requirements of ASTM C 665.
10. Fungi Resistant: Inc accordance with requirements of ASTM C 1338.

- B. Accessibility: Panels shall be downward accessible by disengaging hinge support rail on one side of panel from the T-Bar Flange or optional A-Mount rail flange without the use of tools. Panel shall swing hinge downward to provide complete access without removal of the panel from the ceiling.

2.03 SUSPENSION SYSTEM

- A. General: Provide suspension system as specified in Section 09510.
- B. General: Provide system complying with ASTM C 635, die cut and interlocking components, with matching perimeter moldings and other accessories as required for project conditions.
Materials: Formed galvanized steel, commercial quality cold rolled, intermediate duty.
Profile: Standard 15/16 in (24 mm) tee shape.
Finish: Painted white.
- C. Optional Direct Mount Suspension System: Provide A-Mount rail (AM1) as manufactured by Hunter Douglas, designed to direct mount to in-plane surface with fasteners or optional A-Mount clip (AMC1). A-Mount rail is designed with flanges to accept panel clips. A-Mount rail is spaced on the same centers as the nominal panel length (24", 30", 48", 60" or 72") and creates a nominal 1/4" reveal between panel ends.
Material: Extruded aluminum alloy 6063-T6

Profile: 3/8" height x 15/16" width
Finish: Mill

- D. Optional Trim: Provide matching trim by acoustical panel manufacturer for conditions as follows:
Perimeter trim: 'L' channel 15/16" – white.
- E. Floating edge trim: 1-1/2" Straight for A-Mount application – white.
- F. Support Channels and Hangers and Fasteners: Galvanized steel, size and type to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that layout of hangers will not interfere with other work; make adjustments in layout as necessary. Do not begin ceiling installation until services above ceiling are complete except for final trim.

3.02 PREPARATION

- A. Lay out system to a balanced grid design, with edge units not less than 50 percent of acoustical unit size. Location system on room axis according to reflected ceiling plan.

3.03 INSTALLATION OF SUSPENSION SYSTEM

- A. Conform to the requirements of Cisca (AC) – Acoustical Ceiling: Use and Practice.
- B. Install in accordance with manufacturer's instructions and ASTM C 636.
- C. Attach hangers to structural members. Do not support ceiling directly from permanent metal forms of steel floor or roof deck. Space hangers or direct mount fasteners not more than 48 inches (1220 mm) o.c.
- D. Hang suspension system independent of walls, columns, ducts, pipes and conduit. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.
- E. Where ducts or other equipment prevent the regular spacing of hangers, reinforce the nearest affected hangers and related carrying channels to span the extra distance.
- F. Support fixture loads using supplementary hangers located within 6 inches (150 mm) of each corner, or support components independently. Do not eccentrically load system or induce rotation of runners.
- G. Perimeter Trim: Install at intersection of ceiling and vertical surfaces and at junctions with other interruptions.

3.04 INSTALLATION OF ACOUSTICAL PANELS

- A. Install acoustical panels in accordance with manufacturer's written instructions.
- B. Fit adjoining panels to form nominal 1/4 inch (6 mm) reveal joints. Scribe and cut panels for accurate fit at perimeter and around penetrations.
- C. Hold tile field in compression when performing cuts. Match field cut edges with factory edges in accordance with manufacturer's instructions.
- D. Install acoustical panels after above-ceiling work is complete. Install panels level, in uniform plane, and free from warp, twist, and dents.
- E. Installation Tolerance: Maximum variation from flat and level surface is 1:360.

3.05 CLEANING AND PROTECTION

- A. Clean exposed surfaces of acoustical panel ceilings, including suspension system and edge trim, complying with manufacturer's written instructions for cleaning of minor finish damage. Replace acoustical panels that cannot be cleaned to an appearance matching unmarred panels.
- B. Protect installed acoustical panel ceilings until completion of project.

END OF SECTION



SECTION 09 64 00

WOOD STRIP FLOORING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. Work of this Section includes:
 - 1. Reclaimed wood strip flooring, field finished.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
 - 1. Section 06 20 00, Rough Carpentry.
 - 2. Section 06 40 00, Interior Architectural Woodwork; Wood base.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's printed product data, specifications, standard details, installation instructions, use limitations and recommendations for each material used. Provide certifications that materials and systems comply with specified requirements.
- B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 00, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Specialized wood flooring firm, with at least five years successful experience in installation and field finishing of the types specified, and acceptable to the wood flooring manufacturer.
- B. Manufacturer: Obtain flooring from a single manufacturer or source, to ensure match of quality, color, pattern, and texture.
- C. Association Standards: Strictly comply with the recommendations of the National Oak Flooring Manufacturers Association (NOFMA).

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
- B. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
- C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:

WOOD STRIP FLOORING

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- a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.
- 2. Option B, Paints and Coatings: Comply with the following criteria:
 - a. Architectural Paints, Coatings and Primers: Green Seal GS-11, Paints, First Edition May 20, 1993. For applications on interior walls and ceilings.
 - b. Anti-Corrosive and Anti-Rust Paints: Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997. For applications on interior ferrous metal substrates.
 - c. Clear Wood Finishes, Floor Coatings, Stains, and Shellacs: South Coast Air Quality Management District (SCAQMD) Rule #1113, Architectural Coatings, rules in effect on July 13, 2007. For applications on interior elements.
- 3. Option C, Flooring: Comply with the following criteria:
 - a. Floor Finishes: Concrete, wood, bamboo, and cork floor finishes such as sealer, stain and finish must meet or exceed the requirements of Option B (SCAQMD Rule #1113).
- D. Resource Reuse: Provide salvaged, refurbished or reused materials for the following items:
 - 1. Wood flooring, as indicated.
- 1.07 DELIVERY, STORAGE, AND HANDLING
 - A. Protect wood flooring from excessive moisture during shipment, storage, and handling. Deliver in unopened bundles and store in a dry place, with adequate air circulation. Do not deliver materials to building until "wet work" such as concrete, masonry, and plaster have been completed and cured to a condition of equilibrium.
- 1.08 JOB CONDITIONS
 - A. Do not proceed, deliver, or install wood flooring until after the spaces to receive flooring have been enclosed and are dry and maintained at approximately the same humidity and temperature conditions as planned for occupancy.
 - B. Condition wood flooring materials by placing in the rooms or spaces to be floored, seven days in advance of the start of installation. Open packages of wood flooring which are sealed (if any) to permit natural adjustment of moisture content.
 - C. Temperature Range: Maintain ambient temperatures in range of 65oF to 75oF prior to, during, and after the installation of wood flooring.
 - D. Humidity Range: Maintain relative humidity between 35% and 55%.
- 1.09 WARRANTY
 - A. Warranty: Submit two copies of manufacturer's standard one year warranty for hardwood flooring and associated work, agreeing to repair or replace flooring that shrinks, warps, cracks, or otherwise deteriorates excessively, or which buckles, delaminates, or breaks its anchorage or bond with the substrate, or fails otherwise to perform as required or as represented by the manufacturer, due to failures of materials and workmanship and not due to unusual exposure to moisture or other abusive forces and elements not anticipated for the application.
- 1.10 EXTRA STOCK/REPLACEMENT MATERIAL
 - A. After completion of wood flooring work, deliver to project site not less than 1.0% of quantity of each type wood flooring installed on the project. Provide in manufacturer's original, unopened cartons or bundles.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Wood Strip Flooring: Provide wood strip flooring as follows:
 - 1. Species, Grade and Cut: Refer to Finish Schedule.
 - 2. Back Channeling: Provide manufacturer's standard channeling on back face of each strip.
 - 3. Matching: Tongue and groove and end-matched, with square ends.
 - 4. Thickness: 5/8 inch.
 - 5. Face Width: Varies between 3 and 7 inches.
 - 6. Lengths: Provide standard random length strips, between 1 and 12 feet, complying with applicable grading rules, for Rustic grade.
 - 7. Seasoning: Manufacture wood strip flooring from kiln-dried reclaimed lumber.
 - B. Cork Expansion Strip: Composition cork expansion strip FS HH-C-576, Type I-B, Class 2.
 - C. Wood Base: Provided under Section 06402, Interior Architectural Woodwork.
 - D. Vapor Barrier: 6 mil polyethylene sheet.
 - E. Underlayment: 1/2 inch thick plywood, sanded face, per Section 06100, Rough Carpentry.
 - F. Wood Thresholds and Transition Strips: To match flooring, as indicated.
- 2.02 FINISHING MATERIALS
- A. Field Finish: Provide low VOC (less than 275 g/L each), water based polyurethane matte high traffic floor finish over a penetrating acrylic sealer. Provide products by American Formulating and Manufacturing, Basic Coatings, Bona Kemi USA, or Hydrocote.
 - 1. Acceptable Products: Bona DTS sealer and Bona Naturale finish, by Bona Kemi USA.
 - B. Cleaning solutions shall be as recommended by the flooring finish manufacturer and meeting indoor air quality (IAQ) requirements of this Section.
- 2.03 ACCESSORY MATERIALS
- A. Adhesive: Low VOC (less than 50 g/L), solvent-free, adhesive or special mastic of type recommended by adhesive manufacturer, specifically for use with wood flooring. Provide acceptable product by one of the following manufacturers:
 - 1. CHAPCO 244, by Chicago Adhesive Products Co., Romeoville, IL, telephone 800/621-0220; www.chapco-adhesives.com.
 - 2. HealthyBond Adhesive, by Ecotimber, San Rafael, CA 94901; tel. 415-258-8454; www.ecotimber.com.
 - B. Wood Filler: Low VOC (less than 250 g/L), epoxy wood filler, color as indicated, of type recommended by manufacturer, complying with flammability and environmental control restrictions.
 - 1. Acceptable Product: Clear epoxy with black tinting.

PART 3 EXECUTION

- 3.01 INSPECTION
 - A. Examine substrates on that wood flooring will be installed and conditions under which work will be performed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.
- 3.02 PREPARATION
 - A. Wherever application of wood flooring to concrete substrate is indicated, test for dryness before proceeding with installation. Test with 3% solution of phenolphthalein in grain alcohol. Sprinkle a few drops on concrete at several locations. If drops turn red, do not proceed.

- B. General: Comply with flooring manufacturer's instructions and recommendations, and with NOFMA recommendations.
 - C. Expansion Space: Provide expansion space at walls and other obstructions and terminations of flooring, not less than 1/2" unless otherwise indicated on drawings. Unless fully concealed by trim, fill expansion space with flush cork expansion strip. Nail shoe molding or other trim to baseboard, rather than to flooring.
 - D. Sanding: Lightly buff to eliminate high spots only. Remove sanding dust by tack or vacuum with a HEPA filter.
 - 1. Prior to application of finish coats, fill holes and cracks greater than 3/8 inch thick in any dimension, which might otherwise pose a hazard, with wood filler.
 - E. Finish: Apply sealer and finish coats of finish system according to finish manufacturer's written instructions. Provide not less than four coats total and not less than two finish coats.
 - 1. Water-Based Finishes: Use finishing methods recommended by finish manufacturer to reduce grain raise and sidebonding effect.
- 3.04 PROTECTION
- A. Installer shall advise the Contractor of procedures required for protection of hardwood flooring during remainder of construction period, so that flooring and finish will be without damage or deterioration at time of acceptance.
- 3.05 CONSTRUCTION WASTE MANAGEMENT
- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 09 91 00

PAINTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General Conditions, Modifications, and Division 1 General Requirements, apply to the work of this section.
- B. Carefully examine all of the Contract Documents for requirements which affect the work of this section. The exact scope of work of this section cannot be determined without a thorough review of all specification sections and other Contract Documents.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, painting and finishing of all exposed surfaces, both interior and exterior, except the following:
 - 1. Factory finished items, except as noted.
 - 2. Finished metal surfaces of stainless steel, copper, brass, and bronze.
 - 3. Finished metal surfaces that are color anodized or plated.
 - 4. Surfaces in concealed areas such as crawl spaces, above ceilings and the like.
 - 5. Moving parts, code required labels, and equipment data plates.
 - 6. Mechanical and electrical items not in public spaces.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, paint analysis, application instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements and that paint products used are the highest quality produced by the manufacturer.
- B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 00, LEED SUBMITTALS.

1.04 INTENT

- A. A major intent of the work of this section is to finish all work in the project that is exposed to view and not located in concealed areas, crawl spaces and the like.

1.05 QUALITY ASSURANCE

- A. Source: For each type of material required for the work of this section, provide primary materials which are the products of one manufacturer. Provide thinners and other secondary materials which are acceptable to the manufacturers of the primary materials.

1.06 TESTS

- A. Testing Agency: The Owner may employ an independent testing agency to perform tests, evaluations and certifications. Cooperate and permit samples of materials to be taken as they are used. The Contractor shall pay all costs of tests which show failure to comply with Contract Documents.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Regional Materials: Provide materials and products that are manufactured regionally within a radius of 500 miles.
 - B. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option B, Paints and Coatings: Comply with the following criteria:
 - a. Architectural Paints, Coatings and Primers: Green Seal GS-11, Paints, First Edition May 20, 1993. For applications on interior walls and ceilings.
 - b. Anti-Corrosive and Anti-Rust Paints: Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997. For applications on interior ferrous metal substrates.
 - c. Clear Wood Finishes, Floor Coatings, Stains, and Shellacs: South Coast Air Quality Management District (SCAQMD) Rule #1113, Architectural Coatings, rules in effect on July 13, 2007. For applications on interior elements.
 - 2. Option C, Flooring: Comply with the following criteria:
 - a. Floor Finishes: Concrete, wood, bamboo, and cork floor finishes such as sealer, stain and finish must meet or exceed the requirements of Option B (SCAQMD Rule #1113).
- 1.08 DELIVERY, STORAGE AND HANDLING
- A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturers' instructions and recommendations. Protect from freezing and damage.
 - B. Avoid the possibility of fire by removing flammable materials, solvents and spirits from the project site or by storing materials in UL approved fire-resistive cabinets. Keep work area free from flammable waste and soiled rags.
 - C. Sequence deliveries to avoid delays, but minimize on-site storage.
- 1.09 PROJECT CONDITIONS
- A. Weather, Temperature, and Humidity: Perform work only when existing and forecasted conditions are within the limits established by manufacturers of the materials and products used.
 - 1. Indoor Temperature: Maintain minimum interior temperature of 65°F during application and drying of paints and until occupancy of the building.
 - B. Substrates: Proceed with work only when substrate construction and penetrating work is complete.
 - C. Ventilation: Comply with manufacturer's requirements and recommendations.
 - D. Lighting: Since lighting conditions can change the appearance of the work, work only when permanent lighting system is operational and in use.
- 1.10 SEQUENCING AND SCHEDULING
- A. Coordinate this work with work specified in other sections. Furnish information on finish materials to be used in the field to ensure that correct prime coats are used in the shop.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Latex and Alkyd Based Paints: Provide products of one of the following manufacturers that meet or exceed specified requirements:
 - 1. Benjamin Moore and Co. (Moore).
 - 2. Samuel Cabot and Co. (Cabot).
 - 3. Refer to Finish Schedule.

- B. Materials used shall be best grade products of their respective kinds. The Painting Schedule is based on products the above named manufacturers. These are specified to establish a standard of quality and kind of material desired. Provide these products, or equals as approved by Architect.
 - C. Note: If substitutes are proposed, submit complete schedule showing materials specified and equivalent materials proposed as substitutes. Provide complete manufacturer's product data on proposed materials. Substitutes must be approved by Architect before commitment for materials is made.
 - D. Assume full responsibility for proper performance of materials, for method of application, and for compatibility of materials applied over shop coats or other coats previously applied, including but limited to primers, sealers, preservative treatments, etc. Notwithstanding specific schedules in this Section, select primers which have been verified to be appropriate for each of the substrates and finishes encountered.
 - E. Provide miscellaneous painting materials such as linseed oil, shellac, turpentine, and thinner of the highest quality.
- 2.02 COLORS
- A. Provide colors in accordance with schedule provided by Architect. Tint and match colors to the satisfaction of Architect. Provide facilities for comparison and adjustment of colors. No limit is placed on number of colors that may be required.
 - 1. Access doors shall be painted to match adjacent surfaces.
- 2.03 FILLERS, SOLVENTS, AND MISCELLANEOUS MATERIALS
- A. Turpentine: Pure gum spirits of turpentine conforming to Fed Spec. TT-T-801.
 - B. Drier: Conform to Fed. Spec. TT-D-65.
 - C. Tinting Materials: Best quality, ground in pure boiled linseed oil, limeproof, and non-fading.

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION

- A. Inspection: The Applicator shall examine substrates and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Applicator accepts substrates and conditions.
- B. Responsibility: The Applicator shall be solely responsible for the finishing work and shall prepare substrates as needed to obtain the highest quality finished surfaces.
- C. Manufacturer's Recommendations: Strictly comply with manufacturers' instructions and recommendations, except where more restrictive requirements are specified in this section.
- D. Cleaning: Do not finish over dirt, rust, grease, moisture and other conditions detrimental to formation of a durable finish film. Clean surfaces to remove dirt, oil, grease, mildew, asphalt, concrete splatters, and all other foreign substances.
- E. Removal and Protection: Remove finished hardware, fixtures, accessories, and similar items or provide adequate protection to ensure that these surfaces are not finished or splattered. Replace these items when finishing work is completed.
- F. Shop Primers: Remove incompatible primers and reprime or provide barrier coats in compliance with finish manufacturer's instructions. Metal to receive spray fireproofing shall not be primed and as noted on drawings.

- G. Masonry and Concrete: Prepare materials by removing laitance, efflorescence, form release agents, and surface glaze by cleaning and washing as recommended by finish manufacturer and approved by Architect. Brush surfaces to remove loose particles. Allow a minimum of 60 to 90 days curing time before finishing poured and precast concrete. Allow a minimum of 30 to 60 days curing time before finishing concrete masonry. Determine substrate alkalinity and moisture content and, if necessary, take appropriate remedial actions as recommended by manufacturers of primary finish materials.
 - H. Wood: Prepare wood surfaces by sanding smooth, sealing knots, setting nails and fasteners, and filling holes, cracks, and imperfections with putty acceptable to finish manufacturer. For transparent finished work, use putty and filler color matched to wood to minimize its appearance. Seal and backprime all interior and exterior woodwork immediately after delivery to site and before installation.
 - I. Ferrous Metal: Prepare shop primed metal surfaces by solvent wiping, sanding and touching-up shop prime coats. Prepare bare metal surfaces in accordance with Steel Structures Painting Council SP-6. Remove welding flux and splatter, burrs, and all other surface defects and foreign substances. Clean surfaces by washing with water followed by phosphate rinsing. Apply prime coats immediately after completion of cleaning.
 - J. Galvanized Metal: Aggressively clean new galvanized surfaces with grease cutting solvent, such as undiluted vinegar, to remove fabricating oils. Touch-up abraded surfaces immediately with zinc-rich paint or rust-inhibiting paint acceptable to the Architect.
 - K. Aluminum: Solvent clean surfaces equal to SSPC SP-1. Do not use red lead primers on aluminum surfaces.
 - L. Doors: Finish tops, bottoms, and edges of doors the same as door faces.
 - M. Drywall: Clean surfaces free from dust and foreign substances. Joint treatment materials shall be thoroughly dry. Paint metal corner beads and trim with metal primer before application of water based finish coatings
- 3.02 APPLICATION
- A. Manufacturer's Recommendations: Strictly comply with manufacturers' instructions and recommendations, except where more restrictive requirements are specified in this section.
 - B. Material Preparation: Mix and prepare materials in strict compliance with manufacturer's recommendations. Do not thin materials without Architect's approval. Keep foreign substances out of finishing materials.
 - C. Primers: Provide primers as recommended by finish system manufacturer for substrates encountered. Tint all primers and undercoats to the approximate shade of the finish coat, making each coat slightly darker and closer to the finished shade. Use deep base primers for deeptone, bright, and accent colors. Prime surfaces immediately after surface preparation to prevent contamination of substrate.
 - D. Application: Apply paint and finish systems as scheduled using brushes, rollers, or painter's mitts. Spray application of paint and finish systems is not acceptable for field work, except for variegated paint systems. Apply finish materials at coverage rates and dry film thicknesses recommended by their manufacturers. Provide additional coats as needed to eliminate all show through and bleed through areas.
 - E. Extent: Finish all surfaces behind removable items. Finish inside of ducts and grilles with flat black paint when these surfaces are visible. Finish surfaces of access doors, panels and covers that are visible when opened with same finish and color as face panels.

- F. Sanding: Sand before application and between coats as recommended by finish system manufacturer.
 - G. Recoat Time: Allow manufacturer's recommended waiting period between successive coats.
 - H. Finish Appearance: Provide uniform final finishes, free of runs, sags, wrinkles, streaks, shiners, brush/roller marks, color variations and other imperfections.
- 3.03 FIELD QUALITY CONTROL
- A. Testing: The Owner reserves the right to employ an independent testing agency to conduct material evaluation and application tests. The Contractor shall cooperate fully and, when requested, permit samples of materials to be taken from containers as the materials are applied to building surfaces.
 - B. Cost of Testing: If tests indicate that materials or work does not comply with requirements, the Contractor shall pay for tests performed, all retesting, and shall remove and replace noncomplying work.
- 3.04 TOUCH-UP, CLEANING, AND PROTECTION
- A. Touch-up damaged coatings and finishes to eliminate evidence of repair.
 - B. Clean finished surfaces and remove all finish splatters from adjacent work. Remove and replace work that cannot be successfully cleaned.
 - C. Provide signs and temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.
- 3.05 CONSTRUCTION WASTE MANAGEMENT
- A. Comply with the requirements of Section 01 75 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.
- 3.06 PAINT SCHEDULE
- A. Number of coats scheduled is minimum. Refer to Paragraph 3.02D, hereinbefore.
 - B. Refer to Finish Schedule for paint colors and locations.

END OF SECTION



SECTION 10 11 00

VISUAL DISPLAY BOARDS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Tackboards.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect the work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; Blocking.
 - 2. Section 06402, Interior Architectural Woodwork; Wood trim.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material or product used. Provide certifications stating that materials comply with requirements.
- B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 00, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Source: For each type of material required for the work of this section, provide primary materials which are the products of one manufacturer. Provide secondary materials which are acceptable to the manufacturers of the primary materials.
- B. Burning Characteristics: Provide tackboards with surface burning characteristics, when tested in compliance with ASTM E 84, as follows:
 - 1. Flame Spread: Not more than 25.
 - 2. Smoke Developed: Not more than 25.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
- B. Regional Materials: Provide materials and products manufactured within a 500 mile radius of the project site.
- C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:

VISUAL DISPLAY BOARDS

- a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
- b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products in unopened factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from damage.
- B. Sequence deliveries to avoid delays, but minimize on-site storage.

1.08 WARRANTY

- A. Provide manufacturer's standard written warranty on porcelain on steel chalkboards agreeing to repair or replace work which exhibits defects in materials or workmanship. "Defects" is defined to include, but is not limited to, crazing, cracking, flaking, and loss of original writing and erasing qualities.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Tackboards: Provide products of one of the following manufacturers if they meet or exceed the requirements of these specifications:
 - 1. Baker.
 - 2. Claridge Products and Equipment, Inc.
 - 3. GreenSteel, Inc., a division of PolyVision Corporation (previously AllianceWall or Alliance America), a division of the Steelcase Design Partnership.
 - 4. Homasote.

2.02 PRODUCTS

- A. Tackboards, Linoleum Cork: Provide washable linoleum resilient homogeneous tackable surface material manufactured of linseed oil, granulated cork, resin binders and dry pigments on a natural burlap backing, total thickness of 1/4 in. Provide Uni-Colored Linoleum as manufactured by Forbo Industries, Inc.
 - 1. Color: Provide as selected by Architect from manufacturer's standards.

2.03 FABRICATION

- A. Fabricate work to be truly straight, plumb, level and square. Provide work to sizes, shapes, and profiles indicated on approved shop drawings. Provide one-piece units wherever possible.
- B. Provide factory assembled units with uniform, tight joints.

2.04 SUPPORT METHOD

- A. Provide especially fabricated bent metal "Z" strip wall mounting devices, fabricated of 16 ga. steel, prime painted, secured to rear of assemblies and to face of walls. Provide units with load capacity and fasteners as recommended by visual display board manufacturer.

PART 3 EXECUTION

3.01 INSPECTION

- A. Examine substrates, supports, and conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning of installation will be construed as installer accepting substrates and conditions.

3.02 INSTALLATION

- A. General Installation Requirements: Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.

- B. Install visual display boards with concealed anchors at heights indicated, or if not indicated, as field directed, with work plumb and level. Provide trim pieces, anchors, and components necessary for a complete installation.

3.03 TOLERANCES

- A. The following allowable installed tolerances are allowable variations from locations and dimensions indicated by Contract Documents. Do not add these tolerances to any allowable tolerances indicated for other work.
 - 1. Allowable Variation from True Plumb: + 1/8 in. in 20 ft.-0 in.
 - 2. Allowable Variation from True Line: + 1/8 in. in 20 ft.-0 in.
 - 3. Allowable Variation from True Level: + 1/8 in. in 20 ft.-0 in.

3.04 CLEANING, TOUCH-UP, AND PROTECTION

- A. Clean exposed surfaces using manufacturer recommended materials and methods. Remove and replace work that cannot be successfully cleaned.
- B. Touch-up damaged coatings and finishes. Eliminate visible evidence of repair.
- C. Provide temporary protection during course of work, and immediately after completion, to ensure work of this Section is not damaged or deteriorated in any way at time of final acceptance. Remove temporary protections and reclean as necessary immediately prior to final acceptance.

3.05 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 75 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 10 14 00

SIGNAGE AND GRAPHICS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Interior panel signs as scheduled at the end of this Section.
 - 2. Coordinate installation of exterior LED signage provided by the Owner.
 - 3. Install interior wayfinding signage furnished by the Owner.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; blocking.
 - 2. Section 09 91 00, Painting; painting materials and specifications.
 - 3. Division 28 – Electronic Safety and Security; tour exit routes.
 - 4. Division 16 - Electrical; "Exit" signs; wiring for external sign illumination.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations and recommendations for each material used. Provide certifications stating that materials comply with requirements. Manufacturers shall have at least five years experience in the manufacture of sign systems specified.
- B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 00, LEED SUBMITTALS.

1.05 INTENT

- A. A major intent of the work of this section is to provide colorfast, durable building identification devices as scheduled and as required by codes. Provide all signs and graphics required by authorities having jurisdiction even if not otherwise indicated in the Contract Documents.

1.06 QUALITY ASSURANCE

- A. Source: For each type of material required for the work of this section, provide primary materials which are the products of one manufacturer. Provide secondary materials which are acceptable to the manufacturers of the primary materials.
- B. ADA Requirements: Comply with Commonwealth of Massachusetts requirements and Americans with Disabilities Act requirements, including Type 2 Braille.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.
 - b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.
- 1.08 DELIVERY, STORAGE AND HANDLING
- A. Deliver materials and products in unopened factory labeled packages. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from damage.
 - B. Sequence deliveries to avoid delays, but minimize on-site storage.
- 1.09 SEQUENCING AND SCHEDULING
- A. Delay installation of work of this section until near time of Substantial Completion.
- PART 2 - PRODUCTS
- 2.01 MATERIALS AND PRODUCTS
- A. Panel Signs: As selected by Architect complying with Owner's and accessibility requirements.
- 2.02 FABRICATION
- A. Fabricate work to be truly straight, plumb, level and square with smooth flat surfaces and sharp corners, except where indicated otherwise.
 - B. Precisely form work to sizes, shapes, and profiles indicated on approved shop drawings.
 - C. Fabricate metal work with uniform, invisible joints.
- PART 3 - EXECUTION
- 3.01 INSPECTION
- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.
- 3.02 INSTALLATION
- A. Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.
 - B. Install work plumb, level, in true plane and alignment. Provide signs and graphics where shown or scheduled using mounting methods indicated.
- 3.03 TOLERANCES
- A. The following allowable installed tolerances are allowable variations from locations and dimensions indicated by the Contract Document and shall not be added to allowable tolerances indicated for other work.
 - 1. Allowable Variation from True Plumb, Level and Line: $\pm 1/8"$ in 10'-0"
 - 2. Allowable Variation from True Plane of Adjacent Surfaces: $\pm 1/16"$
- 3.04 ADJUSTING, CLEANING AND PROTECTION
- A. Adjust work to present the best possible appearance. Touch-up damaged finishes and repair damage to eliminate evidence of repair. Clean exposed surfaces using materials and methods recommended by

manufacturer of material or product being cleaned. Remove and replace work that cannot be successfully repaired or cleaned.

- B. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.

3.05 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 75 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

3.06 SIGNAGE AND GRAPHICS SCHEDULE

- A. Schedule as indicated on Drawings and as required by Code.

END OF SECTION



SECTION 10 28 16

BATH ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, providing commercial quality toilet accessories, including metal framed mirrors, as scheduled on the Drawings.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 06 10 00, Rough Carpentry; rough blocking.
 - 2. Section 09 21 16, Gypsum Board Assemblies; concealed blocking.
 - 3. Division 26 - ELECTRICAL; wiring and connections for electric hand dryers.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's product data, installation instructions, use limitations, and recommendations for each material used. Include wiring diagrams.
- B. Setting Drawings: Provide drawings for installation of all accessories. Provide plans, elevations, and details of anchorages, connections and installation aids. Provide installation templates for work installed by others.
- C. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Source: Provide toilet accessories which are the products of one manufacturer.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
- B. Regional Materials: Provide materials and products manufactured within a 500 mile radius of the project site.
- C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.

BATH ACCESSORIES

10 28 16-1

b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products in unopened factory labeled packages. Store and handle in strict compliance with manufacturers' instructions and recommendations. Protect from damage.
- B. Sequence deliveries to avoid delays, but minimize on-site storage.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Manufacturer: Bobrick, Bradley, Watrous or approved equal.
- B. Stainless Steel: AISI type 302/304, with NAAMM no. 4 satin finish, 22 gage minimum.
- C. Galvanized Sheet Steel: ASTM A527, G60.
- D. Chromium Plating: Nickel and chromium electro-deposited on base metal of steel or brass, ASTM B456, type SC2.
- E. Fasteners: Where exposed, provide fasteners finished to match accessory. Where concealed provide galvanized fasteners and mounting kits of type to suit accessory and wall condition.

2.02 FABRICATION

- A. Fabricate accessories to be truly straight, plumb, level and square with uniform, tight joints and smooth and rounded edges.
- B. Provide units to sizes, shapes, and profiles indicated on approved shop drawings.
- C. Provide anchorage arrangement which is fully concealed when unit is closed.
- D. Provide continuous stainless steel piano hinges for all accessories that open.
- E. Do not apply, stamp or engrave any trademark, trade name or manufacturer's name on exposed surfaces.
- F. Provide locks for all accessories that open and provide two keys for each lock. Key all accessories the same.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section. Beginning work means Installer accepts substrates and conditions.
- B. Securely install at heights and locations indicated or if not indicated, at heights and locations as field directed by Architect. Where toilet room is indicated to be handicapped accessible, install toilet accessories at locations and heights required by authorities having jurisdiction for handicapped accessibility as approved by Architect.

3.02 ADJUSTING, CLEANING, PROTECTION

- A. Adjust operating parts to work easily, smoothly, and correctly.

- B. Repair minor damage to eliminate all evidence of repair. Clean exposed surfaces using nonabrasive materials and methods recommended by manufacturer of product being cleaned. Remove and replace work that cannot be successfully cleaned or repaired.
 - C. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.
- 3.03 CONSTRUCTION WASTE MANAGEMENT
- A. Comply with the requirements of Section 01 75 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION



SECTION 10 44 16

FIRE EXTINGUISHERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited to, the following:
 - 1. Under cabinet stored extinguisher as indicated.
 - 2. Surface mounted extinguisher and support brackets at mechanical rooms and other non-public areas as indicated.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

1.03 RELATED WORK

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to:
 - 1. Section 09 91 00, Painting; field painting cabinets.
 - 2. Division 15: Fixed fire protection systems, standpipes, valves and hose cabinets.

1.04 SUBMITTALS

- A. Product Data: Submit cabinet manufacturer's product data, installation instructions and recommendations.
- B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED SUBMITTALS.

1.05 QUALITY ASSURANCE

- A. Source: For each type of product required for the work of this section, provide products which are the products of one manufacturer.
- B. Provide portable extinguishers which bear the UL listing mark.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Recycled Content: Provide products manufactured from recycled content as specified, to be measured and documented according to the LEED Green Building Rating System.
- B. Regional Materials: Provide materials and products manufactured within a 500 mile radius of the project site.
- C. Low-Emitting Materials: Provide the following options, where low-emitting materials are installed in the building interior (defined as inside of the weatherproofing system and applied on-site):
 - 1. Option A, Adhesives and Sealants: Comply with the following criteria:
 - a. Adhesives, Sealants, and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168, requirements in effect on July 1, 2005, and rule amendment date January 7, 2005.

FIRE EXTINGUISHERS

b. Aerosol Adhesives: Green Seal Standard for Commercial Adhesives GS-36, requirements in effect on October 19, 2000.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products in unopened factory labeled packages. Store and handle in strict compliance with manufacturers' instructions and recommendations. Protect from damage.
- B. Sequence deliveries to avoid delays, but minimize on-site storage.

PART 2 - PRODUCTS

2.01 MATERIALS OR PRODUCTS

- A. Extinguishers: Multi-Purpose Dry Chemical Type: UL-rated 3A:40-B:C, 5 lb. nominal capacity, in enameled steel container, for Class A, Class B, and Class C fires.
- B. Brackets: Wherever extinguishers are shown or required without a cabinet, provide manufacturer's standard wall bracket that permits easy removal, but not accidental dislodgment.

2.02 FINISHES

- A. Hardware: Provide chrome plated exposed door pull or fully concealed pull.

PART 3 - EXECUTION

3.01 INSPECTION

- A. The Installer shall examine substrates, supports, and conditions under which this work is to be performed and notify Contractor, in writing, of conditions detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected. Beginning work means Installer accepts substrates and conditions.

3.02 INSTALLATION

- A. Strictly comply with manufacturer's instructions and recommendations, except where more restrictive requirements are specified in this section.
- B. Securely install at heights indicated or, if not indicated, at heights acceptable to authorities having jurisdiction and the Architect. If exact locations are not indicated, locate where field directed by Architect.
- C. Prepare recesses accurately to neatly accept cabinets. Coordinate with work in other sections to ensure proper sequence, position, height and clearances.

3.03 ADJUSTING, CLEANING, PROTECTION

- A. Adjust operating parts to work easily, smoothly, and correctly.
- B. Repair minor damage to eliminate all evidence of repair. Remove and replace work which cannot be satisfactorily repaired.
- C. Clean exposed surfaces using materials and methods recommended by manufacturer of product being cleaned. Remove and replace work that cannot be successfully cleaned.
- D. Provide temporary protection to ensure work being without damage or deterioration at time of final acceptance. Remove protections and reclean as necessary immediately before final acceptance.

3.04 CONSTRUCTION WASTE MANAGEMENT

- A. Comply with the requirements of Section 01 74 00, CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

END OF SECTION

FIRE EXTINGUISHERS

10 44 16-2



SECTION 11 31 13

KITCHEN APPLIANCES

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.02 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. Appliances.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Division 22 - PLUMBING for water distribution piping connections, drainage and vent piping connections, sinks, and waste disposers.
 - 2. Division 26 - ELECTRICAL WORK for services and connections to appliances.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated. Include operating characteristics, dimensions of individual appliances, and finishes for each appliance.
- B. Appliance Schedule: Appliances are scheduled on the Drawings.
- C. Maintenance Data: For each product to include in maintenance manuals.
- D. Warranties: Special warranties specified in this Section.

1.04 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer for installation and maintenance of units required for this Project.
- B. Source Limitations: Provide products from same manufacturer for each type of appliance required.
- C. Regulatory Requirements: Comply with provisions of the following product certifications:
 - 1. NFPA: Provide electrical appliances listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - 2. UL and NEMA: Provide electrical components required as part of residential appliances that are listed and labeled by UL and that comply with applicable NEMA standards.
 - 3. ANSI: Provide gas-burning appliances that comply with ANSI Z21 Series standards.
- D. Regulatory Requirements, Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with Massachusetts Architectural Access Board requirements and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)."
- E. Energy Ratings: Provide residential appliances that carry labels indicating energy-cost analysis (estimated annual operating costs) and efficiency information as required by the FTC Appliance Labeling Rule.
 - 1. Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.

KITCHEN APPLIANCES

- F. Switches: Provide mercury-free switches in appliances.

1.05 WARRANTY

- A. Special Warranties: Manufacturer's standard form in which manufacturer of each appliance specified agrees to repair or replace residential appliances or components that fail in materials or workmanship within manufacturer's standard warranty period.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
 - 1. GE (General Electric Company).
 - 2. Leihberr.
 - 3. KitchenAid and Whirlpool.
 - 4. LG.
 - 5. Fiskal Packell.
- B. Appliance Schedule: Refer to Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. General: Comply with manufacturer's written instructions.
- B. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
- C. Freestanding Equipment: Place units in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
- D. Utilities: Refer to Section Division 22 - PLUMBING for plumbing requirements and Division 26 - ELECTRICAL WORK for electrical requirements.

3.03 CLEANING AND PROTECTION

- A. Test each item to verify proper operation. Make necessary adjustments.
- B. Verify that accessories required have been furnished and installed.
- C. Remove packing material from appliances and leave units in clean condition, ready for operation.

3.04 DEMONSTRATION

- A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain appliances.

END OF SECTION

KITCHEN APPLIANCES

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SECTION 12 35 30

KITCHEN CASEWORK

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.02 DESCRIPTION OF WORK

- A. Work Included: This Section includes Wood and plastic-laminate-faced cabinets and postformed euro-edge countertops, including but not limited to the following:
 - 1. Kitchen base and wall cabinetry.
 - 2. Bathroom vanities.

- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).

- C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

- 1. Section 06 40 00, INTERIOR ARCHITECTURAL WOODWORK; Countertops.
- 2. Section 11 31 13, APPLIANCES.
- 3. Division 24, MECHANICAL "Plumbing Fixtures": sink units mounted in countertops.

1.03 DEFINITIONS

- A. Exposed Surfaces: Surfaces visible when drawers and opaque doors are closed; behind clear glass doors; bottoms of casework 43 inches or more above finished floor.
- B. Semi-Exposed Surfaces: Surfaces which become visible when opaque doors are open or drawers are extended; bottoms of casework are more than 30 inches and less than 42 inches above finished floor.
- C. Concealed Surfaces: Surfaces considered concealed when surfaces not visible after installation; bottoms of casework less than 30 inches above finished floor; tops of casework over 78 inches above finished floor and not visible from an upper level; stretchers, blocking, and components concealed by drawers.
- D. Reveal Overlay: Door and drawer faces partially cover cabinet frame.
- E. Flush Overlay: Door and drawer faces cover cabinet frame with space between faces sufficient for operating clearance.
- F. Flush: Door and drawer faces flush with cabinet face.

1.04 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for each casework type specified.
- C. Product data for each hardware type specified.

KITCHEN CASEWORK

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- D. Product certificates signed by the manufacturer certifying that materials furnished comply with specified requirements.
- 1.05 QUALITY ASSURANCE
- A. KCMA Certification: Provide kitchen casework with Kitchen Cabinet Manufacturers Association (KCMA) "Certified Cabinet" seal affixed in a semiexposed location of each unit, showing compliance with above standard.
 - B. Single-Source Responsibility: Obtain kitchen casework from one source of a single manufacturer.
- 1.06 DELIVERY, STORAGE, AND HANDLING
- A. Deliver casework as factory-assembled units, packaged individually.
- 1.07 PROJECT CONDITIONS
- A. Environmental Conditions: Comply with casework manufacturer's written requirements for temperature and humidity conditions during storage and installation. Do not install casework until these conditions have been attained and stabilized.
 - B. Field Measurements: Verify casework dimensions by field measurements. Verify kitchen casework can be installed in compliance with the original design and referenced standards.
 - C. Field Measurements: Verify countertop size and shape prior to fabrication by field measurements taken after base units are installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Provide products as selected by the Architect.

2.02 CABINET MATERIALS

- A. Wall and Base Cabinets: Shall be of the same construction and outside appearance and must have face frames. Construct cabinets and counter tops of solid lumber and exterior grade plywood with wood veneer core. No particleboard, flakeboard, fiberboard or hardboard will be accepted. All parts touching floor must be pressure treated solid lumber. Brace cabinets as necessary to produce sturdy and rigid construction. Provide an integral toe space of at least 3 inch x 3 inch. Only first quality methods, materials and workmanship will be accepted. Conform to HUD "Severe-Use" guidelines.
 1. Face Frames: 3/4 inch thick of kiln dried solid hardwood, free of knots and selected for light uniform color suitable for natural finish. Frames to be mortised and tenoned, dovetailed, or doweled, glued and stapled under pressure and filed and sanded. Vertical end members between doors and drawers (mulls) to be minimum 2 inch wide. Horizontal members (rails) to be 1-3/4 inch wide. Stiles and tops and bottom rails to be dadoed to receive ends, bottoms and tops.
 2. End Panels: Exposed ends should be minimum 2 2 grade, 1/2 inch thick five (5) ply exterior hardwood plywood, selected for light uniform color. Ends not exposed can be 1/2 inch exterior softwood plywood, grade A D, with "A" side to inside cabinet. Ends shall be dadoed a minimum of 1/4 inch deep to receive shelves, bottoms, and tops. Ends must be let into dadoes in face frames. Base cabinet and panels shall stop 3 1/2 inch above the floor and be supported by 3/4 inch x 3-1/2 inch pressure treated solid lumber member.
 3. Backs: Required on all cabinets. Minimum 3/4 inch thick 2 2 grade exterior hardwood or A D grade exterior softwood plywood. Must be securely glued and stapled to ends, 3 1/2 inch cleats and shelves of cabinet. Back may be let into dadoes of ends and installation cleats or may be applied flush with ends of cabinets and installation cleats.
 4. Installation Cleats: Minimum of 3/4 inch x 3-1/2 inch S4S, "C" grade, kiln dried solid lumber, dadoed to receive bottoms and tops. Two horizontal members running full length of cabinets at tope and bottom required. Base cabinets with drawers must have a third member at drawer height to receive side mount drawer slide bracket.

5. Shelves and Wall Cabinet Bottom: 1/2 inch thick 2 2 grade exterior hardwood or A 2 grade exterior softwood plywood with wood banded front edge, or 3/8 inch thick solid lumber. Shelves to be let into dadoes of end panels and braced behind mulls, installation cleats, and front frames. Both must be glued and stapled.
6. Doors: 3/4 inch thick, seven (7) ply, A 2 grade exterior hardwood plywood with no more than one veneer joint on face. Shall be of overlay type with edges reversed shaped to form continuous finger grip around all sides. Edges shall be filled and sanded smooth prior to finish. Edges can be treated with hot foil transfer. Acceptable hardwoods shall be breece, birch, maple or oak.
7. Base Bottoms: 1/2 inch thick 2 2 grade exterior hardwood or A 3 grade exterior softwood plywood. Bottoms shall be let into end panels, front rails and installation cleats. Bottoms shall be supported by 3/4 inch thick pressure treated solid lumber braces 24 inch o.c. running front to rear of cabinets and resting on floor.
8. Toe Kicks: 3/4 inch thick pressure treated solid lumber.
9. Drawers: Drawer fronts shall be same material as doors. Sides and backs shall be minimum of 1 1/16 inch thick "C" grade solid lumber with sides dovetailed or mortised and tenoned into fronts. Backs shall be dadoed into sides. Drawer bottoms shall be minimum 1/4 inch softwood or hardwood exterior plywood let into front, sides and back. All drawer parts shall be glued, and nailed or stapled together. Mount drawers on pair of 75 lb. Capacity side mounted metal guides. Cabinet member of guides must be attached at rear to 3/4 inch solid lumber hanging rail by use of metal rear mount brackets or by continuous wraparound method.
10. Finish: Exposed surfaces and interior of cabinets shall be factory finished consisting of stain, sealer and polyurethane coats, or an equivalent coating system, lightly sanded between application. Color shall be selected by the BHA from manufacturer's standard colors. Toe kick shall be painted as desired by the BHA. High pressure Decorative Laminates (HPDL) may be supplied in this solicitation I lieu of the finish described above. However, the HPDL shall meet the performance requirement of NEMA LD3 1985.
11. Hardware: Provide corrosion resistant hardware. Hinges shall be manufacturers standard heavy duty with self closing feature and shall be the face mount or the semi concealed type. Cabinet drawers shall be mounted on metal side rails with 75 lb. Loading capacity Washington Manufacturing Model B2310, Knap Vogt Manufacturing Model KY 1300, Grant Manufacturing Model 336 or approved equal.
 - a. Cabinet hinge finish to match drawer pull finish, as approved by Architect.
12. Filler and Molding: Scribe mould and filler shall be utilized to assure accurate job fit.

B. Refer to Section 06 40 00 "Interior Architectural Woodwork" for counters.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install casework with no variations in flushness of adjoining surfaces using concealed shims. Where casework abuts other finished work, scribe and cut for accurate fit. Provide filler strips, scribe strips, and moldings in finish to match casework face.
- B. Install casework without distortion so that doors and drawers fit openings properly and are aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete the installation of hardware and accessories as indicated.
 1. Vertically and horizontally align all finished, exposed, cabinet hardware in kitchens and baths.
- C. Install casework and countertop level and plumb to a tolerance of 1/8 inch in 8 feet.
- D. Fasten unit of casework to adjacent unit and into structural support members of wall construction with #10 sheet metal or wood screws with washer head or washer.

3.02 ADJUSTING AND CLEANING

- A. Adjust hardware to center doors and drawers in openings and lubricate to provide unencumbered operation.

- B. Clean casework on exposed and semi-exposed surfaces. Touch up factory-applied finishes to restore damaged or soiled areas.

END OF SECTION



SECTION 22 00 00

PLUMBING

PART 1 GENERAL INSTRUCTIONS

1.01 SPARE PARTS

- A. Furnish to Owner, with receipt, the spare parts to include faucet washers and O-rings for the fixtures furnished for this project.

1.02 EXTERIOR UTILITY CONNECTIONS

- A. FOR FINAL INSTALLATION: Terminate domestic water, storm, and sewer lines at a point approximately five feet from the building wall, or as shown on the Drawings. Make connection to the various services provided by others and coordinate connection requirements with Civil Engineer. Verify that installation will tie into the various services provided by others at the indicated invert elevation point prior to installation. If the installation will not tie into the indicated invert elevation point while maintaining proper fall, notify Architect and Civil Engineer so that an alternative may be determined.
- B. Provide service piping and accessories required to complete utility connections that are not furnished by the serving utility.
- C. FOR FINAL INSTALLATION: Coordinate with the local gas service company to provide a new gas service line as indicated on the Drawings. Installation shall be by the local gas service company.

1.03 SYSTEM TESTING AND ADJUSTING

- A. Upon completion of each phase of the installation, test each system in conformance with local code requirements and as noted below. Furnish labor and equipment required to test plumbing work installed under this contract, and assume costs involved in making the tests, and repairing and/or replacing damage resulting therefrom.
- B. Notify the Architect and the authority having jurisdiction, three (3) working days prior to making plumbing system tests. Leave concealed work uncovered until the required tests have been completed, but if necessary due to construction procedure, tests on portions of the work may be made, and when satisfactory, the work may be concealed. Test piping before insulation is installed, and before backfill. Pipes, joints, flanges, valve stems, etc., shall be leak tight. Repair or replace system defects with new materials. Caulking of defective joints, cracks or holes will not be permitted. Repeat tests after defects have been eliminated. Make tests in the presence of the administrative authority and/or the Owner's authorized representative.
- C. Upon completion of the systems installation, and prior to acceptance by the Architect and Engineer, make general operating tests to demonstrate that equipment and systems are in proper working order, and are functioning in conformance with the intent of the Drawings and Specifications. As a part of these tests, open every water outlet to ensure complete system flushing, remove and clean faucet aerators, clean strainers, light pilot lights, and operate every piece of equipment furnished under this contract to demonstrate proper functioning.

1.04 WARRANTIES

- A. The work to be performed under this contract shall include the furnishing, installation, and connection of plumbing systems indicated on the Drawings and in the Specifications. By signing the contract, the Contractor acknowledges that he has acquainted himself with the site and the existing conditions under which the work is to be performed, and the Drawings and Specifications pertaining thereto, and the indicates that he will comply with the requirements and intent of pertinent documents in the performance of the work.

- B. Warrant that the plumbing installed under this contract is free of defects in workmanship and materials for a period of one (1) year from the date of job acceptance by the Owner. This shall include a warranty of free circulation of liquids throughout the system as intended without leaks, excessive noise, or water hammer.
- C. If defects occur during the one year warranty period, repair or replace such defects at no expense to the Owner, and to the satisfaction of the Owner, Architect and Engineer.

PART 2 PLUMBING PIPING

2.01 PIPING MATERIALS

- A. Materials specified or noted on the Drawings are subject to the approval of local code authorities. Verify approval before installing any material or joining method.
- B. Domestic Water (cold): Domestic water piping installed above the floor slab inside the building shall be type "L" hard temper copper tube with wrought copper fittings and soldered connections made up with 95/5 solder. Brazed mechanically formed tee connections (T-Drill) may be used in copper lines where approved by code; connection shall be made with brazed silver solder (Silfos) joints in conformance with manufacturer's instructions.
- C. FOR FINAL INSTALLATION: Underground domestic water piping 2" and smaller shall be type "K" soft temper copper tubing with flared copper alloy fittings and connections, or type "K" hard temper copper tubing with conventional wrought copper fittings and silver solder (Silfos) joints. Install as few underground copper piping joints as possible. At building service entrance, no joints shall be installed under or within 5 feet of the building. Install domestic water piping below grade outside building at adequate depth to prevent freezing.
- D. FOR FINAL INSTALLATION: Interior Waste and Vent Below Slab: Waste and vent pipe below slab inside building shall be service weight cast iron soil pipe with hub and spigot fittings with neoprene gasket joints. Hubless waste and vent pipe is not permitted below base slab.
- E. Interior Vent Above Slab: Vent pipe above slab inside building shall be hubless cast iron soil pipe and fittings with hubless couplings.
- F. Interior Storm: Inside building shall be same as specified for interior vent pipe.
- G. Exterior Storm Service: Same as specified for Exterior Sanitary Service.
- H. Condensate Drain Inside Building: Condensate drain pipe installed inside the building shall be type "M" hard copper with wrought copper fittings for 1" and smaller. Install cleanouts at elbows greater than 45 degrees.
- I. FOR FINAL INSTALLATION: Use PVC for below floor sump pump discharge and galvanized steel above floor.
- J. FOR FINAL INSTALLATION: Sump Pump Discharge: Sump pump discharge piping above grade shall be ASTM A53 schedule 40 galvanized steel pipe with galvanized malleable iron fittings.

2.02 PIPING AND EQUIPMENT INSULATION

- A. Domestic cold water and interior horizontal storm drain piping above ceiling 1" one-piece fiberglass covering with fire-resistant jacket with self-sealing lap to provide a continuous vapor barrier by Certainteed, Owens-Corning or Armstrong. For piping at hangers provide 8" long sections of high density, high temperature calcium silicate by Johns-Manville, fiberglass by Knauf, or 8" long Styrofoam billets by Dow. Insulation shall be continuous along the pipe surface, except at valves, unions, and where piping is exposed at fixtures. Provide fiberglass insulation on domestic cold pipe installed in walls and chases. Roof

drain bodies: 2" one-piece fiberglass covering with fire-resistant jacket with self-sealing lap to provide a continuous vapor barrier, by Certainteed, Owens-Corning or Armstrong. Provide insulation protection shield at each hanger for insulated piping.

- B. Cover fittings with Zeston, Knauf, or equal one-piece PVC premolded insulating covers. Fitting covers, jackets and adhesives shall not exceed flame spread rating of 25 and smoke development rating of 50 per ASTM E84. At all elbows and tees, fill voids between covers and piping with fiberglass insulation and tape joints. Install pipe insulation in compliance with manufacturer's recommendations. Where premolded insulating fittings are not approved by local authorities, miter insulation at fittings.

2.03 PIPING JOINTS

- A. Copper Tubing: Joints in hard temper tubing shall be soldered joints using lead-free 95/5 solder except where tubing is installed below grade or below the base slab, in which case joints shall be soldered with silver solder (Silfos). Joints in soft temper copper tubing shall be of the flared type installed in compliance with the fitting manufacturer's recommendations.
- B. Threaded Steel Pipe: Threaded joints shall be full and clean, cut with not more than three (3) threads exposed beyond the fittings. Make joints tight with graphite base pipe joint compound and paint exposed threads of ferrous pipe with acid-resisting paint after piping has been tested and proven tight. No caulking, lamp-wick or other material will be permitted for correction of defective joints.
- C. FOR FINAL INSTALLATION: Cast Iron Pipe Below Grade: Joints in bell and spigot cast iron waste and vent pipe shall be neoprene compression gaskets, Tyseal or equal.
- D. FOR FINAL INSTALLATION: Cast Iron Pipe Above Grade: Joints in hubless pipe shall be standard CISPI 310-85 coupling by Anaco Husky or approved equal. Joints in storm piping 3" and larger shall be heavy duty couplings meeting ASTM C564 and FM 1680, Anaco Husky #SD-4000 or Clamp-All "Hi Torque" 125in. lb.
- E. Pipe Adapters: Make connection of new waste pipe to new or existing dissimilar waste pipe using adapter couplings. Provide FERNCO, Proflex 3000 Series or Mission Flexseal MR56 Series with neoprene adapter gasket with stainless steel shield and hose clamps for connecting dissimilar pipes above grade. Provide FERNCO, 1056 Series or Mission Sewer Couplings with neoprene adapter gasket and hose clamps for connecting dissimilar pipes below grade and coat stainless steel bands with mastic.

2.04 PIPING INSTALLATION

- A. General: Clean pipe thoroughly prior to installation. Ream ends of pipe to remove burrs. Cut pipe accurately to measurements taken on the job. Install with adequate clearance for installation of coverings where required. Pipe shall not be sprung or bent. Neatly align pipe, connect it securely, and support it from the building structure with hangers as specified below. Provide chrome-plated escutcheons on pipes passing through ceilings, floors or walls of finished spaces. Run pipes freely through floor and wall penetrations using pipe sleeves. Do not grout in place unless required for structural fire integrity. Install pipe concealed in finished spaces wherever possible. Use a dielectric union where ferrous and copper pipe connect. Dielectric union shall have a zinc-plated steel body, a threaded nylon insert, and insulating pressure gasket. No ferrous metal-to-copper connection made without insulating unions will be allowed.
- B. Hanger & Supports: Pipe hangers shall be as described in the specifications by B-Line or equal by Anvil, Michigan, Truscon, or Unistrut. Connect hangers to the structure with side beam connectors and all thread hanger rods. Provide engineered support struts between joists and other structural members as required to provide a rigid hanging installation. Do not hang pipes from other pipes, conduit or ductwork. Provide hanger rods and space hangers at intervals as specified in "Hanger Spacing". Provide support within 1' of each elbow and tee. Provide supports within 1' of each equipment connection. Provide two nuts on threaded supports to securely fasten the support. Install hanger types or supports for various piping as follows:

- C. Copper Tube: Adjustable band hangers for bare copper tube 3" and smaller shall be B-Line #B3170 CT copper plated adjustable band swivel ring type. Adjustable band hangers for insulated copper tube and 3" smaller shall be B-Line #B3170 NF adjustable band swivel ring type. Support exposed copper tube 2" and smaller to walls or in chases with B-Line #B3198RCT copper coated extension split ring pipe clamps, 3/8" threaded rod and B-Line #B3199CT ceiling flanges. Support copper tube in chases and walls at plumbing fixtures with plastic or copper brackets secured to structure and U-bolts sized to bare on the pipe. Riser clamps to support vertical copper tube shall be B-Line #B3373CT copper coated steel, cut insulation, seal vapor barrier, and attach to bare tube.
- D. Steel Pipe: Adjustable band hangers for 2" and smaller shall be B-Line #B3170 NF adjustable band swivel ring type. Riser clamps to support vertical pipe shall be B-Line #B3373 galvanized steel.
- E. Cast Iron Pipe: Adjustable band hangers for 2" and smaller. Clevis hangers for 3" and larger shall be B-Line #B3100 galvanized steel clevis type. Riser clamps to support vertical pipe shall be B-Line #B3373 galvanized steel.
- F. Insulation Protection Shields: B-Line #B3151 of 18 gauge galvanized sheet metal. Shield shall cover half of the circumference of the pipe and shall be of length indicated by manufacturer for pipe size and thickness of insulation.
- G. Hanger Spacing, Rod Sizes & Connectors: Connect rods to steel beams or joists with B-Line #B3031 or #B3033 beam clamps as required. Connect rods to concrete with B-Line #3014 malleable iron single type inserts with malleable iron nut. Connect rods in wood construction with B-Line #B3058 side beam connectors. Hang and support piping with spacing and rod sizes as follows:
- H. Copper Tube: 1-1/2" and smaller - every 6' with 3/8" hanger rods; 2" - every 10' with 3/8" hanger rods; 2-1/2" and 3" - every 10' with 1/2" hanger rods, 4" - every 10' with 5/8" hanger rods. Support vertical copper tube every 10'.
- I. Steel Pipe: 1" and smaller - every 8' with 3/8" hanger rods; 1-1/4" to 2" - every 10' with 3/8" hanger rods. Support vertical steel pipe every 10'.
- J. Cast Iron Pipe: Every 10' and within 1' of each joint. 2" and smaller with 3/8" hanger rods; 3" with 1/2" hanger rods; 4" with 5/8" hanger rods; 6" with 3/4" hanger rods; 8" and larger with 7/8" hanger rods. Support vertical cast iron pipe every 15'.
- K. FOR FINAL INSTALLATION: Below Ground Installation for Soil, Waste and Storm: Install soil and waste piping to a uniform slope of not less than 1/8" per foot for piping 4" or larger, and not less than 1/4" per foot for piping 3" or smaller. Slope storm piping at 1/8" per foot. Lay pipe at uniform slope, free from sags, with hub end upstream. Make changes in direction from horizontal to vertical, at fixture branches and other branch connections with sanitary "tees" or short sweep "ells". Make changes in direction from vertical to horizontal or horizontal to horizontal with long radius fittings, long sweeping "ells", combination "Y and 1/8 bend" fittings, or 45 degree "ells" (1/8 bend fittings), 1/6 bend or 1/16 bend and "Y" fittings. Install pipe with the barrel of the pipe on firm, solid earth for its entire length, and excavate holes for the pipe bells. Lay pipe in a straight line and install with uniform grade to line with batten boards set not more than 24'-0" apart. Close open ends of pipe with a stopper when pipe laying is not in progress. Center spigots accurately in bells for uniform caulking. Provide a smooth and uniform invert in the system. Drilling or tapping of soil and waste lines, and saddle hubs and bands are not permitted. Locate and install soil and waste lines as indicated on the Drawings. Determine exact locations in such a manner as to maintain proper clearance. Prior to installation of any building drain pipe, verify elevation of connection point of existing sewer, service line or existing tenant connections indicated on the Drawings. If the installation will not tie into the indicated invert elevation point while maintaining proper fall, notify Architect so that an alternative may be determined.

- L. Above Ground Installation for Storm: Slope storm piping at as noted on Drawings. Lay pipe at uniform slope free from sags. Support pipe within 12" of each joint. Make changes in direction from horizontal to vertical, at fixture branches and other branch connections with sanitary "tees" or short sweep "ells". Make changes in direction from vertical to horizontal or horizontal to horizontal with long radius fittings, long sweeping "ells", combination "Y and 1/8 bend" fittings, or 45 degree "ells" (1/8 bend fittings), 1/6 bend or 1/16 bend and "Y" fittings. Provide a smooth and uniform invert in the system. Drilling or tapping of soil and waste lines, and saddle hubs and bands are not permitted. Locate and install soil and waste lines as indicated on the Drawings. Determine exact locations in such a manner as to maintain proper clearance.
- M. Plumbing Vent: Connect plumbing vent pipes to fixture drain pipes as indicated on the Drawings or as required by the installation practices adopted and enforced by local codes official, and extend vent pipes full size through the roof line. Grade pipe to a uniform slope so as to drain back by gravity to the drainage piping system. Vents passing through the roof shall be minimum 3" size except in tropical climates, per local codes. Turn flashing down into stacks at least 2", and extend flashing 24" in all directions from the pipe at the roof line. Apply white lead pipe dope on male steel pipe threads. Vent lines shall be air and water tight. Vent floor drains individually or connect them to a horizontally vented line as shown on the Drawings.
- N. Domestic Water: Arrange cold piping to drain at the lowest point in each system. Install at least one pipe union adjacent to all shutoff valves, at connection points of each piece of equipment, and elsewhere in the system where required to allow proper maintenance. Provide unions of the ground joint type. Make allowance for expansion and contraction where required by the installation. Where water piping occurs in exterior walls, hold pipe as close as possible to the interior face of wall and install insulation batt or other insulation (minimum R8) between piping and the exterior wall face.

2.05 PIPING SANITIZATION

- A. Sanitize the entire domestic water piping system (cold) with a solution containing not less than 50 PPM available chlorine. Keep solution in the system for a minimum of 24 hours, with each valve being operated several times during the period. After completion, flush system with city water until chlorine residual is lowered to incoming city water level.

2.06 PIPING TESTING

- A. Test the drainage and vent system by plugging openings with test plugs, except those at the top of the stacks. Fill the system with water; test results will be satisfactory if the water level remains stationary for not less than one (1) hour. Subject the drainage and vent system to a pressure of at least ten (10) feet of water. If leaks develop, repair them and repeat the test.
- B. Test the domestic water system by filling it with water and then isolating the system from its source. Keep the system closed for a period of twenty-four hours, with no fixture being used. The pressure differential for this test period shall not exceed 10 PSIG. Test water piping to a 125 PSI hydrostatic pressure.

PART 3 PLUMBING SPECIALTIES

3.01 WATER HAMMER ARRESTORS AND TRAPS

- A. Provide water hammer arrestors at valves as indicated on the Drawings to prevent water hammer. Arrestors shall be Josam, Smith, Precision Plumbing Products, Sioux Chief, Wade, Watts, or Zurn, stainless steel bellows type, or O-ring sealed and lubricated acetal piston. Install water hammer arrestors per the Plumbing and Drainage Institute PDI WH-201 installation instructions.
- B. Provide water-seal traps on floor sinks and equipment with drain connections, including traps not furnished in combination with fixtures and equipment. Place trap as close to the fixture or drain as possible. Exposed traps in finished spaces shall be chrome-plated brass.

- C. Provide conventional "P" type traps, water-sealed self-cleaning design. Full "S" traps or trap standards shall be used only where specifically called for on the Drawings or elsewhere in this Specification. Trap water seals shall not be less than 2", and deep seal traps shall be provided where specified or indicated. Each trap not integral with the fixture or floor drain or installed below the base slab shall be provided with an accessible cleanout of adequate size. Provide trap primers where required by code and where indicated on the Drawings.
- 3.02 CLEANOUTS, FLOOR SINKS AND ROOF DRAINS
- A. Cleanouts, floor drains and roof drains shall be by one manufacturer if possible. Acceptable manufacturers are Josam, Smith, Wade, Watts, and Zurn. Provide long sweep fittings for cleanout extensions; short sweeps at start of runs or change in direction and combination wye and eight bend fittings in horizontal runs. Install cleanouts with a minimum of 18" clear all around, consult local codes for other requirements, for easy system maintenance. Install plug with Teflon joint compound.
 - B. Roof Drains: shall be as scheduled on the Drawings. Provide with roof sump receiver, extension, secondary flashing clamps and underdeck clamp as required; provide expansion joints where required. Provide overflow roof drains where indicated on the Drawings with inlet flow line 2" above the primary roof drain inlet.
- 3.03 VALVES, STRAINERS, HOSE BIBBS, AND UNIONS
- A. Plumbing system valves shall be Crane Company or Nibco of models herein specified, or approved equal by Hammond, Walworth, Stockham or Mueller valves. Valves shall be of the best quality, designed for 125 PSI steam working pressure. Install valves on the hot and cold water lines at the water heater connections and other items of equipment, at branches from mains serving groups of fixtures, and at other places indicated or required by the installation to allow ease of future maintenance.
 - B. Gate Valves: Class 125, size 2-1/2" and smaller shall be Crane #1701 or Nibco T113, non-rising stem, screwed brass body and parts, with wedge disc.
 - C. Ball Valves (may be used in lieu of gate valves up to 2"): 2" and smaller, Nibco #T580; two piece bronze body, with screwed ends, chrome plated bronze ball with conventional port, 400 psi, blow-out proof stem.
 - D. Strainers: Strainers 2-1/2" and smaller shall be Watts #745 with screwed iron body, brass cap and Monel 40 mesh screen.
- 3.04 WATER SERVICE ENTRANCE: PRESSURE REDUCING VALVE AND BACKFLOW PREVENTER
- A. Provide a backflow preventer (BFP) of type required by local code, and a pressure reducing valve (PRV) if required by excessive water pressure, on the domestic water service immediately downstream from the point of water service entry.
 - B. Double Check Valve (DCV) shall be as specified on the Drawings, Watts or equivalent by Febco, Conbraco, or Wilkins. 2" and smaller shall be bronze body with stainless steel trim, bronze ball valve shut-offs on inlet and outlet, and bronze strainer with stainless steel screen and cleanout. Unit shall be suitable for 175 psi working pressure.
 - C. Provide a Pressure Reducing Valve (PRV) only when static domestic water pressure downstream of the BFP exceeds 80 PSI. PRV shall be as specified on the drawings, Watts or equivalent Cash-Acme or Wilkins. For 2" and smaller provide with bronze body with stainless steel trim, direct acting, spring loaded diaphragm type, suitable for 300 psi inlet pressure. For 2-1/2" and larger provide iron body with fused epoxy coating. Outlet pressure shall be 70 psi.

END OF SECTION



SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.02 DESCRIPTION OF WORK

- A. Work Included: This Section includes plumbing fixtures and trim, fittings, and accessories, appliances, appurtenances, equipment, and supports associated with plumbing fixtures.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).
- C. Products furnished but not installed under this Section include:
 - 1. Plumbing fittings (including faucets) and piping indicated, for fixtures, appliances, appurtenances, and equipment provided by Owner.
 - 2. Plumbing fittings (including faucets) and piping indicated, for fixtures, appliances, appurtenances, and equipment specified in other Sections.

1.03 DEFINITIONS

- A. Accessible: Describes a plumbing fixture, building, facility, or portion thereof that can be approached, entered, and used by physically handicapped people.
- B. Accessory: Device that adds effectiveness, convenience, or improved appearance to a fixture but is not essential to its operation.
- C. Appliance: Device or machine designed and intended to perform a specific function.
- D. Appurtenance: Device or assembly designed to perform some useful function when attached to or used with a fixture.
- E. Equipment: Device used with plumbing fixtures or plumbing systems to perform a certain function for plumbing fixtures but that is not part of the fixture.
- F. Fitting: Fitting installed on or attached to a fixture to control the flow of water into or out of the fixture.
- G. Fixture: Installed receptor connected to the water distribution system that receives and makes available potable water and discharges the used liquid or liquid-borne wastes directly or indirectly into the drainage system. The term "Fixture" means the actual receptor, except when used in a general application where terms "Fixture" and "Plumbing Fixture" include associated trim, fittings, accessories, appliances, appurtenances, support, and equipment.

PLUMBING FIXTURES

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- H. Roughing-In: Installation of piping and support for the fixture prior to the actual installation of the fixture.
 - I. Support: Device normally concealed in building construction, for supporting and securing plumbing fixtures to walls and structural members. Supports for urinals, lavatories, and sinks are made in types suitable for fixture construction and the mounting required. Categories of supports are:
 - 1. Carrier: Floor-mounted support for wall-mounted water closet, and support fixed to wall construction for wall-hung fixture.
 - 2. Chair Carrier: Support for wall-hung fixture, having steel pipe uprights that transfer weight to the floor.
 - 3. Chair Carrier, Heavy Duty: Support for wall-hung fixture, having rectangular steel uprights that transfer weight to the floor.
 - 4. Reinforcement: Wood blocking or steel plate built into wall construction, for securing fixture to wall.
 - J. Trim: Hardware and miscellaneous parts, specific to a fixture and normally supplied with it required to complete fixture assembly and installation.
- 1.04 QUALITY ASSURANCE
- A. Regulatory Requirements: Comply with requirements of ANSI Standard A117.1, "Buildings and Facilities -- Providing Accessibility and Useability for Physically Handicapped People," Public Law 90-480, "Architectural Barriers Act, 1968," with respect to plumbing fixtures for the physically handicapped and "Americans with Disabilities Act Accessibility Guidelines for Buildings 1991" with respect to plumbing fixtures for the physically handicapped.
 - B. Regulatory Requirements: Comply with requirements of ATBCB (Architectural and Transportation Barriers Compliance Board) "Uniform Federal Accessibility Standards (UFAS) - 1985-494-187" with respect to plumbing fixtures for the physically handicapped.
 - C. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled.
 - 1. The terms "listed" and "labeled" shall be as defined in the National Electrical Code, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
 - D. Faucets and trim in contact with drinking water shall meet or exceed the Safe Water Drinking Act (SWDA) lead free standards of ANSI/NSF Standard 61, section 9.
 - E. Design Concept: The drawings indicate types of plumbing fixtures and are based on the specific descriptions, manufacturers, models, and numbers indicated. Plumbing fixtures having equal performance characteristics by other manufacturers may be considered provided that deviations in dimensions, operation, color or finish, or other characteristics are minor and do not change the design concept or intended performance as judged by the Architect. Burden of proof for equality of plumbing fixtures is on the proposed.
- 1.05 SPARE PARTS
- A. Deliver spare parts to Owner. Furnish spare parts described below matching products installed, packaged with protective covering for storage, and identified with labels clearly describing contents.

- B. Faucet Washers and O-rings: Furnish quantity of identical units not less than 10 percent of amount of each installed.
- C. Faucet Cartridges and O-rings: Furnish quantity of identical units not less than 5 percent of amount of each installed.
- D. Flushometer Repair Kits: Furnish quantity of identical units not less than 10 percent of amount of each flushometer installed.
- E. Toilet Seats: Furnish quantity of identical units not less than 5 percent of amount of each type toilet seat installed.
- F. Waterless Urinal Sealant & Cartridges: Furnish quantity of sealant per waterless urinal not less than amount for one year of operation per the manufacturer's recommended maintenance schedule. For cartridge type waterless urinals, furnish quantity of cartridges per waterless urinal not less than the amount for one year of operation per manufacturer's recommended maintenance schedule.

PART 2 PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products in each category, by one of the following listed for that category:
 - 1. Water Closets:
 - a. American Standard, Inc.
 - b. Crane Plumbing/Fiat Products.
 - c. Eljer; A Household International Co.
 - d. Gerber Plumbing Fixture Corp.
 - e. Kohler Co.
 - f. TOTO KIKI USA, Inc.
 - g. Zurn Plumbing Products Group
 - 2. Lavatories:
 - a. American Standard, Inc.
 - b. Crane Plumbing/Fiat Products.
 - c. Eljer; A Household International Co.
 - d. Gerber Plumbing Fixture Corp.
 - e. Kohler Co.
 - f. TOTO KIKI USA, Inc.
 - g. Zurn Plumbing Products Group
 - 3. Sinks:
 - a. Elkay Manufacturing Co.
 - b. Just Manufacturing Co.
 - 4. Shower Receptors:
 - a. Aqua Glass Corp.

- b. Best Bath
 - c. Crane Plumbing/Fiat Products.
 - d. Kohler Co.
 - e. LASCO Bathware, Inc.
 - f. Swan Corp.
- 5. Toilet Seats:
 - a. Bemis Mfg. Co.
 - b. Beneke Div.; Sanderson Plumbing Products, Inc.
 - c. Church Seat Co.
 - d. Kohler Co.
 - e. Olsonite Corp.
 - f. Sperzel Industries, Inc.
- 6. Flushometers:
 - a. Coyne & Delany Co.
 - b. Sloan Valve Co.
 - c. Zurn Industries, Inc.; Flush Valve Operations.
- 7. Thermostatic Mixing Valve Shower Faucets:
 - a. Chicago Faucets, Co.
 - b. Lawler Manufacturing Co., Inc.
 - c. Leonard Valve Co.
 - d. Powers Process Controls; A Unit of Mark Controls Corp.
 - e. Speakman Co.
 - f. Symmons Industries, Inc.
 - g. Zurn Industries
- 8. Sensor-Operated Faucets and Devices:
 - a. Acorn Engineering Co.
 - b. Bradley Corp.
 - c. Coyne & Delany Co.
 - d. International Sanitary Ware Manufacturing Co.
 - e. Sloan Valve Co.
 - f. Speakman Co.
 - g. Zurn Industries, LTD. "Aqua Spec"
- 9. Stop Valves & Supplies:
 - a. Brass Craft Subsidiary; Masco Co.
 - b. Engineered Brass Company
 - c. McGuire Manufacturing Co., Inc.
 - d. Zurn Industries
- 10. P-traps, Drains & Miscellaneous Fittings:
 - a. Brass Craft Subsidiary; Masco Co.
 - b. Dearborn Brass

- c. McGuire Manufacturing Co., Inc.
- d. Zurn Industries

11. Supports:

- a. Josam Co.
- b. Smith (Jay R.) Mfg. Co.
- c. Wade Div.; Tyler Pipe.
- d. Watts Drainage Products
- e. Zurn Industries, Inc.; Hydromechanics Div.

12. Insulation Kits

- a. Brocar
- b. McGuire
- c. Plumberex
- d. Trap-Wrap
- e. Truebro, Inc.

2.02 PLUMBING FIXTURES, GENERAL

- A. Provide plumbing fixtures and trim, fittings, other components, and supports as specified on the drawings and below:

2.03 FAUCETS

- A. Faucets General: As described on the drawings.

- 1. Electronic faucets shall be of the same manufacturer as the water closet and urinal flush valves.

2.04 STOP VALVES & SUPPLIES

- A. Supplies General: As described on the drawings.

- 1. Exposed piping and parts shall be polished chrome plated.

2.05 P-TRAPS, DRAINS AND MISCELLANEOUS FITTINGS:

- A. Fittings General: As described on the drawings, except as listed below.

- 1. Exposed piping and fittings shall be polished chrome plated.
- 2. Fittings installed concealed inside a plumbing fixture or within wall construction may be without chrome plate finish.

- B. Sink Continuous Wastes: Polished chrome-plated, tubular brass, 1-1/2 inches, 17 gauge, with brass nuts on slip inlets, and of configurations indicated.

- C. Sink Continuous Wastes: Polished chrome-plated, tubular brass, 2 inches, 17 gauge, with brass nuts on slip inlets, and of configurations indicated.

- D. Escutcheons: Wall flange with set screw.

- E. Escutcheons: Polished chrome-plated, sheet steel wall flange with friction clips.
- F. Deep Pattern Escutcheons: Wall flange with set screw or sheet steel wall flange with friction clips, of depth adequate to conceal protruding roughing-in fittings.

2.06 FLUSHOMETERS

- A. Provide flushometers compatible with fixtures, with features and of consumption indicated As described on the drawings.
 - 1. Exposed metal parts shall be polished chrome plated.
 - 2. Flush valves installed within wall construction may be without chrome plate finish.

2.07 TOILET SEATS

- A. General: As described on the drawings.

2.08 SHOWER RECEPTORS

- A. Shower Receptors: Provide shower receptors of shape, dimensions and other characteristics as specified on the drawings.

2.09 PLUMBING FIXTURE SUPPORTS

- A. Supports: ASME A112.6.1M, categories and types as required for wall-hanging fixtures specified, and wall reinforcement.
- B. Support categories are:
 - 1. Carriers: Supports for wall-hanging fixtures supported from wall construction.
- C. Support Types: Provide support of category specified, of type having features required to match fixture.
- D. Provide supports specified as part of fixture description, in lieu of category and type requirements above.

2.10 INSULATION KITS

- A. Insulation kits for lavatory and sink waste and supplies of vinyl plastic with reusable fasteners and openings for access to supply stop handles.

PART 3 EXECUTION

3.01 APPLICATION

- A. Install plumbing fixtures and specified components, in accordance with designations and locations indicated on Drawings.
- B. Install supports for plumbing fixtures in accordance with categories indicated, and of type required:
 - 1. Carriers for following fixtures:
 - a. Wall hanging lavatories
 - b. Wall hanging electric water coolers and drinking fountains.

c. Wall-hanging fixtures supported from wall construction.

2. Reinforcement for the following fixtures:

a. Floor-mounted sinks required to be secured to wall.

b. Recessed, box-mounted electric water coolers.

c. Wall mounted and mop sink faucets.

3.02 INSTALLATION OF PLUMBING FIXTURES

A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturers' written installation instructions, roughing-in drawings, and referenced standards.

B. Install floor-mounted, back-outlet water closets with fittings and gasket seals.

C. Install wall-hanging, back-outlet urinals with gasket seals.

D. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated.

E. Fasten floor-mounted fixtures and special fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.

F. Fasten wall-mounted fittings to reinforcement built into walls.

G. Fasten counter-mounting-type plumbing fixtures to casework.

H. Secure supplies behind wall or within wall pipe space, providing rigid installation.

I. Set shower receptor and mop basins in leveling bed of cement grout.

J. Install stop valve in an accessible location in each water supply to each fixture.

K. Install trap on fixture outlet except for fixtures having integral trap.

L. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork. Use deep pattern escutcheons where required to conceal protruding pipe fittings.

M. Seal fixtures to walls, floors, and counters using a sanitary-type, one-part, mildew-resistant, silicone sealant in accordance with sealing requirements specified in Division 7 Section "Joint Sealers." Match sealant color to fixture color.

N. Install insulation kits on ADA compliant sink and lavatory waste, continuous wastes, hot and cold water supplies where indicated on the drawings and as required by the ADA.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other sections of Division 15. The Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
 - 1. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other sections of Division 15.
 - 2. Install piping connections indicated between appliances and equipment specified in other sections, direct connected to plumbing piping systems.

3.04 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.05 ADJUSTING AND CLEANING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Operate and adjust disposers, hot water dispensers, and controls. Replace damaged and malfunctioning units and controls.
- C. Adjust water pressure at drinking fountains, electric water coolers, and faucets, shower valves, and flushometers having controls, to provide proper flow and stream.
- D. Replace washers of leaking and dripping faucets and stops.
- E. Clean fixtures, fittings, and spout and drain strainers with manufacturers' recommended cleaning methods and materials.
- F. Review the data in Operating and Maintenance Manuals. Refer to Division 1 Section "Project Closeout."

3.06 FIXTURE SCHEDULE

- A. Provide plumbing fixtures as specified on the drawings.
- B. Install rough-in for plumbing fixtures as scheduled on the drawings.

3.07 MOUNTING HEIGHTS SCHEDULE:

- A. Refer to the architectural drawings for plumbing fixture mounting heights. Unless indicated otherwise, install plumbing fixtures with the mounting heights as listed below with final approval by the Architect:

FIXTURE

Shower valves
Shower heads
Lavatory or Sink
ADA Accessible Lavatories
Water Closet
ADA Accessible Water Closet

MOUNTING HEIGHT

48" men and 42" women floor to centerline
6'-0" men, 5'6" women floor to centerline
31" floor to rim
34" floor to rim
15" floor to rim
17" to 19" floor to top of seat

END OF SECTION



SECTION 23 00 00

HEATING, VENTILATING AND AIR-CONDITIONING

PART 1 GENERAL

1.01 SPARE PARTS

- A. Furnish to Owner, with receipt, the following spare parts for the equipment furnished for this project:
 - 1. One set of spare filters of each type required for each unit. In addition to the spare set of filters, install new filters prior to testing, adjusting, and balancing work and before turning systems over to the Owner.
 - 2. Furnish one complete set of belts for each fan.
 - 3. Furnish three operating keys for each type of air outlet and inlet that require them.

1.02 REFRIGERANT AND OIL

- A. Provide full refrigerant and oil charge in new air conditioning refrigeration systems, and maintain it for full term of the guarantee.

PART 2 PRODUCTS

2.01 SPLIT DUCTLESS AIR-CONDITIONING SYSTEMS

- A. Provide split ductless system consisting of evaporator section for wall mounting and remote condensing section similar to Mitsubishi, Compu-Aire, or Data Aire. Evaporator cabinet shall be factory assembled pre-wired consisting of furniture-grade steel with baked-enamel finish, front access, with direct-drive centrifugal fans, 2-speed motor, AND cleanable foam filter. Evaporator coil shall be direct-expansion cooling coil of seamless copper tubes expanded into aluminum fins, with thermal expansion valve with external equalizer. Air-cooled condenser shall be of corrosion-resistant cabinet containing compressor, copper-tube aluminum-fin coils, direct-drive propeller fans with motors with internal overload protection; capacity control to 0 deg F.
- B. Provide refrigerant piping sized as recommended by equipment manufacturer with foamed plastic insulation on the suction line as specified in this section.
- C. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, solidstate temperature- and humidity-control modules. Provide solid-state, unit-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point. Refer To Sequence Of Operation.

2.02 REFRIGERANT PIPING AND INSULATION

- A. Provide ASTM B 88, Type L or ASTM B 280, Type ACR hard drawn copper refrigerant piping, cleaned and sealed at the factory, and specifically designed for refrigerant. Fittings shall be hard drawn and have long radius turns. Solder joints with "Silfos" (15% silver, 5% phosphorus, 80% copper, 1300 degrees Fahrenheit flow temperature). Solder joints with a slow stream of dry nitrogen passing through the piping.
- B. Insulate suction lines with 1" foamed plastic insulation, Armaflex or equal, having a conductivity (k) not exceeding 0.27 Btu per inch/h • ft² • °F. Piping insulation shall have a flame spread of 25 or less, and a smoke developed rating of 50 or less when tested in accordance with ASTM E84. Coat insulation that is exposed to the elements with a protective sealer. Install and support piping to keep noise and vibration to a minimum. Support and secure piping to Unistrut type supports so that no vibration passes to the building structure. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing. Install a support within one foot of each change of direction. Mount pipe hangers around the outside of the insulation with saddles to prevent hangers from rupturing the insulation. Replace insulation that is cut or broken by the hangers.

- C. Run refrigerant lines parallel and perpendicular to wall and floor lines and to appear straight and in good order. Pitch suction lines down slightly (1" in 20') towards the compressor. Provide oil traps at the base of vertical suction risers over 6 feet high.
- D. Install liquid line sight glasses in liquid lines nearest the condensing units. Factory mount expansion valves with the sensing bulbs shipped loose. Field mount expansion valve bulb after refrigerant piping is complete (damage may occur if bulbs come in contact with heat).
- E. For systems of 5 ton capacity and less, the contractor shall have the option to provide copper refrigerant tubing line set sized as recommended by equipment manufacturer and of length as required for the installation. Provide 1" thick foamed plastic insulation, Armaflex or equal, on the suction line. Provide quick-connect flare tubing compression fittings or solder connections as required to match the connections of the condensing unit and evaporator coil.

2.03 SYSTEM EVACUATION AND CHARGING

- A. Blow out refrigeration lines with dry nitrogen at a suitable pressure before making final connection at the condensing unit or coil to ensure against dirt, scale, or other foreign material being in the lines. Draw a vacuum to 29" of mercury. Break this vacuum by charging dry refrigerant gas into the system, raising the pressure to 0 PSIG. Repeat the latter two steps for a triple evacuation before the final evacuation is started. Make final evacuation by reducing the system absolute pressure to a maximum of 0.5 millimeters (500 microns) and allowing the pump to run at this pressure for a minimum of two hours.
- B. Repeat the proper amount of refrigerant charge per the manufacturer's recommendations. Record the amount of refrigerant by weight charged into the system for each circuit recorded to the nearest 1/4 pound on tags and attach tags to the liquid line near the condensing unit. Refrigerant shall be supplied by the HVAC contractor.

PART 3 EXECUTION

3.01 TEMPERATURE CONTROLS

- A. All thermostats are provided with equipment.
- B. Provide a system of temperature controls including thermostats, control panels, time switches, override timers, damper motors, and relays required to provide the desired sequence of operation. Set points of control devices shall be adjustable. Provide integrated wiring diagrams showing interconnections between field installed equipment and package wiring furnished with the HVAC equipment.
- C. Provide supervision and on-job checkout service as required to ensure that installation meets requirements of the specification. The system shall be guaranteed for a period of one year following the acceptance of the system by the Architect/Engineer. Correct defects occurring during this period at no additional cost to the Owner.

3.02 DUCTLESS SPLIT SYSTEM

- A. Operate ductless split system unit supply fan continuously. Cycle stage(s) of cooling to maintain room thermostat set point (75 degrees Fahrenheit cooling).

END OF SECTION



SECTION 26 00 00

ELECTRICAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section and to all following sections within Division 26.

1.02 SUMMARY

- A. This Division requires providing complete functioning systems, and each element thereof, as specified, indicated, or reasonably inferred, on the Drawings and in these Specifications, including every article, device, or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, supplies, tools, equipment, transportation and utilities.
- B. Division 26 of these Specifications, and Drawings numbered with prefixes E, generally describe these systems, but the scope of the electrical Work includes all such Work indicated in all of the Contract Documents, including, but not limited to: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Structural, Mechanical, Plumbing and Electrical Drawings and Specifications; and Addenda.
- C. Drawings are graphic representations of the Work upon which the Contract is based. They show the materials and their relationship to one another, including sizes, shapes, locations, and connections. They also convey the scope of Work, indicating the intended general arrangement of the equipment, fixtures, outlets and circuits without showing all of the exact details as to elevations, offsets, control lines, and other installation requirements. Use the Drawings as a guide when laying out the Work and to verify that materials and equipment will fit into the designated spaces, and which, when installed per manufacturers' requirements, will ensure a complete, coordinated, satisfactory and properly operating system.
- D. Specifications define the qualitative requirements for products, materials, and workmanship upon which the Contract is based.
- E. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).
- F. Comply with the requirements of Section 01570, Construction Waste Management, for removal and disposal of construction debris and waste.

1.03 QUALITY ASSURANCE

- A. Execute all Work under this Division in a thorough and professional manner by competent and experienced workmen duly trained to perform the Work specified.
- B. Install all Work in strict conformance with all manufacturers' requirements and recommendations, unless these Documents exceed those requirements. Install all equipment and materials in a neat and professional manner, aligned, leveled, and adjusted for satisfactory operation, in accordance with NECA guidelines.

- C. Unless indicated otherwise on the Drawings, provide all material and equipment new, of the best quality and design, free from defects and imperfections and with markings or a nameplate identifying the manufacturer and providing sufficient reference to establish quality, size and capacity. Provide all material and equipment of the same type from the same manufacturer whenever practicable.
- D. Unless specified otherwise, manufactured items of the same types specified within this Division shall have been installed and used, without modification, renovation, or repair for not less than one year prior to date of bidding for this Project.

1.04 CODES, REFERENCES AND STANDARDS

- A. Execute all Work in accordance with, and comply at a minimum with, National Fire Protection Association (NFPA) codes, state and local building codes, and all other applicable codes and ordinances in force, governing the particular class of Work involved, for performance, workmanship, equipment, and materials. Additionally, comply with rules and regulations of public utilities and municipal departments affected by connection of services. Where conflicts between various codes, ordinances, rules, and regulations exist, comply with the most stringent. Wherever requirements of these Specifications, Drawings, or both, exceed those of the above items, the requirements of these Specifications, Drawings, or both, shall govern. Code compliance, at a minimum, is mandatory. Construe nothing in these Construction Documents as permitting work not in compliance, at a minimum, with these codes. Bring all conflicts observed between codes, ordinances, rules, regulations and these documents to the Architect's and Engineer's attention in sufficient time, to prepare the Supplementary Drawings and Specifications Addenda required to resolve the conflict.
- B. If the conflict is not reported timely, prior to the opening of bids, resolve the conflict and provide the installation in accordance with the governing codes and to the satisfaction of the Architect and Engineer, without additional compensation. Contractor will be held responsible for any violation of the law.
- C. Obtain timely inspections by the constituted authorities having jurisdiction; and, upon final completion of the Work, obtain and deliver to the Owner executed final certificates of acceptance from these authorities having jurisdiction.
- D. All material, manufacturing methods, handling, dimensions, methods of installation and test procedures shall conform to industry standards, acts, and codes, including, but not limited to the following, except where these Drawings and Specifications exceed them:
 - IBC International Building Code
 - ADA Americans with Disabilities Act
 - AEIC Association of Edison Illuminating Companies
 - ANSI American National Standards Institute
 - ASTM American Society of Testing Materials
 - AWS American Welding Society
 - AWWA American Water Works Association
 - CSA/USA Canadian Standards Association/USA
 - ICEA Insulated Conductors Engineers Association
 - IEEE Institute of Electrical and Electronics Engineers
 - IES Illuminating Engineering Society
 - NBFU National Board of Fire Underwriters
 - NEC National Electrical Code, NFPA 70
 - NECA National Electrical Contractors Association
 - NEMA National Electrical Manufacturers' Association
 - NETA International Electrical Testing Association
 - NFPA National Fire Protection Association
 - OSHA Occupational Safety and Health Act
 - UL Underwriter's Laboratories

- E. Comply with rules and regulations of public utilities and municipal departments affected by connections of services.
 - F. Perform all electrical work in compliance with applicable safety regulations, including OSHA regulations. All safety lights, guards, and warning signs required for the performance of the electrical work shall be provided by the Contractor.
- 1.05 DEFINITIONS
- A. Whenever used in these Specifications or Drawings, the following terms shall have the indicated meanings:
 - 1. Furnish: "To supply and deliver to the project site, ready for unloading, unpacking, assembling, installing, and similar operations."
 - 2. Install: "To perform all operations at the project site, including, but not limited to, and as required: unloading, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, testing, commissioning, starting up and similar operations, complete, and ready for the intended use."
 - 3. Provide: "To furnish and install complete, and ready for the intended use."
 - 4. Furnished by Owner (or Owner-Furnished) or Furnished by Others: "An item furnished by the Owner or under other Divisions or Contracts, and installed under the requirements of this Division, complete, and ready for the intended use, including all items and services incidental to the Work necessary for proper installation and operation. Include the installation under the warranty required by this Division."
 - 5. Engineer: Where referenced in this Division, "Engineer" is the Engineer of Record and the Design Professional for the Work under this Division, and is a Consultant to, and an authorized representative of, the Architect, as defined in the General and/or Supplementary Conditions. When used in this Division, it means increased involvement by, and obligations to, the Engineer, in addition to involvement by, and obligations to, the "Architect".
 - 6. AHJ: The local code and/or inspection agency (Authority) Having Jurisdiction over the Work.
 - 7. NRTL: Nationally Recognized Testing Laboratory, as defined and listed by OSHA in 29 CFR 1910.7 (e.g., UL, ETL, CSA, etc.), and acceptable to the Authority having Jurisdiction (AHJ) over this project. Nationally Recognized Testing Laboratories and standards listed are used only to represent the characteristics required and are not intended to restrict the use of other NRTLs that are acceptable to the AHJ, and standards that meet the specified criteria.
 - B. The terms "approved equal", "equivalent", or "equal" are used synonymously and shall mean "accepted by or acceptable to the Engineer as equivalent to the item or manufacturer specified". The term "approved" shall mean labeled, listed, or both, by an NRTL, and acceptable to the AHJ over this project.
 - C. Manufacturers: The listing of specific manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.
- 1.06 COORDINATION
- A. Coordinate with other Divisions for electrical work included in them but not listed in Division 26 or indicated on electrical Drawings.
 - B. Visit the site and ascertain the conditions to be encountered in installing the Work under this Division, verify all dimensions and locations before purchasing equipment or commencing work, and make due provisions for same in the bid. Failure to comply with this requirement shall not be considered justification for omission, alteration, and incorrect or faulty installation of any of the Work under this Division or for additional compensation for any Work covered by this Division.
 - C. Refer to Drawings and Divisions of the other trades and to relevant equipment drawings and shop drawings to determine the extent of clear spaces. Make all offsets required to clear equipment, beams

and other structural members, and to facilitate concealing conduit in the manner anticipated in the design.

- D. Provide materials with trim that will fit properly the types of ceiling, wall, or floor finishes actually installed.
- E. Maintain an electrical foreman on the jobsite at all times to coordinate this Work with other trades so that various components of the electrical systems is installed at the proper time, fits the available space, and allows proper service access to all equipment. Carry on the Work in such a manner that the Work of the other trades will not be handicapped, hindered, or delayed at any time.
- F. Work of this Division shall progress according to the "Construction Schedule" as described in Division 1 and as approved by the Architect. Cooperate in establishing these schedules and perform the Work under this Division, in a timely manner in conformance with the construction schedule so as to ensure successful achievement of all schedule dates.

1.07 MEASUREMENTS AND LAYOUTS

- A. The Drawings are schematic in nature, but show the various components of the systems approximately to scale and attempt to indicate how they are to be integrated with other parts of the Work. Figured dimensions take precedence to scaled dimensions. Determine exact locations by job measurements, by checking the requirements of other trades, and by reviewing all Contract Documents. Correct, at no additional costs to the Owner, errors that could have been avoided by proper checking and inspection.

1.08 OPERATION AND MAINTENANCE DATA

- A. Refer to Division 1 and General Conditions for Operation and Maintenance Data.
- B. Instruct the Owner's permanent personnel in the proper operation of, startup and shutdown procedures and maintenance of the equipment and components of the systems installed under this Division.
- C. Prior to Substantial Completion of the project, furnish to the Architect, for Engineer's review, and for the Owner's use, four (4) copies of brochures in three-ring, loose-leaf, hard-back notebook form, divided and tabbed, containing equipment data, approved submittals, shop drawings, diagrams, capacities, spare part numbers, manufacturer's service and maintenance data, warranties, guarantees, etc. Include local contacts complete with address and telephone number, for equipment, apparatus, and system components furnished and installed under this Division of the specifications.

1.09 SPARE PARTS

- A. Provide to the Owner the spare parts specified in the individual sections of this Division.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Refer to Division 1 and General Conditions for Delivery, Storage and Handling.
- B. Deliver equipment and material to the job site in their original containers with labels intact, fully identified with manufacturer's name, make, model, model number, type, size, capacity and Underwriter's Laboratories, Inc. labels and other pertinent information necessary to identify the item.
- C. Deliver, receive, handle and store equipment and materials at the job site in the designated area and in such a manner as to prevent equipment and materials from damage and loss. Store equipment and materials delivered to the site on pallets and cover with waterproof, tear resistant tarp or plastic or as required to keep equipment and materials dry. Follow manufacturer's recommendations, and at all times, take every precaution to properly protect equipment and material from damage, including the erection of temporary shelters to adequately protect equipment and material stored at the Site.

Equipment and/or material which becomes rusted or damaged shall be replaced or restored by the Contractor to a condition acceptable to the Architect and Engineer.

- D. Be responsible for the safe storage of tools, material and equipment.

1.11 WARRANTIES

- A. Refer to Division 1 and General Conditions for Warranties.
- B. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.
- C. Warrant each system and each element thereof against all defects due to faulty workmanship, design or material for a period of 12 months from date of Substantial Completion, unless specific items are noted to carry a longer warranty in these Construction Documents or manufacturer's standard warranty exceeds 12 months. Remedy all defects, occurring within the warranty period(s), as stated in the General Conditions and Division 1.
- D. Also warrant the following additional items:
 - 1. All raceways are free from obstructions, holes, crushing, or breaks of any nature.
 - 2. All raceway seals are effective.
 - 3. The entire electrical system is free from all short circuits and unwanted open circuits and grounds.
- E. The above warranties shall include labor and material. Make repairs or replacements without any additional costs to the Owner.
- F. Perform the remedial work promptly, upon written notice from the Architect or Owner.
- G. At the time of Substantial Completion, deliver to the Owner all warranties, in writing and properly executed, including term limits for warranties extending beyond the one year period, each warranty instrument being addressed to the Owner and stating the commencement date and term.

1.12 TEMPORARY FACILITIES

- A. Refer to Division 1 and General Conditions for Temporary Facilities requirements.
- B. Temporary Utilities: The types of services required include, but are not limited to, electricity, telephone, and internet. When connecting to existing franchised utilities for required services, comply with service companies' recommendations on materials and methods, or engage service companies to install services. Locate and relocate services (as necessary) to minimize interference with construction operations.
- C. Construction Facilities: Provide facilities reasonably required to perform construction operations properly and adequately.
 - 1. Enclosures: When temporary enclosures are required to ensure adequate workmanship, weather protection and ambient conditions required for the work, provide fire-retardant treated lumber and plywood; provide tarpaulins with UL label and flame spread of 15 or less; provide translucent type (nylon reinforced polyethylene) where daylighting of enclosed space would be beneficial for workmanship, and reduce use of temporary lighting.
 - 2. Heating: Provide heat, as necessary, to protect work, materials and equipment from damage due to dampness and cold. In areas where building is occupied, maintain a temperature not less than 65 degrees F. Use steam, hot water, or gas from piped distribution system where available. Where steam, hot water or piped gas are not available, heat with self-contained LP gas or fuel oil heaters, bearing UL, FM or other approval labels appropriate for application. Vent fuel-burning heaters, and equip units with individual-space thermostatic controls. Use electric resistance space heaters only where no other, more energy-efficient, type of heater is available and allowable.

1.13 PROJECT CONDITIONS

- A. Conditions Affecting Work In Existing Buildings: The following project conditions apply:
1. The Drawings describe the general nature of remodeling to the existing building; however, visit the Site prior to submitting bid to determine the nature and extent of work involved.
 2. Schedule Work in the existing building with the Owner.
 3. Remove articles that are not required for the new Work. Unless otherwise indicated, remove each item removed during this demolition from the premises and dispose in accordance with applicable federal, state and local regulations.
 4. Finish material will be installed under other Divisions.
 5. Obtain permission from the Architect for channeling of floors or walls not specifically noted on the Drawings.
 6. Protect adjacent materials indicated to remain. For Work specific to this Division, install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
- B. Use of explosives is not permitted.
- C. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits specified by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

PART 2 - PRODUCTS AND MATERIALS

Not Used.

PART 3 - EXECUTION

3.01 TEMPORARY ELECTRICAL SERVICE AND WIRING

- A. Provide 208Y/120 volt, three-phase, four-wire, temporary electrical service and temporary lighting system to facilitate construction.
- B. In existing facilities, with Owner's approval, Contractor may utilize the existing electrical system as the source of temporary power. Coordinate the point of connection and method of connection to the existing system with the Owner's Representative.
- C. Pay all charges made by the Electric Utility, with respect to installation and energy charges for temporary services.
- D. Work for the temporary power shall consist of all labor and materials, including, but not limited to conduit, wiring, panelboards, fuse blocks, fused disconnecting switches, fuses, pigtails, receptacles, wood panel switch supports, and other miscellaneous materials required to complete the power system.
- E. Install all temporary wiring in accordance with applicable codes, and maintain in an OSHA-approved manner.
- F. Provide an adequate number of GFCI type power distribution centers, rated 208Y/120V, four-wire, and not less than 60A, with sufficient fuse blocks or breakers for lighting and hand tool circuits, 60A four-wire feeders, all mounted within pre-fabricated enclosures UL listed for this application or on suitable wood panels bolted to columns or upright wood supports as required.
- G. Install circuits to points on each level of each building so that service outlets can be reached by a 50-foot extension cord for 120V power and a 100-foot extension cord for 208V power (or as required by OSHA or local authorities).
- H. Provide one lighting outlet per 30 linear feet of corridor and at least one light in each room and for every 800 square feet of floor area. Temporary lighting shall comply with OSHA requirements.

- I. If additional service is required for cranes, electrical welders or for electric motors over 1/2 HP per unit, such additional service shall become the responsibility of the trade involved.
 - J. When the permanent wiring for lighting and power is installed, with approval of the Architect and Owner, the permanent system may be used, provided the Contractor assumes full responsibility for all electrical material, equipment, and devices contained in the systems and provided that roof drainage system and roofing are complete.
 - K. When directed by the Architect, remove all temporary services, lighting, wiring and devices from the property.
- 3.02 SELECTIVE DEMOLITION
- A. Refer to Division 1, Division 2, and General Conditions for Selective Demolition requirements.
 - B. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.
 - C. Electrical Materials and Equipment: Demolish, remove, demount, and disconnect the following items:
 - 1. Inactive and obsolete raceways, fittings, supports and specialties, equipment, wiring, controls, fixtures, and insulation:
 - a. Raceways and outlets embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Cut embedded raceways to below finished surfaces, seal, and refinish surfaces as specified or as indicated on the Architectural finish Drawings. Remove materials above accessible ceilings. Cap raceways allowed to remain.
 - b. Perform cutting and patching required for demolition in accordance with Division 1, General Conditions and "Cutting and Patching" portion of this Section in Division 26.
- 3.03 EXISTING CONDITIONS
- A. Existing conditions indicated on the Drawings are taken from the best information available from the Owner, existing record drawings, and from limited, in-situ, visual site observations; and, they are not to be construed as "AS BUILT" conditions. The information is shown to help establish the extent of the new Work.
 - B. Verify all actual existing conditions at the project site and perform the Work as required to meet the existing conditions and the intent of the Work indicated.
- 3.04 ACCESS TO EQUIPMENT
- A. Locate all pull boxes, junction boxes and controls so as to provide easy access for operation, service inspection and maintenance. Provide an access door where equipment or devices are located above inaccessible ceilings. Refer to Division 26 Section "Basic Electrical Materials And Methods".
 - B. Maintain all code required clearances and clearances required by manufacturers.
- 3.05 CUTTING AND PATCHING
- A. Provide all necessary cutting of walls, floors, ceilings and roofs for work under this Division.
 - B. Cut no structural member without permission from Architect.
 - C. Patch around all openings to match adjacent construction.
 - D. After the final waterproofing membrane has been installed, roofs may be cut only with written permission by the Architect.

3.06 PAINTING

- A. Refer to Division 9 Section "Painting" for painting requirements.
- B. Paint exposed ferrous surfaces, including, but not limited to, hangers, equipment stands and supports using materials and methods as specified under Division 9 of the Specifications; colors shall be as selected by the Architect.
- C. Re-finish all field-threaded ends of galvanized conduits and field-cut ends of galvanized supports with a cold-galvanizing compound approved for use on conductive surfaces. Follow closely manufacturer's instructions for pre-cleaning surfaces and application.
- D. Factory finishes and shop priming and special finishes are specified in the individual equipment Specification sections.
- E. Where factory finishes are provided and no additional field painting is specified, touch up or refinish, as required by, and to the acceptance of, the Architect and Engineer, marred or damaged surfaces so as to leave a smooth, uniform finish. If, in the opinion of the Architect or Engineer, the finish is too badly damaged to be properly re-finished, replace the damaged equipment or materials at no additional costs to the Owner.

3.07 CLEANING

- A. Remove dirt and refuse, resulting from the performance of the Work, from the premises as required to prevent accumulation. Cooperate in maintaining reasonably clean premises at all times.
- B. Immediately prior to final inspection, make a final cleanup of dirt and refuse resulting from Work and assist in making the premises broom clean. Clean all material and equipment installed under this Division.
- C. Remove dirt, dust, plaster, stains, and foreign matter from all surfaces.
- D. Touch up and restore damaged finishes to their original condition.

3.08 ADJUSTING, ALIGNING AND TESTING

- A. Adjust, align and test all electrical equipment furnished and/or installed under this Division.
- B. Check motors for alignment with drive and proper rotation, and adjust as required.
- C. Check and test protective devices for specified and required application, and adjust as required.
- D. Check, test and adjust adjustable parts of all light fixtures and electrical equipment as required to produce the intended performance.
- E. Verify that completed wiring system is free from short circuits, unintentional grounds, low insulation impedances, and unintentional open circuits.
- F. After completion, perform tests for continuity, unwanted grounds, and insulation resistance in accordance with the requirements of NFPA 70 and NETA.
- G. Be responsible for the operation, service and maintenance of all new electrical equipment during construction and prior to acceptance by the Owner of the complete project under this Contract. Maintain all electrical equipment in the best operating condition including proper lubrication.
- H. Notify the Architect immediately of all operational failures caused by defective material, labor or both.

- I. Maintain service and equipment for all testing of electrical equipment and systems until all Work is approved and accepted by the Owner.
 - J. Refer to individual Sections for additional and specific requirements.
- 3.09 START-UP OF SYSTEMS
- A. Prior to start-up of electrical systems, check all components and devices, lubricate items appropriately, and tighten all screwed and bolted connections to manufacturers' recommended torque values using appropriate torque tools.
 - B. Each power, lighting and control circuit shall be energized, tested and proved free of breaks, short circuits and unwanted grounds.
 - C. Adjust taps on each transformer for rated secondary voltages.
 - D. Balance all single phase loads at each panelboard, redistributing branch circuit connections until balance is achieved to plus or minus 10 percent.
 - E. Replace all burned-out lamps. Replace the lamps of all light fixtures that use incandescent, halogen or quartz lamp sources that are installed as part of the finished building, but are used by the Contractor during construction, with new lamps of appropriate type and wattage prior to turning the facility over to the Owner or Tenant.
 - F. After all systems have been inspected and adjusted, confirm all operating features required by the Drawings and Specifications and make final adjustments as necessary.
 - G. Demonstrate that all equipment and systems perform properly as designed per Drawings and Specifications.
 - H. At the time of final review and tests of the power and lighting systems, all equipment and system components shall be in place and all connections at panelboards, switches, circuit breakers, and the like, shall be complete. All fuses shall be in place, and all circuits shall be continuous from point of service connections to all switches, receptacles, outlets, and the like.
- 3.10 TEST REPORTS
- A. Perform tests as required by these Specifications and submit the results in the operations and maintenance manuals. The tests shall establish the adequacy, quality, safety, and reliability for each electrical system installed. Notify the Architect and Engineer two working days prior to each test.
 - B. For specific testing requirements of special systems, refer to the Specification section that describes that system.
 - C. Upon completing each test, record the results, date and time of each test and the conditions under which the test was conducted. Submit to the Architect, for Engineer's review, in duplicate, the test results for the following electrical items:
 - 1. Proper phasing throughout the entire system.
 - 2. Voltages (phase-to-phase and phase-to-neutral) and amperes at each phase for each panelboard, switchboard, and the like.
 - 3. Phase voltages and amperes at each three-phase motor.
 - 4. Test all wiring devices for electrical continuity and proper polarity of connections.
 - D. Promptly correct all failures or deficiencies revealed by these tests as determined by the Engineer.

END OF SECTION



SECTION 26 51 00

INTERIOR LIGHTING

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes the following:
 - 1. Interior light fixtures, lamps, and ballasts (includes exterior light fixtures normally installed on exterior surfaces of buildings).
 - 2. Light fixture supports.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve a certifiable rating, measured and documented according to the LEED for Homes, Green Building Rating System, of the US Green Building Council (USGBC).
- C. Comply with the requirements of Section 01 74 00, Construction Waste Management, for removal and disposal of construction debris and waste.

1.02 RELATED SECTIONS INCLUDE THE FOLLOWING:

- A. Division 26 Section "General Electrical Requirements" for general requirements and related documents that apply to this Section.
- B. Division 26 Section "Basic Electrical Materials and Methods" for raceways, conductors, cables, and cords.
- C. Division 26 Section "Exterior Lighting" for exterior light fixtures, except those normally mounted on exterior surfaces of buildings.

1.03 SUBMITTALS

- A. Product Data: For each type of light fixture, collated and bound in sets, and arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Name of manufacturer.
 - 2. Descriptive cut sheets providing physical description of light fixture including dimensions and weights.
 - 3. Fixture efficiency.
 - 4. Coefficient of utilization tables.
 - 5. Light fixture voltage.
 - 6. The number, type and wattage of the light fixture lamps (including cutsheet).
 - 7. Lens type (if applicable).
 - 8. Light fixture options that are to be provided.
 - 9. Light fixture mounting details, including non-standard outlet boxes.
 - 10. Construction of light fixture housing and door (if applicable).
 - 11. Light fixture ballast manufacturer, number and type per light fixture.
 - 12. Light fixture finish and color (if applicable).
 - 13. Descriptive cut sheets providing physical description of lamps, including voltage, wattage, efficacy, CCT, CRI, lumens, and life expectancy.
 - 14. Photometric data, in IESNA format, based on laboratory tests of each light fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the light fixture as applied in this Project.
 - a. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
 - 15. Descriptive cut sheets providing physical description of emergency ballasts for use in normal light fixtures, including complete battery information, lumens, and method for testing per NFPA 101.

INTERIOR LIGHTING

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- C. Coordination Drawings: Reflected ceiling plan(s) 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. Light fixtures.
 - 2. Suspended ceiling components.
 - 3. Structural members to which suspension systems for light fixtures will be attached.
 - 4. Other items in finished ceiling including the following:
 - a. Air outlets and inlets.
 - b. Speakers.
 - c. Smoke and carbon monoxide detectors.
 - d. Access panels.
 - 5. Perimeter moldings and trims.
 - D. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.
 - E. Qualification Data: For agencies providing photometric data for light fixtures.
 - F. Field quality-control test reports.
 - G. Operation and Maintenance Data: For lighting equipment and fixtures to include in operation and maintenance manuals.
 - H. Warranties: Special warranties specified in this Section.
 - I. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section. Comply with requirements of Section 01 35 15, LEED Submittals.
- 1.04 DEFINITIONS
- A. BF: Ballast factor.
 - B. CCT: Correlated color temperature
 - C. CRI: Color-rendering index.
 - D. CU: Coefficient of utilization.
 - E. HID: High-intensity discharge.
 - F. LER: Light fixture (Luminaire) efficiency rating.
 - G. Light Fixture: Complete light fixture, including ballast housing if provided.
 - H. RCR: Room cavity ratio.
- 1.05 QUALITY ASSURANCE
- A. Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, Article 100, by an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 2. Marked for intended use.
 - B. Comply with NFPA 70.

- C. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - 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.
- 1.06 COORDINATION
- A. Unless otherwise noted, perform all electrical Work required for the proper installation and operation of equipment, furnishings, devices and systems specified in other Divisions of these Specifications, furnished under other contracts, and/or furnished by the Owner for installation under this Contract.
 - B. Coordinate layout and installation of light fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.
- 1.07 WARRANTY
- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
 - 2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.
 - B. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.
 - 2. Warranty Period for Electromagnetic Ballasts: Three years from date of Substantial Completion.
 - C. Special Warranty for T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
 - 1. Warranty Period: Two year(s) from date of Substantial Completion.
- 1.08 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. Additional light fixtures and accessories as scheduled on the Drawings.
 - B. Where light fixtures are specified with tamper proof hardware, provide the Owner with three tools for each different type of hardware.
- 1.09 SPARES
- A. Furnish spare materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Battery and Charger Data: One for each emergency lighting unit.
 - 4. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS AND MATERIALS

2.01 MANUFACTURERS

- A. In Light Fixture Schedule where titles below are column or row headings that 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.
 3. Basis-of-Design Product: The design for each light fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.02 LIGHT FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Provide light fixtures as shown on the drawings and/or specified. This shall include all lamps, material and labor to securely hang light fixtures, clean them and make them completely ready for use. Provide all hangers, supports, and miscellaneous hardware required to install light fixtures. Provide additional tie wires connected to structure to conform to applicable seismic requirements where required.
- B. Light fixture models scheduled on the Drawings are to show the manufacturer, grade and style of light fixtures required. Regardless of the manufacturer's catalog number suffixes indicated, provide all options and features as described in the Light Fixture Schedule.
- C. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- D. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- E. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- F. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
- G. Metal Parts: Free of burrs and sharp corners and edges.
- H. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- I. 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.
- J. 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.
- K. 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 minimum unless different thickness is indicated.
 - b. UV stabilized.
 2. Glass: Annealed crystal glass, unless otherwise indicated.

2.03 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. Electronic Ballasts: 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.
 - 2. Total Harmonic Distortion Rating: Less than 10 percent.
 - 3. Transient Voltage Protection: IEEE C62.41, Category A or better.
 - 4. Operating Frequency: 42 kHz or higher.
 - 5. Lamp Current Crest Factor: 1.7 or less.
 - 6. BF: 0.85 or higher.
 - 7. Power Factor: 0.98 or higher.
 - 8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C 82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
- B. Electronic Programmed-Start Ballasts for T5 and T5HO Lamps: Comply with ANSI C82.11 and the following:
 - 1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
 - 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: 0.98 or higher.
- C. Electromagnetic Ballasts: 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.
- D. Single Ballasts for Multiple Light Fixtures: Factory-wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- E. Ballasts for Low-Temperature Environments:
 - 1. Temperatures 0 Deg F and Higher: Electronic or electromagnetic type rated for 0 deg F starting and operating temperature with indicated lamp types.
 - 2. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with indicated lamp types.
- F. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
- G. Ballasts for Dimmer-Controlled Light Fixtures: 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. Ballasts for Bi-Level Controlled Light Fixtures: 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: 50 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.

2.04 BALLASTS FOR COMPACT FLUORESCENT LAMPS

- A. Description: 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: 0.98 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.
- B. Ballasts for Dimmer-Controlled Light Fixtures: 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.

2.05 BALLASTS FOR HID LAMPS

- A. 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 for single-lamp ballasts.
 3. Normal Ambient Operating Temperature: 104 deg F.
 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.
- B. 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.
 9. Retain subparagraph and associated subparagraphs below for bi-level ballasts.
 10. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
 - a. High-Level Operation: 100 percent of rated lamp lumens.
 - b. Low-Level Operation: 50 percent of rated lamp lumens.
 - c. Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.

11. Continuous Dimming Ballast: Dimming range shall be from 100 to 35 percent of rated lamp lumens without flicker.

- a. Ballast Input Watts: Reduced to a maximum of 50 percent of normal at lowest dimming setting.
- b. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.

C. Auxiliary Instant-On Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent light output.

2.06 LAMPS GENERAL

A. Unless specific manufacturers and lamp types are called for in the Light Fixture Schedule, all lamps provided for this project shall be by the same manufacturer. Lamps shall be manufactured by:

1. Osram/Sylvania
2. Philips
3. General Electric
4. Venture

B. All lamps shall be new and shall be delivered to the project in manufacturer's original sealed package.

2.07 FLUORESCENT LAMPS

A. Low-Mercury 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 lamps, rated 32 W maximum, nominal length of 48 inches, 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 lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

D. T5 rapid-start lamps, rated 28 W maximum, nominal length of 45.2 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3000 K, and average rated life of 20,000 hours, unless otherwise indicated.

E. T5HO rapid-start, high-output low-mercury lamps, rated 54 W maximum, nominal length of 45.2 inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of 20,000 hours, unless otherwise indicated.

F. Compact Fluorescent Lamps: 4-Pin, 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).

2.08 LIGHT FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Electrical Supports and Seismic Restraints" for channel- and angleiron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch 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.
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. 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 EXAMINATION

- A. Verify conditions of equipment and installation prior to beginning work.
- B. Verify that equipment is ready for connecting, wiring, and energizing.

3.02 INSTALLATION

- A. Light Fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Light Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from light fixture corners.
 2. Support Clips: Fasten to light fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
- C. Suspended Light Fixture Support:
 1. Pendants and Rods: Where longer than 48 inches, 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. Provide suitable connectors or collars to connect adjoining units to appear as a continuous unit.
- D. Adjust aimable light fixtures to provide required light intensities.
- E. Connect wiring according to Division 16 Section "Conductors and Cables."
- F. Through wiring of recessed light fixtures, in suspended ceilings, is not permitted. Connect each light fixture by a whip to a junction box. The whip shall be of sufficient length to allow the light fixture to be relocated within a 6-foot radius.
- G. Wall Mounted Light fixtures
 1. Unless otherwise noted, conceal all raceways and back boxes for wall mounted light fixtures.

3.03 MULTI-LEVEL SWITCHING

- A. The lighting design for this project has included multi-level (inboard/outboard) switching. Where indicated, 3-lamp light fixtures shall have the center lamp switched from the switch nearest the door and the outer 2 lamps switched from the other switch.
- B. Where indicated, 4-lamp light fixtures shall have the outer 2 lamps switched from one switch and the center 2 lamps shall be switched from the other switch.
- C. A similar multi-level lighting arrangement shall be provided where 4- and 3-way switches are shown. Where only one switch is shown at the alternate location it shall control the center lamp. Light fixtures indicated to have multi-level switching shall be furnished with the proper number of ballasts.

3.04 COORDINATION

- A. Light fixtures shown on the Electrical Drawings represent general arrangements only. Refer to Architectural Drawings for exact locations.
- B. Coordinate the installation and location of light fixtures with other work and all other trades before installation to avoid conflicts. Coordinate light fixture locations in mechanical rooms with final installed piping and ductwork layouts.
- C. Verify all ceiling systems and coordinate light fixture type and accessories prior to ordering light fixtures. Coordinate and cooperate with ceiling installer in regards to the location and installation of light fixtures.
- D. Wall-Mounted Light fixtures
 - 1. Coordinate all wall-mounted light fixtures with the architectural features of the building. Where specific elevations or dimensions are not indicated, verify the correct location with the Architect prior to beginning any work.

3.05 ADJUSTING

- A. Adjust all light fixture sockets to match the lamp specified and aim all adjustable light fixtures as directed by the Architect.
- B. At the time of substantial completion, aim all track lights, flood lights, spot lights, and other fixtures requiring aiming per the Architect's direction. Provide all scaffolds, lifts, and other tools and equipment as required.

3.06 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. Clean light fixtures of dirt and debris upon completion of the installation. Protect installed light fixtures from damage during the remainder of the construction period.
- C. Upon completion of the installation of light fixtures, and after building circuits have been energized, energize lighting branch circuits to demonstrate capability and compliance with the requirements. Where possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.
- D. At the time of final acceptance of this project by the Owner, ensure that all lamps are in working order and all light fixtures are fully lamped.
- E. 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



TEAM BOSTON
SOLAR DECATHLON 2009

STUCTURAL CALCULATIONS



STRUCTURAL CALCULATIONS TABLE OF CONTENTS SOLAR HOUSE

GENERAL INFORMATION

1. Loading Summary

A. Gravity and Lateral Loads-----pgs 1.1-1.15

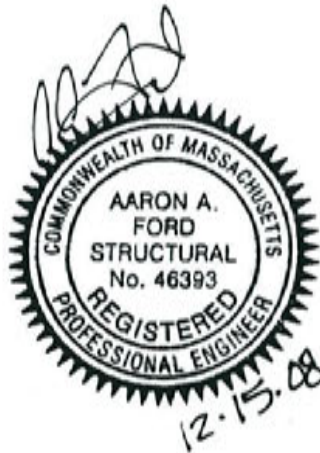
STRUCTURAL DESIGN

2. Gravity Analysis

A. Foundations, Steel and Wood Structure-----pgs 2.1-2.14

3. Lateral Analysis

A. Wood Shear Walls and Steel Brace Frames-----pgs 3.1- 3.19

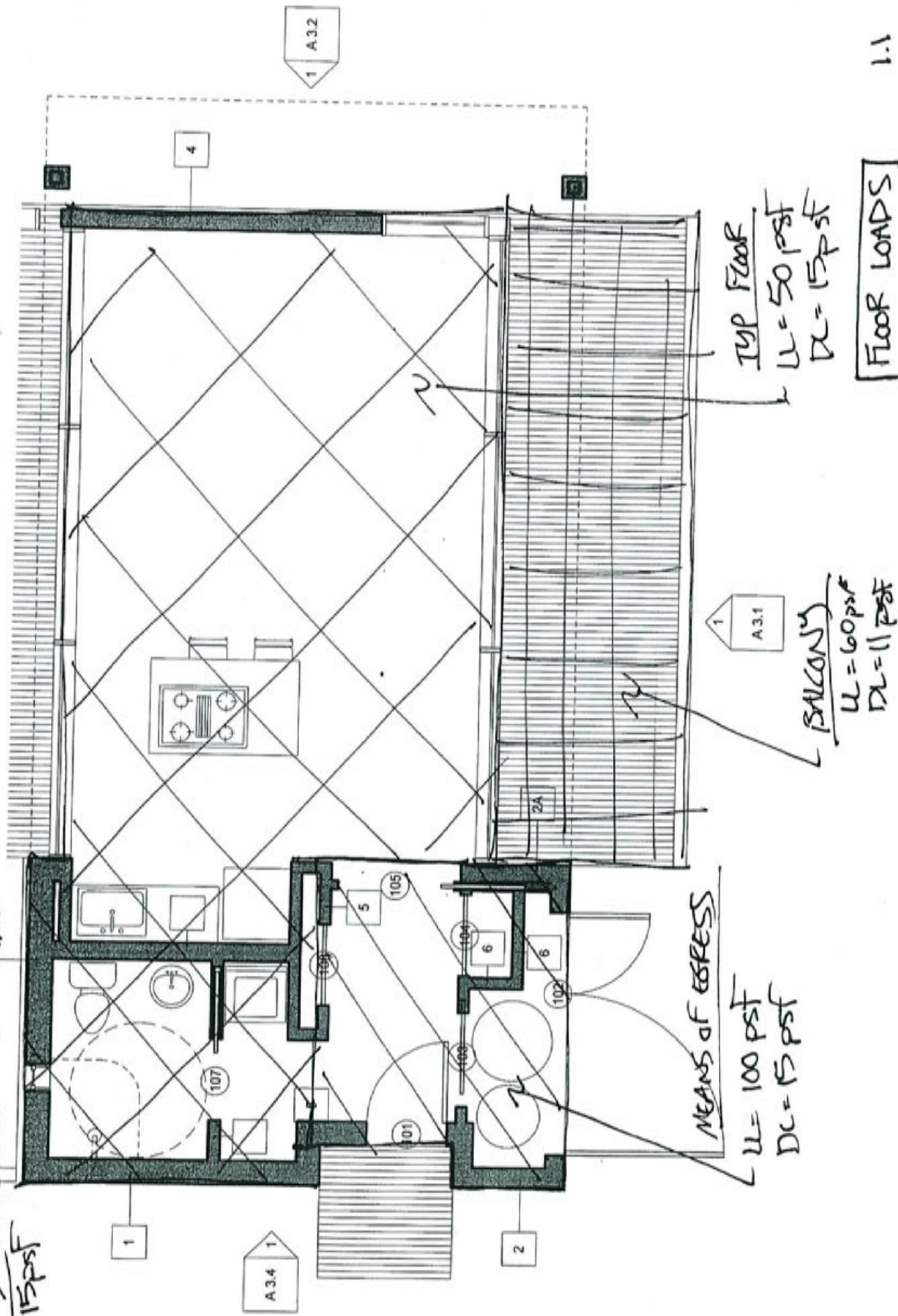


DL Summary

60	3	3 • Sheathing ($\frac{3}{8}$ " 1-layer)
4	4	4 • FRG (2x10 top)
2	2	2 • FLOORING
1	3	3 • CALCATEL
0	3	3 • UNDER FLOOR INSUL - COEFFING
104		<u>15 psf</u>

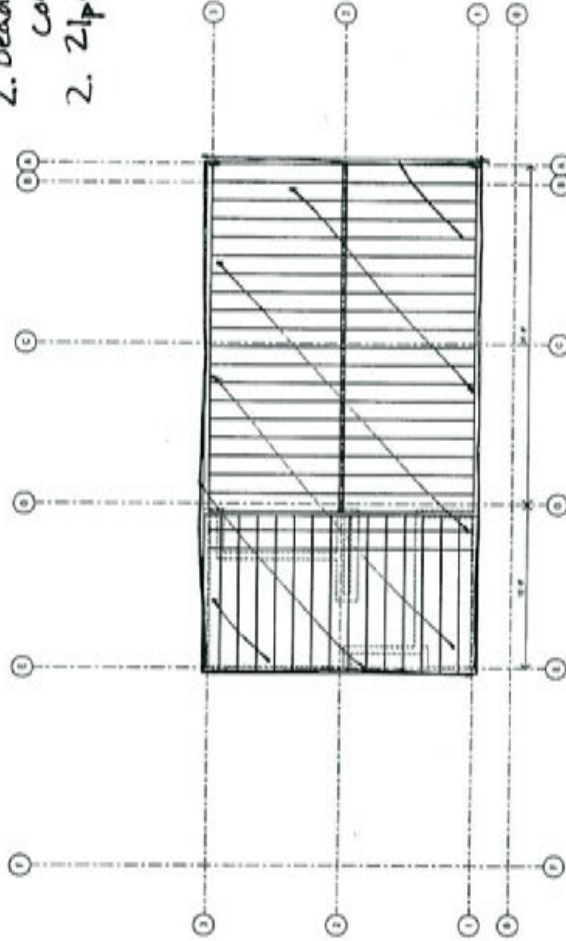
DL BALCONY SUMMARY

4	4 • 2x10 FRG
4	4 • DECKING ($1\frac{1}{2}$ " x 0.5 x 62.4)
3	3 • COLL
	<u>11 psf</u>



1606.2.1 BASIC COMBINATIONS

2. Dead + floor live + roof live (or snow) CONTROLLING
2. $21 \text{ psf} + 0 + 20 \text{ psf} = 41 \text{ psf}$



DL SUMMARY

- 4 • Sheathing (2 layers $\frac{5}{8}$ ")
- 4 • FRG (assume $2 \times 10 @ 16$)
- 3 • Ceiling
- 3 • Collateral (assume asphalt type)
- 2 • Roofing
- 1 • Insulation (batt)
- 4 $\frac{3.5}{13.4} = 2.5 \text{ psf}$ SOLAR PANELS
- 21 psf
- Panel $\frac{3.5 \text{ psf}}{13.4 \text{ ft}} = 2.5 \text{ psf}$
- inverter $\frac{4 \text{ psf}}{13.4 \text{ ft}} = 0.3 \text{ psf}$
- bracket & support = 0.7 psf

DESIGN LOADS - ROOF

$U = 20 \text{ psf}$

$S_L = 20 \text{ psf}$

$D_L = 21 \text{ psf}$

$W_L = -28.6 \text{ OR } +2.5 \text{ psf}$

SEE ATTACHED FOR CONTROLLING ROOF LOAD COMB
CONTROLLING IS $D + 0.75W + 0.75S$
 $= 21 + 9.4 + 15$

ROOF LOADS $\frac{1}{2} 12$

HOUSE NAME

TEAM BOSTON
SOLAR DECATHLON 2008

KEY PLAN

SHEET TITLE
Roof Plan

SCALE: $\frac{1}{4}" = 1'-0"$
DATE: JUN 2008
SHEET NO:

S1.3



NET ROOF WIND LOAD (ROOF + SOAR PANEL)

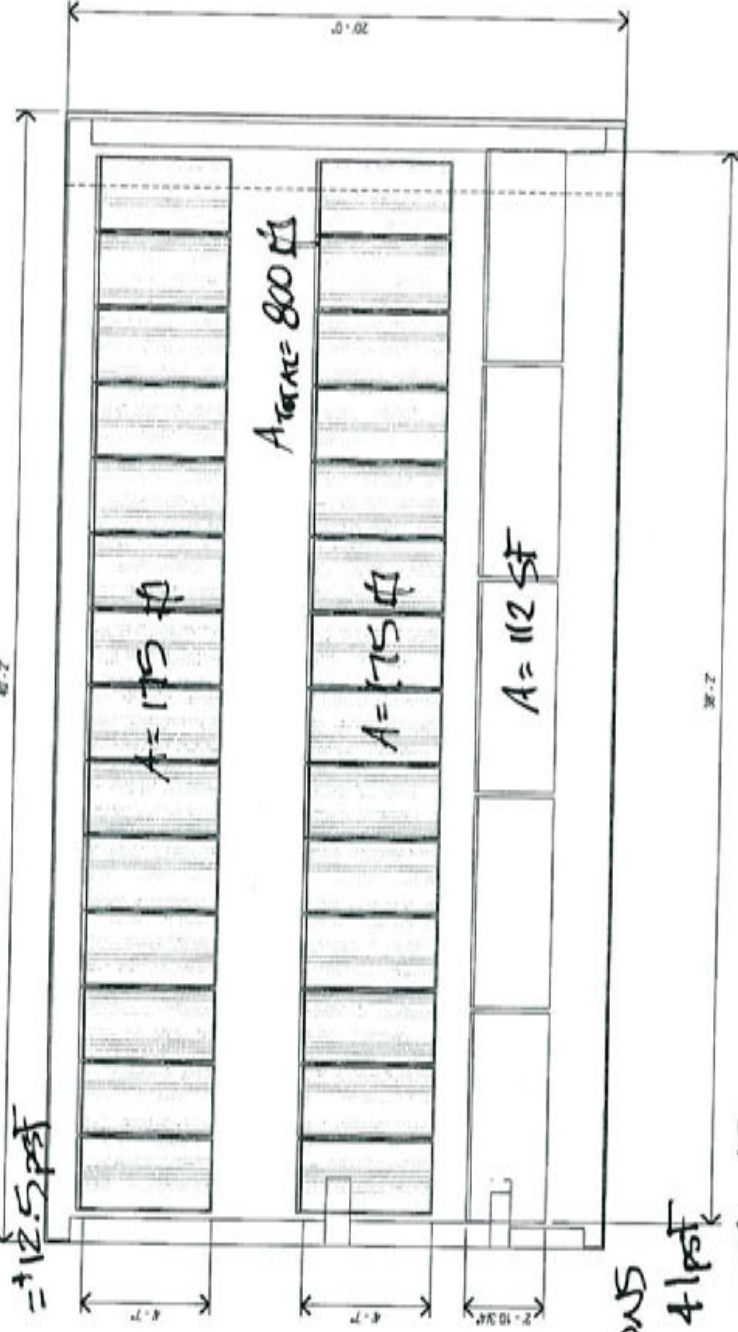
$$P_{NET} = P_{FF} + P_{SOAR \text{ PANEL}}$$

$$= -14.2 \text{ psf} + \left[\frac{462 \text{ SF}}{800 \text{ SF}} \times -25 \text{ psf} \right]$$

$$= -28.6 \text{ psf}$$

$$P_{NET \text{ DOWNWARD}} = \left[\frac{1}{2} \times 0.4 \times 12.2 \right] \left[\frac{462}{800} \times 0.1 \right]$$

$$= -12.5 \text{ psf}$$



ROOF LOAD CONSIDERATIONS

$$D + S = 21 + 20 = 41 \text{ psf}$$

$$D + W = 21 + 12.5 = 33.5 \text{ psf}$$

$$D + 0.75W + 0.75S = 21 + (0.75 \times 12.5) + (0.75 \times 20) = 45.4 \text{ psf} \leftarrow \text{controls}$$

$$0.6D - W = (0.6 \times 13) - 28.6 = -20.8 \text{ psf}$$

$$D = 21$$

$$3 \times W + \frac{3}{4} S = 21 \times A$$

ROOF LOADS

2/2

1.3

SUNPOWER

BENEFITS

High Efficiency
Industry leading panel efficiency of 17.3%.

More Power
Delivers up to 50% more power per unit area than conventional solar panels.

Reduces Installation Cost
More power per panel means fewer panels per install. This saves both time and money.

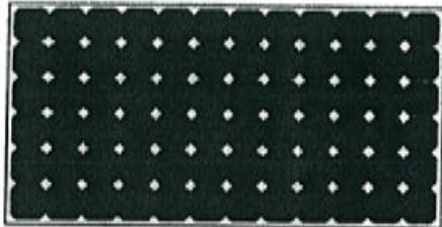
Reliable and Robust Design
Proven materials, tempered front glass, and a sturdy anodized frame allow panel to operate reliably in multiple mounting configurations.



SPR-215-WHT

215 SOLAR PANEL

EXCEPTIONAL EFFICIENCY AND PERFORMANCE



The SunPower 215 Solar Panel provides industry leading efficiency and performance. Utilizing 72 next generation SunPower all-back contact solar cells and an optimized panel design, the SunPower 215 delivers an unprecedented total panel conversion efficiency of 17.3%. The 215 panel's reduced voltage-temperature coefficient and exceptional low-light performance attributes provide for higher energy delivery per peak power than conventional panels.

SunPower's High Efficiency Advantage - up to 50% More Power

Comparable systems covering 25 m ² / 270 ft ²			
	Conventional	SunPower	
Watts / Panel	165	215	
Efficiency	12.0%	17.3%	
W/m ²	3.0	4.3	



PANEL WEIGHT =

$$\frac{33\#}{13.4\text{ ft}^2} = 2.5\text{ PSF}$$

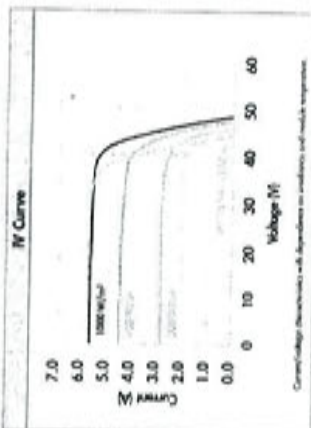
SUNPOWER

215 SOLAR PANEL

EXCEPTIONAL EFFICIENCY AND PERFORMANCE

Electrical Data	
Standard Test Conditions (STC) - irradiance of 1000 W/m ² at 1000 nm (1% total irradiance) 25°C	
Peak Power (P _{max})	215 W
Rated Voltage (V _{mp})	39.8 V
Rated Current (I _{mp})	5.40 A
Open Circuit Voltage (V _{oc})	48.3 V
Short Circuit Current (I _{sc})	5.80 A
Maximum System Voltage (V _{oc})	1000 V, 600 V
Temperature Coefficients	
Power	-0.38% / °C
Voltage (V _{oc})	-136.8 mV / °C
Current (I _{sc})	3.5 mA / °C
Series Fuse Rating	15 A
Peak Power per Unit Area	173 W/m ² , 16.1 W/ft ²
CEC PTC Rating	198.5 W

Mechanical Data	
Solar Cells	72 SunPower all-back contact monocrystalline
Front Glass	3.2 mm (1/8") tempered
Junction Box	IP65 rated with 3 bypass diodes
Output Cables	100 mm length cable / MATEC contact connection
Frame	Anodized aluminum alloy type 6063
Weight	15 kg, 33 lbs



Rated Operating Conditions	
Temperature	+40° C to +85° C (+104° F to +187° F)
Max Load	50 psi (3400 Pascals) front and back
Impact Resistance	1 m-ft - 25 mm (1 in) at 23 m/s (52 mph)
Warranty and Certifications	
Warranty	25 year limited power warranty
	10 year limited product warranty
Certifications	IEC 61215, Safety tested IEC 61730, UL Listed (UL 1700), Class C Fire Rating

Dimensions



$$A = \frac{61.4 \times 31.9}{144\text{ ft}^2} = 13.4\text{ ft}^2$$

About SunPower

SunPower designs, manufactures and delivers high-performance solar electric technology worldwide. Our high-efficiency solar cells generate up to 30 percent more power than conventional solar cells. Our high-performance solar panels, roof tiles and trackers deliver significantly more energy than competing systems.

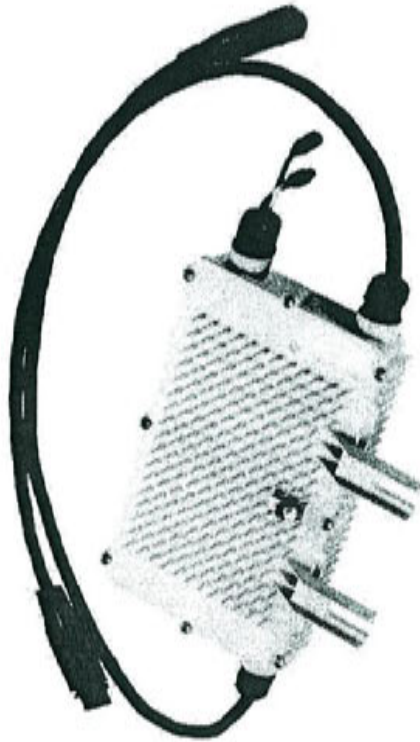
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www.sunpowercorp.com

Solar Panel WEIGHTS



ENPHASE MICRO-INVERTER M175-24-240-S



Enphase Energy presents the first commercially available Micro-Inverter system for residential and commercial solar PV applications. The Enphase Micro-Inverter system utilizes advanced technologies to maximize energy harvest, increase system reliability and dramatically simplify design, installation and management.

PRODUCTIVE

- Maximum energy production
- Resilient to dust, debris and shading
- Performance monitoring per module

RELIABLE

- Very low internal temperature rise
- NEMA 6P rated
- No single point of failure

SMART

- Quick & simple design, installation and management
- Advanced analytics and visualization



MICRO-INVERTER TECHNICAL DATA M175-24-240-S

Input Data (DC)

Recommended Input Power (PTC)	185W
Maximum Input DC Voltage	54V
Peak Power Tracking Voltage	25V ~ 40V
Max. DC Short Circuit Current	10A
Max. Input Current	8A

Output Data (AC)

Maximum Output Power	175W
Nominal Output Current	750mA
Nominal Voltage/Range	240V/211V-264V
Extended Voltage/Range	240V/206V-269V
Nominal Frequency/Range	60.0/59.3-60.5
Extended Frequency/Range	60.0/59.2-60.6
Power Factor	> 0.95
Maximum Units per Branch Circuit	16

Efficiency

Peak Inverter Efficiency	95%
CEC Weighted Efficiency	94.5%
Nominal MPP Tracking	99.6%

Mechanical Data

Dimensions (WxHxD) in Inches	10.5" x 5.5" x 1.5"
Weight	4.0lbs
Ambient Temperature Range	-25°C to +65°C
Nighttime Power Consumption	580mW
Cooling	Natural Convection - No Fans
Enclosure Environmental Rating	Outdoor - NEMA 6P

Features

Communication	Powerline
Warranty	10 Years
Compliance	UL1741/IEEE1547
	FCC Part 15 Class B

Enphase Energy, Inc.

201 1st Street, Suite 111, Berkeley, CA 94612
877 757 4743 www.enphase.com

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1 inverter per solar panel

$$\therefore \frac{4\#}{13.4\text{ kW}} = 0.3\text{ pF}$$

WIND LOADS

① SURF PANELS

$$p_{net30} = -20.7 \text{ psf OF } +7.5$$

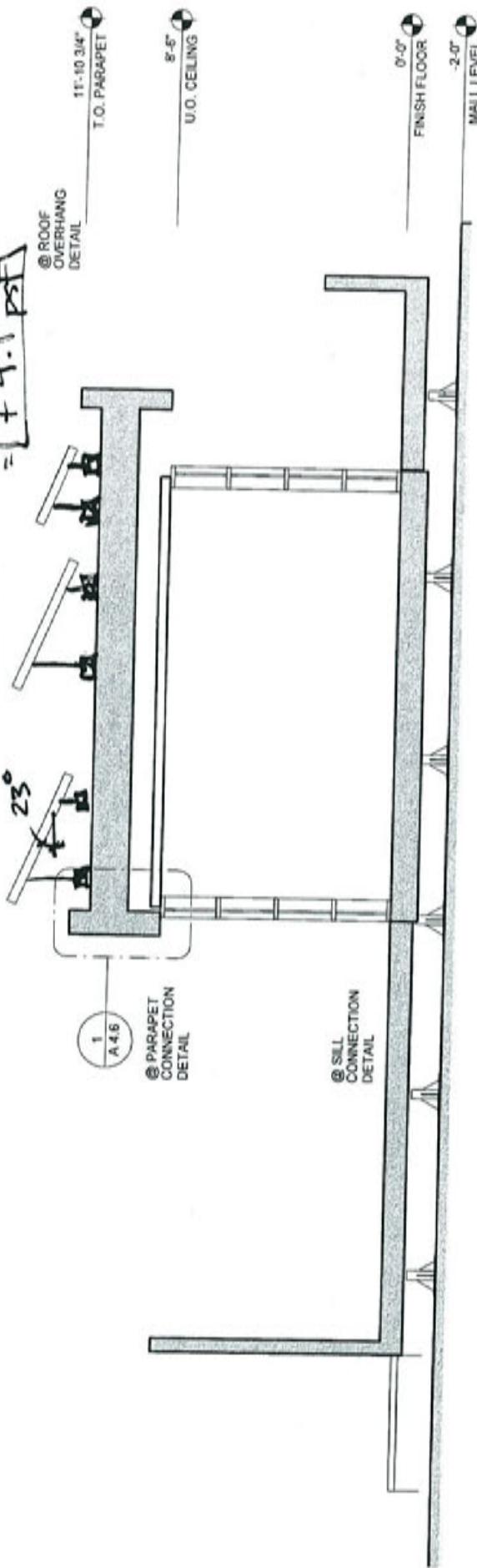
$$I = 1.0$$

$$Z = 1.21$$

$$UPUFT = -20.7 \times 1.0 \times 1.21 = -25 \text{ psf}$$

$$DOWNWARD = 7.5 \times 1.0 \times 1.21 = +9.1 \text{ psf}$$

23°



② ROOF

$$I = 1.0$$

$$Z = 1.21$$

$$\text{WALL PRESSURE} = 10 \text{ psf}$$

$$\text{ROOF} = 11.7 \text{ psf}$$

$$P_{WALL} = 1.0 \times 1.21 \times 11.5 = 14 \text{ psf}$$

$$P_{ROOF} = 1.0 \times 1.21 \times 11.7 = 14.2 \text{ psf}$$

GC_{pf} = product of the equivalent external pressure coefficient and gust-effect factor to be used in determination of wind loads for MWFRS of low-rise buildings

GC_{pi} = product of internal pressure coefficient and gust-effect factor to be used in determination of wind loads for buildings

g_Q = peak factor for background response in Eqs. 6-4 and 6-8

g_R = peak factor for resonant response in Eq. 6-8

g_v = peak factor for wind response in Eqs. 6-4 and 6-8

H = height of hill or escarpment in Fig. 6-4, in ft (m)

h = mean roof height of a building or height of other structure, except that eave height shall be used for roof angle θ of less than or equal to 10° , in ft (m)

h_e = roof eave height at a particular wall, or the average height if the eave varies along the wall

I = importance factor

I_z = intensity of turbulence from Eq. 6-5

K_1, K_2, K_3 = multipliers in Fig. 6-4 to obtain K_{zt}

K_d = wind directionality factor in Table 6-4

K_h = velocity pressure exposure coefficient evaluated at height $z = h$

K_z = velocity pressure exposure coefficient evaluated at height z

K_{zt} = topographic factor as defined in Section 6.5.7

L = horizontal dimension of a building measured parallel to the wind direction, in ft (m)

L_h = distance upwind of crest of hill or escarpment in Fig. 6-4 to where the difference in ground elevation is half the height of hill or escarpment, in ft (m)

L_z = integral length scale of turbulence, in ft (m)

L_r = horizontal dimension of return corner for a solid freestanding wall or solid sign from Fig. 6-20, in ft (m)

ℓ = integral length scale factor from Table 6-2, ft (m)

N_1 = reduced frequency from Eq. 6-12

n_1 = building natural frequency, Hz

p = design pressure to be used in determination of wind loads for buildings, in lb/ft² (N/m²)

p_L = wind pressure acting on leeward face in Fig. 6-9, in lb/ft² (N/m²)

p_{net} = net design wind pressure from Eq. 6-2, in lb/ft² (N/m²)

p_{net30} = net design wind pressure for Exposure B at $h = 30$ ft and $I = 1.0$ from Fig. 6-3, in lb/ft² (N/m²)

p_p = combined net pressure on a parapet from Eq. 6-20, in lb/ft² (N/m²)

p_s = net design wind pressure from Eq. 6-1, in lb/ft² (N/m²)

p_{s30} = simplified design wind pressure for Exposure B at $h = 30$ ft and $I = 1.0$ from Fig. 6-2, in lb/ft² (N/m²)

p_w = wind pressure acting on windward face in Fig. 6-9, in lb/ft² (N/m²)

Q = background response factor from Eq. 6-6

q = velocity pressure, in lb/ft² (N/m²)

q_h = velocity pressure evaluated at height $z = h$, in lb/ft² (N/m²)

q_i = velocity pressure for internal pressure determination, in lb/ft² (N/m²)

q_p = velocity pressure at top of parapet, in lb/ft² (N/m²)

q_z = velocity pressure evaluated at height z above ground, in lb/ft² (N/m²)

R = resonant response factor from Eq. 6-10

R_B, R_h, R_L = values from Eq. 6-13

R_i = reduction factor from Eq. 6-16

R_n = value from Eq. 6-11

s = vertical dimension of the solid freestanding wall or solid sign from Fig. 6-20, in ft (m)

r = rise-to-span ratio for arched roofs

V = basic wind speed obtained from Fig. 6-1, in mi/h (m/s). The basic wind speed corresponds to a 3-s gust speed at 33 ft (10 m) above ground in exposure Category C

V_i = unpartitioned internal volume ft³ (m³)

\bar{V}_z = mean hourly wind speed at height z , ft/s (m/s)

W = width of building in Figs. 6-12 and 6-14A and B and width of span in Figs. 6-13 and 6-15, in ft (m)

X = distance to center of pressure from windward edge in Fig. 6-18, in ft (m)

x = distance upwind or downwind of crest in Fig. 6-4, in ft (m)

z = height above ground level, in ft (m)

\bar{z} = equivalent height of structure, in ft (m)

z_a = nominal height of the atmospheric boundary layer used in this standard. Values appear in Table 6-2

z_{min} = exposure constant from Table 6-2

α = 3-s gust-speed power law exponent from Table 6-2

$\hat{\alpha}$ = reciprocal of α from Table 6-2

$\bar{\alpha}$ = mean hourly wind-speed power law exponent in Eq. 6-14 from Table 6-2

β = damping ratio, percent critical for buildings or other structures

ϵ = ratio of solid area to gross area for solid freestanding wall, solid sign, open sign, face of a trussed tower, or lattice structure

λ = adjustment factor for building height and exposure from Figs. 6-2 and 6-3

$\bar{\epsilon}$ = integral length scale power law exponent in Eq. 6-7 from Table 6-2

η = value used in Eq. 6-13 (see Section 6.5.8.2)

θ = angle of plane of roof from horizontal, in degrees

v = height-to-width ratio for solid sign

6.4 METHOD 1—SIMPLIFIED PROCEDURE

6.4.1 Scope. A building whose design wind loads are determined in accordance with this section shall meet all the conditions of

6.4.1.1 or 6.4.1.2. If a building qualifies only under 6.4.1.2 for design of its components and cladding, then its MWFRS shall be designed by Method 2 or Method 3.

6.4.1.1 Main Wind-Force Resisting Systems. For the design of MWFRS the building must meet all of the following conditions:

1. The building is a simple diaphragm building as defined in Section 6.2.
2. The building is a low-rise building as defined in Section 6.2.
3. The building is enclosed as defined in Section 6.2 and conforms to the wind-borne debris provisions of Section 6.5.9.3.
4. The building is a regular-shaped building or structure as defined in Section 6.2.
5. The building is not classified as a flexible building as defined in Section 6.2.
6. The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
7. The building has an approximately symmetrical cross-section in each direction with either a flat roof or a gable or hip roof with $\theta \leq 45^\circ$.
8. The building is exempted from torsional load cases as indicated in Note 5 of Fig. 6-10, or the torsional load cases defined in Note 5 do not control the design of any of the MWFRSs of the building.

6.4.1.2 Components and Cladding. For the design of components and cladding the building must meet all the following conditions:

1. The mean roof height h must be less than or equal to 60 ft ($h \leq 60$ ft).
2. The building is enclosed as defined in Section 6.2 and conforms to the wind-borne debris provisions of Section 6.5.9.3.
3. The building is a regular-shaped building or structure as defined in Section 6.2.
4. The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
5. The building has either a flat roof, a gable roof with $\theta \leq 45^\circ$, or a hip roof with $\theta \leq 27^\circ$.

6.4.2 Design Procedure.

1. The *basic wind speed* V shall be determined in accordance with Section 6.5.4. The wind shall be assumed to come from any horizontal direction.
2. An *importance factor* I shall be determined in accordance with Section 6.5.5.
3. An *exposure category* shall be determined in accordance with Section 6.5.6.
4. A height and exposure adjustment coefficient, λ , shall be determined from Fig. 6-2.

6.4.2.1 Main Wind-Force Resisting System. Simplified design wind pressures, p_s , for the MWFRSs of low-rise simple diaphragm buildings represent the net pressures (sum of internal and external) to be applied to the horizontal and vertical projections

of building surfaces as shown in Fig. 6-2. For the horizontal pressures (zones A, B, C, D), p_s is the combination of the windward and leeward net pressures. p_s shall be determined by the following equation:

$$p_s = \lambda K_{zt} I p_{s30} \quad (6-1)$$

where

λ = adjustment factor for building height and exposure from Fig. 6-2

K_{zt} = topographic factor as defined in Section 6.5.7 evaluated at mean roof height, h

I = importance factor as defined in Section 6.2

p_{s30} = simplified design wind pressure for Exposure B, at $h = 30$ ft, and for $I = 1.0$, from Fig. 6-2

6.4.2.1.1 Minimum Pressures. The load effects of the design wind pressures from Section 6.4.2.1 shall not be less than the minimum load case from Section 6.1.4.1 assuming the pressures, p_s , for zones A, B, C, and D all equal to +10 psf, while assuming zones E, F, G, and H all equal to 0 psf.

6.4.2.2 Components and Cladding. Net design wind pressures, p_{net} , for the components and cladding of buildings designed using Method 1 represent the net pressures (sum of internal and external) to be applied normal to each building surface as shown in Fig. 6-3. p_{net} shall be determined by the following equation:

$$p_{net} = \lambda K_{zt} I p_{net30} \quad (6-2)$$

where

λ = adjustment factor for building height and exposure from Fig. 6-3

K_{zt} = topographic factor as defined in Section 6.5.7 evaluated at mean roof height, h

I = importance factor as defined in Section 6.2

p_{net30} = net design wind pressure for exposure B, at $h = 30$ ft, and for $I = 1.0$, from Fig. 6-3

6.4.2.2.1 Minimum Pressures. The positive design wind pressures, p_{net} , from Section 6.4.2.2 shall not be less than +10 psf, and the negative design wind pressures, p_{net} , from Section 6.4.2.2 shall not be less than -10 psf.

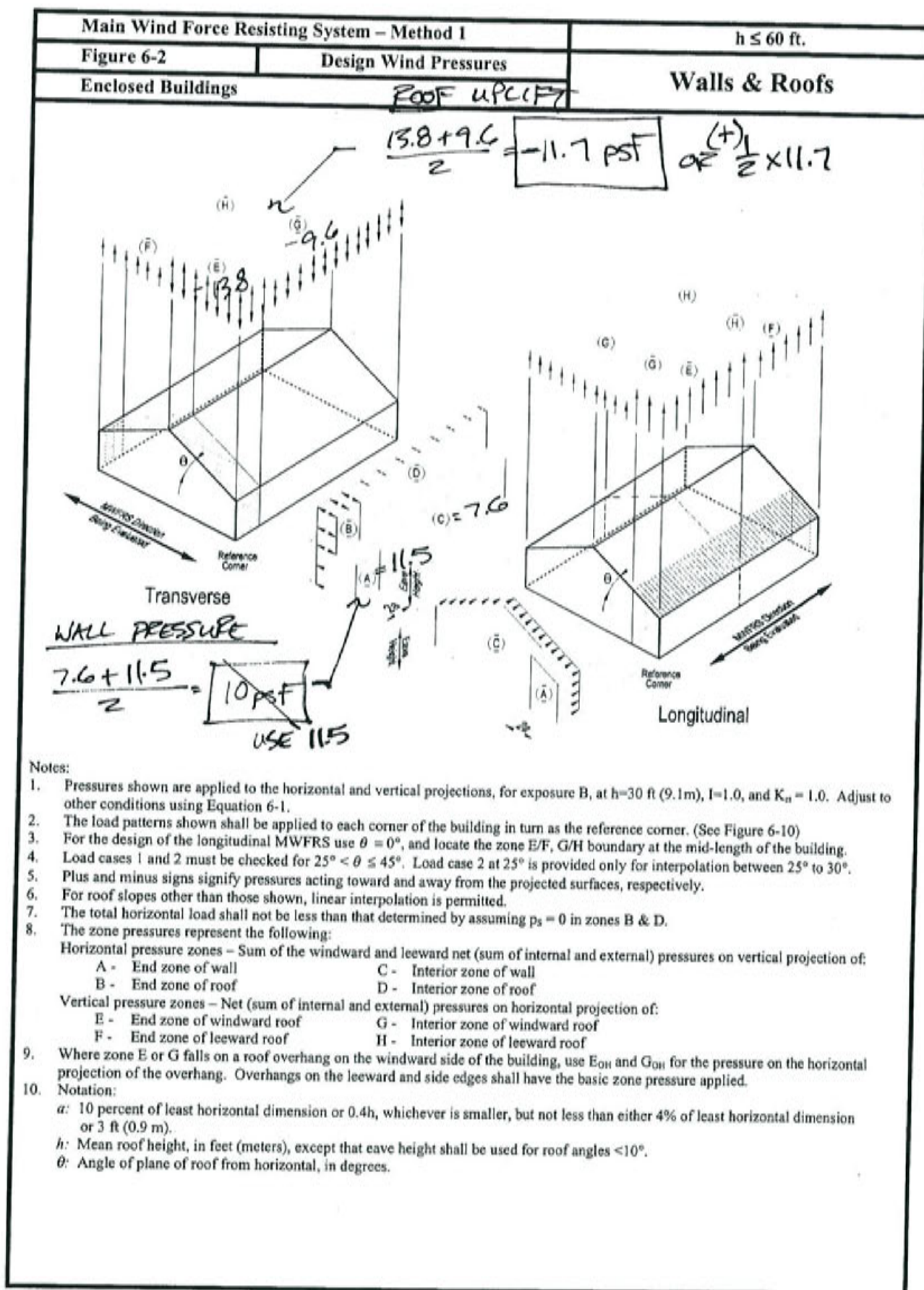
6.4.3 Air Permeable Cladding. Design wind loads determined from Fig. 6.3 shall be used for all air permeable cladding unless approved test data or the recognized literature demonstrate lower loads for the type of air permeable cladding being considered.

6.5 METHOD 2—ANALYTICAL PROCEDURE

6.5.1 Scope. A building or other structure whose design wind loads are determined in accordance with this section shall meet all of the following conditions:

1. The building or other structure is a regular-shaped building or structure as defined in Section 6.2.
2. The building or other structure does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; or does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.

6.5.2 Limitations. The provisions of Section 6.5 take into consideration the load magnification effect caused by gusts in resonance with along-wind vibrations of flexible buildings or other structures. Buildings or other structures not meeting the requirements of Section 6.5.1, or having unusual shapes or response



Simplified Design Wind Pressure, p_{s30} (psf) (Exposure B at $h = 30$ ft., $K_{zt} = 1.0$, with $I = 1.0$)

Basic Wind Speed (mph)	Roof Angle (degrees)	Load Case	Zones									
			Horizontal Pressures				Vertical Pressures				Overhangs	
			A	B	C	D	E	F	G	H	EOH	GCH
85	0 to 5°	1	11.5	-5.9	7.6	-3.5	-13.8	-7.8	-9.6	-6.1	-19.3	-15.1
	10°	1	12.9	-5.4	8.6	-3.1	-13.8	-8.4	-9.6	-6.5	-19.3	-15.1
	15°	1	14.4	-4.8	9.6	-2.7	-13.8	-9.0	-9.6	-6.9	-19.3	-15.1
	20°	1	15.9	-4.2	10.6	-2.3	-13.8	-9.6	-9.6	-7.3	-19.3	-15.1
	25°	1	14.4	2.3	10.4	2.4	-6.4	-8.7	-4.6	-7.0	-11.9	-10.1
		2	-----	-----	-----	-----	-2.4	-4.7	-0.7	-3.0	-----	-----
	30 to 45	1	12.9	8.8	10.2	7.0	1.0	-7.8	0.3	-6.7	-4.5	-5.2
		2	12.9	8.8	10.2	7.0	5.0	-3.9	4.3	-2.8	-4.5	-5.2
	0 to 5°	1	12.8	-6.7	8.5	-4.0	-15.4	-8.8	-10.7	-6.8	-21.6	-16.9
	10°	1	14.5	-6.0	9.6	-3.5	-15.4	-9.4	-10.7	-7.2	-21.6	-16.9
90	15°	1	16.1	-5.4	10.7	-3.0	-15.4	-10.1	-10.7	-7.7	-21.6	-16.9
	20°	1	17.8	-4.7	11.9	-2.6	-15.4	-10.7	-10.7	-8.1	-21.6	-16.9
	25°	1	16.1	2.6	11.7	2.7	-7.2	-9.8	-5.2	-7.6	-13.3	-11.4
		2	-----	-----	-----	-----	-2.7	-5.3	-0.7	-3.4	-----	-----
	30 to 45	1	14.4	9.9	11.5	7.9	1.1	-8.8	0.4	-7.5	-5.1	-5.8
		2	14.4	9.9	11.5	7.9	5.6	-4.3	4.3	-3.1	-5.1	-5.8
	0 to 5°	1	15.9	-8.2	10.5	-4.9	-19.1	-10.8	-13.3	-8.4	-26.7	-20.9
	10°	1	17.9	-7.4	11.9	-4.3	-19.1	-11.6	-13.3	-8.9	-26.7	-20.9
	15°	1	19.9	-6.6	13.3	-3.8	-19.1	-12.4	-13.3	-9.5	-26.7	-20.9
	20°	1	22.0	-5.8	14.6	-3.2	-19.1	-13.3	-13.3	-10.1	-26.7	-20.9
100	25°	1	19.9	3.2	14.4	3.3	-8.8	-12.0	-6.4	-9.7	-16.5	-14.0
		2	-----	-----	-----	-----	-2.4	-6.6	-0.9	-4.2	-----	-----
	30 to 45	1	17.8	12.2	14.2	9.8	1.4	-10.8	0.5	-9.3	-6.3	-7.2
		2	17.8	12.2	14.2	9.8	6.9	-5.3	5.9	-3.8	-6.3	-7.2
	0 to 5°	1	17.5	-9.0	11.6	-5.4	-21.1	-11.9	-14.7	-9.3	-29.4	-23.0
	10°	1	19.7	-8.2	13.1	-4.7	-21.1	-12.8	-14.7	-9.8	-29.4	-23.0
	15°	1	21.9	-7.4	14.6	-4.2	-21.1	-13.7	-14.7	-10.5	-29.4	-23.0
	20°	1	24.3	-6.6	16.1	-3.5	-21.1	-14.7	-14.7	-11.1	-29.4	-23.0
	25°	1	21.9	3.5	15.9	3.5	-9.7	-13.2	-7.1	-10.7	-18.2	-15.4
		2	-----	-----	-----	-----	-3.7	-7.3	-1.0	-4.6	-----	-----
105	30 to 45	1	19.6	13.5	15.7	10.8	1.5	-11.9	0.6	-10.3	-6.9	-7.9
		2	19.6	13.5	15.7	10.8	7.6	-5.8	6.5	-4.2	-6.9	-7.9
	0 to 5°	1	19.5	-10.0	12.7	-5.9	-23.1	-13.1	-16.0	-10.1	-32.3	-25.3
	10°	1	21.6	-9.0	14.4	-5.2	-23.1	-14.1	-16.0	-10.8	-32.3	-25.3
	15°	1	24.1	-8.0	16.0	-4.5	-23.1	-15.1	-16.0	-11.5	-32.3	-25.3
	20°	1	26.6	-7.0	17.7	-3.9	-23.1	-16.0	-16.0	-12.2	-32.3	-25.3
	25°	1	24.1	3.9	17.4	4.0	-10.7	-14.6	-7.7	-11.7	-19.9	-17.0
		2	-----	-----	-----	-----	-4.1	-7.9	-1.1	-5.1	-----	-----
	30 to 45	1	21.6	14.8	17.2	11.8	1.1	-13.1	0.6	-11.3	-7.6	-8.7
		2	21.6	14.8	17.2	11.8	8.3	-6.5	7.2	-4.6	-7.6	-8.7
110	0 to 5°	1	22.8	-11.9	15.1	-7.0	-27.4	-15.6	-19.1	-12.1	-38.4	-30.1
	10°	1	25.8	-10.7	17.1	-6.2	-27.4	-16.8	-19.1	-12.9	-38.4	-30.1
	15°	1	28.7	-9.5	19.1	-5.4	-27.4	-17.9	-19.1	-13.7	-38.4	-30.1
	20°	1	31.6	-8.3	21.1	-4.6	-27.4	-19.1	-19.1	-14.5	-38.4	-30.1
	25°	1	28.6	4.6	20.7	4.7	-12.7	-17.3	-9.2	-13.9	-23.7	-20.2
		2	-----	-----	-----	-----	-4.8	-9.4	-3.3	-6.0	-----	-----
	30 to 45	1	25.7	17.6	20.4	14.0	2.0	-15.6	0.7	-13.4	-9.0	-10.3
		2	25.7	17.6	20.4	14.0	9.9	-7.7	8.6	-5.5	-9.0	-10.3
120	0 to 5°	1	22.8	-11.9	15.1	-7.0	-27.4	-15.6	-19.1	-12.1	-38.4	-30.1
	10°	1	25.8	-10.7	17.1	-6.2	-27.4	-16.8	-19.1	-12.9	-38.4	-30.1
	15°	1	28.7	-9.5	19.1	-5.4	-27.4	-17.9	-19.1	-13.7	-38.4	-30.1
	20°	1	31.6	-8.3	21.1	-4.6	-27.4	-19.1	-19.1	-14.5	-38.4	-30.1
	25°	1	28.6	4.6	20.7	4.7	-12.7	-17.3	-9.2	-13.9	-23.7	-20.2
		2	-----	-----	-----	-----	-4.8	-9.4	-3.3	-6.0	-----	-----
	30 to 45	1	25.7	17.6	20.4	14.0	2.0	-15.6	0.7	-13.4	-9.0	-10.3
		2	25.7	17.6	20.4	14.0	9.9	-7.7	8.6	-5.5	-9.0	-10.3

Unit Conversions—1.0 ft = 0.3048 m; 1.0 psf = 0.0479 kN/m²

Main Wind Force Resisting System – Method 1		$h \leq 60$ ft.
Figure 6-2 (cont'd)	Design Wind Pressures	Walls & Roofs
Enclosed Buildings		

Adjustment Factor for Building Height and Exposure, λ			
Mean roof height (ft)	Exposure		
	B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

Components and Cladding – Method 1

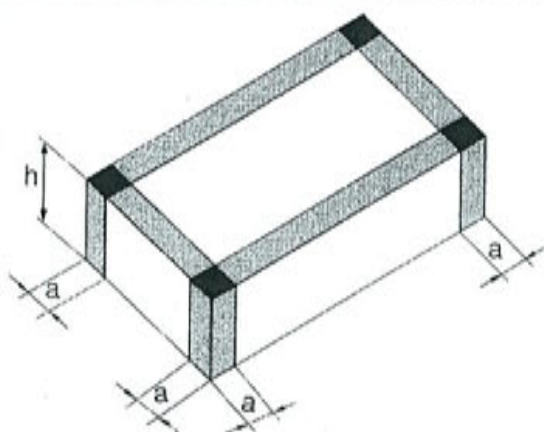
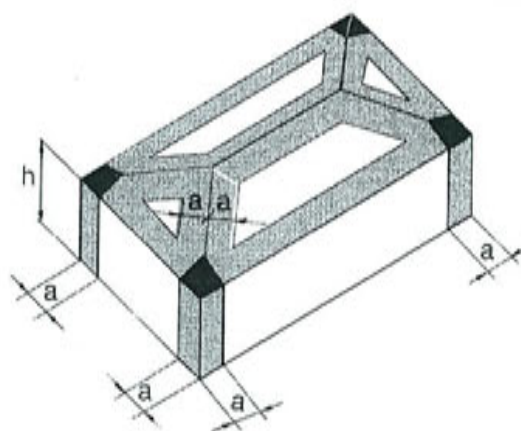
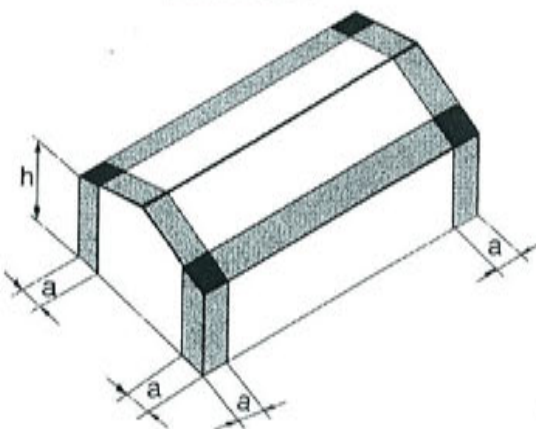
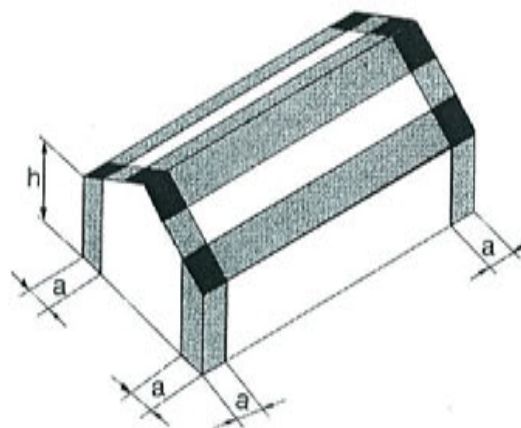
 $h \leq 60$ ft.

Figure 6-3

Design Wind Pressures

Enclosed Buildings

Walls & Roofs

**Flat Roof****Hip Roof ($7^\circ < \theta \leq 27^\circ$)****Gable Roof ($\theta \leq 7^\circ$)****Gable Roof ($7^\circ < \theta \leq 45^\circ$)**

Interior Zones
Roofs - Zone 1/Walls - Zone 4

End Zones
Roofs - Zone 2/Walls - Zone 5

Corner Zones
Roofs - Zone 3

Notes:

1. Pressures shown are applied normal to the surface, for exposure B, at $h = 30$ ft (9.1m), $I = 1.0$, and $K_{zt} = 1.0$. Adjust to other conditions using Equation 6-2.
2. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
3. For hip roofs with $\theta \leq 25^\circ$, Zone 3 shall be treated as Zone 2.
4. For effective wind areas between those given, value may be interpolated, otherwise use the value associated with the lower effective wind area.
5. Notation:
 a : 10 percent of least horizontal dimension or $0.4h$, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
 h : Mean roof height, in feet (meters), except that eave height shall be used for roof angles $< 10^\circ$.
 θ : Angle of plane of roof from horizontal, in degrees.

Components and Cladding – Method 1				$h \leq 60$ ft.										
Figure 6-3 (cont'd)		Net Design Wind Pressures		Walls & Roofs										
Enclosed Buildings														
Net Design Wind Pressure, p_{net30} (psf) (Exposure B at $h = 30$ ft. with $I = 1.0$ and $K_d = 1.0$)														
	Zone	Effective wind area (sf)	Basic Wind Speed V (mph)											
			85	90	95	100	105	110	115	120	125	130	135	
Roof 0 to 7 degrees	1	10	5.3	-13.0	5.9	-14.6	7.3	-18.0	8.1	-19.8	8.9	-21.8	10.5	-24.9
	1	20	5.0	-12.7	5.6	-14.2	6.9	-17.5	7.6	-19.3	8.3	-21.2	9.9	-25.2
	1	50	4.5	-12.2	5.1	-13.7	6.3	-16.9	6.9	-18.7	7.6	-20.5	9.0	-24.4
	1	100	4.2	-11.9	4.7	-13.3	5.8	-16.5	6.4	-18.2	7.0	-19.9	8.3	-23.7
	2	10	5.3	-21.8	5.9	-23.4	7.3	-30.2	8.1	-33.3	8.9	-36.5	10.5	-43.5
	2	20	5.0	-19.5	5.6	-21.8	6.9	-27.0	7.6	-29.7	8.3	-32.6	9.9	-38.8
	2	50	4.5	-16.4	5.1	-18.4	6.3	-22.7	6.9	-25.1	7.6	-27.5	9.0	-32.7
	2	100	4.2	-14.1	4.7	-15.8	5.8	-19.5	6.4	-21.5	7.0	-23.6	8.3	-28.1
	3	10	5.3	-32.8	5.9	-36.8	7.3	-45.4	8.1	-50.1	8.9	-55.0	10.5	-65.4
	3	20	5.0	-27.2	5.6	-30.5	6.9	-37.6	7.6	-41.5	8.3	-45.8	9.9	-54.2
	3	50	4.5	-19.7	5.1	-22.1	6.3	-27.3	6.9	-30.1	7.6	-33.1	9.0	-39.3
	3	100	4.2	-14.1	4.7	-15.8	5.8	-19.5	6.4	-21.5	7.0	-23.6	8.3	-28.1
Roof > 7 to 27 degrees	1	10	7.5	-11.9	8.4	-13.3	10.4	-16.5	11.4	-18.2	12.5	-19.9	14.9	-23.7
	1	20	6.8	-11.6	7.7	-13.0	9.4	-16.0	10.4	-17.6	11.4	-19.4	13.6	-23.0
	1	50	6.0	-11.1	6.7	-12.5	8.2	-15.4	9.1	-17.0	10.0	-18.6	11.9	-22.7
	1	100	5.3	-10.8	5.9	-12.1	7.3	-14.5	8.1	-16.5	8.9	-18.1	10.5	-21.5
	2	10	7.5	-20.7	8.4	-23.2	10.4	-28.7	11.4	-31.6	12.5	-34.7	14.9	-41.1
	2	20	6.8	-19.0	7.7	-21.4	9.4	-26.4	10.4	-29.1	11.4	-31.9	13.6	-38.1
	2	50	6.0	-16.9	6.7	-18.9	8.2	-23.3	9.1	-25.5	10.0	-28.2	11.9	-33.5
	2	100	5.3	-15.2	5.9	-17.0	7.3	-21.0	8.1	-23.2	8.9	-25.5	10.5	-30.1
	3	10	7.5	-30.6	8.4	-34.3	10.4	-42.4	11.4	-46.7	12.5	-51.3	14.9	-61.6
	3	20	6.8	-28.6	7.7	-32.1	9.4	-39.6	10.4	-43.7	11.4	-47.9	13.6	-57.1
	3	50	6.0	-26.0	6.7	-29.1	8.2	-36.0	9.1	-39.7	10.0	-43.5	11.9	-51.8
	3	100	5.3	-24.0	5.9	-26.9	7.3	-33.2	8.1	-36.6	8.9	-40.2	10.5	-47.5
Roof > 27 to 45 degrees	1	10	11.9	-13.0	13.3	-14.6	16.5	-18.0	18.2	-19.8	19.9	-21.8	23.7	-25.9
	1	20	11.6	-12.3	13.0	-13.8	16.0	-17.1	17.6	-18.8	19.4	-20.7	23.0	-24.6
	1	50	11.1	-11.5	12.5	-12.8	15.4	-15.9	17.0	-17.5	18.6	-19.2	22.2	-22.8
	1	100	10.8	-10.8	12.1	-12.1	14.9	-14.9	16.5	-16.5	18.1	-18.1	21.5	-21.5
	2	10	11.9	-15.2	13.3	-17.0	16.5	-21.0	18.2	-23.2	19.9	-25.5	23.7	-30.3
	2	20	11.6	-14.5	13.0	-16.3	16.0	-20.1	17.6	-22.2	19.4	-24.3	23.0	-29.0
	2	50	11.1	-13.7	12.5	-15.3	15.4	-18.9	17.0	-20.8	18.6	-22.9	22.2	-27.2
	2	100	10.8	-13.0	12.1	-14.6	14.9	-18.0	16.5	-19.8	18.1	-21.8	21.5	-25.9
	3	10	11.9	-15.2	13.3	-17.0	16.5	-21.0	18.2	-23.2	19.9	-25.5	23.7	-30.3
	3	20	11.6	-14.5	13.0	-16.3	16.0	-20.1	17.6	-22.2	19.4	-24.3	23.0	-29.0
	3	50	11.1	-13.7	12.5	-15.3	15.4	-18.9	17.0	-20.8	18.6	-22.9	22.2	-27.2
	3	100	10.8	-13.0	12.1	-14.6	14.9	-18.0	16.5	-19.8	18.1	-21.8	21.5	-25.9
Wall	4	10	13.0	-14.1	14.6	-15.8	18.0	-19.5	19.8	-21.5	21.8	-23.6	25.9	-28.1
	4	20	12.4	-13.5	13.9	-15.1	17.2	-18.7	18.9	-20.6	20.8	-22.6	24.7	-26.9
	4	50	11.6	-12.7	13.0	-14.3	16.1	-17.6	17.8	-19.4	19.5	-21.3	23.2	-25.4
	4	100	11.1	-12.2	12.4	-13.6	15.3	-16.8	16.9	-18.5	18.5	-20.4	22.0	-24.2
	4	500	9.7	-10.8	10.9	-12.1	13.4	-14.9	14.8	-16.5	16.2	-18.1	19.3	-21.5
	5	10	13.0	-17.4	14.6	-19.5	18.0	-24.1	19.8	-26.6	21.8	-29.1	25.9	-34.7
	5	20	12.4	-16.2	13.9	-18.2	17.2	-22.5	18.9	-24.8	20.8	-27.2	24.7	-33.4
	5	50	11.6	-14.7	13.0	-16.5	16.1	-20.3	17.8	-22.4	19.5	-24.6	23.2	-29.7
	5	100	11.1	-13.5	12.4	-15.1	15.3	-18.7	16.9	-20.6	18.5	-22.6	22.0	-26.9
	5	500	9.7	-10.8	10.9	-12.1	13.4	-14.9	14.8	-16.5	16.2	-18.1	19.3	-21.5

Unit Conversions – 1.0 ft = 0.3048 m; 1.0 psf = 0.0479 kN/m²

Unit Conversions – 1.0 ft = 0.3048 m; 1.0 psf = 0.0479 kN/m²

Components and Cladding – Method 1		$h \leq 60$ ft.
Figure 6-3 (cont'd)	Net Design Wind Pressures	Walls & Roofs
Enclosed Buildings		

Roof Overhang Net Design Wind Pressure, p_{net30} (psf)

(Exposure B at $h = 30$ ft. with $I = 1.0$)

(Exposure B at h = 30 ft, with $\eta = 1.0$)

	Zone	Effective Wind Area (sf)	Basic Wind Speed V (mph)							
			90	100	110	120	130	140	150	170
Roof 0 to 7 degrees	2	10	-21.0	-25.9	-31.4	-37.3	-43.8	-50.8	-58.3	-74.9
	2	20	-20.6	-25.5	-30.8	-36.7	-43.0	-49.9	-57.3	-73.6
	2	50	-20.1	-24.9	-30.1	-35.8	-42.0	-48.7	-55.9	-71.8
	2	100	-19.8	-24.4	-29.5	-35.1	-41.2	-47.8	-54.9	-70.5
	3	10	-34.6	-42.7	-51.6	-61.5	-72.1	-83.7	-96.0	-123.4
	3	20	-27.1	-33.5	-40.5	-48.3	-56.6	-65.7	-75.4	-96.8
	3	50	-17.3	-21.4	-25.9	-30.8	-36.1	-41.9	-48.1	-61.8
	3	100	-10.0	-12.2	-14.8	-17.6	-20.6	-23.9	-27.4	-35.2
Roof > 7 to 27 degrees	2	10	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	2	20	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	2	50	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	2	100	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	3	10	-45.7	-56.4	-68.3	-81.2	-95.3	-110.6	-126.9	-163.0
	3	20	-41.2	-50.9	-61.6	-73.3	-86.0	-99.8	-114.5	-147.1
	3	50	-35.3	-43.6	-52.8	-62.8	-73.7	-85.5	-98.1	-126.1
	3	100	-30.9	-38.1	-46.1	-54.9	-64.4	-74.7	-85.8	-110.1
Roof > 27 to 45 degrees	2	10	-24.7	-30.5	-36.9	-43.9	-51.5	-59.8	-68.6	-88.1
	2	20	-24.0	-29.6	-35.8	-42.6	-50.0	-58.0	-66.5	-85.5
	2	50	-23.0	-28.4	-34.3	-40.8	-47.9	-55.6	-63.8	-82.0
	2	100	-22.2	-27.4	-33.2	-39.5	-46.4	-53.8	-61.7	-79.3
	3	10	-24.7	-30.5	-36.9	-43.9	-51.5	-59.8	-68.6	-88.1
	3	20	-24.0	-29.6	-35.8	-42.6	-50.0	-58.0	-66.5	-85.5
	3	50	-23.0	-28.4	-34.3	-40.8	-47.9	-55.6	-63.8	-82.0
	3	100	-22.2	-27.4	-33.2	-39.5	-46.4	-53.8	-61.7	-79.3

Adjustment Factor for Building Height and Exposure, λ

Mean roof height (ft)	Exposure		
	B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

Unit Conversions – 1.0 ft = 0.3048 m; 1.0 sf = 0.0929 m²; 1.0 psf = 0.0479 kN/m



CURIO HOUSE

TEAM BOSTON
SOLAR DECATHLON 2009



11/21/08 Project Status
NO DATE DESCRIPTION



NO	DATE	DESCRIPTION
1	11/21/08	Project Status

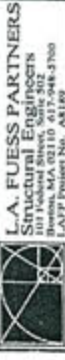
Ground Floor Plan

SCALE: Scales noted are half size

DATE: 12-15-08

SHEET NO:

S1.1



FOUNDATION LOADS

trib = 11x7
DL+LL = 11+60
 $P_{TL} = 5467 \#$
 $\frac{1500 \#}{15\%}$

LIVING + PORCH
trib = 7-6x5-4 + PORCH
DL+LL = (9+50) + PORCH
 $P_{TL} = 2600 \# + 5467 \#$
 $= 8067 \#$
 $\frac{1500 \#}{15\%} = 26 \times 26$

LIVING ONLY
 $P_{TL} = \frac{2600 \#}{1500 \#} = 19 \times 19$

LIVING + PORCH
trib = LIVING + 5-4x2-4
DL+LL = LIVING + (11+60)
 $P_{TL} = 2600 \# + 884 \#$
 $= 3500 \#$
 $\frac{3500 \#}{1500 \#} = 24 \times 24$

PORCH
trib = 2-6x6-0
DL+LL = 11+60
 $P_{TL} = 1065 \# \rightarrow \text{use } 10 \times 10$

KITCHEN
trib = 4-6x5
DL+LL = 15+50
 $P_{TL} = \frac{1500 \#}{1500 \#} = 10 \times 10$

- FLOOR PLAN NOTES
1. FINISH FLOOR ELEVATION IS 100'-0" (RELATIVE TO DATUM 100'-0").
 2. FINISH FLOOR IS FINISH FLOOR UNLESS SHOWN OTHERWISE.
 3. GENERAL NOTES:
 - SD-1, 3-2
 - SD-1, 3-2
 4. BUILDING SECTIONS:
 - SD-1
 - SD-1
 5. FLOOR JOISTS SHALL BE 2x8@16" ON CENTER UNLESS NOTED OTHERWISE.

SW 1. 2x8 OYSPUM WALL BOARD, 1 SIDE
CONNECT SHEATHING USING
6x COOLER NAILS 1 3/4" x 30" HEADS 12" MAX AT 6" O.C.
OR 1x4 DRIFTWALL SCREW 1 1/4" x 16" x 16" x 16" W/ 6" O.C.
PROVIDE HOLD-DOWN EX END OF SW PER S531

SW 1. 2x8 PLYWOOD OR OSB, 1 SIDE
CONNECT SHEATHING USING 6x COOLER NAILS 1 3/4" x 30" HEADS 12" MAX AT 6" O.C.
OR 1x4 DRIFTWALL SCREW 1 1/4" x 16" x 16" x 16" W/ 6" O.C.
PROVIDE HOLD-DOWN EX END OF SW PER S531

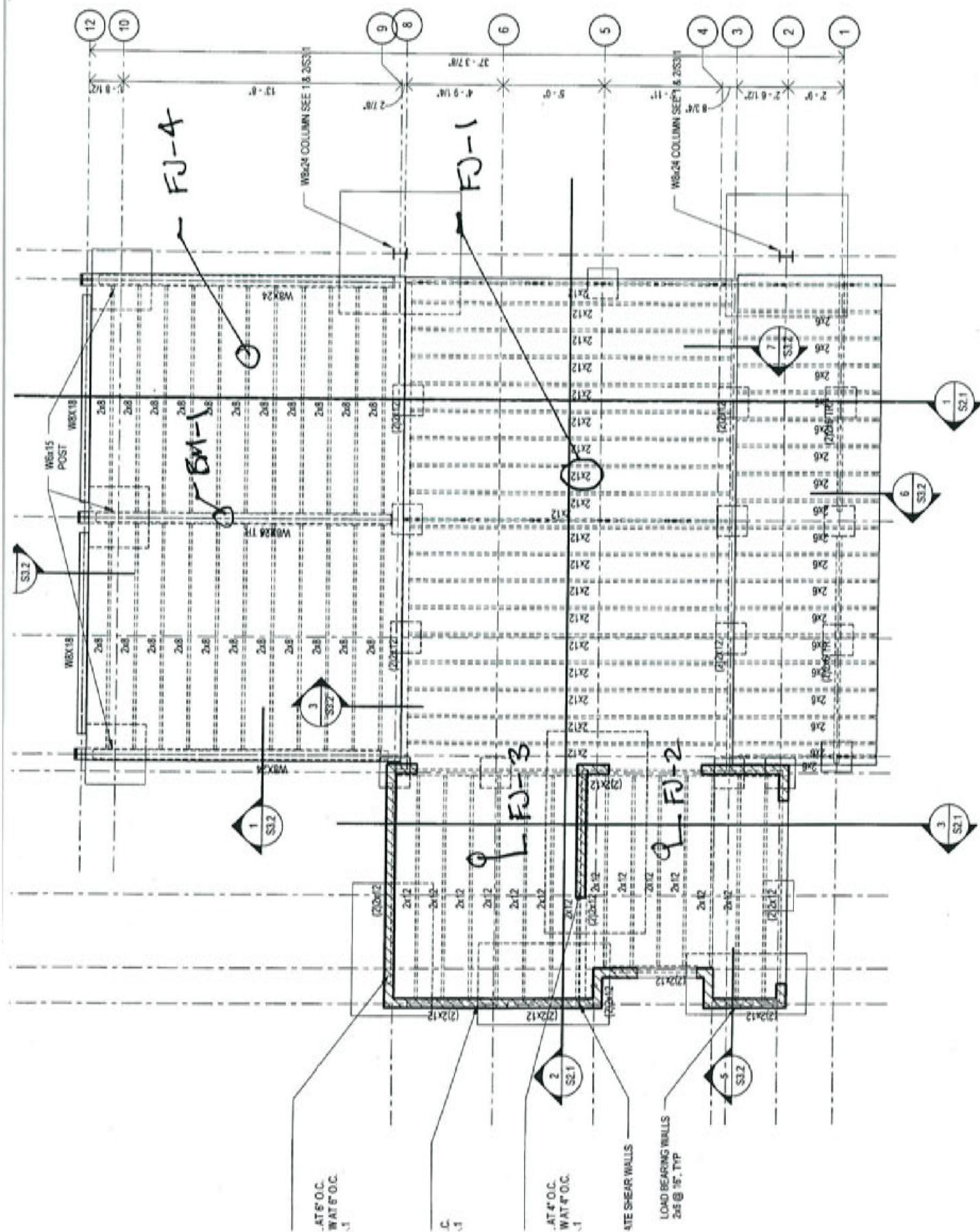
SW 2. 5x8 OYSPUM WALL BOARD, 2 SIDES
CONNECT SHEATHING USING
6x COOLER NAILS 1 3/4" x 30" HEADS 12" MAX AT 6" O.C.
OR 1x4 DRIFTWALL SCREW 1 1/4" x 16" x 16" x 16" W/ 6" O.C.
PROVIDE HOLD-DOWN EX END OF SW PER S531

HATCHED WALLS INDICATE SHEAR WALLS
LOAD BEARING WALLS
2x6 @ 16" TYP

01 GROUND LEVEL FRAMING PLAN

1/4" = 1'-0"

FOUNDATION LOADS



Floor Plan



PROJECT

floor beam in living.wwb

Sizer 2004a

Load	Type	Distribution	Magnitude		Location [ft]		Pat- tern
			Start	End	Start	End	
Load1	Dead	Full UDL	20.0				No
Load2	Live	Full UDL	66.7				No

Dead	191		15.1
Live	531		191
Total	722		531
Bearing:			722
LC number	2		
Length	1.00		2
			1.00

Spaced at 16" c/c; Self Weight of 4.01 plf automatically included in loads:

Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC.

WARNING: This section violates the following design criteria: Bending

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 57$	$F_v' = 180$	$f_v/F_v' = 0.31$
Bending (+)	$f_b = 1089$	$F_b' = 1035$	$f_b/F_b' = 1.05$
Live Defl'n	$0.34 = L/564$	$0.53 = L/360$	0.64
Total Defl'n	$0.52 = L/366$	$0.80 = L/240$	0.65

M is OKAY, w/in 5%

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfxt	Ci	Cn	LC#
Fb'+	900	1.00	1.00	1.00	1.000	1.000	1.00	1.15	1.00	1.00	-	2
Fv'	180	1.00	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	625	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.6 million	1.00	1.00	1.00	-	-	-	-	1.00	1.00	-	2

Bending(+): LC# 2 = D+L, M = 2872 lbs-ft
Shear : LC# 2 = D+L, V = 722, V design = .637 lbs
Deflection: LC# 2 = D+L EI= 285e06 lb-in2
Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.
(D=dead L=live S=snow W=wind I=impact C=construction CLD=concentrated)
(All LC's are listed in the Analysis output)

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

FJ-1



WoodWorks®
SOFTWARE FOR WOOD DESIGN

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PROJECT

Dec. 15, 2008 14:59

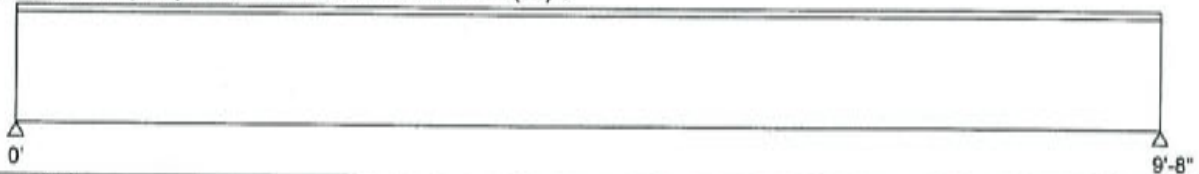
floor joist-egress.wwb

Design Check Calculation Sheet
Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start End	Location [ft] Start End	Pat- tern
Load1	Dead	Full UDL	15.0		No
Load2	Dead	Full UDL	100.0		No
Load3	Dead	Full UDL	15.0		No
Load4	Live	Full UDL	100.0		No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :



Dead	648		648
Live	483		483
Total	1131		1131
Bearing:			
LC number	2		2
Length	1.21		1.21

Lumber-soft, D.Fir-L, No.2, 2x12"

Spaced at 12" c/c; Self Weight of 4.01 plf automatically included in loads;

Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 81$	$F_v' = 180$	$f_v/F_v' = 0.45$
Bending(+)	$f_b = 1037$	$F_b' = 1035$	$f_b/F_b' = 1.00$
Live Defl'n	$0.07 = < L/999$	$0.32 = L/360$	0.21
Total Defl'n	$0.21 = L/558$	$0.48 = L/240$	0.43

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrr	Ci	Cn	LC#
Fb'+	900	1.00	1.00	1.00	1.000	1.000	1.00	1.15	1.00	1.00	-	2
Fv'	180	1.00	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	625	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.6 million	1.00	1.00	1.00	-	-	-	-	1.00	1.00	-	2

Bending(+): LC# 2 = D+L, M = 2733 lbs-ft

Shear : LC# 2 = D+L, V = 1131, V design = 912 lbs

Deflection: LC# 2 = D+L EI= 285e06 lb-in²

Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.

(D=dead L=live S=snow W=wind I=impact C=construction CLd=concentrated)

(All LC's are listed in the Analysis output)

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

FJ-2



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PROJECT

Dec. 15, 2008 15:00

floor joist in kitch.wwb

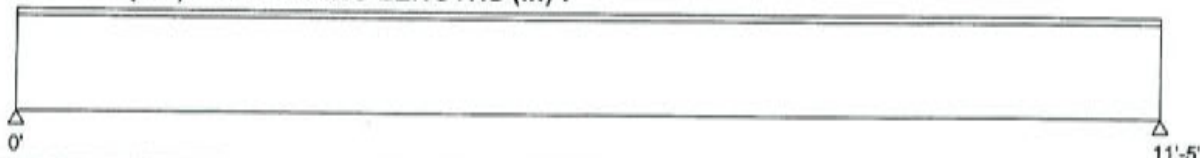
Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start End	Location [ft] Start End	Pat- tern
Load1	Dead	Full UDL	20.0		No
Load2	Live	Full UDL	66.7		No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :



Dead	137		137
Live	381		381
Total	518		518
Bearing:			
LC number	2		2
Length	1.00		1.00

Lumber-soft, D.Fir-L, No.2, 2x12"

Spaced at 16" c/c; Self Weight of 4.01 plf automatically included in loads;

Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 38$	$F_v' = 180$	$f_v/F_v' = 0.21$
Bending(+)	$f_b = 560$	$F_b' = 1035$	$f_b/F_b' = 0.54$
Live Defl'n	$0.09 = < L/999$	$0.38 = L/360$	0.24
Total Defl'n	$0.14 = L/993$	$0.57 = L/240$	0.24

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrt	Ci	Cn	LC#
Fb'+	900	1.00	1.00	1.00	1.000	1.000	1.00	1.15	1.00	1.00	-	2
Fv'	180	1.00	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	625	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.6 million	1.00	1.00	-	-	-	-	-	1.00	1.00	-	2

Bending(+): LC# 2 = D+L, M = 1477 lbs-ft

Shear : LC# 2 = D+L, V = 518, V design = 433 lbs

Deflection: LC# 2 = D+L EI= 285e06 lb-in²

Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.

(D=dead L=live S=snow W=wind I=impact C=construction CLD=concentrated)

(All LC's are listed in the Analysis output)

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

2.5



COMPANY

PROJECT

Dec. 15, 2008 15:11

balcony flr joist.wwb

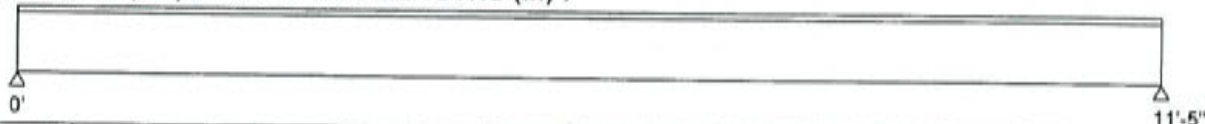
Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start End	Location [ft] Start End	Pat- tern
Load1	Dead	Full UDL	11.0		No
Load2	Live	Full UDL	60.0		No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :



Dead	78		78
Live	343		343
Total	420		420
Bearing:			
LC number	2		2
Length	1.00		1.00

Lumber-soft, D.Fir-L, No.2, 2x8"

Spaced at 12" c/c; Self Weight of 2.58 plf automatically included in loads;

Service: wet; Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 52$	$F_v' = 175$	$f_v/F_v' = 0.30$
Bending(+)	$f_b = 1095$	$F_b' = 1242$	$f_b/F_b' = 0.88$
Live Defl'n	$0.33 = L/409$	$0.38 = L/360$	0.88
Total Defl'n	$0.45 = L/305$	$0.57 = L/240$	0.78

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrr	Ci	Cn	LC#
Fb'+	900	1.00	1.00	1.00	1.000	1.200	1.00	1.15	1.00	1.00	-	2
Fv'	180	1.00	0.97	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	625	-	0.67	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.6 million	0.90	1.00	-	-	-	-	-	1.00	1.00	-	2

Bending(+): LC# 2 = D+L, M = 1199 lbs-ft

Shear : LC# 2 = D+L, V = 420, V design = 376 lbs

Deflection: LC# 2 = D+L EI= 76e06 lb-in²

Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.

(D=dead L=live S=snow W=wind I=impact C=construction CLd=concentrated)

(All LC's are listed in the Analysis output)

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

FJ-4



Gravity Beam Design

RAM SBeam v3.0

Licensed to: L.A. Fuess Partners, Inc.

12/15/08 15:19:50

2.6

STEEL CODE: ASD 9th Ed.

SPAN INFORMATION (ft): I-End (0.00,0.00) J-End (15.60,0.00)

Maximum Depth Limitation specified = 8.50 in

Beam Size (Optimum) = W8X18

Fy = 50.0 ksi

Total Beam Length (ft) = 15.60

Top flange braced by decking.

LINE LOADS (k/ft):

Load	Dist (ft)	DL	LL
1	0.000	0.018	0.000
	15.600	0.018	0.000
2	0.000	0.128	0.700
	15.600	0.128	0.700

SHEAR: Max V (DL+LL) = 6.60 kips fv = 3.52 ksi Fv = 20.00 ksi

MOMENTS:

Span	Cond	Moment kip-ft	@ ft	Lb ft	Cb	Tension Flange fb Fb	Compr Flange fb Fb
Center	Max +	25.7	7.8	0.0	1.00	20.31 33.00	20.31 33.00
Controlling		25.7	7.8	0.0	1.00	20.31 33.00	--- ---

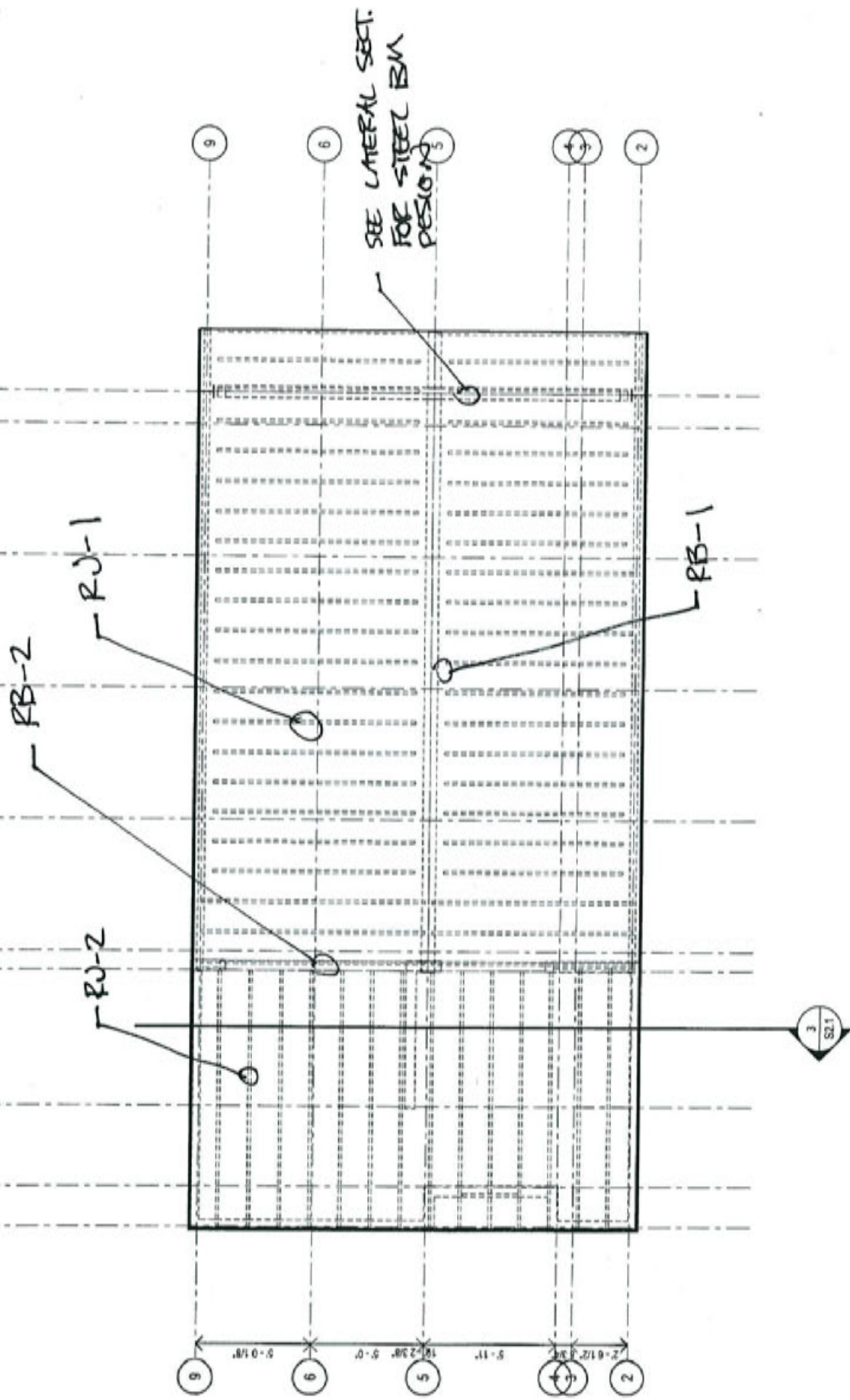
REACTIONS (kips):

	Left	Right
DL reaction	1.14	1.14
Max +LL reaction	5.46	5.46
Max +total reaction	6.60	6.60

DEFLECTIONS:

Dead load (in)	at	7.80 ft =	-0.108	L/D =	1728
Live load (in)	at	7.80 ft =	-0.520	L/D =	360
Net Total load (in)	at	7.80 ft =	-0.628	L/D =	298

BM-1



Roof Plan



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PROJECT

Dec. 15, 2008 14:31

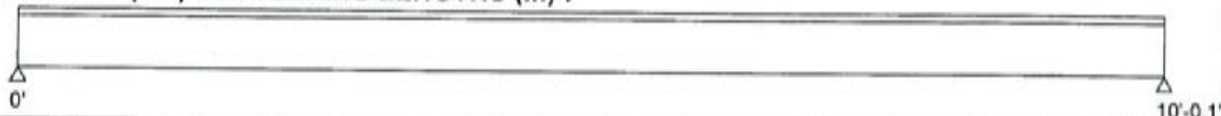
RF joist above living.wwb

Design Check Calculation Sheet
Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start End	Location [ft] Start End	Pat- tern
Load1	Dead	Full UDL	28.0		No
Load2	Live	Full UDL	32.5		No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :



Dead	148		148
Live	163		163
Total	311		311
Bearing:			
LC number	2		2
Length	1.00		1.00

USE 2x8 OR
2x10 @ 16"

Lumber-soft, S-P-F, No.1/No.2, 2x6"

Spaced at 16" c/c; Self Weight of 1.67 plf automatically included in loads;

Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 51$	$F_v' = 135$	$f_v/F_v' = 0.38$
Bending(+)	$f_b = 1236$	$F_b' = 1308$	$f_b/F_b' = 0.95$
Live Defl'n	$0.25 = L/475$	$0.50 = L/240$	0.50
Total Defl'n	$0.60 = L/200$	$0.67 = L/180$	0.90

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrt	Ci	Cn	LC#
$F_b' +$	875	1.00	1.00	1.00	1.000	1.300	1.00	1.15	1.00	1.00	-	2
F_v'	135	1.00	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
F_{cp}'	425	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.4 million	1.00	1.00	-	-	-	-	-	1.00	1.00	-	2

Bending(+): LC# 2 = D+L, M = 779 lbs-ft

Shear : LC# 2 = D+L, V = 311, V design = 283 lbs

Deflection: LC# 2 = D+L EI= 29e06 lb-in²

Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.

(D=dead L=live S=snow W=wind I=impact C=construction CLD=concentrated)

(All LC's are listed in the Analysis output)

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

RJ-1



COMPANY

PROJECT

Dec. 15, 2008 14:42

roof joist over kitchen.wwb

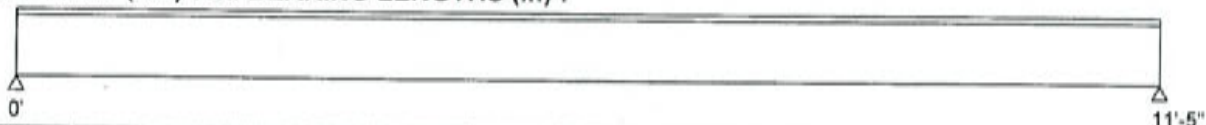
Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start End	Location (ft) Start End	Pat- tern
Load1	Dead	Full UDL	28.0		No
Load2	Live	Full UDL	32.5		No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :



Dead	172		172
Live	186		186
Total	358		358
Bearing:			
LC number	2		2
Length	1.00		1.00

Lumber-soft, S-P-F, No.1/No.2, 2x8"

Spaced at 16" c/c; Self Weight of 2.2 plf automatically included in loads;

Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 44$	$F_v' = 135$	$f_v/F_v' = 0.33$
Bending(+)	$f_b = 933$	$F_b' = 1207$	$f_b/F_b' = 0.77$
Live Defl'n	$0.19 = L/734$	$0.57 = L/240$	0.33
Total Defl'n	$0.45 = L/307$	$0.76 = L/180$	0.59

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cfrt	Ci	Cn	LC#
$F_b' +$	875	1.00	1.00	1.00	1.000	1.200	1.00	1.15	1.00	1.00	-	2
F_v'	135	1.00	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
F_{cp}'	425	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.4 million	1.00	1.00	-	-	-	-	-	1.00	1.00	-	2

Bending(+): LC# 2 = D+L, M = 1022 lbs-ft

Shear : LC# 2 = D+L, V = 358, V design = 320 lbs

Deflection: LC# 2 = D+L EI= 67e06 lb-in²

Total Deflection = 1.50(Dead Load Deflection) + Live Load Deflection.

(D=dead L=live S=snow W=wind I=impact C=construction CLd=concentrated)

(All LC's are listed in the Analysis output)

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.

2.9

RJ-2



WoodWorks®
SOFTWARE FOR WOOD DESIGN

COMPANY

PROJECT

Dec. 15, 2008 14:38

lvl rf beam over living.wvb

Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude Start End	Location (ft) Start End	Pat- tern
1 j16	Dead	Full UDL	111.4		No
2 j16	Live	Full UDL	122.1		No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :

		0'		25'	
Dead	1569			1569	
Live	1527			1527	
Total	3095			3095	
Bearing:					
LC number	2			2	
Length	1.18			1.18	

LVL n-ply, 2.2E, 2800Fb, 1-3/4x14", 2-Plys

Self Weight of 14.12 plf automatically included in loads;

Lateral support: top= full, bottom= at supports; Load combinations: ICC-IBC;

This section FAILS the design check

WARNING: This section violates the following design criteria: Deflection

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001:

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 86$	$F_v' = 285$	$f_v/F_v' = 0.30$
Bending(+)	$f_b = 2030$	$F_b' = 2741$	$f_b/F_b' = 0.74$
Live Defl'n	$0.61 = L/492$	$0.83 = L/360$	0.73
Total Defl'n	$1.55 = L/193$	$1.25 = L/240$	1.24

Δ IS APPROPRIATE
FOR USE - \therefore OKAY

V & M OKAY

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CV	Cfu	Cx	Cft	Ci	Cn	LC#
Fb'+	2800	1.00	-	1.00	1.000	0.98	-	1.00	1.00	-	-	2
Fv'	285	1.00	-	1.00	-	-	-	-	1.00	-	1.00	2
Fcp'	750	-	-	1.00	-	-	-	-	1.00	-	-	-
E'	2.2 million	-	-	1.00	-	-	-	-	1.00	-	-	2

Bending(+): LC# 2 = D+L, M = 19345 lbs-ft

Shear : LC# 2 = D+L, V = 3095, V design = 2806 lbs

Deflection: LC# 2 = D+L EI= 880e06 lb-in²/ply

Total Deflection = 1.50 (Dead Load Deflection) + Live Load Deflection.

(D=dead L=live S=snow W=wind I=impact C=construction CLd=concentrated)

(All LC's are listed in the Analysis output)

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. SCL-BEAMS (Structural Composite Lumber): the attached SCL selection is for preliminary design only. For final member design contact your local SCL manufacturer.
3. Size factors vary from one manufacturer to another for SCL materials. They can be changed in the database editor.
4. BUILT-UP SCL-BEAMS: contact manufacturer for connection details when loads are not applied equally to all plys.

RB-1

2.10



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COMPANY

PROJECT

Dec. 15, 2008 14:45

rf beam btwn kitch and living.wwb

Design Check Calculation Sheet

Sizer 2004a

LOADS (lbs, psf, or plf) :

Load	Type	Distribution	Magnitude		Location [ft]		Pat-tern
			Start	End	Start	End	
1_j11	Dead	Partial UDL	128.3	128.3	5.00	9.55	No
2_j11	Live	Partial UDL	139.3	139.3	5.00	9.55	No
3_j12	Dead	Partial UDL	128.3	128.3	0.00	5.00	No
4_j12	Live	Partial UDL	139.3	139.3	0.00	5.00	No

MAXIMUM REACTIONS (lbs) and BEARING LENGTHS (in) :

Dead	653		653
Live	665		665
Total	1318		1318
Bearing:			
LC number	2		2
Length	1.00		1.00

Lumber n-ply, S-P-F, No.1/No.2, 2x10", 3-Plys

Self Weight of 8.41 plf automatically included in loads;

Lateral support: top= full, bottom= at supports; Repetitive factor: applied where permitted (refer to online help); Load combinations: ICC-IBC;

Analysis vs. Allowable Stress (psi) and Deflection (in) using NDS 2001 :

Criterion	Analysis Value	Design Value	Analysis/Design
Shear	$f_v = 40$	$F_v' = 135$	$f_v/F_v' = 0.30$
Bending(+)	$f_b = 589$	$F_b' = 1107$	$f_b/F_b' = 0.53$
Live Defl'n	$0.06 = < L/999$	$0.32 = L/360$	0.20
Total Defl'n	$0.16 = L/738$	$0.48 = L/240$	0.32

ADDITIONAL DATA:

FACTORS:	F	CD	CM	Ct	CL	CF	Cfu	Cr	Cft	Ci	Cn	LC#
Fb'+	875	1.00	1.00	1.00	1.000	1.100	1.00	1.15	1.00	1.00	-	2
Fv'	135	1.00	1.00	1.00	-	-	-	-	1.00	1.00	1.00	2
Fcp'	425	-	1.00	1.00	-	-	-	-	1.00	1.00	-	-
E'	1.4 million	1.00	1.00	1.00	-	-	-	-	1.00	1.00	-	2

Bending(+): LC# 2 = D+L, M = 3147 lbs-ft

Shear : LC# 2 = D+L, V = 1318, V design = 1105 lbs

Deflection: LC# 2 = D+L EI= 139e06 lb-in²/ply

Total Deflection = 1.50 (Dead Load Deflection) + Live Load Deflection.

(D=dead L=live S=snow W=wind I=impact C=construction CLD=concentrated)

(All LC's are listed in the Analysis output)

DESIGN NOTES:

1. Please verify that the default deflection limits are appropriate for your application.
2. Sawn lumber bending members shall be laterally supported according to the provisions of NDS Clause 4.4.1.
3. BUILT-UP BEAMS: it is assumed that each ply is a single continuous member (that is, no butt joints are present) fastened together securely at intervals not exceeding 4 times the depth and that each ply is equally top-loaded. Where beams are side-loaded, special fastening details may be required.

RB-2

L.A.FUESS PARTNERS ENGINEERS
Foundation Design

Project - BAC Solar House
Job Number - A8189
Engineer - AF
Date - 12-15-2008

Design of Concrete Footings

Bearing Strata - soil
Bearing Pressure (ksf) - 1500
Footings in Rock? - N

Design Parameters

Conc Strength (psi) - 3000
Reinf Yield (ksi) - 60
Dead Load Factor - 1.4
Live Load Factor - 1.7
Wind Load factor - 1.3
Pier Load Factor - 1
Minimum Add-on Load - 0

Concrete Footing Design No. 1 Mark 2-6X2-6

*Load Combinations:

Pdl, Pll, Pwl, Padd	= 5	5	0
0			
Pdl + Pll + Padd	= 10		
.75(Pdl + Pll + Pwl + Padd)	= 7.5		
.75(Pdl - Pwl)	= 3.75		
1.4 Pdl + 1.7 (Pll+Padd)	= 15.5		
.75(1.4 Pdl+ 1.7 Pll+ 1.7 Pwl)	= 11.625		
.9(1.4 Pdl- 1.3 Pwl)	= 6.3		
Aspect Ratio	= 1.		

*Footing Design per ACI 318 Strength Design

Pu (kips)	= 15.5
Pservice (kips)	= 10.
Footing Size	= 1.5 ft. x 1.5 ft.
Footing Thickness (in)	= 12
Bearing Pressure (ksf)	= 4.44
Ult. Brg. Cap. of Ped. (kips)	= 385.56
Pedestal Size	= 12in. x 12 in.

*Footing Reinforcing

Parallel to 1.5 ft. Side:		
200/fy Reinforcing (in.2)	= 0.51	
Flexural Reinforcing (in.2)	= .01	1# 1
Parallel to 1.5 ft. Side:		
200/fy Reinforcing (in.2)	= 0.51	
Flexural Reinforcing (in.2)	= .01	1# 1

← USE #5 @ 10" EW

*Estimated Cost

Concrete	0.08	CY	@	\$60.	\$5.00
Reinforcing	0.00	TN	@	\$650.	\$0.03
Formwork	6.00	SF	@	\$3.	\$18.00

FTB DESIGN

Excavation	0.08	IN	@	\$5.	\$0.42
Total					\$23.45

Concrete Footing Design No. 2 Mark 6X6

*Load Combinations:

Pdl, Pll, Pwl, Padd	= 8	8	0
Pdl + Pll + Padd	= 16		
.75(Pdl + Pll + Pwl + Padd)	= 12		
.75(Pdl - Pwl)	= 6		
1.4 Pdl + 1.7 (Pll+Padd)	= 24.8		
.75(1.4 Pdl+ 1.7 Pll+ 1.7 Pwl)	= 18.6		
.9(1.4 Pdl- 1.3 Pwl)	= 10.08		
Aspect Ratio	= 1.		

*Footing Design per ACI 318 Strength Design

Pu (kips)	= 24.8
Pservice (kips)	= 16.
Footing Size	= 1.5 ft. x 1.5 ft.
Footing Thickness (in)	= 12
Bearing Pressure (ksf)	= 7.11
Ult. Brg. Cap. of Ped. (kips)	= 385.56
Pedestal Size	= 12in. x 12 in.

*Footing Reinforcing

Parallel to 1.5 ft. Side:	
200/fy Reinforcing (in.2)	= 0.51
Flexural Reinforcing (in.2)	= .02 2# 1
Parallel to 1.5 ft. Side:	
200/fy Reinforcing (in.2)	= 0.51
Flexural Reinforcing (in.2)	= .02 2# 1

$$= \frac{200 \text{ b x d}}{F_y}$$

$$= \frac{200 \times 12'' \times 9''}{60,000} = 0.36 \frac{\#}{\text{ft}}$$

*Estimated Cost

Concrete	0.08	CY	@	\$60.	\$5.00
Reinforcing	0.00	TN	@	\$650.	\$0.06
Formwork	6.00	SF	@	\$3.	\$18.00
Excavation	0.08	IN	@	\$5.	\$0.42

Total \$23.48

$$\frac{0.36}{12}$$

$$\frac{0.31}{X=10}$$

Concrete Footing Design No. 3 Mark 10X5

*Load Combinations:

Pdl, Pll, Pwl, Padd	= 8	8	0
Pdl + Pll + Padd	= 16		
.75(Pdl + Pll + Pwl + Padd)	= 12		
.75(Pdl - Pwl)	= 6		
1.4 Pdl + 1.7 (Pll+Padd)	= 24.8		
.75(1.4 Pdl+ 1.7 Pll+ 1.7 Pwl)	= 18.6		
.9(1.4 Pdl- 1.3 Pwl)	= 10.08		
Aspect Ratio	= 2.		

*Footing Design per ACI 318 Strength Design

Pu (kips) = 24.8
 Pservice (kips) = 16.
 Footing Size = 1.5 ft. x 3 ft.
 Footing Thickness (in) = 12
 Bearing Pressure (ksf) = 3.56
 Ult. Brg. Cap. of Ped. (kips) = 771.12
 Pedestal Size = 12in. x 24 in.

*Footing Reinforcing

Parallel to 1.5 ft. Side:
 200/fy Reinforcing (in.2) = 1.02
 Flexural Reinforcing (in.2) = .02 3# 1
 Parallel to 3 ft. Side:
 200/fy Reinforcing (in.2) = 0.51
 Flexural Reinforcing (in.2) = .14 2# 3

*Estimated Cost

Concrete	0.17	CY	@	\$60.	\$10.00
Reinforcing	0.00	TN	@	\$650.	\$0.72
Formwork	9.00	SF	@	\$3.	\$27.00
Excavation	0.17	IN	@	\$5.	\$0.83

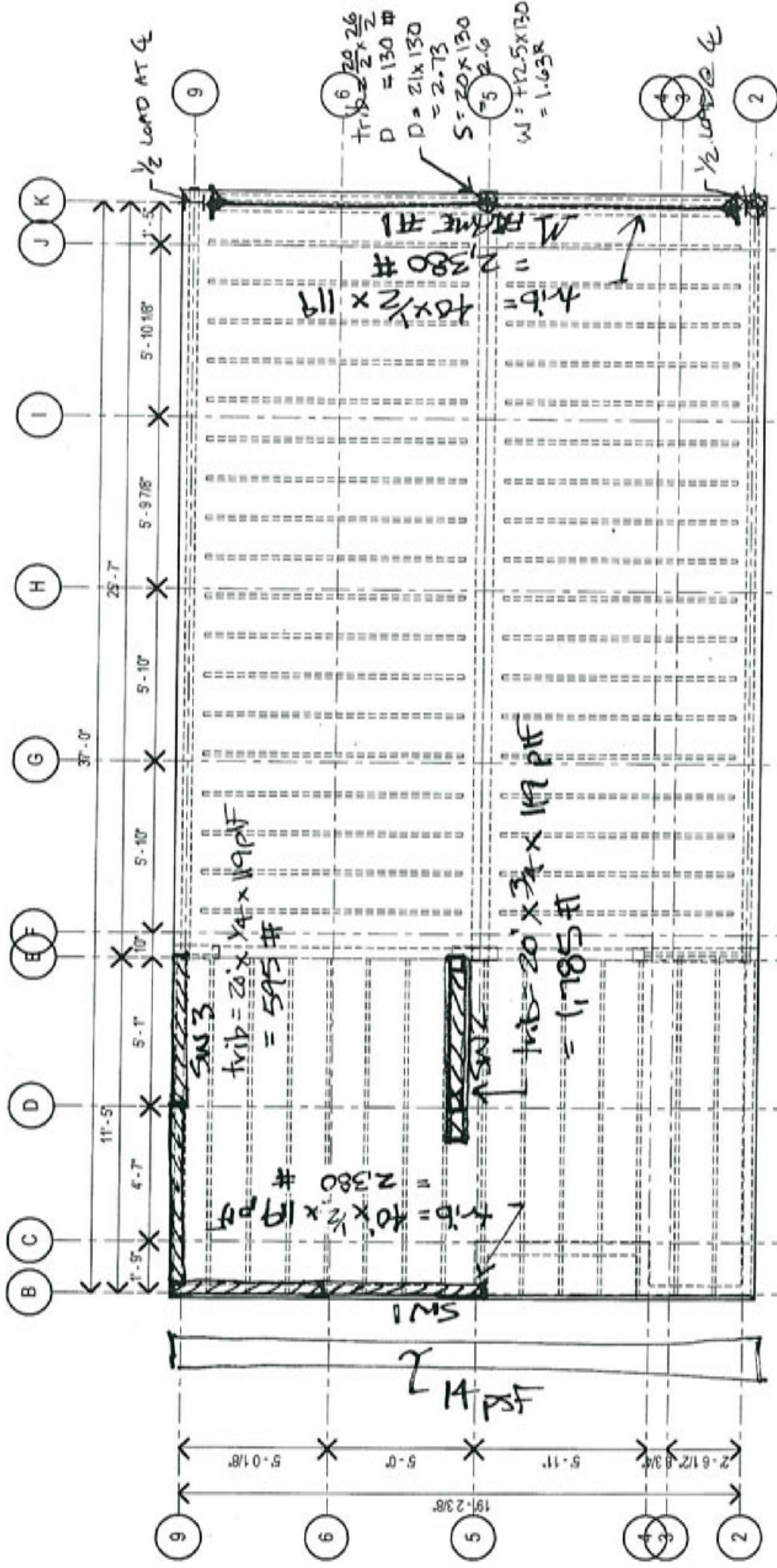
Total					\$38.55
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=====

FOOTING SCHEDULE

=====

Footing Mark	Width /Reinf	Length /Reinf	Thick. (in)	Design Load (k)	Cost \$
2-6X2-6	1.5	1.5	12	10	\$23
	1# 1	1# 1			
6X6	1.5	1.5	12	16	\$23
	2# 1	2# 1			
10X5	1.5	3	12	16	\$39
	3# 1	2# 3			



↑ N
3.1

Job Number A8189 Date 12-12-08 Engineer AFJob Name SOLAR HOUSESubject LATERAL DESIGN - WALL MATERIAL & CONNECTION SCHEDULE 1/1

3.2

WOOD STEEL WALLS

SW1

$$l = 10'-0"$$

$$P = 2,380 \text{ \#}$$

$$= \frac{2,380 \text{ \#}}{10 \text{ ft}} = 238 \text{ pif}$$

RESISTANCE: $7/16"$ T2XWOOD OF OSB,
1 SIDE
= 336 pif - USE 8d NAILS @ 6" SPAC

SW2

$$l = 6'-6"$$

$$P = 1,785 \text{ \#}$$

$$= \frac{1,785 \text{ \#}}{6'-6"} = 275 \text{ pif}$$

RESISTANCE: $5/8"$ GYP WALL BOARD X
2 SIDES
= $2 \times 145 \text{ pif}$
= 290 pif
- USE 4" SPACING
- 6d COOLER NAIL X $1\frac{3}{4}"$
 $3/8"$ head x .12" NAIL
OR
- DRU WALL SCREW X $1\frac{1}{4}"$
TYPE S OR W X #6

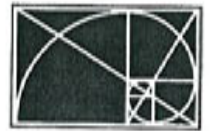
SW3

$$l = 11'-5"$$

$$P = 595 \text{ \#}$$

$$= \frac{595 \text{ \#}}{11.5} = 52 \text{ pif}$$

RESISTANCE: USE 1 SIDE, $5/8"$ GYP WALL BOARD,
FASTER SPACING 7" O.C.,
6d COOLER NAIL X $1\frac{3}{4}"$ long x
 $3/8"$ head x .12" NAIL OR
 $1\frac{1}{4}"$ TYPE S OR W #6
DRU WALL SCREW



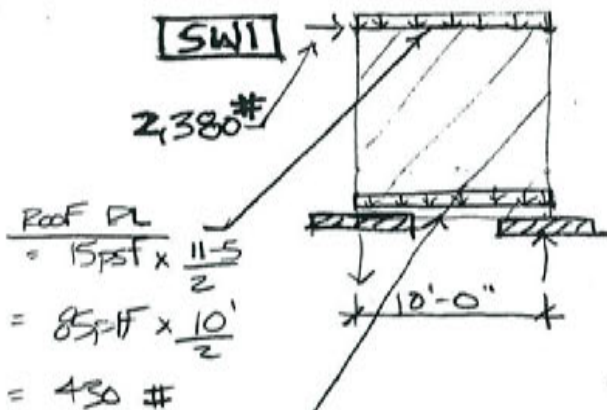
OVER TURNING

WALL HEIGHT:

$$\text{TOP OF WALL} = 110'-10''$$

$$\text{TOP OF FOOTINGS} = 101'-0''$$

$$= (110-10) - 101 = 9'-10''$$



$$W_{\text{uplift}} = \frac{2380 \text{ \#} \times 9-10}{10-0} = 2,340 \text{ \#}$$

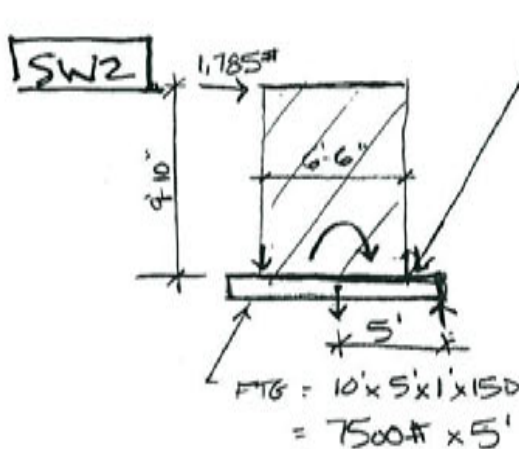
$$\text{GRAVITY} \leq 2 \times W_{\text{uplift}}$$

$$3,900 + 130 + 285 = 4,680 \text{ \#}$$

$$4,615 \leq 4,680$$

OKAY, WITHIN 2%

FOOTINGS
 $= 4' \times 6'-6'' \times 150 \text{ pcf}$
 $= 3,900 \text{ \#}$



$$P_{\text{uplift}} = 2710 \text{ \#}$$

$$\text{WIND OVERTURNING} = 9'-10'' \times 1,785 \text{ \#}$$

$$= 17,550 \text{ \# FT}$$

$$\text{GRAVITY} \leq 2 \times \text{WIND OVERTURNING}$$

$$\leq 2 \times 17,550 \text{ \# FT}$$

$$37,500 \text{ \# FT} \leq 35,100 \text{ \# FT}$$

OKAY





3.4

CONNECTION TO CONC FOOTING: SW1, SW2, SW3

P_u LIFT

$$SW1 = 2,340 \#$$

$$SW2 = 2,710 \# \leftarrow \text{CONTROLS}$$

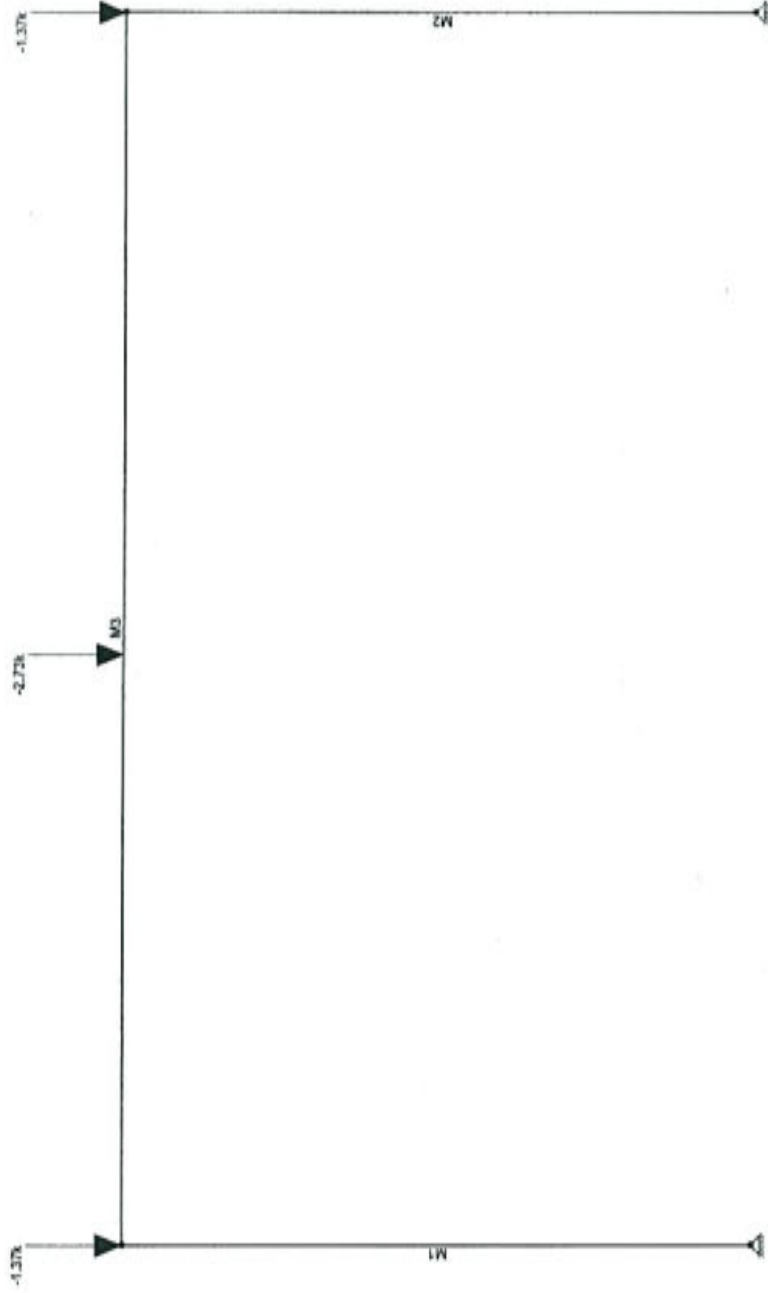
$$SW3 = 513 \#$$

WOOD HOLD DOWN - SIMPSON

$$\begin{aligned} &\text{USE HD6A, 3" WD MEMBER THICKNESS} \\ &= 3,680 \# > P_{u \text{ LIFT}} \end{aligned}$$

USE 3/4" DIA THREADED ROD, EMBEDDED 6 5/8" INTO CONCRETE FOOTING

$$\begin{aligned} &= 7,347 \# \text{ ALLOWABLE BOND TO CONCRETE CAPACITY} \\ &\quad \swarrow \text{OKAY, } > P_{u \text{ LIFT}} \end{aligned}$$



Loads: DL - Dead Load
Results for LC 5, ASCE 6 (c)

L.A. Fuess Partners

AF

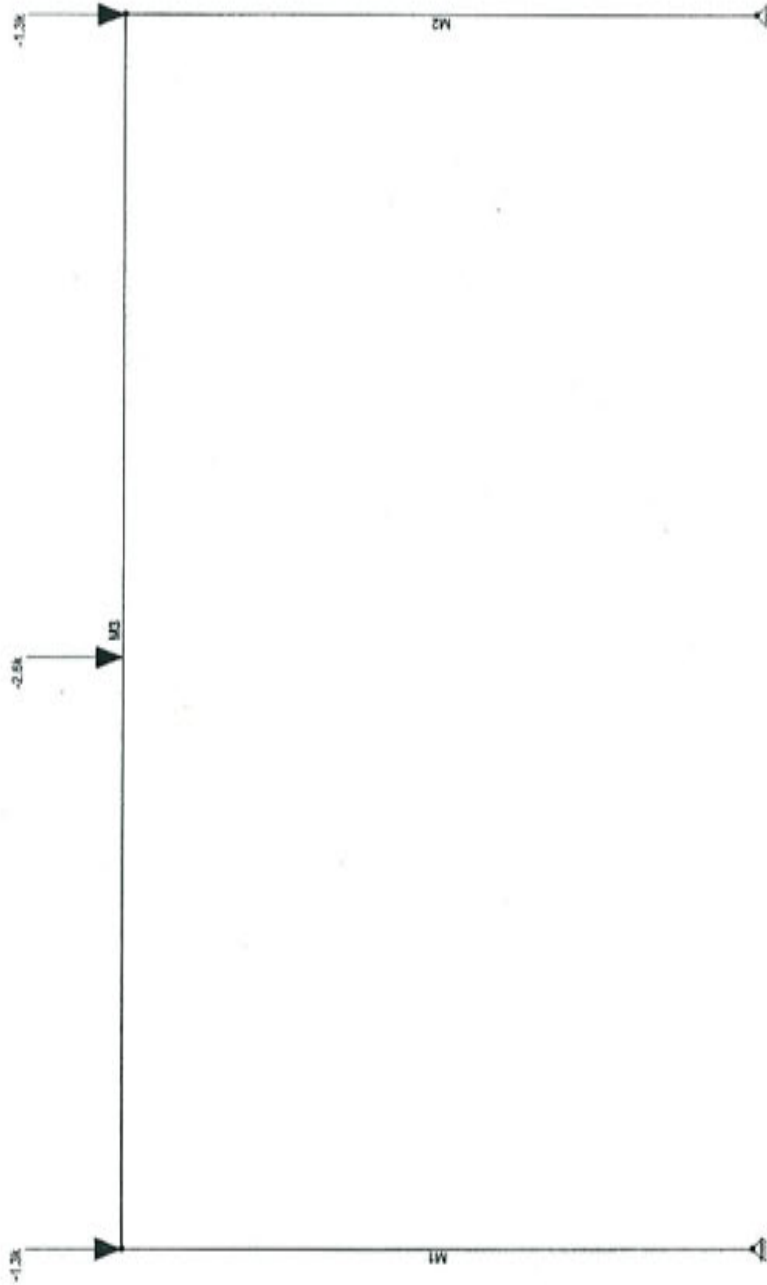
A8189

Solar House Lateral Frame

dead load

Dec 14, 2008 at 3:54 PM

A8189_M frame_lateral design.r3d



Load: SL - Snow Load
Results for LC 3, ASCE 6 (c)

L.A. Fuess Partners

AF

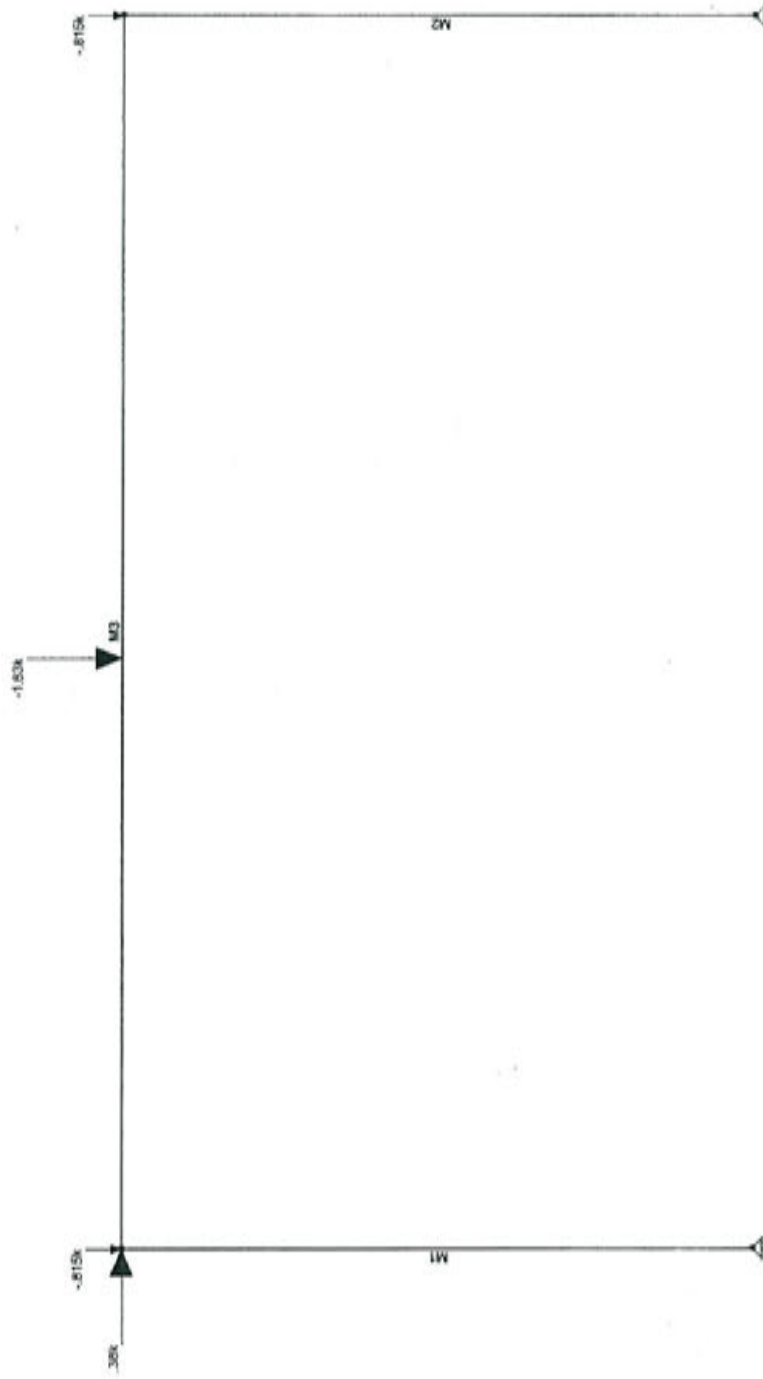
A8189

Solar House Lateral Frame

snow load

Dec 14, 2008 at 3:54 PM

A8189_M frame_lateral design.r3d



Loads: WL - Wind Load
Results for LC 5, ASCE 6 (c)

L.A. Fuess Partners

AF

A8189

Solar House Lateral Frame

wind load

Dec 14, 2008 at 3:53 PM

A8189_M frame_lateral design.r3d

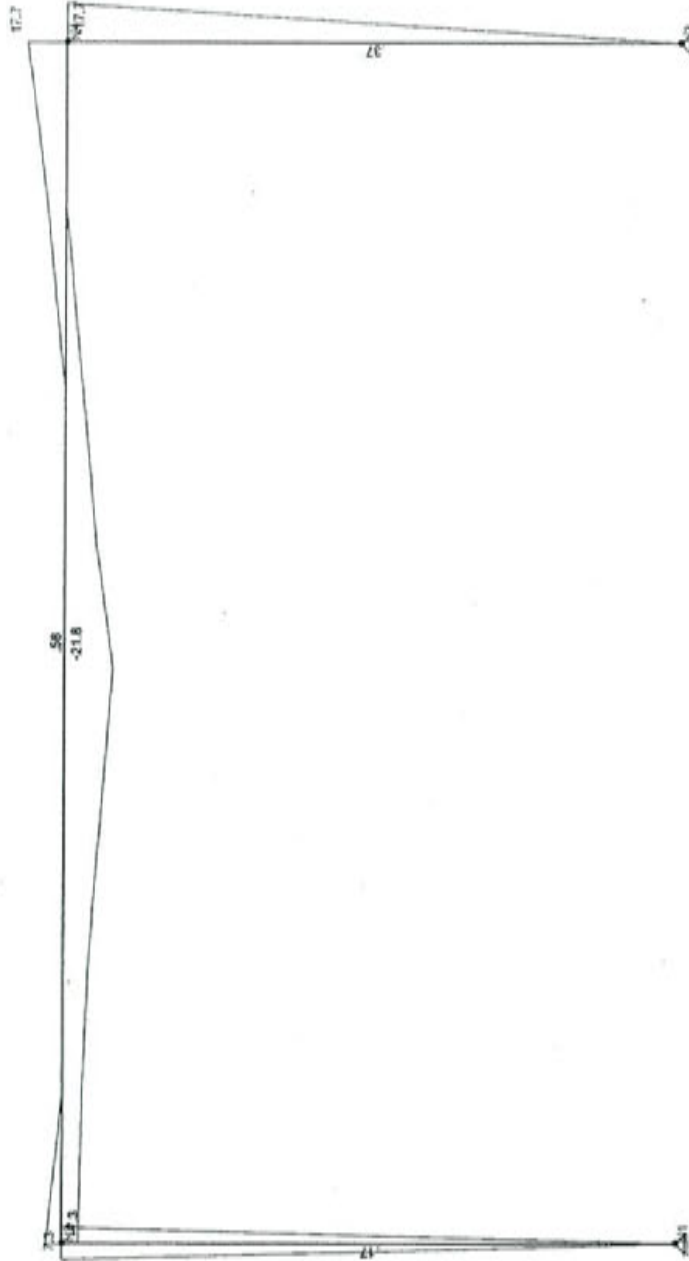
Company : L.A. Fuess Partners
Designer : AF
Job Number : A8189

Dec 14, 2008
3:35 PM
Checked By:

Solar House Lateral Frame

Envelope AISC ASD Steel Code Checks

Member	Shape	Code...	Loc[ft]	Ic	Shear Check	Loc[ft]	Dir	Ic	Fa [ksi]	Ft [ksi]	Fb y-y [ksi]	Fb z-z [ksi]	Cb	Cmy	Cmz	ASD Eqn
1	M1	W8X24	.166	9.833	2	.019	0	6	20.301	30	37.5	30	1.75	.6	.6	H1-2
2	M2	W8X24	.366	9.833	4	.046	0	4	20.301	30	37.5	30	1.75	.6	.6	H1-2
3	M3	W12X...	.579	19.167	5	.071	19.167	5	20.599	30	37.5	10.529	1	.6	.85	H1-2



Member Code Checks Displayed
Solution: Envelope
Member z Bending Moments (k-ft)
Reaction units are k and k-ft

L.A. Fuess Partners

AF

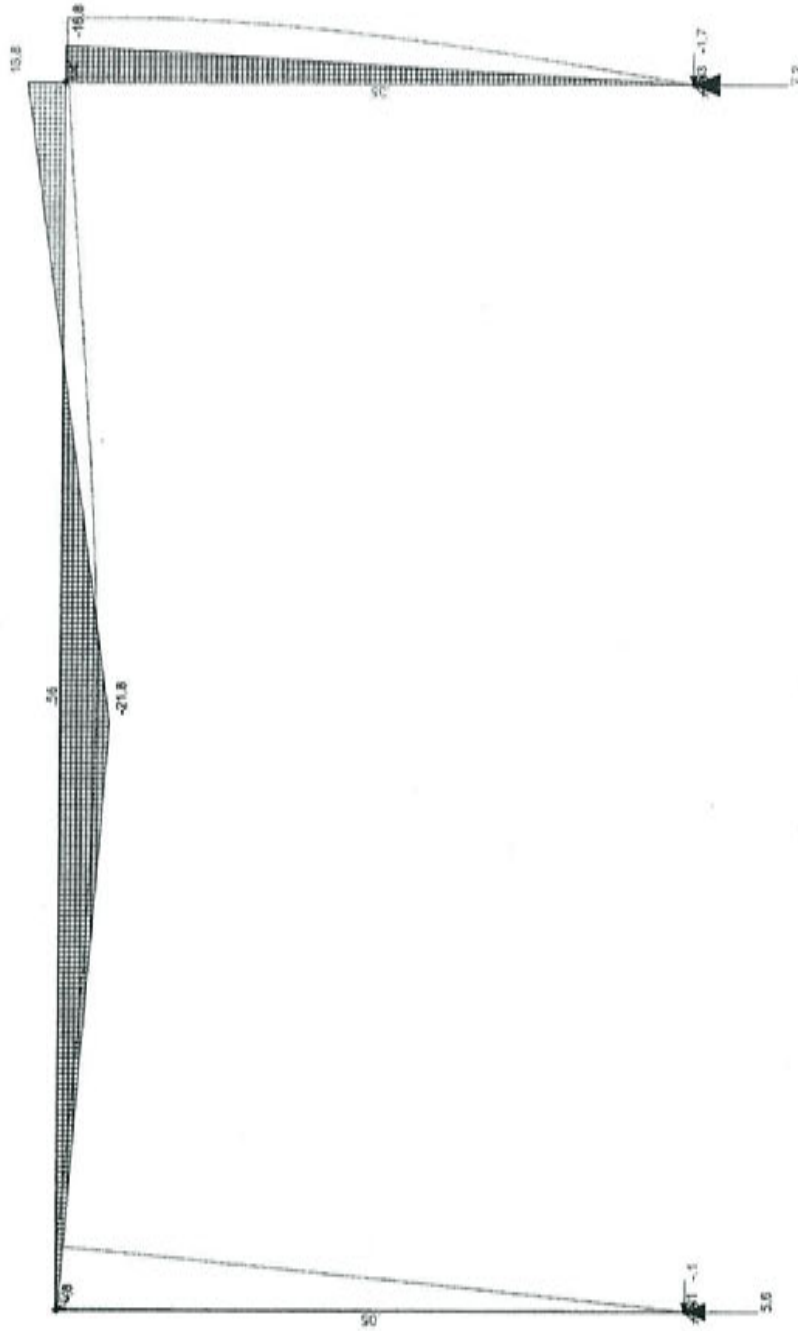
A8189

Solar House Lateral Frame

ENVELOP

Dec 14, 2008 at 3:41 PM

A8189_M frame_lateral design.r3d



Member Code Checks Displayed
Results for LC 5, ASCE 6 (c)
Member 2 Bending Moments (k-ft)
Reaction units are k and k-ft

L.A. Fuess Partners

AF

A8189

Solar House Lateral Frame

Dec 14, 2008 at 3:28 PM

A8189_M frame_lateral design.r3d

LC 5: lateral defl controlled = 0.3" for pin at base condition, bm controlled ...

Column: **M1**

Shape: **W8X24**

Material: **A572 Gr.50**

Length: **9.833 ft**

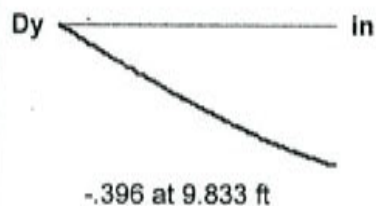
I Joint: **N1**

J Joint: **N2**

LC 6: **ASCE 7**

Code Check: **0.150 (bending)**

Report Based On 97 Sections

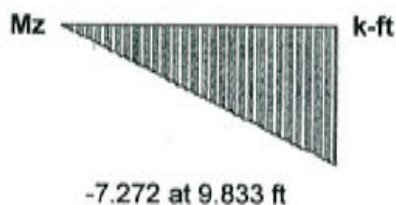


Dz _____ in

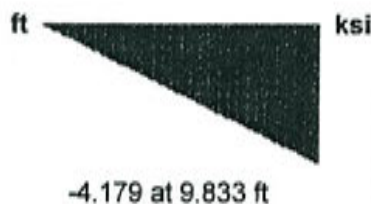
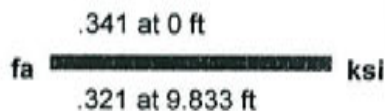


Vz _____ k

T _____ k-ft



My _____ k-ft



AISC ASD 9th Ed. Code Check

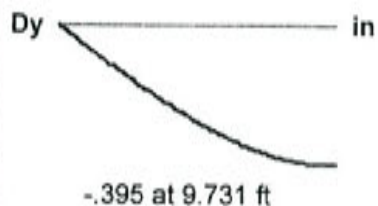
Max Bending Check **0.150**
 Location **9.833 ft**
 Equation **H1-2**

Max Shear Check **0.019 (y)**
 Location **0 ft**
 Max Defl Ratio **L/3636**

Compact

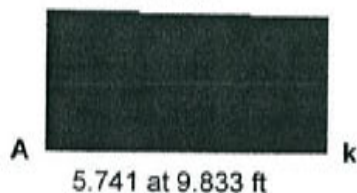
Fy **50 ksi**
 Fa **20.301 ksi**
 Ft **30 ksi**
 Fby **37.5 ksi**
 Fbz **30 ksi**
 Fvy **20 ksi**
 Fvz **20 ksi**
 Cb **1.75**

	Y-Y	Z-Z
Cm	.6	.6
Lb	9.833 ft	9.833 ft
KL/r	73.394	34.504
Sway	No	No
L Comp Flange	9.833 ft	
Torque Length	9.833 ft	

Column: **M2**Shape: **W8X24**Material: **A572 Gr.50**Length: **9.833 ft**I Joint: **N3**J Joint: **N4**LC 4: **ASCE 5 (a)**Code Check: **0.366 (bending)**Report Based On **97 Sections**

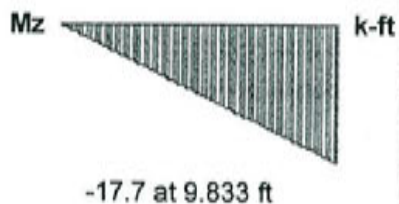
Dz _____ in

5.978 at 0 ft

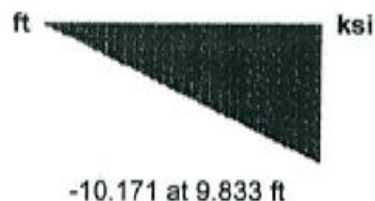
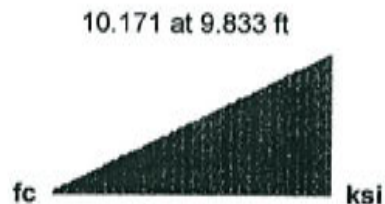
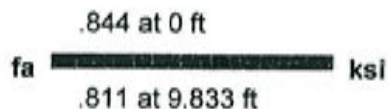


Vz _____ k

T _____ k-ft



My _____ k-ft

**AISC ASD 9th Ed. Code Check**

Max Bending Check **0.366**
 Location **9.833 ft**
 Equation **H1-2**

Max Shear Check **0.046 (y)**
 Location **0 ft**
 Max Defl Ratio **L/1494**

Compact

Fy **50 ksi**
 Fa **20.301 ksi**
 Ft **30 ksi**
 Fby **37.5 ksi**
 Fbz **30 ksi**
 Fvy **20 ksi**
 Fvz **20 ksi**
 Cb **1.75**

	Y-Y	Z-Z
Cm	.6	.6
Lb	9.833 ft	9.833 ft
KL/r	73.394	34.504
Sway	No	No
L Comp Flange	9.833 ft	
Torque Length	9.833 ft	

Beam: **M3**

Shape: **W12X26**

Material: **A572 Gr.50**

Length: **19.167 ft**

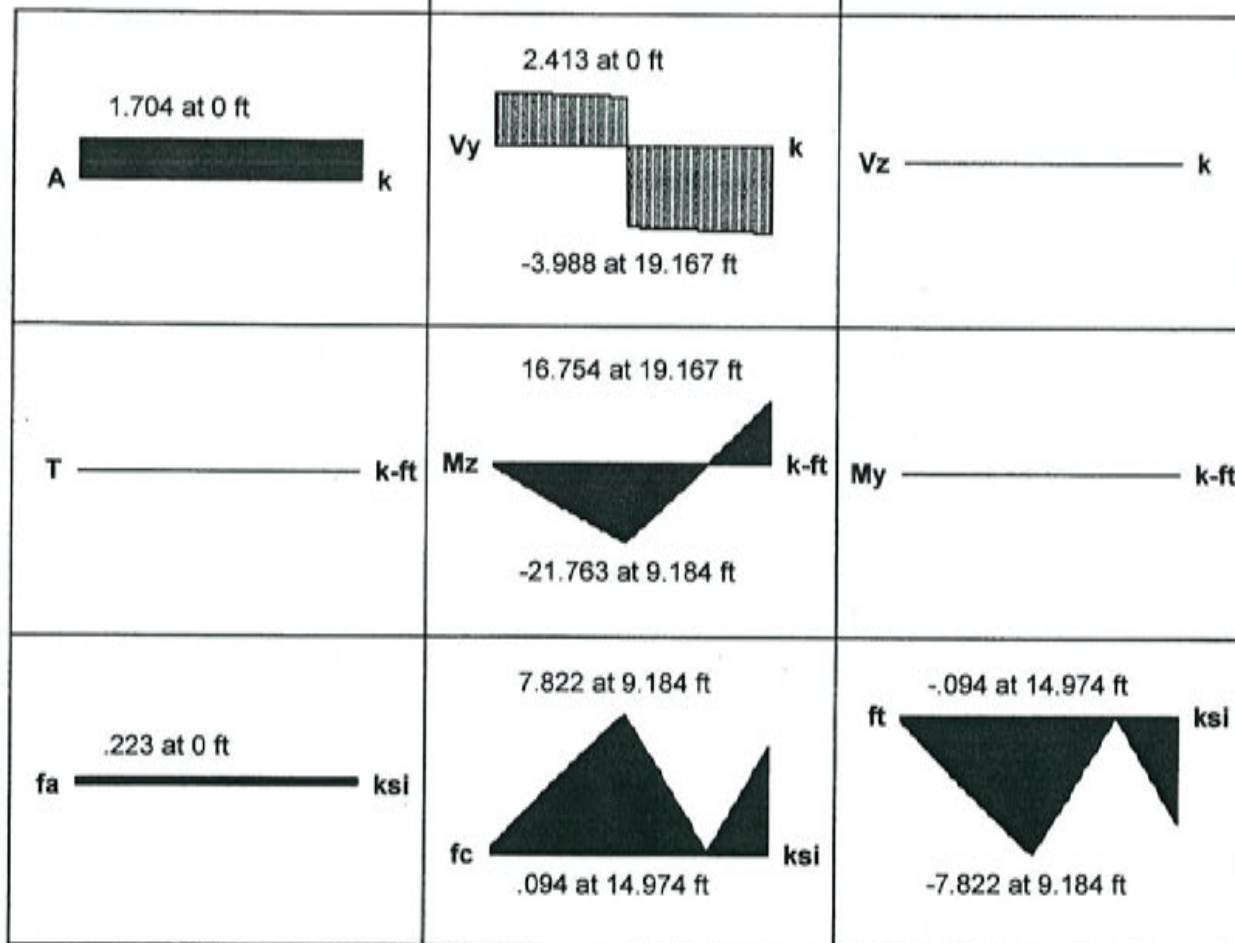
I Joint: **N2**

J Joint: **N4**

LC 5: **ASCE 6 (c)**

Code Check: **0.750 (bending)**

Report Based On 97 Sections



AISC ASD 9th Ed. Code Check

Max Bending Check **0.750**
 Location **9.184 ft**
 Equation **H1-2**

Max Shear Check **0.071 (y)**
 Location **19.167 ft**
 Max Defl Ratio **L/1431**

Compact

Fy **50 ksi**
 Fa **6.384 ksi**
 Ft **30 ksi**
 Fby **37.5 ksi**
 Fbz **10.529 ksi**
 Fvy **20 ksi**
 Fvz **20 ksi**
 Cb **1**

Y-Y
 Cm **.6**
 Lb **19.167 ft**
 KL/r **152.948**
 Sway **No**
 L Comp Flange **19.167 ft**
 Torque Length **19.167 ft**

Z-Z
 .85
19.167 ft
44.54
No

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distributed Area (Me...	Surface (...)
1	DEAD	DL		-1		2	1		
2	SNOW	SL				2	1		
3	WIND	WL				3	1		

Hot Rolled Steel Design Parameters

	Label	Shape	Length...	Lbyy[ft]	Lbzz[ft]	Lcomp to...	Lcomp b...	Kyy	Kzz	Cm-yy	Cm-zz	Cb	y swayz	sway	Function
1	M1	column	9.833												Lateral
2	M2	column	9.833												Lateral
3	M3	beam	19.167	9											Lateral

Global

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation	Yes
Include Warping	Yes
Area Load Mesh (in^2)	144
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.50%
Vertical Axis	Y

Hot Rolled Steel Code	AISC: ASD 9th
Cold Formed Steel Code	AISI 99: ASD
Wood Code	NDS 91/97: ASD
Wood Temperature	< 100F
Concrete Code	ACI 2002

Number of Shear Regions	4
Region Spacing Increment (in)	4
Biaxial Column Method	PCA Load Contour
Parame Beta Factor (PCA)	.65
Concrete Stress Block	Rectangular
Use Cracked Sections	Yes
Bad Framing Warnings	No
Unused Force Warnings	Yes

Member AISC ASD Steel Code Checks (By Combination)

	LC	Member	Shape	UC Max	Loc[ft]	Shear ...	Loc[ft]	Dir	Fa[ksi]	Ft[ksi]	Fby[ksi]	Fbz[ksi]	Cb	Cmy	Cmz	Eqn
1	4	M1	W8X24	.126	9.833	.015	0	y	20.301	30	37.5	30	1.75	.6	.6	H1-2
2	4	M2	W8X24	.366	9.833	.046	0	y	20.301	30	37.5	30	1.75	.6	.6	H1-2
3	4	M3	W12X26	.296	19.167	.063	19.167	y	20.599	30	37.5	22.316	2.119	.6	.85	H1-3

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
1	N1	0	0	0	0	
2	N2	0	9.833	0	0	
3	N3	19.167	0	0	0	
4	N4	19.167	9.833	0	0	

3.15

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
1	4	N1	0	0	0	0	0	-3.894e-3
2	4	N2	.397	-.002	0	0	0	-2.213e-3
3	4	N3	0	0	0	0	0	-4.994e-3
4	4	N4	.395	-.003	0	0	0	2.246e-4

Joint Reactions

	LC	Joint Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	4	N1	-.58	3.725	0	0	0	0
2	4	N3	-1.8	5.978	0	0	0	0
3	4	N2	0	0	0	0	0	0
4	4	N4	0	0	0	0	0	0
5	4	Totals:	-2.38	9.703	0			
6	4	COG (ft):	X: 9.396	Y: 9.593	Z: 0			

Load Combination Design

	Description	ASIF	CD	ABIF	Service	Hot Rolled	Cold Formed	Wood	Concrete	Footings
1	ASCE 1		.9		Yes	Yes	Yes	Yes		
2	ASCE 3 (b)		1.15		Yes	Yes	Yes	Yes		
3	ASCE 4 (b)		1.15		Yes	Yes	Yes	Yes		
4	ASCE 5 (a)		1.6		Yes	Yes	Yes	Yes		
5	ASCE 6 (c)		1.6		Yes	Yes	Yes	Yes		
6	ASCE 7		1.6		Yes	Yes	Yes	Yes		

Load Combinations

	Description	Solve PD...	SR...	BLC Factor	BLC Factor	BLC Factor	BLC Factor	BLC Factor	BLC Factor	BLC Factor	BLC Factor
1	ASCE 1	Yes		DL	1						
2	ASCE 3 (b)	Yes		DL	1	SL	1				
3	ASCE 4 (b)	Yes		DL	1	LL	.75	SL	.75		
4	ASCE 5 (a)	Yes		DL	1	WL	1				
5	ASCE 6 (c)	Yes		DL	1	WL	.75	LLS	.75	SL	.75
6	ASCE 7	Yes		DL	.6	WL	1				

Member Area Loads

Joint A	Joint B	Joint C	Joint D	Direction	Distribution	Magnitude[ksf]
No Data to Print ...						

Member Distributed Loads

Member Label	Direction	Start Magnitude[k/ft]...	End Magnitude[k/ft,d...	Start Location[ft.%]	End Location[ft.%]
No Data to Print ...					

Joint Loads and Enforced Displacements (BLC 1 : DEAD)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N2	L	Y	-1.37
2	N4	L	Y	-1.37

Joint Loads and Enforced Displacements (BLC 2 : SNOW)

Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
-------------	-------	-----------	---

Joint Loads and Enforced Displacements (BLC 2 : SNOW) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...]
1	N2	L	Y	-1.3
2	N4	L	Y	-1.3

Joint Loads and Enforced Displacements (BLC 3 : WIND)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...]
1	N2	L	X	2.38
2	N2	L	Y	-.815
3	N4	L	Y	-.815

Member Point Loads (BLC 1 : DEAD)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M3	y	-2.73	9.167

Member Point Loads (BLC 2 : SNOW)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M3	y	-2.6	9.167

Member Point Loads (BLC 3 : WIND)

	Member Label	Direction	Magnitude[k,k-ft]	Location[ft,%]
1	M3	y	-1.63	9.167

Plate Surface Loads

Plate Label	Direction	Magnitude[ksf,deg]
No Data to Print ...		

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (1/E5 F)	Density[k/ft^3]	Yield[ksi]
1	A36 Gr.36	29000	11154	.3	.65	.49	36
2	A572 Gr.50	29000	11154	.3	.65	.49	50
3	A992	29000	11154	.3	.65	.49	50
4	A500 Gr.42	29000	11154	.3	.65	.49	42
5	A500 Gr.46	29000	11154	.3	.65	.49	46

Member Primary Data

	Label	I Joint	J Joint	K Joint	Rotate(deg)	Section/Shape	Type	Design List	Material	Design Rules
1	M1	N1	N2			column	Column	Wide Flange	A572 Gr.50	Typical
2	M2	N3	N4			column	Column	Wide Flange	A572 Gr.50	Typical
3	M3	N2	N4			beam	Beam	Wide Flange	A572 Gr.50	Typical

Member Section Deflections

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
1	4	M1	1	0	0	0	0	NC	NC
2			2	0	-.115	0	0	7613.28	NC
3			3	-.001	-.223	0	0	4758.3	NC
4			4	-.002	-.319	0	0	5438.057	NC
5			5	-.002	-.397	0	0	NC	NC
6	4	M2	1	0	0	0	0	NC	NC
7			2	0	-.147	0	0	2452.675	NC
8			3	-.002	-.274	0	0	1532.922	NC

Member Section Deflections (Continued)

	LC	Member Label	Sec	x [in]	y [in]	z [in]	x Rotate[rad]	(n) L/y Ratio	(n) L/z Ratio
9			4	-.003	-.364	0	0	1751.91	NC
10			5	-.003	-.395	0	0	NC	NC
11	4	M3	1	.397	-.002	0	0	NC	NC
12			2	.396	-.101	0	0	2335.484	NC
13			3	.396	-.122	0	0	1929.659	NC
14			4	.395	-.059	0	0	4092.064	NC
15			5	.395	-.003	0	0	NC	NC

Member Section Forces

	LC	Member Label	Sec	Axial[k]	y Shear[k]	z Shear[k]	Torque[k-ft]	y-y Moment[k-...	z-z Moment[k-...
1	4	M1	1	3.725	.58	0	0	0	0
2			2	3.666	.58	0	0	0	-1.426
3			3	3.607	.58	0	0	0	-2.851
4			4	3.547	.58	0	0	0	-4.277
5			5	3.488	.58	0	0	0	-5.702
6	4	M2	1	5.978	1.8	0	0	0	0
7			2	5.918	1.8	0	0	0	-4.425
8			3	5.859	1.8	0	0	0	-8.85
9			4	5.8	1.8	0	0	0	-13.275
10			5	5.741	1.8	0	0	0	-17.7
11	4	M3	1	1.8	1.303	0	0	0	-5.702
12			2	1.8	1.178	0	0	0	-11.648
13			3	1.8	-3.306	0	0	0	-15.18
14			4	1.8	-3.431	0	0	0	.961
15			5	1.8	-3.556	0	0	0	17.7

Member Section Stresses

	LC	Member Label	Sec	Axial[ksi]	y Shear[ksi]	z Shear[ksi]	y top Bendin...	y bot Bendin...	z top Bendin...	z bot Bendin...
1	4	M1	1	.526	.298	0	0	0	0	0
2			2	.518	.298	0	.819	-.819	0	0
3			3	.509	.298	0	1.638	-1.638	0	0
4			4	.501	.298	0	2.458	-2.458	0	0
5			5	.493	.298	0	3.277	-3.277	0	0
6	4	M2	1	.844	.927	0	0	0	0	0
7			2	.836	.927	0	2.543	-2.543	0	0
8			3	.828	.927	0	5.086	-5.086	0	0
9			4	.819	.927	0	7.628	-7.628	0	0
10			5	.811	.927	0	10.171	-10.171	0	0
11	4	M3	1	.235	.464	0	2.049	-2.049	0	0
12			2	.235	.419	0	4.186	-4.186	0	0
13			3	.235	-1.176	0	5.456	-5.456	0	0
14			4	.235	-1.221	0	-.345	.345	0	0
15			5	.235	-1.265	0	-6.362	6.362	0	0

Hot Rolled Steel Section Sets

	Label	Shape	Type	Design List	Material	Design Rules	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	column	W8X24	Column	Wide Flange	A572 Gr.50	Typical	7.08	18.3	82.8	.35
2	beam	W12X26	Beam	Wide Flange	A572 Gr.50	Typical	7.65	17.3	204	.3

Envelope Joint Reactions

	Joint	X [k]	lc	Y [k]	lc	Z [k]	lc	MX [k-ft]	lc	MY [k-ft]	lc	MZ [k-ft]	lc
1	N1	max	738	2	5.937	2	0	0	1	0	1	0	1
2		min	-74	6	2.413	6	0	0	1	0	1	0	1
3	N3	max	-399	1	7.181	5	0	0	1	0	1	0	1
4		min	-1.8	4	3.162	1	0	0	1	0	1	0	1
5	N2	max	0	1	0	1	0	0	1	0	1	0	1
6		min	0	1	0	1	0	0	1	0	1	0	1
7	N4	max	0	1	0	1	0	0	1	0	1	0	1
8		min	0	1	0	1	0	0	1	0	1	0	1
9	Totals:	max	0	2	12.788	5	0	0	1	0	1	0	1
10		min	-2.38	4	6.443	1	0	0	1	0	1	0	1

CONTROLLING AXIAL LOAD FOR
 FTES SUPPORTING THE STEEL COLUMNS

SOIL BEG CAPACITY = 1500 PSF

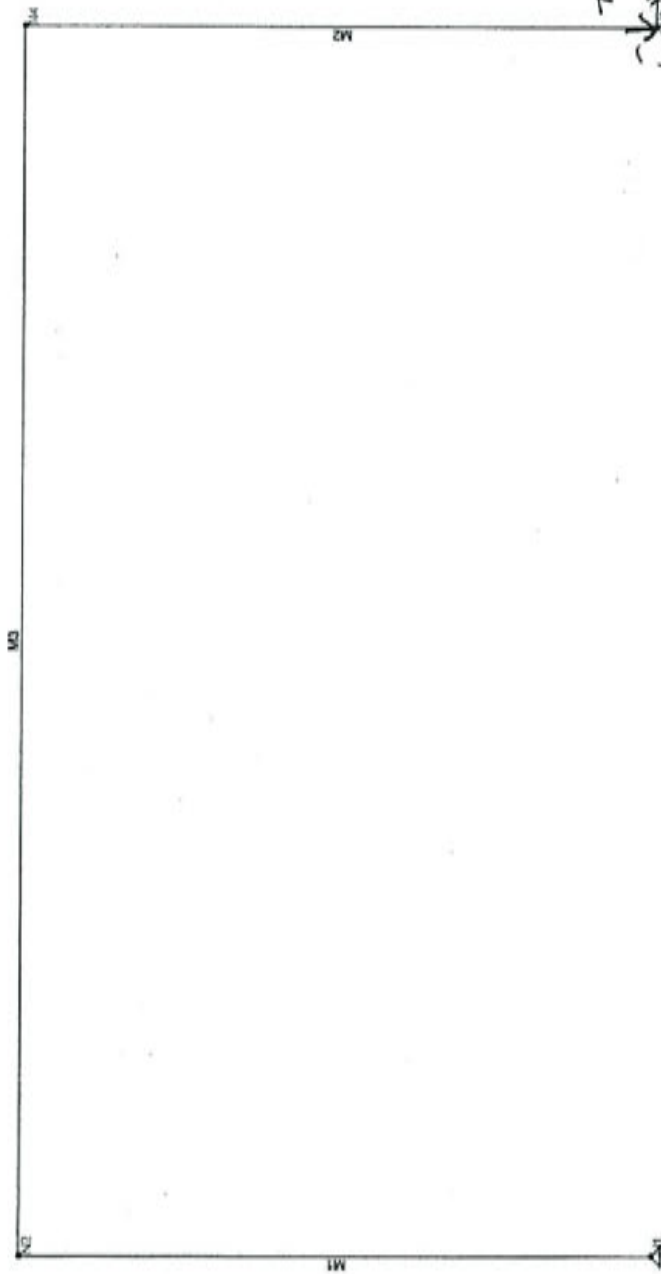
$$\frac{P}{Q} = \frac{7,181 \text{ k}}{1500 \text{ PSF}} = 4.8 \text{ SF} \approx 2'-3" \times 2'-3"$$

$$\text{SIDING} = 1800 \text{ \#} \leq \mu \times W$$

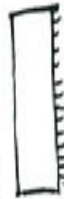
$$\frac{1800}{0.4} \leq W$$

$$4500 \text{ \#} \leq W$$

$$\approx 5'-6" \text{ } 30 \times 1'-0" \text{ thick Fbg}$$



7.181 kips
(X) → AF - 1800#
[PG - check sliding



Solution: Envelope

L.A. Fuess Partners

AF

A8189

Solar House Lateral Frame

member and node labels

Dec 14, 2008 at 4:01 PM

A8189_M frame_lateral design.r3d



TEAM BOSTON
SOLAR DECATHLON 2009

DETAILED WATER BUDGET



DETAILED WATER BUDGET

LOW CONSUMPTION			
HOT WATER LOADS			
UTILITIES	GALLONS/USE	NO. OF OPERATIONS	GALLONS
Clothes washer	12 Gal.	10	120 Gallons
Dishwasher	4 Gal.	5	20 Gallons
Showers	15 Gal.	20	300 Gallons
Total Hot Water Consumption (per week)			440 Gallons

HIGH CONSUMPTION			
HOT WATER LOADS			
UTILITIES	GALLONS/USE	NO. OF OPERATIONS	GALLONS
Clothes washer	14.2 Gal.	10	142 Gallons
Dishwasher	13 Gal.	5	65 Gallons
Showers	30 Gal.	20	600 Gallons
Total Hot Water Consumption (per week)			807 Gallons



TEAM BOSTON
SOLAR DECATHLON 2009

SUMMARY OF UNLISTED ELECTRICAL COMPONENTS



SUMMARY OF UNLISTED COMPONENTS

* At this time, there are no non-UL listed components in the design of Team Boston's Curio House.

<u>ITEM</u>	<u>SHEET/SECTION</u>	<u>DATE</u>	<u>DESCRIPTION</u>
-------------	----------------------	-------------	--------------------

This section is a place holder for detailed information for any revision to the current documents that would incorporate the use of unlisted electrical components.



TEAM BOSTON
SOLAR DECATHLON 2009

PHOTOVOLTAIC AND ELECTRICAL CALCULATIONS



BRANCH CIRCUIT CALCULATIONS

NEC 220.12 Lighting Loads:

3 volt-amperes/ft² for general lighting and general-use receptacles

Total area from building roof footprint = 790

$$790 \text{ ft}^2 \times 3 \text{ VA per ft}^2 = 2370 \text{ VA}$$

NEC 220.14(A)

Circuit 1, 3, 4, 5. Water Circulation Pumps (Taco): 1.1 amp

Circuit 2. Refrigerator (typical): $700 \text{ VA} / 120\text{V} = 5.83 \text{ amps}$

Circuit 14. Dishwasher (Bosch): $1400\text{VA} / 120\text{V} = 11.67 \text{ amps}$

Circuit 17/18. Electric Water Heating Element (typical): $5500\text{VA} / 240\text{V} = 22.92 \text{ amps}$

NEC 220.14(B)

NEC 220.54

Circuit 16/18. Clothes Dryer (typical): $5000\text{VA} = 5500 \text{ VA} / 240\text{V} = 20.83 \text{ amps}$

NEC 220.55

Note: Although a demand factor of 80% may be applied for this section, they were not in the interest of a more conservative calculation of the load.

Circuit 6/8. Oven (typical): $2000\text{VA} / 120\text{V} = 16.67 \text{ amps}$

Circuit 10/12. Cooktop (Electrolux induction): $7100\text{VA} / 240\text{V} = 29.58 \text{ amps}$

NEC 220.14(J)

The following branch circuits do not need any additional load calculations as per NEC 220.14(J)

NEC 220.14(J)(1): 4, 9, 11, 13, 15, 20, 24, 25, 26

NEC 220.14(J)(3): 21, 22, 23, 28, 30

The sizes of the circuit breakers were often sized much larger than necessary than these calculations dictated, for not all of the appliances have been finalized and typical values have been used for a number of branches which might not be entirely accurate.



FEEDER AND SERVICE LOAD CALCULATIONS

Feeder and service load calculations are done in accordance with NEC 220.82. The calculated load shall be the result of adding the loads from 220.82(B) and 220.82(C) which is as follows:

220.82(B) General Loads: 100% of the first 10 kVA plus 40% of the remainder

1. 3 volt-amperes/ft² for general lighting and general-use receptacles

Total Area from building roof footprint = 790

$$790 \text{ ft}^2 \times 3 \text{ VA per ft}^2 = 2370 \text{ VA}$$

2. 1500 volt-amperes for each 2-wire, 20-ampere small-appliance branch circuit and each laundry branch circuit and each laundry branch circuit covered in 210.11(C)(1) and (C)(2). The assumption was made that 1500 volt-amperes will apply for 15 amp circuits as well.

Small Appliance Circuits:

Circuits: 4 (Kitchen Outlets), 9 (ERV), 11 (Energy Monitor), 13 (Mechanical Room Outlet), 15 (Heat Pumps 1 & 2), 20 (Bathroom Outlets), 24 (Bathroom Fan), 26 (Living Room Outlet)

$$8 \times 1500 \text{ VA} = \mathbf{12000 \text{ VA}}$$

Laundry Circuit:

1500 VA

3. Nameplate rating of appliances fastened in plate, etc.

Electric cook top: 7.1kW = **7100 VA**

Electric oven (typical): 2kW = **2000 VA**

Dishwasher: 1400W = **1400 VA**

Refrigerator (typical): 700W = **700 VA**

Total of **bold** numbers = **27070 VA**

Total volt-amperes from 220.82(B):

$$10,000 + (27070 - 10000) \times 0.4 = 16828 \text{ volt-amperes}$$

220.82(C) Heating and Air Conditioning Load:

The largest of the six selections will be (1), the air conditioning and cooling.

1. 100 percent of the nameplate rating of the air conditioning and cooling: 6 kW = **6000 VA**

The total requirements in 220.82(C) calculate the dwelling Heating and Cooling load at 6000 VA.

The total requirements of 220.82(B) and 220.82(C) is calculated to be **22,828** volt-amperes.

$$22828 \text{ VA} / 240 \text{ V} = 95.12 \text{ amps}$$

This shows that the estimates of NEC220 show that our service of 150 amps is more than sufficient as the total of the estimate comes to only about 95 amps.



PV SYSTEM CALCULATIONS

All data used in these calculations were taken from either the Sunpower Datasheetsⁱ or the Enphase Datasheets.ⁱⁱ All references to the NEC or to various tables are found in the 2008 National Electric Code.ⁱⁱⁱ

A Special thanks to Chris Kilfoyle of Berkshire Photovoltaic Systems for his help with these calculations and making sure the system is up to code.

1. **Temperatures used for ampacity corrections for each conductor.**

The conductors on the roof may or may not be in a conduit, thus conduit temperature corrections will be employed anyways. Either way they will most likely be shaded by the solar panels, but conservative conditions of full, direct sunlight will be employed. Ambient temperature of 86°F + 60°F (worst case scenario from table 310.15(b)(2)(c) in the NEC)

86°F + 60°F = 146°F or 85.6°C is the adjusted temperature for conduit on a rooftop.

From table 310.16 for copper 194°F THWN-2 insulated conductors, the correction factor for 146°F is .58

There will be 10 cables in the conduit which is assumed to be the same as the “raceway” from table 310.15(B)(2)(a), but only 6 of them will be current carrying (3 branches with +, -, and neutral and 1 ground make 10 wires, subtract the neutral and ground lines, yields 6 current-carrying conductors). Thus the adjustment factor for 6 current-carrying conductors in a raceway is 80%.

These correction factors will be used in section 7 to determine the size of the conductor necessary.

2. **Expected cold temperatures used to determine PV open circuit voltage in cold weather.**

Inverter Operating Temperature Range (Enphase M210-84-240-12): -40°C to +65°C

The lowest recorded temperature in Boston was -18°F / -27.7°C in February 1934 and the highest recorded temperature was 104°F / 40°C in July, 1911.^{iv} Our inverter operating range is more than sufficient given these records.

Voltage Correction Factor for Ambient Temperature -36°C to -40° is 1.25 X V_{oc} as per NEC code: 690.7

Sunpower 230 Watt V_{oc} = 48.7V

$V_{oc} \times 1.25$ = Corrected Voltage

48.7 V X 1.25 = 60.875 V

3. **Maximum Inverter Input Voltage.**

62 Volts

4. **Ampacity or size calculations for all conductors.**

Maximum Output Power from inverters = 210W

210 Watts / 240V = 0.875 Amps

0.875 Amps X 10 inverters = 8.75 Amps for Branch 1

0.875 Amps X 9 inverters = 7.875 Amps for branches 2 and 3

8.75 Amps X 1.25 overcurrent protection factor = 10.9375 Amps

Any wire or circuit component must be able to handle 11 amps

5. **Calculations/methods for conduit sizes**

There will be 9 conductors (a positive, negative, and neutral for each of the three branches) and 1 ground wire from the roof to the AC combiner panel for a total of 10 wires. From table C-1, ¾" conduit will hold 16 #12 AWG (#12 AWG was determined in section 7) wires or 4 #6 AWG wires. Using 1 #6 AWG ground wire leaves room for 12 #12 AWG wires of which we only have 9, thus a ¾" conduit will be more than sufficient.

6. **Calculations for overcurrent device ratings**

Highest capacity branch: 8.75 Amps x 1.25 = 10.9375 Amps

7. **690.64B calculations for all applicable load centers and conductors**

11 amps nominal per branch circuit (this includes overcurrent protection from section 6.), thus 15 amp circuit breakers for each branch will be sufficient.

The highest branch load will be 11 amps, now the temperature and conduit correction factors will be added from section 1.

Temperature correction factor for conduits on a rooftop (tables 310.15(B)(2)(c) and 310.16):

11 Amps / 0.58 = 18.97 Amps

Correction factor for more than 3 current-carrying conductors in a conduit (table 310.15(B)(2)(a)):

18.97 Amps / 0.8 = 23.73 Amps

From table 310.16, the #12 AWG sized copper wire of type THWN-2 with a conductor temperature rating of 194°F or 90°C will be used. The table shows 30 amps as the maximum allowable ampacity which leaves plenty of room over 23.73 amps, especially with the incredibly conservative assumptions and calculations.

Grounding Conductor:

NEC code permits #8 AWG, but we will use a #6 AWG because the #6 does not need to be in conduit in areas "subject to abuse"

ⁱ Sunpower 230 Watt Solar Panel Datasheet can be found on the Sunpower website here:

<http://www.sunpowercorp.com/Products-and-Services/Residential-Solar-Panels.aspx>

ⁱⁱ Enphase Micro-Inverter M210-84-240-S01/02 Datasheet. Not found online at the time this document was created.

ⁱⁱⁱ The National Electric Code for 2008 was used. The acronym NEC and all tables noted in this document are in reference to this edition. The full name of the book is NEC2008 NFPA70.

^{iv} Temperature records obtained from Boston.com at

<http://boston.about.com/od/bostonliving/qt/WeatherStats.htm> and confirmed by The National Weather Services at <http://www.erh.noaa.gov/box/climate/bosrecords.html>



TEAM BOSTON
SOLAR DECATHLON 2009

RETAIL PHOTOVOLTAIC PRICE QUOTE



RETAIL QUOTE FOR TEAM BOSTON
CURIO HOUSE PHOTOVOLTAIC SYSTEM

PART NUMBER	PRODUCT DESCRIPTION	MANUFACTURER	LIST PRICE	QTY	TOTAL
SPR-230	SunPower SPR-230 White PV Panels	SunPower Corp. San Jose, CA 95134	\$900.89 ea.	28	\$25,224.92
PV-A-KBT3-KST4	Female MC3 to Male MC4 adapter cable		\$10.75 ea.	28	\$301.00
M210-84-240-S12	Micro-inverter, 240Vac, for 60 & 72 cell modules	Enphase Energy Petaluma, CA 94952	\$215.00 ea.	28	\$6,020.00
IEMU-01	Envoy Energy Management Unit, indoor enclosure	Enphase Energy Petaluma, CA 94952	\$365.00 ea.	1	\$365.00
EKIT-01-001	Install kit, AC Branch Circuit, for 240 or 280Vac	Enphase Energy Petaluma, CA 94952	\$68.00 ea.	1	\$68.00
ENLS-01-Y1	Enlighten 1-year subscription, priced per module	Enphase Energy Petaluma, CA 94952	\$2.00 ea.	28	\$56.00
TOTAL					\$32,034.92



TEAM BOSTON
SOLAR DECATHLON 2009

SUMMARY OF RECONFIGURABLE FEATURES



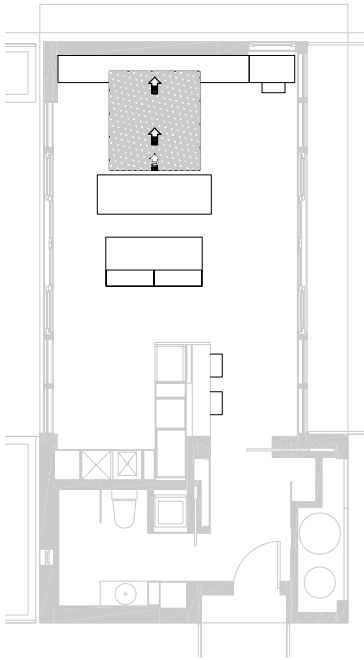
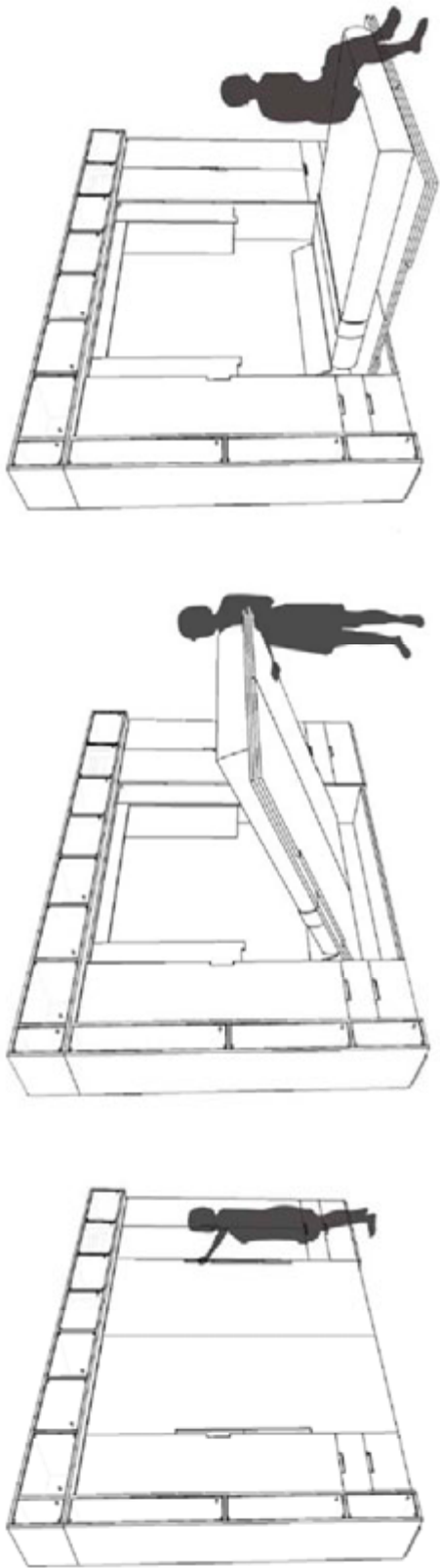
RECONFIGURABLE FEATURES

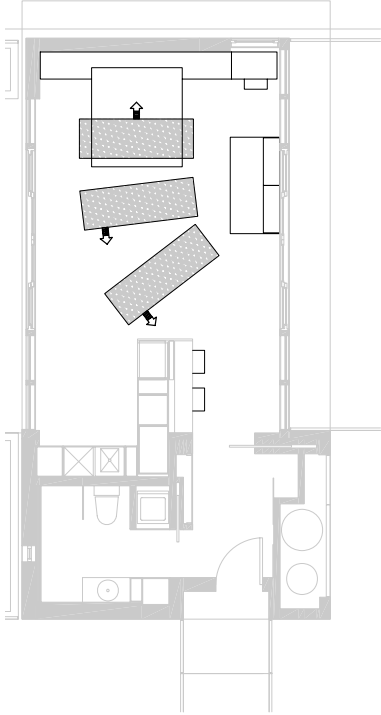
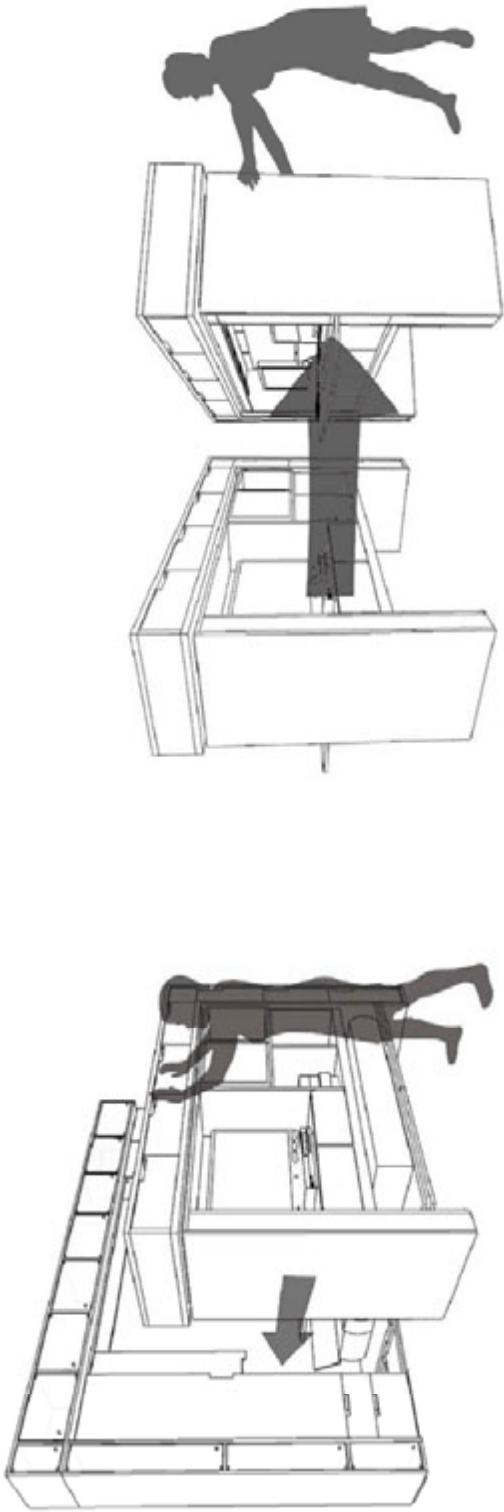
The Moveable Furniture Wall Piece

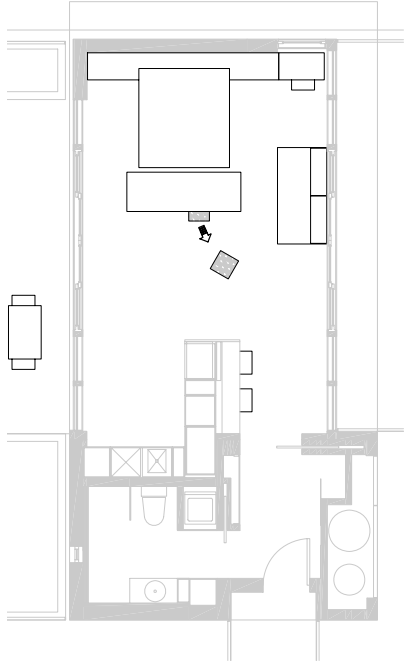
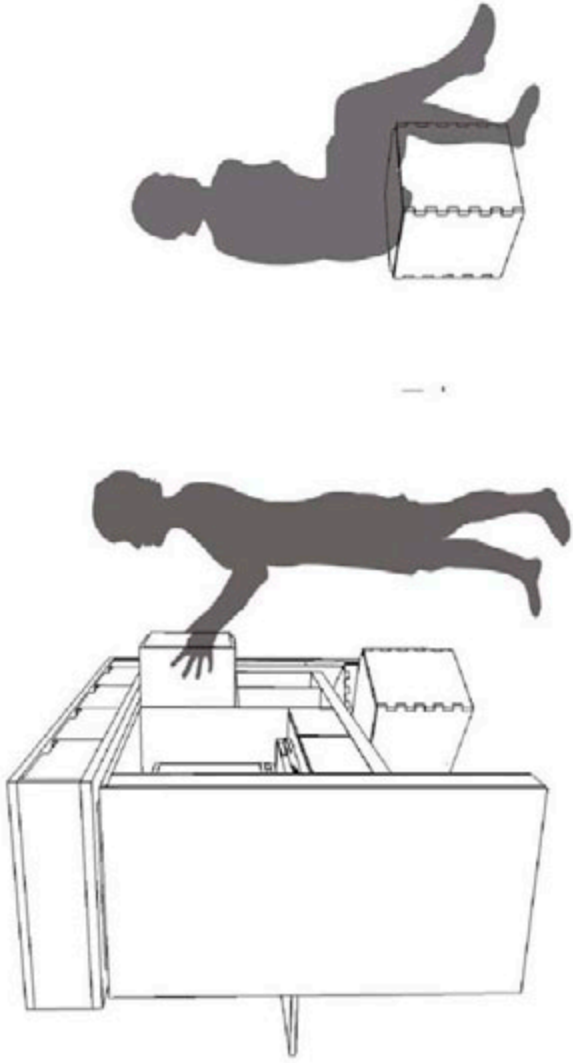
The Curio.House's interior design follows the notion of flexible space, allowing such a seemingly small space to function in a variety of ways. The central living space is treated as a studio that can be separated into traditional areas for sleeping, studying and dining on a daily basis or left open to accommodate a large indoor-outdoor event on a comfortable autumn evening.

Furniture, particularly the movable furniture wall, is adaptable to allow for user defined flexibility. The east wall features a Murphy Bed system built into a custom millwork piece with shelving and closet space in addition to the bed system. The central piece of furniture in the space has been designed to interact with fixed wall millwork moving on casters to pull in and out of the fixed wall arrangement and create a space for home entertainment equipment, work space and privacy.

The following is a visual depiction of the furniture piece's intent in the house. One designated arrangement will be maintained throughout tours and the course of the competition.









TEAM BOSTON
SOLAR DECATHLON 2009

INTERCONNECTION APPLICATION FORM



INTERCONNECTION APPLICATION FORM

Team Boston Curio House Lot Number: 113

team name and lot number**PV SYSTEMS**

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
Sunpower Corporation	28 panels in three branches	6.4 kW

Total DC power of all arrays is 6.4 kW (in tenths).**XXXXXXXXXXXXXXXXXXXXXXXXXXXX****INVERTERS**

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or kW)	Quantity
Enphase Energy	M210-84-240-S12	Output: 240 VAC	210 W	28 units
		Max. In.: 62 VDC		

Total AC power of all inverters is 5.88 kW kVA or kW (in whole numbers).**XXXXXXXXXXXXXXXXXXXXXXXXXXXX**

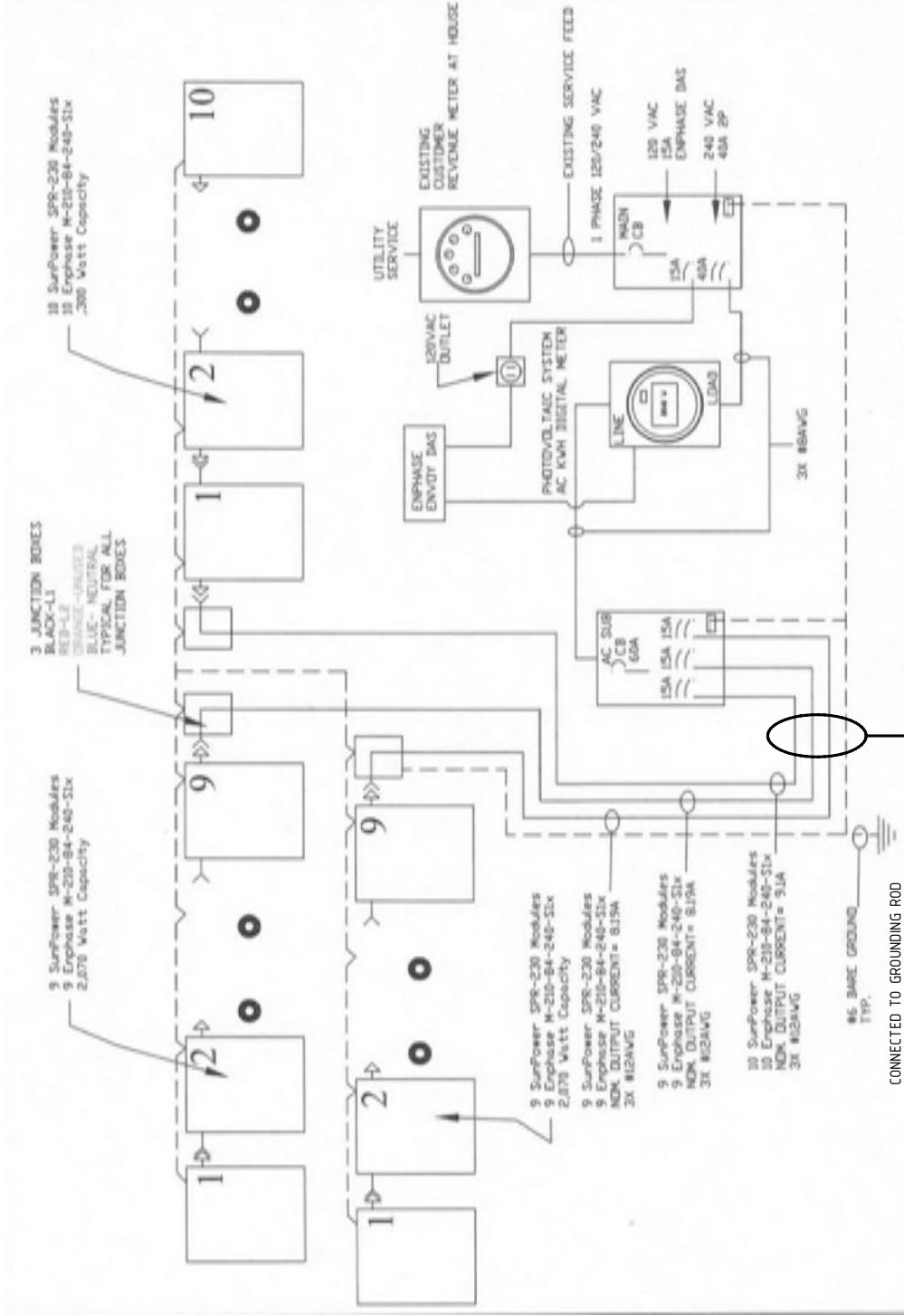
Please include the following in the Project Manual:

- 1) One-line electrical schematic - the loads do not have to be detailed.
- 2) Calculations of service/feeder net computed load and neutral load (NEC 220)
- 3) Plan view of the lot showing the house, decks, ramps, tour paths and the service point.
- 4) Elevation view(s) showing the terminal box (contains the service point), meter, and other service equipment (such as the distribution panel or load center).

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Provide the Team's "Electrical Engineer" contact info in the "Team Officer Contact Info" database on the Yahoo Group. See Rule 3-2.

Please see the "Grid Interconnection Process for Teams" file on the Yahoo Group for more details on the interconnection process and the Terminal Box Mounting Panel.



NOTE: FOR CONDUCTOR AND
CONDUIT SIZING CALCULATIONS
REFER TO DRAWING E603

CONDUCTORS TO BE
HOUSED IN 1" CONDUIT



CONSULTANT INFO

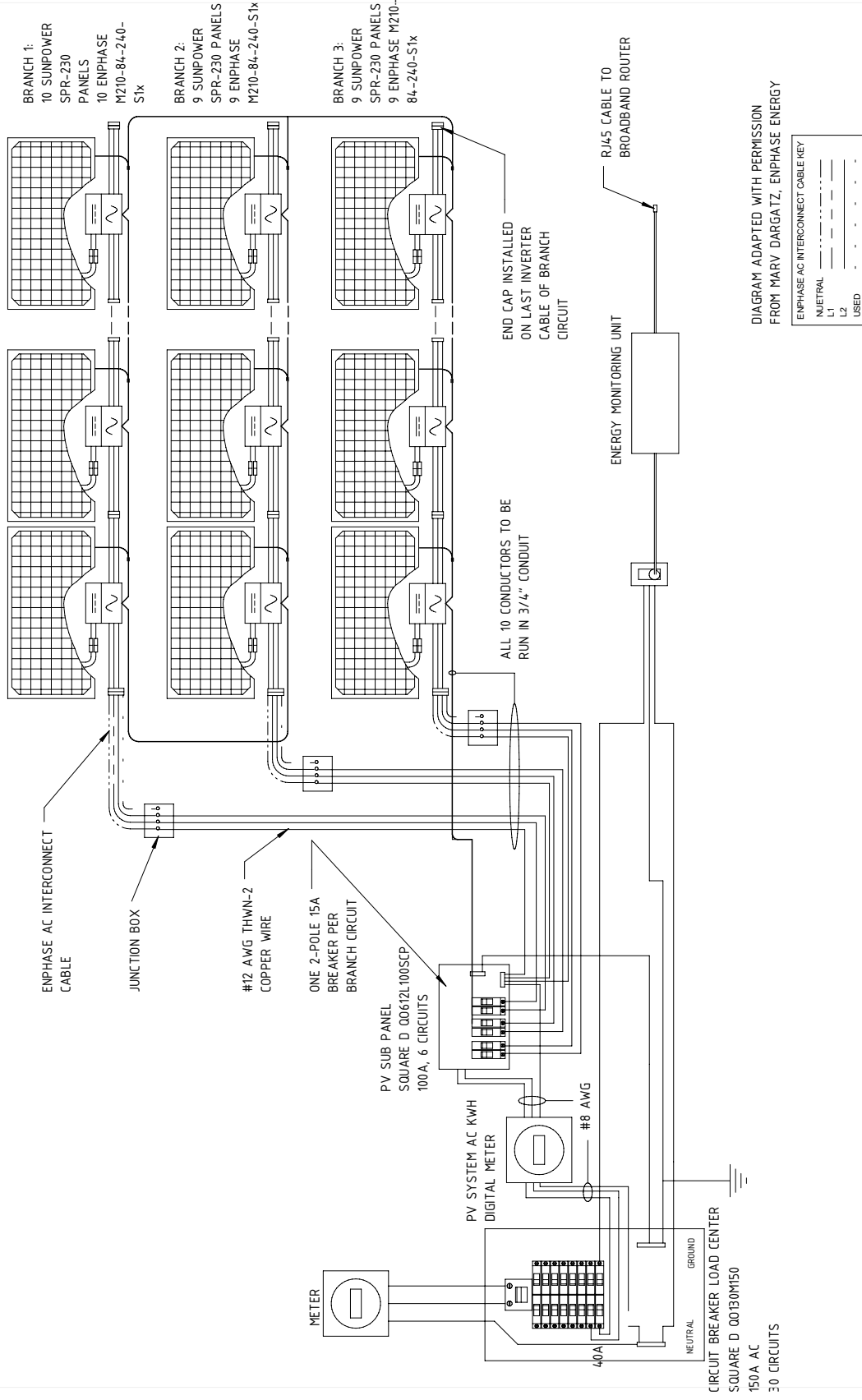


TEAM BOSTON
SOLAR DECATHLON
2009

CONSTRUCTION
DOCUMENTS
96_01_09
SCALE: 12" = 1'-0"

SHEET
TITLE
THREE-LINE
DIAGRAM

SHEET
NO
E602.



DRAWING
TITLE
THREE-LINE PV DIAGRAM



CONSULTANT INFO



TEAM BOSTON
SOLAR DECATHLON
2009

CONSTRUCTION
DOCUMENTS
98_01_09
SCALE: 3" = 1'-0"

SHEET
TITLE

AC CIRCUIT LAYOUT

DRAWING
TITLE

AC CIRCUIT DIAGRAM

E603



For all load calculations in
compliance with NEC 220,
please refer to drawing A603



CONSULTANT INFO



TEAM BOSTON
SOLAR DECATHLON 2009

06_01_09

CONSTRUCTION
DOCUMENTS

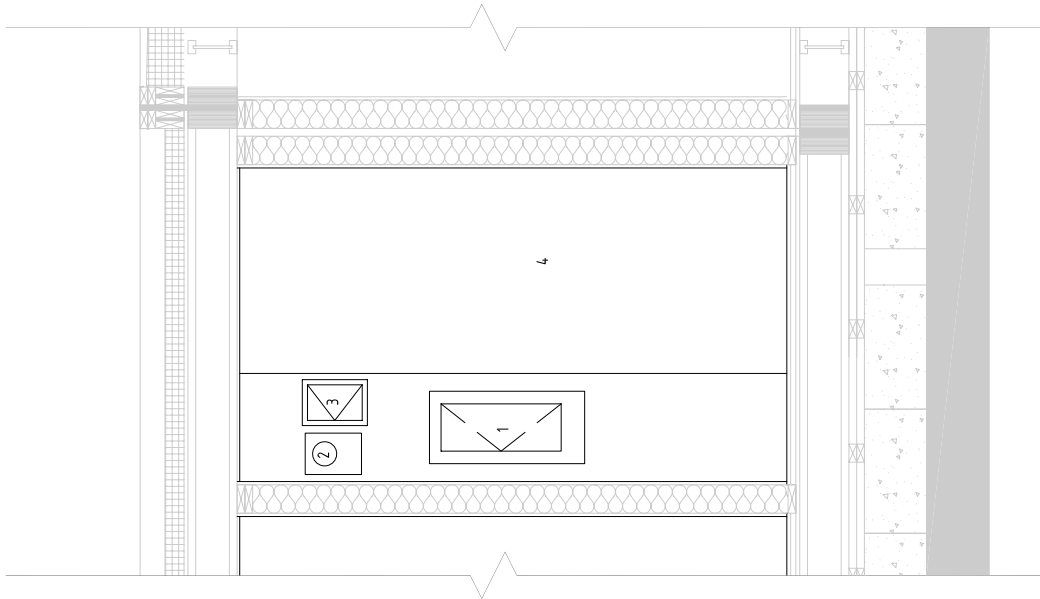
SCALE: 1/4" = 1'-0"

SHEET TITLE:

ELECTRICAL_CLOSET
_ELEVATION

SHEET NO:

E201



- 1 ELECTRICAL CIRCUIT
BREAKER PANEL
- 2 ELECTRICAL METER BASE
- 3 ELECTRICAL SUB PANEL
- 4 CLOSET

DRAWING TITLE: ELECTRICAL_CLOSET_ELEVATION



TEAM BOSTON
SOLAR DECATHLON 2009

ENERGY ANALYSIS & DISCUSSION



ENERGY ANALYSIS

I. Analysis Overview

Throughout the course of designing the engineering systems of the Curio House, many software programs were used to predict the various heating, cooling, lighting, and electrical loads that the house will experience in its operation. These programs include the National Renewable Energy Lab's PV Watts, the U.S. Department of Energy's EnergyPlus, Integrated Environmental Solutions Virtual Environment (IES-VE) with Autodesk Revit, T*SOL Pro, and WrightSoft. The results of these analyses will be discussed in more detail as justification for many of the systems chosen for the house. The analyses were often performed under the assumption that the house will be located in Boston to ensure that the heating system will be able to accommodate the harsh Massachusetts winter. In many cases, the analyses were also run for Washington D.C. to guarantee successful performance on the National Mall and under the additional summer heat load. With an understanding of the house's predicted performance, the information was available for the team to make informed decisions about the house's systems and to ensure that these decisions aligned with our established values.

II. Comfort

The heating and cooling loads for the house were calculated using a program called WrightSoft. This program computes the energy needed to heat or cool each room for a specific location on the design day (typically worst case ambient conditions). The program takes into account many factors such as infiltration, ambient conditions, internal gains, and solar gains to provide a very accurate heat load analysis (Appendix A).

The house has three zones of heating and cooling: the bathroom, the foyer, and the main room. The main room is more than three times as large as the other two rooms and contains glazing along the north and south facades. The foyer is adjacent to the south wall that contains all the mechanical equipment and the bathroom is situated on the north wall. The WrightSoft calculations displayed exactly what we had predicted: vastly different energy loads for each room. The challenge became how to provide heating and cooling to the conditioned spaces while maintaining the focus on efficiency, comfort, and cost-effectiveness that was established as our team's values.

Heating

The project initially had many different ideas for the heating of the building. After some research, there was a clear solution. The building would be heated using radiant floor heat (RFH). This means that heat generated from the solar thermal panels would be transferred to water running through cross-linked polyethylene plastic pipe (PEX) which is attached to aluminum heat transfer plates located in the subfloor of the building. This hot water then radiates heat upward through the floor into the conditioned spaces. One reason we chose RFH is that this type of heating system uses the best heat transfer medium: water. Another benefit of RFH is that due to the large surface area of the heat transfer plates, a relatively low water temperature can be used to heat the building. This is essential to efficiency because as we decrease the water temperature needed to heat the home, we increase the efficiency of our solar thermal system as well as save electricity that would have been needed to heat the water to a higher temperature. RFH also gives us the ability to control the heating of each zone in the house individually. A mixing valve that operates based on outdoor temperature as well as each room's temperature will be able to control the temperature of the water needed to heat the house. The radiant manifold will be equipped with zone valves to control and optimize the flow of water to each zone. The capability to control the temperature and the flow of the water allows us to control the comfort inside the house. RFH is also a cost-effective solution that does not cost much more than a conventional ducted hot air system, making it an ideal solution for heating our house.

Ventilation

The next challenge was to provide adequate air quality for the house. Based on the ASHRAE codes we needed to provide a minimum of 0.3 air changes per hour, which equates to a minimum of 1800 cubic feet of air change per hour. The most economical and efficient way to accomplish this was to use an energy recovery ventilator (ERV). The ERV uses an enthalpy wheel to exchange the temperature and humidity between the exhaust air from the house with the fresh incoming air. The ventilator also contains an air filter to separate the particulates suspended in the air from entering the house. Another benefit of the ERV is that it can be used to heat or cool the building during certain parts of the year with limited use of the actual heating and cooling system.

Cooling

The cooling system needed to be efficient but also capable of conditioning vastly different loads for each room. Originally our team was contemplating the use of a ground source heat pump but when the rules called for no penetration of the land on the National Mall, we realized that was not an option. We then looked at a liquid desiccant cooling system (LDCS). We decided this was not a feasible solution for the competition as our calculations showed that there would be times during the summer when the LDCS would not be able to handle the sensible cooling load of the house. We also looked at an absorption chiller that would run off the solar thermal collectors but our analysis showed that our solar thermal collector array would need to be larger in addition to larger water tanks. Another downside of the absorption chiller was the high initial investment and its low coefficient of performance.

After much research and discussion we decided to use a Mitsubishi heat pump. The reason we chose this system is because it fit well within the competition requirements, it is reliable, efficient and cost-effective. The heat pump uses the ambient air to cool or heat the conditioned spaces. This can be done efficiently by using a scroll compressor and inverter technology. The system along with the inverter technology allows each room to be heated or cooled comfortably while maintaining high levels of efficiency.

III. Energy

Passive Solar Design

Before exploring the most effective strategy for using photovoltaic panels to produce sufficient electricity to heat and cool the house, the team first investigated methods of regulating the temperature and lighting of the Curio House to the largest extent possible without relying on electricity or hot water. In order to best utilize natural daylight to minimize the need for electrical lights, the house is oriented from East to West with a large southern façade. In the northern hemisphere, the southern façade will receive the most exposure to the sun and is predominantly glazing to maximize the daylight that reaches the living space. However, the solar irradiation that provides daylight for the living space also brings a considerable amount of heat, a factor that makes keeping the house cool in the summer even more challenging.

Early in the design process, a roof that extends past the glazing on the south façade was proposed with the intention of permitting the low winter sun to warm the living space while blocking the high summer sun from overheating the interior. A daylight analysis was run on a preliminary design of the house (Figure 1) using IES-VE to confirm the utility of such an overhang. The daylight analysis was completed for a clear day in Washington D.C. at 12:00 PM on December 21st (Figure 2) and June 21st (Figure 3) to provide an instance of the low winter sun as well as the high summer sun. The analysis returns the floor plan of the house with a color gradient to indicate the intensity of illuminance in foot-candles, the illuminance on a surface caused by a single candle at a distance of one foot.

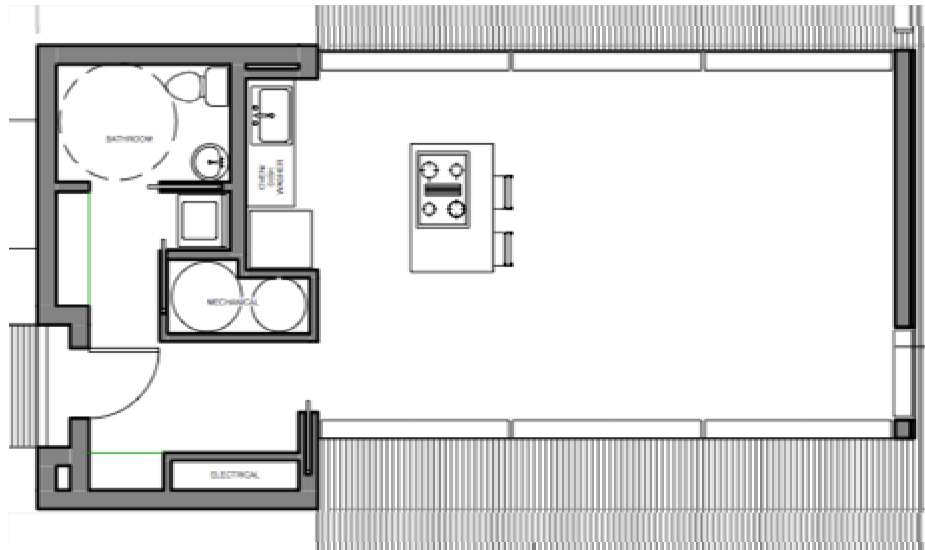


Figure 1: Floor plan of preliminary design of the Curio House

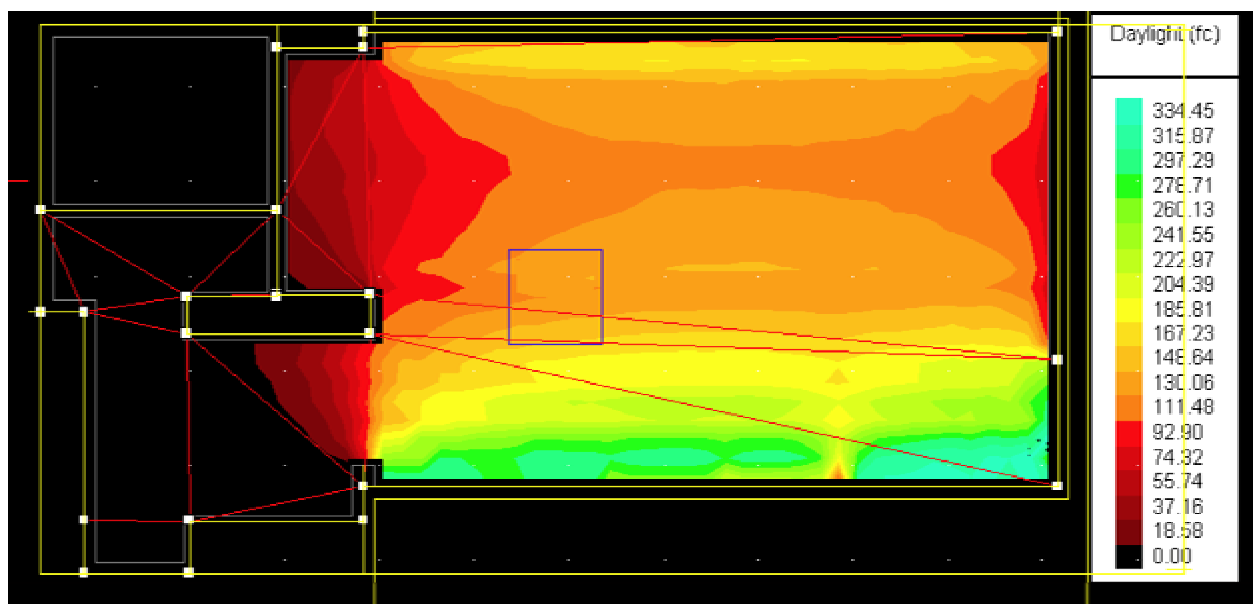


Figure 2: Daylight analysis at 12:00 PM on December 21

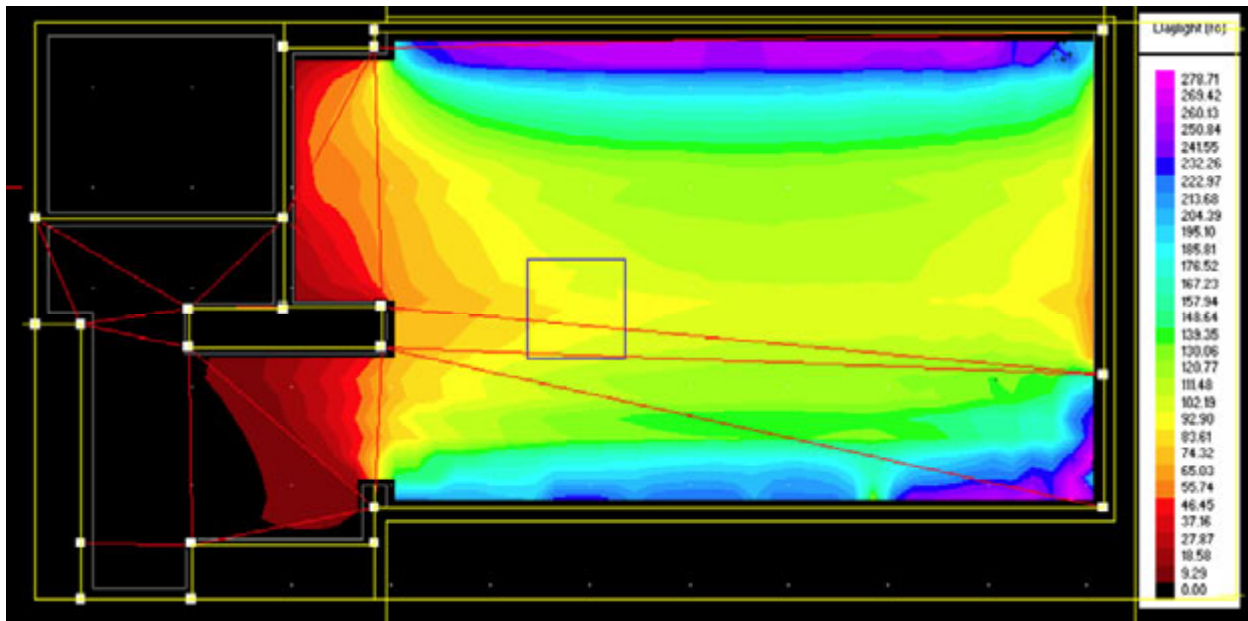


Figure 3: Daylight analysis at 12:00 PM on June 21

An important intention that the daylighting analyses confirm is the reduction of solar gain during the summer. The analyses show that during the summer the average illuminance decreases by 12.24% and the maximum illuminance decreases by 20.57% (Figure 4). These reductions in both average and maximum illuminance speak to the effectiveness of the passive shading design. While the IES-VE analysis verifies the effectiveness of the overhang at controlling the daylight in the living space, the model produced using EnergyPlus further analyzes the implications that the solar irradiation has on the house's heating and cooling loads. This analysis is explained later in the report.

	Average Illuminance	Maximum Illuminance
December 21 st	130.92 fc	352.37 fc
June 21 st	114.89 fc	279.88 fc
Difference	16.03 fc	72.49 fc
Percent Decrease	12.24%	20.57%

Figure 4: IES-VE daylight analysis data

An additional passive design technique is the use of water-filled windows on the north and south façade, a technology being developed by Hunter-Dougllass inventor Wendell Colson. The large thermal mass within the glazing will act similar to a Trombe wall to regulate the temperature throughout the day and dampen the house's peak heating and cooling loads. In the winter, the water will absorb much of the solar irradiation throughout the day and retain that heat into the night, keeping the house warm. In the summer, the cool nights will help to remove heat from the water and cool the house throughout the day as long as the glazing is properly shaded from the summer solar irradiation during they daytime.

Photovoltaic Design

The first step in designing the photovoltaic system to be used in the Curio House was to approximate the electricity consumption over the course of a year. Upon tabulating the electricity consumption of the various appliances and systems in the house, it was determined that around 22 kWh of electricity would be used on a peak day. To be conservative, it was estimated that the daily electricity use would be 80% of that on the peak day, 17.6 kWh per day or 6,424 kWh per year. In order to meet this load, the National Renewable Energy Lab's PV Watts tool was used to help determine that a 5.2 kW (STC) photovoltaic array would be needed, given a 0.77 DC to AC conversion factor. This electricity demand translates to 23 of Sun Power 230 Watt panels, the most efficient photovoltaic panels on the market.

Due to the competitive nature of the net metering competition, we have decided to cover the roof of the Curio House with as many panels as it can fit. The 28 Sun Power 230 Watt panels will produce approximately 7,885 kWh per year (Appendix B), enough to handle our calculated peak day for 340 days of the year. More realistically, this additional electricity means less electricity purchased from the utility company, more savings on the homeowner's electric bill, and ultimately less harmful pollutants from traditional electricity generation methods.

One of the exciting features of the Curio House is the use of the Enphase Energy micro-inverter system on the photovoltaic array. In this system, each photovoltaic panel receives its own dedicated micro-inverter to convert the electricity produced by the panel from DC to AC. The benefits of the micro-inverter system align very closely with our team goals of affordability and accessibility. If the homeowner ever wishes to add more photovoltaic panels to the array, the system will require an additional micro-inverter for each new panel at around \$200 a piece. In a photovoltaic system that uses a standard inverter, expanding the array often requires an additional standard inverter that costs a few thousand dollars. This technology allows the homeowner to begin his or her photovoltaic array with as many panels that he or she can initially afford and easily expand the capacity of the array as funds permit.

Furthermore, the micro-inverter system contributes to a more efficient photovoltaic array. In a standard photovoltaic array, the inverter manages the string of panels, wired in series, to produce the best possible power output. However, when one of the panels in the string has a drop in current, often due to shading from trees or clouds, the power output of the entire string suffers. On the other hand, each panel in the micro-inverter system is converting from DC to AC independent of each other. If any panel experiences a drop in current, the reduction in power output is confined to that single panel. In this case, the choice of adopting an innovative technology allows the Curio House to perform more efficiently while offering the homeowner an incentive to further invest in sustainable energy systems.

Solar Thermal

In order to specify the solar thermal components for the Curio House, an annual simulation of hot water consumption and production was performed using T*SOL Pro 4.5 (Appendix C). As we had hoped, the analysis confirms that the house's hot water demands can be met by five flat plate solar thermal collectors. The flat plate system will provide 94% of the annual domestic hot water, assuming 80 gallons consumed per day, and 46.2% of the total hot water load of the house. Although evacuated tube collectors are often more efficient, their enhanced performance does not justify their additional cost when flat plate collectors can provide sufficient energy for the house.

To increase the efficiency of the house's hot water system, two water tanks will be used, one 132-gallon tank and one 42-gallon tank with an electric heating element. Although two tanks may seem excessive for a single-family residence, the system has a number of benefits. The primary advantage of this configuration comes to light when the solar thermal panels are not meeting the hot water demand of the house. In order to meet the additional demand, the heating element in the water tank must be used. Rather than heating well over 100 gallons of water with an electric heating element, an extremely electricity-intensive task, our two-tank system will

only need enough electricity to heat 42 gallons of water, a more feasible quantity to be consumed in such a scenario. Moreover, an additional tank will increase the reliability of the system by allowing the water system to operate in the event that one tank ever needs to be serviced or replaced.

III. Comprehensive Yearly Analysis

In order to best estimate the performance of the Curio House, a thorough analysis has been performed that quantifies the amount of energy, as electricity or heat, that is produced and consumed by the house using the U.S. Department of Energy's EnergyPlus software. This model was used to verify that the house's systems, many of which were specified with the help of specialized computer applications, performed together as expected. Furthermore, the information from the model provides an accurate confirmation that the house produces more energy than it consumes, surpassing the team's goal to design a zero net energy residence.

The EnergyPlus software compiles information about the photovoltaic, solar thermal, and HVAC systems in addition to properties of the house's building materials to provide an exhaustive model of the house with all of the available information (Appendix D). This model is combined with a schedule of the typical usage of house's systems as well as local weather information, in this case TMY2 data, to produce an abundance of projected performance data at all times throughout the year. The more salient results include a comparison of the electricity produced by the photovoltaic system and the total electricity consumed (Figure 5) as well as an evaluation of the total hot water produced by the solar thermal collectors and consumed for domestic and heating needs (Figure 6). The analysis concludes that the house will produce an excess of 3491.9 kWh of electricity annually; this result speaks to the projected success of the Curio House as a zero net energy home.

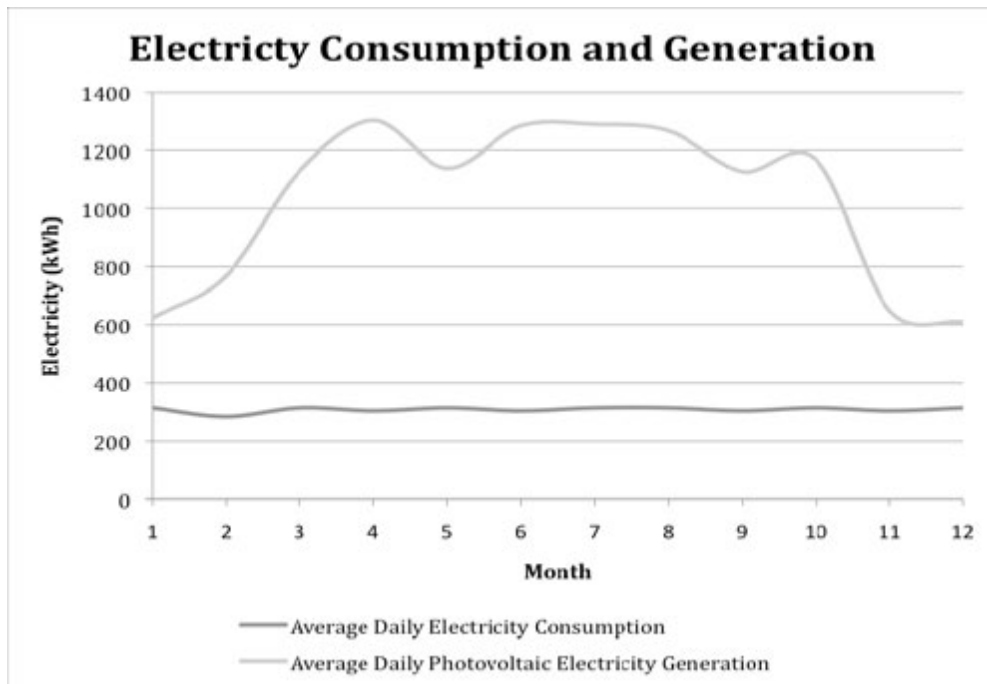


Figure 5: EnergyPlus annual energy usage

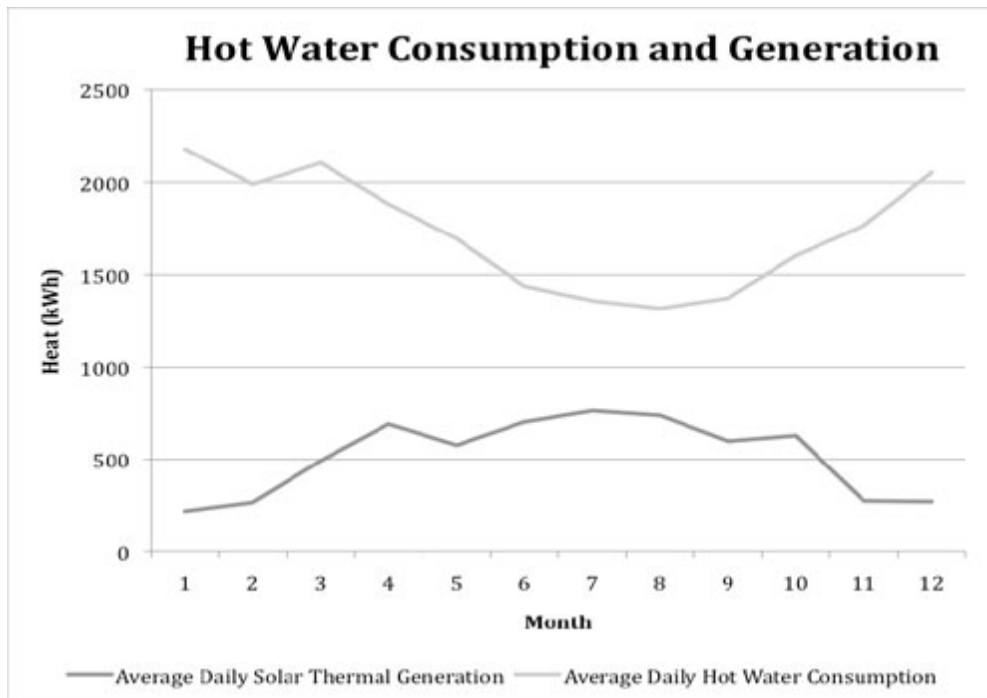


Figure 6: EnergyPlus annual hot water usage



TEAM BOSTON
SOLAR DECATHLON 2009

ENERGY ANALYSIS APPENDIX A:
WRIGHTSOFT ENERGY MODEL

Project Information

For: Solar Decathlon House, Team Boston SD

Web: www.teambostonSD.com

Design Information

	Htg	Clg	Infiltration	Simplified
Outside db (°F)	17	91	Method	Tight
Inside db (°F)	68	72	Construction quality	0
Design TD (°F)	51	19	Fireplaces	
Daily range	-	M		
Inside humidity (%)	30	50		
Moisture difference (gr/lb)	20	41		

HEATING EQUIPMENT

Make	Mitsubishi Electric
Trade	Mr. Slim
Model	MXZ-3A30NA
Efficiency	8.7 HSPF
Heating input	
Heating output	28600 Btuh @ 47°F
Temperature rise	27 °F
Actual air flow	947 cfm
Air flow factor	0.060 cfm/Btuh
Static pressure	0.00 in H2O
Space thermostat	

COOLING EQUIPMENT

Make	Mitsubishi Electric
Trade	Mr. Slim
Cond	MXZ-3A30NA
Coil	MSZ-A09NA+MSZ-A09NA+MSZ-A12NA
Efficiency	16 EER
Sensible cooling	19880 Btuh
Latent cooling	8520 Btuh
Total cooling	28400 Btuh
Actual air flow	947 cfm
Air flow factor	0.052 cfm/Btuh
Static pressure	0.00 in H2O
Load sensible heat ratio	0.88

ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Bathroom	100	1007	2889	61	151
Foyer	90	1256	4255	76	222
Main Room	448	13474	11029	811	575
Entire House	638	15737	18173	947	947
Other equip loads		3559	328		
Equip. @ 0.96 RSM			17761		
Latent cooling			2609		
TOTALS	638	19296	20370	947	947

Printout certified by ACCA to meet all requirements of Manual J 8th Ed.

Project Information

For: Solar Decathlon House, Team Boston SD

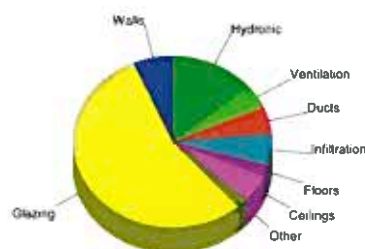
Web: www.teamboston.com

Design Conditions

Location:		Indoor:		Heating	Cooling
Washington National AP, DC, US		Indoor temperature (°F)		68	72
Elevation: 0 ft		Design TD (°F)		51	19
Latitude: 38°N		Relative humidity (%)		30	50
		Moisture difference (gr/lb)		20.0	41.1
Outdoor:		Heating	Cooling		
Dry bulb (°F)	17	91			
Daily range (°F)	-	18 (M)			
Wet bulb (°F)	-	74			
Wind speed (mph)	15.0	7.5			
		Infiltration:			
		Method	Simplified		
		Construction quality	Tight		
		Fireplaces	0		

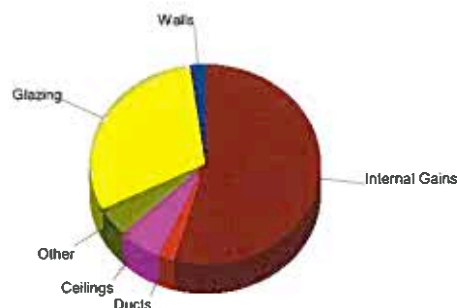
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	2.4	1245	6.5
Glazing	20.5	10625	55.1
Doors	14.8	311	1.6
Ceilings	0.8	1041	5.4
Floors	0.6	386	2.0
Infiltration	1.1	1152	6.0
Ducts		976	5.1
Piping		2678	13.9
Humidification		0	0.0
Ventilation		881	4.6
Adjustments		0	0.0
Total		19296	100.0



Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	0.8	400	2.2
Glazing	10.8	5611	30.3
Doors	9.1	192	1.0
Ceilings	0.9	1123	6.1
Floors	0.2	144	0.8
Infiltration	0.2	225	1.2
Ducts		418	2.3
Ventilation		328	1.8
Internal gains		10060	54.4
Blower		0	0.0
Adjustments		0	0.0
Total		18501	100.0



Overall U-value = 0.095 Btuh/ft²-°F

WARNING: window to floor area ratio = 81.4% - more than 25%.

Project Information

For: Solar Decathlon House, Team Boston SD

Web: www.teambostonSD.com

Design Conditions

Location:		Indoor:		Heating	Cooling
Washington National AP, DC, US		Indoor temperature (°F)		68	72
Elevation:	0 ft	Design TD (°F)		51	19
Latitude:	38°N	Relative humidity (%)		30	50
Outdoor:		Moisture difference (gr/lb)		20.0	41.1
Dry bulb (°F)	17	Infiltration:			
Daily range (°F)	-	Method		Simplified	
Wet bulb (°F)	-	Construction quality		Tight	
Wind speed (mph)	15.0	Fireplaces		0	
		Cooling			
		91			
		18 (M)			
		74			
		7.5			

Construction descriptions

	Or	Area ft²	U-value Btu/h/ft²·°F	Insul R ft²·°F/Btu/h	Htg HTM Btu/h/ft²	Loss Btu/h	Clg HTM Btu/h/ft²	Gain Btu/h
Walls								
12F-6sw: Wood stud frame, siding or stucco, R-6 foam board, R-21 cavity insulation	n	106	0.048	27.0	2.45	260	0.79	84
	e	138	0.048	27.0	2.45	338	0.79	109
	s	110	0.048	27.0	2.45	270	0.79	87
	w	154	0.048	27.0	2.45	377	0.79	121
	all	509	0.048	27.0	2.45	1245	0.79	400
Partitions								
(none)								
Windows								
1F-r3of: Operable, insul. fiberglass frame, reflective glass, 3 pane; 50% roller shades, white	n	147	0.380	0.0	19.4	2853	9.27	1364
1F-r3ocd: Sliding glass door, reflective glass, metal clad wood frame, 3 pane; 50% roller shades, white	n	92	0.440	0.0	22.4	2064	10.7	982
1F-r3of: Operable, insul. fiberglass frame, reflective glass, 3 pane	n	4	0.380	0.0	19.4	78	10.8	43
1F-r3of: Operable, insul. fiberglass frame, reflective glass, 3 pane; 50% roller shades, white; 2 ft overhang (9.2 ft window ht, 0 ft sep.)	e	37	0.380	0.0	19.4	713	16.9	622
	s	147	0.380	0.0	19.4	2853	10.3	1513
	all	184	0.380	0.0	19.4	3566	11.6	2135
1F-r3ocd: Sliding glass door, reflective glass, metal clad wood frame, 3 pane; 50% roller shades, white; 2 ft overhang (9.2 ft window ht, 0 ft sep.)	s	92	0.440	0.0	22.4	2064	11.8	1087
Doors								
11P0: Metal door, polyurethane core, no storm	w	21	0.290	0.0	14.8	311	9.13	192
Ceilings								
47B0: Radiant panel on exp beams/rafters, 1½" wd deck, Omega heat xfer plates		638	0.000	0.0	0.00	0	0.00	0
16B-30ad: Ceiling under vented attic, no radiant barrier, dark shingles, R-30 insulation		638	0.032	30.0	1.63	1041	1.76	1123

Floors

19D-30cstp: Tile floor over tight enclosed crawl, R-19 wall, R-30
blanket

638 0.034 30.0 0.61 386 0.23 144

Project Information

For: Solar Decathlon House, Team Boston SD

Web: www.teambostonSD.com

Notes:

Design Information

Weather: Washington National AP, DC, US

Winter Design Conditions

Outside db	17 °F
Inside db	68 °F
Design TD	51 °F

Summer Design Conditions

Outside db	91 °F
Inside db	72 °F
Design TD	19 °F
Daily range	M
Relative humidity	50 %
Moisture difference	41 gr/lb

Heating Summary

Structure	14761 Btuh
Ducts	976 Btuh
Central vent (39 cfm)	881 Btuh
Humidification	0 Btuh
Piping	2678 Btuh
Equipment load	19296 Btuh

Sensible Cooling Equipment Load Sizing

Structure	17755 Btuh
Ducts	418 Btuh
Central vent (39 cfm)	328 Btuh
Blower	0 Btuh
Use manufacturer's data	n
Rate/swing multiplier	0.96
Equipment sensible load	17761 Btuh

Infiltration

Method	Simplified Tight	
Construction quality	Tight	
Fireplaces	0	
	Heating	Cooling
Area (ft²)	638	638
Volume (ft³)	5870	5870
Air changes/hour	0.21	0.11
Equiv. AVF (cfm)	21	11

Latent Cooling Equipment Load Sizing

Structure	700 Btuh
Ducts	813 Btuh
Central vent (39 cfm)	1095 Btuh
Equipment latent load	2609 Btuh
Equipment total load	20370 Btuh
Req. total capacity at 0.70 SHR	2.1 ton

Heating Equipment Summary

Make	Mitsubishi Electric
Trade	Mr. Slim
Model	MXZ-3A30NA
Efficiency	8.7 HSPF
Heating input	
Heating output	28600 Btuh @ 47°F
Temperature rise	27 °F
Actual air flow	947 cfm
Air flow factor	0.060 cfm/Btuh
Static pressure	0.00 in H2O
Space thermostat	

Cooling Equipment Summary

Make	Mitsubishi Electric
Trade	Mr. Slim
Cond	MXZ-3A30NA
Coil	MSZ-A09NA+MSZ-A09NA+MSZ-A12NA
Efficiency	16 EER
Sensible cooling	19880 Btuh
Latent cooling	8520 Btuh
Total cooling	28400 Btuh
Actual air flow	947 cfm
Air flow factor	0.052 cfm/Btuh
Static pressure	0.00 in H2O
Load sensible heat ratio	0.88

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1	Room name					Entire House				Bathroom				
2	Exposed wall					114.0 ft				20.0 ft				
3	Ceiling height					9.2 ft				9.2 ft				
4	Room dimensions					d				10.0 x 10.0 ft				
5	Room area					638.0 ft²				100.0 ft²				
	Ty	Construction number	U-value (Btuh/ft²·°F)	Or	HTM (Btuh/ft²)		Area (ft²) or perimeter (ft)		Load (Btuh)		Area (ft²) or perimeter (ft)		Load (Btuh)	
					Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool
6	W	12F-6sw	0.048	n	2.45	0.79	350	106	260	84	92	88	215	69
11	G	1F-r3of	0.380	n	19.38	9.27	147	0	2853	1364	0	0	0	0
	G	1F-r3ocd	0.440	n	22.44	10.68	92	0	2064	982	0	0	0	0
	G	1F-r3of	0.380	n	19.38	10.76	4	0	78	43	4	0	78	43
	W	12F-6sw	0.048	e	2.45	0.79	175	138	338	109	0	0	0	0
	G	1F-r3of	0.380	e	19.38	18.53	37	6	713	622	0	0	0	0
	W	12F-6sw	0.048	s	2.45	0.79	350	110	270	87	0	0	0	0
	G	1F-r3of	0.380	s	19.38	11.59	147	83	2853	1513	0	0	0	0
	G	1F-r3ocd	0.440	s	22.44	13.31	92	52	2064	1087	0	0	0	0
	W	12F-6sw	0.048	w	2.45	0.79	175	154	377	121	92	92	225	72
	D	11P0	0.290	w	14.79	9.13	21	21	311	192	0	0	0	0
	C	47B0	0.038	-	0.00	0.00	638	638	0	0	100	100	0	0
C	16B-30ad	0.032	-	1.63	1.76	638	638	1041	1123	100	100	163	176	
F	19D-30cstp	0.034	-	0.61	0.23	638	114	386	144	100	20	61	23	
6	c) AED excursion								0				0	
	Envelope loss/gain							13608	7470			742	383	
12	a) Infiltration							1152	225			202	39	
	b) Room ventilation							0	0			0	0	
13	Internal gains:		Occupants @	230			2			460	0			0
			Appliances @	1200			8			9600	2			2400
	Subtotal (lines 6 to 13)							14761	17755			944	2823	
14	Less external load								0	0			0	0
	Less transfer								0	0			0	0
	Redistribution								0	0			0	0
	Subtotal							14761	17755			944	2823	
15	Duct loads					7%	2%	976	418	7%	2%	62	2889	151
	Total room load								15737	18173			1007	2889
	Air required (cfm)								947	947			61	151

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1	Room name						Foyer				Main Room			
2	Exposed wall						22.0 ft				72.0 ft			
3	Ceiling height						9.2 ft 10.0 x 9.0 ft heat/cool				9.2 ft 28.0 x 16.0 ft heat/cool			
4	Room dimensions						90.0 ft²				448.0 ft²			
5	Room area													
	Ty	Construction number	U-value (Btuh/ft²·°F)	Or	HTM (Btuh/ft²)		Area (ft²) or perimeter (ft)		Load (Btuh)		Area (ft²) or perimeter (ft)		Load (Btuh)	
					Heat	Cool	Gross	N/P/S	Heat	Cool	Gross	N/P/S	Heat	Cool
6	W	12F-6sw	0.048	n	2.45	0.79	0	0	0	0	258	18	45	14
	G	1F-r3of	0.380	n	19.38	9.27	0	0	0	0	147	0	2853	1364
	G	1F-r3ocd	0.440	n	22.44	10.68	0	0	0	0	92	0	2064	982
	G	1F-r3of	0.380	n	19.38	10.76	0	0	0	0	0	0	0	0
11	W	12F-6sw	0.048	e	2.45	0.79	28	28	68	22	147	110	270	87
	G	1F-r3of	0.380	e	19.38	18.53	0	0	0	0	37	6	713	622
	W	12F-6sw	0.048	s	2.45	0.79	92	92	225	72	258	18	45	14
	G	1F-r3of	0.380	s	19.38	11.59	0	0	0	0	147	83	2853	1513
	G	1F-r3ocd	0.440	s	22.44	13.31	0	0	0	0	92	52	2064	1087
	W	12F-6sw	0.048	w	2.45	0.79	83	62	151	49	0	0	0	0
	D	11P0	0.290	w	14.79	9.13	21	21	311	192	0	0	0	0
	C	47B0	0.038	-	0.00	0.00	90	90	0	0	448	448	0	0
	C	16B-30ad	0.032	-	1.63	1.76	90	90	147	158	448	448	731	788
	F	19D-30cstp	0.034	-	0.61	0.23	90	22	55	20	448	72	271	101
6	c) AED excursion									0				0
	Envelope loss/gain								956	513			11910	6573
12	a) Infiltration								222	43			728	142
	b) Room ventilation								0	0			0	0
13	Internal gains:		Occupants @ 230				0			0	2			460
			Appliances @ 1200				3			3600	3			3600
	Subtotal (lines 6 to 13)								1178	4157			12638	10775
	Less external load								0	0			0	0
	Less transfer								0	0			0	0
	Redistribution								0	0			0	0
14	Subtotal								1178	4157			12638	10775
15	Duct loads						7%	2%	78	98	7%	2%	836	254
	Total room load								1256	4255			13474	11029
	Air required (cfm)								76	222			811	575

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Tufts University

Project Information

For: Solar Decathlon House, Team Boston SD

Web: www.teambostonsd.com**Tubing Requirements**

Roll 1: 600 ft 3/8" BPEX (Part # WX-BP3-600)	3 lengths 115 ft waste	
Main Room-Ceiling-A: 169 ft	Main Room-Ceiling-B: 161 ft	Main Room-Ceiling-C: 157 ft
Roll 2: 600 ft 3/8" BPEX (Part # WX-BP3-600)	3 lengths 93 ft waste	
Main Room-Ceiling-D: 165 ft	Main Room-Ceiling-E: 173 ft	Bathroom-Ceiling: 171 ft
Roll 3: 300 ft 3/8" BPEX (Part # WX-BP3-300)	1 length 148 ft waste	
Foyer-Ceiling: 153 ft		

Project Information

For: Solar Decathlon House, Team Boston SD

Web: www.teambostonSD.com

Design Information

Total floor area:	638 ft ²	Design temperature:	17 °F
Radiantly heated area:	638 ft ²	Maximum supply temperature:	131 °F
Total panel area:	638 ft ²	Total flow rate:	2.01 gpm
Total tubing area:	631 ft ²	Maximum head loss:	5.02 ft H ₂ O
Total room load:	14761 Btuh	Total tubing required:	1146 ft
Total panel output:	14761 Btuh	Number of loops:	7
Total supplemental heat:	0 Btuh	Number of zones:	1
Total back loss:	2678 Btuh	Number of manifolds:	1
Boiler output required:	17439 Btuh		

Space Heating Information

Room name	Room area (ft ²)	Air temp (°F)	Room load (Btuh)	Supp. heat (Btuh)	F/C	Panel area (ft ²)	Tubing area (ft ²)	Surf. temp. (°F)	Deliv. temp. (°F)	Panel output (Btuh /ft ²)	Back loss (Btuh /ft ²)
Bathroom	100	68	944	0	C	100	98	76	131	9.4	3.1
Foyer	90	68	1178	0	C	90	88	80	131	13.1	3.4
Main Room	448	68	12638	0	C	448	444	95	131	28.2	4.6
Totals	638		14761	0		638	631				

Project Information

For: Solar Decathlon House, Team Boston SD

Web: www.teambostonSD.com

Manifold name:
Manifold location:

	Loop number				
	1	2	3	4	5
Name	Main Room-	Main Room	Main Room	Main Room	Main Room-
Heating zone	Entire House	Entire House	Entire House	Entire House	Entire House
Heated area (ft²)	92	87	85	90	94
Room temperature (°F)	68	68	68	68	68
Cover R (ft²·°F/Btuh)	0.00	0.00	0.00	0.00	0.00
Surface temperature (°F)	94	95	95	95	94
Radiant panel CST	47B0	47B0	47B0	47B0	47B0
Radiant panel type					Omni-grip
Tube spacing (in)	6.0	6.0	6.0	6.0	6.0
Tube type/size	3/8" BPEX	3/8" BPEX	3/8" BPEX	3/8" BPEX	3/8" BPEX
Distance to manifold (ft)	0	0	0	0	0
Loop length (ft)	169	161	157	165	173
Temperature drop (°F)	16.0	15.0	14.4	15.5	16.5
Flow (gpm)	0.38	0.39	0.40	0.39	0.38
Head loss (ft H2O)	5.01	5.00	4.99	5.01	5.02
Supply temperature (°F)	131	131	131	131	131
Balance valve (turns from closed)					

Totals

Max. head loss (ft H2O)	5.02	Total flow (gpm)	2.01
Valves head in worst loop (ft H2O)		Total panel output (Btuh)	14761
Max. supply temp. (°F)	131	Total tubing required (ft)	1146

continued...

Project Information

For: Solar Decathlon House, Team Boston SD

Web: www.teambostonSD.com

Manifold name:
Manifold location:

	Loop number				
	6	7			
Name	Bathroom	Foyer			
Heating zone	Entire House	Entire House			
Heated area (ft²)	100	90			
Room temperature (°F)	68	68			
Cover R (ft²·°F/Btuh)	0.00	0.00			
Surface temperature (°F)	76	80			
Radiant panel CST	47B0	47B0			
Radiant panel type					
Tube spacing (in)	6.0	6.0			
Tube type/size	3/8" BPEX	3/8" BPEX			
Distance to manifold (ft)	0	0			
Loop length (ft)	171	153			
Temperature drop (°F)	63.0	63.0			
Flow (gpm)	0.04	0.05			
Head loss (ft H2O)	0.10	0.12			
Supply temperature (°F)	131	131			
Balance valve (turns from closed)					

Totals

Max. head loss (ft H2O)	5.02	Total flow (gpm)	2.01
Valves head in worst loop (ft H2O)		Total panel output (Btuh)	14761
Max. supply temp. (°F)	131	Total tubing required (ft)	1146



TEAM BOSTON
SOLAR DECATHLON 2009

ENERGY ANALYSIS APPENDIX B:
PV WATTS PHOTOVOLTAIC SIMULATION



**AC ENERGY
&
COST SAVINGS**



Station Identification	
City:	Boston
State:	Massachusetts
Latitude:	42.37° N
Longitude:	71.03° W
Elevation:	5 m
PV System Specifications	
DC Rating:	6.4 kW
DC to AC Derate Factor:	0.770
AC Rating:	5.0 kW
Array Type:	Fixed Tilt
Array Tilt:	25.0°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	11.8 ¢/kWh

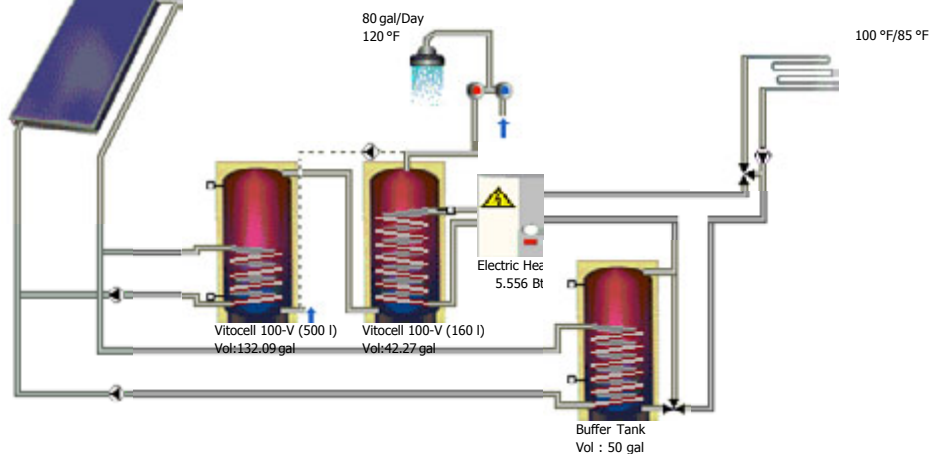
Results			
Month	Solar Radiation (kWh/m ² /day)	AC Energy (kWh)	Energy Value (\$)
1	2.89	458	54.04
2	3.88	561	66.20
3	4.61	712	84.02
4	5.04	737	86.97
5	5.71	824	97.23
6	5.94	803	94.75
7	6.07	847	99.95
8	5.85	819	96.64
9	5.03	696	82.13
10	4.26	630	74.34
11	2.76	407	48.03
12	2.52	389	45.90
Year	4.55	7885	930.43



TEAM BOSTON
SOLAR DECATHLON 2009

ENERGY ANALYSIS APPENDIX C:
T*SOL PRO SOLAR THERMAL MODEL

5 x Vitosol 200-F
 Total Gross Surface Area: 134.98 sq.ft
 Azi
 Inc



Results of Annual Simulation

Installed Collector Power:	29.95 kBtu/hr	
Installed Gross Solar Surface Area:	134.979 sq.ft	
Collector Surface Area Irradiation:	71.96 MBtu	574.65 kBtu/sq.ft
Energy Produced by Collectors:	25.72 MBtu	205.42 kBtu/sq.ft
Energy Produced by Collector Loop:	23.47 MBtu	187.45 kBtu/sq.ft

DHW Heating Energy Supply:	16.99 MBtu
Space Heating Energy Supply:	21.91 MBtu
Solar Contribution to DHW:	18.29 MBtu
Solar Contribution to Heating:	844.76 kBtu
Energy from Auxiliary Heating:	22.28 MBtu

Electricity Savings:	22,598.9 kBtu
CO2 Emissions Avoided:	9,689.05 lbs
DHW Solar Fraction:	93.8 %
Total Solar Fraction:	46.2 %
Fractional Energy Saving (EN 12976):	45.4 %
System Efficiency:	26.6 %

Basic Data

Climate File

Location:	Washington DC
Climate Data Record:	"Washington DC"
Total Annual Global Radiation:	5.46 MBtu
Latitude:	38.98 °
Longitude:	77.47 °

Domestic Hot Water



Average Daily Consumption:	80 gal
Desired Temperature:	120 °F
Load Profile:	Detached House (evening max)
Cold Water Temperature:	February:45 °F / August:55 °F

Space Heating

Standard Building Heat Flow Requirement:	19.3 kBtu/hr
Standard External Temperature:	1.32 °F
Design Temperatures :	100 °F/85 °F

System Components

Collector Loop

Manufacturer:	 Viessmann
Type:	 Vitosol 200-F
Number:	5.00
Total Gross Surface Area:	134.979 sq.ft
Total Active Solar Surface Area:	125.238 sq.ft
Tilt Angle:	30 °
Azimuth:	0 °

DHW Standby Tank

Manufacturer:	Viessmann
Type:	 Vitocell 100-V (160 l)
Volume:	42.27 gal

Buffer Tank

Manufacturer:	Viessmann
Type:	Buffer Tank
Volume:	50 gal




Solar Preheating Tank

Manufacturer:	Viessmann
Type:	Vitocell 100-V (500 l)
Volume:	132.09 gal

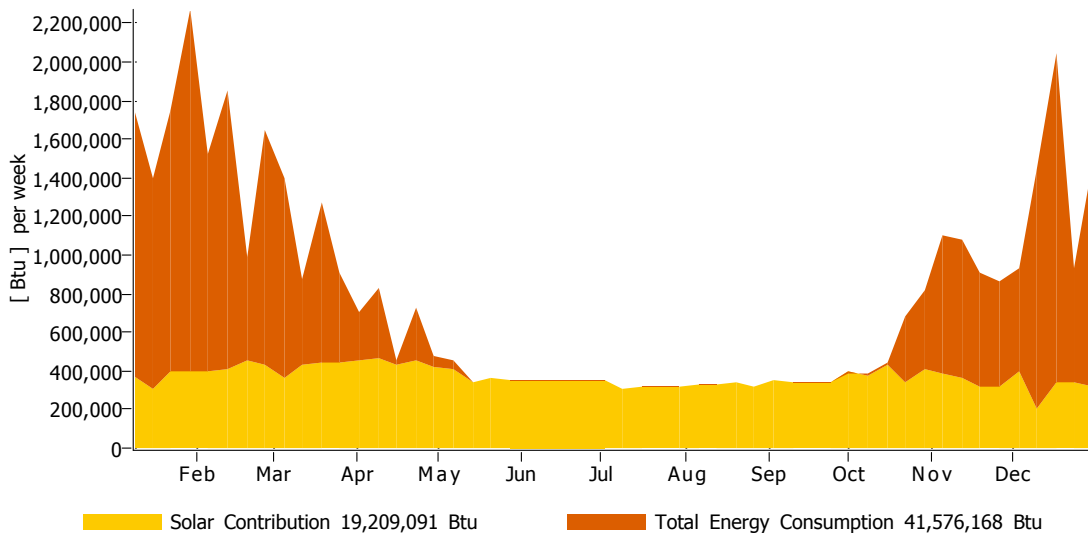
Auxiliary Heating

Manufacturer:	Generic
Type:	Electric Heating Element
Nominal Output:	20 kBtu/hr

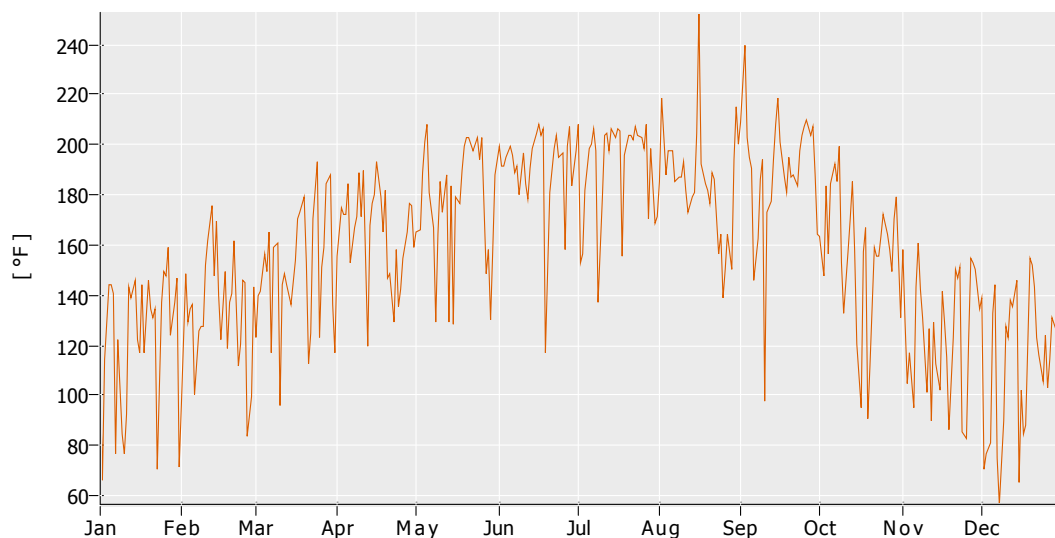
Legend

-  Original T*SOL Database
-  With Test Report
-  Solar Keymark

Solar Energy Consumption as Percentage of Total Consumption

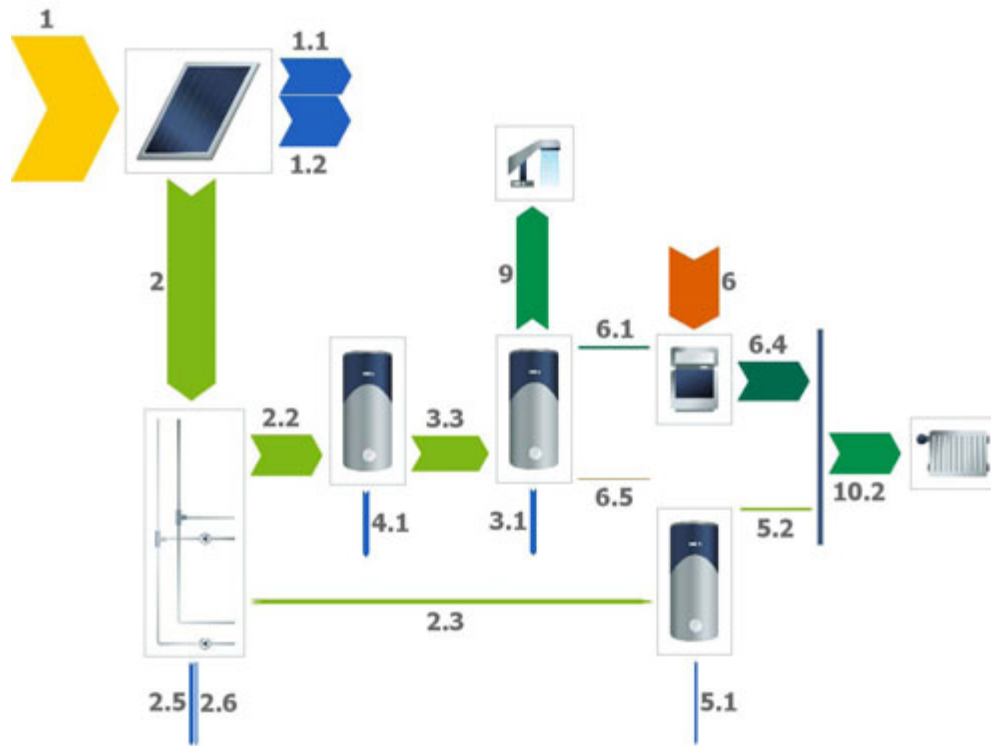


Daily Maximum Collector Temperature



These calculations were carried out by T*SOL Pro 4.5 - the Simulation Programme for Solar Thermal Heating Systems. The results are determined by a mathematical model calculation with variable time steps of up to 6 minutes. Actual yields can deviate from these values due to fluctuations in climate, consumption and other factors. The system schematic diagram above does not represent and cannot replace a full technical drawing of the solar system.

Energy Balance Schematic



Legend

1	Collector Surface Area Irradiation	779 therm
1.1	Optical Collector Losses	19,307 kBtu
1.2	Thermal Collector Losses	27,105 kBtu
2	Energy from Collector Array	25,820 kBtu
2.2	Solar Energy to Preheating Tank	21,364 kBtu
2.3	Solar Energy to Buffer Tank	2,198 kBtu
2.5	External Piping Losses	1,899 kBtu
2.6	Internal Piping Losses	360 kBtu
3.1	Tank Losses	2,526 kBtu
3.3	Preheating Tank to Tank	18,361 kBtu
4.1	Tank Losses	2,981 kBtu
5.1	Buffer Tank Losses	1,351 kBtu
5.2	Buffer Tank to Heating	848 kBtu
6	Final Energy	26,314 kBtu
6.1	Supplementary Energy to Tank	1,223 kBtu
6.4	Supplementary Energy to Space Heating	21,144 kBtu
6.5	Heating Element	0 kBtu
9	DHW Energy from Tank	17,054 kBtu
10.2	Heat to LT Heating	21,992 kBtu

Glossary

- 1 Collector Surface Area Irradiation
Energy Irradiated onto Tilted Collector Area (Active Solar Surface)
- 1.1 Optical Collector Losses
Reflection and Other Losses
- 1.2 Thermal Collector Losses
Heat Conduction and Other Losses
- 2 Energy from Collector Array
Energy Output at Collector Array Outlet (i.e. Before the Piping)
- 2.2 Solar Energy to Preheating Tank
Collector Array Energy Minus Piping Losses
- 2.3 Solar Energy to Buffer Tank
Energy from Collector Loop to Buffer Tank (Minus Piping Losses)
- 2.5 External Piping Losses
External Piping Losses
- 2.6 Internal Piping Losses
Internal Piping Losses
- 3.1 Tank Losses
Heat Losses via Surface Area
- 3.3 Preheating Tank to Tank
Heat from Preheating Tank to Tank
- 4.1 Tank Losses
Heat Losses via Surface Area
- 5.1 Buffer Tank Losses
Heat Losses via Surface Area
- 5.2 Buffer Tank to Heating
Heat from Buffer Tank to HT/LT Heating
- 6 Final Energy
Final Energy Current into System. This can flow in as natural gas, oil or electricity (not including solar energy) taking efficiency levels into account
- 6.1 Supplementary Energy to Tank
Supplementary Energy (e.g. Boiler) to Tank
- 6.4 Supplementary Energy to Space Heating
Supplementary Energy (e.g. Boiler) to HT/LT Heating
- 6.5 Heating Element
Energy from Heating Element
- 9 DHW Energy from Tank
Heat for DHW Appliances from Tank
- 10.2 Heat to LT Heating
Heat to Low Temperature Heating



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ENERGY ANALYSIS APPENDIX D:
ENERGYPLUS CURIO HOUSE MODEL

!-Generator IDFEditor 1.34
!-Option SortedOrder

!-NOTE: All comments with '!' are ignored by the IDFEditor and are generated automatically.
!- Use '!' comments if they need to be retained when using the IDFEditor.

!- ===== ALL OBJECTS IN CLASS: VERSION =====

Version,
3.1; !- Version Identifier

!- ===== ALL OBJECTS IN CLASS: SIMULATIONCONTROL =====

SimulationControl,
Yes, !- Do Zone Sizing Calculation
Yes, !- Do System Sizing Calculation
Yes, !- Do Plant Sizing Calculation
Yes, !- Run Simulation For Sizing Periods
Yes; !- Run Simulation for Weather File Run Periods

!- ===== ALL OBJECTS IN CLASS: BUILDING =====

Building,
Curio House, !- Name
0.0, !- North Axis {deg}
Suburbs, !- Terrain
0.04, !- Loads Convergence Tolerance Value
0.4, !- Temperature Convergence Tolerance Value {deltaC}
FullInteriorAndExterior, !- Solar Distribution
25; !- Maximum Number of Warmup Days

!- ===== ALL OBJECTS IN CLASS: SURFACECONVECTIONALGORITHM:INSIDE =====

SurfaceConvectionAlgorithm:Inside,
Detailed; !- Algorithm

!- ===== ALL OBJECTS IN CLASS: SURFACECONVECTIONALGORITHM:OUTSIDE =====

SurfaceConvectionAlgorithm:Outside,
DOE-2; !- Algorithm

!- ===== ALL OBJECTS IN CLASS: HEATBALANCEALGORITHM =====

HeatBalanceAlgorithm,
ConductionTransferFunction, !- Algorithm
200; !- Surface Temperature Upper Limit

!- ===== ALL OBJECTS IN CLASS: TIMESTEP =====

Timestep,
6; !- Number of Timesteps per Hour

!- ===== ALL OBJECTS IN CLASS: SITE:LOCATION =====

CORRELATION, !- Calculation Method
14, !- Temperature Schedule Name
25.9; !- Annual Average Outdoor Air Temperature {C}
Temperatures {deltaC} !- Maximum Difference In Monthly Average Outdoor Air

!- ===== ALL OBJECTS IN CLASS: SCHEDULETYPELIMITS =====

ScheduleTypeLimits,
Temperatures, !- Name
-60:200, !- Range
Continuous; !- Numeric Type

ScheduleTypeLimits,
Fraction, !- Name
0:1, !- Range
Continuous; !- Numeric Type

ScheduleTypeLimits,
Number, !- Name
0:200, !- Range
Discrete; !- Numeric Type

ScheduleTypeLimits,
On/Off, !- Name
0:1, !- Range
Discrete; !- Numeric Type

ScheduleTypeLimits,
Any Number; !- Name

ScheduleTypeLimits,
Control Type, !- Name
0:4, !- Range
DISCRETE; !- Numeric Type

ScheduleTypeLimits,
TEMPERATURE, !- Name
-60:200, !- Range
Continuous; !- Numeric Type

!- ===== ALL OBJECTS IN CLASS: SCHEDULE:COMPACT =====

Schedule:Compact,
ERV Availability, !- Name
Fraction, !- Schedule Type Limits Name
Through: 12/31, !- Field 1
For: Alldays, !- Field 2
Until: 24:00, !- Field 3
1; !- Field 4

Schedule:Compact,
AmbientLightSchedule, !- Name
Fraction, !- Schedule Type Limits Name
Through: 12/31, !- Field 1
For: Alldays, !- Field 2
Until: 6:00, !- Field 3
0, !- Field 4
Until: 18:00, !- Field 5
0.3, !- Field 6
Until: 23:00, !- Field 7

Site:Location,
Washington DC, !- Name
38.85, !- Latitude {deg}
-77.04, !- Longitude {deg}
-5.0, !- Time Zone {hr}
5; !- Elevation {m}

!- ===== ALL OBJECTS IN CLASS: SIZINGPERIOD:DESIGNDAY =====

SizingPeriod:DesignDay,
Reagan National 1% Winter Design, !- Name
-6.6, !- Maximum Dry-Bulb Temperature {C}
0.0, !- Daily Temperature Range {deltaC}
-16.4, !- Humidity Indicating Conditions at Maximum Dry-Bulb
101289, !- Barometric Pressure {Pa}
4.9, !- Wind Speed {m/s}
330, !- Wind Direction {deg}
0.0, !- Sky Clearness
0, !- Rain Indicator
0, !- Snow Indicator
21, !- Day of Month
1, !- Month
WinterDesignDay, !- Day Type
0, !- Daylight Saving Time Indicator
DewPoint; !- Humidity Indicating Type

SizingPeriod:DesignDay,
Reagan National 1% Cooling Design, !- Name
33.3, !- Maximum Dry-Bulb Temperature {C}
9.1, !- Daily Temperature Range {deltaC}
24, !- Humidity Indicating Conditions at Maximum Dry-Bulb
101289, !- Barometric Pressure {Pa}
4.7, !- Wind Speed {m/s}
170, !- Wind Direction {deg}
1.0, !- Sky Clearness
0, !- Rain Indicator
0, !- Snow Indicator
21, !- Day of Month
7, !- Month
SummerDesignDay, !- Day Type
0, !- Daylight Saving Time Indicator
WetBulb; !- Humidity Indicating Type

!- ===== ALL OBJECTS IN CLASS: RUNPERIOD =====

RunPeriod,
1, !- Begin Month
1, !- Begin Day of Month
12, !- End Month
31, !- End Day of Month
SUNDAY, !- Day of Week for Start Day
Yes, !- Use Weather File Holidays and Special Days
Yes, !- Use Weather File Daylight Saving Period
No, !- Apply Weekend Holiday Rule
Yes, !- Use Weather File Rain Indicators
; !- Use Weather File Snow Indicators

!- ===== ALL OBJECTS IN CLASS: SITE:WATERMAINSTEMPERATURE =====

Site:WaterMainsTemperature,

1, !- Field 8
Until: 24:00, !- Field 9
0.3; !- Field 10

Schedule:Compact,
TasklightSchedule, !- Name
Fraction, !- Schedule Type Limits Name
Through: 12/31, !- Field 1
For: Alldays, !- Field 2
Until: 6:00, !- Field 3
0, !- Field 4
Until: 9:00, !- Field 5
0.5, !- Field 6
Until: 17:00, !- Field 7
0, !- Field 8
Until: 18:00, !- Field 9
0.25, !- Field 10
Until: 22:00, !- Field 11
1, !- Field 12
Until: 24:00, !- Field 13
0.5; !- Field 14

Schedule:Compact,
Occupancy, !- Name
Number, !- Schedule Type Limits Name
Through: 12/31, !- Field 1
For: Weekdays WinterDesignDay SummerDesignDay, !- Field 2
Until: 7:00, !- Field 3
1, !- Field 4
Until: 9:00, !- Field 5
0.5, !- Field 6
Until: 18:00, !- Field 7
0, !- Field 8
Until: 19:00, !- Field 9
0.5, !- Field 10
Until: 24:00, !- Field 11
1, !- Field 12
For: Saturday, !- Field 13
Until: 12:00, !- Field 14
1, !- Field 15
Until: 18:00, !- Field 16
0.5, !- Field 17
Until: 24:00, !- Field 18
1, !- Field 19
For: Sunday Holiday CustomDay1 CustomDay2, !- Field 20
Until: 24:00, !- Field 21
1; !- Field 22

Schedule:Compact,
Constant, !- Name
On/Off, !- Schedule Type Limits Name
Through: 12/31, !- Field 1
For: AllDays, !- Field 2
Until: 24:00, !- Field 3
1.0; !- Field 4

Schedule:Compact,
Occupant Activity Level, !- Name
Number, !- Schedule Type Limits Name
Through: 12/31, !- Field 1
For: Alldays, !- Field 2
Until: 7:00, !- Field 3
80, !- Field 4

Until: 24:00,	!- Field 5	1,	!- Field 18
131.8;	!- Field 6	Through: 12/31,	!- Field 19
Schedule:Compact,		For: AllDays,	!- Field 20
Living Appliance Schedule,	!- Name	Until: 24:00,	!- Field 21
Fraction,	!- Schedule Type Limits Name	1.0;	!- Field 22
Through: 12/31,	!- Field 1	Schedule:Compact,	
For: AllDays,	!- Field 2	Zone Control Type Sched,	!- Name
Until: 10:00,	!- Field 3	Control Type,	!- Schedule Type Limits Name
0.01,	!- Field 4	Through: 12/31,	!- Field 1
Until: 11:00,	!- Field 5	For: AllDays,	!- Field 2
0.05,	!- Field 6	Until: 24:00,	!- Field 3
Until: 14:00,	!- Field 7	3;	!- Field 4
0.07,	!- Field 8	Schedule:Compact,	
Until: 17:00,	!- Field 9	Constant T Setpoint,	!- Name
0.03,	!- Field 10	TEMPERATURE,	!- Schedule Type Limits Name
Until: 18:00,	!- Field 11	Through: 12/31,	!- Field 1
0.01,	!- Field 12	For: AllDays,	!- Field 2
Until: 19:00,	!- Field 13	Until: 24:00,	!- Field 3
1,	!- Field 14	23.3;	!- Field 4
Until: 20:00,	!- Field 15	Schedule:Compact,	
0.07,	!- Field 16	OutsideAirEconSched,	!- Name
Until: 21:00,	!- Field 17	Number,	!- Schedule Type Limits Name
0.21,	!- Field 18	Through: 12/31,	!- Field 1
Until: 23:00,	!- Field 19	For: AllDays,	!- Field 2
0.09,	!- Field 20	Until: 24:00,	!- Field 3
Until: 24:00,	!- Field 21	1;	!- Field 4
0.01;	!- Field 22	Schedule:Compact,	
Schedule:Compact,		ConstantFanSch,	!- Name
Bath Appliance Schedule,	!- Name	Fraction,	!- Schedule Type Limits Name
Fraction,	!- Schedule Type Limits Name	Through: 12/31,	!- Field 1
Through: 12/31,	!- Field 1	For: AllDays,	!- Field 2
For: AllDays,	!- Field 2	Until: 24:00,	!- Field 3
Until: 20:00,	!- Field 3	1.0;	!- Field 4
0,	!- Field 4	Schedule:Compact,	
Until: 21:00,	!- Field 5	Heat Exchanger Supply Air Temp Sch,	!- Name
0.09,	!- Field 6	TEMPERATURE,	!- Schedule Type Limits Name
Until: 22:00,	!- Field 7	Through: 12/31,	!- Field 1
1,	!- Field 8	For: AllDays,	!- Field 2
Until: 24:00,	!- Field 9	Until: 24:00,	!- Field 3
0;	!- Field 10	14;	!- Field 4
Schedule:Compact,		Schedule:Compact,	
FanAndCoilAvailSched,	!- Name	Activity Sch,	!- Name
Fraction,	!- Schedule Type Limits Name	Any Number,	!- Schedule Type Limits Name
Through: 3/31,	!- Field 1	Through: 12/31,	!- Field 1
For: AllDays,	!- Field 2	For: AllDays,	!- Field 2
Until: 24:00,	!- Field 3	Until: 24:00,	!- Field 3
1.0,	!- Field 4	131.8;	!- Field 4
Through: 9/30,	!- Field 5	Schedule:Compact,	
For: WeekDays SummerDesignDay,	!- Field 6	Work Eff Sch,	!- Name
Until: 7:00,	!- Field 7	Any Number,	!- Schedule Type Limits Name
1,	!- Field 8	Through: 12/31,	!- Field 1
Until: 17:00,	!- Field 9	For: AllDays,	!- Field 2
1.0,	!- Field 10	Until: 24:00,	!- Field 3
Until: 24:00,	!- Field 11	0.0;	!- Field 4
1,	!- Field 12	Schedule:Compact,	
For: WinterDesignDay,	!- Field 13	Until: 17:00,	!- Field 5
Until: 24:00,	!- Field 14	1.0,	!- Field 6
1,	!- Field 15	Until: 24:00,	!- Field 7
For: AllOtherDays,	!- Field 16	1;	!- Field 8
Until: 24:00,	!- Field 17	Schedule:Compact,	
		FanModeSchedule,	!- Name
Clothing Sch,	!- Name	Fraction,	!- Schedule Type Limits Name
Any Number,	!- Schedule Type Limits Name	Through: 12/31,	!- Field 1
Through: 12/31,	!- Field 1	For: AllDays,	!- Field 2
For: AllDays,	!- Field 2	Until: 7:00,	!- Field 3
Until: 24:00,	!- Field 3	1,	!- Field 4
1.0;	!- Field 4	Until: 17:00,	!- Field 5
Schedule:Compact,		1.0,	!- Field 6
Air Velo Sch,	!- Name	Until: 24:00,	!- Field 7
Any Number,	!- Schedule Type Limits Name	1;	!- Field 8
Through: 12/31,	!- Field 1	Schedule:Compact,	
For: AllDays,	!- Field 2	RadiantAvailSched,	!- Name
Until: 24:00,	!- Field 3	Fraction,	!- Schedule Type Limits Name
0.137;	!- Field 4	Through: 3/31,	!- Field 1
Schedule:Compact,		For: AllDays,	!- Field 2
INTERMITTENT,	!- Name	Until: 24:00,	!- Field 3
Fraction,	!- Schedule Type Limits Name	1.0,	!- Field 4
Through: 12/31,	!- Field 1	Through: 9/30,	!- Field 5
For: WeekDays SummerDesignDay,	!- Field 2	For: WeekDays SummerDesignDay,	!- Field 6
Until: 8:00,	!- Field 3	Until: 7:00,	!- Field 7
0.0,	!- Field 4	1,	!- Field 8
Until: 18:00,	!- Field 5	Until: 17:00,	!- Field 9
1.00,	!- Field 6	0,	!- Field 10
Until: 24:00,	!- Field 7	Until: 24:00,	!- Field 11
0.0,	!- Field 8	1,	!- Field 12
For: AllOtherDays,	!- Field 9	For: WinterDesignDay,	!- Field 13
Until: 24:00,	!- Field 10	Until: 24:00,	!- Field 14
0.0;	!- Field 11	1,	!- Field 15
Schedule:Compact,		For: AllOtherDays,	!- Field 16
OutdoorAirAvailSched,	!- Name	Until: 24:00,	!- Field 17
Fraction,	!- Schedule Type Limits Name	1,	!- Field 18
Through: 3/31,	!- Field 1	Through: 12/31,	!- Field 19
For: AllDays,	!- Field 2	For: AllDays,	!- Field 20
Until: 24:00,	!- Field 3	Until: 24:00,	!- Field 21
1.0,	!- Field 4	1.0;	!- Field 22
Through: 9/30,	!- Field 5	Schedule:Compact,	
For: WeekDays,	!- Field 6	RADIANT HEATING SETPOINTS,	!- Name
Until: 7:00,	!- Field 7	TEMPERATURE,	!- Schedule Type Limits Name
0.0,	!- Field 8	Through: 12/31,	!- Field 1
Until: 17:00,	!- Field 9	For: AllDays,	!- Field 2
1.0,	!- Field 10	Until: 7:00,	!- Field 3
Until: 24:00,	!- Field 11	12.00,	!- Field 4
0.0,	!- Field 12	Until: 17:00,	!- Field 5
For: SummerDesignDay WinterDesignDay,	!- Field 13	17.00,	!- Field 6
Until: 24:00,	!- Field 14	Until: 24:00,	!- Field 7
0.0,	!- Field 15	12.00;	!- Field 8
For: AllOtherDays,	!- Field 16	Schedule:Compact,	
Until: 24:00,	!- Field 17	Radiant Temp Throttling Schedule,	!- Name
0.0,	!- Field 18	Temperatures,	!- Schedule Type Limits Name
Through: 12/31,	!- Field 19	Through: 12/31,	!- Field 1
For: AllDays,	!- Field 20	For: AllDays,	!- Field 2
Until: 24:00,	!- Field 21	Until: 24:00,	!- Field 3
1.0;	!- Field 22	22.3;	!- Field 4
Schedule:Compact,			
OAFractionSched,	!- Name		
Fraction,	!- Schedule Type Limits Name		
Through: 12/31,	!- Field 1		
For: AllDays,	!- Field 2		
Until: 7:00,	!- Field 3		
0.0,	!- Field 4		

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Schedule:Compact,
  Radiant Loop Temp Schedule, !- Name
  TEMPERATURE, !- Schedule Type Limits Name
  Through: 12/31, !- Field 1
  For: AllDays, !- Field 2
  Until: 24:00, !- Field 3
  38; !- Field 4

Schedule:Compact,
  ON, !- Name
  Fraction, !- Schedule Type Limits Name
  Through: 12/31, !- Field 1
  For: AllDays, !- Field 2
  Until: 24:00, !- Field 3
  1.0; !- Field 4

Schedule:Compact,
  AlwaysOnSchedule, !- Name
  Fraction, !- Schedule Type Limits Name
  THROUGH: 12/31, !- Field 1
  FOR: AllDays, !- Field 2
  UNTIL: 24:00, !- Field 3
  1.0; !- Field 4

Schedule:Compact,
  Collector Loop Temperature Schedule, !- Name
  Any Number, !- Schedule Type Limits Name
  THROUGH: 12/31, !- Field 1
  FOR: AllDays, !- Field 2
  UNTIL: 24:00, !- Field 3
  80; !- Field 4

Schedule:Compact,
  Secondary Loop Setpoint Temp Schedule, !- Name
  Any Number, !- Schedule Type Limits Name
  THROUGH: 12/31, !- Field 1
  FOR: AllDays, !- Field 2
  UNTIL: 24:00, !- Field 3
  80; !- Field 4

Schedule:Compact,
  Sinks and Showers Temp Schedule, !- Name
  Any Number, !- Schedule Type Limits Name
  THROUGH: 12/31, !- Field 1
  FOR: AllDays, !- Field 2
  UNTIL: 24:00, !- Field 3
  43.3; !- Field 4

Schedule:Compact,
  Washers Temp Schedule, !- Name
  Any Number, !- Schedule Type Limits Name
  THROUGH: 12/31, !- Field 1
  FOR: AllDays, !- Field 2
  UNTIL: 24:00, !- Field 3
  50.0; !- Field 4

Schedule:Compact,
  Sinks, !- Name
  Fraction, !- Schedule Type Limits Name
  Through: 12/31, !- Field 1
  For: AllDays, !- Field 2
  Until: 7:00, !- Field 3
  0.0, !- Field 4

  Until: 20:30, !- Field 5
  1.0, !- Field 6
  Until: 24:00, !- Field 7
  0.0; !- Field 8

Schedule:Compact,
  DownWinter Shading Schedule, !- Name
  On/Off, !- Schedule Type Limits Name
  Through: 4/30, !- Field 1
  For: AllDays, !- Field 2
  Until: 24:00, !- Field 3
  1, !- Field 4
  Through: 9/30, !- Field 5
  For: AllDays, !- Field 6
  Until:24:00, !- Field 7
  0, !- Field 8
  Through: 12/31, !- Field 9
  For: AllDays, !- Field 10
  Until: 24:00, !- Field 11
  1, !- Field 12

Schedule:Compact,
  North Moveable Insulation Schedule, !- Name
  On/Off, !- Schedule Type Limits Name
  Through: 3/1, !- Field 1
  For: AllDays, !- Field 2
  Until: 24:00, !- Field 3
  1, !- Field 4
  Through: 11/1, !- Field 5
  For: AllDays, !- Field 6
  Until: 24:00, !- Field 7
  0, !- Field 8
  Through: 12/31, !- Field 9
  For: AllDays, !- Field 10
  Until: 24:00, !- Field 11
  1, !- Field 12

Schedule:Compact,
  DownSummer Shading Schedule, !- Name
  On/Off, !- Schedule Type Limits Name
  Through: 4/30, !- Field 1
  For: AllDays, !- Field 2
  Until: 24:00, !- Field 3
  0, !- Field 4
  Through: 9/30, !- Field 5
  For: AllDays, !- Field 6
  Until: 24:00, !- Field 7
  1, !- Field 8
  Through: 12/31, !- Field 9
  For: AllDays, !- Field 10
  Until: 24:00, !- Field 11
  0, !- Field 12

!- ===== ALL OBJECTS IN CLASS: MATERIAL =====

Material,
  F06 EIFS finish, !- Name
  Smooth, !- Roughness
  0.0095, !- Thickness {m}
  0.72, !- Conductivity {W/m-K}
  1856, !- Density {kg/m3}
  840; !- Specific Heat {J/kg-K}

  Until: 8:00, !- Field 5
  0.3, !- Field 6
  Until: 9:00, !- Field 7
  0.7, !- Field 8
  Until: 11:00, !- Field 9
  0.0, !- Field 10
  Until: 12:00, !- Field 11
  0.1, !- Field 12
  Until: 13:00, !- Field 13
  0.3, !- Field 14
  Until: 17:00, !- Field 15
  0.0, !- Field 16
  Until: 18:00, !- Field 17
  0.2, !- Field 18
  Until: 19:00, !- Field 19
  0.5, !- Field 20
  Until: 20:00, !- Field 21
  0.2, !- Field 22
  Until: 24:00, !- Field 23
  0.0; !- Field 24

Schedule:Compact,
  Showers, !- Name
  Fraction, !- Schedule Type Limits Name
  Through: 12/31, !- Field 1
  For: AllDays, !- Field 2
  Until: 7:00, !- Field 3
  0.0, !- Field 4
  Until: 7:30, !- Field 5
  0.2, !- Field 6
  Until: 8:00, !- Field 7
  0.8, !- Field 8
  Until: 8:30, !- Field 9
  0.1, !- Field 10
  Until: 19:00, !- Field 11
  0.0, !- Field 12
  Until: 19:30, !- Field 13
  0.3, !- Field 14
  Until: 24:00, !- Field 15
  0.0; !- Field 16

Schedule:Compact,
  Clotheswasher, !- Name
  Fraction, !- Schedule Type Limits Name
  Through: 12/31, !- Field 1
  For: Weekends SummerDesignDay WinterDesignDay, !- Field 2
  Until: 10:00, !- Field 3
  0.0, !- Field 4
  Until: 11:00, !- Field 5
  1.0, !- Field 6
  Until: 24:00, !- Field 7
  0.0, !- Field 8
  For: AllOtherDays, !- Field 9
  Until: 24:00, !- Field 10
  0.0; !- Field 11

Schedule:Compact,
  Dishwasher, !- Name
  Fraction, !- Schedule Type Limits Name
  Through: 12/31, !- Field 1
  For: AllDays, !- Field 2
  Until: 20:00, !- Field 3
  0.0, !- Field 4

Material,
  F07 25mm stucco, !- Name
  Smooth, !- Roughness
  0.0254, !- Thickness {m}
  0.72, !- Conductivity {W/m-K}
  1856, !- Density {kg/m3}
  840; !- Specific Heat {J/kg-K}

Material,
  F08 Metal surface, !- Name
  Smooth, !- Roughness
  0.0008, !- Thickness {m}
  45.28, !- Conductivity {W/m-K}
  7824, !- Density {kg/m3}
  500; !- Specific Heat {J/kg-K}

Material,
  F09 Opaque spandrel glass, !- Name
  Smooth, !- Roughness
  0.0064, !- Thickness {m}
  0.99, !- Conductivity {W/m-K}
  2528, !- Density {kg/m3}
  880; !- Specific Heat {J/kg-K}

Material,
  F10 25mm stone, !- Name
  MediumRough, !- Roughness
  0.0254, !- Thickness {m}
  3.17, !- Conductivity {W/m-K}
  2560, !- Density {kg/m3}
  790; !- Specific Heat {J/kg-K}

Material,
  3/4" wood siding, !- Name
  MediumSmooth, !- Roughness
  0.019, !- Thickness {m}
  0.09, !- Conductivity {W/m-K}
  592, !- Density {kg/m3}
  1170; !- Specific Heat {J/kg-K}

Material,
  F12 Asphalt shingles, !- Name
  VeryRough, !- Roughness
  0.0032, !- Thickness {m}
  0.04, !- Conductivity {W/m-K}
  1120, !- Density {kg/m3}
  1260; !- Specific Heat {J/kg-K}

Material,
  F13 Built-up roofing, !- Name
  Rough, !- Roughness
  0.0095, !- Thickness {m}
  0.16, !- Conductivity {W/m-K}
  1120, !- Density {kg/m3}
  1460; !- Specific Heat {J/kg-K}

Material,
  F14 Slate or tile, !- Name
  VeryRough, !- Roughness
  0.0127, !- Thickness {m}
  1.59, !- Conductivity {W/m-K}
  1920, !- Density {kg/m3}

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MediumRough, !- Roughness
0.1016, !- Thickness {m}
1.95, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
M14 150mm heavyweight concrete, !- Name
MediumRough, !- Roughness
0.1524, !- Thickness {m}
1.95, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
M15 200mm heavyweight concrete, !- Name
MediumRough, !- Roughness
0.2032, !- Thickness {m}
1.95, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
M16 300mm heavyweight concrete, !- Name
MediumRough, !- Roughness
0.3048, !- Thickness {m}
1.95, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
M17 50mm lightweight concrete roof ballast, !- Name
MediumRough, !- Roughness
0.0508, !- Thickness {m}
0.19, !- Conductivity {W/m-K}
640, !- Density {kg/m3}
840, !- Specific Heat {J/kg-K}

Material,
Asbestos-cement board - 3.2mm, !- Name
Smooth, !- Roughness
0.0032, !- Thickness {m}
0.58, !- Conductivity {W/m-K}
1900, !- Density {kg/m3}
1000, !- Specific Heat {J/kg-K}

Material,
Asbestos-cement board - 6.4mm, !- Name
Smooth, !- Roughness
0.0064, !- Thickness {m}
0.58, !- Conductivity {W/m-K}
1900, !- Density {kg/m3}
1000, !- Specific Heat {J/kg-K}

Material,
Gypsum or plaster board - 9.5mm, !- Name
MediumSmooth, !- Roughness
0.0095, !- Thickness {m}
0.58, !- Conductivity {W/m-K}
800, !- Density {kg/m3}
1090, !- Specific Heat {J/kg-K}

Material,

Material,
Sheathing - regular density - 19.8mm, !- Name
Smooth, !- Roughness
0.0198, !- Thickness {m}
0.055, !- Conductivity {W/m-K}
290, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Sheathing intermediate density - 12.7mm, !- Name
Smooth, !- Roughness
0.0127, !- Thickness {m}
0.057, !- Conductivity {W/m-K}
350, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Nail-base sheathing - 12.7mm, !- Name
Smooth, !- Roughness
0.0127, !- Thickness {m}
0.057, !- Conductivity {W/m-K}
400, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Shingle backer - 9.5mm, !- Name
Smooth, !- Roughness
0.0095, !- Thickness {m}
0.063, !- Conductivity {W/m-K}
290, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Shingle backer - 7.9mm, !- Name
Smooth, !- Roughness
0.0079, !- Thickness {m}
0.063, !- Conductivity {W/m-K}
290, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Sound deadening board, !- Name
Smooth, !- Roughness
0.0127, !- Thickness {m}
0.063, !- Conductivity {W/m-K}
240, !- Density {kg/m3}
1260, !- Specific Heat {J/kg-K}

Material,
Tile and lay-in panels - plain or acoustic - 12.7mm, !- Name
MediumSmooth, !- Roughness
0.0127, !- Thickness {m}
0.057, !- Conductivity {W/m-K}
290, !- Density {kg/m3}
590, !- Specific Heat {J/kg-K}

Material,
Tile and lay-in panels - plain or acoustic - 19mm, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.057, !- Conductivity {W/m-K}
290, !- Density {kg/m3}
590, !- Specific Heat {J/kg-K}

Gypsum or plaster board - 2.7mm, !- Name
MediumSmooth, !- Roughness
0.0027, !- Thickness {m}
0.58, !- Conductivity {W/m-K}
800, !- Density {kg/m3}
1090, !- Specific Heat {J/kg-K}

Material,
Gypsum or plaster board - 5.9mm, !- Name
MediumSmooth, !- Roughness
0.0059, !- Thickness {m}
0.58, !- Conductivity {W/m-K}
800, !- Density {kg/m3}
1090, !- Specific Heat {J/kg-K}

Material,
Plywood (Douglas Fir) - 6.4mm, !- Name
MediumSmooth, !- Roughness
0.0064, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
540, !- Density {kg/m3}
1210, !- Specific Heat {J/kg-K}

Material,
Plywood (Douglas Fir) - 9.5mm, !- Name
Smooth, !- Roughness
0.0095, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
540, !- Density {kg/m3}
1210, !- Specific Heat {J/kg-K}

Material,
Plywood (Douglas Fir) - 12.7mm, !- Name
Smooth, !- Roughness
0.0127, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
540, !- Density {kg/m3}
1210, !- Specific Heat {J/kg-K}

Material,
Plywood (Douglas Fir) - 15.9mm, !- Name
Smooth, !- Roughness
0.0159, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
540, !- Density {kg/m3}
1210, !- Specific Heat {J/kg-K}

Material,
Plywood or wood panels - 19.0mm, !- Name
Smooth, !- Roughness
0.019, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
540, !- Density {kg/m3}
1210, !- Specific Heat {J/kg-K}

Material,
Sheathing - regular density - 12.7mm, !- Name
Smooth, !- Roughness
0.0127, !- Thickness {m}
0.055, !- Conductivity {W/m-K}
290, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Laminated paperboard, !- Name
MediumSmooth, !- Roughness
0.0032, !- Thickness {m}
0.072, !- Conductivity {W/m-K}
480, !- Density {kg/m3}
1380, !- Specific Heat {J/kg-K}

Material,
Homogeneous board from repulped paper, !- Name
MediumSmooth, !- Roughness
0.0032, !- Thickness {m}
0.072, !- Conductivity {W/m-K}
480, !- Density {kg/m3}
1170, !- Specific Heat {J/kg-K}

Material,
Hardboard Medium density, !- Name
Smooth, !- Roughness
0.019, !- Thickness {m}
0.105, !- Conductivity {W/m-K}
800, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Hardboard High density - service-tempered grade and service grade, !- Name
Smooth, !- Roughness
0.019, !- Thickness {m}
0.82, !- Conductivity {W/m-K}
880, !- Density {kg/m3}
1340, !- Specific Heat {J/kg-K}

Material,
Hardboard High density - standard-tempered grade, !- Name
Smooth, !- Roughness
0.019, !- Thickness {m}
0.144, !- Conductivity {W/m-K}
1010, !- Density {kg/m3}
1340, !- Specific Heat {J/kg-K}

Material,
Particleboard Low density, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.102, !- Conductivity {W/m-K}
590, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Particleboard Medium density, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.135, !- Conductivity {W/m-K}
800, !- Density {kg/m3}
1300, !- Specific Heat {J/kg-K}

Material,
Particleboard High density, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.17, !- Conductivity {W/m-K}
1000, !- Density {kg/m3}

1300; !- Specific Heat {J/kg-K}

Material,
Particleboard Underlayment - 15.9mm, !- Name
MediumRough, !- Roughness
0.0159, !- Thickness {m}
0.311, !- Conductivity {W/m-K}
640, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
Waferboard, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.091, !- Conductivity {W/m-K}
590, !- Density {kg/m3}
1300; !- Specific Heat {J/kg-K}

Material,
Wood subfloor - 19mm, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.115, !- Conductivity {W/m-K}
800, !- Density {kg/m3}
1380; !- Specific Heat {J/kg-K}

Material,
Insulation: Cellular glass - 25mm, !- Name
MediumRough, !- Roughness
0.025, !- Thickness {m}
0.05, !- Conductivity {W/m-K}
136, !- Density {kg/m3}
750; !- Specific Heat {J/kg-K}

Material,
Insulation: Cellular glass - 50mm, !- Name
MediumRough, !- Roughness
0.05, !- Thickness {m}
0.05, !- Conductivity {W/m-K}
136, !- Density {kg/m3}
750; !- Specific Heat {J/kg-K}

Material,
Insulation: Cellular glass - 75mm, !- Name
MediumRough, !- Roughness
0.075, !- Thickness {m}
0.05, !- Conductivity {W/m-K}
136, !- Density {kg/m3}
750; !- Specific Heat {J/kg-K}

Material,
Insulation: Glass fiber - organic bonded - 25mm, !- Name
MediumRough, !- Roughness
0.025, !- Thickness {m}
0.036, !- Conductivity {W/m-K}
64, !- Density {kg/m3}
960; !- Specific Heat {J/kg-K}

Material,
Insulation: Glass fiber - organic bonded - 50mm, !- Name
MediumRough, !- Roughness
0.05, !- Thickness {m}
0.036, !- Conductivity {W/m-K}

VeryRough, !- Roughness
0.025, !- Thickness {m}
0.035, !- Conductivity {W/m-K}
24, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded polystyrene - molded beads - 28 k6/m3 density, !- Name
VeryRough, !- Roughness
0.025, !- Thickness {m}
0.035, !- Conductivity {W/m-K}
28, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded polystyrene - molded beads - 32 kg/m3 density, !- Name
VeryRough, !- Roughness
0.025, !- Thickness {m}
0.033, !- Conductivity {W/m-K}
32, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
2" Polyiso-Cellular polyurethane/polyisocyanurate] (CFC11 exp.) (unfaced), !- Name
Rough, !- Roughness
0.05, !- Thickness {m}
0.0245, !- Conductivity {W/m-K}
24, !- Density {kg/m3}
1590; !- Specific Heat {J/kg-K}

Material,
2" Polyiso-Cellular polyisocyanurate] (CFC-11 exp.) (gasimpermeable facers), !- Name
Rough, !- Roughness
0.05, !- Thickness {m}
0.0245, !- Conductivity {W/m-K}
32, !- Density {kg/m3}
920; !- Specific Heat {J/kg-K}

Material,
2" Polyiso-Cellular polyisocyanurate] (CFC-11 exp.) (gasimpermeable facers), !- Name
Rough, !- Roughness
0.05, !- Thickness {m}
0.02, !- Conductivity {W/m-K}
32, !- Density {kg/m3}
920; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 2400 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.34, !- Conductivity {W/m-K}
2400, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 2240 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.185, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,

140, !- Density {kg/m3}
960; !- Specific Heat {J/kg-K}

Material,
Insulation: Glass fiber - organic bonded - 75mm, !- Name
MediumRough, !- Roughness
0.075, !- Thickness {m}
0.036, !- Conductivity {W/m-K}
140, !- Density {kg/m3}
960; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded perlite - organic bonded - 25mm, !- Name
MediumSmooth, !- Roughness
0.025, !- Thickness {m}
0.052, !- Conductivity {W/m-K}
16, !- Density {kg/m3}
1260; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded rubber (rigid) - 25mm, !- Name
MediumRough, !- Roughness
0.025, !- Thickness {m}
0.032, !- Conductivity {W/m-K}
72, !- Density {kg/m3}
1680; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded polystyrene - extruded (smooth skin surface) (CFC-12 exp.), !- Name
MediumSmooth, !- Roughness
0.025, !- Thickness {m}
0.029, !- Conductivity {W/m-K}
29, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded polystyrene - extruded (smooth skin surface) (HCFC-142b exp.), !- Name
MediumSmooth, !- Roughness
0.025, !- Thickness {m}
0.029, !- Conductivity {W/m-K}
29, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded polystyrene - molded beads - 16kg/m3 density, !- Name
VeryRough, !- Roughness
0.025, !- Thickness {m}
0.037, !- Conductivity {W/m-K}
16, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded polystyrene - molded beads - 20kg/m3 density, !- Name
VeryRough, !- Roughness
0.025, !- Thickness {m}
0.036, !- Conductivity {W/m-K}
20, !- Density {kg/m3}
1210; !- Specific Heat {J/kg-K}

Material,
Insulation: Expanded polystyrene - molded beads - 24kg/m3 density, !- Name

Brick - fired clay - 2080 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.02, !- Conductivity {W/m-K}
2080, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 1920 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.895, !- Conductivity {W/m-K}
1920, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 1760 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.78, !- Conductivity {W/m-K}
1760, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 1600 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.675, !- Conductivity {W/m-K}
1600, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 1440 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.57, !- Conductivity {W/m-K}
1440, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 1280 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.48, !- Conductivity {W/m-K}
1280, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Brick - fired clay - 1120 kg/m3 - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.405, !- Conductivity {W/m-K}
1120, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Quartzitic and sandstone - 2880 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
10.4, !- Conductivity {W/m-K}
2880, !- Density {kg/m3}
790; !- Specific Heat {J/kg-K}

Material,
Quartzitic and sandstone - 2560 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
6.2, !- Conductivity {W/m-K}
2560, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

Material,
Quartzitic and sandstone - 2240 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
3.5, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

Material,
Quartzitic and sandstone - 1920 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
1.9, !- Conductivity {W/m-K}
1920, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

Material,
Calclitic - dolomitic - limestone - marble - and granite - 2880 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
4.3, !- Conductivity {W/m-K}
2880, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

Material,
Calclitic - dolomitic - limestone - marble - and granite - 2560 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
3.2, !- Conductivity {W/m-K}
2560, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

Material,
Calclitic - dolomitic - limestone - marble - and granite - 2240 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
2.3, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

Material,
Calclitic - dolomitic - limestone - marble - and granite - 1920 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
1.6, !- Conductivity {W/m-K}
1920, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

Material,
Calclitic - dolomitic - limestone - marble - and granite - 1600 kg/m3 - 13mm, !- Name
MediumRough, !- Roughness
0.013, !- Thickness {m}
1.1, !- Conductivity {W/m-K}
1600, !- Density {kg/m3}
790, !- Specific Heat {J/kg-K}

900, !- Specific Heat {J/kg-K}

Material,
Concrete: Cement/lime - mortar - and stucco - 1600 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.97, !- Conductivity {W/m-K}
1600, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Cement/lime - mortar - and stucco - 1280 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.65, !- Conductivity {W/m-K}
1280, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 1920 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
1.1, !- Conductivity {W/m-K}
1920, !- Density {kg/m3}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 1600 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.785, !- Conductivity {W/m-K}
1600, !- Density {kg/m3}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 1280 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.535, !- Conductivity {W/m-K}
1280, !- Density {kg/m3}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 960 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
960, !- Density {kg/m3}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 640 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.18, !- Conductivity {W/m-K}
640, !- Density {kg/m3}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Sand and gravel or stone aggregate concretes - 2400 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
2.15, !- Conductivity {W/m-K}
2400, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Sand and gravel or stone aggregate concretes - 2240 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
1.95, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Sand and gravel or stone aggregate concretes - 2080 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
1.45, !- Conductivity {W/m-K}
2080, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Limestone concretes - 2240 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
1.6, !- Conductivity {W/m-K}
2240, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Limestone concretes - 1920 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
1.14, !- Conductivity {W/m-K}
1920, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Limestone concretes - 1600 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.79, !- Conductivity {W/m-K}
1600, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Gypsum-fiber concrete (87.5% gypsum - 12.5% wood chips) - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.24, !- Conductivity {W/m-K}
816, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete: Cement/lime - mortar - and stucco - 1920 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
1.4, !- Conductivity {W/m-K}
1920, !- Density {kg/m3}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 800 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.265, !- Conductivity {W/m-K}
800, !- Density {kg/m3}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 640 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.21, !- Conductivity {W/m-K}
640, !- Density {kg/m3}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 480 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.16, !- Conductivity {W/m-K}
480, !- Density {kg/m3}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 320 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
320, !- Density {kg/m3}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes - 1920 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.75, !- Conductivity {W/m-K}
1920, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes - 1600 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.6, !- Conductivity {W/m-K}
1600, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes - 1280 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.44, !- Conductivity {W/m-K}
1280, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes - 1120 kg/m3 - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.36, !- Conductivity {W/m-K}
1120, !- Density {kg/m3}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes and cellular concretes - 960 kg/m³ - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.3, !- Conductivity {W/m-K}
960, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes and cellular concretes - 640 kg/m³ - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.2, !- Conductivity {W/m-K}
640, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes and cellular concretes - 320 kg/m³ - 51mm, !- Name
MediumRough, !- Roughness
0.051, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
320, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Sand and gravel or stone aggregate concretes - 2400 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
2.15, !- Conductivity {W/m-K}
2400, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Sand and gravel or stone aggregate concretes - 2240 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.95, !- Conductivity {W/m-K}
2240, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Sand and gravel or stone aggregate concretes - 2080 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.45, !- Conductivity {W/m-K}
2080, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Limestone concretes - 2240 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.6, !- Conductivity {W/m-K}
2240, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Limestone concretes - 1920 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.14, !- Conductivity {W/m-K}
1920, !- Density {kg/m³}

MediumRough, !- Roughness
0.102, !- Thickness {m}
0.535, !- Conductivity {W/m-K}
1280, !- Density {kg/m³}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 960 kg/
m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
960, !- Density {kg/m³}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 640 kg/
m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.18, !- Conductivity {W/m-K}
640, !- Density {kg/m³}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 800 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.265, !- Conductivity {W/m-K}
800, !- Density {kg/m³}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 640 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.21, !- Conductivity {W/m-K}
640, !- Density {kg/m³}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 480 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.16, !- Conductivity {W/m-K}
480, !- Density {kg/m³}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Perlite - vermiculite - and polystyrene beads - 320 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
320, !- Density {kg/m³}
795, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes - 1920 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.75, !- Conductivity {W/m-K}
1920, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

900, !- Specific Heat {J/kg-K}

Material,
Concrete: Limestone concretes - 1600 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.79, !- Conductivity {W/m-K}
1600, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Gypsum-fiber concrete (87.5% gypsum - 12.5% wood chips) - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.24, !- Conductivity {W/m-K}
816, !- Density {kg/m³}
880, !- Specific Heat {J/kg-K}

Material,
Concrete: Cement/lime - mortar - and stucco - 1920 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.4, !- Conductivity {W/m-K}
1920, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Cement/lime - mortar - and stucco - 1600 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.97, !- Conductivity {W/m-K}
1600, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Cement/lime - mortar - and stucco - 1280 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.65, !- Conductivity {W/m-K}
1280, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 1920
kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
1.1, !- Conductivity {W/m-K}
1920, !- Density {kg/m³}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 1600
kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.785, !- Conductivity {W/m-K}
1600, !- Density {kg/m³}
840, !- Specific Heat {J/kg-K}

Material,
Concrete: Expanded shale - clay - slate - expanded slags - cinders - pumice - 1280
kg/m³ - 102mm, !- Name

Material,
Concrete: Foam concretes - 1600 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.6, !- Conductivity {W/m-K}
1600, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes - 1280 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.44, !- Conductivity {W/m-K}
1280, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes - 1120 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.36, !- Conductivity {W/m-K}
1120, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes and cellular concretes - 960 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.3, !- Conductivity {W/m-K}
960, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes and cellular concretes - 640 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.2, !- Conductivity {W/m-K}
640, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Concrete: Foam concretes and cellular concretes - 320 kg/m³ - 102mm, !- Name
MediumRough, !- Roughness
0.102, !- Thickness {m}
0.12, !- Conductivity {W/m-K}
320, !- Density {kg/m³}
900, !- Specific Heat {J/kg-K}

Material,
Hardwood - 12.9mm, !- Name
MediumSmooth, !- Roughness
0.0129, !- Thickness {m}
0.167, !- Conductivity {W/m-K}
680, !- Density {kg/m³}
1630, !- Specific Heat {J/kg-K}

Material,
Hardwood - 19mm, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.167, !- Conductivity {W/m-K}
680, !- Density {kg/m³}

1630;	1- Specific Heat {J/kg-K}	496;	1- Density {kg/m3}
Material,		1630;	1- Specific Heat {J/kg-K}
Hardwood - 25mm,	1- Name	Material,	
MediumSmooth,	1- Roughness	Southern Pine - 25mm,	1- Name
0.025,	1- Thickness {m}	MediumSmooth,	1- Roughness
0.167,	1- Conductivity {W/m-K}	0.025,	1- Thickness {m}
680,	1- Density {kg/m3}	0.153,	1- Conductivity {W/m-K}
1630;	1- Specific Heat {J/kg-K}	615,	1- Density {kg/m3}
		1630;	1- Specific Heat {J/kg-K}
Material,		Material,	
Oak - 25mm,	1- Name	Douglas Fir-Larch - 25mm,	1- Name
MediumSmooth,	1- Roughness	MediumSmooth,	1- Roughness
0.025,	1- Thickness {m}	0.025,	1- Thickness {m}
0.17,	1- Conductivity {W/m-K}	0.141,	1- Conductivity {W/m-K}
704,	1- Density {kg/m3}	559,	1- Density {kg/m3}
1630;	1- Specific Heat {J/kg-K}	1630;	1- Specific Heat {J/kg-K}
Material,		Material,	
Birch - 25mm,	1- Name	Southern Cypress - 25mm,	1- Name
MediumSmooth,	1- Roughness	MediumSmooth,	1- Roughness
0.025,	1- Thickness {m}	0.025,	1- Thickness {m}
0.172,	1- Conductivity {W/m-K}	0.131,	1- Conductivity {W/m-K}
704,	1- Density {kg/m3}	508,	1- Density {kg/m3}
1630;	1- Specific Heat {J/kg-K}	1630;	1- Specific Heat {J/kg-K}
Material,		Material,	
Maple - 25mm,	1- Name	Hem-Fir - Spruce-Pine-Fir - 25mm,	1- Name
MediumSmooth,	1- Roughness	MediumSmooth,	1- Roughness
0.025,	1- Thickness {m}	0.025,	1- Thickness {m}
0.164,	1- Conductivity {W/m-K}	0.119,	1- Conductivity {W/m-K}
671,	1- Density {kg/m3}	447,	1- Density {kg/m3}
1630;	1- Specific Heat {J/kg-K}	1630;	1- Specific Heat {J/kg-K}
Material,		Material,	
Ash - 25mm,	1- Name	West Coast Woods - Cedars - 25mm,	1- Name
MediumSmooth,	1- Roughness	MediumSmooth,	1- Roughness
0.025,	1- Thickness {m}	0.025,	1- Thickness {m}
0.159,	1- Conductivity {W/m-K}	0.114,	1- Conductivity {W/m-K}
642,	1- Density {kg/m3}	425,	1- Density {kg/m3}
1630;	1- Specific Heat {J/kg-K}	1630;	1- Specific Heat {J/kg-K}
Material,		Material,	
Softwood - 12.9mm,	1- Name	California Redwood - 25mm,	1- Name
MediumSmooth,	1- Roughness	MediumSmooth,	1- Roughness
0.019,	1- Thickness {m}	0.025,	1- Thickness {m}
0.129,	1- Conductivity {W/m-K}	0.113,	1- Conductivity {W/m-K}
496,	1- Density {kg/m3}	420,	1- Density {kg/m3}
1630;	1- Specific Heat {J/kg-K}	1630;	1- Specific Heat {J/kg-K}
Material,		Material,	
Softwood - 19mm,	1- Name	Concrete Block: Limestone Aggregate: 200mm - 16.3 kg - 2 cores,	1- Name
MediumSmooth,	1- Roughness	MediumRough,	1- Roughness
0.019,	1- Thickness {m}	0.2,	1- Thickness {m}
0.129,	1- Conductivity {W/m-K}	1.13,	1- Conductivity {W/m-K}
496,	1- Density {kg/m3}	2210,	1- Density {kg/m3}
1630;	1- Specific Heat {J/kg-K}	920;	1- Specific Heat {J/kg-K}
Material,		Material,	
Softwood - 25mm,	1- Name	Concrete Block: Limestone Aggregate: 200mm - 16.3 kg - 2 cores - perlite filled	
MediumSmooth,	1- Roughness	cores,	1- Name
0.025,	1- Thickness {m}	MediumRough,	1- Roughness
0.129,	1- Conductivity {W/m-K}		
0.2,	1- Thickness {m}	Material,	
1.13,	1- Conductivity {W/m-K}	Concrete Block: Medium Mass Aggregate: 2 or 3 cores - perlite filled cores,	1- Name
2210,	1- Density {kg/m3}	MediumRough,	1- Roughness
920;	1- Specific Heat {J/kg-K}	0.3,	1- Thickness {m}
		1.13,	1- Conductivity {W/m-K}
Material,		1790,	1- Density {kg/m3}
Concrete Block: Limestone Aggregate: 300mm - 25 kg - 2 cores,	1- Name	920;	1- Specific Heat {J/kg-K}
MediumRough,	1- Roughness		
0.3,	1- Thickness {m}	Material,	
1.13,	1- Conductivity {W/m-K}	Concrete Block: Medium Mass Aggregate: 2 or 3 cores - vermiculite filled cores,	1- Name
2210,	1- Density {kg/m3}	MediumRough,	1- Roughness
920;	1- Specific Heat {J/kg-K}	0.3,	1- Thickness {m}
		1.13,	1- Conductivity {W/m-K}
Material,		1790,	1- Density {kg/m3}
Concrete Block: Limestone Aggregate: 300mm - 25 kg - 2 cores - perlite filled		920;	1- Specific Heat {J/kg-K}
cores,	1- Name		
MediumRough,	1- Roughness	Material,	
0.3,	1- Thickness {m}	Concrete Block: Medium Mass Aggregate: 2 or 3 cores - molded EPS (beads) filled	
1.13,	1- Conductivity {W/m-K}	cores,	1- Name
2210,	1- Density {kg/m3}	MediumRough,	1- Roughness
920;	1- Specific Heat {J/kg-K}	0.3,	1- Thickness {m}
		1.13,	1- Conductivity {W/m-K}
Material,		1790,	1- Density {kg/m3}
Concrete Block: Sand and Gravel Aggregate: 15-16 kg - 2 or 3 cores,	1- Name	920;	1- Specific Heat {J/kg-K}
MediumRough,	1- Roughness		
0.2,	1- Thickness {m}	Material,	
1.13,	1- Conductivity {W/m-K}	Concrete Block: Medium Mass Aggregate: 2 or 3 cores - molded EPS inserts in	
2180,	1- Density {kg/m3}	cores,	1- Name
920;	1- Specific Heat {J/kg-K}	MediumRough,	1- Roughness
		0.3,	1- Thickness {m}
Material,		1.13,	1- Conductivity {W/m-K}
Concrete Block: Sand and Gravel Aggregate: 15-16 kg - 2 or 3 cores - perlite filled		1790,	1- Density {kg/m3}
cores,	1- Name	920;	1- Specific Heat {J/kg-K}
MediumRough,	1- Roughness		
0.2,	1- Thickness {m}	Material,	
1.13,	1- Conductivity {W/m-K}	Concrete Block: Low Mass Aggregate: 7.3-7.7 kg - 2 or 3 cores,	1- Name
2180,	1- Density {kg/m3}	MediumRough,	1- Roughness
920;	1- Specific Heat {J/kg-K}	0.15,	1- Thickness {m}
		0.33,	1- Conductivity {W/m-K}
Material,		1390,	1- Density {kg/m3}
Concrete Block: Sand and Gravel Aggregate: 15-16 kg - 2 or 3 cores - vermiculite		880;	1- Specific Heat {J/kg-K}
filled cores,	1- Name		
MediumRough,			

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Concrete Block: Low Mass Aggregate: 8.6-10.0 kg, !- Name
MediumRough, !- Roughness
0.2, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1380, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 8.6-10.0 kg - perlite filled cores, !- Name
MediumRough, !- Roughness
0.2, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1380, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 8.6-10.0 kg - vermiculite filled cores, !- Name
MediumRough, !- Roughness
0.2, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1380, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 8.6-10.0 kg - molded EPS (beads) filled
cores, !- Name
MediumRough, !- Roughness
0.2, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1380, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 8.6-10.0 kg - UF foam filled cores, !- Name
MediumRough, !- Roughness
0.2, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1380, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 8.6-10.0 kg - molded EPS inserts in cores, !-
Name
MediumRough, !- Roughness
0.2, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1380, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 14.5-16.3 kg - 2 or 3 cores, !- Name
MediumRough, !- Roughness
0.3, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1440, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 14.5-16.3 kg - 2 or 3 cores - perlite filled
cores, !- Name
MediumRough, !- Roughness
0.3, !- Thickness {m}
0.33, !- Conductivity {W/m-K}

Rough, !- Roughness
0.0127, !- Thickness {m}
0.0245, !- Conductivity {W/m-K}
32, !- Density {kg/m3}
920, !- Specific Heat {J/kg-K}

Material,
1/2" Polyiso-Cellular polyisocyanuratej (CFC-11 exp.) (gasimpermeable facers), !-
Name
Rough, !- Roughness
0.0127, !- Thickness {m}
0.02, !- Conductivity {W/m-K}
32, !- Density {kg/m3}
920, !- Specific Heat {J/kg-K}

Material,
Composite 2x4 Wood Stud R11 #1, !- Name
Smooth, !- Roughness
0.019, !- Thickness {m}
0.186, !- Conductivity {W/m-K}
640.0, !- Density {kg/m3}
1048, !- Specific Heat {J/kg-K}
0.9, !- Thermal Absorptance
0.7, !- Solar Absorptance
0.7, !- Visible Absorptance

Material,
Composite 2x4 Wood Stud R11 #2, !- Name
Smooth, !- Roughness
0.083, !- Thickness {m}
0.049, !- Conductivity {W/m-K}
119.63, !- Density {kg/m3}
1048, !- Specific Heat {J/kg-K}
0.9, !- Thermal Absorptance
0.7, !- Solar Absorptance
0.7, !- Visible Absorptance

Material,
Composite 2x4 Wood Stud R11 #3, !- Name
Smooth, !- Roughness
0.025, !- Thickness {m}
0.124, !- Conductivity {W/m-K}
508.45, !- Density {kg/m3}
1048, !- Specific Heat {J/kg-K}
0.9, !- Thermal Absorptance
0.7, !- Solar Absorptance
0.7, !- Visible Absorptance

Material,
Asbestos-cement board - 12.7mm, !- Name
Smooth, !- Roughness
0.0127, !- Thickness {m}
0.58, !- Conductivity {W/m-K}
1900, !- Density {kg/m3}
1000, !- Specific Heat {J/kg-K}

!- ===== ALL OBJECTS IN CLASS: MATERIAL:NOMASS =====

Material:NoMass,
Vaporpermeable felt, !- Name
Rough, !- Roughness
0.011, !- Thermal Resistance {m2-K/W}

Concrete Block: Low Mass Aggregate: 8.6-10.0 kg, !- Name
MediumRough, !- Roughness
0.2, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1380, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
Concrete Block: Low Mass Aggregate: 8.6-10.3 kg - 2 or 3 cores - vermiculite filled
cores, !- Name
MediumRough, !- Roughness
0.3, !- Thickness {m}
0.33, !- Conductivity {W/m-K}
1440, !- Density {kg/m3}
880, !- Specific Heat {J/kg-K}

Material,
West Coast Woods - Cedars - 19 mm, !- Name
MediumSmooth, !- Roughness
0.019, !- Thickness {m}
0.114, !- Conductivity {W/m-K}
425, !- Density {kg/m3}
1630, !- Specific Heat {J/kg-K}

Material,
Composite 2x6 Wood Stud R19 #1, !- Name
Smooth, !- Roughness
0.019, !- Thickness {m}
0.137, !- Conductivity {W/m-K}
640.0, !- Density {kg/m3}
1006, !- Specific Heat {J/kg-K}
0.9, !- Thermal Absorptance
0.7, !- Solar Absorptance
0.7, !- Visible Absorptance

Material,
Composite 2x6 Wood Stud R19 #2, !- Name
Smooth, !- Roughness
0.133, !- Thickness {m}
0.047, !- Conductivity {W/m-K}
93.8, !- Density {kg/m3}
1006, !- Specific Heat {J/kg-K}
0.9, !- Thermal Absorptance
0.7, !- Solar Absorptance
0.7, !- Visible Absorptance

Material,
Composite 2x6 Wood Stud R19 #3, !- Name
Smooth, !- Roughness
0.025, !- Thickness {m}
0.246, !- Conductivity {W/m-K}
492.67, !- Density {kg/m3}
1006, !- Specific Heat {J/kg-K}
0.9, !- Thermal Absorptance
0.7, !- Solar Absorptance
0.7, !- Visible Absorptance

Material,
1/2" Polyiso-Cellular polyurethane/polyisocyanuratei (CFC11 exp.) (unfaced), !- Name
Rough, !- Roughness
0.0127, !- Thickness {m}
0.0245, !- Conductivity {W/m-K}
24, !- Density {kg/m3}
1590, !- Specific Heat {J/kg-K}

Material,
1/2" Polyiso-Cellular polyisocyanuratei (CFC-11 exp.) (gaspermeable facers), !- Name

Material:NoMass,
Vaporseal - 2 layers of mopped 0.73 kg/m2 felt, !- Name
Rough, !- Roughness
0.21, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Vaporseal - plastic film, !- Name
Rough, !- Roughness
0.002, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Carpet and fibrous pad, !- Name
Rough, !- Roughness
0.37, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Carpet and rubber pad, !- Name
Rough, !- Roughness
0.22, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Cork tile - 3.2mm, !- Name
MediumRough, !- Roughness
0.049, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Terrazzo - 25mm, !- Name
Rough, !- Roughness
0.014, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Tile: asphalt - linoleum - vinyl - rubber, !- Name
MediumSmooth, !- Roughness
0.009, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Tile: vinyl asbestos, !- Name
VeryRough, !- Roughness
0.009, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Wood - hardwood finish - 19mm, !- Name
MediumSmooth, !- Roughness
0.12, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Insulation: Mineral fiber - processed from rock - slag - or glass - 75-100mm 6.4-32
kg/m3, !- Name
Rough, !- Roughness
1.94, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Insulation: Mineral fiber - processed from rock - slag - or glass - 90mm -6.4-32 kg/
m3, !- Name
Rough, !- Roughness
2.29, !- Thermal Resistance {m2-K/W}

Material:NoMass,
Insulation: Mineral fiber - processed from rock - slag - or glass - 90mm - 19-26 kg/
m3, !- Name
Rough, !- Roughness
2.63, !- Thermal Resistance {m2-K/W}

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Material:NoMass, Insulation: Mineral fiber - processed from rock - slag - or glass - 140-165mm - 6.4-32 kg/m3, !- Name Rough, !- Roughness 3.32; !- Thermal Resistance {m2-K/W}	VeryRough, !- Roughness 2.3; !- Thermal Resistance {m2-K/W}
Material:NoMass, Insulation: Mineral fiber - processed from rock - slag - or glass - 140mm - 10-26 kg/m3, !- Name Rough, !- Roughness 3.67; !- Thermal Resistance {m2-K/W}	Material:NoMass, Asbestos-cement shingles, !- Name VeryRough, !- Roughness 0.037; !- Thermal Resistance {m2-K/W}
Material:NoMass, Insulation: Mineral fiber - processed from rock - slag - or glass - 150-190mm - 6.4-32 kg/m3, !- Name Rough, !- Roughness 3.91; !- Thermal Resistance {m2-K/W}	Material:NoMass, Asphalt roll roofing, !- Name VeryRough, !- Roughness 0.026; !- Thermal Resistance {m2-K/W}
Material:NoMass, Insulation: Mineral fiber - processed from rock - slag - or glass - 210-250mm - 6.4-32 kg/m3, !- Name Rough, !- Roughness 5.34; !- Thermal Resistance {m2-K/W}	Material:NoMass, Asphalt shingles, !- Name VeryRough, !- Roughness 0.077; !- Thermal Resistance {m2-K/W}
Material:NoMass, Insulation: Mineral fiber - processed from rock - slag - or glass - 250-330mm - 6.4-32 kg/m3, !- Name Rough, !- Roughness 6.77; !- Thermal Resistance {m2-K/W}	Material:NoMass, Built-up roofing - 10mm, !- Name VeryRough, !- Roughness 0.058; !- Thermal Resistance {m2-K/W}
Material:NoMass, Acoustical tile - 12.7mm, !- Name MediumSmooth, !- Roughness 0.22; !- Thermal Resistance {m2-K/W}	Material:NoMass, Slate - 13mm, !- Name VeryRough, !- Roughness 0.009; !- Thermal Resistance {m2-K/W}
Material:NoMass, Acoustical tile - 19mm, !- Name MediumSmooth, !- Roughness 0.33; !- Thermal Resistance {m2-K/W}	Material:NoMass, Wood shingles - plain and plastic film faced, !- Name VeryRough, !- Roughness 0.166; !- Thermal Resistance {m2-K/W}
Material:NoMass, Mineral fiber (rock - slag - glass) - 95-130mm, !- Name VeryRough, !- Roughness 1.94; !- Thermal Resistance {m2-K/W}	Material:NoMass, Cement Plaster: Sand aggregate - 10mm, !- Name Smooth, !- Roughness 0.013; !- Thermal Resistance {m2-K/W}
Material:NoMass, Mineral fiber (rock - slag - glass) - 170-220mm, !- Name VeryRough, !- Roughness 3.35; !- Thermal Resistance {m2-K/W}	Material:NoMass, Cement Plaster: Sand aggregate - 20mm, !- Name Smooth, !- Roughness 0.026; !- Thermal Resistance {m2-K/W}
Material:NoMass, Mineral fiber (rock - slag - glass) - 190-250mm, !- Name VeryRough, !- Roughness 3.87; !- Thermal Resistance {m2-K/W}	Material:NoMass, Gypsum plaster: Lightweight aggregate - 13mm, !- Name Smooth, !- Roughness 0.056; !- Thermal Resistance {m2-K/W}
Material:NoMass, Mineral fiber (rock - slag - glass) - 260-350mm, !- Name VeryRough, !- Roughness 5.28; !- Thermal Resistance {m2-K/W}	Material:NoMass, Gypsum plaster: Lightweight aggregate - 16mm, !- Name Smooth, !- Roughness 0.066; !- Thermal Resistance {m2-K/W}
Material:NoMass, Mineral fiber (rock - slag - glass) - 90mm (closed sidewall application), !- Name	Material:NoMass, Gypsum plaster: Lightweight aggregate on metal lath - 19mm, !- Name Smooth, !- Roughness 0.083; !- Thermal Resistance {m2-K/W}
	Material:NoMass, Perlite aggregate plaster: Sand aggregate - 13mm, !- Name Smooth, !- Roughness 0.016; !- Thermal Resistance {m2-K/W}
Material:NoMass, Perlite aggregate plaster: Sand aggregate - 16mm, !- Name Smooth, !- Roughness 0.019; !- Thermal Resistance {m2-K/W}	0.15; !- Thermal Resistance {m2-K/W}
Material:NoMass, Perlite aggregate plaster: Sand aggregate on metal lath - 19mm, !- Name Smooth, !- Roughness 0.023; !- Thermal Resistance {m2-K/W}	Material:NoMass, Shingles: Wood -double 400mm - 300-mm exposure, !- Name MediumRough, !- Roughness 0.21; !- Thermal Resistance {m2-K/W}
Material:NoMass, Clay tile - hollow - 1 cell deep - 75mm, !- Name MediumSmooth, !- Roughness 0.14; !- Thermal Resistance {m2-K/W}	Material:NoMass, Shingles: Wood - plus insul. backer board, !- Name MediumRough, !- Roughness 0.25; !- Thermal Resistance {m2-K/W}
Material:NoMass, Clay tile - hollow - 1 cell deep - 100mm, !- Name MediumSmooth, !- Roughness 0.2; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Asbestos-cement 6.4mm, !- Name VeryRough, !- Roughness 0.037; !- Thermal Resistance {m2-K/W}
Material:NoMass, Clay tile - hollow - 2 cells deep - 150mm, !- Name MediumSmooth, !- Roughness 0.27; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Asphalt roll, !- Name VeryRough, !- Roughness 0.026; !- Thermal Resistance {m2-K/W}
Material:NoMass, Clay tile - hollow - 2 cells deep - 200mm, !- Name MediumSmooth, !- Roughness 0.33; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Asphalt insulating, !- Name VeryRough, !- Roughness 0.26; !- Thermal Resistance {m2-K/W}
Material:NoMass, Clay tile - hollow - 2 cells deep - 250mm, !- Name MediumSmooth, !- Roughness 0.39; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Hardboard 11mm, !- Name MediumSmooth, !- Roughness 0.12; !- Thermal Resistance {m2-K/W}
Material:NoMass, Clay tile - hollow - 3 cells deep - 300mm, !- Name MediumSmooth, !- Roughness 0.44; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Wood - drop 20 by 200mm, !- Name Rough, !- Roughness 0.14; !- Thermal Resistance {m2-K/W}
Material:NoMass, Gypsum partition tile 75 by 300 by 760mm - solid, !- Name MediumRough, !- Roughness 0.222; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Wood - bevel 13 by 200mm - lapped, !- Name Rough, !- Roughness 0.14; !- Thermal Resistance {m2-K/W}
Material:NoMass, Gypsum partition tile 75 by 300 by 760mm - 4 cells, !- Name MediumRough, !- Roughness 0.238; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Wood - bevel 19 by 250mm - lapped, !- Name Rough, !- Roughness 0.18; !- Thermal Resistance {m2-K/W}
Material:NoMass, Gypsum partition tile 100 by 300 by 760mm - 3 cells, !- Name MediumRough, !- Roughness 0.294; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Wood - plywood 9.5mm - lapped, !- Name Rough, !- Roughness 0.1; !- Thermal Resistance {m2-K/W}
Material:NoMass, Shingles: Asbestos-cement, !- Name VeryRough, !- Roughness 0.037; !- Thermal Resistance {m2-K/W}	Material:NoMass, Siding: Hollow-backed, !- Name Smooth, !- Roughness 0.11; !- Thermal Resistance {m2-K/W}
Material:NoMass, Shingles: Wood 400mm - 190-mm exposure, !- Name MediumRough, !- Roughness	Material:NoMass, Siding: Insulating-board backed 9.5mm nominal, !- Name Smooth, !- Roughness 0.32; !- Thermal Resistance {m2-K/W}
	Material:NoMass,

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Siding: Insulating-board backed 9.5mm nominal foil backed, !- Name  
Smooth, !- Roughness  
0.52; !- Thermal Resistance {m2-K/W}  
  
Material:NoMass,  
Siding: Architectural (soda-lime float) glass, !- Name  
Smooth, !- Roughness  
0.018; !- Thermal Resistance {m2-K/W}  
  
Material:NoMass,  
Cellulosic Insulation, !- Name  
VeryRough, !- Roughness  
6.18, !- Thermal Resistance {m2-K/W}  
0.9, !- Thermal Absorptance  
0, !- Solar Absorptance  
0.7; !- Visible Absorptance  
  
!- ===== ALL OBJECTS IN CLASS: MATERIAL:AIRGAP =====  
  
Material:AirGap,  
F04 Wall air space resistance, !- Name  
0.15; !- Thermal Resistance {m2-K/W}  
  
Material:AirGap,  
F05 Ceiling air space resistance, !- Name  
0.18; !- Thermal Resistance {m2-K/W}  
  
!- ===== ALL OBJECTS IN CLASS: WINDOWMATERIAL:GLAZING =====  
  
WindowMaterial:Glazing,  
CLEAR 2.5MM, !- Name  
SpectralAverage, !- Optical Data Type  
, !- Window Glass Spectral Data Set Name  
, !- Thickness {m}  
0.0025, !- Solar Transmittance at Normal Incidence  
0.850, !- Front Side Solar Reflectance at Normal Incidence  
0.075, !- Back Side Solar Reflectance at Normal Incidence  
0.901, !- Visible Transmittance at Normal Incidence  
0.081, !- Front Side Visible Reflectance at Normal Incidence  
0.081, !- Back Side Visible Reflectance at Normal Incidence  
0.0, !- Infrared Transmittance at Normal Incidence  
0.84, !- Front Side Infrared Hemispherical Emissivity  
0.84, !- Back Side Infrared Hemispherical Emissivity  
0.9; !- Conductivity {W/m-K}  
  
WindowMaterial:Glazing,  
CLEAR 3MM, !- Name  
SpectralAverage, !- Optical Data Type  
, !- Window Glass Spectral Data Set Name  
, !- Thickness {m}  
0.003, !- Solar Transmittance at Normal Incidence  
0.837, !- Front Side Solar Reflectance at Normal Incidence  
0.075, !- Back Side Solar Reflectance at Normal Incidence  
0.901, !- Visible Transmittance at Normal Incidence  
0.081, !- Front Side Visible Reflectance at Normal Incidence  
0.081, !- Back Side Visible Reflectance at Normal Incidence  
0.0, !- Infrared Transmittance at Normal Incidence  
0.84, !- Front Side Infrared Hemispherical Emissivity  
0.84, !- Back Side Infrared Hemispherical Emissivity  
0.9; !- Conductivity {W/m-K}  
  
WindowMaterial:Glazing,  
BRONZE 10MM, !- Name  
SpectralAverage, !- Optical Data Type  
, !- Window Glass Spectral Data Set Name  
, !- Thickness {m}  
0.010, !- Solar Transmittance at Normal Incidence  
0.326, !- Front Side Solar Reflectance at Normal Incidence  
0.048, !- Back Side Solar Reflectance at Normal Incidence  
0.048, !- Visible Transmittance at Normal Incidence  
0.379, !- Front Side Visible Reflectance at Normal Incidence  
0.050, !- Back Side Visible Reflectance at Normal Incidence  
0.050, !- Infrared Transmittance at Normal Incidence  
0.84, !- Front Side Infrared Hemispherical Emissivity  
0.84, !- Back Side Infrared Hemispherical Emissivity  
0.9; !- Conductivity {W/m-K}  
  
WindowMaterial:Glazing,  
GREY 3MM, !- Name  
SpectralAverage, !- Optical Data Type  
, !- Window Glass Spectral Data Set Name  
, !- Thickness {m}  
0.003, !- Solar Transmittance at Normal Incidence  
0.626, !- Front Side Solar Reflectance at Normal Incidence  
0.061, !- Back Side Solar Reflectance at Normal Incidence  
0.061, !- Visible Transmittance at Normal Incidence  
0.061, !- Front Side Visible Reflectance at Normal Incidence  
0.061, !- Back Side Visible Reflectance at Normal Incidence  
0.0, !- Infrared Transmittance at Normal Incidence  
0.84, !- Front Side Infrared Hemispherical Emissivity  
0.84, !- Back Side Infrared Hemispherical Emissivity  
0.9; !- Conductivity {W/m-K}  
  
WindowMaterial:Glazing,  
GREY 6MM, !- Name  
SpectralAverage, !- Optical Data Type  
, !- Window Glass Spectral Data Set Name  
, !- Thickness {m}  
0.006, !- Solar Transmittance at Normal Incidence  
0.455, !- Front Side Solar Reflectance at Normal Incidence  
0.053, !- Back Side Solar Reflectance at Normal Incidence  
0.053, !- Visible Transmittance at Normal Incidence  
0.431, !- Front Side Visible Reflectance at Normal Incidence  
0.052, !- Back Side Visible Reflectance at Normal Incidence  
0.052, !- Infrared Transmittance at Normal Incidence  
0.84, !- Front Side Infrared Hemispherical Emissivity  
0.84, !- Back Side Infrared Hemispherical Emissivity  
0.9; !- Conductivity {W/m-K}  
  
WindowMaterial:Glazing,  
GREY 12MM, !- Name  
SpectralAverage, !- Optical Data Type  
, !- Window Glass Spectral Data Set Name  
, !- Thickness {m}  
0.012, !- Solar Transmittance at Normal Incidence  
0.217, !- Front Side Solar Reflectance at Normal Incidence  
0.044, !- Back Side Solar Reflectance at Normal Incidence  
0.044, !- Visible Transmittance at Normal Incidence  
0.187, !- Front Side Visible Reflectance at Normal Incidence  
0.045, !- Back Side Visible Reflectance at Normal Incidence  
0.045, !- Infrared Transmittance at Normal Incidence  
0.84, !- Front Side Infrared Hemispherical Emissivity  
0.84, !- Back Side Infrared Hemispherical Emissivity  
0.9; !- Conductivity {W/m-K}
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[illegible]

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WindowMaterial:Glazing,
    LoE CLEAR 6MM,
    SpectralAverage,
    0.006,
    0.600,
    !- Name
    !- Optical Data Type
    !- Window Glass Spectral Data Set Name
    !- Thickness [m]
    !- Solar Transmittance at Normal Incidence
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WindowMaterial:Glazing,
LoE SPEC SEL CLEAR 6MM,  !- Name
SpectralAverage,          !- Optical Data Type
                           !- Window Glass Spectral Data Set Name
0.006,                   !- Thickness {m}
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0.430,	!- Solar Transmittance at Normal Incidence	0.00051,	!- Thickness {m}
0.300,	!- Solar Transmittance at Normal Incidence	0.504,	!- Solar Transmittance at Normal Incidence
0.420,	!- Back Side Solar Reflectance at Normal Incidence	0.402,	!- Front Side Solar Reflectance at Normal Incidence
0.770,	!- Visible Transmittance at Normal Incidence	0.398,	!- Back Side Solar Reflectance at Normal Incidence
0.070,	!- Front Side Visible Reflectance at Normal Incidence	0.766,	!- Visible Transmittance at Normal Incidence
0.060,	!- Back Side Visible Reflectance at Normal Incidence	0.147,	!- Front Side Visible Reflectance at Normal Incidence
0.84,	!- Infrared Transmittance at Normal Incidence	0.167,	!- Back Side Visible Reflectance at Normal Incidence
0.03,	!- Front Side Infrared Hemispherical Emissivity	0.0,	!- Infrared Transmittance at Normal Incidence
0.84,	!- Back Side Infrared Hemispherical Emissivity	0.075,	!- Front Side Infrared Hemispherical Emissivity
0.9;	!- Conductivity {W/m-K}	0.720,	!- Back Side Infrared Hemispherical Emissivity
		0.14;	!- Conductivity {W/m-K}

WindowMaterial:Glazing,	!- Name	WindowMaterial:Glazing,	!- Name
LoE SPEC SEL CLEAR 6MM Rev,	!- Optical Data Type	COATED POLY-66,	!- Optical Data Type
SpectralAverage,	!- Window Glass Spectral Data Set Name	SpectralAverage,	!- Window Glass Spectral Data Set Name
0.006,	!- Thickness {m}	0.00051,	!- Thickness {m}
0.430,	!- Solar Transmittance at Normal Incidence	0.403,	!- Solar Transmittance at Normal Incidence
0.420,	!- Front Side Solar Reflectance at Normal Incidence	0.514,	!- Front Side Solar Reflectance at Normal Incidence
0.300,	!- Back Side Solar Reflectance at Normal Incidence	0.515,	!- Back Side Solar Reflectance at Normal Incidence
0.770,	!- Visible Transmittance at Normal Incidence	0.658,	!- Visible Transmittance at Normal Incidence
0.060,	!- Front Side Visible Reflectance at Normal Incidence	0.256,	!- Front Side Visible Reflectance at Normal Incidence
0.070,	!- Back Side Visible Reflectance at Normal Incidence	0.436,	!- Back Side Visible Reflectance at Normal Incidence
0.84,	!- Infrared Transmittance at Normal Incidence	0.0,	!- Infrared Transmittance at Normal Incidence
0.03,	!- Front Side Infrared Hemispherical Emissivity	0.087,	!- Front Side Infrared Hemispherical Emissivity
0.84,	!- Back Side Infrared Hemispherical Emissivity	0.720,	!- Back Side Infrared Hemispherical Emissivity
0.9;	!- Conductivity {W/m-K}	0.14;	!- Conductivity {W/m-K}

WindowMaterial:Glazing,	!- Name	WindowMaterial:Glazing,	!- Name
LoE SPEC SEL TINT 6MM,	!- Optical Data Type	COATED POLY-55,	!- Optical Data Type
SpectralAverage,	!- Window Glass Spectral Data Set Name	SpectralAverage,	!- Window Glass Spectral Data Set Name
0.006,	!- Thickness {m}	0.00051,	!- Thickness {m}
0.260,	!- Solar Transmittance at Normal Incidence	0.320,	!- Solar Transmittance at Normal Incidence
0.140,	!- Front Side Solar Reflectance at Normal Incidence	0.582,	!- Front Side Solar Reflectance at Normal Incidence
0.410,	!- Back Side Solar Reflectance at Normal Incidence	0.593,	!- Back Side Solar Reflectance at Normal Incidence
0.460,	!- Visible Transmittance at Normal Incidence	0.551,	!- Visible Transmittance at Normal Incidence
0.060,	!- Front Side Visible Reflectance at Normal Incidence	0.436,	!- Front Side Visible Reflectance at Normal Incidence
0.040,	!- Back Side Visible Reflectance at Normal Incidence	0.375,	!- Back Side Visible Reflectance at Normal Incidence
0.0,	!- Infrared Transmittance at Normal Incidence	0.0,	!- Infrared Transmittance at Normal Incidence
0.84,	!- Front Side Infrared Hemispherical Emissivity	0.046,	!- Front Side Infrared Hemispherical Emissivity
0.03,	!- Back Side Infrared Hemispherical Emissivity	0.720,	!- Back Side Infrared Hemispherical Emissivity
0.9;	!- Conductivity {W/m-K}	0.14;	!- Conductivity {W/m-K}

WindowMaterial:Glazing,	!- Name	WindowMaterial:Glazing,	!- Name
16mm Polycarb,	!- Optical Data Type	COATED POLY-44,	!- Optical Data Type
SpectralAverage,	!- Window Glass Spectral Data Set Name	SpectralAverage,	!- Window Glass Spectral Data Set Name
0.016,	!- Thickness {m}	0.00051,	!- Thickness {m}
0.656,	!- Solar Transmittance at Normal Incidence	0.245,	!- Solar Transmittance at Normal Incidence
0.249,	!- Front Side Solar Reflectance at Normal Incidence	0.626,	!- Front Side Solar Reflectance at Normal Incidence
0.227,	!- Back Side Solar Reflectance at Normal Incidence	0.641,	!- Back Side Solar Reflectance at Normal Incidence
0.868,	!- Visible Transmittance at Normal Incidence	0.436,	!- Visible Transmittance at Normal Incidence
0.064,	!- Front Side Visible Reflectance at Normal Incidence	0.397,	!- Front Side Visible Reflectance at Normal Incidence
0.060,	!- Back Side Visible Reflectance at Normal Incidence	0.453,	!- Back Side Visible Reflectance at Normal Incidence
0.0,	!- Infrared Transmittance at Normal Incidence	0.0,	!- Infrared Transmittance at Normal Incidence
0.136,	!- Front Side Infrared Hemispherical Emissivity	0.037,	!- Front Side Infrared Hemispherical Emissivity
0.720,	!- Back Side Infrared Hemispherical Emissivity	0.720,	!- Back Side Infrared Hemispherical Emissivity
0.14;	!- Conductivity {W/m-K}	0.14;	!- Conductivity {W/m-K}

WindowMaterial:Glazing,	!- Name	WindowMaterial:Glazing,	!- Name
COATED POLY-77,	!- Optical Data Type	COATED POLY-33,	!- Optical Data Type
SpectralAverage,	!- Window Glass Spectral Data Set Name	SpectralAverage,	!- Window Glass Spectral Data Set Name
0.00051,	!- Thickness {m}	0.006,	!- Thickness {m}
0.178,	!- Solar Transmittance at Normal Incidence	0.099,	!- Solar Transmittance at Normal Incidence
0.739,	!- Front Side Solar Reflectance at Normal Incidence	0.219,	!- Front Side Solar Reflectance at Normal Incidence
0.738,	!- Back Side Solar Reflectance at Normal Incidence	0.219,	!- Back Side Solar Reflectance at Normal Incidence
0.330,	!- Visible Transmittance at Normal Incidence	0.155,	!- Visible Transmittance at Normal Incidence
0.566,	!- Front Side Visible Reflectance at Normal Incidence	0.073,	!- Front Side Visible Reflectance at Normal Incidence
0.591,	!- Back Side Visible Reflectance at Normal Incidence	0.073,	!- Back Side Visible Reflectance at Normal Incidence
0.0,	!- Infrared Transmittance at Normal Incidence	0.0,	!- Infrared Transmittance at Normal Incidence
0.035,	!- Front Side Infrared Hemispherical Emissivity	0.84,	!- Front Side Infrared Hemispherical Emissivity
0.720,	!- Back Side Infrared Hemispherical Emissivity	0.84,	!- Back Side Infrared Hemispherical Emissivity
0.14;	!- Conductivity {W/m-K}	0.9;	!- Conductivity {W/m-K}

WindowMaterial:Glazing,	!- Name	WindowMaterial:Glazing,	!- Name
ECABS-1 BLEACHED 6MM,	!- Optical Data Type	ECABS-2 BLEACHED 6MM,	!- Optical Data Type
SpectralAverage,	!- Window Glass Spectral Data Set Name	SpectralAverage,	!- Window Glass Spectral Data Set Name
0.006,	!- Thickness {m}	0.006,	!- Thickness {m}
0.814,	!- Solar Transmittance at Normal Incidence	0.814,	!- Solar Transmittance at Normal Incidence
0.086,	!- Front Side Solar Reflectance at Normal Incidence	0.086,	!- Front Side Solar Reflectance at Normal Incidence
0.086,	!- Back Side Solar Reflectance at Normal Incidence	0.086,	!- Back Side Solar Reflectance at Normal Incidence
0.847,	!		

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ECREF-2 COLORED 6MM,    !- Name
SpectralAverage,        !- Optical Data Type
,                        !- Window Glass Spectral Data Set Name
0.006,                  !- Thickness {m}
0.099,                  !- Solar Transmittance at Normal Incidence
0.219,                  !- Front Side Solar Reflectance at Normal Incidence
0.219,                  !- Back Side Solar Reflectance at Normal Incidence
0.155,                  !- Visible Transmittance at Normal Incidence
0.073,                  !- Front Side Visible Reflectance at Normal Incidence
0.073,                  !- Back Side Visible Reflectance at Normal Incidence
0.0,                    !- Infrared Transmittance at Normal Incidence
0.84,                  !- Front Side Infrared Hemispherical Emissivity
0.10,                  !- Back Side Infrared Hemispherical Emissivity
0.9;                    !- Conductivity {W/m-K}

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!- ===== ALL OBJECTS IN CLASS: WINDOWMATERIAL:GAS =====

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WindowMaterial:Gas,
AIR 3MM,                !- Name
Air,                    !- Gas Type
0.0032;                 !- Thickness {m}

WindowMaterial:Gas,
AIR 6MM,                !- Name
Air,                    !- Gas Type
0.0063;                 !- Thickness {m}

WindowMaterial:Gas,
AIR 8MM,                !- Name
Air,                    !- Gas Type
0.0079;                 !- Thickness {m}

WindowMaterial:Gas,
AIR 13MM,               !- Name
Air,                    !- Gas Type
0.0127;                 !- Thickness {m}

WindowMaterial:Gas,
ARGON 3MM,              !- Name
Argon,                  !- Gas Type
0.0032;                 !- Thickness {m}

WindowMaterial:Gas,
ARGON 6MM,              !- Name
Argon,                  !- Gas Type
0.0063;                 !- Thickness {m}

WindowMaterial:Gas,
ARGON 8MM,              !- Name
Argon,                  !- Gas Type
0.0079;                 !- Thickness {m}

WindowMaterial:Gas,
ARGON 13MM,             !- Name
Argon,                  !- Gas Type
0.0127;                 !- Thickness {m}

WindowMaterial:Gas,
KRYPTON 3MM,            !- Name
Krypton,                !- Gas Type
0.0032;                 !- Thickness {m}

```

```

2" Polyiso-Cellular polyisocyanuratej (CFC-11 exp.) (gasimpermeable facers), !-
Layer 4
Sheathing - regular density - 12.7mm, !- Layer 5
Composite 2x6 Wood Stud R19 #3, !- Layer 6
Composite 2x6 Wood Stud R19 #2, !- Layer 7
Composite 2x6 Wood Stud R19 #1, !- Layer 8
Vaporseal - plastic film,!- Layer 9
G01 16mm gypsum board; !- Layer 10

Construction,
Drop Ceiling,          !- Name
F16 Acoustic tile;     !- Outside Layer

Construction,
Curio Roof,           !- Name
F13 Built-up roofing,  !- Outside Layer
2" Polyiso-Cellular polyisocyanuratej (CFC-11 exp.) (gasimpermeable facers), !-
Layer 2
Sheathing - regular density - 19.8mm, !- Layer 3
Cellulosic Insulation; !- Layer 4

Construction,
Curio Floor,          !- Name
Cellulosic Insulation, !- Outside Layer
Wood subfloor - 19mm;  !- Layer 2

Construction,
Curio Window,         !- Name
CLEAR 3MM,             !- Outside Layer
ARGON 13MM,            !- Layer 2
CLEAR 3MM,             !- Layer 3
AIR 13MM,              !- Layer 4
LoE CLEAR 3MM Rev;     !- Layer 5

Construction,
Void,                  !- Name
G06 50mm wood;         !- Outside Layer

Construction,
Curio West Door,      !- Name
G04 13mm wood,         !- Outside Layer
I02 50mm insulation board, !- Layer 2
G04 13mm wood;         !- Layer 3

Construction,
Wall-2,                !- Name
West Coast Woods - Cedars - 19 mm, !- Outside Layer
Vaporseal - plastic film,!- Layer 2
Sheathing - regular density - 12.7mm, !- Layer 3
1/2" Polyiso-Cellular polyisocyanuratej (CFC-11 exp.) (gasimpermeable facers), !-
Layer 4
Sheathing - regular density - 12.7mm, !- Layer 5
Composite 2x4 Wood Stud R11 #3, !- Layer 6
Composite 2x4 Wood Stud R11 #2, !- Layer 7
Composite 2x4 Wood Stud R11 #1, !- Layer 8
Vaporseal - plastic film,!- Layer 9
G01 16mm gypsum board; !- Layer 10

Construction,
Wall-3,                !- Name
West Coast Woods - Cedars - 19 mm, !- Outside Layer
Vaporseal - plastic film,!- Layer 2
Sheathing - regular density - 12.7mm, !- Layer 3

```

```

WindowMaterial:Gas,
KRYPTON 6MM,           !- Name
Krypton,               !- Gas Type
0.0063;                !- Thickness {m}

WindowMaterial:Gas,
KRYPTON 8MM,           !- Name
Krypton,               !- Gas Type
0.0079;                !- Thickness {m}

WindowMaterial:Gas,
KRYPTON 13MM,          !- Name
Krypton,               !- Gas Type
0.0127;                !- Thickness {m}

WindowMaterial:Gas,
XENON 3MM,              !- Name
Xenon,                 !- Gas Type
0.0032;                !- Thickness {m}

WindowMaterial:Gas,
XENON 6MM,              !- Name
Xenon,                 !- Gas Type
0.0063;                !- Thickness {m}

WindowMaterial:Gas,
XENON 8MM,              !- Name
Xenon,                 !- Gas Type
0.0079;                !- Thickness {m}

WindowMaterial:Gas,
XENON 13MM,            !- Name
Xenon,                 !- Gas Type
0.0127;                !- Thickness {m}

```

!- ===== ALL OBJECTS IN CLASS: WINDOWMATERIAL:SHADE =====

```

WindowMaterial:Shade,
HIGH REFLECT - LOW TRANS SHADE, !- Name
0.1,                          !- Solar Transmittance
0.8,                          !- Solar Reflectance
0.1,                          !- Visible Transmittance
0.8,                          !- Visible Reflectance
0.9,                          !- Thermal Hemispherical Emissivity
0.0,                          !- Thermal Transmittance
0.005,                        !- Thickness {m}
0.1,                          !- Conductivity {W/m-K}
0.05,                         !- Shade to Glass Distance {m}
0.5,                          !- Top Opening Multiplier
0.5,                          !- Bottom Opening Multiplier
0.5,                          !- Left-Side Opening Multiplier
0.5,                          !- Right-Side Opening Multiplier
0.0;                          !- Airflow Permeability

```

!- ===== ALL OBJECTS IN CLASS: CONSTRUCTION =====

```

Construction,
Wall-1,                !- Name
West Coast Woods - Cedars - 19 mm, !- Outside Layer
Vaporseal - plastic film,!- Layer 2
Sheathing - regular density - 12.7mm, !- Layer 3

```

```

2" Polyiso-Cellular polyisocyanuratej (CFC-11 exp.) (gasimpermeable facers), !-
Layer 4
Sheathing - regular density - 12.7mm, !- Layer 5
Composite 2x6 Wood Stud R19 #3, !- Layer 6
Composite 2x6 Wood Stud R19 #2, !- Layer 7
Composite 2x6 Wood Stud R19 #1, !- Layer 8
Vaporseal - plastic film,!- Layer 9
Asbestos-cement board - 12.7mm; !- Layer 10

```

```

Construction,
Wall-4,                !- Name
Sheathing - regular density - 19.8mm, !- Outside Layer
Vaporseal - plastic film,!- Layer 2
Sheathing - regular density - 12.7mm, !- Layer 3
2" Polyiso-Cellular polyisocyanuratej (CFC-11 exp.) (gasimpermeable facers), !-
Layer 4
Sheathing - regular density - 12.7mm, !- Layer 5
Composite 2x6 Wood Stud R19 #3, !- Layer 6
Composite 2x6 Wood Stud R19 #2, !- Layer 7
Composite 2x6 Wood Stud R19 #1, !- Layer 8
Vaporseal - plastic film,!- Layer 9
G01 16mm gypsum board; !- Layer 10

```

```

Construction,
Wall-5,                !- Name
G01 16mm gypsum board, !- Outside Layer
F04 Wall air space resistance, !- Layer 2
Asbestos-cement board - 12.7mm, !- Layer 3
Tile: asphalt - linoleum - vinyl - rubber; !- Layer 4

```

```

Construction,
Wall-6,                !- Name
G01 16mm gypsum board, !- Outside Layer
F04 Wall air space resistance, !- Layer 2
G01 16mm gypsum board; !- Layer 3

```

```

Construction,
Wall-6A,               !- Name
G01 16mm gypsum board, !- Outside Layer
F04 Wall air space resistance, !- Layer 2
G01 16mm gypsum board; !- Layer 3

```

```

Construction,
Curio Window Interior Shade, !- Name
CLEAR 3MM,               !- Outside Layer
ARGON 13MM,              !- Layer 2
CLEAR 3MM,               !- Layer 3
AIR 13MM,                !- Layer 4
LoE CLEAR 3MM Rev,       !- Layer 5
HIGH REFLECT - LOW TRANS SHADE; !- Layer 6

```

```

Construction,
Curio Window Exterior Shade, !- Name
HIGH REFLECT - LOW TRANS SHADE, !- Outside Layer
CLEAR 3MM,               !- Layer 2
ARGON 13MM,              !- Layer 3
CLEAR 3MM,               !- Layer 4
AIR 13MM,                !- Layer 5
LoE CLEAR 3MM Rev;       !- Layer 6

```

!- ===== ALL OBJECTS IN CLASS: CONSTRUCTION:INTERNALSOURCE =====


```

Construction:InternalSource, 0.0, !- Z Origin {m}
Radiant Floor Construction, !- Name
3, !- Source Present After Layer Number
3, !- Temperature Calculation Requested After Layer Number
1, !- Dimensions for the CTF Calculation
0.3, !- Tube Spacing {m}
Cellulosic Insulation, !- Outside Layer
Wood subfloor - 19mm, !- Layer 2
F08 Metal surface, !- Layer 3
Softwood - 12.9mm; !- Layer 4

!- ===== ALL OBJECTS IN CLASS: GLOBALGEOMETRYRULES =====

GlobalGeometryRules,
UpperLeftCorner, !- Starting Vertex Position
Counterclockwise, !- Vertex Entry Direction
Absolute; !- Coordinate System

!- ===== ALL OBJECTS IN CLASS: ZONE =====

Zone,
Mechanical, !- Name
0.0, !- Direction of Relative North {deg}
-0.551397, !- X Origin {m}
-0.552885, !- Y Origin {m}
0.0, !- Z Origin {m}
1, !- Type
1; !- Multiplier

Zone,
Bath-Hall, !- Name
0.0, !- Direction of Relative North {deg}
3.34363, !- X Origin {m}
4.047221, !- Y Origin {m}
0.0, !- Z Origin {m}
1, !- Type
1; !- Multiplier

Zone,
Living-Kitchen, !- Name
0.0, !- Direction of Relative North {deg}
10.6315, !- X Origin {m}
-2.168479, !- Y Origin {m}
0.0, !- Z Origin {m}
1, !- Type
1; !- Multiplier

Zone,
Mechanical-Plenum, !- Name
0.0, !- Direction of Relative North {deg}
-8.572985, !- X Origin {m}
-2.558507, !- Y Origin {m}
0.0, !- Z Origin {m}
1, !- Type
1; !- Multiplier

Zone,
BathPlenum, !- Name
0.0, !- Direction of Relative North {deg}
-3.732118, !- X Origin {m}
4.968616, !- Y Origin {m}

3.131988, !- Vertex 3 X-coordinate {m}
-2.021550, !- Vertex 3 Y-coordinate {m}
0.381000, !- Vertex 3 Z-coordinate {m}
3.131988, !- Vertex 4 X-coordinate {m}
-2.021550, !- Vertex 4 Y-coordinate {m}
2.819400, !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
MechRoomWestWall, !- Name
Wall, !- Surface Type
Wall-2, !- Construction Name
Mechanical, !- Zone Name
Outdoors, !- Outside Boundary Condition
!- Outside Boundary Condition Object
SunExposed, !- Sun Exposure
WindExposed, !- Wind Exposure
1, !- View Factor to Ground
4, !- Number of Vertices
0.506263, !- Vertex 1 X-coordinate {m}
-1.431000, !- Vertex 1 Y-coordinate {m}
2.819400, !- Vertex 1 Z-coordinate {m}
0.506263, !- Vertex 2 X-coordinate {m}
-1.431000, !- Vertex 2 Y-coordinate {m}
0.381000, !- Vertex 2 Z-coordinate {m}
0.506263, !- Vertex 3 X-coordinate {m}
-2.631150, !- Vertex 3 Y-coordinate {m}
0.381000, !- Vertex 3 Z-coordinate {m}
0.506263, !- Vertex 4 X-coordinate {m}
-2.631150, !- Vertex 4 Y-coordinate {m}
2.819400, !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
MechEastExtWall, !- Name
Wall, !- Surface Type
Wall-2, !- Construction Name
Mechanical, !- Zone Name
Outdoors, !- Outside Boundary Condition
!- Outside Boundary Condition Object
SunExposed, !- Sun Exposure
WindExposed, !- Wind Exposure
1, !- View Factor to Ground
4, !- Number of Vertices
4.046388, !- Vertex 1 X-coordinate {m}
-2.631150, !- Vertex 1 Y-coordinate {m}
2.819400, !- Vertex 1 Z-coordinate {m}
4.046388, !- Vertex 2 X-coordinate {m}
-2.631150, !- Vertex 2 Y-coordinate {m}
0.381000, !- Vertex 2 Z-coordinate {m}
4.046388, !- Vertex 3 X-coordinate {m}
-2.021550, !- Vertex 3 Y-coordinate {m}
0.381000, !- Vertex 3 Z-coordinate {m}
4.046388, !- Vertex 4 X-coordinate {m}
-2.021550, !- Vertex 4 Y-coordinate {m}
2.819400, !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
MechRoomSouthWall, !- Name
Wall, !- Surface Type
Wall-2, !- Construction Name
Mechanical, !- Zone Name
Outdoors, !- Outside Boundary Condition
!- Outside Boundary Condition Object
SunExposed, !- Sun Exposure

Zone,
LivingPlenum, !- Name
0.0, !- Direction of Relative North {deg}
9.36196, !- X Origin {m}
-5.369855, !- Y Origin {m}
0.0, !- Z Origin {m}
1, !- Type
1; !- Multiplier

!- ===== ALL OBJECTS IN CLASS: BUILDINGSURFACE:DETAILED =====

BuildingSurface:Detailed,
MechFloor, !- Name
Floor, !- Surface Type
Curio Floor, !- Construction Name
Mechanical, !- Zone Name
Outdoors, !- Outside Boundary Condition
!- Outside Boundary Condition Object
SunExposed, !- Sun Exposure
WindExposed, !- Wind Exposure
1, !- View Factor to Ground
6, !- Number of Vertices
4.046388, !- Vertex 1 X-coordinate {m}
-2.631150, !- Vertex 1 Y-coordinate {m}
0.381000, !- Vertex 1 Z-coordinate {m}
0.506263, !- Vertex 2 X-coordinate {m}
-2.631150, !- Vertex 2 Y-coordinate {m}
0.381000, !- Vertex 2 Z-coordinate {m}
0.506263, !- Vertex 3 X-coordinate {m}
-1.431000, !- Vertex 3 Y-coordinate {m}
0.381000, !- Vertex 3 Z-coordinate {m}
3.131988, !- Vertex 4 X-coordinate {m}
-1.431000, !- Vertex 4 Y-coordinate {m}
0.381000, !- Vertex 4 Z-coordinate {m}
3.131988, !- Vertex 5 X-coordinate {m}
-2.021550, !- Vertex 5 Y-coordinate {m}
0.381000, !- Vertex 5 Z-coordinate {m}
4.046388, !- Vertex 6 X-coordinate {m}
-2.021550, !- Vertex 6 Y-coordinate {m}
0.381000, !- Vertex 6 Z-coordinate {m}

BuildingSurface:Detailed,
Mech North East Int Wall, !- Name
Wall, !- Surface Type
Wall-2, !- Construction Name
Mechanical, !- Zone Name
Surface, !- Outside Boundary Condition
Bath South East Int Wall, !- Outside Boundary Condition Object
NoSun, !- Sun Exposure
NoWind, !- Wind Exposure
0.0, !- View Factor to Ground
4, !- Number of Vertices
4.046388, !- Vertex 1 X-coordinate {m}
-2.021550, !- Vertex 1 Y-coordinate {m}
2.819400, !- Vertex 1 Z-coordinate {m}
4.046388, !- Vertex 2 X-coordinate {m}
-2.021550, !- Vertex 2 Y-coordinate {m}
0.381000, !- Vertex 2 Z-coordinate {m}

WindExposed, !- Wind Exposure
1, !- View Factor to Ground
4, !- Number of Vertices
0.506263, !- Vertex 1 X-coordinate {m}
-2.631150, !- Vertex 1 Y-coordinate {m}
2.819400, !- Vertex 1 Z-coordinate {m}
0.506263, !- Vertex 2 X-coordinate {m}
-2.631150, !- Vertex 2 Y-coordinate {m}
0.381000, !- Vertex 2 Z-coordinate {m}
4.046388, !- Vertex 3 X-coordinate {m}
-2.631150, !- Vertex 3 Y-coordinate {m}
0.381000, !- Vertex 3 Z-coordinate {m}
4.046388, !- Vertex 4 X-coordinate {m}
-2.631150, !- Vertex 4 Y-coordinate {m}
2.819400, !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
MechEastIntWall, !- Name
Wall, !- Surface Type
Wall-2, !- Construction Name
Mechanical, !- Zone Name
Surface, !- Outside Boundary Condition
Bath West South Int Wall, !- Outside Boundary Condition Object
NoSun, !- Sun Exposure
NoWind, !- Wind Exposure
0.0, !- View Factor to Ground
4, !- Number of Vertices
3.131988, !- Vertex 1 X-coordinate {m}
-2.021550, !- Vertex 1 Y-coordinate {m}
2.819400, !- Vertex 1 Z-coordinate {m}
3.131988, !- Vertex 2 X-coordinate {m}
-2.021550, !- Vertex 2 Y-coordinate {m}
0.381000, !- Vertex 2 Z-coordinate {m}
3.131988, !- Vertex 3 X-coordinate {m}
-1.431000, !- Vertex 3 Y-coordinate {m}
0.381000, !- Vertex 3 Z-coordinate {m}
3.131988, !- Vertex 4 X-coordinate {m}
-1.431000, !- Vertex 4 Y-coordinate {m}
2.819400, !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
MechRoom Ceiling, !- Name
Ceiling, !- Surface Type
Drop Ceiling, !- Construction Name
Mechanical, !- Zone Name
Surface, !- Outside Boundary Condition
MechPlenumCeiling, !- Outside Boundary Condition Object
NoSun, !- Sun Exposure
NoWind, !- Wind Exposure
0.0, !- View Factor to Ground
6, !- Number of Vertices
0.506263, !- Vertex 1 X-coordinate {m}
-1.431000, !- Vertex 1 Y-coordinate {m}
2.819400, !- Vertex 1 Z-coordinate {m}
0.506263, !- Vertex 2 X-coordinate {m}
-2.631150, !- Vertex 2 Y-coordinate {m}
2.819400, !- Vertex 2 Z-coordinate {m}
4.046388, !- Vertex 3 X-coordinate {m}
-2.631150, !- Vertex 3 Y-coordinate {m}
2.819400, !- Vertex 3 Z-coordinate {m}
4.046388, !- Vertex 4 X-coordinate {m}
-2.021550, !- Vertex 4 Y-coordinate {m}
2.819400, !- Vertex 4 Z-coordinate {m}

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3.131988,      !- Vertex 5 X-coordinate {m}
-2.021550,    !- Vertex 5 Y-coordinate {m}
2.819400,     !- Vertex 5 Z-coordinate {m}
3.131988,     !- Vertex 6 X-coordinate {m}
-1.431000,    !- Vertex 6 Y-coordinate {m}
2.819400;     !- Vertex 6 Z-coordinate {m}

BuildingSurface:Detailed,
Mech North West Ext Wall, !- Name
Wall,              !- Surface Type
Wall-2,            !- Construction Name
Mechanical,        !- Zone Name
Outdoors,          !- Outside Boundary Condition
SunExposed,         !- Outside Boundary Condition Object
WindExposed,       !- Sun Exposure
!- Wind Exposure
!- View Factor to Ground
4,                 !- Number of Vertices
1.268263,         !- Vertex 1 X-coordinate {m}
-1.431000,        !- Vertex 1 Y-coordinate {m}
2.819400,         !- Vertex 1 Z-coordinate {m}
1.268263,         !- Vertex 2 X-coordinate {m}
-1.431000,        !- Vertex 2 Y-coordinate {m}
0.381000,         !- Vertex 2 Z-coordinate {m}
0.506263,         !- Vertex 3 X-coordinate {m}
-1.431000,        !- Vertex 3 Y-coordinate {m}
0.381000,         !- Vertex 3 Z-coordinate {m}
0.506263,         !- Vertex 4 X-coordinate {m}
-1.431000,        !- Vertex 4 Y-coordinate {m}
2.819400;         !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
Mech North West Int Wall, !- Name
Wall,             !- Surface Type
Void,             !- Construction Name
Mechanical,       !- Zone Name
Surface,          !- Outside Boundary Condition
Bath South West Int Wall, !- Outside Boundary Condition Object
NoSun,           !- Sun Exposure
NoWind,           !- Wind Exposure
0.0,              !- View Factor to Ground
4,               !- Number of Vertices
3.131988,         !- Vertex 1 X-coordinate {m}
-1.431000,        !- Vertex 1 Y-coordinate {m}
2.819400,         !- Vertex 1 Z-coordinate {m}
3.131988,         !- Vertex 2 X-coordinate {m}
-1.431000,        !- Vertex 2 Y-coordinate {m}
0.381000,         !- Vertex 2 Z-coordinate {m}
1.268263,         !- Vertex 3 X-coordinate {m}
-1.431000,        !- Vertex 3 Y-coordinate {m}
0.381000,         !- Vertex 3 Z-coordinate {m}
1.268263,         !- Vertex 4 X-coordinate {m}
-1.431000,        !- Vertex 4 Y-coordinate {m}
2.819400;         !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
BathFloor,       !- Name
Floor,           !- Surface Type
Radiant Floor Construction, !- Construction Name
Bath-Hall,       !- Zone Name
Outdoors,        !- Outside Boundary Condition
SunExposed,      !- Outside Boundary Condition Object
WindExposed,     !- Sun Exposure
!- Wind Exposure
!- View Factor to Ground
4,               !- Number of Vertices
3.131988,         !- Vertex 1 X-coordinate {m}
-1.431000,        !- Vertex 1 Y-coordinate {m}
2.819400,         !- Vertex 1 Z-coordinate {m}
1.268263,         !- Vertex 2 X-coordinate {m}
-1.431000,        !- Vertex 2 Y-coordinate {m}
0.381000,         !- Vertex 2 Z-coordinate {m}
1.268263,         !- Vertex 3 X-coordinate {m}
-1.431000,        !- Vertex 3 Y-coordinate {m}
0.381000,         !- Vertex 3 Z-coordinate {m}
1.268263,         !- Vertex 4 X-coordinate {m}
-1.431000,        !- Vertex 4 Y-coordinate {m}
2.819400;         !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
BathSouthEastIntWall, !- Name
Wall,             !- Surface Type
Wall-2,           !- Construction Name
Bath-Hall,        !- Zone Name
Surface,          !- Outside Boundary Condition
Mech North East Int Wall, !- Outside Boundary Condition Object
NoSun,           !- Sun Exposure
NoWind,           !- Wind Exposure
0.0,              !- View Factor to Ground
4,               !- Number of Vertices
3.131988,         !- Vertex 1 X-coordinate {m}
-2.021550,        !- Vertex 1 Y-coordinate {m}
2.819400,         !- Vertex 1 Z-coordinate {m}
3.131988,         !- Vertex 2 X-coordinate {m}
-2.021550,        !- Vertex 2 Y-coordinate {m}
0.381000,         !- Vertex 2 Z-coordinate {m}
4.046388,         !- Vertex 3 X-coordinate {m}
-2.021550,        !- Vertex 3 Y-coordinate {m}
0.381000,         !- Vertex 3 Z-coordinate {m}
4.046388,         !- Vertex 4 X-coordinate {m}
-2.021550,        !- Vertex 4 Y-coordinate {m}
2.819400;         !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
BathCeiling,     !- Name
Ceiling,         !- Surface Type
Drop Ceiling,     !- Construction Name
Bath-Hall,       !- Zone Name
Surface,         !- Outside Boundary Condition
BathPlenumCeiling, !- Outside Boundary Condition Object
NoSun,           !- Sun Exposure
NoWind,           !- Wind Exposure
!- View Factor to Ground
10,              !- Number of Vertices
1.268263,         !- Vertex 1 X-coordinate {m}
0.245400,         !- Vertex 1 Y-coordinate {m}
2.819400,         !- Vertex 1 Z-coordinate {m}
1.268263,         !- Vertex 2 X-coordinate {m}
-1.431000,        !- Vertex 2 Y-coordinate {m}
2.819400,         !- Vertex 2 Z-coordinate {m}
2.819400,         !- Vertex 3 X-coordinate {m}
3.131988,         !- Vertex 3 Y-coordinate {m}
3.131988,         !- Vertex 3 Z-coordinate {m}
0.550200,         !- Vertex 4 X-coordinate {m}
2.819400,         !- Vertex 4 Y-coordinate {m}
2.819400,         !- Vertex 4 Z-coordinate {m}
3.131988,         !- Vertex 5 X-coordinate {m}
0.550200,         !- Vertex 5 Y-coordinate {m}
2.819400,         !- Vertex 5 Z-coordinate {m}
3.131988,         !- Vertex 6 X-coordinate {m}
0.550200,         !- Vertex 6 Y-coordinate {m}
2.819400,         !- Vertex 6 Z-coordinate {m}
3.131988,         !- Vertex 7 X-coordinate {m}
2.819400,         !- Vertex 7 Y-coordinate {m}
2.819400,         !- Vertex 7 Z-coordinate {m}
3.131988,         !- Vertex 8 X-coordinate {m}
3.131988,         !- Vertex 8 Y-coordinate {m}
2.819400;         !- Vertex 8 Z-coordinate {m}

BuildingSurface:Detailed,
BathNorthWall,   !- Name
Wall,            !- Surface Type
Wall-3,          !- Construction Name
Bath-Hall,       !- Zone Name
Outdoors,        !- Outside Boundary Condition
SunExposed,      !- Outside Boundary Condition Object
WindExposed,     !- Sun Exposure
!- Wind Exposure
!- View Factor to Ground
4,               !- Number of Vertices
3.131988,         !- Vertex 1 X-coordinate {m}
3.414050,         !- Vertex 1 Y-coordinate {m}
2.819400,         !- Vertex 1 Z-coordinate {m}
3.131988,         !- Vertex 2 X-coordinate {m}
3.414050,         !- Vertex 2 Y-coordinate {m}
0.381000,         !- Vertex 2 Z-coordinate {m}
3.131988,         !- Vertex 3 X-coordinate {m}
3.414050,         !- Vertex 3 Y-coordinate {m}
0.381000,         !- Vertex 3 Z-coordinate {m}
3.131988,         !- Vertex 4 X-coordinate {m}
3.414050,         !- Vertex 4 Y-coordinate {m}
0.381000;         !- Vertex 4 Z-coordinate {m}

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3.506263,      !- Vertex 9 X-coordinate {m}
3.414050,      !- Vertex 9 Y-coordinate {m}
2.819400,      !- Vertex 9 Z-coordinate {m}
0.506263,      !- Vertex 10 X-coordinate {m}
0.245400,      !- Vertex 10 Y-coordinate {m}
2.819400,      !- Vertex 10 Z-coordinate {m}

BuildingSurface:Detailed,
  Bath West South Ext Wall, !- Name
  Wall,                  !- Surface Type
  Wall-3,                !- Construction Name
  Bath-Hall,             !- Zone Name
  Outdoors,              !- Outside Boundary Condition
  SunExposed,             !- Outside Boundary Condition Object
  WindExposed,            !- Sun Exposure
  4,                      !- View Factor to Ground
  0.0,                   !- Number of Vertices
  1.268263,             !- Vertex 1 X-coordinate {m}
  0.245400,             !- Vertex 1 Y-coordinate {m}
  2.819400,             !- Vertex 1 Z-coordinate {m}
  1.268263,             !- Vertex 2 X-coordinate {m}
  0.245400,             !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  1.268263,             !- Vertex 3 X-coordinate {m}
  -1.431000,            !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  1.268263,             !- Vertex 4 X-coordinate {m}
  -1.431000,            !- Vertex 4 Y-coordinate {m}
  2.819400,             !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  BathSouthWall,         !- Name
  Wall,                  !- Surface Type
  Wall-3,                !- Construction Name
  Bath-Hall,             !- Zone Name
  Outdoors,              !- Outside Boundary Condition
  SunExposed,             !- Outside Boundary Condition Object
  WindExposed,            !- Sun Exposure
  4,                      !- View Factor to Ground
  0.0,                   !- Number of Vertices
  0.506263,             !- Vertex 1 X-coordinate {m}
  0.245400,             !- Vertex 1 Y-coordinate {m}
  2.819400,             !- Vertex 1 Z-coordinate {m}
  0.506263,             !- Vertex 2 X-coordinate {m}
  0.245400,             !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  1.268263,             !- Vertex 3 X-coordinate {m}
  0.245400,             !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  1.268263,             !- Vertex 4 X-coordinate {m}
  0.245400,             !- Vertex 4 Y-coordinate {m}
  2.819400,             !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  Bath North Int Wall,   !- Name
  Wall,                  !- Surface Type
  Wall-5,                !- Construction Name
  Bath-Hall,             !- Zone Name
  Surface,               !- Outside Boundary Condition
  Living-South-Int-Wall, !- Outside Boundary Condition Object
  NoSun,                 !- Sun Exposure
  NoWind,                !- Wind Exposure
  0.0,                   !- View Factor to Ground
  4,                      !- Number of Vertices
  3.131988,             !- Vertex 1 X-coordinate {m}
  -1.431000,            !- Vertex 1 Y-coordinate {m}
  2.819400,             !- Vertex 1 Z-coordinate {m}
  3.131988,             !- Vertex 2 X-coordinate {m}
  -1.431000,            !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  3.131988,             !- Vertex 3 X-coordinate {m}
  -2.021550,            !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  3.131988,             !- Vertex 4 X-coordinate {m}
  -2.021550,            !- Vertex 4 Y-coordinate {m}
  2.819400,             !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  LivingFloor,           !- Name
  Floor,                 !- Surface Type
  Radiant Floor Construction, !- Construction Name
  Living-Kitchen,        !- Zone Name
  Outdoors,              !- Outside Boundary Condition
  SunExposed,             !- Sun Exposure
  WindExposed,            !- Wind Exposure
  1,                      !- View Factor to Ground
  6,                      !- Number of Vertices
  11.885463,             !- Vertex 1 X-coordinate {m}
  3.414050,             !- Vertex 1 Y-coordinate {m}
  0.381000,             !- Vertex 1 Z-coordinate {m}
  11.885463,             !- Vertex 2 X-coordinate {m}
  -1.431000,            !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  4.046388,             !- Vertex 3 X-coordinate {m}
  -1.431000,            !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  4.046388,             !- Vertex 4 X-coordinate {m}
  0.550200,             !- Vertex 4 Y-coordinate {m}
  0.381000,             !- Vertex 4 Z-coordinate {m}
  3.131988,             !- Vertex 5 X-coordinate {m}
  0.550200,             !- Vertex 5 Y-coordinate {m}
  0.381000,             !- Vertex 5 Z-coordinate {m}
  3.131988,             !- Vertex 6 X-coordinate {m}
  3.414050,             !- Vertex 6 Y-coordinate {m}
  0.381000,             !- Vertex 6 Z-coordinate {m}

BuildingSurface:Detailed,
  South Living Wall,     !- Name
  Wall,                  !- Surface Type
  Wall-1,                !- Construction Name
  Living-Kitchen,        !- Zone Name
  Outdoors,              !- Outside Boundary Condition
  SunExposed,             !- Sun Exposure
  WindExposed,            !- Wind Exposure
  4,                      !- View Factor to Ground
  4,                      !- Number of Vertices
  4.046388,             !- Vertex 1 X-coordinate {m}
  -1.431000,            !- Vertex 1 Y-coordinate {m}
  2.819400,             !- Vertex 1 Z-coordinate {m}
  4.046388,             !- Vertex 2 X-coordinate {m}
  -1.431000,            !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  11.885463,             !- Vertex 3 X-coordinate {m}
  -1.431000,            !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  11.885463,             !- Vertex 4 X-coordinate {m}
  -1.431000,            !- Vertex 4 Y-coordinate {m}
  2.819400,             !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  LivingCeiling,         !- Name
  Ceiling,               !- Surface Type
  Drop Ceiling,          !- Construction Name
  Living-Kitchen,        !- Zone Name
  Surface,               !- Outside Boundary Condition
  Living Plenum Ceiling, !- Outside Boundary Condition Object
  NoSun,                 !- Sun Exposure
  NoWind,                !- Wind Exposure
  0.0,                   !- View Factor to Ground
  4,                      !- Number of Vertices
  3.131988,             !- Vertex 1 X-coordinate {m}
  0.550200,             !- Vertex 1 Y-coordinate {m}
  2.819400,             !- Vertex 1 Z-coordinate {m}
  3.131988,             !- Vertex 2 X-coordinate {m}
  0.550200,             !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  0.381000,             !- Vertex 3 X-coordinate {m}
  0.381000,             !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  4.046388,             !- Vertex 4 X-coordinate {m}
  -1.431000,            !- Vertex 4 Y-coordinate {m}
  2.819400,             !- Vertex 4 Z-coordinate {m}

NoWind,             !- Wind Exposure
0.0,                 !- View Factor to Ground
0,                   !- Number of Vertices
4.046388,            !- Vertex 1 X-coordinate {m}
0.550200,            !- Vertex 1 Y-coordinate {m}
2.819400,            !- Vertex 1 Z-coordinate {m}
4.046388,            !- Vertex 2 X-coordinate {m}
0.550200,            !- Vertex 2 Y-coordinate {m}
0.381000,            !- Vertex 2 Z-coordinate {m}
0.381000,            !- Vertex 3 X-coordinate {m}
0.550200,            !- Vertex 3 Y-coordinate {m}
0.381000,            !- Vertex 3 Z-coordinate {m}
0.381000,            !- Vertex 4 X-coordinate {m}
0.550200,            !- Vertex 4 Y-coordinate {m}
2.819400,            !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  Bath East-North Int Wall, !- Name
  Wall,                  !- Surface Type
  Wall-5,                !- Construction Name
  Bath-Hall,             !- Zone Name
  Surface,               !- Outside Boundary Condition
  Living-West-North Wall, !- Outside Boundary Condition Object
  NoSun,                 !- Sun Exposure
  NoWind,                !- Wind Exposure
  0.0,                   !- View Factor to Ground
  4,                      !- Number of Vertices
  3.131988,             !- Vertex 1 X-coordinate {m}
  0.550200,             !- Vertex 1 Y-coordinate {m}
  2.819400,             !- Vertex 1 Z-coordinate {m}
  3.131988,             !- Vertex 2 X-coordinate {m}
  0.550200,             !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  3.131988,             !- Vertex 3 X-coordinate {m}
  3.414050,             !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  3.131988,             !- Vertex 4 X-coordinate {m}
  3.414050,             !- Vertex 4 Y-coordinate {m}
  2.819400,             !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  Bath West South Int Wall, !- Name
  Wall,                  !- Surface Type
  Wall-2,                !- Construction Name
  Bath-Hall,             !- Zone Name
  Surface,               !- Outside Boundary Condition
  MechEastIntWall,       !- Outside Boundary Condition Object
  NoSun,                 !- Sun Exposure
  NoWind,                !- Wind Exposure
  0.0,                   !- View Factor to Ground
  4,                      !- Number of Vertices
  3.131988,             !- Vertex 1 X-coordinate {m}
  -1.431000,            !- Vertex 1 Y-coordinate {m}
  2.819400,             !- Vertex 1 Z-coordinate {m}
  3.131988,             !- Vertex 2 X-coordinate {m}
  -1.431000,            !- Vertex 2 Y-coordinate {m}
  0.381000,             !- Vertex 2 Z-coordinate {m}
  3.131988,             !- Vertex 3 X-coordinate {m}
  -2.021550,            !- Vertex 3 Y-coordinate {m}
  0.381000,             !- Vertex 3 Z-coordinate {m}
  3.131988,             !- Vertex 4 X-coordinate {m}
  -2.021550,            !- Vertex 4 Y-coordinate {m}
  2.819400,             !- Vertex 4 Z-coordinate {m}

NoWind,             !- Wind Exposure
0.0,                 !- View Factor to Ground
6,                   !- Number of Vertices
4.046388,            !- Vertex 1 X-coordinate {m}
0.550200,            !- Vertex 1 Y-coordinate {m}
2.819400,            !- Vertex 1 Z-coordinate {m}
4.046388,            !- Vertex 2 X-coordinate {m}
-1.431000,           !- Vertex 2 Y-coordinate {m}
2.819400,            !- Vertex 2 Z-coordinate {m}
11.885463,           !- Vertex 3 X-coordinate {m}
-1.431000,           !- Vertex 3 Y-coordinate {m}
2.819400,            !- Vertex 3 Z-coordinate {m}
11.885463,           !- Vertex 4 X-coordinate {m}
3.414050,            !- Vertex 4 Y-coordinate {m}
2.819400,            !- Vertex 4 Z-coordinate {m}
3.131988,            !- Vertex 5 X-coordinate {m}
3.414050,            !- Vertex 5 Y-coordinate {m}
2.819400,            !- Vertex 5 Z-coordinate {m}
3.131988,            !- Vertex 6 X-coordinate {m}
0.550200,            !- Vertex 6 Y-coordinate {m}
2.819400,            !- Vertex 6 Z-coordinate {m}

BuildingSurface:Detailed,
  Living-West-South-Int-Wall, !- Name
  Wall,                  !- Surface Type
 
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[illegible]


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4.046388,      !- Vertex 9 X-coordinate {m}
0.550200,     !- Vertex 9 Y-coordinate {m}
3.556000,     !- Vertex 9 Z-coordinate {m}
3.131988,     !- Vertex 10 X-coordinate {m}
0.550200,     !- Vertex 10 Y-coordinate {m}
3.556000;     !- Vertex 10 Z-coordinate {m}

BuildingSurface:Detailed,
Bath Plenum South-East-Int Wall, !- Name
Wall,           !- Surface Type
Wall-2,         !- Construction Name
BathPlenum,    !- Zone Name
Surface,        !- Outside Boundary Condition
MechPlenumIntWall, !- Outside Boundary Condition Object
NoSun,          !- Sun Exposure
NoWind,         !- Wind Exposure
0.0,            !- View Factor to Ground
4,              !- Number of Vertices
3.131988,      !- Vertex 1 X-coordinate {m}
-2.021550,     !- Vertex 1 Y-coordinate {m}
3.556000,      !- Vertex 1 Z-coordinate {m}
3.131988,      !- Vertex 2 X-coordinate {m}
-2.021550,     !- Vertex 2 Y-coordinate {m}
2.819400,      !- Vertex 2 Z-coordinate {m}
4.046388,      !- Vertex 3 X-coordinate {m}
-2.021550,     !- Vertex 3 Y-coordinate {m}
2.819400,      !- Vertex 3 Z-coordinate {m}
4.046388,      !- Vertex 4 X-coordinate {m}
-2.021550,     !- Vertex 4 Y-coordinate {m}
3.556000;     !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
Bath Plenum East-North Int Wall, !- Name
Wall,           !- Surface Type
Wall-5,         !- Construction Name
BathPlenum,    !- Zone Name
Surface,        !- Outside Boundary Condition
Living Plenum West-North Int Wall, !- Outside Boundary Condition Object
NoSun,          !- Sun Exposure
NoWind,         !- Wind Exposure
0.0,            !- View Factor to Ground
4,              !- Number of Vertices
3.131988,      !- Vertex 1 X-coordinate {m}
0.550200,      !- Vertex 1 Y-coordinate {m}
3.556000,      !- Vertex 1 Z-coordinate {m}
3.131988,      !- Vertex 2 X-coordinate {m}
0.550200,      !- Vertex 2 Y-coordinate {m}
2.819400,      !- Vertex 2 Z-coordinate {m}
3.131988,      !- Vertex 3 X-coordinate {m}
3.414050,      !- Vertex 3 Y-coordinate {m}
2.819400,      !- Vertex 3 Z-coordinate {m}
3.131988,      !- Vertex 4 X-coordinate {m}
3.414050,      !- Vertex 4 Y-coordinate {m}
3.556000;     !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
BathPlenumSouthWestIntWall, !- Name
Wall,           !- Surface Type
Wall-2,         !- Construction Name
BathPlenum,    !- Zone Name
Surface,        !- Outside Boundary Condition
MechPlenumNorthHallExtWall, !- Outside Boundary Condition Object
NoSun,          !- Sun Exposure

3.131988,      !- Vertex 5 X-coordinate {m}
0.550200,      !- Vertex 5 Y-coordinate {m}
2.819400,      !- Vertex 5 Z-coordinate {m}
3.131988,      !- Vertex 6 X-coordinate {m}
3.414050,      !- Vertex 6 Y-coordinate {m}
2.819400;     !- Vertex 6 Z-coordinate {m}

BuildingSurface:Detailed,
Living Plenum Roof, !- Name
Roof,             !- Surface Type
Curio Roof,       !- Construction Name
LivingPlenum,     !- Zone Name
Outdoors,          !- Outside Boundary Condition
SunExposed,        !- Outside Boundary Condition Object
WindExposed,       !- Wind Exposure
0,                 !- View Factor to Ground
6,                 !- Number of Vertices
4.046388,          !- Vertex 1 X-coordinate {m}
0.550200,          !- Vertex 1 Y-coordinate {m}
3.556000,          !- Vertex 1 Z-coordinate {m}
4.046388,          !- Vertex 2 X-coordinate {m}
-1.431000,         !- Vertex 2 Y-coordinate {m}
3.556000,          !- Vertex 2 Z-coordinate {m}
11.885463,         !- Vertex 3 X-coordinate {m}
-1.431000,         !- Vertex 3 Y-coordinate {m}
3.556000,          !- Vertex 3 Z-coordinate {m}
11.885463,         !- Vertex 4 X-coordinate {m}
3.414050,          !- Vertex 4 Y-coordinate {m}
3.556000,          !- Vertex 4 Z-coordinate {m}
3.131988,          !- Vertex 5 X-coordinate {m}
3.414050,          !- Vertex 5 Y-coordinate {m}
2.819400,          !- Vertex 5 Z-coordinate {m}
0.550200,          !- Vertex 6 X-coordinate {m}
0.550200,          !- Vertex 6 Y-coordinate {m}
3.556000;          !- Vertex 6 Z-coordinate {m}

BuildingSurface:Detailed,
Living Plenum East Wall, !- Name
Wall,                   !- Surface Type
Wall-1,                 !- Construction Name
LivingPlenum,           !- Zone Name
Outdoors,               !- Outside Boundary Condition
SunExposed,             !- Outside Boundary Condition Object
WindExposed,            !- Wind Exposure
0,                       !- View Factor to Ground
4,                       !- Number of Vertices
11.885463,              !- Vertex 1 X-coordinate {m}
-1.431000,              !- Vertex 1 Y-coordinate {m}
3.556000,               !- Vertex 1 Z-coordinate {m}
11.885463,              !- Vertex 2 X-coordinate {m}
-1.431000,              !- Vertex 2 Y-coordinate {m}
2.819400,               !- Vertex 2 Z-coordinate {m}
11.885463,              !- Vertex 3 X-coordinate {m}
3.414050,               !- Vertex 3 Y-coordinate {m}
2.819400,               !- Vertex 3 Z-coordinate {m}
11.885463,              !- Vertex 4 X-coordinate {m}
3.414050,               !- Vertex 4 Y-coordinate {m}
3.556000;               !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
Living Plenum West-North Int Wall, !- Name
Wall,                               !- Surface Type
Wall-1,                             !- Construction Name
LivingPlenum,                       !- Zone Name
Outdoors,                           !- Outside Boundary Condition
SunExposed,                         !- Outside Boundary Condition Object
WindExposed,                        !- Wind Exposure
0,                                  !- View Factor to Ground
4,                                  !- Number of Vertices
11.885463,                          !- Vertex 1 X-coordinate {m}
-1.431000,                          !- Vertex 1 Y-coordinate {m}
3.556000,                           !- Vertex 1 Z-coordinate {m}
11.885463,                          !- Vertex 2 X-coordinate {m}
-1.431000,                          !- Vertex 2 Y-coordinate {m}
2.819400,                           !- Vertex 2 Z-coordinate {m}
11.885463,                          !- Vertex 3 X-coordinate {m}
3.414050,                           !- Vertex 3 Y-coordinate {m}
2.819400,                           !- Vertex 3 Z-coordinate {m}
11.885463,                          !- Vertex 4 X-coordinate {m}
3.414050,                           !- Vertex 4 Y-coordinate {m}
3.556000;                           !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
Living Plenum West-South Int Wall, !- Name
Wall,                               !- Surface Type
Wall-5,                             !- Construction Name
LivingPlenum,                       !- Zone Name
Surface,                            !- Outside Boundary Condition
Bath Plenum East-South Int Wall, !- Outside Boundary Condition Object
NoSun,                              !- Sun Exposure
NoWind,                             !- Wind Exposure
0.0,                                !- View Factor to Ground
4,                                  !- Number of Vertices
4.046388,                          !- Vertex 1 X-coordinate {m}
0.550200,                          !- Vertex 1 Y-coordinate {m}
3.556000,                           !- Vertex 1 Z-coordinate {m}
4.046388,                          !- Vertex 2 X-coordinate {m}
0.550200,                          !- Vertex 2 Y-coordinate {m}
2.819400,                           !- Vertex 2 Z-coordinate {m}
4.046388,                          !- Vertex 3 X-coordinate {m}
-1.431000,                          !- Vertex 3 Y-coordinate {m}
2.819400,                           !- Vertex 3 Z-coordinate {m}
4.046388,                          !- Vertex 4 X-coordinate {m}
-1.431000,                          !- Vertex 4 Y-coordinate {m}
3.556000;                           !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
Living Plenum North Wall, !- Name
Wall,                     !- Surface Type
Wall-1,                   !- Construction Name
LivingPlenum,             !- Zone Name
Outdoors,                 !- Outside Boundary Condition
SunExposed,               !- Outside Boundary Condition Object
WindExposed,              !- Wind Exposure
0,                         !- View Factor to Ground
4,                         !- Number of Vertices
11.885463,                !- Vertex 1 X-coordinate {m}
3.414050,                 !- Vertex 1 Y-coordinate {m}
3.556000,                 !- Vertex 1 Z-coordinate {m}
11.885463,                !- Vertex 2 X-coordinate {m}
3.414050,                 !- Vertex 2 Y-coordinate {m}
2.819400,                 !- Vertex 2 Z-coordinate {m}
11.885463,                !- Vertex 3 X-coordinate {m}
3.414050,                 !- Vertex 3 Y-coordinate {m}
2.819400,                 !- Vertex 3 Z-coordinate {m}
11.885463,                !- Vertex 4 X-coordinate {m}
3.414050,                 !- Vertex 4 Y-coordinate {m}
3.556000;                 !- Vertex 4 Z-coordinate {m}

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3.131988,      !- Vertex 3 X-coordinate {m}
3.414050,      !- Vertex 3 Y-coordinate {m}
2.819400,      !- Vertex 3 Z-coordinate {m}
3.131988,      !- Vertex 4 X-coordinate {m}
3.414050,      !- Vertex 4 Y-coordinate {m}
3.556000;      !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  Living Plenum South Int Wall, !- Name
  Wall, !- Surface Type
  Wall-5, !- Construction Name
  LivingPlenum, !- Zone Name
  Surface, !- Outside Boundary Condition
  BathPlenum North Int Wall, !- Outside Boundary Condition Object
  NoSun, !- Sun Exposure
  NoWind, !- Wind Exposure
  0.0, !- View Factor to Ground
  4, !- Number of Vertices
  3.131988, !- Vertex 1 X-coordinate {m}
  0.550200, !- Vertex 1 Y-coordinate {m}
  3.556000, !- Vertex 1 Z-coordinate {m}
  3.131988, !- Vertex 2 X-coordinate {m}
  0.550200, !- Vertex 2 Y-coordinate {m}
  2.819400, !- Vertex 2 Z-coordinate {m}
  4.046388, !- Vertex 3 X-coordinate {m}
  0.550200, !- Vertex 3 Y-coordinate {m}
  2.819400, !- Vertex 3 Z-coordinate {m}
  4.046388, !- Vertex 4 X-coordinate {m}
  0.550200, !- Vertex 4 Y-coordinate {m}
  3.556000; !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  Living Plenum South Wall, !- Name
  Wall, !- Surface Type
  Wall-1, !- Construction Name
  LivingPlenum, !- Zone Name
  Outdoors, !- Outside Boundary Condition
  , !- Outside Boundary Condition Object
  SunExposed, !- Sun Exposure
  WindExposed, !- Wind Exposure
  0, !- View Factor to Ground
  4, !- Number of Vertices
  4.046388, !- Vertex 1 X-coordinate {m}
  -1.431000, !- Vertex 1 Y-coordinate {m}
  3.556000, !- Vertex 1 Z-coordinate {m}
  4.046388, !- Vertex 2 X-coordinate {m}
  -1.431000, !- Vertex 2 Y-coordinate {m}
  2.819400, !- Vertex 2 Z-coordinate {m}
  11.885463, !- Vertex 3 X-coordinate {m}
  -1.431000, !- Vertex 3 Y-coordinate {m}
  2.819400, !- Vertex 3 Z-coordinate {m}
  11.885463, !- Vertex 4 X-coordinate {m}
  -1.431000, !- Vertex 4 Y-coordinate {m}
  3.556000; !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  Bath East South Int Wall, !- Name
  Wall, !- Surface Type
  Void, !- Construction Name
  Bath-Hall, !- Zone Name
  Zone, !- Outside Boundary Condition
  Living-Kitchen, !- Outside Boundary Condition Object
  NoSun, !- Sun Exposure

!- ===== ALL OBJECTS IN CLASS: FENESTRATIONSURFACE:DETAILED =====

FenestrationSurface:Detailed,
  S Win 7, !- Name
  Window, !- Surface Type
  Curio Window, !- Construction Name
  South Living Wall, !- Building Surface Name
  , !- Outside Boundary Condition Object
  , !- View Factor to Ground
  South Exterior Shading Control, !- Shading Control Name
  , !- Frame and Divider Name
  , !- Multiplier
  4, !- Number of Vertices
  10.749201, !- Vertex 1 X-coordinate {m}
  -1.431000, !- Vertex 1 Y-coordinate {m}
  2.743929, !- Vertex 1 Z-coordinate {m}
  10.749201, !- Vertex 2 X-coordinate {m}
  -1.431000, !- Vertex 2 Y-coordinate {m}
  0.457929, !- Vertex 2 Z-coordinate {m}
  11.755041, !- Vertex 3 X-coordinate {m}
  -1.431000, !- Vertex 3 Y-coordinate {m}
  0.457929, !- Vertex 3 Z-coordinate {m}
  11.755041, !- Vertex 4 X-coordinate {m}
  -1.431000, !- Vertex 4 Y-coordinate {m}
  2.743929; !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
  S Win 1, !- Name
  Window, !- Surface Type
  Curio Window, !- Construction Name
  South Living Wall, !- Building Surface Name
  , !- Outside Boundary Condition Object
  , !- View Factor to Ground
  South Exterior Shading Control, !- Shading Control Name
  , !- Frame and Divider Name
  , !- Multiplier
  4, !- Number of Vertices
  4.133930, !- Vertex 1 X-coordinate {m}
  -1.431000, !- Vertex 1 Y-coordinate {m}
  2.729013, !- Vertex 1 Z-coordinate {m}
  4.133930, !- Vertex 2 X-coordinate {m}
  -1.431000, !- Vertex 2 Y-coordinate {m}
  0.443013, !- Vertex 2 Z-coordinate {m}
  5.139770, !- Vertex 3 X-coordinate {m}
  -1.431000, !- Vertex 3 Y-coordinate {m}
  0.443013, !- Vertex 3 Z-coordinate {m}
  5.139770, !- Vertex 4 X-coordinate {m}
  -1.431000, !- Vertex 4 Y-coordinate {m}
  2.729013; !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
  S Win 2, !- Name
  Window, !- Surface Type
  Curio Window, !- Construction Name
  South Living Wall, !- Building Surface Name
  , !- Outside Boundary Condition Object
  , !- View Factor to Ground
  South Exterior Shading Control, !- Shading Control Name
  , !- Frame and Divider Name
  , !- Multiplier
  4, !- Number of Vertices

NoWind, !- Wind Exposure
0.0, !- View Factor to Ground
4, !- Number of Vertices
3.131988, !- Vertex 1 X-coordinate {m}
-1.431000, !- Vertex 1 Y-coordinate {m}
3.556000, !- Vertex 1 Z-coordinate {m}
2.819400, !- Vertex 2 X-coordinate {m}
-1.431000, !- Vertex 2 Y-coordinate {m}
2.819400, !- Vertex 2 Z-coordinate {m}
1.268263, !- Vertex 3 X-coordinate {m}
-1.431000, !- Vertex 3 Y-coordinate {m}
2.819400, !- Vertex 3 Z-coordinate {m}
1.268263, !- Vertex 4 X-coordinate {m}
-1.431000, !- Vertex 4 Y-coordinate {m}
3.556000; !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  MechPlenumNorthHallIntWall, !- Name
  Wall, !- Surface Type
  Wall-2, !- Construction Name
  Mechanical-Plenum, !- Zone Name
  Surface, !- Outside Boundary Condition
  BathPlenumSouthWestIntWall, !- Outside Boundary Condition Object
  NoSun, !- Sun Exposure
  NoWind, !- Wind Exposure
  0.0, !- View Factor to Ground
  4, !- Number of Vertices
  3.131988, !- Vertex 1 X-coordinate {m}
  -1.431000, !- Vertex 1 Y-coordinate {m}
  3.556000, !- Vertex 1 Z-coordinate {m}
  3.131988, !- Vertex 2 X-coordinate {m}
  -1.431000, !- Vertex 2 Y-coordinate {m}
  2.819400, !- Vertex 2 Z-coordinate {m}
  1.268263, !- Vertex 3 X-coordinate {m}
  -1.431000, !- Vertex 3 Y-coordinate {m}
  2.819400, !- Vertex 3 Z-coordinate {m}
  1.268263, !- Vertex 4 X-coordinate {m}
  -1.431000, !- Vertex 4 Y-coordinate {m}
  3.556000; !- Vertex 4 Z-coordinate {m}

BuildingSurface:Detailed,
  BathPlenumEastSouthExtWall, !- Name
  Wall, !- Surface Type
  Wall-5, !- Construction Name
  BathPlenum, !- Zone Name
  Outdoors, !- Outside Boundary Condition
  , !- Outside Boundary Condition Object
  NoSun, !- Sun Exposure
  NoWind, !- Wind Exposure
  0.0, !- View Factor to Ground
  4, !- Number of Vertices
  4.046388, !- Vertex 1 X-coordinate {m}
  -2.021550, !- Vertex 1 Y-coordinate {m}
  3.556000, !- Vertex 1 Z-coordinate {m}
  4.046388, !- Vertex 2 X-coordinate {m}
  -2.021550, !- Vertex 2 Y-coordinate {m}
  2.819400, !- Vertex 2 Z-coordinate {m}
  4.046388, !- Vertex 3 X-coordinate {m}
  -1.431000, !- Vertex 3 Y-coordinate {m}
  2.819400, !- Vertex 3 Z-coordinate {m}
  4.046388, !- Vertex 4 X-coordinate {m}
  -1.431000, !- Vertex 4 Y-coordinate {m}
  3.556000; !- Vertex 4 Z-coordinate {m}

5.237718, !- Vertex 1 X-coordinate {m}
-1.431000, !- Vertex 1 Y-coordinate {m}
2.736471, !- Vertex 1 Z-coordinate {m}
5.237718, !- Vertex 2 X-coordinate {m}
-1.431000, !- Vertex 2 Y-coordinate {m}
0.450471, !- Vertex 2 Z-coordinate {m}
6.243558, !- Vertex 3 X-coordinate {m}
-1.431000, !- Vertex 3 Y-coordinate {m}
0.450471, !- Vertex 3 Z-coordinate {m}
6.243558, !- Vertex 4 X-coordinate {m}
-1.431000, !- Vertex 4 Y-coordinate {m}
2.736471; !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
  S Win 3, !- Name
  GlassDoor, !- Surface Type
  Curio Window, !- Construction Name
  South Living Wall, !- Building Surface Name
  , !- Outside Boundary Condition Object
  , !- View Factor to Ground
  South Exterior Shading Control, !- Shading Control Name
  , !- Frame and Divider Name
  , !- Multiplier
  4, !- Number of Vertices
  6.348965, !- Vertex 1 X-coordinate {m}
  -1.431000, !- Vertex 1 Y-coordinate {m}
  2.736471, !- Vertex 1 Z-coordinate {m}
  6.348965, !- Vertex 2 X-coordinate {m}
  -1.431000, !- Vertex 2 Y-coordinate {m}
  0.450471, !- Vertex 2 Z-coordinate {m}
  7.354805, !- Vertex 3 X-coordinate {m}
  -1.431000, !- Vertex 3 Y-coordinate {m}
  0.450471, !- Vertex 3 Z-coordinate {m}
  7.354805, !- Vertex 4 X-coordinate {m}
  -1.431000, !- Vertex 4 Y-coordinate {m}
  2.736471; !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
  S Win 4, !- Name
  GlassDoor, !- Surface Type
  Curio Window, !- Construction Name
  South Living Wall, !- Building Surface Name
  , !- Outside Boundary Condition Object
  , !- View Factor to Ground
  South Exterior Shading Control, !- Shading Control Name
  , !- Frame and Divider Name
  , !- Multiplier
  4, !- Number of Vertices
  7.452753, !- Vertex 1 X-coordinate {m}
  -1.431000, !- Vertex 1 Y-coordinate {m}
  2.736471, !- Vertex 1 Z-coordinate {m}
  7.452753, !- Vertex 2 X-coordinate {m}
  -1.431000, !- Vertex 2 Y-coordinate {m}
  0.450471, !- Vertex 2 Z-coordinate {m}
  8.458593, !- Vertex 3 X-coordinate {m}
  -1.431000, !- Vertex 3 Y-coordinate {m}
  0.450471, !- Vertex 3 Z-coordinate {m}
  8.458593, !- Vertex 4 X-coordinate {m}
  -1.431000, !- Vertex 4 Y-coordinate {m}
  2.736471; !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
  S Win 5, !- Name

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Window,                !- Surface Type
Curio Window,          !- Construction Name
South Living Wall,      !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
South Exterior Shading Control, !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
8.549083,               !- Vertex 1 X-coordinate {m}
-1.431000,             !- Vertex 1 Y-coordinate {m}
2.743929,              !- Vertex 1 Z-coordinate {m}
8.549083,               !- Vertex 2 X-coordinate {m}
-1.431000,             !- Vertex 2 Y-coordinate {m}
0.457929,              !- Vertex 2 Z-coordinate {m}
9.554923,              !- Vertex 3 X-coordinate {m}
-1.431000,             !- Vertex 3 Y-coordinate {m}
0.457929,              !- Vertex 3 Z-coordinate {m}
9.554923,              !- Vertex 4 X-coordinate {m}
-1.431000,             !- Vertex 4 Y-coordinate {m}
2.743929;             !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
S Win 6,                !- Name
Window,                !- Surface Type
Curio Window,          !- Construction Name
South Living Wall,      !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
                        !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
9.652871,               !- Vertex 1 X-coordinate {m}
-1.431000,             !- Vertex 1 Y-coordinate {m}
2.743929,              !- Vertex 1 Z-coordinate {m}
9.652871,               !- Vertex 2 X-coordinate {m}
-1.431000,             !- Vertex 2 Y-coordinate {m}
0.457929,              !- Vertex 2 Z-coordinate {m}
10.658711,             !- Vertex 3 X-coordinate {m}
-1.431000,             !- Vertex 3 Y-coordinate {m}
0.457929,              !- Vertex 3 Z-coordinate {m}
10.658711,             !- Vertex 4 X-coordinate {m}
-1.431000,             !- Vertex 4 Y-coordinate {m}
2.743929;             !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
LivingEastWindow,       !- Name
Window,                !- Surface Type
Curio Window,          !- Construction Name
LivingEastWall,         !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
                        !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
11.885463,              !- Vertex 1 X-coordinate {m}
-1.344664,             !- Vertex 1 Y-coordinate {m}
2.718146,              !- Vertex 1 Z-coordinate {m}
11.885463,              !- Vertex 2 X-coordinate {m}
-1.344664,             !- Vertex 2 Y-coordinate {m}
0.432146,              !- Vertex 2 Z-coordinate {m}

                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
9.561694,               !- Vertex 1 X-coordinate {m}
3.414050,              !- Vertex 1 Y-coordinate {m}
2.725604,              !- Vertex 1 Z-coordinate {m}
9.561694,               !- Vertex 2 X-coordinate {m}
3.414050,              !- Vertex 2 Y-coordinate {m}
0.439604,              !- Vertex 2 Z-coordinate {m}
8.555854,              !- Vertex 3 X-coordinate {m}
3.414050,              !- Vertex 3 Y-coordinate {m}
0.439604,              !- Vertex 3 Z-coordinate {m}
8.555854,              !- Vertex 4 X-coordinate {m}
3.414050,              !- Vertex 4 Y-coordinate {m}
2.725604;             !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
N Win 3,                !- Name
GlassDoor,             !- Surface Type
Curio Window,          !- Construction Name
LivingNorthWall,        !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
North Interior Shading Control, !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
8.457906,               !- Vertex 1 X-coordinate {m}
3.414050,              !- Vertex 1 Y-coordinate {m}
2.733062,              !- Vertex 1 Z-coordinate {m}
8.457906,               !- Vertex 2 X-coordinate {m}
3.414050,              !- Vertex 2 Y-coordinate {m}
0.447062,              !- Vertex 2 Z-coordinate {m}
7.452066,               !- Vertex 3 X-coordinate {m}
3.414050,              !- Vertex 3 Y-coordinate {m}
0.447062,              !- Vertex 3 Z-coordinate {m}
7.452066,               !- Vertex 4 X-coordinate {m}
3.414050,              !- Vertex 4 Y-coordinate {m}
2.733062;             !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
N Win 4,                !- Name
Window,                !- Surface Type
Curio Window,          !- Construction Name
LivingNorthWall,        !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
North Interior Shading Control, !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
7.354118,               !- Vertex 1 X-coordinate {m}
3.414050,              !- Vertex 1 Y-coordinate {m}
2.733062,              !- Vertex 1 Z-coordinate {m}
7.354118,               !- Vertex 2 X-coordinate {m}
3.414050,              !- Vertex 2 Y-coordinate {m}
0.447062,              !- Vertex 2 Z-coordinate {m}
6.348278,               !- Vertex 3 X-coordinate {m}
3.414050,              !- Vertex 3 Y-coordinate {m}
0.447062,              !- Vertex 3 Z-coordinate {m}
6.348278,               !- Vertex 4 X-coordinate {m}
3.414050,              !- Vertex 4 Y-coordinate {m}
2.733062;             !- Vertex 4 Z-coordinate {m}

                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
11.268263,              !- Vertex 1 X-coordinate {m}
-0.415814,             !- Vertex 1 Y-coordinate {m}
2.514600,              !- Vertex 1 Z-coordinate {m}

FenestrationSurface:Detailed,
N Win 5,                !- Name
Window,                !- Surface Type
Curio Window,          !- Construction Name
LivingNorthWall,        !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
North Interior Shading Control, !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
6.242871,               !- Vertex 1 X-coordinate {m}
3.414050,              !- Vertex 1 Y-coordinate {m}
2.733062,              !- Vertex 1 Z-coordinate {m}
6.242871,               !- Vertex 2 X-coordinate {m}
3.414050,              !- Vertex 2 Y-coordinate {m}
0.447062,              !- Vertex 2 Z-coordinate {m}
5.237031,               !- Vertex 3 X-coordinate {m}
3.414050,              !- Vertex 3 Y-coordinate {m}
0.447062,              !- Vertex 3 Z-coordinate {m}
5.237031,               !- Vertex 4 X-coordinate {m}
3.414050,              !- Vertex 4 Y-coordinate {m}
2.733062;             !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
Bath North Window,     !- Name
Window,                !- Surface Type
Curio Window,          !- Construction Name
Bath North Wall,        !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
                        !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
1.700062,               !- Vertex 1 X-coordinate {m}
3.414050,              !- Vertex 1 Y-coordinate {m}
2.730603,              !- Vertex 1 Z-coordinate {m}
1.700062,               !- Vertex 2 X-coordinate {m}
3.414050,              !- Vertex 2 Y-coordinate {m}
0.444603,              !- Vertex 2 Z-coordinate {m}
1.395262,               !- Vertex 3 X-coordinate {m}
3.414050,              !- Vertex 3 Y-coordinate {m}
0.444603,              !- Vertex 3 Z-coordinate {m}
1.395262,               !- Vertex 4 X-coordinate {m}
3.414050,              !- Vertex 4 Y-coordinate {m}
2.730603;             !- Vertex 4 Z-coordinate {m}

FenestrationSurface:Detailed,
Bath Hall Door West,   !- Name
Door,                  !- Surface Type
Curio West Door,       !- Construction Name
Bath West South Ext Wall, !- Building Surface Name
                        !- Outside Boundary Condition Object
                        !- View Factor to Ground
                        !- Shading Control Name
                        !- Frame and Divider Name
                        !- Multiplier
4,                      !- Number of Vertices
1.268263,               !- Vertex 1 X-coordinate {m}
-0.415814,             !- Vertex 1 Y-coordinate {m}
2.514600,              !- Vertex 1 Z-coordinate {m}
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1.268263,      !- Vertex 2 X-coordinate {m}
-0.415184,    !- Vertex 2 Y-coordinate {m}
0.381000,     !- Vertex 2 Z-coordinate {m}
1.268263,      !- Vertex 3 X-coordinate {m}
-1.330214,    !- Vertex 3 Y-coordinate {m}
0.381000,     !- Vertex 3 Z-coordinate {m}
1.268263,      !- Vertex 4 X-coordinate {m}
-1.330214,    !- Vertex 4 Y-coordinate {m}
2.514600;      !- Vertex 4 Z-coordinate {m}

!- ===== ALL OBJECTS IN CLASS: WINDOWPROPERTY:SHADINGCONTROL =====

WindowProperty:ShadingControl,
South Exterior Shading Control, !- Name
ExteriorShade,                !- Shading Type
,                              !- Construction with Shading Name
OnIfScheduleAllows,           !- Shading Control Type
DownSummer Shading Schedule,  !- Schedule Name
,                              !- Setpoint {W/m2, W or deg C}
Yes,                          !- Shading Control Is Scheduled
No,                           !- Glare Control Is Active
HIGH REFLECT - LOW TRANS SHADE, !- Shading Device Material Name
FixedSlatAngle,               !- Type of Slat Angle Control for Blinds
;                              !- Slat Angle Schedule Name

WindowProperty:ShadingControl,
North Interior Shading Control, !- Name
InteriorShade,                !- Shading Type
,                              !- Construction with Shading Name
OnIfScheduleAllows,           !- Shading Control Type
DownWinter Shading Schedule,  !- Schedule Name
,                              !- Setpoint {W/m2, W or deg C}
Yes,                          !- Shading Control Is Scheduled
No,                           !- Glare Control Is Active
HIGH REFLECT - LOW TRANS SHADE, !- Shading Device Material Name
FixedSlatAngle,               !- Type of Slat Angle Control for Blinds
;                              !- Slat Angle Schedule Name

!- ===== ALL OBJECTS IN CLASS: SHADING:SITE:DETAILED =====

Shading:Site:Detailed,
!F601C,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
4.046388,             !- Vertex 1 X-coordinate {m}
-3.259800,            !- Vertex 1 Y-coordinate {m}
0.381000,             !- Vertex 1 Z-coordinate {m}
4.046388,             !- Vertex 2 X-coordinate {m}
-1.431000,            !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
11.885539,            !- Vertex 3 X-coordinate {m}
-1.431000,            !- Vertex 3 Y-coordinate {m}
0.381000,             !- Vertex 3 Z-coordinate {m}
11.885539,            !- Vertex 4 X-coordinate {m}
-3.259800,            !- Vertex 4 Y-coordinate {m}
0.381000;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
DE910B,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices

Shading:Site:Detailed,
A0EE2E,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
4.046388,             !- Vertex 1 X-coordinate {m}
-3.336000,            !- Vertex 1 Y-coordinate {m}
1.143000,             !- Vertex 1 Z-coordinate {m}
4.046388,             !- Vertex 2 X-coordinate {m}
-3.259800,            !- Vertex 2 Y-coordinate {m}
1.143000,             !- Vertex 2 Z-coordinate {m}
11.885539,            !- Vertex 3 X-coordinate {m}
-3.259800,            !- Vertex 3 Y-coordinate {m}
1.143000,             !- Vertex 3 Z-coordinate {m}
11.885539,            !- Vertex 4 X-coordinate {m}
-3.336000,            !- Vertex 4 Y-coordinate {m}
1.143000;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
CBFFE9,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
3.131912,             !- Vertex 1 X-coordinate {m}
9.205250,             !- Vertex 1 Y-coordinate {m}
0.381000,             !- Vertex 1 Z-coordinate {m}
11.809263,            !- Vertex 2 X-coordinate {m}
9.205250,             !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
11.809263,            !- Vertex 3 X-coordinate {m}
9.205250,             !- Vertex 3 Y-coordinate {m}
3.414050,             !- Vertex 3 Z-coordinate {m}
0.381000,             !- Vertex 4 X-coordinate {m}
3.131912,             !- Vertex 4 Y-coordinate {m}
3.414050,             !- Vertex 4 Z-coordinate {m}
0.381000;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
A202C0,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
11.885463,            !- Vertex 1 X-coordinate {m}
9.281450,             !- Vertex 1 Y-coordinate {m}
2.819400,             !- Vertex 1 Z-coordinate {m}
11.885463,            !- Vertex 2 X-coordinate {m}
9.205250,             !- Vertex 2 Y-coordinate {m}
2.819400,             !- Vertex 2 Z-coordinate {m}
3.131912,             !- Vertex 3 X-coordinate {m}
9.205250,             !- Vertex 3 Y-coordinate {m}
2.819400,             !- Vertex 3 Z-coordinate {m}
3.131912,             !- Vertex 4 X-coordinate {m}
9.281450,             !- Vertex 4 Y-coordinate {m}
2.819400,             !- Vertex 4 Z-coordinate {m}
0.381000;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
AA72F6,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
3.131912,             !- Vertex 1 X-coordinate {m}
9.205250,             !- Vertex 1 Y-coordinate {m}
2.819400,             !- Vertex 1 Z-coordinate {m}
3.131912,             !- Vertex 2 X-coordinate {m}
9.205250,             !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
3.131912,             !- Vertex 3 X-coordinate {m}

11.885539,          !- Vertex 1 X-coordinate {m}
-3.336000,          !- Vertex 1 Y-coordinate {m}
1.143000,           !- Vertex 1 Z-coordinate {m}
11.885539,          !- Vertex 2 X-coordinate {m}
-3.336000,          !- Vertex 2 Y-coordinate {m}
1.143000,           !- Vertex 2 Z-coordinate {m}
0.381000,           !- Vertex 3 X-coordinate {m}
-3.259800,          !- Vertex 3 Y-coordinate {m}
1.143000,           !- Vertex 3 Z-coordinate {m}
11.885539,          !- Vertex 4 X-coordinate {m}
-3.259800,          !- Vertex 4 Y-coordinate {m}
1.143000;           !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
B9D96C,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
11.885539,            !- Vertex 1 X-coordinate {m}
-3.259800,            !- Vertex 1 Y-coordinate {m}
1.143000,             !- Vertex 1 Z-coordinate {m}
11.885539,            !- Vertex 2 X-coordinate {m}
-3.259800,            !- Vertex 2 Y-coordinate {m}
1.143000,             !- Vertex 2 Z-coordinate {m}
0.381000,             !- Vertex 3 X-coordinate {m}
-3.336000,            !- Vertex 3 Y-coordinate {m}
0.381000,             !- Vertex 3 Z-coordinate {m}
11.885539,            !- Vertex 4 X-coordinate {m}
-3.336000,            !- Vertex 4 Y-coordinate {m}
1.143000;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
6AC08A,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
4.046388,             !- Vertex 1 X-coordinate {m}
-3.259800,            !- Vertex 1 Y-coordinate {m}
1.143000,             !- Vertex 1 Z-coordinate {m}
4.046388,             !- Vertex 2 X-coordinate {m}
-3.259800,            !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
11.885539,            !- Vertex 3 X-coordinate {m}
-3.259800,            !- Vertex 3 Y-coordinate {m}
0.381000,             !- Vertex 3 Z-coordinate {m}
11.885539,            !- Vertex 4 X-coordinate {m}
-3.259800,            !- Vertex 4 Y-coordinate {m}
1.143000;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
E1CA37,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
4.046388,             !- Vertex 1 X-coordinate {m}
-3.336000,            !- Vertex 1 Y-coordinate {m}
1.143000,             !- Vertex 1 Z-coordinate {m}
4.046388,             !- Vertex 2 X-coordinate {m}
-3.336000,            !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
4.046388,             !- Vertex 3 X-coordinate {m}
-3.259800,            !- Vertex 3 Y-coordinate {m}
0.381000,             !- Vertex 3 Z-coordinate {m}
4.046388,             !- Vertex 4 X-coordinate {m}
-3.259800,            !- Vertex 4 Y-coordinate {m}
1.143000;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
88E2E8,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
11.885463,            !- Vertex 1 X-coordinate {m}
9.281450,             !- Vertex 1 Y-coordinate {m}
2.819400,             !- Vertex 1 Z-coordinate {m}
11.885463,            !- Vertex 2 X-coordinate {m}
9.281450,             !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
11.885463,            !- Vertex 3 X-coordinate {m}
9.205250,             !- Vertex 3 Y-coordinate {m}
0.381000,             !- Vertex 3 Z-coordinate {m}
11.885463,            !- Vertex 4 X-coordinate {m}
9.205250,             !- Vertex 4 Y-coordinate {m}
2.819400;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
B880CE,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
11.809263,            !- Vertex 1 X-coordinate {m}
9.205250,             !- Vertex 1 Y-coordinate {m}
2.819400,             !- Vertex 1 Z-coordinate {m}
11.809263,            !- Vertex 2 X-coordinate {m}
9.205250,             !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
3.131912,             !- Vertex 3 X-coordinate {m}
9.205250,             !- Vertex 3 Y-coordinate {m}
0.381000,             !- Vertex 3 Z-coordinate {m}
3.131912,             !- Vertex 4 X-coordinate {m}
9.281450,             !- Vertex 4 Y-coordinate {m}
2.819400;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
CFA923,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
3.131912,             !- Vertex 1 X-coordinate {m}
9.281450,             !- Vertex 1 Y-coordinate {m}
2.819400,             !- Vertex 1 Z-coordinate {m}
3.131912,             !- Vertex 2 X-coordinate {m}
9.281450,             !- Vertex 2 Y-coordinate {m}
0.381000,             !- Vertex 2 Z-coordinate {m}
11.885463,            !- Vertex 3 X-coordinate {m}
9.281450,             !- Vertex 3 Y-coordinate {m}
0.381000,             !- Vertex 3 Z-coordinate {m}
11.885463,            !- Vertex 4 X-coordinate {m}
9.281450,             !- Vertex 4 Y-coordinate {m}
2.819400;            !- Vertex 4 Z-coordinate {m}

Shading:Site:Detailed,
8352C4,                !- Name
,                      !- Transmittance Schedule Name
4,                    !- Number of Vertices
3.131912,             !- Vertex 1 X-coordinate {m}
9.205250,             !- Vertex 1 Y-coordinate {m}

```

```
Shading:Building:Detailed,      !- Name
253206,                        !- Transmittance Schedule Name
4,                              !- Number of Vertices
1.268263,                      !- Vertex 1 X-coordinate {m}
```

```

0.245400,      !- Vertex 1 Y-coordinate {m}
2.819400,      !- Vertex 1 Z-coordinate {m}
1.268263,      !- Vertex 2 X-coordinate {m}
-1.431000,     !- Vertex 2 Y-coordinate {m}
2.819400,      !- Vertex 2 Z-coordinate {m}
0.506263,      !- Vertex 3 X-coordinate {m}
-1.431000,     !- Vertex 3 Y-coordinate {m}
2.819400,      !- Vertex 3 Z-coordinate {m}
0.506263,      !- Vertex 4 X-coordinate {m}
0.245400,      !- Vertex 4 Y-coordinate {m}
2.819400;      !- Vertex 4 Z-coordinate {m}

Shading:Building:Detailed,
DoorOverhang,  !- Name
4,             !- Transmittance Schedule Name
4,             !- Number of Vertices
1.268263,      !- Vertex 1 X-coordinate {m}
0.245400,      !- Vertex 1 Y-coordinate {m}
3.556000,      !- Vertex 1 Z-coordinate {m}
1.268263,      !- Vertex 2 X-coordinate {m}
0.245400,      !- Vertex 2 Y-coordinate {m}
2.819400,      !- Vertex 2 Z-coordinate {m}
0.506263,      !- Vertex 3 X-coordinate {m}
0.245400,      !- Vertex 3 Y-coordinate {m}
2.819400,      !- Vertex 3 Z-coordinate {m}
0.506263,      !- Vertex 4 X-coordinate {m}
0.245400,      !- Vertex 4 Y-coordinate {m}
3.556000;      !- Vertex 4 Z-coordinate {m}

Shading:Building:Detailed,
Door Overhang, !- Name
4,             !- Transmittance Schedule Name
4,             !- Number of Vertices
0.506263,      !- Vertex 1 X-coordinate {m}
0.245400,      !- Vertex 1 Y-coordinate {m}
3.556000,      !- Vertex 1 Z-coordinate {m}
0.506263,      !- Vertex 2 X-coordinate {m}
0.245400,      !- Vertex 2 Y-coordinate {m}
2.819400,      !- Vertex 2 Z-coordinate {m}
0.506263,      !- Vertex 3 X-coordinate {m}
-1.431000,     !- Vertex 3 Y-coordinate {m}
2.819400,      !- Vertex 3 Z-coordinate {m}
0.506263,      !- Vertex 4 X-coordinate {m}
-1.431000,     !- Vertex 4 Y-coordinate {m}
3.556000;      !- Vertex 4 Z-coordinate {m}

Shading:Building:Detailed,
35748C,        !- Name
4,             !- Transmittance Schedule Name
4,             !- Number of Vertices
1.268263,      !- Vertex 1 X-coordinate {m}
-1.431000,     !- Vertex 1 Y-coordinate {m}
3.556000,      !- Vertex 1 Z-coordinate {m}
1.268263,      !- Vertex 2 X-coordinate {m}
-1.431000,     !- Vertex 2 Y-coordinate {m}
2.819400,      !- Vertex 2 Z-coordinate {m}
1.268263,      !- Vertex 3 X-coordinate {m}
0.245400,      !- Vertex 3 Y-coordinate {m}
2.819400,      !- Vertex 3 Z-coordinate {m}
1.268263,      !- Vertex 4 X-coordinate {m}
0.245400,      !- Vertex 4 Y-coordinate {m}
3.556000;      !- Vertex 4 Z-coordinate {m}

3.708400,      !- Vertex 3 Z-coordinate {m}
12.286783,     !- Vertex 4 X-coordinate {m}
0.756059,      !- Vertex 4 Y-coordinate {m}
4.487164;      !- Vertex 4 Z-coordinate {m}

Shading:Building:Detailed,
Solar Thermal Collector, !- Name
4,             !- Transmittance Schedule Name
4,             !- Number of Vertices
0.658663,      !- Vertex 1 X-coordinate {m}
-1.227513,     !- Vertex 1 Y-coordinate {m}
4.237228,      !- Vertex 1 Z-coordinate {m}
0.658663,      !- Vertex 2 X-coordinate {m}
-2.143470,     !- Vertex 2 Y-coordinate {m}
3.708400,      !- Vertex 2 Z-coordinate {m}
12.545863,     !- Vertex 3 X-coordinate {m}
-2.143470,     !- Vertex 3 Y-coordinate {m}
3.708400,      !- Vertex 3 Z-coordinate {m}
12.545863,     !- Vertex 4 X-coordinate {m}
-1.227513,     !- Vertex 4 Y-coordinate {m}
4.237228;      !- Vertex 4 Z-coordinate {m}

!- ===== ALL OBJECTS IN CLASS: SURFACECONTROL:MOVABLEINSULATION =====

SurfaceControl:MovableInsulation,
Outside,        !- Insulation Type
LivingNorthWall, !- Surface Name
16mm Polycarb,  !- Material Name
North Moveable Insulation Schedule; !- Schedule Name

!- ===== ALL OBJECTS IN CLASS: PEOPLE =====

People,
Living Occupants, !- Name
Living-Kitchen,   !- Zone Name
Occupancy,        !- Number of People Schedule Name
People,           !- Number of People Calculation Method
2,               !- Number of People
,               !- People per Zone Floor Area {person/m2}
,               !- Zone Floor Area per Person {m2/person}
0.3,            !- Fraction Radiant
autocalculate,   !- Sensible Heat Fraction
Occupant Activity Level, !- Activity Level Schedule Name
No,              !- Enable ASHRAE 55 Comfort Warnings
ZoneAveraged;    !- Mean Radiant Temperature Calculation Type

!- ===== ALL OBJECTS IN CLASS: LIGHTS =====

Lights,
Living Ambient Lighting, !- Name
Living-Kitchen,         !- Zone Name
AmbientLightSchedule,   !- Schedule Name
LightingLevel,          !- Design Level Calculation Method
206,                    !- Lighting Level {W}
,                        !- Watts per Zone Floor Area {W/m2}
,                        !- Watts per Person {W/person}
0,                      !- Return Air Fraction
0.7,                   !- Fraction Radiant
0.3,                   !- Fraction Visible
0,                      !- Fraction Replaceable
General,               !- End-Use Subcategory
No;                    !- Return Air Fraction Calculated from Plenum Temperature

!- ===== ALL OBJECTS IN CLASS: ELECTRIC EQUIPMENT =====

ElectricEquipment,
Living Appliances,      !- Name
Living-Kitchen,         !- Zone Name
Living Appliance Schedule, !- Schedule Name
EquipmentLevel,         !- Design Level Calculation Method
2186,                   !- Design Level {W}
,                       !- Watts per Zone Floor Area {W/m2}
,                       !- Watts per Person {W/person}
0.1,                   !- Fraction Latent
0.6,                   !- Fraction Radiant
0,                     !- Fraction Lost
General;               !- End-Use Subcategory

```

```

ElectricEquipment,
  Bath Appliances,      !- Name
  Bath-Hall,           !- Zone Name
  Bath Appliance Schedule, !- Schedule Name
  EquipmentLevel,      !- Design Level Calculation Method
  1000,                !- Design Level {W}
  ,                    !- Watts per Zone Floor Area {W/m2}
  ,                    !- Watts per Person {W/person}
  0.2,                 !- Fraction Latent
  0.6,                 !- Fraction Radiant
  0,                   !- Fraction Lost
  General;             !- End-Use Subcategory

!- ===== ALL OBJECTS IN CLASS: ZONEINFILTRATION:DESIGNFLOWRATE =====

ZoneInfiltration:DesignFlowRate,
  Living Infiltration, !- Name
  Living-Kitchen,     !- Zone Name
  Constant,           !- Schedule Name
  AirChanges/Hour,    !- Design Flow Rate Calculation Method
  ,                   !- Design Flow Rate {m3/s}
  ,                   !- Flow per Zone Floor Area {m3/s-m2}
  ,                   !- Flow per Exterior Surface Area {m3/s-m2}
  0.5,                !- Air Changes per Hour
  1,                  !- Constant Term Coefficient
  0,                  !- Temperature Term Coefficient
  0,                  !- Velocity Term Coefficient
  0;                  !- Velocity Squared Term Coefficient

ZoneInfiltration:DesignFlowRate,
  Bath Infiltration,  !- Name
  Bath-Hall,          !- Zone Name
  Constant,           !- Schedule Name
  AirChanges/Hour,    !- Design Flow Rate Calculation Method
  ,                   !- Design Flow Rate {m3/s}
  ,                   !- Flow per Zone Floor Area {m3/s-m2}
  ,                   !- Flow per Exterior Surface Area {m3/s-m2}
  0.5,                !- Air Changes per Hour
  1,                  !- Constant Term Coefficient
  0,                  !- Temperature Term Coefficient
  0,                  !- Velocity Term Coefficient
  0;                  !- Velocity Squared Term Coefficient

ZoneInfiltration:DesignFlowRate,
  Living Plenum Infiltration, !- Name
  LivingPlenum,          !- Zone Name
  Constant,              !- Schedule Name
  AirChanges/Hour,       !- Design Flow Rate Calculation Method
  ,                      !- Design Flow Rate {m3/s}
  ,                      !- Flow per Zone Floor Area {m3/s-m2}
  ,                      !- Flow per Exterior Surface Area {m3/s-m2}
  0.5,                  !- Air Changes per Hour
  1,                    !- Constant Term Coefficient
  0,                    !- Temperature Term Coefficient
  0,                    !- Velocity Term Coefficient
  0;                    !- Velocity Squared Term Coefficient

ZoneInfiltration:DesignFlowRate,
  Bath Plenum Infiltration, !- Name
  BathPlenum,              !- Zone Name
  Constant,                !- Schedule Name

0.8,                      !- Zone Cooling Design Supply Air Humidity Ratio {kg-H2O/kg-
air}
0.8,                      !- Zone Heating Design Supply Air Humidity Ratio {kg-H2O/kg-
air}
Flow/Person,              !- Outdoor Air Method
0.00944,                  !- Outdoor Air Flow per Person {m3/s}
,                          !- Outdoor Air Flow per Zone Floor Area {m3/s-m2}
,                          !- Outdoor Air Flow per Zone {m3/s}
,                          !- Zone Sizing Factor
DesignDay,                !- Cooling Design Air Flow Method
0.000762,                 !- Cooling Design Air Flow Rate {m3/s}
,                          !- Cooling Minimum Air Flow per Zone Floor Area {m3/s-m2}
,                          !- Cooling Minimum Air Flow {m3/s}
,                          !- Cooling Minimum Air Flow Fraction
DesignDay,                !- Heating Design Air Flow Method
0.002032,                 !- Heating Design Air Flow Rate {m3/s}
0.1415762,               !- Heating Maximum Air Flow per Zone Floor Area {m3/s-m2}
0.3;                      !- Heating Maximum Air Flow {m3/s}
                          !- Heating Maximum Air Flow Fraction

Sizing:Zone,
  Bath-Hall,              !- Zone Name
  14,                     !- Zone Cooling Design Supply Air Temperature {C}
  40,                     !- Zone Heating Design Supply Air Temperature {C}
  0.8,                    !- Zone Cooling Design Supply Air Humidity Ratio {kg-H2O/kg-
air}
0.8,                      !- Zone Heating Design Supply Air Humidity Ratio {kg-H2O/kg-
air}
Flow/Person,              !- Outdoor Air Method
0.00944,                  !- Outdoor Air Flow per Person {m3/s}
,                          !- Outdoor Air Flow per Zone Floor Area {m3/s-m2}
,                          !- Outdoor Air Flow per Zone {m3/s}
,                          !- Zone Sizing Factor
DesignDay,                !- Cooling Design Air Flow Method
0.000762,                 !- Cooling Design Air Flow Rate {m3/s}
,                          !- Cooling Minimum Air Flow per Zone Floor Area {m3/s-m2}
,                          !- Cooling Minimum Air Flow {m3/s}
,                          !- Cooling Minimum Air Flow Fraction
DesignDay,                !- Heating Design Air Flow Method
0.002032,                 !- Heating Design Air Flow Rate {m3/s}
0.1415762,               !- Heating Maximum Air Flow per Zone Floor Area {m3/s-m2}
0.3;                      !- Heating Maximum Air Flow {m3/s}
                          !- Heating Maximum Air Flow Fraction

!- ===== ALL OBJECTS IN CLASS: SIZING:PLANT =====

Sizing:Plant,
  Radiant Loop,           !- Plant or Condenser Loop Name
  Heating,                !- Loop Type
  40,                     !- Design Loop Exit Temperature {C}
  5;                       !- Loop Design Temperature Difference {deltaC}

Sizing:Plant,
  Collector Loop,         !- Plant or Condenser Loop Name
  Heating,                !- Loop Type
  80,                     !- Design Loop Exit Temperature {C}
  11;                     !- Loop Design Temperature Difference {deltaC}

Sizing:Plant,
  Secondary Loop,         !- Plant or Condenser Loop Name
  Heating,                !- Loop Type
  80,                     !- Design Loop Exit Temperature {C}

AirChanges/Hour,          !- Design Flow Rate Calculation Method
,                          !- Design Flow Rate {m3/s}
,                          !- Flow per Zone Floor Area {m3/s-m2}
0.5,                      !- Flow per Exterior Surface Area {m3/s-m2}
1,                        !- Air Changes per Hour
0,                        !- Constant Term Coefficient
0,                        !- Temperature Term Coefficient
0;                        !- Velocity Term Coefficient
0;                        !- Velocity Squared Term Coefficient

ZoneInfiltration:DesignFlowRate,
  Mech Plenum Infiltration, !- Name
  Mechanical-Plenum,       !- Zone Name
  Constant,                !- Schedule Name
  AirChanges/Hour,         !- Design Flow Rate Calculation Method
  ,                        !- Design Flow Rate {m3/s}
  ,                        !- Flow per Zone Floor Area {m3/s-m2}
  ,                        !- Flow per Exterior Surface Area {m3/s-m2}
  0.5,                    !- Air Changes per Hour
  1,                      !- Constant Term Coefficient
  0,                      !- Temperature Term Coefficient
  0,                      !- Velocity Term Coefficient
  0;                      !- Velocity Squared Term Coefficient

!- ===== ALL OBJECTS IN CLASS: ZONEINFILTRATION:EFFECTIVELEAKAGEAREA =====

ZoneInfiltration:EffectiveLeakageArea,
  Mech Infiltration,      !- Name
  Mechanical,             !- Zone Name
  Constant,               !- Schedule Name
  1500,                   !- Effective Air Leakage Area
  0.000145,               !- Stack Coefficient
  0.000174;               !- Wind Coefficient

!- ===== ALL OBJECTS IN CLASS: ZONECROSSMIXING =====

ZoneCrossMixing,
  LivingBathMixing,       !- Name
  Living-Kitchen,         !- Zone Name
  Constant,               !- Schedule Name
  Flow/Zone,              !- Design Flow Rate Calculation Method
  0.01,                   !- Design Flow Rate {m3/s}
  ,                       !- Flow Rate per Zone Floor Area {m3/s-m2}
  ,                       !- Flow Rate per Person {m3/s-person}
  ,                       !- Air Changes per Hour
  Bath-Hall;              !- Source Zone Name

!- ===== ALL OBJECTS IN CLASS: SIZING:PARAMETERS =====

Sizing:Parameters,
  1.15;                   !- Sizing Factor

!- ===== ALL OBJECTS IN CLASS: SIZING:ZONE =====

Sizing:Zone,
  Living-Kitchen,         !- Zone Name
  14,                     !- Zone Cooling Design Supply Air Temperature {C}
  40,                     !- Zone Heating Design Supply Air Temperature {C}

11;                       !- Loop Design Temperature Difference {deltaC}

!- ===== ALL OBJECTS IN CLASS: ZONECONTROL:THERMOSTAT =====

ZoneControl:Thermostat,
  Living Thermostat,      !- Name
  Living-Kitchen,         !- Zone Name
  Zone Control Type Sched, !- Control Type Schedule Name
  ThermostatSetpoint:SingleHeatingOrCooling, !- Control 1 Object Type
  Constant Temperature Setpoint; !- Control 1 Name

ZoneControl:Thermostat,
  Bath Thermostat,        !- Name
  Bath-Hall,              !- Zone Name
  Zone Control Type Sched, !- Control Type Schedule Name
  ThermostatSetpoint:SingleHeatingOrCooling, !- Control 1 Object Type
  Constant Temperature Setpoint; !- Control 1 Name

!- ===== ALL OBJECTS IN CLASS: THERMOSTATSETPPOINT:SINGLEHEATINGORCOOLING =====

ThermostatSetpoint:SingleHeatingOrCooling,
  Constant Temperature Setpoint, !- Name
  Constant T Setpoint;          !- Setpoint Temperature Schedule Name

!- ===== ALL OBJECTS IN CLASS: ZONEHVAC:PACKAGEDTERMINALHEATPUMP =====

ZoneHVAC:PackagedTerminalHeatPump,
  Living PTHP,             !- Name
  FanAndCoilAvailSched,   !- Availability Schedule Name
  Living PTHP Inlet Node,  !- Air Inlet Node Name
  Living PTHP Supp Heating Coil Outlet Node, !- Air Outlet Node Name
  Living PTHP OA Mixer,    !- Outdoor Air Mixer Name
  autosize,                !- Supply Air Flow Rate During Cooling Operation {m3/s}
  autosize,                !- Supply Air Flow Rate During Heating Operation {m3/s}
  autosize,                !- Supply Air Flow Rate When No Cooling or Heating is Needed
  {m3/s}
  0,                       !- Outdoor Air Flow Rate During Cooling Operation {m3/s}
  0,                       !- Outdoor Air Flow Rate During Heating Operation {m3/s}
  0,                       !- Outdoor Air Flow Rate When No Cooling or Heating is
  Needed {m3/s}
  Fan:OnOff,              !- Supply Air Fan Object Type
  Living PTHP Supply Fan,  !- Supply Air Fan Name
  Coil:Heating:DX:SingleSpeed, !- Heating Coil Object Type
  Living PTHP Heating Coil, !- Heating Coil Name
  0.001,                   !- Heating Convergence Tolerance {dimensionless}
  -8,                      !- Minimum Outdoor Dry-Bulb Temperature for Compressor
  Operation {C}
  Coil:Cooling:DX:SingleSpeed, !- Cooling Coil Object Type
  Living PTHP Cooling Coil, !- Cooling Coil Name
  0.001,                   !- Cooling Convergence Tolerance {dimensionless}
  Coil:Heating:Electric,    !- Supplemental Heating Coil Object Type
  Living PTHP Supp Heating Coil, !- Supplemental Heating Coil Name
  autosize,                !- Maximum Supply Air Temperature from Supplemental Heater
  {C}
  21,                      !- Maximum Outdoor Dry-Bulb Temperature for Supplemental
  Heater Operation {C}
  DrawThrough,             !- Fan Placement
  FanModeSchedule;         !- Supply Air Fan Operating Mode Schedule Name

```

```

ZoneHVAC:PackagedTerminalHeatPump,
  Bath PTHP,           !- Name
  FanAndCoilAvailSched, !- Availability Schedule Name
  Bath PTHP Inlet Node, !- Air Inlet Node Name
  Bath PTHP Supp Heating Coil, !- Air Outlet Node Name
  Bath PTHP OA Mixer,   !- Outdoor Air Mixer Name
  autosize,            !- Supply Air Flow Rate During Cooling Operation {m3/s}
  autosize,            !- Supply Air Flow Rate During Heating Operation {m3/s}
  autosize,            !- Supply Air Flow Rate When No Cooling or Heating is Needed
{m3/s}
0,                     !- Outdoor Air Flow Rate During Cooling Operation {m3/s}
0,                     !- Outdoor Air Flow Rate During Heating Operation {m3/s}
0,                     !- Outdoor Air Flow Rate When No Cooling or Heating is
Needed {m3/s}
Fan:OnOff,            !- Supply Air Fan Object Type
Bath PTHP Supply Fan, !- Supply Air Fan Name
Coil:Heating:DX:SingleSpeed, !- Heating Coil Object Type
Bath PTHP Heating Coil, !- Heating Coil Name
0.001,               !- Heating Convergence Tolerance {dimensionless}
-8,                  !- Minimum Outdoor Dry-Bulb Temperature for Compressor
Operation {C}
Coil:Cooling:DX:SingleSpeed, !- Cooling Coil Object Type
Bath PTHP Cooling Coil, !- Cooling Coil Name
0.001,               !- Cooling Convergence Tolerance {dimensionless}
Coil:Heating:Electric, !- Supplemental Heating Coil Object Type
Bath PTHP Supp Heating Coil, !- Supplemental Heating Coil Name
autosize,            !- Maximum Supply Air Temperature from Supplemental Heater
{C}
21,                  !- Maximum Outdoor Dry-Bulb Temperature for Supplemental
Heater Operation {C}
DrawThrough,         !- Fan Placement
FanModeSchedule;     !- Supply Air Fan Operating Mode Schedule Name

```

!- ===== ALL OBJECTS IN CLASS: ZONEHVAC:ENERGYRECOVERYVENTILATOR =====

```

ZoneHVAC:EnergyRecoveryVentilator,
  ERV,                !- Name
  ERV Availability,    !- Availability Schedule Name
  ERV HX,             !- Heat Exchanger Name
  0.05,               !- Supply Air Flow Rate {m3/s}
  0.05,               !- Exhaust Air Flow Rate {m3/s}
  ERV Supply Fan,     !- Supply Air Fan Name
  ERV Exhaust Fan,    !- Exhaust Air Fan Name
  ERV Controller;     !- Controller Name

```

!- ===== ALL OBJECTS IN CLASS: ZONEHVAC:ENERGYRECOVERYVENTILATOR:CONTROLLER =====

```

ZoneHVAC:EnergyRecoveryVentilator:Controller,
  ERV Controller,     !- Name
  ,                   !- Temperature High Limit {C}
  ,                   !- Temperature Low Limit {C}
  ,                   !- Enthalpy High Limit {J/kg}
  ,                   !- Dewpoint Temperature Limit {C}
  ,                   !- Electronic Enthalpy Limit Curve Name
  NoExhaustAirTemperatureLimit, !- Exhaust Air Temperature Limit
  NoExhaustAirEnthalpyLimit,    !- Exhaust Air Enthalpy Limit
  No,                          !- Time of Day Economizer Flow Control Schedule Name
  1,                            !- High Humidity Control Flag
  1,                            !- Humidistat Control Zone Name
  1,                            !- High Humidity Outdoor Air Flow Ratio

```

```

Living Radiant,      !- Zone Equipment 3 Name
3,                   !- Zone Equipment 3 Cooling Priority
2;                   !- Zone Equipment 3 Heating Priority

```

```

ZoneHVAC:EquipmentList,
  Bath Equipment,    !- Name
  ZoneHVAC:PackagedTerminalHeatPump, !- Zone Equipment 1 Object Type
  Bath PTHP,         !- Zone Equipment 1 Name
  1,                 !- Zone Equipment 1 Cooling Priority
  2,                 !- Zone Equipment 1 Heating Priority
  ZoneHVAC:LowTemperatureRadiant:VariableFlow, !- Zone Equipment 2 Object Type
  Bath Radiant,      !- Zone Equipment 2 Name
  2,                 !- Zone Equipment 2 Cooling Priority
  1;                 !- Zone Equipment 2 Heating Priority

```

!- ===== ALL OBJECTS IN CLASS: ZONEHVAC:EQUIPMENTCONNECTIONS =====

```

ZoneHVAC:EquipmentConnections,
  Living-Kitchen,    !- Zone Name
  Living Equipment,  !- Zone Conditioning Equipment List Name
  LivingInlets,      !- Zone Air Inlet Node or NodeList Name
  LivingExhausts,    !- Zone Air Exhaust Node or NodeList Name
  Living Air Node,   !- Zone Air Node Name
  Living Outlet Node; !- Zone Return Air Node Name

```

```

ZoneHVAC:EquipmentConnections,
  Bath-Hall,         !- Zone Name
  Bath Equipment,    !- Zone Conditioning Equipment List Name
  BathInlets,        !- Zone Air Inlet Node or NodeList Name
  BathExhausts,      !- Zone Air Exhaust Node or NodeList Name
  Bath Air Node,     !- Zone Air Node Name
  Bath Outlet Node;  !- Zone Return Air Node Name

```

!- ===== ALL OBJECTS IN CLASS: FAN:ONOFF =====

```

Fan:OnOff,
  ERV Supply Fan,     !- Name
  ERV Availability,   !- Availability Schedule Name
  0.7,                !- Fan Efficiency
  100,               !- Pressure Rise {Pa}
  0.05,              !- Maximum Flow Rate {m3/s}
  0.9,               !- Motor Efficiency
  0,                 !- Motor In Airstream Fraction
  ERV HX Supply Outlet Node, !- Air Inlet Node Name
  ERV Supply Fan Outlet Node, !- Air Outlet Node Name
  ,                  !- Fan Power Ratio Function of Speed Ratio Curve Name
  ,                  !- Fan Efficiency Ratio Function of Speed Ratio Curve Name
  General;           !- End-Use Subcategory

```

```

Fan:OnOff,
  ERV Exhaust Fan,    !- Name
  ERV Availability,   !- Availability Schedule Name
  0.7,                !- Fan Efficiency
  100,               !- Pressure Rise {Pa}
  0.05,              !- Maximum Flow Rate {m3/s}
  0.9,               !- Motor Efficiency
  0,                 !- Motor In Airstream Fraction
  ERV HX Exhaust Outlet Node, !- Air Inlet Node Name
  ERV Exhaust Fan Outlet Node, !- Air Outlet Node Name
  ,                  !- Fan Power Ratio Function of Speed Ratio Curve Name
  ,                  !- Fan Efficiency Ratio Function of Speed Ratio Curve Name

```

```

No;                  !- Control High Indoor Humidity Based on Outdoor Humidity
Ratio

```

!- ===== ALL OBJECTS IN CLASS: ZONEHVAC:LOWTEMPERATURERADIANT:VARIABLEFLOW =====

```

ZoneHVAC:LowTemperatureRadiant:VariableFlow,
  Living Radiant,     !- Name
  RadiantAvailSched, !- Availability Schedule Name
  Living-Kitchen,     !- Zone Name
  LivingFloor,        !- Surface Name or Radiant Surface Group Name
  0.013,              !- Hydronic Tubing Inside Diameter {m}
  autosize,           !- Hydronic Tubing Length {m}
  MeanAirTemperature, !- Temperature Control Type
  autosize,           !- Maximum Hot Water Flow {m3/s}
  Living Radiant Inlet Node, !- Heating Water Inlet Node Name
  Living Radiant Outlet Node, !- Heating Water Outlet Node Name
  2,                  !- Heating Control Throttling Range {deltaC}
  Radiant Temp Throttling Schedule, !- Heating Control Temperature Schedule Name
  ,                   !- Maximum Cold Water Flow {m3/s}
  ,                   !- Cooling Water Inlet Node Name
  ,                   !- Cooling Water Outlet Node Name
  ,                   !- Cooling Control Throttling Range {deltaC}
  ,                   !- Cooling Control Temperature Schedule Name
  SimpleOff,          !- Condensation Control Type
  1;                  !- Condensation Control Dewpoint Offset {C}

```

```

ZoneHVAC:LowTemperatureRadiant:VariableFlow,
  Bath Radiant,       !- Name
  RadiantAvailSched, !- Availability Schedule Name
  Bath-Hall,          !- Zone Name
  BathFloor,          !- Surface Name or Radiant Surface Group Name
  0.013,              !- Hydronic Tubing Inside Diameter {m}
  autosize,           !- Hydronic Tubing Length {m}
  MeanAirTemperature, !- Temperature Control Type
  autosize,           !- Maximum Hot Water Flow {m3/s}
  Bath Radiant Inlet Node, !- Heating Water Inlet Node Name
  Bath Radiant Outlet Node, !- Heating Water Outlet Node Name
  2,                  !- Heating Control Throttling Range {deltaC}
  Radiant Temp Throttling Schedule, !- Heating Control Temperature Schedule Name
  ,                   !- Maximum Cold Water Flow {m3/s}
  ,                   !- Cooling Water Inlet Node Name
  ,                   !- Cooling Water Outlet Node Name
  ,                   !- Cooling Control Throttling Range {deltaC}
  ,                   !- Cooling Control Temperature Schedule Name
  SimpleOff,          !- Condensation Control Type
  1;                  !- Condensation Control Dewpoint Offset {C}

```

!- ===== ALL OBJECTS IN CLASS: ZONEHVAC:EQUIPMENTLIST =====

```

ZoneHVAC:EquipmentList,
  Living Equipment,   !- Name
  ZoneHVAC:EnergyRecoveryVentilator, !- Zone Equipment 1 Object Type
  ERV,                !- Zone Equipment 1 Name
  1,                  !- Zone Equipment 1 Cooling Priority
  1,                  !- Zone Equipment 1 Heating Priority
  ZoneHVAC:PackagedTerminalHeatPump, !- Zone Equipment 2 Object Type
  Living PTHP,        !- Zone Equipment 2 Name
  2,                  !- Zone Equipment 2 Cooling Priority
  3,                  !- Zone Equipment 2 Heating Priority
  ZoneHVAC:LowTemperatureRadiant:VariableFlow, !- Zone Equipment 3 Object Type

```

```

General;             !- End-Use Subcategory

```

```

Fan:OnOff,
  Living PTHP Supply Fan, !- Name
  FanAndCoilAvailSched, !- Availability Schedule Name
  0.7,                   !- Fan Efficiency
  100,                  !- Pressure Rise {Pa}
  autosize,             !- Maximum Flow Rate {m3/s}
  0.9,                  !- Motor Efficiency
  1,                    !- Motor In Airstream Fraction
  Living PTHP Heating Coil Outlet Node, !- Air Inlet Node Name
  Living PTHP Supply Fan Outlet Node, !- Air Outlet Node Name
  ,                     !- Fan Power Ratio Function of Speed Ratio Curve Name
  ,                     !- Fan Efficiency Ratio Function of Speed Ratio Curve Name
  General;              !- End-Use Subcategory

```

```

Fan:OnOff,
  Bath PTHP Supply Fan, !- Name
  FanAndCoilAvailSched, !- Availability Schedule Name
  0.7,                   !- Fan Efficiency
  100,                  !- Pressure Rise {Pa}
  autosize,             !- Maximum Flow Rate {m3/s}
  0.9,                  !- Motor Efficiency
  1,                    !- Motor In Airstream Fraction
  Bath PTHP Heating Coil Outlet Node, !- Air Inlet Node Name
  Bath PTHP Supply Fan Outlet Node, !- Air Outlet Node Name
  ,                     !- Fan Power Ratio Function of Speed Ratio Curve Name
  ,                     !- Fan Efficiency Ratio Function of Speed Ratio Curve Name
  General;              !- End-Use Subcategory

```

!- ===== ALL OBJECTS IN CLASS: COIL:COOLING:DX:SINGLESPEED =====

```

Coil:Cooling:DX:SingleSpeed,
  Living PTHP Cooling Coil, !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  autosize,                 !- Rated Total Cooling Capacity {W}
  autosize,                 !- Rated Sensible Heat Ratio
  3.8,                     !- Rated COP
  autosize,                 !- Rated Air Flow Rate {m3/s}
  Living OA Mixer Outlet Node, !- Air Inlet Node Name
  Living PTHP Cooling Coil Outlet Node, !- Air Outlet Node Name
  HPACCoolCapFF,           !- Total Cooling Capacity Function of Temperature Curve Name
  HPACCoolCapFFF,          !- Total Cooling Capacity Function of Flow Fraction Curve Name
  Name
  HPACCOOLEIRFT,           !- Energy Input Ratio Function of Temperature Curve Name
  HPACCOOLEIRFFF,          !- Energy Input Ratio Function of Flow Fraction Curve Name
  HPACCOOLPLFFPLR,         !- Part Load Fraction Correlation Curve Name
  CyclingFanAndCompressor, !- Supply Air Fan Operating Mode
  100,                      !- Nominal Time for Condensate Removal to Begin {s}
  1.5,                     !- Ratio of Initial Moisture Evaporation Rate and Steady
State Latent Capacity {dimensionless}
3,                          !- Maximum Cycling Rate {cycles/hr}
45,                         !- Latent Capacity Time Constant {s}
Living PTHP Condenser Outdoor Air Node, !- Condenser Air Inlet Node Name
AirCooled,                 !- Condenser Type
0.9,                       !- Evaporative Condenser Effectiveness {dimensionless}
autosize,                  !- Evaporative Condenser Air Flow Rate {m3/s}
autosize,                  !- Evaporative Condenser Pump Rated Power Consumption {W}
10;                         !- Crankcase Heater Capacity {W}
10;                         !- Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater
Operation {C}

```

```

Coil:Cooling:DX:SingleSpeed,
  Bath PTHP Cooling Coil,      !- Name
  FanAndCoilAvailSched,      !- Availability Schedule Name
  autosize,                   !- Rated Total Cooling Capacity {W}
  autosize,                   !- Rated Sensible Heat Ratio
  3.8,                        !- Rated COP
  autosize,                   !- Rated Air Flow Rate {m3/s}
  Bath OA Mixer Outlet Node,   !- Air Inlet Node Name
  Bath PTHP Cooling Coil Outlet Node, !- Air Outlet Node Name
  HPACCoolCapFT,              !- Total Cooling Capacity Function of Temperature Curve Name
  HPACCoolCapFFF,            !- Total Cooling Capacity Function of Flow Fraction Curve
Name
  HPACCOLEIRFT,               !- Energy Input Ratio Function of Temperature Curve Name
  HPACCOLEIRFFF,              !- Energy Input Ratio Function of Flow Fraction Curve Name
  HPACCOOLPLFFPLR,           !- Part Load Fraction Correlation Curve Name
  CyclingFanAndCompressor,    !- Supply Air Fan Operating Mode
  100,                        !- Nominal Time for Condensate Removal to Begin {s}
  1.5,                        !- Ratio of Initial Moisture Evaporation Rate and Steady
State Latent Capacity {dimensionless}
  3,                          !- Maximum Cycling Rate {cycles/hr}
  45,                         !- Latent Capacity Time Constant {s}
  Bath PTHP Condenser Outdoor Air Node, !- Condenser Air Inlet Node Name
  AirCooled,                  !- Condenser Type
  0.9,                        !- Evaporative Condenser Effectiveness {dimensionless}
  autosize,                   !- Evaporative Condenser Air Flow Rate {m3/s}
  autosize,                   !- Evaporative Condenser Pump Rated Power Consumption {W}
  10,                         !- Crankcase Heater Capacity {W}
  10,                         !- Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater
Operation {C}

!- ===== ALL OBJECTS IN CLASS: COIL:HEATING:ELECTRIC =====

Coil:Heating:Electric,
  Living PTHP Supp Heating Coil, !- Name
  FanAndCoilAvailSched,        !- Availability Schedule Name
  1,                            !- Efficiency
  0,                            !- Nominal Capacity {W}
  Living PTHP Supply Fan Outlet Node, !- Air Inlet Node Name
  Living PTHP Supp Heating Coil Outlet Node; !- Air Outlet Node Name

Coil:Heating:Electric,
  Bath PTHP Supp Heating Coil, !- Name
  FanAndCoilAvailSched,      !- Availability Schedule Name
  1,                          !- Efficiency
  0,                          !- Nominal Capacity {W}
  Bath PTHP Supply Fan Outlet Node, !- Air Inlet Node Name
  Bath PTHP Supp Heating Coil Outlet Node; !- Air Outlet Node Name

!- ===== ALL OBJECTS IN CLASS: COIL:HEATING:DX:SINGLE SPEED =====

Coil:Heating:DX:SingleSpeed,
  Living PTHP Heating Coil, !- Name
  FanAndCoilAvailSched,    !- Availability Schedule Name
  autosize,                 !- Rated Total Heating Capacity {W}
  3.2,                      !- Rated COP
  autosize,                 !- Rated Air Flow Rate {m3/s}
  Living PTHP Cooling Coil Outlet Node, !- Air Inlet Node Name
  Living PTHP Heating Coil Outlet Node, !- Air Outlet Node Name
  HPACHeatCapFT,           !- Total Heating Capacity Function of Temperature Curve Name
  HPACHeatCapFFF,         !- Total Heating Capacity Function of Flow Fraction Curve
Name

  0.76,                    !- Sensible Effectiveness at 100% Cooling Air Flow
  {dimensionless}
  0.68,                    !- Latent Effectiveness at 100% Cooling Air Flow
  {dimensionless}
  0.81,                    !- Sensible Effectiveness at 75% Cooling Air Flow
  {dimensionless}
  0.73,                    !- Latent Effectiveness at 75% Cooling Air Flow
  {dimensionless}
  ERV Outdoor Air Inlet Node, !- Supply Air Inlet Node Name
  ERV HX Supply Outlet Node, !- Supply Air Outlet Node Name
  Living Exhaust Node, !- Exhaust Air Inlet Node Name
  ERV HX Exhaust Outlet Node, !- Exhaust Air Outlet Node Name
  30,                      !- Nominal Electric Power {W}
  No,                      !- Supply Air Outlet Temperature Control
  Rotary,                  !- Heat Exchanger Type
  None,                    !- Frost Control Type
  1.7,                     !- Threshold Temperature {C}
  0.083,                   !- Initial Defrost Time Fraction {dimensionless}
  0.012,                   !- Rate of Defrost Time Fraction Increase {1/K}
  Yes,                     !- Economizer Lockout

!- ===== ALL OBJECTS IN CLASS: OUTDOORAIR:MIXER =====

OutdoorAir:Mixer,
  Living PTHP OA Mixer,      !- Name
  Living OA Mixer Outlet Node, !- Mixed Air Node Name
  Living PTHP Outdoor Air Inlet Node, !- Outdoor Air Stream Node Name
  Living PTHP Relief Node, !- Relief Air Stream Node Name
  Living PTHP Inlet Node; !- Return Air Stream Node Name

OutdoorAir:Mixer,
  Bath PTHP OA Mixer,      !- Name
  Bath OA Mixer Outlet Node, !- Mixed Air Node Name
  Bath PTHP Outdoor Air Inlet Node, !- Outdoor Air Stream Node Name
  Bath PTHP Relief Node, !- Relief Air Stream Node Name
  Bath PTHP Inlet Node; !- Return Air Stream Node Name

!- ===== ALL OBJECTS IN CLASS: BRANCH =====

Branch,
  Radiant Supply Inlet Branch, !- Name
  autosize,                   !- Maximum Flow Rate {m3/s}
  Pump:VariableSpeed,         !- Component 1 Object Type
  Radiant Circ Pump,          !- Component 1 Name
  Radiant Supply Inlet Node, !- Component 1 Inlet Node Name
  Radiant Pump Outlet Node, !- Component 1 Outlet Node Name
  Active;                      !- Component 1 Branch Control Type

Branch,
  Secondary Storage Tank Use Branch, !- Name
  autosize,                    !- Maximum Flow Rate {m3/s}
  WaterHeater:Mixed,           !- Component 1 Object Type
  Secondary Storage Tank,       !- Component 1 Name
  Secondary Storage Tank Use Inlet Node, !- Component 1 Inlet Node Name
  Secondary Storage Tank Use Outlet Node, !- Component 1 Outlet Node Name
  Active;                      !- Component 1 Branch Control Type

Branch,
  Radiant Supply Bypass Branch, !- Name
  autosize,                    !- Maximum Flow Rate {m3/s}
  Pipe:Adiabatic,              !- Component 1 Object Type

HPACHeatEIRFT,               !- Energy Input Ratio Function of Temperature Curve Name
HPACHeatEIRFFF,              !- Energy Input Ratio Function of Flow Fraction Curve Name
HPACCOOLPLFFPLR,            !- Part Load Fraction Correlation Curve Name
Name
  CyclingFanAndCompressor,    !- Supply Air Fan Operating Mode
  8,                          !- Minimum Outdoor Dry-Bulb Temperature for Compressor
Operation {C}
  5,                          !- Maximum Outdoor Dry-Bulb Temperature for Defrost
Operation {C}
  10,                         !- Crankcase Heater Capacity {W}
  10,                         !- Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater
Resistive,                    !- Defrost Strategy
  Timed,                      !- Defrost Control
  0.058333,                   !- Defrost Time Period Fraction
  autosize;                   !- Resistive Defrost Heater Capacity {W}

Coil:Heating:DX:SingleSpeed,
  Bath PTHP Heating Coil,      !- Name
  FanAndCoilAvailSched,      !- Availability Schedule Name
  autosize,                   !- Rated Total Heating Capacity {W}
  3.2,                        !- Rated COP
  autosize,                   !- Rated Air Flow Rate {m3/s}
  Bath PTHP Cooling Coil Outlet Node, !- Air Inlet Node Name
  Bath PTHP Heating Coil Outlet Node, !- Air Outlet Node Name
  HPACHeatCapFT,              !- Total Heating Capacity Function of Temperature Curve Name
  HPACHeatCapFFF,            !- Total Heating Capacity Function of Flow Fraction Curve
Name
  HPACHeatEIRFT,               !- Energy Input Ratio Function of Temperature Curve Name
  HPACHeatEIRFFF,              !- Energy Input Ratio Function of Flow Fraction Curve Name
  HPACCOOLPLFFPLR,            !- Part Load Fraction Correlation Curve Name
  CyclingFanAndCompressor,    !- Supply Air Fan Operating Mode
  8,                          !- Minimum Outdoor Dry-Bulb Temperature for Compressor
Operation {C}
  5,                          !- Maximum Outdoor Dry-Bulb Temperature for Defrost
Operation {C}
  10,                         !- Crankcase Heater Capacity {W}
  10,                         !- Maximum Outdoor Dry-Bulb Temperature for Crankcase Heater
Resistive,                    !- Defrost Strategy
  Timed,                      !- Defrost Control
  0.058333,                   !- Defrost Time Period Fraction
  autosize;                   !- Resistive Defrost Heater Capacity {W}

!- ===== ALL OBJECTS IN CLASS: HEATEXCHANGER:AIRTOAIR:SENSIBLEANDLATENT =====

HeatExchanger:AirToAir:SensibleAndLatent,
  ERV HX,                     !- Name
  FanAndCoilAvailSched,      !- Availability Schedule Name
  0.05,                       !- Nominal Supply Air Flow Rate {m3/s}
  0.76,                       !- Sensible Effectiveness at 100% Heating Air Flow
  {dimensionless}
  0.68,                       !- Latent Effectiveness at 100% Heating Air Flow
  {dimensionless}
  0.81,                       !- Sensible Effectiveness at 75% Heating Air Flow
  {dimensionless}
  0.73,                       !- Latent Effectiveness at 75% Heating Air Flow
  {dimensionless}

Radiant Supply Side Bypass, !- Component 1 Name
Radiant Supply Bypass Inlet Node, !- Component 1 Inlet Node Name
Radiant Supply Bypass Outlet Node, !- Component 1 Outlet Node Name
Bypass;                      !- Component 1 Branch Control Type

Branch,
  Radiant Supply Outlet Branch, !- Name
  autosize,                    !- Maximum Flow Rate {m3/s}
  Pipe:Adiabatic,              !- Component 1 Object Type
  Radiant Supply Outlet,       !- Component 1 Name
  Radiant Supply Exit Pipe Inlet Node, !- Component 1 Inlet Node Name
  Radiant Supply Outlet Node, !- Component 1 Outlet Node Name
  Passive;                     !- Component 1 Branch Control Type

Branch,
  ZonesRadiantInletBranch, !- Name
  autosize,                    !- Maximum Flow Rate {m3/s}
  Pipe:Adiabatic,              !- Component 1 Object Type
  ZonesRadiantInletPipe,       !- Component 1 Name
  Radiant Demand Inlet Node, !- Component 1 Inlet Node Name
  Radiant Demand Entrance Pipe Outlet Node, !- Component 1 Outlet Node Name
  Passive;                     !- Component 1 Branch Control Type

Branch,
  ZonesRadiantOutletBranch, !- Name
  autosize,                    !- Maximum Flow Rate {m3/s}
  Pipe:Adiabatic,              !- Component 1 Object Type
  ZonesRadiantOutletPipe,       !- Component 1 Name
  Radiant Demand Exit Pipe Inlet Node, !- Component 1 Inlet Node Name
  Radiant Demand Outlet Node, !- Component 1 Outlet Node Name
  Passive;                     !- Component 1 Branch Control Type

Branch,
  LivingRadiantBranch, !- Name
  autosize,              !- Maximum Flow Rate {m3/s}
  ZoneHVAC:LowTemperatureRadiant:VariableFlow, !- Component 1 Object Type
  Living Radiant,         !- Component 1 Name
  Living Radiant Inlet Node, !- Component 1 Inlet Node Name
  Living Radiant Outlet Node, !- Component 1 Outlet Node Name
  Active;                  !- Component 1 Branch Control Type

Branch,
  BathRadiantBranch, !- Name
  autosize,           !- Maximum Flow Rate {m3/s}
  ZoneHVAC:LowTemperatureRadiant:VariableFlow, !- Component 1 Object Type
  Bath Radiant,       !- Component 1 Name
  Bath Radiant Inlet Node, !- Component 1 Inlet Node Name
  Bath Radiant Outlet Node, !- Component 1 Outlet Node Name
  Active;              !- Component 1 Branch Control Type

Branch,
  ZonesRadiantBypassBranch, !- Name
  autosize,                 !- Maximum Flow Rate {m3/s}
  Pipe:Adiabatic,           !- Component 1 Object Type
  ZonesRadiantBypassPipe,   !- Component 1 Name
  Zones Radiant Bypass Pipe Inlet Node, !- Component 1 Inlet Node Name
  Zones Radiant Bypass Pipe Outlet Node, !- Component 1 Outlet Node Name
  Bypass;                   !- Component 1 Branch Control Type

Branch,
  Collector Inlet Branch, !- Name
  autosize,               !- Maximum Flow Rate {m3/s}
  Pipe:Adiabatic,         !- Component 1 Object Type

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```

Collector Inlet Pipe,      !- Component 1 Name
Collector Loop Inlet Node, !- Component 1 Inlet Node Name
Collector Pipe-Collector Node, !- Component 1 Outlet Node Name
PASSIVE;                  !- Component 1 Branch Control Type

Branch,
Collector Branch,         !- Name
autosize,                 !- Maximum Flow Rate {m3/s}
SolarCollector:FlatPlate:Water, !- Component 1 Object Type
Collector,                !- Component 1 Name
Collector Inlet Node,     !- Component 1 Inlet Node Name
Collector Outlet Node,    !- Component 1 Outlet Node Name
ACTIVE;                   !- Component 1 Branch Control Type

Branch,
Collector Outlet Branch,  !- Name
autosize,                 !- Maximum Flow Rate {m3/s}
Pipe:Adiabatic,          !- Component 1 Object Type
Collector Outlet Pipe,    !- Component 1 Name
Collector Collector-Pipe Node, !- Component 1 Inlet Node Name
Collector Loop Outlet Node, !- Component 1 Outlet Node Name
PASSIVE;                  !- Component 1 Branch Control Type

Branch,
Collector Storage Tank Source Inlet Branch, !- Name
autosize,                 !- Maximum Flow Rate {m3/s}
Pump:VariableSpeed,      !- Component 1 Object Type
Collector Loop Pump,      !- Component 1 Name
Collector Storage Tank Source Loop Inlet Node, !- Component 1 Inlet Node Name
Collector Storage Tank Source Pump Outlet Node, !- Component 1 Outlet Node Name
ACTIVE;                   !- Component 1 Branch Control Type

Branch,
Collector Storage Tank Source Branch, !- Name
autosize,                 !- Maximum Flow Rate {m3/s}
WaterHeater:Mixed,        !- Component 1 Object Type
Collector Storage Tank,    !- Component 1 Name
Collector Storage Tank Source Inlet Node, !- Component 1 Inlet Node Name
Collector Storage Tank Source Outlet Node, !- Component 1 Outlet Node Name
PASSIVE;                  !- Component 1 Branch Control Type

Branch,
Collector Storage Tank Source Outlet Branch, !- Name
autosize,                 !- Maximum Flow Rate {m3/s}
Pipe:Adiabatic,          !- Component 1 Object Type
Collector Storage Tank Source Outlet Pipe, !- Component 1 Name
Collector Storage Tank Source Outlet Pipe Inlet Node, !- Component 1 Inlet Node Name
Collector Storage Tank Source Loop Outlet Node, !- Component 1 Outlet Node Name
PASSIVE;                  !- Component 1 Branch Control Type

Branch,
Collector Storage Tank Use Inlet Branch, !- Name
autosize,                 !- Maximum Flow Rate {m3/s}
Pump:VariableSpeed,      !- Component 1 Object Type
Secondary Loop Pump,      !- Component 1 Name
Collector Storage Tank Use Loop Inlet Node, !- Component 1 Inlet Node Name
Secondary Loop Pump Outlet Node, !- Component 1 Outlet Node Name
ACTIVE;                   !- Component 1 Branch Control Type

Branch,
Collector Storage Tank Use Branch, !- Name
autosize,                 !- Maximum Flow Rate {m3/s}
WaterHeater:Mixed,        !- Component 1 Object Type

Radiant Supply Bypass Branch, !- Branch 3 Name
Radiant Supply Outlet Branch; !- Branch 4 Name

BranchList,
Radiant Demand Side Branches, !- Name
ZonesRadiantInletBranch, !- Branch 1 Name
LivingRadiantBranch,      !- Branch 2 Name
BathRadiantBranch,        !- Branch 3 Name
ZonesRadiantBypassBranch, !- Branch 4 Name
ZonesRadiantOutletBranch; !- Branch 5 Name

BranchList,
Collector Branches,        !- Name
Collector Inlet Branch,    !- Branch 1 Name
Collector Branch,          !- Branch 2 Name
Collector Outlet Branch;   !- Branch 3 Name

BranchList,
Collector Storage Tank Source Branches, !- Name
Collector Storage Tank Source Inlet Branch, !- Branch 1 Name
Collector Storage Tank Source Branch, !- Branch 2 Name
Collector Storage Tank Source Outlet Branch; !- Branch 3 Name

BranchList,
Collector Storage Tank Use Branches, !- Name
Collector Storage Tank Use Inlet Branch, !- Branch 1 Name
Collector Storage Tank Use Branch, !- Branch 2 Name
Collector Storage Tank Use Outlet Branch; !- Branch 3 Name

BranchList,
Secondary Storage Tank Source Branches, !- Name
Secondary Storage Tank Source Inlet Branch, !- Branch 1 Name
Secondary Storage Tank Source Branch, !- Branch 2 Name
Secondary Storage Tank Bypass Branch, !- Branch 3 Name
Secondary Storage Tank Source Outlet Branch; !- Branch 4 Name

!- ===== ALL OBJECTS IN CLASS: CONNECTOR:SPLITTER =====

Connector:Splitter,
Radiant Supply Splitter, !- Name
Radiant Supply Inlet Branch, !- Inlet Branch Name
Secondary Storage Tank Use Branch, !- Outlet Branch 1 Name
Radiant Supply Bypass Branch; !- Outlet Branch 2 Name

Connector:Splitter,
Zones Radiant Splitter, !- Name
ZonesRadiantInletBranch, !- Inlet Branch Name
LivingRadiantBranch,     !- Outlet Branch 1 Name
BathRadiantBranch,       !- Outlet Branch 2 Name
ZonesRadiantBypassBranch; !- Outlet Branch 3 Name

Connector:Splitter,
Collector Splitter, !- Name
Collector Inlet Branch, !- Inlet Branch Name
Collector Branch;      !- Outlet Branch 1 Name

Connector:Splitter,
Collector Storage Tank Source Splitter, !- Name
Collector Storage Tank Source Inlet Branch, !- Inlet Branch Name
Collector Storage Tank Source Branch, !- Outlet Branch 1 Name

Connector:Splitter,
Radiant Supply Side Branches, !- Name
Radiant Supply Inlet Branch, !- Branch 1 Name
Secondary Storage Tank Use Branch, !- Branch 2 Name

Collector Storage Tank Use Splitter, !- Name
Collector Storage Tank Use Inlet Branch, !- Inlet Branch Name
Collector Storage Tank Use Branch; !- Outlet Branch 1 Name

Connector:Splitter,
Secondary Storage Tank Source Splitter, !- Name
Secondary Storage Tank Source Inlet Branch, !- Inlet Branch Name
Secondary Storage Tank Source Branch, !- Outlet Branch 1 Name
Secondary Storage Tank Bypass Branch; !- Outlet Branch 2 Name

!- ===== ALL OBJECTS IN CLASS: CONNECTOR:MIXER =====

Connector:Mixer,
Radiant Supply Mixer, !- Name
Radiant Supply Outlet Branch, !- Outlet Branch Name
Radiant Supply Bypass Branch, !- Inlet Branch 1 Name
Secondary Storage Tank Use Branch; !- Inlet Branch 2 Name

Connector:Mixer,
Zones Radiant Mixer, !- Name
ZonesRadiantOutletBranch, !- Outlet Branch Name
LivingRadiantBranch,      !- Inlet Branch 1 Name
BathRadiantBranch,        !- Inlet Branch 2 Name
ZonesRadiantBypassBranch; !- Inlet Branch 3 Name

Connector:Mixer,
Collector Mixer, !- Name
Collector Outlet Branch, !- Outlet Branch Name
Collector Branch;      !- Inlet Branch 1 Name

Connector:Mixer,
Collector Storage Tank Source Mixer, !- Name
Collector Storage Tank Source Outlet Branch, !- Outlet Branch Name
Collector Storage Tank Source Branch; !- Inlet Branch 1 Name

Connector:Mixer,
Collector Storage Tank Use Mixer, !- Name
Collector Storage Tank Use Outlet Branch, !- Outlet Branch Name
Collector Storage Tank Use Branch; !- Inlet Branch 1 Name

Connector:Mixer,
Secondary Storage Tank Source Mixer, !- Name
Secondary Storage Tank Source Outlet Branch, !- Outlet Branch Name
Secondary Storage Tank Source Branch, !- Inlet Branch 1 Name
Secondary Storage Tank Bypass Branch; !- Inlet Branch 2 Name

!- ===== ALL OBJECTS IN CLASS: CONNECTORLIST =====

ConnectorList,
Radiant Supply Side Connectors, !- Name
Connector:Splitter, !- Connector 1 Object Type
Radiant Supply Splitter, !- Connector 1 Name
Connector:Mixer, !- Connector 2 Object Type
Radiant Supply Mixer; !- Connector 2 Name

ConnectorList,
Radiant Demand Side Connectors, !- Name
Connector:Splitter, !- Connector 1 Object Type
Zones Radiant Splitter, !- Connector 1 Name
Connector:Mixer, !- Connector 2 Object Type
Zones Radiant Mixer; !- Connector 2 Name

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```

ConnectorList,
  Collector Connectors,      !- Name
  Connector:Splitter,        !- Connector 1 Object Type
  Collector Splitter,        !- Connector 1 Name
  Connector:Mixer,           !- Connector 2 Object Type
  Collector Mixer;           !- Connector 2 Name

ConnectorList,
  Collector Storage Tank Source Connectors, !- Name
  Connector:Splitter,        !- Connector 1 Object Type
  Collector Storage Tank Source Splitter,   !- Connector 1 Name
  Connector:Mixer,           !- Connector 2 Object Type
  Collector Storage Tank Source Mixer;      !- Connector 2 Name

ConnectorList,
  Collector Storage Tank Use Connectors,    !- Name
  Connector:Splitter,        !- Connector 1 Object Type
  Collector Storage Tank Use Splitter,      !- Connector 1 Name
  Connector:Mixer,           !- Connector 2 Object Type
  Collector Storage Tank Use Mixer;         !- Connector 2 Name

ConnectorList,
  Secondary Storage Tank Source Connectors, !- Name
  Connector:Splitter,        !- Connector 1 Object Type
  Secondary Storage Tank Source Splitter,   !- Connector 1 Name
  Connector:Mixer,           !- Connector 2 Object Type
  Secondary Storage Tank Source Mixer;      !- Connector 2 Name

!- ===== ALL OBJECTS IN CLASS: NODELIST =====

NodeList,
  OutdoorAirInletNodes,      !- Name
  ERV Outdoor Air Inlet Node, !- Node 1 Name
  Living PTHP Outdoor Air Inlet Node, !- Node 2 Name
  Bath PTHP Outdoor Air Inlet Node, !- Node 3 Name
  Living PTHP Condenser Outdoor Air Node, !- Node 4 Name
  Bath PTHP Condenser Outdoor Air Node; !- Node 5 Name

NodeList,
  LivingInlets,              !- Name
  ERV Supply Fan Outlet Node, !- Node 1 Name
  Living PTHP Supp Heating Coil Outlet Node; !- Node 2 Name

NodeList,
  LivingExhausts,           !- Name
  Living Exhaust Node,      !- Node 1 Name
  Living PTHP Inlet Node;    !- Node 2 Name

NodeList,
  HX Supply Air Nodes,       !- Name
  ERV Supply Fan Outlet Node, !- Node 1 Name
  ERV HX Supply Outlet Node; !- Node 2 Name

NodeList,
  BathInlets,               !- Name
  Bath PTHP Supp Heating Coil Outlet Node; !- Node 1 Name

NodeList,
  BathExhausts,             !- Name
  Bath PTHP Inlet Node;     !- Node 1 Name

,
  !- Fraction of Motor Inefficiencies to Fluid Stream
  1,
  !- Coefficient 1 of the Part Load Performance Curve
  !- Coefficient 2 of the Part Load Performance Curve
  !- Coefficient 3 of the Part Load Performance Curve
  !- Coefficient 4 of the Part Load Performance Curve
  !- Minimum Flow Rate {m3/s}
  Intermittent;            !- Pump Control Type

!- ===== ALL OBJECTS IN CLASS: TEMPERINGVALVE =====

TemperingValve,
  Secondary Storage Tank Tempering Valve, !- Name
  Secondary Storage Tank Tempering Valve Inlet Node, !- Inlet Node Name
  Secondary Storage Tank Tempering Valve Outlet Node, !- Outlet Node Name
  Secondary Storage Tank Source Outlet Node, !- Stream 2 Source Node Name
  Domestic Hot Water Inlet Node, !- Temperature Setpoint Node Name
  Secondary Loop Pump Outlet Node; !- Pump Outlet Node Name

!- ===== ALL OBJECTS IN CLASS: SOLARCOLLECTORPERFORMANCE:FLATPLATE =====

SolarCollectorPerformance:FlatPlate,
  Viessmann Manufacturing Company US Inc SV1 SH1, !- Name
  2.5, !- Gross Area {m2}
  Water, !- Test Fluid
  0.0000498, !- Test Flow Rate {m3/s}
  Inlet, !- Test Correlation Type
  0.7162, !- Coefficient 1 of Efficiency Equation {dimensionless}
  -3.0562, !- Coefficient 2 of Efficiency Equation {W/m2-K}
  -0.00674, !- Coefficient 3 of Efficiency Equation {W/m2-K2}
  -0.0707, !- Coefficient 2 of Incident Angle Modifier
  -0.1232; !- Coefficient 3 of Incident Angle Modifier

!- ===== ALL OBJECTS IN CLASS: SOLARCOLLECTOR:FLATPLATE:WATER =====

SolarCollector:FlatPlate:Water,
  Collector, !- Name
  Viessmann Manufacturing Company US Inc SV1 SH1, !- SolarCollectorPerformance Name
  Solar Thermal Collector, !- Surface Name
  Collector Inlet Node, !- Inlet Node Name
  Collector Outlet Node, !- Outlet Node Name
  0.0002; !- Maximum Flow Rate {m3/s}

!- ===== ALL OBJECTS IN CLASS: WATERHEATER:MIXED =====

WaterHeater:Mixed,
  Secondary Storage Tank, !- Name
  0.3, !- Tank Volume {m3}
  Secondary Loop Setpoint Temp Schedule, !- Setpoint Temperature Schedule Name
  , !- Deadband Temperature Difference {deltaC}
  82.2222, !- Maximum Temperature Limit {C}
  Cycle, !- Heater Control Type
  autosize, !- Heater Maximum Capacity {W}
  , !- Heater Minimum Capacity {W}
  , !- Heater Ignition Minimum Flow Rate {m3/s}
  , !- Heater Ignition Delay {s}
  ELECTRICITY, !- Heater Fuel Type
  0.90, !- Heater Thermal Efficiency
  , !- Part Load Factor Curve Name
  , !- Off Cycle Parasitic Fuel Consumption Rate {W}

NodeList,
  Radiant Loop Setpoint Node List, !- Name
  Radiant Supply Outlet Node; !- Node 1 Name

NodeList,
  Secondary Loop Setpoint Node List, !- Name
  Secondary Storage Tank Source Outlet Node, !- Node 1 Name
  Secondary Storage Tank Source Inlet Node, !- Node 2 Name
  Domestic Hot Water Inlet Node; !- Node 3 Name

NodeList,
  Collector Loop Setpoint Node List, !- Name
  Collector Storage Tank Source Loop Outlet Node; !- Node 1 Name

!- ===== ALL OBJECTS IN CLASS: OUTDOORAIR:NODELIST =====

OutdoorAir:NodeList,
  OutdoorAirInletNodes; !- Node or NodeList Name 1

!- ===== ALL OBJECTS IN CLASS: PUMP:VARIABLESPEED =====

Pump:VariableSpeed,
  Radiant Circ Pump, !- Name
  Radiant Supply Inlet Node, !- Inlet Node Name
  Radiant Pump Outlet Node, !- Outlet Node Name
  autosize, !- Rated Flow Rate {m3/s}
  50000, !- Rated Pump Head {Pa}
  autosize, !- Rated Power Consumption {W}
  0.9, !- Motor Efficiency
  0, !- Fraction of Motor Inefficiencies to Fluid Stream
  0, !- Coefficient 1 of the Part Load Performance Curve
  1, !- Coefficient 2 of the Part Load Performance Curve
  0, !- Coefficient 3 of the Part Load Performance Curve
  0, !- Coefficient 4 of the Part Load Performance Curve
  0, !- Minimum Flow Rate {m3/s}
  Intermittent; !- Pump Control Type

Pump:VariableSpeed,
  Collector Loop Pump, !- Name
  Collector Storage Tank Source Loop Inlet Node, !- Inlet Node Name
  Collector Storage Tank Source Pump Outlet Node, !- Outlet Node Name
  autosize, !- Rated Flow Rate {m3/s}
  50000, !- Rated Pump Head {Pa}
  autosize, !- Rated Power Consumption {W}
  0.9, !- Motor Efficiency
  , !- Fraction of Motor Inefficiencies to Fluid Stream
  1, !- Coefficient 1 of the Part Load Performance Curve
  , !- Coefficient 2 of the Part Load Performance Curve
  , !- Coefficient 3 of the Part Load Performance Curve
  , !- Coefficient 4 of the Part Load Performance Curve
  , !- Minimum Flow Rate {m3/s}
  Intermittent; !- Pump Control Type

Pump:VariableSpeed,
  Secondary Loop Pump, !- Name
  Collector Storage Tank Use Loop Inlet Node, !- Inlet Node Name
  Secondary Storage Tank Use Loop Pump Outlet Node, !- Outlet Node Name
  autosize, !- Rated Flow Rate {m3/s}
  50000, !- Rated Pump Head {Pa}
  autosize, !- Rated Power Consumption {W}
  0.9, !- Motor Efficiency
  , !- Off Cycle Parasitic Fuel Type
  , !- Off Cycle Parasitic Heat Fraction to Tank
  , !- On Cycle Parasitic Fuel Consumption Rate {W}
  , !- On Cycle Parasitic Heat Fraction to Tank
  Zone, !- Ambient Temperature Indicator
  Mechanical, !- Ambient Temperature Schedule Name
  !- Ambient Temperature Zone Name
  1.0, !- Ambient Temperature Outdoor Air Node Name
  1, !- Off Cycle Loss Coefficient to Ambient Temperature {W/K}
  1.0, !- Off Cycle Loss Fraction to Zone
  1, !- On Cycle Loss Coefficient to Ambient Temperature {W/K}
  1, !- On Cycle Loss Fraction to Zone
  , !- Peak Use Flow Rate {m3/s}
  , !- Use Flow Rate Fraction Schedule Name
  , !- Cold Water Supply Temperature Schedule Name
  Secondary Storage Tank Use Inlet Node, !- Use Side Inlet Node Name
  Secondary Storage Tank Use Outlet Node, !- Use Side Outlet Node Name
  1.0, !- Use Side Effectiveness
  Secondary Storage Tank Source Inlet Node, !- Source Side Inlet Node Name
  Secondary Storage Tank Source Outlet Node, !- Source Side Outlet Node Name
  , !- Source Side Effectiveness
  autosize, !- Use Side Design Flow Rate {m3/s}
  autosize; !- Source Side Design Flow Rate {m3/s}

WaterHeater:Mixed,
  Collector Storage Tank, !- Name
  0.7, !- Tank Volume {m3}
  Collector Loop Temperature Schedule, !- Setpoint Temperature Schedule Name
  5.0, !- Deadband Temperature Difference {deltaC}
  82.2222, !- Maximum Temperature Limit {C}
  CYCLE, !- Heater Control Type
  0, !- Heater Maximum Capacity {W}
  , !- Heater Minimum Capacity {W}
  , !- Heater Ignition Minimum Flow Rate {m3/s}
  , !- Heater Ignition Delay {s}
  ELECTRICITY, !- Heater Fuel Type
  0.90, !- Heater Thermal Efficiency
  , !- Part Load Factor Curve Name
  , !- Off Cycle Parasitic Fuel Consumption Rate {W}
  , !- Off Cycle Parasitic Heat Fraction to Tank
  , !- On Cycle Parasitic Fuel Consumption Rate {W}
  , !- On Cycle Parasitic Heat Fraction to Tank
  Zone, !- Ambient Temperature Indicator
  Mechanical, !- Ambient Temperature Schedule Name
  !- Ambient Temperature Zone Name
  5.0, !- Ambient Temperature Outdoor Air Node Name
  1, !- Off Cycle Loss Coefficient to Ambient Temperature {W/K}
  5.0, !- Off Cycle Loss Fraction to Zone
  , !- On Cycle Loss Coefficient to Ambient Temperature {W/K}
  , !- On Cycle Loss Fraction to Zone
  , !- Peak Use Flow Rate {m3/s}
  , !- Use Flow Rate Fraction Schedule Name
  , !- Cold Water Supply Temperature Schedule Name
  Collector Storage Tank Use Inlet Node, !- Use Side Inlet Node Name
  Collector Storage Tank Use Outlet Node, !- Use Side Outlet Node Name
  1.0, !- Use Side Effectiveness
  Collector Storage Tank Source Inlet Node, !- Source Side Inlet Node Name
  Collector Storage Tank Source Outlet Node, !- Source Side Outlet Node Name
  1.0, !- Source Side Effectiveness
  autosize, !- Use Side Design Flow Rate {m3/s}

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autosize;                !- Source Side Design Flow Rate {m3/s}

!- ===== ALL OBJECTS IN CLASS: WATERHEATER:SIZING =====
WaterHeater:Sizing,
  Secondary Storage Tank, !- WaterHeater Name
  PeakDraw,              !- Design Node
  1,                     !- Time Storage Can Meet Peak Draw {hr}
  1,                     !- Time for Tank Recovery {hr}
  0.3;                   !- Nominal Tank Volume for Autosizing Plant Connections {m3}

!- ===== ALL OBJECTS IN CLASS: PLANTLOOP =====
PlantLoop,
  Collector Loop,        !- Name
  WATER,                 !- Fluid Type
  Collector Loop Operation, !- Plant Equipment Operation Scheme Name
  Collector Storage Tank Source Loop Outlet Node, !- Loop Temperature Setpoint Node
  Name
  80,                    !- Maximum Loop Temperature {C}
  3,                     !- Minimum Loop Temperature {C}
  AUTOSIZE,              !- Maximum Loop Flow Rate {m3/s}
  0.0,                   !- Minimum Loop Flow Rate {m3/s}
  autocalculate,         !- Plant Loop Volume {m3}
  Collector Storage Tank Source Loop Inlet Node, !- Plant Side Inlet Node Name
  Collector Storage Tank Source Loop Outlet Node, !- Plant Side Outlet Node Name
  Collector Storage Tank Source Branches, !- Plant Side Branch List Name
  Collector Storage Tank Source Connectors, !- Plant Side Connector List Name
  Collector Loop Inlet Node, !- Demand Side Inlet Node Name
  Collector Loop Outlet Node, !- Demand Side Outlet Node Name
  Collector Branches, !- Demand Side Branch List Name
  Collector Connectors, !- Demand Side Connector List Name
  OPTIMAL, !- Load Distribution Scheme
  Collector Loop Availability Manager List, !- Availability Manager List Name

PlantLoop,
  Secondary Loop,        !- Name
  WATER,                 !- Fluid Type
  Secondary Loop Operation, !- Plant Equipment Operation Scheme Name
  Domestic Hot Water Inlet Node, !- Loop Temperature Setpoint Node Name
  80,                    !- Maximum Loop Temperature {C}
  3,                     !- Minimum Loop Temperature {C}
  AUTOSIZE,              !- Maximum Loop Flow Rate {m3/s}
  0,                     !- Minimum Loop Flow Rate {m3/s}
  autocalculate,         !- Plant Loop Volume {m3}
  Collector Storage Tank Use Loop Inlet Node, !- Plant Side Inlet Node Name
  Collector Storage Tank Use Loop Outlet Node, !- Plant Side Outlet Node Name
  Collector Storage Tank Use Branches, !- Plant Side Branch List Name
  Collector Storage Tank Use Connectors, !- Plant Side Connector List Name
  Secondary Storage Tank Source Loop Inlet Node, !- Demand Side Inlet Node Name
  Secondary Storage Tank Source Loop Outlet Node, !- Demand Side Outlet Node Name
  Secondary Storage Tank Source Branches, !- Demand Side Branch List Name
  Secondary Storage Tank Source Connectors, !- Demand Side Connector List Name
  OPTIMAL, !- Load Distribution Scheme
  Secondary Loop Availability Manager, !- Availability Manager List Name
  SingleSetpoint;        !- Plant Loop Demand Calculation Scheme

PlantLoop,
  Radiant Loop,         !- Name
  Water,                !- Fluid Type
  Radiant Loop Operation, !- Plant Equipment Operation Scheme Name

Collector Storage Tank Use Outlet Pipe, !- Name
Collector Storage Tank Use Outlet Pipe Inlet Node, !- Inlet Node Name
Collector Storage Tank Use Loop Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  Secondary Storage Tank Source Inlet Pipe, !- Name
  Secondary Storage Tank Source Loop Inlet Node, !- Inlet Node Name
  Secondary Storage Tank Source Inlet Pipe Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  Secondary Storage Tank Source Outlet Pipe, !- Name
  Domestic Hot Water Outlet Node, !- Inlet Node Name
  Secondary Storage Tank Source Loop Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  Secondary Storage Tank Bypass Pipe, !- Name
  Secondary Storage Tank Bypass Pipe Inlet Node, !- Inlet Node Name
  Secondary Storage Tank Bypass Pipe Outlet Node; !- Outlet Node Name

!- ===== ALL OBJECTS IN CLASS: PLANTEQUIPMENTLIST =====
PlantEquipmentList,
  Collector Plant Equipment, !- Name
  WaterHeater:Mixed, !- Equipment 1 Object Type
  Collector Storage Tank; !- Equipment 1 Name

PlantEquipmentList,
  Secondary Plant Equipment, !- Name
  WaterHeater:Mixed, !- Equipment 1 Object Type
  Collector Storage Tank, !- Equipment 1 Name
  WaterHeater:Mixed, !- Equipment 2 Object Type
  Secondary Storage Tank; !- Equipment 2 Name

PlantEquipmentList,
  Radiant Plant Equipment, !- Name
  WaterHeater:Mixed, !- Equipment 1 Object Type
  Secondary Storage Tank; !- Equipment 1 Name

!- ===== ALL OBJECTS IN CLASS: PLANTEQUIPMENTOPERATION:HEATINGLOAD =====
PlantEquipmentOperation:HeatingLoad,
  Secondary Loop Control Scheme, !- Name
  0, !- Load Range 1 Lower Limit {W}
  1000000, !- Load Range 1 Upper Limit {W}
  Secondary Plant Equipment; !- Priority Control 1 Equipment List Name

PlantEquipmentOperation:HeatingLoad,
  Collector Control Scheme, !- Name
  0, !- Load Range 1 Lower Limit {W}
  1000000, !- Load Range 1 Upper Limit {W}
  Collector Plant Equipment; !- Priority Control 1 Equipment List Name

PlantEquipmentOperation:HeatingLoad,
  Radiant Plant Equipment, !- Name
  0, !- Load Range 1 Lower Limit {W}
  1000000, !- Load Range 1 Upper Limit {W}
  Radiant Plant Equipment; !- Priority Control 1 Equipment List Name

!- ===== ALL OBJECTS IN CLASS: PLANTEQUIPMENTOPERATIONSCHMES =====

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Radiant Supply Outlet Node, !- Loop Temperature Setpoint Node Name
40, !- Maximum Loop Temperature {C}
15, !- Minimum Loop Temperature {C}
autosize, !- Maximum Loop Flow Rate {m3/s}
0, !- Minimum Loop Flow Rate {m3/s}
autocalculate, !- Plant Loop Volume {m3}
Radiant Supply Inlet Node, !- Plant Side Inlet Node Name
Radiant Supply Outlet Node, !- Plant Side Outlet Node Name
Radiant Supply Side Branches, !- Plant Side Branch List Name
Radiant Supply Side Connectors, !- Plant Side Connector List Name
Radiant Demand Inlet Node, !- Demand Side Inlet Node Name
Radiant Demand Outlet Node, !- Demand Side Outlet Node Name
Radiant Demand Side Branches, !- Demand Side Branch List Name
Radiant Demand Side Connectors, !- Demand Side Connector List Name
Optimal, !- Load Distribution Scheme
, !- Availability Manager List Name
SingleSetpoint, !- Plant Loop Demand Calculation Scheme
None; !- Common Pipe Simulation

!- ===== ALL OBJECTS IN CLASS: PIPE:ADIABATIC =====
Pipe:Adiabatic,
  Radiant Supply Side Bypass, !- Name
  Radiant Supply Bypass Inlet Node, !- Inlet Node Name
  Radiant Supply Bypass Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  Radiant Supply Outlet, !- Name
  Radiant Supply Exit Pipe Inlet Node, !- Inlet Node Name
  Radiant Supply Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  ZonesRadiantInletPipe, !- Name
  Radiant Demand Inlet Node, !- Inlet Node Name
  Radiant Demand Entrance Pipe Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  ZonesRadiantOutletPipe, !- Name
  Radiant Demand Exit Pipe Inlet Node, !- Inlet Node Name
  Radiant Demand Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  ZonesRadiantBypassPipe, !- Name
  Zones Radiant Bypass Pipe Inlet Node, !- Inlet Node Name
  Zones Radiant Bypass Pipe Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  Collector Inlet Pipe, !- Name
  Collector Loop Inlet Node, !- Inlet Node Name
  Collector Pipe-Collector Node; !- Outlet Node Name

Pipe:Adiabatic,
  Collector Outlet Pipe, !- Name
  Collector Collector-Pipe Node, !- Inlet Node Name
  Collector Loop Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,
  Collector Storage Tank Source Outlet Pipe, !- Name
  Collector Storage Tank Source Outlet Pipe Inlet Node, !- Inlet Node Name
  Collector Storage Tank Source Loop Outlet Node; !- Outlet Node Name

Pipe:Adiabatic,

PlantEquipmentOperationSchemes,
  Radiant Loop Operation, !- Name
  PlantEquipmentOperation:HeatingLoad, !- Control Scheme 1 Object Type
  Radiant Plant Equipment, !- Control Scheme 1 Name
  ON; !- Control Scheme 1 Schedule Name

PlantEquipmentOperationSchemes,
  Collector Loop Operation, !- Name
  PlantEquipmentOperation:HeatingLoad, !- Control Scheme 1 Object Type
  Collector Control Scheme, !- Control Scheme 1 Name
  ON; !- Control Scheme 1 Schedule Name

PlantEquipmentOperationSchemes,
  Secondary Loop Operation, !- Name
  PlantEquipmentOperation:HeatingLoad, !- Control Scheme 1 Object Type
  Secondary Loop Control Scheme, !- Control Scheme 1 Name
  ON; !- Control Scheme 1 Schedule Name

!- ===== ALL OBJECTS IN CLASS: AVAILABILITYMANAGER:DIFFERENTIALTHERMOSTAT =====
AvailabilityManager:DifferentialThermostat,
  Differential Thermostat Availability Manager, !- Name
  Collector Outlet Node, !- Hot Node Name
  Collector Storage Tank Source Outlet Node, !- Cold Node Name
  5, !- Temperature Difference On Limit {deltaC}
  2.0; !- Temperature Difference Off Limit {deltaC}

AvailabilityManager:DifferentialThermostat,
  Collector-Secondary Differential Thermostat, !- Name
  Collector Storage Tank Use Loop Outlet Node, !- Hot Node Name
  Secondary Storage Tank Source Loop Inlet Node, !- Cold Node Name
  5, !- Temperature Difference On Limit {deltaC}
  2; !- Temperature Difference Off Limit {deltaC}

!- ===== ALL OBJECTS IN CLASS: AVAILABILITYMANAGER:HIGHTTEMPERATURETURNOFF =====
AvailabilityManager:HighTemperatureTurnOff,
  High Temperature Turn Off Availability Manager, !- Name
  Collector Storage Tank Use Outlet Node, !- Sensor Node Name
  90; !- Temperature {C}

!- ===== ALL OBJECTS IN CLASS: AVAILABILITYMANAGERASSIGNMENTLIST =====
AvailabilityManagerAssignmentList,
  Collector Loop Availability Manager List, !- Name
  AvailabilityManager:HighTemperatureTurnOff, !- Availability Manager 1 Object Type
  High Temperature Turn Off Availability Manager, !- Availability Manager 1 Name
  AvailabilityManager:DifferentialThermostat, !- Availability Manager 2 Object Type
  Differential Thermostat Availability Manager; !- Availability Manager 2 Name

AvailabilityManagerAssignmentList,
  Secondary Loop Availability Manager, !- Name
  AvailabilityManager:DifferentialThermostat, !- Availability Manager 1 Object Type
  Collector-Secondary Differential Thermostat; !- Availability Manager 1 Name

!- ===== ALL OBJECTS IN CLASS: SETPOINTMANAGER:SCHEDULED =====

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SetpointManager:Scheduled,
  Radiant Loop Setpoint Manager, !- Name
  Temperature, !- Control Variable
  Radiant Loop Temp Schedule, !- Schedule Name
  Radiant Loop Setpoint Node List; !- Setpoint Node or NodeList Name

SetpointManager:Scheduled,
  Collector Loop Setpoint Manager, !- Name
  Temperature, !- Control Variable
  Collector Loop Temperature Schedule, !- Schedule Name
  Collector Loop Setpoint Node List; !- Setpoint Node or NodeList Name

SetpointManager:Scheduled,
  Secondary Loop Setpoint Manager, !- Name
  Temperature, !- Control Variable
  Secondary Loop Setpoint Temp Schedule, !- Schedule Name
  Secondary Loop Setpoint Node List; !- Setpoint Node or NodeList Name

!- ===== ALL OBJECTS IN CLASS: GENERATOR:PHOTOVOLTAIC =====

Generator:Photovoltaic,
  PV Array 2, !- Name
  SolarPV South, !- Surface Name
  PhotovoltaicPerformance:EquivalentOne-Diode, !- Photovoltaic Performance Object Type
  Sunpower230 Inputs, !- Module Performance Name
  Decoupled, !- Heat Transfer Integration Mode
  1, !- Number of Modules in Parallel {dimensionless}
  19; !- Number of Modules in Series {dimensionless}

Generator:Photovoltaic,
  PV Array 1, !- Name
  SolarPV North, !- Surface Name
  PhotovoltaicPerformance:EquivalentOne-Diode, !- Photovoltaic Performance Object Type
  Sunpower230 Inputs, !- Module Performance Name
  Decoupled, !- Heat Transfer Integration Mode
  1, !- Number of Modules in Parallel {dimensionless}
  19; !- Number of Modules in Series {dimensionless}

!- ===== ALL OBJECTS IN CLASS: PHOTOVOLTAICPERFORMANCE:SIMPLE =====

PhotovoltaicPerformance:Simple,
  SPR230, !- Name
  1, !- Fraction of Surface Area with Active Solar Cells
  {dimensionless}
  Fixed, !- Conversion Efficiency Input Mode
  0.185; !- Value for Cell Efficiency if Fixed

!- ===== ALL OBJECTS IN CLASS: PHOTOVOLTAICPERFORMANCE:EQUIVALENTONE-DIODE =====

PhotovoltaicPerformance:EquivalentOne-Diode,
  Sunpower230 Inputs, !- Name
  CrystallineSilicon, !- Cell type
  72, !- Number of Cells in Series {dimensionless}
  1.24, !- Active Area {m2}
  0.95, !- Transmittance Absorptance Product {dimensionless}
  1.12, !- Semiconductor Bandgap {eV}
  1000000, !- Shunt Resistance {ohms}
  5.99, !- Short Circuit Current {A}
  48.7, !- Open Circuit Voltage {V}

ElectricLoadCenter:Distribution,
  Curio Electric Load Center 2, !- Name
  PV List 2, !- Generator List Name
  Baseload, !- Generator Operation Scheme Type
  , !- Demand Limit Scheme Purchased Electric Demand Limit {W}
  , !- Track Schedule Name Scheme Schedule Name
  , !- Track Meter Scheme Meter Name
  DirectCurrentWithInverter, !- Electrical Buss Type
  Simple Ideal Inverter 2; !- Inverter Object Name

!- ===== ALL OBJECTS IN CLASS: WATERUSE:EQUIPMENT =====

WaterUse:Equipment,
  Sinks, !- Name
  Sinks, !- End-Use Subcategory
  0.000126, !- Peak Flow Rate {m3/s}
  Sinks, !- Flow Rate Fraction Schedule Name
  Sinks and Showers Temp Schedule; !- Target Temperature Schedule Name

WaterUse:Equipment,
  Showers, !- Name
  Showers, !- End-Use Subcategory
  0.000189, !- Peak Flow Rate {m3/s}
  Showers, !- Flow Rate Fraction Schedule Name
  Sinks and Showers Temp Schedule; !- Target Temperature Schedule Name

WaterUse:Equipment,
  Clotheswasher, !- Name
  Clotheswasher, !- End-Use Subcategory
  0.000063, !- Peak Flow Rate {m3/s}
  Clotheswasher, !- Flow Rate Fraction Schedule Name
  Washers Temp Schedule; !- Target Temperature Schedule Name

WaterUse:Equipment,
  Dishwasher, !- Name
  Dishwasher, !- End-Use Subcategory
  0.000126, !- Peak Flow Rate {m3/s}
  Dishwasher, !- Flow Rate Fraction Schedule Name
  Washers Temp Schedule; !- Target Temperature Schedule Name

!- ===== ALL OBJECTS IN CLASS: WATERUSE:CONNECTIONS =====

WaterUse:Connections,
  Domestic Hot Water, !- Name
  Domestic Hot Water Inlet Node, !- Inlet Node Name
  Domestic Hot Water Outlet Node, !- Outlet Node Name
  , !- Supply Water Storage Tank Name
  , !- Reclamation Water Storage Tank Name
  , !- Hot Water Supply Temperature Schedule Name
  , !- Cold Water Supply Temperature Schedule Name
  NONE, !- Drain Water Heat Exchanger Type
  , !- Drain Water Heat Exchanger Destination
  , !- Drain Water Heat Exchanger U-Factor Times Area {W/K}
  Sinks, !- Water Use Equipment 1 Name
  Showers, !- Water Use Equipment 2 Name
  Clotheswasher, !- Water Use Equipment 3 Name
  Dishwasher, !- Water Use Equipment 4 Name

!- ===== ALL OBJECTS IN CLASS: CURVE:QUADRATIC =====

25, !- Reference Temperature {C}
1000, !- Reference Insolation {W/m2}
5.61, !- Module Current at Maximum Power {A}
41, !- Module Voltage at Maximum Power {V}
0.0035, !- Temperature Coefficient of Short Circuit Current {A/K}
1325, !- Temperature Coefficient of Open Circuit Voltage {V/K}
20, !- Nominal Operating Cell Temperature Test Ambient
Temperature {C}
40, !- Nominal Operating Cell Temperature Test Cell Temperature
{C}
800, !- Nominal Operating Cell Temperature Test Insolation {W/m2}
30, !- Module Heat Loss Coefficient {W/m2-K}
50000; !- Total Heat Capacity {J/m2-K}

!- ===== ALL OBJECTS IN CLASS: ELECTRICLOADCENTER:GENERATORS =====

ElectricLoadCenter:Generators,
  PV List, !- Name
  PV Array 1, !- Generator 1 Name
  Generator:Photovoltaic, !- Generator 1 Object Type
  4370, !- Generator 1 Rated Electric Power Output
  ON, !- Generator 1 Availability Schedule Name
  ; !- Generator 1 Rated Thermal to Electrical Power Ratio

ElectricLoadCenter:Generators,
  PV List 2, !- Name
  PV Array 2, !- Generator 1 Name
  Generator:Photovoltaic, !- Generator 1 Object Type
  4370, !- Generator 1 Rated Electric Power Output
  ON, !- Generator 1 Availability Schedule Name
  ; !- Generator 1 Rated Thermal to Electrical Power Ratio

!- ===== ALL OBJECTS IN CLASS: ELECTRICLOADCENTER:INVERTER:SIMPLE =====

ElectricLoadCenter:Inverter:Simple,
  Simple Ideal Inverter, !- Name
  ON, !- Availability Schedule Name
  Mechanical, !- Zone Name
  0, !- Radiative Fraction
  0.95; !- Inverter Efficiency

ElectricLoadCenter:Inverter:Simple,
  Simple Ideal Inverter 2, !- Name
  ON, !- Availability Schedule Name
  Mechanical, !- Zone Name
  0, !- Radiative Fraction
  0.95; !- Inverter Efficiency

!- ===== ALL OBJECTS IN CLASS: ELECTRICLOADCENTER:DISTRIBUTION =====

ElectricLoadCenter:Distribution,
  Curio Electric Load Center, !- Name
  PV List, !- Generator List Name
  Baseload, !- Generator Operation Scheme Type
  , !- Demand Limit Scheme Purchased Electric Demand Limit {W}
  , !- Track Schedule Name Scheme Schedule Name
  , !- Track Meter Scheme Meter Name
  DirectCurrentWithInverter, !- Electrical Buss Type
  Simple Ideal Inverter; !- Inverter Object Name

Curve:Quadratic,
  HPACCoolCapFFF, !- Name
  0.8, !- Coefficient1 Constant
  0.2, !- Coefficient2 x
  0.0, !- Coefficient3 x**2
  0.5, !- Minimum Value of x
  1.5; !- Maximum Value of x

Curve:Quadratic,
  HPACCOOLAIRFFF, !- Name
  1.156, !- Coefficient1 Constant
  -0.1816, !- Coefficient2 x
  0.0256, !- Coefficient3 x**2
  0.5, !- Minimum Value of x
  1.5; !- Maximum Value of x

Curve:Quadratic,
  HPACCOOLPLFFPLR, !- Name
  0.85, !- Coefficient1 Constant
  0.15, !- Coefficient2 x
  0.0, !- Coefficient3 x**2
  0.0, !- Minimum Value of x
  1.0; !- Maximum Value of x

Curve:Quadratic,
  HPACHeatAIRFFF, !- Name
  1.3824, !- Coefficient1 Constant
  -0.4336, !- Coefficient2 x
  0.0512, !- Coefficient3 x**2
  0.0, !- Minimum Value of x
  1.0; !- Maximum Value of x

!- ===== ALL OBJECTS IN CLASS: CURVE:CUBIC =====

Curve:Cubic,
  HPACHeatCapFT, !- Name
  0.758746, !- Coefficient1 Constant
  0.027626, !- Coefficient2 x
  0.000148716, !- Coefficient3 x**2
  0.0000034992, !- Coefficient4 x**3
  -20.0, !- Minimum Value of x
  20.0; !- Maximum Value of x

Curve:Cubic,
  HPACHeatCapFFF, !- Name
  0.84, !- Coefficient1 Constant
  0.16, !- Coefficient2 x
  0.0, !- Coefficient3 x**2
  0.0, !- Coefficient4 x**3
  0.5, !- Minimum Value of x
  1.5; !- Maximum Value of x

Curve:Cubic,
  HPACHeatAIRFT, !- Name
  1.19248, !- Coefficient1 Constant
  -0.0300438, !- Coefficient2 x
  0.00103745, !- Coefficient3 x**2
  -0.000023328, !- Coefficient4 x**3
  -20.0, !- Minimum Value of x
  20.0; !- Maximum Value of x

```

!- ===== ALL OBJECTS IN CLASS: CURVE:BIQUADRATIC =====

```
Curve:Biquadratic,
  HPACCoolCapFT,      !- Name
  0.766956,           !- Coefficient1 Constant
  0.0107756,          !- Coefficient2 x
  -0.0000414703,      !- Coefficient3 x**2
  0.00134961,         !- Coefficient4 y
  -0.000261144,       !- Coefficient5 y**2
  0.000457488,        !- Coefficient6 x*y
  12.77778,           !- Minimum Value of x
  23.88889,           !- Maximum Value of x
  21.11111,           !- Minimum Value of y
  46.11111,           !- Maximum Value of y
```

```
Curve:Biquadratic,
  HPACCOOLEIRFT,      !- Name
  0.297145,           !- Coefficient1 Constant
  0.0430933,          !- Coefficient2 x
  -0.000748766,       !- Coefficient3 x**2
  0.00597727,         !- Coefficient4 y
  0.000482112,        !- Coefficient5 y**2
  -0.000956448,       !- Coefficient6 x*y
  12.77778,           !- Minimum Value of x
  23.88889,           !- Maximum Value of x
  21.11111,           !- Minimum Value of y
  46.11111,           !- Maximum Value of y
```

!- ===== ALL OBJECTS IN CLASS: OUTPUT:REPORTS =====

```
Output:Reports,
  VariableDictionary, !- Type of Report
  Timestep;           !- Report Name
```

!- ===== ALL OBJECTS IN CLASS: OUTPUT:TABLE:SUMMARYREPORTS =====

```
Output:Table:SummaryReports,
  AllSummary,          !- Report 1 Name
  AllMonthly;          !- Report 2 Name
```

!- ===== ALL OBJECTS IN CLASS: OUTPUTCONTROL:TABLE:STYLE =====

```
OutputControl:Table:Style,
  CommaAndHTML,        !- Column Separator
  JtoKWH;              !- Unit Conversion
```

!- ===== ALL OBJECTS IN CLASS: OUTPUT:VARIABLE =====

```
Output:Variable,
  *,                   !- Key Value
  Outdoor Dry Bulb ,   !- Variable Name
  Timestep;            !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Zone Mean Air Temperature, !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
```

```
Output:Variable,
  *,                   !- Key Value
  Packaged Terminal Heat Pump Electric Power , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Packaged Terminal Heat Pump Electric Consumption , !- Variable Name
  Timestep;           !- Reporting Frequency
```

!- ===== ALL OBJECTS IN CLASS: OUTPUT:METER =====

```
Output:Meter,
  Electricity:Building , !- Name
  Timestep;             !- Reporting Frequency
```

```
Output:Meter,
  Photovoltaic:ElectricityProduced , !- Name
  Timestep;             !- Reporting Frequency
```

```
Output:Meter,
  SolarWater:Plant ,    !- Name
  Timestep;             !- Reporting Frequency
```

!- ===== ALL OBJECTS IN CLASS: OUTPUT:METER:CUMULATIVE:METERFILEONLY =====

```
Output:Meter:Cumulative:MeterFileOnly,
  Electricity:Building , !- Name
  Daily;                !- Reporting Frequency
```

```
Output:Meter:Cumulative:MeterFileOnly,
  Photovoltaic:ElectricityProduced , !- Name
  Daily;                !- Reporting Frequency
```

```
*,                   !- Key Value
  Water Heater Tank Temperature , !- Variable Name
  Timestep;          !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Water Heater Use Energy , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Water Heater Source Energy , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Water Heater Plant Hot Water Consumption , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Solar Collector Heat Transfer Rate , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Load Center Electric Power Produced , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Total Electric Power Purchased , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Net Electric Power Purchased , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Total HVAC Electric Demand , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  PV Generator DC Power , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Hydronic Low Temp Radiant Heating Rate , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Packaged Terminal Heat Pump Total Zone Heating Rate , !- Variable Name
  Timestep;           !- Reporting Frequency
```

```
Output:Variable,
  *,                   !- Key Value
  Packaged Terminal Heat Pump Total Zone Cooling Rate , !- Variable Name
  Timestep;           !- Reporting Frequency
```



TEAM BOSTON
SOLAR DECATHLON 2009

SUMMARY OF HOUSE MONITORING SYSTEM



SENSORING AND MONITORING SYSTEM

This document was prepared by the Internet Zero (i0) team from MIT.

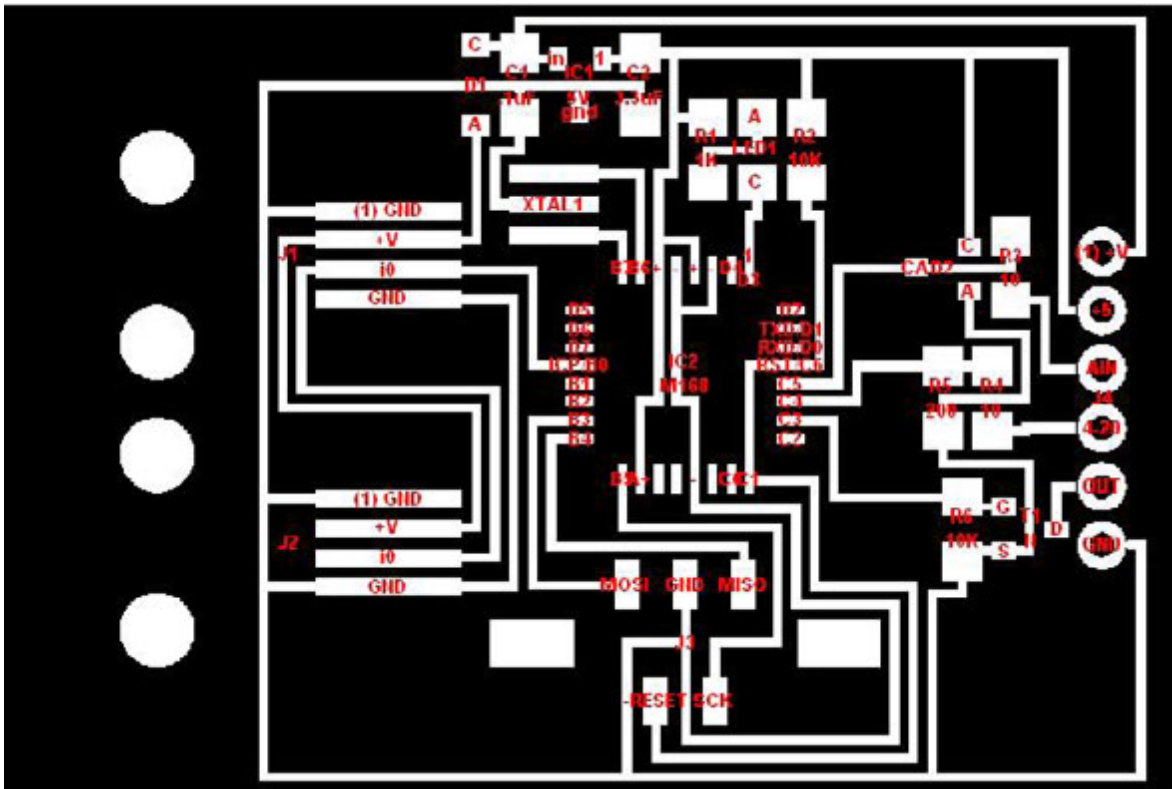
Project Description:

The MIT team lead by Stephen Samouhos and in collaboration with Soldier Design Inc. and Sarvanet Inc., plans to deliver an energy measurement and visualization system to Curio via deployment of a new MIT networking technology, Internet Zero (i0) within the Curio house. The project, which is under the auspices of Professor Neil Gershenfeld of the MIT Center for Bits and Atoms, and the MIT Intelligent Infrastructure for Energy Efficiency consortium (i2e), includes several dozen networked sensors (UL listed and otherwise) that are positioned throughout the house to measure and record critical energy aspects of the building. The sensors are powered by a UL-listed, commercial DC power supply, where the transmission wiring is also used as the network communication medium.

Soldier Design Inc. is providing the appropriate user interface that will access the sensor database in order to visualize the key energy consuming aspects of the building. Sarvanet Inc. will provide and support all networking technology needed to collect that data. The system as a whole will collect and present information that educates building inhabitants on their energy consuming behaviors, as well as the efficacy of unique design choices made during the development of the Curio house.

Project Technology:

This project will be the first implementation of Internet Zero (i0) networking technology in a stand-alone building application. i0 and the related i2e consortium are outgrowths of research and development at MIT's Center for Bits and Atoms. The networking technology, which was publicly demonstrated 5 years ago, enables 'interdevice internetworking' of unlike devices. This philosophy is especially applicable within buildings where there are still numerous devices that are either not networked, or networked only within their small vendor or product category. This lack of device networking within buildings is very much akin to the state of computer networking just before the dawn of the Internet; the success of the Internet was in 'internetworking' across unlike computer networks. i0 was designed to extend the success of the internet by accomplishing the same task within networks of simpler devices, or in this case, within buildings. This project with Curio is a critical step towards this goal and developing the technology beyond printed circuit boards and DC wire communication. The future vision of i0 consists of interoperable communication over any medium, with a few kilobytes of code running on an inexpensive microcontroller, corresponding to a fraction of a square millimeter of silicon and pennies of added cost in a custom chip. At that cost factor and composition, the Internet may proliferate from our laptops and cell phones to reach our light bulbs and toasters.



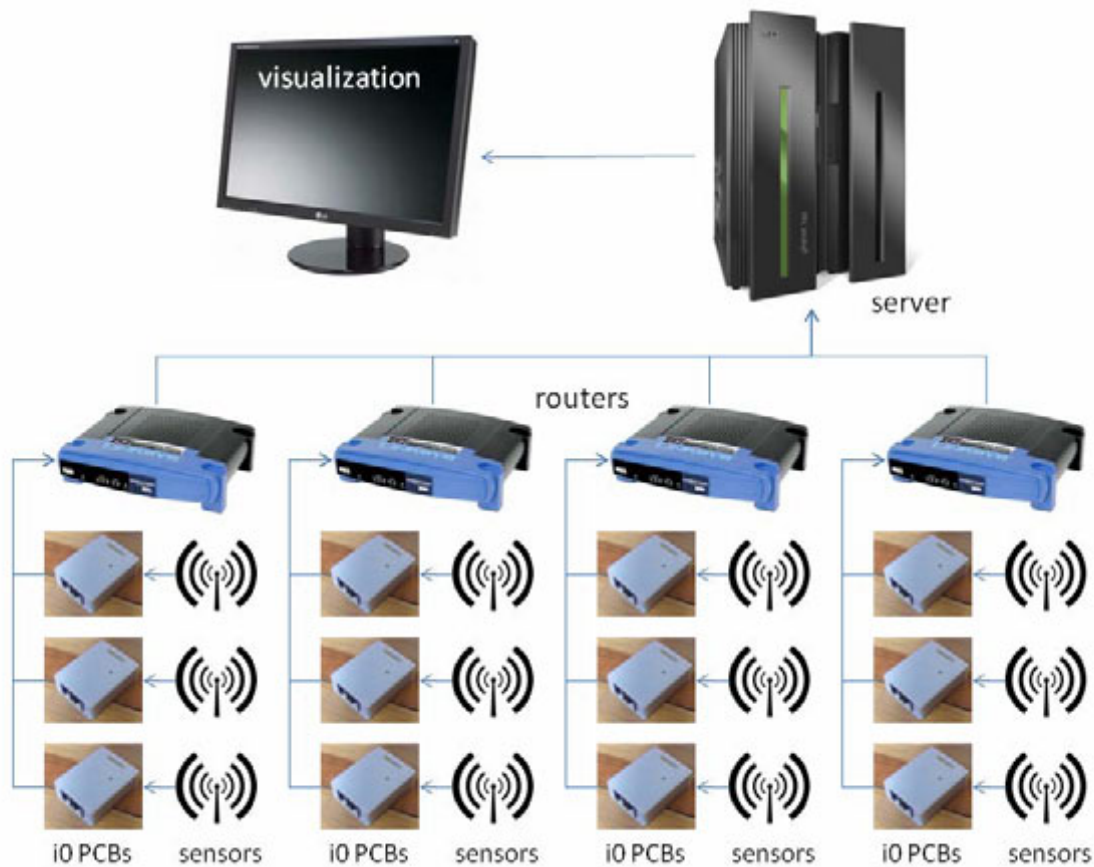
A CAD drawing of i0 board components and wiring.



Assembled i0 PCB with plastic housing.

System Architecture:

Sixty six sensors will be placed at key points throughout the Curio house to gauge a number of energy related functions. These include dynamic efficiency of PV panels, thermal performance of walls, energy flow in the mechanical HVAC system, appliance energy consumption, and occupancy based electricity use. Each sensor will be attached to an Internet Zero printed circuit board (i0 PCB), which is designed and manufactured by Sarvanet. The i0PCB-sensor pairs plug in to a modified Linksys router via silver satin data cable. These routers are wired to a server, which stores the sensor information. The server is then accessed by a visualization interface designed by Soldier Design, which displays the information about the Curio house in a user-friendly manner.



Technology Certification:

Due to the experimental nature of this project, we will document and present information concerning the physical testing of all non-UL listed items. We will be using non-UL listed networking devices (iO PCB's) in conjunction with UL-listed devices (Linksys Routers) that have been physically modified (new connection port for iO PCBs). We will also be using several non-UL listed sensors that we have made to monitor room occupancy and door position. Neither set of non-UL listed devices is involved with any aspect of the building that could impact life safety. All of our devices will remain at a consumer-grade "plug-and-play" level with no attempts to exhibit closed-loop control over potentially life-threatening appliances or situations. Our primary focus is on data acquisition, storage, visualization and inference, not system control and optimization. UL listed devices that we will be using include commercially available sensors from www.kele.com, Cisco routers, DC power supplies, and silver satin telephone wiring.

Itemized List of Costs:

Sensor	No. of Units	Unit Cost	Total Sensor Cost
Temperature Sensor	37	\$25.00	\$925.00
strap-on temp sensor	4	\$25.00	\$100.00
Outdoor Light Sensor	3	\$202.00	\$606.00
Occupancy Sensor	9	\$10.00	\$90.00
Magnetic Contact Sensor	3	\$10.00	\$30.00
Humidity Sensor	2	\$240.00	\$480.00
Current Transducer	6	\$250.00	\$1,500.00
External Water Flow	2	\$560.00	\$1,120.00
Total	66	--	\$4,851.00

Auxiliary Item	No. of Units	Unit Cost	Total Aux. Cost
Internet Zero Printed Circuit Boards	66	\$15.00	\$990.00
Routers	5	\$70.00	\$350.00
DC Power Supply	1	\$200.00	\$200.00
Silver Satin Data Cable	1	\$100.00	\$100.00
Software	1	\$1,500.00	\$1,500.00
Total	--	--	\$3,140.00

Labor	Hours	Cost Per Hour	Total Labor Cost
Engineering (0.5 hours per point)	31.5 hours	\$75	\$2,362.50
Installation (0.5 hours per point)	31.5 hours	\$50	\$1,575.00
Total	157.5	--	\$3,937.50

Delivery Estimate:

Summing the totals from above yields a net cost of \$11,928.50, which is \$180.75 per point. After accounting for a 12% margin in the final cost, we expect a commercial distribution of this system to about \$202.50 per point, which is a significant reduction from industry standard of at least \$550 per point (generally closer to \$850 or \$1,000 per point).



TEAM BOSTON
SOLAR DECATHLON 2009

SUBJECTIVE CONTEST SUPPORT DOCUMENTS



ARCHITECTURAL DESIGN NARRATIVE

“The curious shall inherit the earth.”

Jim Coudal, Design/Web Entrepreneur & Founder of Coudal Partners

Sustainable design requires an integrated design process: Team Boston approached this competition by deciding that we could only demonstrate the design and implementation of a truly sustainable house by considering each of the “3 Es of sustainability”: ecology, economy, and social equity. We therefore built our design team with students representing each of these, which included design students (architectural, interior, landscape, and graphic), engineering students (civil, mechanical, electrical, structural, and chemical), and public policy students (social, environmental, and urban planning).

In preparation for the integrated design process, the team took part in a series of workshops designed to enhance each group’s understanding of the various issues: Biomimicry for an ecological perspective, current prefabrication strategies for an economic perspective, and Universal Design for a socially equitable perspective. The first four months were dedicated to a series of multi-disciplinary charrettes in order to train the various team members to produce coherent concepts despite a lack of a common process and language. In addition, a large portion of time was dedicated to current housing market research and focus groups with green affordable housing leaders in the Boston area. Throughout the extended design process we have engaged dozens of green and affordable housing experts for feedback on goals, process, outcomes, and details. It is because of these extensive processes that our house embodies a holistic approach to sustainability.

Sustainable lifestyle requires an evolution of shelter: In considering how to evolve the design of shelter, a building and its inhabitants should be viewed as a single functioning organism. It is from this perspective that we determined that the way in which we understand and interact with our homes is more important than any single technological strategy. It is the interface between human and home that is at the center of how we evolve our lifestyles as part of a more efficient whole. This understanding of human-shelter relationship is primarily achieved through architectural form, construction sequence, and an ambient feedback system, which is further reinforced by systems, interior, and lighting designs.

Awareness: A large portion of “sustainable living” can be achieved through low-tech and passive strategies, which have historically connected people on a very deep level to traditional, vernacular homes. The remaining portion of what will comprise a sustainable home of the future is decidedly high-tech. These high-tech systems have a tendency to alienate, disorient, and intimidate those without a technical understanding of building systems. While the combination between the active and passive is critical in any efficient building, the interface between the two is seldom given attention. The Curio.House provides a number of ways in which to understand the importance of this relationship, and seeks to reconnect Modern Man to home, site, and the natural and artificial systems that sustain him.

Form: The first expression of this active/passive relationship is in the architectural form, which is divided into two major pieces. The heart of the Curio.House is a core module housing all of the active systems and spaces critical for creating an efficient home, including the airlock entry, kitchen, bathroom, central plumbing equipment, mechanical closet, and electrical closet. These spaces are more opaque and intimate, providing an experience distinct from the rest of the house. The second major piece is the passive, human-centered portion, focusing on an open, flexible, studio-like floor plan that extends to the north and south exterior spaces visually and via fixed and sliding door glazing. This architecture encourages the homeowner to live with the seasons, orienting their winter living southward for free passive heat, and their summer living northward for an exterior, green living room, complete with food garden and miniature hydrologic cycle. This active vs. passive form gives them a formal understanding of how these two strategies can work in concert to provide a holistically sustainable home.

Feedback: The second expression of active/passive partnership is a monitoring and feedback system. The most significant factor in effecting behavior and encouraging lifestyle evolution is not home automation, but instant feedback. The Curio.House feedback system effectively engages the inhabitants by providing the full spectrum of relevant information via an ambient feedback wall and a web-based display that can be accessed from a home computer or remotely. The ambient wall communicates general resource usage in an intuitive manner, sparking curiosity from the homeowner. The computer user interface provides information on various conditions and systems in the house, allowing for further exploration and charting for those who want to dig deeper, and will be available via the team website as well as the on-site tour. This approach to informing the owner puts faith in the human ability to make the right lifestyle and resource management decisions if properly informed. It encourages one to be aware, learn more, and improve choices based on personal metrics and not what an automated system dictates. This is counter to the typical “house of the future” strategies that have failed to ignite any significantly broad markets. The Curio strategy for engaging, communicating, and educating is an effective way to counter the anxiety of anyone unsure of purchasing complex equipment.

Comfort: Spatial, visual, and environmental comfort were important factors in the design of the Curio.House. The expansive use of glazing provides an abundance of either southern or indirect northern light. It also vastly improves the perceived size of the living space by providing visual connections to the public street to the south and the deck to the north. Utilization of radiant heat is an important factor, as the tactile characteristic of surfaces is one third of perceived comfort, after ambient temperature and humidity. Aside from radiant floor heat, the Curio.House also employs a “heat glass” system, incorporating a transparent thermal mass embedded within the southern glazing. This heat glass provides interior temperature modulation during the summer, and lasting radiant heat when the low winter sun provides direct solar gain. Where windows have always meant sacrificing efficiency for views and natural light, this product turns that same window into a source for free, comfortable, supplemental heat.

Adaptable Living: The Curio design team worked closely with the Boston-based Institute for Human-Centered Design to ensure proper inclusion of “universal design” ideals so that the broadest range of people could best utilize the house. This is reflected in a wide range of design decisions, from hardware to clearances to surface treatments to daily maintenance plans.

The living space incorporates custom furniture that provides designed adaptability, the key to efficiency of any small space. The fixed and moveable furniture walls include ample storage space, a fold-down bed, an entertainment area, a work space, and additional pieces of furniture. This allows for an incredibly flexible interior space that can effectively serve a number of different functions simultaneously for a single person, or can all be packed away tight for an indoor-outdoor dance party for 75 people.

Context: The design reinforces the intention of an urban context. By placing the house close to “decathlete way,” the southern deck will act as a public porch while the dedicated north deck and the rest of the site design will allude to back alleys and bike racks. The house will also be linked into DC area bike networks, so that during the competition, our site will serve as a hub for bicycle traffic and storage, further reinforcing an urban feel.

Buildability & Adaptability: The Curio.House is easy to construct because it is based on well-known methods, which are clearly explained in the construction documents. It is easy to deploy because it uses manageably sized modules appropriate for standard size trucking and avoids cranes for placement. It is easy to expand because of the modular segregation, so that the active module can support one, or several, passive areas, with the mechanical systems supporting each zone individually. And finally, it is easy to adapt because of how its central active core module can support a highly personal, highly open passive space. This also means that an active module could be deployed to be coupled with a traditionally on-site built portion.



MARKET VIABILITY DESIGN NARRATIVE

"The curious shall inherit the earth."

Jim Coudal, Design/Web Entrepreneur & Founder of Coudal Partners

CURIO

The Curio.House presents a new way to interact with one's home, connecting sustainable thinking with sustainable living. The Solar Decathlon Competition is primarily about education. Likewise the Curio.House is about curiosity, focusing on the interface between the sovereign human and increasingly complex technologies. It invites the inhabitants to learn about their home, and therefore about themselves, in order to make better informed choices that positively impact the earth, and to live symbiotically with the next stage of sustainable architecture.

The Curio.House is a product of the Curio brand, the development of which served as a compass, leading us through much of the design process. The brand was developed as if launching a real product. It is the public face of Team Boston, and targets a market seldom tapped in a truly accessible, holistically-designed fashion that negates the intimidating nature of technical architecture. The engaging style of all public materials, not to mention the house, provides an easy opportunity for the informed user to take a giant step forward in improving the efficiency of their own lifestyle.

DEFINING THE TARGET MARKET

While the ideas behind the Curio.House can be applied to a wide variety of sites, densities, and demographics (as explored in the "curio.city" portion of www.livecurio.us, launched August 2009), this document focuses on those to whom we would sell this competition house if put on the open market. Our target market is exactly that group of people most attracted to middle class, modern, sustainable living in a moderately dense urban environment; in this case Boston.

"Dennis", as we are naming our target homeowner, is a young professional, exploring the ways in which he can use his income to improve the efficiency of his lifestyle, without compromising too many of his modern comforts. He reads Dwell magazine, shops at Whole Foods Market, carries an iPhone, and commutes to work via public transportation. To Dennis, the Curio brand is seen as an easy way to buy into the exploding green movement, similar to the Toyota Prius. It is both an investment and personal statement of how Dennis has chosen to live a sustainable lifestyle.

Profiled homeowner	Dennis
Location of permanent site	Fort Hill area, Boston, MA
Occupant demographic	Single professional male
Occupation	Graphic designer
Mode of transportation	Public transportation commuter, Zipcar
Design and aesthetic preference	"Dwell Modern"
Identifying products/brands	Apple iPhone, Toyota Prius, local organic food, Patagonia
Modes of recreation	Bicycling, hosting dinner parties, watching the Red Sox
Homeowner annual income	\$70,000
Housing type	Studio apartment/flat
No. of occupants	1
No. of bedrooms	1

LIVABILITY

Awareness: A large portion of “sustainable living” can be achieved through low-tech and passive strategies, which have historically connected people on a very deep level to traditional, vernacular homes. The remaining portion of what will comprise a sustainable home of the future is decidedly high-tech. These high-tech systems have a tendency to alienate, disorient, and intimidate those without a technical understanding of building systems. While the combination between the active and passive is critical in any efficient building, the interface between the two is seldom given attention. The Curio.House provides a number of ways in which to understand the importance of this relationship, and seeks to reconnect Modern Man to home, site, and the natural and artificial systems that sustain him.

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Adaptable Living: The Curio design team worked closely with the Boston-based Institute for Human-Centered Design to ensure proper inclusion of “universal design” ideals so that the broadest range of people could best utilize the house. This is reflected in a wide range of design decisions, from hardware to clearances to surface treatments to daily maintenance plans.

The living space incorporates custom furniture that provides designed adaptability, the key to efficiency of any small space. The fixed and moveable furniture walls include ample storage space, a fold-down bed, an entertainment area, a work space, and additional pieces of furniture. This allows for an incredibly flexible interior space that can effectively serve a number of different functions simultaneously for a single person, or can all be packed away tight for when Dennis wants to host an indoor-outdoor dance party for 75 people.

Maintenance: Ongoing maintenance of mechanical systems is made simple by the use of quality materials and mostly off-the-shelf components. These systems will be familiar to standard maintenance workers, and are found in central easy-access locations, increasing long-term and short-term economic accessibility. The single prototypical element in the Curio.House is the heat glass, as described above. The team has chosen to make this one exception because we feel so strongly about the revolutionary effects this product will have on sustainable design worldwide.

Context: The design reinforces the intention of an urban context. By placing the house close to “decathlete way,” the southern deck will act as a public porch while the dedicated north deck and the rest of the site design will allude to back alleys and bike racks. The house will also be linked into DC area bike networks, so that during the competition, our site will serve as a hub for bicycle traffic and storage, further reinforcing an urban feel.

Buildability: This was a major consideration from the beginning of conceptual design. In order to meet the needs of economic accessibility, we consulted with over a dozen local experts in affordable housing design, green construction, and off-site construction and implementation. This is reflected not only in our construction and deployment methods, but also permeates even our conceptual philosophies of active and passive differentiation and interface.

Adaptability: The Curio.House is easy to construct because it is based on well-known methods, which are clearly explained in the construction documents. It is easy to deploy because it uses manageably sized modules appropriate for standard size trucking and avoids cranes for placement. It is easy to expand because of the modular segregation, so that the active module can support one, or several, passive areas, with the mechanical systems supporting each zone individually. And finally, it is easy to adapt because of how its central active core module can support a highly personal, highly open passive space. This also means that an active module could be deployed to be coupled with a traditionally on-site built portion.

While Team Boston has opted to execute construction of the Curio.House, it was designed to be easily built by either conventional construction teams or by modular manufacturers. In fact, Curio will be available for purchase in the northeast region through several companies, as homes and as modular classrooms.

CONCLUSION

The Curio.House begins with a fictional homeowner, Dennis, but will soon catch on, as others see how adaptable this design is, and how applicable these concepts are. Whether it’s a bachelor pad, a summer cottage, a single family, deployed for disaster relief, used as a modular classroom, or stacked to create truly dense urban living, Curio is ripe for a wide variety of markets. By balancing economic needs through materials and methods, social needs through universal design, and environmental needs through active and passive strategies, the Curio.House provides a holistic way for anyone to live sustainably.

ASK WHY. LEARN HOW. LIVE CURIOUS.



ENGINEERING DESIGN NARRATIVE

"The curious shall inherit the earth."

Jim Coudal, Design/Web Entrepreneur & Founder of Coudal Partners

FOUNDATION

Team Boston's Curio.House is an innovative, energy efficient residence that upholds the team's commitment to the social responsibility that accompanies truly sustainable design. In line with the team's core values, the design of the house has always been centered around balancing the "three Es of sustainability": ecology, economy, and social equity. These principles have been translated into goals for the house's engineering systems that will help ensure the design of the house is healthy not only for the environment, but for communities as well.

Ecology

In order to minimize the use of electricity generated from fossil fuels, the Curio.House will be a zero net energy residence that produces more electricity than it consumes over the course of a year. With a strong focus on passive solar design, the house will be extremely energy efficient and low maintenance, utilizing techniques such as a carefully engineered southern overhang and water-filled windows that act as a thermal mass to help regulate the temperature in the house. A significantly lower dependence on energy from the grid will help reduce the amount of harmful CO₂, NO_x, and SO_x released into the atmosphere from standard electricity generation methods.

Economy

By minimizing the use of prototypical systems, the Curio.House aims to be affordable as well as energy efficient. When applicable, each technology used in the house has been analyzed to weigh the value of increased efficiency against the first cost, maintenance, and durability of the system. For example, the house's five flat plate solar thermal collectors will provide 94% of the domestic hot water at a fraction of the cost of evaporated tube collectors.

Social Equity

The house design showcases primarily "off-the-shelf" systems. These currently available systems (such as the micro-inverters on the photovoltaic array, flat plate collectors, and ERV) can be easily reproduced and have already been proven reliable, reducing the perceived risk to cautious homeowners. Additionally, the team has focused on design strategies to "level the playing field" through affordable or adaptable systems. The micro-inverters, for example, allow the homeowner to expand the system when funds are available. This significantly reduces first costs and creates an opportunity for lower income households to invest slowly in sustainable systems.

PROCESS

Beginning with the first round of preliminary design exercises, the engineering and architecture students have worked together side by side researching systems and stewarding the design process. Nearly 18 months later, a constant dialog between architecture, engineering, and public policy students has produced a set of engineering systems that are highly efficient as well as reliable and fiscally sensible. After a detailed analysis, the Curio.House is anticipated to generate a surplus of nearly 3500 kWh annually, a number that attests to the feasibility of affordable and accessible sustainable residences.



LIGHTING DESIGN NARRATIVE

"The curious shall inherit the earth."

Jim Coudal, Design/Web Entrepreneur & Founder of Coudal Partners

Natural Lighting

Light within the Curio.House was a critical design driver. The minimal interior space could have a claustrophobic feeling for the user if ample views and connections to natural daylight and exterior vistas did not exist. While the house was designed for an urban location, the use of expansive windows to the north and south is essential for the feeling of an expanded living space. To the south, our street front, the raised floor level and half-height partition wall allow for the inhabitants to have a clear view out, but still remain semi-concealed from the public.

The extensive use of glass in the design may seem counter-intuitive for a New England sited home, however, the incorporation of roller shades on both the interior and exterior surfaces helps to increase the thermal values of the window. In the summer months, as the interior space heats up, exterior roller shades are designed to drop from the soffit to block the solar thermal gain and direct sunlight from pouring into the house. Also, the overhang on the south roof is sized to shade the full window from the high summer sun. In the winter, the southern glazing helps to passively heat the space as the natural light comes in. To the north, polycarbonate panels are attached to the window frames, a practice commonly seen in conservatories in Europe, which decrease thermal loss, but allow for a view to the outside and help to block the frigid northwestern winter winds of New England. Interior shades on both the north and south facades can be dropped to provide an additional sense of thermal comfort in the winter months in addition to the year round privacy and shading they provide.

Active and Interactive Lighting Systems

The electrical lighting design for the Curio.House consists of two parts: general lighting throughout the living space, and traditional task lighting particular to the program of each zone. The general lighting is spread evenly to ensure ample light throughout the flexible space and any infill architectural configuration that the user can define.

Throughout the house, the design utilizes LED fixtures with compact fluorescent pendants and sconces. The color temperature and light level are automatically determined by the exterior environmental conditions. The intent is to reduce the amount of energy typically needed to condition the interior by psychologically affecting the space. For example, a hot summer day would result in a cooler color temperature for the general lighting, thereby making the inhabitants feel cooler, in turn reducing the energy loads from turning up the air conditioning.

On the exterior, lighting is designed minimally to help reduce any light pollution, no matter how small one residence's contribution can be. LED lights are spaced along the entry and exit ramps to aim light downwards, illuminating the path. On the north and south deck walls, running aligned through the house, fixtures are incorporated as breaks to mimic the decking pattern that connects back to the interior living space. Accent lighting is also incorporated into the growing wall and rain water catchment feature to the east of the north deck.