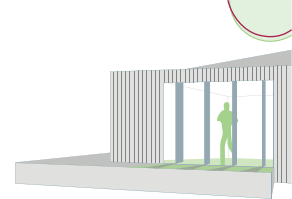
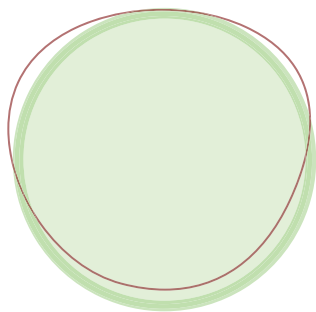


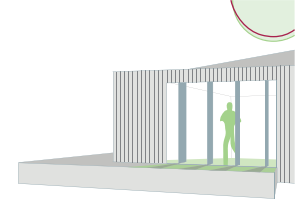
# Project Manual



U.S. DEPARTMENT OF  
**ENERGY**



# Table of Contents\_1

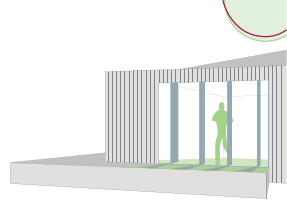


1	<b>Table of Contents</b>
2	<b>Summary of Changes</b>
3	<b>Rules Compliance Checklist</b>
4	<b>Construction Specifications</b>
5	<b>Structural Calculations</b>
6	<b>Detailed Water Budget</b>
7	<b>Summary of Unlisted Electrical Components</b>
8	<b>Retail PV Price Quote(s)</b>
9	<b>Summary of Reconfigurable Features</b>
10	<b>Interconnection Application Form</b>
11	<b>Energy Analysis Results and Discussion</b>
12	<b>Subjective Contest Support Documents</b>
12.1	architecture design narrative
12.2	market viability justification
12.3	engineering design narrative
12.4	lighting design narrative

## COMPLETED BY:

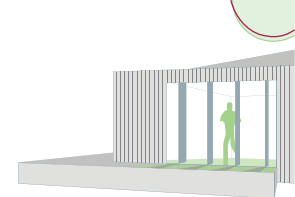
The Ohio State University (OSU)  
Solar Decathlon Team  
Mechanical Engineering, E331 SO  
Columbus OH 43210  
614-292-6081

## Summary of Changes\_2

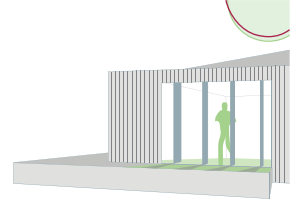


The following submission is a new document and should not be reviewed as a revised set.

# Rules of Compliance Checklist\_3

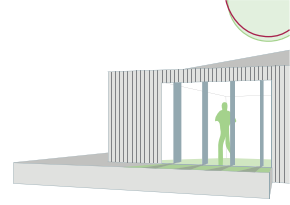


Rule	Description	Content Required	Relevant Sections
4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site	G.101 G.102
4-2	Construction Equipment	Specs for heavy machinery	N/A
4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	S.101, S.602
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	S.101, S.602 S.003, S.401
4-5	Generators	Specifications for generators	N/A
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	Subsets P&M
4-6	Spill Containment	Specifications for all equipment, tanks, and pipes that will contain fluids at any point during the event	Subset P ref. Subset M ref.
4-7	Lot Conditions	Calculations showing that structural design remains compliant even if 18 in. (45.7 cm) of vertical elevation change exists	S.602 ref.
4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 18 in. (45.7 cm) of vertical elevation change exists on the lot	S.602, S.003 S.101
5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	C.201 C.202
5-2	Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references	N/A
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.	S.001 thru S.603  S.602 ref.
6-2	Maximum Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to measure the architectural footprint electronically	G.201
6-2	Maximum Architectural Footprint	Drawing(s) showing all movable components that may increase the footprint if operated during contest week	G.302
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)	N/A
6-3	Minimum Conditioned Space	Drawing(s) showing space conditioning means in primary living spaces	G.202, M.102
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	G1.05
7-1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	L.101 thru L.103
7-2	Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems	N/A
8-1	PV Technology Limitations	Specifications for photovoltaic components	A.108 ref



Rule	Description	Content Required	Relevant Sections
8-1	PV Technology Limitations	Retail price quote for photovoltaic components	A.108 ref
8-3	Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components	N/A
8-3	Thermal Energy Storage	Specifications for thermal energy storage components	N/A
8-3	Thermal Energy Storage	Shading calculations and/or diagrams for thermal energy storage components (if necessary)	N/A
8-4	Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices	L.101
8-4	Batteries	Specifications for all stand-alone, PV-powered devices	L.101 ref
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.	E.102 ref
8-6	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	E.101, E.102 E.103, A.108
8-6	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	A.108 ref E.102 ref E.103 ref E.301 ref
8-6	Village Grid	One-line electrical diagram	E.101
8-6	Village Grid	Calculation of service/feeder net computed load per NEC 220	E.201
8-6	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	E.102
8-6	Village Grid	Elevation(s) showing the terminal box, meter housing, main utility disconnect, and other service equipment	E.301
9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	N/A
9-6	Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems	N/A
9-6	Thermal Mass	Specifications for components of water-based thermal mass systems	N/A
10-2	Event Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	N/A
10-3	Team Sponsor Recognition	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	N/A
11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	G.301
11-4	Public Exhibit	Drawing(s) showing the dimensions, materials, artwork, and content of handout	N/A
11-4	Public Exhibit	Drawing(s) showing the artwork and content of the team uniform	N/A

# Construction Specifications\_4



## TABLE OF CONTENTS

DIVISION 01:	GENERAL REQUIREMENTS
01 10 00	SUMMARY
01 50 00	TEMPORARY FACILITIES AND CONTROLS
01 74 19	CONSTRUCTION WASTE MANAGEMENT
01 81 13	SUSTAINABLE DESIGN REQUIREMENTS
DIVISION 05:	METALS
05 12 00	STRUCTURAL STEEL FRAMING
05 50 00	METAL FABRICATIONS
05 52 00	METAL RAILINGS
DIVISION 06:	WOOD, PLASTICS AND COMPOSITES
06 10 00	ROUGH CARPENTRY
06 10 63	EXTERIOR ROUGH CARPENTRY
06 16 00	SHEATHING
06 20 00	FINISH CARPENTRY
06 40 23	INTERIOR ARCHITECTURAL WOODWORK
DIVISION 07:	THERMAL AND MOISTURE PROTECTION
07 21 00	THERMAL INSULATION
07 25 00	WEATHER BARRIERS
07 46 00	SIDING
07 53 23	KETONE-ETHYLENE-ESTER (KEE) ROOFING
07 26 00	SHEET METAL FLASHING
07 71 00	ROOF SPECIALTIES
07 72 00	ROOF ACCESSORIES
07 92 00	JOINT SEALANTS
DIVISION 08:	OPENINGS
08 14 16	FLUSH WOOD DOORS
08 32 19	WOOD-FRAMED GLASS DOORS
08 35 13	FOLDING DOORS
08 41 13	ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
08 52 00	WOOD WINDOWS
08 71 00	DOOR HARDWARE
08 80 00	GLAZING
DIVISION 09:	FINISHES
09 29 00	GYPSUM BOARD
09 30 00	TILING
09 64 00	WOOD FLOORING

09 91 00	PAINING
DIVISION 10:	SPECIALTIES
10 28 00	TOILET, BATH AND LAUNDRY ACCESSORIES
10 44 16	FIRE EXTINGUISHERS
DIVISION 11:	EQUIPMENT
11 28 13	COMPUTERS
11 31 00	RESIDENTIAL APPLIANCES
11 52 00	AUDIO-VISUAL EQUIPMENT
DIVISION 12:	FURNISHINGS
12 24 00	WINDOWSHADES
12 35 30	RESIDENTIAL CASEWORK
12 36 40	STONE COUNTERTOPS
DIVISION 22:	PLUMBING
22 05 00	COMMON WORK RESULTS FOR PLUMBING
22 05 23	GENERAL-DUTY VALVES FOR PLUMBING PIPING
22 07 00	PLUMBING INSULATION
22 11 16	DOMESTIC WATER PIPING
22 11 19	PLUMBING SPECIALTIES
22 11 23	DOMESTIC WATER PUMPS
22 13 16	SANITARY WASTE AND VENT PIPING
22 13 53	FACILITY SEPTIC TANKS
22 33 00	ELECTRIC DOMESTIC WATER HEATERS
22 33 01	SOLAR THERMAL
22 40 00	PLUMBING FIXTURES
DIVISION 23:	HVAC
23 05 23	GENERAL-DUTY VALVES FOR HVAC PIPING
23 05 93	TESTING, ADJUSTING, AND BALANCING FOR HVAC
23 07 00	HVAC INSULATION
23 09 00	INSTRUMENTATION AND CONTROL FOR HVAC
23 21 23	HYDRONIC PUMPS
23 31 00	HVAC DUCTS AND CASINGS
23 34 23	HVAC POWER VENTILATORS
23 37 13	DIFFUSERS, REGISTERS AND GRILLES
23 81 19	SELF-CONTAINED AIR-CONDITIONERS
23 83 16	RADIANT-HEATING HYDRONIC PIPING



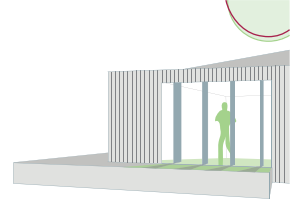
DIVISION 25:	INTEGRATED AUTOMATION
25 11 13	HOME AUTOMATION AND CONTROLS SYSTEM

DIVISION 26:	ELECTRICAL
26 05 00	COMMON WORK RESULTS FOR ELECTRICAL
26 09 23	LIGHTING CONTROL DEVICES
26 24 16	PANELBOARDS
26 27 13	ELECTRICITY METERING
26 27 26	WIRING DEVICES
26 28 13	FUSES
26 31 00	PHOTOVOLTAIC COLLECTORS
26 41 13	LIGHTNING PROTECTION FOR STRUCTURES
26 50 00	LIGHTING

DIVISION 28:	ELECTRONIC SAFETY AND SECURITY
28 31 00	FIRE DETECTION AND ALARM

DIVISION 32:	EXTERIOR IMPROVEMENTS
32 93 00	PLANTS

## Division\_01 General Requirements



## SECTION 011000 - SUMMARY

## PART 1 - GENERAL

## 1.1 PROJECT INFORMATION

- A. Project: The Ohio State University Solar House I.
  - 1. Project Location: The Ohio State University Campus in Columbus, Ohio. Site is located in the open area immediately northeast of the bend in the road where Tuttle Park Place transitions in to West 17<sup>th</sup> Ave. The site is bordered by the university power plant to the east, a facilities building to the north, Ohio Stadium to the west (across Tuttle Park Place) and the RPAC Student Activities Center to the South (across West 17<sup>th</sup> Ave).
- B. Owner: The Ohio State University
- C. Architect: The Knowlton School of Architecture. Keoni Fleming (Advisor).
- D. Contractor: The Ohio State University Solar Decathlon Team. Steven Winter (Coordinator).
- E. The Work consists of construction of a 1 story, 22'-8" x 30" house with exterior decks per the referenced drawings and specifications. The house is a light wood frame constructed in three modules on mobile steel trailers that can be separated for transport following completion of construction.

## 1.2 WORK RESTRICTIONS

- A. Contractor's Use of Premises: During construction, Contractor will have full use of the area indicated. Contractor's use of premises is limited only by Owner's right to perform work or employ other contractors on portions of Project.
  - 1. Driveways, Walkways, and Entrances: Keep driveways and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.
- B. Nonsmoking Building: Smoking is not permitted within the building or within 25 feet (8 m) of entrances, operable windows, or outdoor-air intakes.
- C. The site gate must remain closed during construction to keep onlookers from entering the site, and to keep Motown, Steve Winter's black Labrador retriever, from escaping.
- D. Work must be completed in accordance with the Solar Decathlon Work Safety Plan, which sets forth requirements for safe construction.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 011000

## SECTION 015000 - TEMPORARY FACILITIES AND CONTROLS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Electric Power: Available from a portable generator provided by the contractor. Provide connections and extensions of services as required for construction operations.
- B. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.

## PART 2 - PRODUCTS

## 2.1 EQUIPMENT

- A. Generators:
  - 1. 3800 Watt 120/240 Honda Generator
  - 2. Full GFCI Protection  
<http://www.hondapowerequipment.com/products/modeldetail.aspx?page=modeldetail&section=P2GG&modelname=EB3800&modelid=EB3800XA>

## PART 3 - EXECUTION

## 3.1 TEMPORARY UTILITY INSTALLATION

- A. Provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, inspections, and traffic conditions.

## 3.2 SECURITY AND PROTECTION FACILITIES INSTALLATION

- A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.
- B. Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion.

END OF SECTION 015000

## SECTION 017419 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Performance Requirements: Achieve end-of-Project rates for salvage/recycling of 75.

## 1.2 SUBMITTALS

- A. Waste Management Plan: Submit plan within 30 days of date established for commencement of the Work.
- B. Waste Reduction Progress Reports: Submit concurrent with each Application for Payment. Include total quantity of waste, total quantity of waste salvaged and recycled, and percentage of total waste salvaged and recycled.
- C. Records of Donations and Sales: N/A
- D. Recycling and Processing Facility Records: Receipts and invoices.
- E. Landfill and Incinerator Disposal Records: N/A.
- F. Waste Management Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Administrative Requirements." Review methods and procedures related to waste management.
- G. Waste Management Plan: Develop a waste management plan consisting of waste identification, waste reduction work plan, and cost/revenue analysis. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.
  - 1. Salvaged Materials for Reuse: Reusable wood and metal products.
  - 2. Salvaged Materials for Sale: N/A.
  - 3. Salvaged Materials for Donation: N/A.
  - 4. Recycled Materials: The Ohio State University, Facilities Operation and Development, Enarson Hall 154 W 12th Avenue, 614-292-1528.
  - 5. Cost/Revenue Analysis: N/A.

## PART 2 - PRODUCTS (Not Used)

## PART 3 - EXECUTION

## 3.1 PLAN IMPLEMENTATION

- A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.
- B. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work occurring at Project site.
- C. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.

## 3.2 SALVAGING DEMOLITION WASTE

- A. N/A

## 3.3 RECYCLING WASTE

- A. General: Recycle paper and beverage containers used by on-site workers.
- B. Packaging:
  - 1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
  - 2. Polystyrene Packaging: Separate and bag materials.
  - 3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
  - 4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.
  - 5. Clean and stack undamaged, whole masonry units on wood pallets.
- C. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.
- D. Metals: Separate metals by type.
- E. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.
- F. Piping: Reduce piping to straight lengths and store by type and size. Separate supports, hangers, valves, sprinklers, and other components by type and size.
- G. Conduit: Reduce conduit to straight lengths and store by type and size.

3.4 DISPOSAL OF WASTE

- A. Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.
- B. Do not burn waste materials.

END OF SECTION 017419



## SECTION 018113 - SUSTAINABLE DESIGN REQUIREMENTS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

## A. Definitions:

1. Regional Materials: Materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value.
2. Recycled Content: The recycled content shall be determined by weight.
  - a. "Post-consumer" material is defined as waste material generated by end users of the product, which can no longer be used for its intended purpose.
  - b. "Pre-consumer" material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as scrap generated in a process that is reclaimed in the same process that generated it.

## B. Submittals:

1. List of proposed materials with recycled content. Indicate post-consumer recycled content and pre-consumer recycled content for each product. Submit within 60 days of date established for commencement of the Work.
2. List of proposed regional materials. Submit within 60 days of date established for commencement of the Work.
3. List of proposed certified wood products. Submit within 60 days of date established for commencement of the Work.
4. Product Data.

## PART 2 - PRODUCTS

## 2.1 MATERIALS

- A. Recycled Content of Materials: Provide building materials with recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content constitutes a minimum of 10 percent of cost of materials used for Project.
  1. Do not include mechanical and electrical components in the calculation.
- B. Regional Materials: Provide 10 percent of building materials (by cost) that are regional materials.

## 2.2 LOW-EMITTING MATERIALS

- A. Use adhesives and sealants that comply with the following limits for VOC content:
1. Wood Glues: 30 g/L.
  2. Subfloor Adhesives: 50 g/L.
  3. Multipurpose Construction Adhesives: 70 g/L.
  4. Contact Adhesive: 80 g/L.
  5. Structural Glazing Adhesives: 100 g/L.
  6. Special-Purpose Contact Adhesive (contact adhesive that is used to bond melamine covered board, metal, unsupported vinyl, PTFE, ultra-high molecular weight polyethylene, rubber or wood veneer 1/16 inch or less in thickness to any surface): 250 g/L.
  7. Plastic Cement Welding Compounds: 350 g/L.
  8. PVC Welding Compounds: 510 g/L.
  9. Adhesive Primer for Plastic: 650 g/L.
  10. Other Adhesives: 250 g/L.
  11. Architectural Sealants: 250 g/L.
  12. Single-Ply Roof Membrane Sealants: 450 g/L.
  13. Other Sealants: 420 g/L.
  14. Sealant Primers for Nonporous Substrates: 250 g/L.
- B. Use interior paints and coatings that comply with the following limits for VOC content:
1. Flat Paints and Coatings: 50 g/L.
  2. Nonflat Paints, Coatings: 150 g/L.
  3. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
  4. Clear Wood Finishes, Varnishes: 350 g/L.
  5. Stains: 250 g/L.
  6. Primers, Sealers, and Undercoaters: 200 g/L.
- C. Do not use composite wood or agrifiber products or adhesives that contain urea-formaldehyde resin.

## PART 3 - EXECUTION

### 3.1 REFRIGERANT REMOVAL

- A. N/A

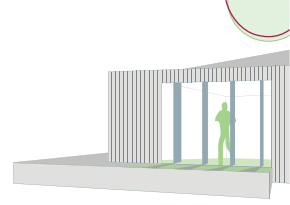
### 3.2 CONSTRUCTION INDOOR-AIR-QUALITY MANAGEMENT

- A. Comply with SMACNA's "SMACNA IAQ Guideline for Occupied Buildings under Construction."
1. If Owner authorizes use of permanent heating, cooling, and ventilating systems during construction period as specified in Division 01 Section "Temporary Facilities and

- Controls," install filter media having a MERV 8 according to ASHRAE 52.2 at each return-air inlet for the air-handling system used during construction.
2. Replace all air filters immediately prior to occupancy.

END OF SECTION 018113

## Division\_05 Metals



## SECTION 051200 - STRUCTURAL STEEL FRAMING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Comply with applicable provisions of the following:
  - 1. AISC 303.
  - 2. AISC 341 and AISC 341s1.
  - 3. AISC 360.
  - 4. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

## PART 2 - PRODUCTS

## 2.1 STRUCTURAL STEEL

- A. W-Shapes: ASTM A 992/A 992M.
- B. 12 inch -14 inch metal piers and CP anchor piers.  
<http://www.centralpiers.com/piers.html>
- C. Flat Top Jacks
- D. CP Anchor Brace for Later Stability  
<http://www.centralpiers.com/piers.html>

## 2.2 ACCESSORIES

- A. High-Strength Bolts, Nuts, and Washers: Type 1, heavy-hex steel structural bolts.
- B. Primer: Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer.
- C. 16 inch x 16 inch ABS pads.

## 2.3 FABRICATION

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible.
- A. Weld Connections: Comply with AWS D1.1/D1.1M N/A
- B. Shop Priming: Prepare surfaces according to SSPC-SP 2, Shop prime steel to a dry film thickness of at least 1.5 mils (0.038 mm).

## PART 3 - EXECUTION

### 3.1 ERECTION

- A. Structural Steel frames are built to be transportable.
- B. 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.
- C. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

END OF SECTION 051200

## SECTION 055000 - METAL FABRICATIONS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A.

### PART 2 - PRODUCTS

#### 2.1 METALS

- A. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- B. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T6.

#### 2.2 FABRICATION

- A. Welding: Weld corners and seams continuously. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals. At exposed connections, finish welds and surfaces smooth with contour of welded surface matching those adjacent.
- B. Fabricate steel girders for wood frame construction from continuous steel shapes of sizes indicated.

#### 2.3 STEEL AND IRON FINISHES

- A. Prepare uncoated ferrous metal surfaces to comply with SSPC-SP 3, "Power Tool Cleaning," and paint with a fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Perform cutting, drilling, and fitting required for installing miscellaneous metal fabrications. Set metal fabrication accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack.
- B. Fit exposed connections accurately together to form hairline joints.
- C. END OF SECTION 055000

## SECTION 055200 - METAL RAILINGS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

### PART 2 - PRODUCTS

#### 2.1 RAILING SYSTEMS

- A. Provide railings capable of withstanding a uniform load of 50 lbf/ ft. (0.73 kN/m) and a concentrated load of 200 lbf (0.89 kN) applied to handrails and top rails of guards in any direction. Uniform and concentrated loads need not be assumed to act concurrently.
- B. Provide railing infill capable of withstanding a concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m). Infill load and other railing loads need not be assumed to act concurrently.

#### 2.2 METALS

- A. Aluminum, Extruded Bars and Tubing: ASTM B 221 (ASTM B 221M), Alloy 6063-T5/T52.
- B. Aluminum Castings: ASTM B 26/B 26M, Alloy A356.0-T6.
- C. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

#### 2.3 OTHER MATERIALS

- A. N/A

#### 2.4 FABRICATION

- A. Assemble railing systems in shop to the greatest extent possible. Use connections that maintain structural value of joined pieces.
- B. Form changes in direction of railing members by use of prefabricated fittings.
- C. Fabricate railing systems and handrails for connecting members with concealed mechanical fasteners and fittings.



- D. Provide manufacturer's standard wall brackets, flanges, miscellaneous fittings, and anchors to connect handrail and railing members to other construction.
- E. Provide wall returns at ends of wall-mounted handrails.

## 2.5 FINISHES

- A. Aluminum Railings: Class I, clear anodic finish; AA-M12C22A41; complying with AAMA 611.

## PART 3 - EXECUTION

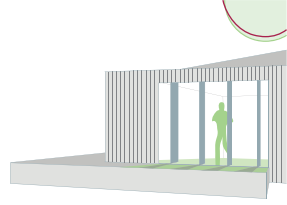
### 3.1 INSTALLATION

- A. Fit exposed connections accurately together to form tight, hairline joints.
- B. Set railings accurately in location, alignment, and elevation and free of rack.
- C. Attach handrails to wall with wall brackets.

END OF SECTION 055200

## Division\_06

### Wood, Plastics and Composites



## SECTION 061000 - ROUGH CARPENTRY

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 WOOD PRODUCTS, GENERAL

- A. Lumber: Provide dressed lumber, S4S, marked with grade stamp of inspection agency.
- B. Engineered Wood Products: Acceptable to authorities having jurisdiction and for which current model code research or evaluation reports exist that show compliance with building code in effect for Project.

## 2.2 TREATED MATERIALS

- A. Preservative-Treated Materials: AWPAC2
  - 1. Use treatment containing no arsenic or chromium.
  - 2. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent.
  - 3. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
- B. Provide preservative-treated materials for all rough carpentry.
- C. Fire-Retardant-Treated Materials: N/A

## 2.3 LUMBER

- A. Dimension Lumber:
  - 1. Maximum Moisture Content: 15 percent.
  - 2. Framing Other Than Non-Load-Bearing Interior Partitions: No. 2
  - 3. Exposed Framing: Provide material hand-selected for uniformity of appearance and freedom from characteristics, on exposed surfaces and edges, that would impair finish appearance, including decay, honeycomb, knot-holes, shake, splits, torn grain, and wane.
    - a. Species: As specified for framing other than non-load-bearing interior partitions.
    - b. Grade: No. 2.
  - 4. Maximum Moisture Content: 20 percent.

## 2.4 ENGINEERED WOOD PRODUCTS

- A. Engineered wood products with allowable design stresses, as published by manufacturer, that meet or exceed those indicated. Manufacturer's published values shall be demonstrated by comprehensive testing.
- B. Laminated-Veneer Lumber: Manufactured with exterior-type adhesive complying with ASTM D 2559. Allowable design values determined according to ASTM D 5456.
  - 1. Extreme Fiber Stress in Bending, Edgewise: 2900 psi (20.0 MPa).
  - 2. Modulus of Elasticity, Edgewise: 2,000,000 psi (13 800 MPa)
- C. Wood I-Joists: Prefabricated units, made with solid or structural composite lumber flanges and wood-based structural panel webs, let into and bonded to flanges. Provide units complying with material requirements of and with structural capacities established and monitored according to ASTM D 5055.
  - 1. Web Material: Either oriented strand board or plywood, Exposure 1
  - 2. Structural Properties: Provide units with depths and design values not less than those indicated.
  - 3. Provide units complying with APA PRI-400, factory marked with nominal joist depth, joist class, span ratings, mill identification, and compliance with APA standard.
- D. Rim Boards: Product designed to be used as a load-bearing member and to brace wood I-joists at bearing ends, complying with research/evaluation report for I-joists.
  - 1. Material: glued-laminated wood.
  - 2. Thickness: 1-1/4 inches (32 mm).

## 2.5 PLYWOOD BACKING PANELS

- A. Telephone and Electrical Equipment Backing Panels: Plywood, fire-retardant treated, not less than 1/2-inch (13-mm).

## 2.6 MISCELLANEOUS PRODUCTS

- A. Fasteners: Size and type indicated. Where rough carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.
  - 1. Bolts: Steel bolts complying with ASTM A 307.
- B. Metal Framing Anchors: Structural capacity, type, and size indicated.
  - 1. Use anchors made from hot-dip galvanized steel complying with ASTM A 653/A 653M, G60 (Z180) coating designation for interior locations where stainless steel is not indicated.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.
- B. Securely attach rough carpentry to substrates, complying with the following:
  - 1. CABO NER-272 for power-driven fasteners.

END OF SECTION 061000

## SECTION 061063 - EXTERIOR ROUGH CARPENTRY

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 WOOD PRODUCTS, GENERAL

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

## 2.2 TREATED MATERIALS

- A. Preservative-Treated Boards and Dimension Lumber: AWPA C2.
  - 1. Use treatment containing no arsenic or chromium.
- B. Mark treated wood with treatment quality mark of an inspection agency approved by ALSC's Board of Review.
- C. Provide preservative-treated materials for all exterior rough carpentry unless otherwise indicated.
  - 1. Framing members.
  - 2. Sills and ledgers.
  - 3. Decking.
  - 4. Stair treads.

## 2.3 LUMBER

- A. Dimension Lumber:
  - 1. Maximum Moisture Content: 15 percent
  - 2. Deck and Stair Framing: No. 2
  - 3. Dimension Lumber Decking and Stair Treads: No. 2
  - 4. Dimension Lumber Railing Members and Benches: No. 2

## 2.4 PLASTIC DECKING

- A. Plastic Lumber, General: Products acceptable to authorities having jurisdiction and for which current model code evaluation reports exist that show compliance with building code in effect for Project for indicated occupancy and type of construction.
  - 1. Allowable loads and spans, as documented in evaluation reports or in information referenced in evaluation reports, shall not be less than design loads and spans indicated.
- B. Composite Plastic Lumber: Solid shapes made from a mixture of cellulose fiber and polyethylene.
- C. Decking Size: 1-1/4 by 6 nominal.
- D. Surface Texture: Woodgrain.

## 2.5 MISCELLANEOUS PRODUCTS

- A. Fasteners: Use fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M or ASTM F 2329 unless otherwise indicated.
  - 1. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches (38 mm) into wood substrate.
  - 2. Carbon-Steel Bolts: ASTM A 307 (ASTM F 568M) with ASTM A 563 (ASTM A 563M) hex nuts and, where indicated, flat washers all hot-dip zinc coated.
- B. Postinstalled Anchors: Stainless-steel anchors with capability to sustain, without failure, a load equal to six times the load imposed as determined by testing per ASTM E 488.
- C. Flexible Flashing: UV-resistant, self-adhesive, elastomeric thermoplastic flashing material with an overall thickness of not less than 0.040 inch (1.0 mm).

# PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.
- B. Framing Standard: Comply with AF&PA's "Details for Conventional Wood Frame Construction" unless otherwise indicated.
- C. Securely attach rough carpentry to substrates, complying with the following:
  - 1. CABO NER-272 for power-driven fasteners.
  - 2. Published requirements of metal framing anchor manufacturer.
  - 3. Table 2304.9.1, "Fastening Schedule," in the IBC.

- D. Secure stair treads and risers by gluing and screwing to carriages. Extend treads over carriages.

END OF SECTION 061063



## SECTION 061600 - SHEATHING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 WOOD PANEL PRODUCTS, GENERAL

- A. Plywood: DOC PS 1.

## 2.2 TREATED PLYWOOD

- A. N/A

## 2.3 WALL SHEATHING

- A. Plywood Wall Sheathing: Exposure 1, Structural I.
- B. Gypsum Wall Sheathing:
  - 1. Paper-Surfaced Gypsum Wall Sheathing: ASTM C 79/C 79M or

## 2.4 ROOF SHEATHING

- A. Plywood Roof Sheathing: Exposure 1, Structural I.

## 2.5 SUBFLOORING AND UNDERLAYMENT

- A. Combination Subfloor:
  - 1. Warmboard Radiant Subfloor.
  - 2. Plywood Combination Subfloor-Aluminum coated surface, 1 1/8 inch thickness: Exposure 1, Structural I.

<http://www.warmboard.com/wp-content/uploads/2008/10/0908-warmboard-brochure.pdf>

## 2.6 MISCELLANEOUS PRODUCTS

### A. Fasteners: Size and type indicated.

1. For roof and wall sheathing, provide fasteners of Type 304 stainless steel.

### B. Sheathing Joint-and-Penetration Treatment Materials:

1. Sheathing Tape for Foam-Plastic Sheathing: Pressure-sensitive plastic tape recommended by sheathing manufacturer for sealing joints and penetrations in sheathing.

### C. Adhesives for Field Gluing Panels to Framing: APA AFG-01.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

#### A. Securely attach to substrates, complying with the following:

1. Table 2304.9.1, "Fastening Schedule," in the IBC.

#### B. Fastening Methods:

1. Combination Subfloor-Underlayment:
  - a. Glue and nail to wood framing.
2. Wall and Roof Sheathing:
  - a. Nail to wood framing.

END OF SECTION 061600

## SECTION 062000 - FINISH CARPENTRY

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 MATERIALS, GENERAL

- A. Lumber: DOC PS 20 and grading rules of inspection agencies certified by American Lumber Standards Committee Board of Review.
- B. Hardwood Plywood: HPVA HP-1.

## 2.2 EXTERIOR FINISH CARPENTRY

- A. Lumber Siding: Reclaimed oak and poplar barn siding.

## 2.3 INTERIOR STANDING AND RUNNING TRIM

- A. Interior Hardwood Lumber Trim: Clear, kiln-dried, white maple and ash.
- B. Wood Moldings: WMMPA WM 4 made to patterns in WMMPA WM 12 from kiln-dried stock.

## 2.4 FIRE-RATED INTERIOR DOOR AND SIDELIGHT FRAMES

- A. No fire rated frames.

## 2.5 PANELING

- 1. Hardwood Veneer Plywood Paneling: Manufacturer's stock panels complying with HPVA HP-1.
- 2. Face Veneer Species: Plain sliced white maple and ash.
- 3. Veneer Matching: Random match.
- 4. Thickness: 1/8 inch (3.2 mm).
- 5. Face Pattern: Manufacturer's standard grooved pattern, with grooves at edges, center, and third points of panels, and at other locations to provide pattern resembling random width boards.

## 2.6 SHELVING AND CLOTHES RODS

- A. Shelving: White maple and ash boards.
- B. Shelf Brackets with Rod Support: BHMA A156.16, B04051; prime-painted formed steel.

## 2.7 MISCELLANEOUS MATERIALS

- A. Fasteners for Exterior Finish Carpentry: Hot-dip galvanized steel.
- B. Glue: Aliphatic-resin, polyurethane, or resorcinol wood glue recommended by manufacturer.
  - 1. Use waterproof resorcinol glue for exterior applications.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Condition finish carpentry in installation areas for 24 hours before installing.
- B. Prime and backprime lumber for painted finish exposed on the exterior.
- C. Install finish carpentry level, plumb, true, and aligned with adjacent materials. Scribe and cut to fit adjoining work. Refinish and seal cuts.
- D. Install standing and running trim with minimum number of joints practical, using full-length pieces from maximum lengths of lumber available. Stagger joints in adjacent and related trim. Cope at returns and miter at corners.
- E. Nail siding at each stud. Do not allow nails to penetrate more than one thickness of siding, unless otherwise recommended by siding manufacturer. Seal joints at inside and outside corners and at trim locations.
- F. Select and arrange paneling for best match of adjacent units. Install with uniform tight joints.
- G. Exterior Stairs: Secure treads and risers by gluing and nailing to carriages. Countersink nail heads, fill flush, and sand filler. Extend treads over carriages.

END OF SECTION 062000

## SECTION 064013 - EXTERIOR ARCHITECTURAL WOODWORK

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Quality Standard: Architectural Woodwork Institute's "Architectural Woodwork Quality Standards."
- C. Forest Certification: Provide woodwork produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."

## PART 2 - PRODUCTS

## 2.1 MATERIALS

- A. Hardboard: AHA A135.4.
- B. Softwood Plywood: DOC PS 1.
- C. Preservative Treatment: Comply with WDMA I.S.4 for items indicated to receive water-repellent preservative treatment.
- D. Fasteners for Exterior Woodwork:
  - 1. Nails: Hot-dip galvanized.
  - 2. Screws: Hot-dip galvanized or stainless steel.

## 2.2 EXTERIOR WOODWORK

- A. Wood Moisture Content: 9 to 15 percent.
- B. Complete fabrication to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
- C. Backout or groove backs of flat trim members and kerf backs of other wide, flat members, except for members with ends exposed in finished work.
- D. Exterior Louvers: Custom grade, made from reclaimed oak and poplar barn siding.
- E. Shop prime woodwork for opaque finish with one coat of specified wood primer.

- F. Shop seal woodwork for transparent finish with stain (if required), other required pretreatments, and first coat of specified finish.
- G. Backprime with one coat of sealer or primer, compatible with finish coats.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install woodwork to comply with referenced quality standard for grade specified.
- B. Install woodwork true and straight with no distortions. Shim as required with concealed shims. Install level and plumb to a tolerance of 1/8 inch in 96 inches.
- C. Scribe and cut woodwork to fit adjoining work, and refinish cut surfaces or repair damaged finish at cuts.
- D. Anchor woodwork to anchors or blocking built in or directly attached to substrates. Fasten with countersunk concealed fasteners and blind nailing. Use fine finishing nails for exposed nailing, countersunk and filled flush with woodwork.
- E. Standing and Running Trim: Install with minimum number of joints possible, using full-length pieces (from maximum length of lumber available) to greatest extent possible. Do not use pieces less than 36 inches long, except where shorter single-length pieces are necessary. Scarf running joints and stagger in adjacent and related members.

END OF SECTION 064013

## SECTION 064023 - INTERIOR ARCHITECTURAL WOODWORK

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Quality Standard: Architectural Woodwork Institute's "Architectural Woodwork Quality Standards.
- C. Environmental Limitations: Do not deliver or install woodwork until building is enclosed, wet work is completed, and HVAC system is operating.

## PART 2 - PRODUCTS

## 2.1 MATERIALS

- A. Hardboard: AHA A135.4.
- B. Hardwood Plywood and Face Veneers: HPVA HP-1, made with adhesive containing no urea formaldehyde.

## 2.2 CABINET HARDWARE AND ACCESSORY MATERIALS

- A. Butt Hinges: 2-3/4-inch (70-mm), 5-knuckle steel hinges made from 0.095-inch- (2.4-mm-) thick metal, and as follows:
  - 1. Semiconcealed Hinges for Flush Doors: BHMA A156.9, B01361.
  - 2. Semiconcealed Hinges for Overlay Doors: BHMA A156.9, B01521.
- B. Frameless Concealed Hinges (European Type): BHMA A156.9, B01602, 170 degrees of opening.
- C. Catches: Ball friction catches, BHMA A156.9, B03013.
- D. Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081.
- E. Drawer Slides: BHMA A156.9, B05091.
  - 1. Box Drawer Slides: Grade 1.
- F. Drawer Locks: BHMA A156.11, E07041.
- G. Exposed Hardware Finishes: Comply with BHMA A156.18 for BHMA code number indicated.

1. Finish: Satin Chrome: BHMA 626 or BHMA 652.

H. Furring, Blocking, Shims, and Hanging Strips: Softwood or hardwood lumber, kiln dried to 15 percent moisture content.

## 2.3 INTERIOR WOODWORK

A. Complete fabrication to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

B. Backout or groove backs of flat trim members and kerf backs of other wide, flat members, except for members with ends exposed in finished work.

## 2.4 INTERIOR CUSTOM FURNITURE

A. Complete fabrication to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

## 2.5 SHOP FINISHING OF INTERIOR ARCHITECTURAL WOODWORK

A. Finishes: Same grades as items to be finished.

B. Finish architectural woodwork at the fabrication shop; defer only final touch up until after installation.

1. Apply one coat of sealer or primer to concealed surfaces of woodwork. Apply two coats to back of paneling and to end-grain surfaces.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Before installation, condition woodwork to average prevailing humidity conditions in installation areas.

B. Install woodwork to comply with referenced quality standard for grade specified.

C. Install woodwork level, plumb, true, and straight. Shim as required with concealed shims. Install level and plumb (including tops) to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm).

D. Scribe and cut woodwork to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.

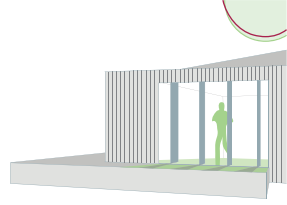


- E. Anchor woodwork to anchors or blocking built in or directly attached to substrates. Fasten with countersunk concealed fasteners and blind nailing. Use fine finishing nails or finishing screws for exposed nailing, countersunk and filled flush with woodwork.
- F. Standing and Running Trim: Install with minimum number of joints possible, using full-length pieces (from maximum length of lumber available) to greatest extent possible. Do not use pieces less than 36 inches (900 mm) long, except where shorter single-length pieces are necessary. Scarf running joints and stagger in adjacent and related members.
- G. Anchor paneling to supports with concealed panel-hanger clips and by blind nailing on back-up strips, splined-connection strips, and similar associated trim and framing.
- H. Cabinets: Install so doors and drawers are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation.
  - 1. Fasten wall cabinets through back, near top and bottom, at ends and not more than 16 inches (400 mm) o.k. with No. 10 wafer-head screws sized for 1-inch (25-mm) penetration into wood framing, blocking, or hanging strips.

END OF SECTION 064023

## Division\_07

### Thermal and Moisture Protection



## SECTION 072100 - THERMAL INSULATION

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 INSULATION PRODUCTS

- A. Surface-Burning Characteristics: ASTM E 84, and as follows:
  - 1. Flame-Spread Index: 25 or less where exposed; otherwise, as indicated in Part 2 "Insulation Products" Article.
  - 2. Smoked-Developed Index: 450 or less.
- B. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV with flame-spread index of 75 or less.
  - 1. Owens Corning Foamular
    - a. 1/2 inch rigid insulation.  
<http://insulation.owenscorning.com/homeowners/insulation-products/foamular-150.aspx>
- C. Paper-Faced Polyisocyanurate Board Insulation: ASTM C 1289, Type I, Class 1 faced on both sides with aluminum foil, with flame-spread index of 75 or less for unfaced core material.
- D. Mineral-Fiber-Blanket Insulation: ASTM C 665, Type I, unfaced with fibers manufactured from glass with flame-spread index of 25 or less.
  - 1. Owens Corning Energy Complete
    - a. R 21 fiberglass insulation  
<http://insulation.owenscorning.com/professionals/insulation-products/r-21-fiberglass-insulation.aspx>

## 2.2 ACCESSORIES

- A. Liquid applied interior air infiltration barrier.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install insulation in areas and in thicknesses indicated or required to produce R-values indicated. Cut and fit tightly around obstructions and fill voids with insulation.
- B. Except for loose-fill insulation and insulation that is friction fitted in stud cavities, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.

END OF SECTION 072100

## SECTION 072500 - WEATHER BARRIERS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

### PART 2 - PRODUCTS

#### 2.1 WATER-RESISTIVE BARRIERS

- A. Building Wrap: ASTM E 1677, Type I air barrier; with water-vapor permeance not less than 5 perms (287 ng/Pa x s x sq. m) per ASTM E 96, Desiccant Method (Procedure A); flame-spread and smoke-developed indexes not greater than 25 and 450, respectively, when tested according to ASTM E 84; UV stabilized; and acceptable to authorities having jurisdiction.

1. Products:

- a. Owens Corning Pro Pink House Wrap  
<http://insulation.owenscorning.com/homeowners/insulation-products/pinkwrap-housewrap.aspx>

#### 2.2 ACCESSORIES

- A. Flexible Flashing: Adhesive butyl rubber compound, bonded to plastic film or spunbonded polyolefin, with an overall thickness of 0.030 inch.
- B. Building Wrap Tape: Pressure-sensitive plastic tape recommended by building-wrap manufacturer for sealing joints and penetrations in building wrap.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Building Wrap Installation:
1. Apply building wrap immediately after sheathing is installed.
  2. Seal seams, edges, fasteners, and penetrations with tape.
  3. Extend into jambs of openings and seal corners with tape.

END OF SECTION 072500

## SECTION 074600 - SIDING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A.

## PART 2 - PRODUCTS

## 2.1 SIDING

- A. Reclaimed poplar and oak barn siding.
  - 1. VerticalPattern: 6-inch exposure in plain board style.
  - 2. Finish: Unfinished.
- B. Fiber-Cement Siding: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84. Factory primed.
  - 1. Products
    - a. Hardie Board.  
[http://www.jameshardie.com/builder/designBuildCenter\\_technicalDocuments.shtml](http://www.jameshardie.com/builder/designBuildCenter_technicalDocuments.shtml)  
1
  - 2. Depth: 3/4 inch.
  - 3. Width: 6 inches.

## 2.2 SOFFIT

- A. Fiber-Cement Soffit: ASTM C 1186, Type A, Grade II, fiber-cement board, noncombustible when tested according to ASTM E 136; with a flame-spread index of 25 or less when tested according to ASTM E 84. Factory primed.
  - 1. Products:
    - a. Hardie Board.  
[http://www.jameshardie.com/builder/designBuildCenter\\_technicalDocuments.shtml](http://www.jameshardie.com/builder/designBuildCenter_technicalDocuments.shtml)  
1
  - 2. Pattern: 6 inch wide sheets with smooth texture.
  - 3. Ventilation: Provide unperforated soffit.

## 2.3 ACCESSORIES

- A. Siding Accessories, General: Provide starter strips, edge trim, outside and inside corner caps, and other items as recommended by siding manufacturer for building configuration.
  - 1. Provide accessories made from same material as adjacent siding unless otherwise indicated.
  - 2. Louvers.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install fiber-cement siding and soffit and related accessories.
  - 1. Install fasteners no more than 16inches (600 mm) o.c.

END OF SECTION 074600

## SECTION 075323 – KETONE-ETHYLENE-ESTER (KEE) ROOFING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Warranties: N/A

## PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- A. Energy Performance: Provide roofing system with initial solar reflectance not less than 0.79 and emissivity not less than 0.75 when tested according to CRRC-1.
- B. Exterior Fire-Test Exposure: ASTM E 108, Class A.

## 2.2 ROOFING MATERIALS

- A. KEE Sheet: ASTM D 4637, Type I, nonreinforced 36 mils white.
  - 1. Products:
    - a. FiberTite 8530 KEE Membrane  
<http://www.fibertite.com/downloads/products/8530.pdf>
- B. Auxiliary Materials: Recommended by roofing system manufacturer for intended use and as follows:
  - 1. Sheet Flashing: 36-mil- thick KEE.
  - 2. Seaming Material: Heat welded membrane with no less than 6 inch overlaps.

## 2.3 ROOF INSULATION

- A. Polyisocyanurate Board Insulation: ASTM C 1289, Type II.
- B. Fabricate tapered insulation with slope of 1/4 inch per 12 inches (1:48) unless otherwise indicated.



## 2.4 BALLAST

- A. No ballast used.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Mechanically fasten each layer of insulation to deck.
- B. Install KEE sheet according to roofing system manufacturer's written instructions and as follows:
  - 1. Adhered Sheet Installation: Apply bonding adhesive to substrate and underside of sheet and allow to partially dry. Do not apply bonding adhesive to splice area of sheet.
  - 2. Mechanically Fastened Sheet Installation: Secure one edge of sheet using fastening plates or battens centered within the membrane splice and mechanically fasten sheet to roof deck.
- C. Seams: Clean splices and heat weld, firmly roll side and end laps of overlapping sheets. Seal exposed edges of sheet terminations.
- D. Install sheet flashings and preformed flashing accessories and adhere to substrates.

END OF SECTION 075323

## SECTION 076200 - SHEET METAL FLASHING AND TRIM

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Comply with SMACNA's "Architectural Sheet Metal Manual." Conform to dimensions and profiles shown unless more stringent requirements are indicated.
- C. Coordinate installation of sheet metal flashing and trim with interfacing and adjoining construction to provide a leakproof, secure, and noncorrosive installation.

### PART 2 - PRODUCTS

#### 2.1 SHEET METAL

- A. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required, not less than 0.032 inch (0.8 mm) thick; and finished as follows:
  - 1. Concealed Finish: Manufacturer's standard white or light-colored acrylic or polyester backer finish.

#### 2.2 ACCESSORIES

- A. Fasteners: Wood screws, annular-threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners.
  - 1. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
- B. Butyl Sealant: ASTM C 1311, solvent-release butyl rubber sealant.

#### 2.3 FABRICATION

- A. Fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of the item indicated.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Comply with SMACNA's "Architectural Sheet Metal Manual." Allow for thermal expansion; set true to line and level. Install Work with laps, joints, and seams permanently watertight and weatherproof; conceal fasteners where possible.
- B. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
- C. Fabricate nonmoving seams in sheet metal with flat-lock seams. For aluminum, form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
- D. Aluminum Flashing and Trim: Coat back side of aluminum flashing and trim with bituminous coating where it will contact wood, ferrous metal, or cementitious construction.
- E. Separate dissimilar metals with a bituminous coating or polymer-modified, bituminous sheet underlayment.

END OF SECTION 076200

## SECTION 077100 - ROOF SPECIALTIES

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Warranties: N/A

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy as standard with manufacturer for finish required.
- B. Aluminum Finish: Three-coat fluoropolymer system with color coat and clear coat containing not less than 70 percent PVDF resin by weight.
- C. Self-Adhering Sheet Underlayment, High Temperature: Butyl or SBS-modified asphalt; slip-resisting-polyethylene surfaced; with release paper backing; cold applied. Stable after testing at 240 deg F (116 deg C) and passes after testing at minus 20 deg F (29 deg C); ASTM D 1970.
- D. Fasteners: Manufacturer's recommended fasteners, suitable for application and designed to meet performance requirements.
  - 1. Fasteners for Aluminum: Aluminum or Series 300 stainless steel.
- E. Butyl Sealant: ASTM C 1311, solvent-release butyl rubber sealant.

#### 2.2 ROOF SPECIALTIES

- A. SPRI Wind Design Standard: Provide roof-edge flashings tested according to SPRI ES-1 and capable of resisting the following design pressures:
  - 1. Design Pressure: As indicated on Drawings.
- B. Copings: Manufactured coping system consisting of formed-metal coping cap, concealed anchorage; corner units, end cap units, and concealed splice plates.
  - 1. Extruded Aluminum: 0.040 inch (1.02 mm) thick.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. General: Install roof specialties according to manufacturer's written instructions. Anchor roof specialties securely in place, with provisions for thermal and structural movement.
- B. Coat back side of aluminum roof specialties with bituminous coating where they will contact wood, ferrous metal, or cementitious construction.
- C. Separate dissimilar metals with a bituminous coating or polymer-modified, bituminous sheet underlayment.
- D. Fastener Sizes: Use fasteners of sizes that will penetrate wood blocking or sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws.

END OF SECTION 077100

## SECTION 077200 - ROOF ACCESSORIES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Sheet Metal Standard: Comply with SMACNA's "Architectural Sheet Metal Manual."

## PART 2 - PRODUCTS

## 2.1 MATERIALS

- A. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy and temper recommended by manufacturer for type of use and finish. Coil-coat finish as follows:
  - 1. Baked-Enamel Finish: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm), medium gloss.

## 2.2 ROOF ACCESSORIES

- A. Fall Protection Anchors: Secure anchors in to framing with 1/2 inch x 3 1/2 inch lag screws.
  - 1. Products:
    - a. SNAPPY anchor, meets ANSI Z359.1 and OSHA requirements for a fall protection device.  
<https://www.mysupplieronline.com/catalog/product.php?printable=Y&productid=67&cat=10&bestseller=Y>
- B. Equipment Supports: Fabricate from 0.052-inch- thick, metallic-coated steel with welded or sealed mechanical corner joints.
  - 1. Products:
    - a. Unistrut channel and Telestrut Support Posts.  
[http://www.unistrut.com/Browse/cat\\_pg.php?P=S00\\_Channel](http://www.unistrut.com/Browse/cat_pg.php?P=S00_Channel)  
[http://www.unistrut.com/Browse/cat\\_pg.php?P=product\\_ts](http://www.unistrut.com/Browse/cat_pg.php?P=product_ts)
  - 2. Provide manufacturer's standard rigid or semirigid insulation.
  - 3. Finish: Baked enamel posts and galvanized Unistrut channel.
- C. Scuppers: 3 high thru wall scuppers

1. 12 inch x 4 inch aluminum wall scuppers.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Installation: Unless otherwise indicated, install roof accessory items according to construction details of NRCA's "Roofing and Waterproofing Manual." Coordinate with installation of roof deck, vapor barriers, roof insulation, roofing, and flashing to ensure combined elements are secure, waterproof, and weathertight.

END OF SECTION 077200

## SECTION 079200 - JOINT SEALANTS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Environmental Limitations: Do not proceed with installation of joint sealants when ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (4.4 deg C).

### PART 2 - PRODUCTS

#### 2.1 JOINT SEALANTS

- A. Compatibility: Provide joint sealants, joint fillers, and other related materials that are compatible with one another and with joint substrates under service and application conditions.
- B. Sealant for General Exterior Use Where Another Type Is Not Specified. Retain one or more of three subparagraphs below.
  - 1. Single-component, neutral-curing silicone sealant, ASTM C 920, Type S; Grade NS; Class 25; for Use NT.
- C. Sealant for Use in Interior Joints in Ceramic Tile and Other Hard Surfaces in Kitchens and Toilet Rooms and Around Plumbing Fixtures:
  - 1. Single-component, mildew-resistant silicone sealant, ASTM C 920, Type S; Grade NS; Class 25; for Use NT; formulated with fungicide.
- D. Sealant for Interior Use at Perimeters of Door and Window Frames:
  - 1. Acrylic latex or siliconized acrylic latex, ASTM C 834, Type OP, Grade NF.
- E. Acoustical Sealant:
  - 1. Nonsag, paintable, nonstaining latex sealant complying with ASTM C 834 that effectively reduces airborne sound transmission as demonstrated by testing according to ASTM E 90.

#### 2.2 MISCELLANEOUS MATERIALS

- A. Provide sealant backings of material that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.



- B. Cylindrical Sealant Backings: ASTM C 1330, of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.
- D. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

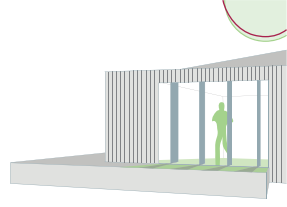
### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with ASTM C 1193.
- B. Install sealant backings to support sealants during application and to produce cross-sectional shapes and depths of installed sealants that allow optimum sealant movement capability.
- C. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- D. Acoustical Sealant Installation: At sound-rated assemblies and elsewhere as indicated, seal perimeters, control joints, openings, and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions. Comply with ASTM C 919.

END OF SECTION 079200

## Division\_08 Openings



## SECTION 081416 - FLUSH WOOD DOORS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

### PART 2 - PRODUCTS

#### 2.1 DOOR CONSTRUCTION, GENERAL

- A. Quality Standard: WDMA I.S.1-A.
- B. Low-Emitting Materials: Provide doors made with adhesives and composite wood products that do not contain urea formaldehyde.
- C. WDMA I.S.1-A Performance Grade:
  - 1. Heavy Duty unless otherwise indicated.

#### 2.2 FLUSH WOOD DOORS

- A. Doors for Opaque Finish:
  - 1. Exterior Solid-Core Doors: Premium grade, five ply, structural composite lumber cores.
    - a. Faces: Any closed-grain hardwood.
  - 2. Interior Hollow-Core Doors: Premium grade, three ply, standard hollow cores with lock blocks on both sides.
    - a. Faces: Any closed-grain hardwood.

#### 2.3 LOUVERS AND LIGHT FRAMES

- A. Louvers: Wood louvers of same species as door faces.
- B. Light Frames: Wood beads of same species as door faces.

#### 2.4 FABRICATION AND FINISHING

- A. Factory fit doors to suit frame-opening sizes indicated and to comply with clearances specified.

- B. Factory machine doors for hardware that is not surface applied. Locate hardware to comply with DHI-WDHS-3.
- C. Cut and trim openings to comply with referenced standards.
  - 1. Trim light openings with moldings indicated.
  - 2. Factory install glazing in doors indicated to be factory finished.
  - 3. Factory install louvers in prepared openings.
- D. Factory finish doors indicated for opaque finish with manufacturer's standard finish complying with WDMA OP-4, conversion varnish for grade specified for doors.
  - 1. Sheen: Satin.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install doors to comply with manufacturer's written instructions and WDMA I.S.1-A, and as indicated.
- B. Align and fit doors in frames with uniform clearances and bevels. Machine doors for hardware. Seal cut surfaces after fitting and machining.
- C. Clearances: As follows unless otherwise indicated:
  - 1. 1/8 inch (3.2 mm) at heads, jambs, and between pairs of doors.
  - 2. 1/8 inch (3.2 mm) from bottom of door to top of decorative floor finish or covering.
  - 3. 1/4 inch (6.4 mm) from bottom of door to top of threshold.
  - 4. Comply with NFPA 80 for fire-rated doors.
- D. Repair, refinish, or replace factory-finished doors damaged during installation, as directed by Architect.

END OF SECTION 081416

## SECTION 083219 - WOOD-FRAMED GLASS DOORS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Provide AAMA- or WDMA-certified, sliding wood-framed glass doors with an attached label.

## PART 2 - PRODUCTS

## 2.1 WOOD-FRAMED GLASS DOORS

- A. Products:
  - 1. Pella Designer Series.  
<http://web.pella.com/products/doors/DSfrenchpatiodoor/Pages/detailpage.aspx>
- B. Performance Requirements: AAMA/WDMA/CSA 101/I.S.2/A440.
  - 1. Triple Glazed
  - 2. Performance Class: AW
  - 3. Performance Grade: 50
  - 4. Thermal Transmittance: Maximum whole fenestration product U-factor of .27, when tested according to AAMA 1503
  - 5. Solar Heat-Gain Coefficient (SHGC): Whole-fenestration product SHGC maximum of 0.40 determined according to NFRC 200.
- C. Provide Aluminum-clad wood doors.
  - 1. Exterior Color: White
- D. Lock: Install manufacturer's keyed cylinder lock and multipoint locking device on each movable panel, lockable from the inside and outside.
- E. Glaze units with clear low-e coated, argon-filled, safety glass complying with Division 08 Section "Glazing" and with testing requirements in 16 CFR 1201 for Category II materials.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Set units level, plumb, and true to line, without warp or rack of frames and panels and anchor securely in place.
- B. Separate aluminum and other corrodible surfaces from sources of corrosion or electrolytic action at points of contact with other materials.
- C. Set sill members in bed of sealant or with gaskets, as indicated, to provide weathertight construction.
- D. Adjust operating panels, screens, and hardware to provide a tight fit at contact points and weather stripping for smooth operation and weathertight closure. Lubricate hardware and moving parts.
- E. Clean frame surfaces and glass immediately after installing sliding wood-framed glass doors. Remove nonpermanent labels from glass surfaces.

END OF SECTION 083219

## SECTION 083513 - FOLDING DOORS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

### PART 2 - PRODUCTS

#### 2.1 FOLDING DOORS

- A. Panel-Folding Doors: Top-supported panels, continuous hinges on alternate sides of panels, and manufacturer's standard track and hardware.
  - 1. Products:
    - a. Columbus Wood Products Hollow Core Door.  
[http://www.columbuswoodproducts.com/doors\\_interior.htm](http://www.columbuswoodproducts.com/doors_interior.htm)
  - 2. Facing: Ash veneer, whitewash finished.
  - 3. Panel Nominal Width: 30 inches.
  - 4. Carriers: Four-wheel carriers at lead post and two-wheel intermediate carriers.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install track in one piece.
- B. Install folding doors with floor clearances of 1/4 to 3/4 inch (6.4 to 19 mm).
- C. Adjust units as necessary to ensure smooth, quiet operation without warping or binding. Adjust operating hardware so latches engage accurately and securely without forcing or binding.

END OF SECTION 083513

## SECTION 084113 - ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 ALUMINUM-FRAMED STOREFRONTS

A. Products:

1. Vistawall CW 250 Screw Spline  
[http://vistawall.com/dcma/system\\_html\\_pages/43c2scrspl.htm](http://vistawall.com/dcma/system_html_pages/43c2scrspl.htm)

B. Performance Requirements:

1. Limit deflection of framing members normal to wall plane to 1/175 of clear span for spans up to 10 feet.
2. Limit deflection of framing members parallel to glazing plane to L/360 of clear span or 1/8 inch (3.2 mm), whichever is smaller.
3. Air Infiltration: Limited to 0.06 cfm/sq. ft. (0.03 L/s per sq. m) of system surface area when tested according to ASTM E 283 at a static-air-pressure difference of 1.57 lbf/sq. ft. (75 Pa) 6.24 lbf/sq. ft. (300 Pa).
4. Water Penetration: Systems do not evidence water leakage when tested according to ASTM E 331 at minimum differential pressure of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft. (300 Pa).
5. Thermal Conductance: Average U-factor of not more than 0.57 Btu/sq. ft. x h x deg F (3.23 W/sq. m x K) 0.69 Btu/sq. ft. x h x deg F (3.92 W/sq. m x K) when tested according to AAMA 1503.

- C. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated; ASTM B 209 sheet; ASTM B 221 extrusions.

- D. Glazing: As specified in Division 08 Section "Glazing."

- E. Framing Members: Manufacturer's standard extruded-aluminum framing members of thickness required and reinforced as required to support imposed loads.

- F. Fasteners and Accessories: Compatible with adjacent materials, corrosion resistant, nonstaining, and nonbleeding. Use concealed fasteners except for application of door hardware.

- G. Fabrication: Fabricate framing in profiles indicated for flush glazing (without projecting stops). Provide subframes and reinforcing of types indicated or, if not indicated, as required for a



complete system. Factory assemble components to greatest extent possible. Disassemble components only as necessary for shipment and installation.

- H. Aluminum Finish: Class II, clear anodic finish; AA-M12C22A31; complying with AAMA 611.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Isolate metal surfaces in contact with incompatible materials, including wood, by painting contact surfaces with bituminous coating or primer, or by applying sealant or tape recommended by manufacturer.
- B. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.
- C. Set continuous sill members and flashing in full sealant bed as specified in Division 07 Section "Joint Sealants" to produce weathertight installation.
- D. Install framing components true in alignment with established lines and grades to the following tolerances:
  - 1. Variation from Plane: Limit to 1/8 inch in 10 feet, 1/4 inch (6 mm) over total length.
  - 2. Alignment: For surfaces abutting in line, limit offset to 1/16 inch (1.5 mm). For surfaces meeting at corners, limit offset to 1/32 inch (0.8 mm).
  - 3. Diagonal Measurements: Limit difference between diagonal measurements to 1/8 inch (3 mm).

END OF SECTION 084113

## SECTION 085200 - WOOD WINDOWS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 WOOD WINDOWS

- A. Products:
  - 1. Pella Designer Series.  
<http://web.pella.com/products/productlines/designerseries/Pages/DesignerSeries.aspx>
- B. Provide aluminum-clad wood windows.
- C. Window Types: As indicated on Drawings.
- D. Performance Requirements: AAMA/WDMA/CSA 101/I.S.2/A440.
  - 1. Triple Glazed
  - 2. Performance Class: AW
  - 3. Performance Grade: 50
  - 4. Thermal Transmittance: Whole-window U-factor not more than U .27 at 15-mph (24-km/h) wind velocity and winter temperatures per AAMA 1503.
  - 5. Solar Heat-Gain Coefficient: Whole-window SHGC not more than .27 per NFRC 200.
- E. Trim: Provide indicated trim, matching material and finish of frame members.
- F. Equip units with aluminum mesh insect screens on operable sashes.
- G. Exterior Color: White.
- H. Glaze units with clear, low-e coated, argon-filled, sealed insulating glass, complying with Division 08 Section "Glazing."

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Set units level, plumb, and true to line, without warp or rack of frames and panels. Provide proper support and anchor securely in place.

- B. Set sill members in bed of sealant or with gaskets, as indicated, to provide weathertight construction.
- C. Adjust operating panels, screens, and hardware to provide a tight fit at contact points and weather stripping for smooth operation and weathertight closure. Lubricate hardware and moving parts.
- D. Clean glass and aluminum surfaces immediately after installing windows. Remove nonpermanent labels from glass surfaces.

END OF SECTION 085200

## SECTION 088000 - GLAZING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Safety Glass: Category II materials complying with testing requirements in 16 CFR 1201.
- C. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated.
  - 1. GANA Publications: GANA's "Laminated Glazing Reference Manual" and GANA's "Glazing Manual."

## PART 2 - PRODUCTS

## 2.1 GLASS PRODUCTS

- A. Polycarbonate: ASTM D-3029, BS 2782 and DIN 53443.
  - 1. Products
    - a. Polygal Thermogal  
<http://www.polygal.com/Media/Uploads/Thermogal0508EngA4a.pdf>
- A. Tempered Patterned Glass: ASTM C 1048, Kind FT (fully tempered), Type II, Class 1 (clear), Form 3; Quality-Q6.

## 2.2 MONOLITHIC-GLASS TYPES

- A. Glass Type: Tinted fully tempered float glass.
  - 1. Thickness: 6.0 mm.
  - 2. Tint Color: Frosted.
  - 3. Provide safety glazing labeling.
- B. Type: Primalite insulated polycarbonate.
  - 1. Thickness: 25 mm
  - 2. U value: .31
  - 3. Light transmission: .19
  - 4. Minimum cold bending radius: 4.37

## 2.3 GLAZING SEALANTS

- A. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use NT.

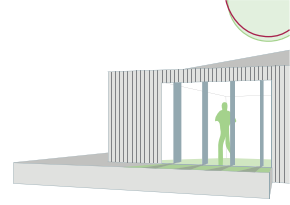
## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with combined recommendations of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are contained in GANA's "Glazing Manual."
- B. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.
- C. Remove nonpermanent labels, and clean surfaces immediately after installation.

END OF SECTION 088000

## Division\_09 Finishes



## SECTION 092900 - GYPSUM BOARD

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- A. No fire resistance or STC rated assemblies required.

## 2.2 PANEL PRODUCTS

- A. Provide in maximum lengths available to minimize end-to-end butt joints.
- B. Interior Gypsum Board: ASTM C 36/C 36M or ASTM C 1396/C 1396M, in thickness indicated, with manufacturer's standard edges. Regular type unless otherwise indicated.
- C. Water-Resistant Gypsum Backing Board: ASTM C 630/C 630M or ASTM C 1396/C 1396M, in thickness indicated. Regular type unless otherwise indicated.

## 2.3 ACCESSORIES

- A. Trim Accessories: ASTM C 1047, formed from galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized-steel sheet. For exterior trim, use accessories formed from hot-dip galvanized-steel sheet, plastic, or rolled zinc.
  - 1. Provide cornerbead at outside corners unless otherwise indicated.
  - 2. Provide LC-bead (J-bead) at exposed panel edges.
  - 3. Provide control joints where indicated.
- B. Joint-Treatment Materials: ASTM C 475/C 475M.
  - 1. Joint Tape: Paper unless otherwise recommended by panel manufacturer.
  - 2. Joint Compounds: Drying-type, ready-mixed, all-purpose compounds.
- C. Acoustical Sealant for Exposed and Concealed Joints: Nonsag, paintable, nonstaining latex sealant complying with ASTM C 834.
- D. Sound-Attenuation Blankets: ASTM C 665, Type I (unfaced).

## PART 3 - EXECUTION

## 3.1 INSTALLATION

## A. Install gypsum board to comply with ASTM C 840.

1. Single-Layer Fastening Methods: Fasten gypsum panels to supports with screws.

## B. Finishing Gypsum Board: ASTM C 840.

1. At concealed areas, unless a higher level of finish is required for fire-resistance-rated assemblies, provide Level 1 finish: Embed tape at joints.
2. At substrates for tile, provide Level 2 finish: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges.
3. Unless otherwise indicated, provide Level 4 finish: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges.

END OF SECTION 092900



## SECTION 093000 - TILING

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

### PART 2 - PRODUCTS

#### 2.1 CERAMIC TILE

- A. Ceramic tile that complies with Standard grade requirements in ANSI A137.1, "Specifications for Ceramic Tile."
  - a. Hamilton Parker Company, Delaware, Ohio
  - b. Surface Finish: White.

#### 2.2 INSTALLATION MATERIALS

- A. Cementitious Backer Units: ANSI A118.9 or ASTM C 1325, 1/2 inch (12.7 mm) thick.
- B. Fiber-Cement Underlayment: ASTM C 1288, 1/4 inch (12.7 mm) thick.
- C. VOC Limit for Adhesives and Fluid-Applied Waterproofing Membranes: 65 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. Waterproofing Membranes for Thin-Set Installations: ANSI A118.10.
- E. Setting and Grouting Materials: Comply with material standards in ANSI's "Specifications for the Installation of Ceramic Tile" that apply to materials and methods indicated.
  - 1. Thin-Set Mortar Type: Latex-portland cement.
  - 2. Thin-Set Mortar Type for Wood Subfloors: EGP latex-portland cement.
  - 3. Grout Type: Water-cleanable epoxy unless otherwise indicated.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in tile installation schedules. Comply with parts of ANSI A108 Series "Specifications

for Installation of Ceramic Tile" that are referenced in TCA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.

1. For installations indicated below, follow procedures in ANSI's "Specifications for the Installation of Ceramic Tile" for providing 95 percent mortar coverage. Listed locations below are examples only; revise to suit Project.
  - a. Tile floors in wet areas.
- B. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- C. Lay tile in grid pattern unless otherwise indicated. Align joints where adjoining tiles on floor, base, walls, and trim are the same size.
- D. Install cementitious backer units and treat joints according to ANSI A108.11.
- E. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot (1:50) toward drains.
- F. Install waterproofing to comply with ANSI A108.13.
- G. Do not install tile over waterproofing until waterproofing has cured and been tested to determine that it is watertight.
- H. Interior Floor Tile Installation Method(s):
  1. Over Wood Subfloors: TCA F144 (thin-set mortar bonded on cementitious backer units or fiber cement underlayment.)
- I. Interior Wall Tile Installation Method(s):
  1. Over Wood Studs or Furring: Thinset mortar over 1/2" cement backer board over 20# asphalt felt paper.

END OF SECTION 093000

## SECTION 096400 - WOOD FLOORING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Hardwood Flooring: Comply with NOFMA grading rules for species, grade, and cut.

## PRODUCTS

## 1.2 FIELD-FINISHED WOOD FLOORING

- A. N/A

## 1.3 FACTORY-FINISHED WOOD FLOORING

- A. Solid-Wood Strip and Plank Flooring: Kiln dried and as follows:
  - 1. Species: Maple
  - 2. Grade: 1
  - 3. Cut: Plain sawn
  - 4. Thickness: 3/4 inch
  - 5. Face Width: 5-1/8 inches
  - 6. Lengths: Random-length strips complying with applicable grading rules.
  - 7. Edge Style: Beveled.
  - 8. Finish: UV urethane system.

## 1.4 FINISHING MATERIALS

- A. Urethane Finish System: Complete water-based system of compatible components that is recommended by finish manufacturer for application indicated.
  - 1. Stain: Penetrating and nonfading type.
    - a. Color: As selected.
  - 2. Floor Sealer: Pliable, penetrating type.
  - 3. Finish Coats: Formulated for multicoat application on wood flooring.
- B. Wood Filler: Formulated to fill and repair seams, defects, and open-grain hardwood floors; compatible with finish system components and recommended by filler and finish manufacturers for use indicated. If required to match approved samples, provide pigmented filler.

## 1.5 ACCESSORY MATERIALS

- A. Fasteners: As recommended by manufacturer, but not less than that recommended in NWFA's "Installation Guidelines: Wood Flooring."

## PART 2 - EXECUTION

### 2.1 INSTALLATION

- A. Comply with flooring manufacturer's written installation instructions, but not less than applicable recommendations in NWFA's "Installation Guidelines: Wood Flooring."
- B. Provide expansion space at walls and other obstructions and terminations of flooring of not less than 3/4 inch (19 mm).
- C. Solid-Wood, Flooring: Blind nail or staple flooring to substrate.
  - 1. Plank Flooring: For flooring of face width more than 3 inches (75 mm), Fill holes with matching wood filler.

### 2.2 SANDING AND FINISHING

- A. Machine-sand flooring to remove offsets, ridges, cups, and sanding-machine marks that would be noticeable after finishing. Vacuum and tack with a clean cloth immediately before applying finish.
- B. Fill open-grained hardwood.
- C. Apply floor-finish materials in number of coats recommended by finish manufacturer for application indicated, but not less than one coat of floor sealer and three finish coats.
  - 1. Apply stains to achieve an even color distribution matching approved Samples.

END OF SECTION 096400

## SECTION 099100 - PAINTING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 PAINT

- A. MPI Standards: Provide materials that comply with MPI standards indicated and listed in its "MPI Approved Products List."
- B. Material Compatibility: Provide materials that are compatible with one another and with substrates.
- C. Use interior paints and coatings that comply with the following limits for VOC content:
  - 1. Flat Paints and Coatings: 50
  - 2. Nonflat Paints, Coatings: 150
  - 3. Primers, Sealers, and Undercoaters: 200
- D. Colors: As selected.

## PART 3 - EXECUTION

## 3.1 PREPARATION

- A. Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.
- B. Remove hardware, lighting fixtures, and similar items that are not to be painted. Mask items that cannot be removed. Reinstall items in each area after painting is complete.
- C. Clean and prepare surfaces in an area before beginning painting in that area. Schedule painting so cleaning operations will not damage newly painted surfaces.

## 3.2 APPLICATION

- A. Comply with recommendations in MPI's "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

- B. Paint exposed surfaces unless otherwise indicated.
  - 1. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces.
  - 2. Paint surfaces behind permanently fixed equipment or furniture with prime coat only.
  - 3. Paint the back side of access panels.
- C. Apply paints according to manufacturer's written instructions.
  - 1. Use brushes only for exterior painting and where the use of other applicators is not practical.
  - 2. Use rollers for finish coat on interior walls and ceilings.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
  - 1. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- E. Apply stains and transparent finishes to produce surface films without color irregularity, cloudiness, holidays, lap marks, brush marks, runs, ropiness, or other imperfections. Use multiple coats to produce a smooth surface film of even luster.

### 3.3 EXTERIOR PAINT APPLICATION SCHEDULE

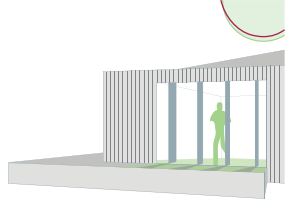
- A. N/A

### 3.4 INTERIOR PAINT APPLICATION SCHEDULE

- A. Dressed Lumber: Including architectural woodwork, doors.
  - 1. Semigloss Latex: Two coats over primer: MPI INT 6.3T.
- B. Gypsum Board:
  - 1. Eggshell Latex: Two coats over primer/sealer: MPI INT 9.2A.
  - 2. Low-Sheen Latex: One coat over alkyd primer/sealer: MPI INT 9.1B.

END OF SECTION 099100

## Division\_10 Specialties



## SECTION 102800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 MATERIALS

- A. Stainless Steel: ASTM A 666, Type 304, No. 4 finish (satin), 0.0312-inch minimum nominal thickness unless otherwise indicated.
- B. Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6063-T6 or 6463-T6.
- C. Chromium Plating: ASTM B 456, Service Condition Number SC 2 (moderate service).
- D. Baked-Enamel Finish: Factory-applied, gloss-white, baked-acrylic-enamel coating.
- E. Mirrors: ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.
- F. Galvanized-Steel Mounting Devices: ASTM A 153/A 153M, hot-dip galvanized after fabrication.
- G. Fasteners: Screws, bolts, and other devices of same material as accessory unit, tamper and theft resistant when exposed, and of galvanized steel when concealed.

## 2.2 TOILET AND BATH ACCESSORIES

- A. Manufacturers:
  - 1. Kohler
- B. Mirror Unit:
  - 1. Basis-of-Design Product: Tigris
  - 2. Frame: No Frame.
  - 3. Wall mounted mirror unit with integrated light.
- C. Towel Bar:
  - 1. Basis-of-Design Product: Kohler
  - 2. Description: 3/4-inch round tube with circular end brackets.
  - 3. Mounting: Flanges with concealed fasteners.



4. Length: 24 inches Material and Finish: Vibrant brushed nickel.

D. Towel Hook.

1. Basis-of-Design Product: Kohler
2. Description: Pin projecting approximately 2-1/2 inches (63 mm) from wall with.
3. Pin Material and Finish: Stainless steel finished in vibrant brushed nickel.

E. Towel Rack

1. Basis-of-Design Product: Kohler
2. Description: Surface-mounted, guest-towel unit with approximately 1/4-inch- (6-mm-) diameter wire rings welded to upright wire bracket.
3. Capacity: Three sets of bath towels.
4. Nominal Height: 17 inches
5. Material and Finish: Stainless steel finished in vibrant brushed nickel.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install accessories using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
- B. Adjust accessories for unencumbered, smooth operation and verify that mechanisms function properly. Replace damaged or defective items. Remove temporary labels and protective coatings.

END OF SECTION 102800

## SECTION 104416 - FIRE EXTINGUISHERS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.

### PART 2 - PRODUCTS

#### 2.1 FIRE EXTINGUISHERS

- A. Portable Fire Extinguishers NFPA 10, listed and labeled for the type, rating, and classification of extinguisher.
  - 1. Multipurpose Dry-Chemical Type:
  - 2. UL-rated 1-A:10-B:C, 2.5-lb nominal capacity, in chrome-plated brass container.

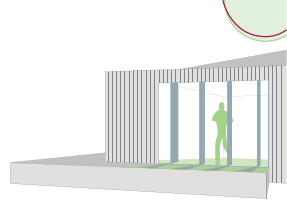
### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install fire extinguishers in where indicated.

END OF SECTION 104416

## Division\_11 Equipment



## SECTION 112813 – COMPUTERS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Allowances: See Division 01 Section "Price and Payment Procedures" for computer allowances.
- B. Submittals: Product Data.
- 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.
- D. Energy Ratings: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program where possible.

## PART 2 - PRODUCTS

## 2.1 COMPUTERS

- A. Portable Laptop Computer: Energy star rated, 2.4GHz, 3MB L2 Cache, 1066MHz FSB with 17" or greater monitor size and DVD playing capability
  - 1. Dell Vostro 1720 Laptop:  
[http://www.dell.com/downloads/global/products/vostro/b/dell\\_rec\\_vostro\\_1320\\_%201520\\_1720\\_en.pdf](http://www.dell.com/downloads/global/products/vostro/b/dell_rec_vostro_1320_%201520_1720_en.pdf)
- B. Touchscreen Computer: To be wall mounted, with wireless internet connection and Windows operating system.
  - 1. Advantech 5.7" LCD Touch Screen Computer:  
[http://download.advantech.com/ProductFile/1-317QXV/TPC-66T\\_DS.pdf](http://download.advantech.com/ProductFile/1-317QXV/TPC-66T_DS.pdf)

## 2.2 WIRELESS ROUTERS

- A. Wireless Router: Wireless G Broadband Router with 4-port Ethernet switch and 54 Mbps and better data transfer rate
  - 1. Linksys WRT54G2: [http://www.latinsoft.lv/UserFiles/file/linksys\\_34343.pdf](http://www.latinsoft.lv/UserFiles/file/linksys_34343.pdf)

## 2.3 SURGE PROTECTORS

- A. Straight Plug, 1875 W Rating, Max spike current H-N 24000A, Max spike voltage 6000V, with overload protection and power safety shut down
  - 1. Belkin 6 Outlet Home/Office Surge Protector Part #BE106000-2.5:  
[http://catalog.belkin.com/IWCatProductPage.process?Product\\_Id=299645](http://catalog.belkin.com/IWCatProductPage.process?Product_Id=299645)

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Mounted Equipment: Use only wall mounting approved for use with selected equipment. Minimum of one fastener to be secured to an existing wall stud. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
- B. Freestanding Equipment: Place in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
- C. Test each item of audio-visual equipment to verify proper operation. Make necessary adjustments.
- D. Verify that accessories required have been furnished and installed.

END OF SECTION 112813

## SECTION 113100 - RESIDENTIAL APPLIANCES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Allowances: See Division 01 Section "Price and Payment Procedures" for appliance allowances.
- B. Submittals: Product Data.
- 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.
  - 4. NAECA: Provide residential appliances that comply with NAECA standards.
- D. Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines.
- E. Energy Ratings: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.

## PART 2 - PRODUCTS

## 2.1 RESIDENTIAL APPLIANCES

- A. Electric Cooktop: 30-inch built-in induction cooktop with four burner elements.
  - 1. Wolf 30" Induction Cooktop CT301:  
<http://www.wolfappliance.com/resources/products/downloads/PS-CT30I.pdf>
- B. Combination Microwave and Convection Oven: Undercabinet Speedcook oven, 2.0-cu. ft. capacity, 1200 W cooking power, 1500 W convection power, 1500 W grilling power.
  - 1. Whirlpool GH7208XRQ:  
<http://whirlpool.com/catalog/product.jsp?src=BUILT-IN+OVENS&cat=83&prod=1298>
- C. Exhaust Hood: 30-inch retractable-downdraft ventilating exhaust hood with 3-speed automatic fan.
  - 1. Fan Control: Wall-mounted switch, with separate light switch.
  - 2. Weatherproof wall cap with backdraft damper and rodent-proof screening.

3. Wolf 30" Downdraft DD30I:  
<http://www.wolfappliance.com/resources/products/downloads/DD30.pdf>
- D. Refrigerator/Freezer: Freestanding, cycle-defrost, two-door refrigerator with top-mounted freezer.
  1. Fresh Food Compartment Volume: 10.8 cu. ft.
  2. Freezer Compartment Volume: 3.8 cu. ft.
  3. Shelf Area: 3 adjustable wire shelves, 1 crisper pan drawer.
  4. Whirlpool W5TXEWFQ:  
<http://whirlpool.com/catalog/product.jsp?src=REFRIGERATORS&cat=96&prod=1580>
- E. Dishwasher: Built-in, undercounter, automatic dishwasher, sized to replace 24-inch base cabinet, 6 wash cycles with hot-air and heat-off drying cycles, [porcelain-enamel tub and door liner] [polypropylene tub and door liner] [stainless-steel tub and door liner] [porcelain-enamel tub and molded-plastic door liner], [nylon-coated sliding dish racks] [PVC-coated sliding dish racks].
  1. KitchenAid KUDD03STWH:  
<http://kitchenaid.com/flash.cmd?#/product/KUDD03STSS/>
- F. Clothes Washer: Stacked, front-loading, automatic clothes washer with 2.3-cu. ft. capacity stainless-steel tub and 11 wash cycles including regular, delicate, and permanent press; 1200 RPM reversible motor.
  1. Whirlpool WFC7500VW:  
<http://www.whirlpool.com/catalog/product.jsp?src=WASHERS&cat=115&prod=1420>
- G. Electric Clothes Dryer: Stackable, front-loading clothes dryer, 3.8-cu. ft. capacity with stainless-steel interior.
  1. Whirlpool WED7500VW:  
<http://www.whirlpool.com/catalog/product.jsp?src=DRYERS&cat=119&prod=1413>

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Built-in Appliances: Securely anchor to supporting cabinetry or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
- B. Freestanding Appliances: Place in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
- C. Test each item of residential appliances to verify proper operation. Make necessary adjustments.
- D. Verify that accessories required have been furnished and installed.

END OF SECTION 113100

## SECTION 115200 – AUDIO-VISUAL EQUIPMENT

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Allowances: See Division 01 Section "Price and Payment Procedures" for audio-visual equipment allowances.
- B. Submittals: Product Data.
- 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.
- D. Energy Ratings: Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program where possible.

### PART 2 - PRODUCTS

#### 2.1 AUDIO-VISUAL EQUIPMENT

- A. Television: Wall Mounted Flat Screen Television, LED lighting system, 1.5” and less depth, 46” and greater width. Compatible with HDTV.
  - 1. Samsung UN46B7000:  
<http://www.samsung.com/us/system/consumer/product/2009/04/17/un46b7000wfxza/UN46B7000-FINAL-041609-R6.pdf>
- B. Digital Sound Projector: Includes the following audio features: 1080p-compatible HDMI, analog to HDMI digital video, analog video upscaling to HD quality, iPod compatible, XM HD surround compatible, and built in FM tuner. Provides an RS-232C port and IR Pass-through.
  - 1. Yamaha YSP-4000:  
[http://www.yamahamusic.com.au/products/avit/digitalsound/YSP4000\\_NPB.pdf](http://www.yamahamusic.com.au/products/avit/digitalsound/YSP4000_NPB.pdf)

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

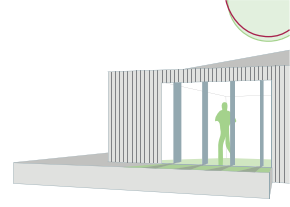
- A. Mounted Equipment: Use only wall mounting approved for use with selected equipment. Minimum of one fastener to be secured to an existing wall stud. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.



1. Samsung WMN1000B Wall Mount for use with Samsung LED UN46B7000 HDTV:  
<http://www.samsung.com/us/system/consumer/product/2009/04/17/un46b7000wfxza/UN46B7000-FINAL-041609-R6.pdf>
- B. Freestanding Equipment: Place in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
- C. Test each item of audio-visual equipment to verify proper operation. Make necessary adjustments.
- D. Verify that accessories required have been furnished and installed.

END OF SECTION 115200

## Division\_12 Furnishings



## SECTION 122400 – WINDOW SHADES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A

## PART 2 - PRODUCTS

## 2.1 WINDOW SHADES

- A. Products:

1. MechoShade Systems  
[http://www.mechoshade.com/specs/Website\\_Specs\\_063004.dot](http://www.mechoshade.com/specs/Website_Specs_063004.dot)

## 2.2 MATERIALS

- A. Window Shade System: MechoShade window shade system with bead chain clutch operator.

1. Fabric: White.
2. Hembars and Hempockets: Fabric Hempocket with RF welded seams, including welded ends, and concealed hemweights. Hempocket construction will be consistent for each shade.
3. Hemweights: Appropriate size and weight for shadband, continuous inside the sealed hempocket.

- B. Manually Operated Window Shade System:

1. Manually Operated Hardware: Minimum 1/8 inch thick cadmium plated steel or heavier as required to support 150 percent of the full weight of each shade.
  - a. Hardware: Shade hardware system shall allow for removal of shade roller tube from remounting of the shade band without having to remove shade tubes, drive, or operating support bracket.
  - b. Provide positive mechanical engagement of drive mechanism to shade roller tube.
  - c. Plastic components: Dupont Delrin engineered plastics. Styrene based plastics are not acceptable.
2. Drive Bracket/Brake Assembly: MechoShade Drive Bracket Model 5.
3. Drive Chain: No. 10 qualified stainless steel chain rated to 90 pound minimum breaking strength.

## 2.3 ACCESSORIES

- A. Shade Pocket: Provide formed steel shade pocket with exposed extruded aluminum removable closure panel to provide access to shades.
- B. Blackout Shade Side Channels: Extruded aluminum channels with polybond edge seals. Side channels to be recessed into jams with concealed fasteners.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install each type of window shade system in accordance with manufacturer's written installation instructions and final shop drawings. Install window shades plumb, level and securely anchored in place with recommended hardware and accessories to provide smooth operation without binding.
- B. Installation Tolerances:
  - 1. Maximum Variation of Gap at Window Opening Perimeter: 1/4 inch per 8 feet (plus or minus 1/8 inch) of shade height.
  - 2. Maximum Offset from Level: 1/16 inch per 5 feet of shade width.
- C. Test operation of each window shade to ensure unencumbered operation. Adjust and balance window shades that do not operate smoothly. Replace shade units or components that do not hang properly or operate smoothly.

END OF SECTION 122400

## SECTION 123530 - RESIDENTIAL CASEWORK

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Verify dimensions by field measurements; measure for countertops after base cabinets are installed.

## PART 2 - PRODUCTS

## 2.1 CASEWORK

- A. Comply with KCMA A161.1.
- B. Cabinets:
  - 1. Products:
    - a. Cabinets are custom manufactured by the OSU Solar Decathlon Team.
  - 2. Face Style: Flush overlay.
  - 3. Cabinet Style: Frameless.
  - 4. Door and Drawer Fronts: Veneer-faced plywood.
  - 5. Face Frame Finish: Wood
  - 6. Exposed Cabinet End Finish: Wood
  - 7. Exposed Wood: Maple clear solid wood or hardwood plywood with Grade A faces per HPVA HP-1, selected for compatible color and grain.
  - 8. Semiexposed Materials: Solid wood or hardwood plywood with Grade C faces per HPVA HP-1, clear finish, Plastic laminate, NEMA LD 3, Grade VGS or Medium-density particleboard, with melamine surface. Any are acceptable
  - 9. Hinges: Concealed European-style self-closing hinges.
  - 10. Drawer Guides: Epoxy-coated-metal, self-closing drawer guides with nylon-tired, ball-bearing rollers.
- C. Countertop Configuration:
  - 1. See drawings for profile, dimension, and construction.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install cabinets with no variations in flushness of adjoining surfaces by 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 cabinets without distortion so doors and drawers fit openings properly and are aligned.
- C. Install level and plumb to a tolerance of 1/8 inch in 8 feet.
- D. Fasten each cabinet to adjacent unit and to structural members of wall construction. Fasten wall cabinets through back, near top and bottom, at ends and not less than 24 inches o.c.
  - 1. Use No. 10 wafer-head screws sized for 1-inch penetration into wood framing, blocking, or hanging strips.
  - 2. Use toggle bolts through metal backing behind gypsum board.
- E. Fasten countertops by adhering with silicone adhesive on the underside of countertop. Align adjacent surfaces.
  - 1. Seal counters with manufacturer recommended sealer for porous surfaces.

END OF SECTION 123530

## SECTION 123640 - STONE COUNTERTOPS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Not Applicable.
- B. Verify dimensions of stone countertops by field measurements and indicate on Shop Drawings.

## PART 2 - PRODUCTS

## 2.1 STONE

- A. Concrete: ASTM C 615.
  - 1. Uniform color (selected from standard fabricator color offerings).
  - 2. Finish: Honed

## 2.2 SETTING MATERIALS

- A. Sealant: Clear 100% kitchen and bath silicone sealant.
- B. Stone Sealer: Colorless, stain-resistant sealer that does not affect color or physical properties of stone surfaces, as recommended by stone producer for application indicated.

## 2.3 COUNTERTOP FABRICATION

- A. Comply with recommendations in MIA's "Dimensional Stone - Design Manual IV."
  - 1. Thickness: 1-1/4 inches
  - 2. Edge Detail: Straight, slightly eased at top
- B. Splashes: Not applicable.
- C. Fabricate molded edges with machines having abrasive shaping wheels made to reverse contour of edge profile. Form corners of molded edges as indicated with outside corners slightly eased.
- D. Seams: Seams will not be accepted. All counters shall be continuous pieces.
- E. Cutouts and Holes:
  - 1. Undercounter Fixtures: Make cutouts for undercounter fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.

- a. Edge Detail: Vertical, slightly eased at top and bottom surfaces and projecting 3/16 inch into fixture opening.
2. Counter-Mounted Fixtures: Prepare countertops in shop for field cutting openings for counter-mounted fixtures. Mark tops for cutouts and drill holes at corners of cutout locations. Make corner holes of largest radius practical.
3. Fittings: Drill countertops in shop for plumbing fittings, undercounter soap dispensers, and similar items.

## PART 3 - EXECUTION

### 3.1 INSTALLING COUNTERTOPS

- A. Install countertops by adhering to supports with water-cleanable epoxy adhesive.
- B. Install backsplash and end splashes by adhering to wall with water-cleanable epoxy adhesive. Leave 1/16-inch gap between countertop and splash for filling with sealant. Use temporary shims to ensure uniform spacing.
- C. Apply sealant to gap between countertops and splashes.

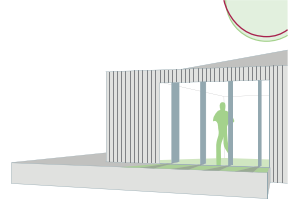
### 3.2 CLEANING

- A. Clean countertops as work progresses. Remove adhesive, grout, mortar, and sealant smears immediately.
- B. Clean stone countertops not less than six days after completion of sealant installation, using clean water and soft rags. Do not use materials or methods that could damage stone.
- C. Apply stone sealer to comply with stone producer's and sealer manufacturer's written instructions.

END OF SECTION 123640



## Division\_22 Plumbing



## SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.

## PART 2 - PRODUCTS

## 2.1 SLEEVES

- A. Mechanical Sleeve Seals: Modular rubber sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
- B. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- C. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- D. PVC Pipe: ASTM D 1785, Schedule 40.

## 2.2 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

## 2.3 MOTORS

- A. Motor Characteristics:
  - 1. Motors 1/2 HP and Larger: Three phase.
  - 2. Motors Smaller Than 1/2 HP: Single phase.
  - 3. Frequency Rating: 60 Hz.
  - 4. Voltage Rating: NEMA standard voltage for circuit voltage to which motor is connected.
  - 5. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
  - 6. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.
  - 7. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
  - 8. Enclosure: Unless otherwise indicated, open dripproof.
  - 9. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

## 2.4 HANGERS AND SUPPORTS

- A. Hanger and Pipe Attachments: Factory fabricated with galvanized coatings; nonmetallic coated for hangers in direct contact with copper tubing.
- B. Powder-Actuated Fasteners: Threaded-steel stud, with pull-out and shear capacities appropriate for supported loads and building materials where used.
- C. Mechanical-Expansion Anchors: Insert-wedge-type, [zinc-coated] [stainless] steel, with pull-out and shear capacities appropriate for supported loads and building materials where used.

## 2.5 PRESSURE GAGES AND TEST PLUGS

- A. Pressure Gages: Direct-mounting, indicating-dial type complying with ASME B40.100. Dry metal case, minimum 2-1/2-inch diameter with red pointer on white face, and plastic window. Minimum accuracy 3 percent of middle half of range. Range two times operating pressure.
- B. Test Plug: Corrosion-resistant brass or stainless-steel body with two self-sealing rubber core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping. Minimum pressure and temperature rating 500 psig at 200 deg F.

# PART 3 - EXECUTION

## 3.1 MOTOR INSTALLATION

- A. Anchor motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions.

## 3.2 GENERAL PIPING INSTALLATIONS

- A. Install piping free of sags and bends.
- B. Install fittings for changes in direction and branch connections.
- C. Install sleeves for pipes passing through concrete walls, gypsum board partitions, and concrete floor and roof slabs.
- D. Exterior Wall, Pipe Penetrations: Mechanical sleeve seals installed in steel or cast-iron pipes for wall sleeves.
- E. Comply with requirements in Division 07 Section "Penetration Firestopping" for sealing pipe penetrations in fire-rated construction.
- F. Install unions at final connection to each piece of equipment.
- G. Install dielectric unions and flanges to connect piping materials of dissimilar metals in gas piping.

- H. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in water piping.

### 3.3 GENERAL EQUIPMENT INSTALLATIONS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

### 3.4 BASES, SUPPORTS, AND ANCHORAGES

- A. Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
  - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
  - 2. Install dowel rods on 18-inch centers around the full perimeter of the base to connect concrete base to concrete floor.
  - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Use 3000-psi 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete"
- B. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors. Place grout, completely filling equipment bases.

### 3.5 HANGERS AND SUPPORTS

- A. Comply with MSS SP-69 and MSS SP-89. Install building attachments within concrete or to structural steel.
- B. Install hangers and supports to allow controlled thermal and seismic movement of piping systems.
- C. Install powder-actuated fasteners and mechanical-expansion anchors in concrete after concrete is cured. Do not use in lightweight concrete or in slabs less than 4 inches thick.

- D. Load Distribution: Install hangers and supports so piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
- E. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
  - 1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30
  - 2. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 to allow off-center closure for hanger installation before pipe erection.
  - 3. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
  - 4. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
  - 5. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
- F. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
  - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
  - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

END OF SECTION 220500

## SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. NSF Compliance: NSF 61 for valve materials for potable-water service.

## PART 2 - PRODUCTS

## 2.1 GENERAL-DUTY VALVES

- A. Valve Sizes: Same as upstream piping unless otherwise indicated.
- B. Valves in Insulated Piping: With 2-inch stem extensions.
- C. End Connections: Threads shall comply with ANSI B1.20.1. Flanges shall comply with ANSI B16.1 for cast-iron valves and with ANSI B16.24 for bronze valves. Solder-joint connections shall comply with ANSI B16.18.
- D. One-Piece, Copper-Alloy Ball Valves: Brass or bronze body with chrome-plated bronze ball, PTFE or TFE seats, and 400-psig minimum CWP rating.
- E. Two-Piece, Copper-Alloy Ball Valves: Brass or bronze body with regular-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
- F. Bronze, Swing Check Valves: Class 125, bronze body with bronze disc and seat.
- G. Bronze Gate Valves: Class 125, bronze body with rising or non-rising stem and bronze solid wedge
- H. Bronze Globe Valves: Class 125, bronze body with bronze disc.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Use gate and ball valves for shutoff duty; globe and ball for throttling duty.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves for each fixture and item of equipment.

- D. Install three-valve bypass around each pressure-reducing valve using throttling-type valves.
- E. Install valves in horizontal piping with stem at or above center of pipe.
- F. Install valves in a position to allow full stem movement.
- G. Install check valves for proper direction of flow in horizontal position with hinge pin level.

END OF SECTION 220523

## SECTION 220700 - PLUMBING INSULATION

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Quality Assurance: Labeled with maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to ASTM E 84.

## PART 2 - PRODUCTS

## 2.1 INSULATION MATERIALS

- A. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- B. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
- C. Mineral-Fiber Blanket Insulation: Comply with ASTM C 553, Type II and ASTM C 1290, Type I.
- D. Mineral-Fiber Board Insulation: Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation factory-applied FSK jacket.
- E. Mineral-Fiber, Preformed Pipe Insulation: Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ.
- F. Mineral-Fiber, Pipe and Tank Insulation: Complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB; and having factory-applied FSK jacket. Nominal density is 2.5 lb/cu. ft or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.
- G. Polyolefin Insulation: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
- H. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- I. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- J. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.



- K. Factory-Applied Jackets: When factory-applied jackets are indicated, comply with the following:
  - 1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
- L. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

## PART 3 - EXECUTION

### 3.1 PIPE INSULATION INSTALLATION

- A. Comply with requirements of the Midwest Insulation Contractors Association's "National Commercial & Industrial Insulation Standards" for insulation installation on pipes and equipment.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Insulation Installation at Fire-Rated Wall, Partition, and Floor Penetrations: Install insulation continuously through penetrations. Seal penetrations. Comply with requirements in Division 07 Section "Penetration Firestopping."
- D. Flexible Elastomeric Insulation Installation:
  - 1. Seal longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- E. Mineral-Fiber Insulation Installation:
  - 1. Insulation Installation on Straight Pipes and Tubes: Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  - 2. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
  - 3. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- F. Polyolefin Insulation Installation:
  - 1. Seal split-tube longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of polyolefin pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

G. Interior Piping System Applications: Insulate the following piping systems:

1. Domestic hot water.
2. Recirculated domestic hot water.
3. Roof drain bodies and horizontal rainwater leaders of storm water piping.
4. Exposed water supplies and sanitary drains of fixtures for people with disabilities.

H. Do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.
2. Sanitary drainage and vent piping.
3. Drainage piping located in crawlspaces unless otherwise indicated.
4. Chrome-plated pipes and fittings, except for plumbing fixtures for people with disabilities.
5. Piping specialties, including air chambers, unions, strainers, check valves, plug valves, and flow regulators.

### 3.2 EQUIPMENT INSULATION SCHEDULE

- A. Domestic hot-water storage tank insulation shall be included with the tank

### 3.3 INDOOR PIPING INSULATION SCHEDULE

- A. Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawlspaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

- B. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation shall be one of the following:
  - a. Flexible Elastomeric: 3/4 inch thick.
  - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
2. NPS 1-1/4 and Larger: Insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch thick.
  - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

- C. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 and smaller: Insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch thick.
  - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
2. NPS 1-1/2 and Larger: Insulation shall be one of the following:

- a. Flexible Elastomeric: 1 inch thick.
  - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
  - 1. All Pipe Sizes: Insulation shall be[ one of] the following:
    - a. Flexible Elastomeric: 3/4 inch thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

END OF SECTION 220700

## SECTION 221116 - DOMESTIC WATER PIPING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Comply with NSF 14 for plastic, potable domestic water piping and components.
- B. Comply with NSF 61 for potable domestic water piping and components.

## PART 2 - PRODUCTS

## 2.1 PIPE AND FITTINGS

- A. Hard Copper Tubing: ASTM B 88, Types L and M, water tube, drawn temper with wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
  - 1. Copper Unions: Cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
  - 2. Joining Materials: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder.
- B. Soft Copper Tubing: ASTM B 88, Types K and L water tube, annealed temper with copper pressure fittings, cast-copper-alloy or wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
  - 1. Joining Materials: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder.
- C. Galvanized-Steel Piping: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe, with ASME B16.4, Class 125, galvanized, standard pattern gray-iron, threaded fittings.
- D. CPVC Piping: ASTM F 441/F 441M, Schedule 40 pipe with ASTM F 438, CPVC Schedule 40 socket-type fittings.
- E. PEX Tube and Fittings: ASTM F 877, SDR 9 PEX tubing and ASTM F 1807, metal insert-type fittings with copper or stainless-steel crimp rings.
  - 1. Manifold: ASTM F 877 plastic or corrosion-resistant-metal assembly, with a plastic or corrosion-resistant-metal valve for each outlet.
- F. PVC Pipe: ASTM D 1785, Schedule 40.
  - 1. PVC Fittings: ASTM D 2466, Schedule 40, socket type.
- G. Special-Duty Valves:

1. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.
  2. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.
  3. PVC Union Ball Valves: MSS SP-122, with full-port ball, socket and threaded detachable end connectors, and pressure rating not less than 125 psig at 73 deg F.
  4. PVC Non-Union Ball Valves: MSS SP-122, with full- or reduced-port ball, socket or threaded ends, and pressure rating not less than 125 psig at 73 deg F.
  5. PVC Butterfly Valves: With lever handle and pressure rating not less than 125 psig at 73 deg F.
  6. PVC Check Valves: Swing or ball-check design and pressure rating not less than 125 psig at 73 deg F.
- H. Transition Fittings: Manufactured piping coupling or specified piping system fitting. Same size as pipes to be joined and pressure rating at least equal to pipes to be joined.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping installation requirements.
- B. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for wall penetration systems.
- C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
- D. Install domestic water piping without pitch for horizontal piping and plumb for vertical piping.
- E. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- F. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.
  1. Soldered Joints: Comply with procedures in ASTM B 828 unless otherwise indicated.
- G. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for pipe hanger and support devices.
- H. Support vertical piping at each floor.
- I. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.

### 3.2 INSPECTING AND CLEANING

- A. Inspect and test piping systems as follows:
  - 1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
  - 2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
- B. Clean and disinfect potable and non-potable domestic water piping by filling system with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

### 3.3 PIPING SCHEDULE

- A. Underground, Service Entrance Piping: Not Applicable.
- B. Aboveground Distribution Piping: PEX piping

### 3.4 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
  - 1. Shutoff Duty: Use bronze ball or gate valves for piping NPS 2 and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 and larger.
  - 2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
  - 3. Hot-Water-Piping, Balancing Duty: Calibrated balancing valves.
  - 4. Drain Duty: Hose-end drain valves.
- B. Install gate valves close to main on each branch and riser serving two or more plumbing fixtures or equipment connections and where indicated.
- C. Install gate or ball valves on inlet to each plumbing equipment item, on each supply to each plumbing fixture not having stops on supplies, and elsewhere as indicated.
- D. PVC ball, butterfly, and check valves may be used in matching piping materials.
- E. Install drain valve at base of each riser, at low points of horizontal runs, and where required to drain water distribution piping system.
- F. Install swing check valve on discharge side of each pump and elsewhere as indicated.
- G. Install ball valves in each hot-water circulating loop and discharge side of each pump.

END OF SECTION 221116

## SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Comply with NSF 14 for plastic, potable domestic water piping and components.
- B. Comply with NSF 61 for potable domestic water piping and components.

## PART 2 - PRODUCTS

## 2.1 POTABLE DOMESTIC WATER STORAGE TANK

- A. Provide Potable Water Storage Tank to hold a minimum of 500 gallons of potable water, with a height no greater than 12" for storing below the house
- B. Material to be XR3 FDA/NSF-61 approved material for storing consumable fluids
- C. Have a 2" PVC flange fill fitting and 3/4" drain fitting for connecting to domestic water piping

## 2.2 INSTALLATION

- A. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping installation requirements.
- B. Tank shall not be sitting directly on the ground. Raised stand or mounting points for suspension should be provided for the tank below the house.

## 2.3 INSPECTING AND CLEANING

- A. Inspect and test piping systems as follows:
  - 1. Fill domestic water piping. Test for leaks and defects in new supply tanks and connections to piping that have been altered, extended, or repaired.
- B. Clean and disinfect potable domestic water tank piping by filling system with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

## 2.4 PIPING SPECIALTIES SCHEDULE

- A. Supply Tank: 500 Gallon Fresh Water Pillow Tank

1. Gototanks.com tank 950-250510: <http://www.gototanks.com/500-Gallon-Pillow-Tank.aspx>

END OF SECTION 221119



## SECTION 221123 - DOMESTIC WATER PUMPS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data. Include certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Comply with UL 778 for motor-operated water pumps.

## PART 2 - PRODUCTS

## 2.1 DOMESTIC WATER PUMPS

- A. In-Line, Single Stage, Self-Priming Centrifugal Pumps: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps. Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal; rated for 108-psig maximum working pressure, maximum suction lift of 25 ft, minimum continuous water temperature of 32 deg F and maximum continuous water temperature of 95 deg F.
  - 1. Products:
    - a. Grundfos MQ3-45-115:  
[http://www.us.grundfos.com/Web/Download.nsf/Pages/6A0893C7B967963088256EDF00546536/\\$File/L-MQ-PG-001.pdf](http://www.us.grundfos.com/Web/Download.nsf/Pages/6A0893C7B967963088256EDF00546536/$File/L-MQ-PG-001.pdf)
  - 2. Casing: Plastic or other corrosion-resistant material
  - 3. Impeller: 304 Stainless Steel
  - 4. Sound Pressure Level: equal or less than 70 dB

## 2.2 MOTORS

- A. NEMA MG 1, "Standard for Motors and Generators." Include NEMA listing and labeling.
- B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.
- C. Support pumps and piping so weight of piping is not supported by pump volute.
- D. Install electrical connections for power, controls, and devices.
- E. Suspend in-line pumps independent from piping. Use continuous-thread hanger rods and vibration isolation hangers. Fabricate brackets or supports as required for pumps.
- F. Install vertical in-line pumps on concrete bases.
- G. Connect piping with valves that are at least the same size as piping connecting to pumps.
- H. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- I. Install shutoff valve and strainer on suction side of pumps.
- J. Install nonslam check valve and throttling valve on discharge side of pumps.
- K. Install thermostats in hot-water return piping.
- L. Install pressure gages on suction and discharge of each pump. Install at integral pressure gage tapings where provided.

END OF SECTION 221123

## SECTION 221316 - SANITARY WASTE AND VENT PIPING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Minimum Pressure Requirement for Soil, Waste, and Vent: 10-foot head of water (30 kPa).
- B. Comply with NSF 14, "Plastic Piping Components and Related Materials," for plastic piping components.

## PART 2 - PRODUCTS

## 2.1 PIPES AND FITTINGS

- A. PVC Plastic, DWV Pipe and Fittings: ASTM D 2665, Schedule 40, plain ends with PVC socket-type, DWV pipe fittings.

## PART 3 - EXECUTION

## 3.1 PIPING INSTALLATION

- A. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping installation requirements.
- B. Install wall penetration system at each pipe penetration through foundation wall. Make installation watertight. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for wall penetration systems.
  - 1. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- C. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- D. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of

lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

- E. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
  - 1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
  - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
  - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- F. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- G. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- H. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- I. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.
- J. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure unless otherwise indicated.
- K. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for pipe hanger and support devices.

### 3.2 PIPE SCHEDULE

- A. Aboveground Applications: PVC plastic, DWV pipe and fittings with solvent-cemented joints
- B. Belowground Applications: PVC plastic, DWV pipe and drainage-pattern fittings with cemented joints

END OF SECTION 221316

## SECTION 221353 - FACILITY SEPTIC TANKS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.

## PART 2 - PRODUCTS

## 2.1 SEPTIC TANKS

- A. No septic tanks being used.

## 2.2 GRAYWATER TANKS

- A. 500 gallon bladder tank , 6' 8" x 10' x 12", 2" PVC fitting, 3/4" drain fitting:  
<http://www.gototanks.com/950-250500.aspx>

## 2.3 DISTRIBUTION PIPES AND FITTINGS

- A. PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, nonperforated, for solvent-cement or elastomeric gasket joints.
  - 1. Solvent Cement: ASTM D 2564.
  - 2. Gaskets: ASTM F 477, elastomeric seal.
- B. ABS Sewer Pipe and Fittings: ASTM D 2751, SDR 35, for solvent-cement or elastomeric gasket joints.
  - 1. Solvent Cement: ASTM D 2235.
  - 2. Gaskets: ASTM F 477, elastomeric seal.
- C. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 , Class 2, for rubber gasket joints, with ASTM C 443 , rubber gaskets.
- D. Vitrified-Clay Sewer Pipe and Fittings: ASTM C 700, Standard Strength, unglazed, with gasket joints, and ASTM C 425, rubber sealing elements.

END OF SECTION 221353

## SECTION 223300 - ELECTRIC DOMESTIC WATER HEATERS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Comply with requirements of applicable NSF, AWWA, or FDA and EPA regulatory standards for tasteless and odorless, potable-water-tank linings.
- C. Comply with performance efficiencies prescribed in ASHRAE 90.2, "Energy Efficient Design of New Low-Rise Residential Buildings."
- D. Warranties: Submit a written warranty executed by manufacturer agreeing to repair or replace water heaters that fail in materials or workmanship within five years from date of Substantial Completion. Failures include, but are not limited to, tanks and elements.

## PART 2 - PRODUCTS

## 2.1 WATER HEATERS, GENERAL

- A. Insulation: Suitable for operating temperature and required insulating value. Include insulation material that surrounds entire tank except connections and controls.
- B. Anode Rods: Factory installed, magnesium.
- C. Combination Temperature and Pressure Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input and pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into tank.
- D. Drain Valve: Factory or field installed.

## 2.2 ELECTRIC WATER HEATERS

- A. Products:
  - 1. Eemax, Electric Tankless Water Heaters, Model #48  
<http://eemax.com/images/flowspecs.pdf>
  - 2. E-tech R060, Residential High Efficiency Heat Pump Water Heater:  
[http://www.aers.com/aers/system/data/editor/File/R060 Data Sheet Rev.F 5-08.pdf](http://www.aers.com/aers/system/data/editor/File/R060%20Data%20Sheet%20Rev.F%205-08.pdf)
- B. Household, Storage, Electric Water Heaters: UL 174, 80-gal. capacity; steel with 150-psig (1035-kPa) working-pressure rating. Two electric, screw-in, immersion-type heating elements

with adjustable thermostat for each element and wiring arrangement for nonsimultaneous operation with maximum 30-A circuit.

- C. Flow-Control, Instantaneous Electric Water Heaters: UL 499, 0.5-gal. (1.89-L) capacity; with 150-psig (1035-kPa) working-pressure rating; 120 volts, 750 watts.
- D. Household, Backup Heat Pump Water Heater, ½ ton compressor, 40 gallon storage tank, 1.7 gpm flowrate, COP greater or equal to 3.3, 230 VAC, 1phase, 60 Hz.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install temperature and pressure relief valves and extend to closest floor drain.
- B. Install vacuum relief valves in cold-water-inlet piping.
- C. Install shutoff valves and unions at hot- and cold-water piping connections.
- D. Make piping connections with dielectric fittings where dissimilar piping materials are joined.
- E. Electrically ground units according to authorities having jurisdiction.

END OF SECTION 223300

## SECTION 223301 - SOLAR THERMAL WATER HEATING SYSTEM

## PART 1 - GENERAL

- 1.1 Domestic water heating system complete, ready for operation including water heat tubes, drain-back loop with pump, storage tank and all accessories shall be provided as shown on the drawings and as specified.
- 1.2 Refer to equipment bases and supports, plumbing specialties and other sections for work related to this section.

## PART 2 - PRODUCTS

## 2.1 Solar Collection Units

- A. Evacuated tube type solar collection panels shall be water based heat pipe units bonded to a copper heat transfer header; the heat pipe and header unit shall be factory assembled on a stainless steel frame. The complete unit shall be tested and certified hail and wind exposure based on the area of installation.
- B. Collector tubing shall be 3/4" Type L soft copper tubing running a direct path through heat pipe manifold.
- C. Units shall be rated for the capacity indicated on the drawings for de-ionized water heat transfer fluid.
- D. Evacuated tube units shall be as manufactured by Apricus.
  1. Apricus AP-30 drain-back manifold and Tubes: [www.apricus.com.au](http://www.apricus.com.au)

## 2.2 Storage Tank

- A. Tank shall be unpressurized 80 gallon capacity, featuring two stainless steel heat exchangers for domestic hot water and radiant floor systems with unpressurized inlets and outlets for heat pump and solar thermal heating applications.
- B. Unit shall be as manufactured by Rotex.
  1. Rotex Sanicube Mini SCS 328/14/0: Products:  
<http://en.rotex.de/fileadmin/prospekte/en/Prospekte/rotexSANICUBEengl.pdf>

## 2.3 Circulation Pump

- A. Circulation pump shall be 115V 1/25 HP stainless steel meeting requirements of the drain-back loop recirculation pump.



- B. Unit shall be as manufactured by Grundfos.
  - 1. Grundfos UP15-10SU7:  
<http://www.houseneeds.com/shop/manuals/grundfospumps60hz.pdf>

#### 2.4 Control Panel

- A. Unit shall control the operation of the circulation pump and monitor drain-back evacuated tube array, loop supply and return temperatures. Digital temperature difference logic and intelligent control algorithms shall be fully customizable to specifications. The system shall be single point power connection, 12V, 1PH, 60Hz.
- B. Unit shall be as manufactured by Solastat.
  - 1. Solastat-Plus-2:  
<http://www.solastat.com/info/pdf/ss-plus%20installation.pdf>

### PART 3 - EXECUTION

#### 3.1 Installation

- A. Units shall be installed on a structural steel with prime coat or aluminum frame to achieve the direction and solar angle necessary to optimize performance and achieve the design capacity.
- B. Provide insulation on heaters where insulation and jacket are not included as a part of factory packaged equipment. All insulation shall meet the energy code requirements.

END OF SECTION 223301

## SECTION 224000 - PLUMBING FIXTURES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: N/A
- B. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

## PART 2 - PRODUCTS

## 2.1 WATER CLOSET

- A. Vitreous-China Water Closet: Elongated, siphon-jet type, floor-mounted.
  - 1. Basis-of-Design Product: Presuade Dual Flush Toilet K-3654 or comparable product by one of the following:
    - a. Kohler  
<http://www.us.kohler.com/onlinecatalog/detail.jsp?item=13118302&section=2&category=13&subcategory=117>
  - 2. Design Consumption: 1.6 gal./flush (solid waste) or 0.8 gal./flush (liquid only waste).
- B. Toilet Seat: Elongated solid plastic closed front with cover with bumpers and hardware, Residential class.
  - 1. Basis-of-Design Product: Brevia toilet Seat K-4664 or comparable product by one of the following:
    - a. Kohler  
<http://www.us.kohler.com/onlinecatalog/detail.jsp?item=291502&section=2&category=14>

## 2.2 LAVATORY

- A. Faucets: ASME A112.18.1; solid brass.
  - 1. Basis-of-Design Product: Purist Wall-mount faucet K-T14412-3 or comparable product by one of the following:

- a. Kohler  
<http://www.us.kohler.com/onlinecatalog/detail.jsp?item=10172502&section=2&category=8&subcategory=49>
  - 2. Finish: Polished chrome.
  - 3. Handle(s): Dual, metal knobs.
  - 4. Maximum Flow Rate: 2.2 gpm.
- B. Trap: Chrome-plated with slip-joint inlet and wall flange.

## 2.3 SHOWER

- A. Mixing-Valve Faucet and Miscellaneous Fittings: Single-lever, thermostatic antiscald-type faucet K-687-K; maximum 1.5-gpm flow rate.
- 1. Basis-of-Design Product: Master Shower Thermo valve or comparable product by one of the following:
    - a. Kohler  
<http://www.us.kohler.com/onlinecatalog/detail.jsp?item=11849302&section=2&category=12&subcategory=126>
    - 2. Include ball, gate, or globe valves on supplies if check stops are not included with faucet.
    - 3. Body Material: Solid brass.
    - 4. Shower Arm, Flow-Control Fitting: 1-1/2 gpm.
- B. Drain: Slatted wood floor drains in to shower pan with 3" standard floor drain.

## 2.4 SINK

- A. Enameled Cast Iron: Above counter mounting, 0.063 inch thick.
- 1. Basis-of-Design Product: Inscribe Wading Pool Lavatory K-2388 or comparable product by one of the following:
    - a. Kohler  
<http://www.us.kohler.com/onlinecatalog/detail.jsp?item=13497302&section=2&category=16>
- B. Faucet: Solid brass Maximum 2.5-gpm flow rate.
- 1. Basis-of-Design Product: Purist Wall Mount Faucet K-T14414-4 or comparable product by one of the following:
    - a. Kohler  
<http://www.us.kohler.com/onlinecatalog/detail.jsp?item=10173202&section=2&category=8&subcategory=49>
    - 2. Type: Widespread with inlets on 9-inch centers.
    - 3. Finish: Polished chrome.

- 4. Handle(s): Dual lever.
  - 5. Spout: Wall Mounted
- C. Drain(s): 2 1/8 inch chrome pop up drain K - 7114.  
<http://search.us.kohler.com/?q=K-7114&x=12&y=0>

## PART 3 - EXECUTION

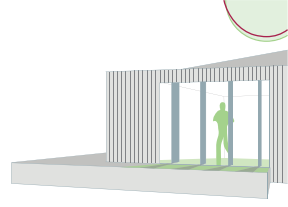
### 3.1 INSTALLATIONS

- A. Install fitting insulation kits on fixtures for people with disabilities.
- B. Install fixtures with flanges and gasket seals.
- C. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
- D. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.
- E. 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.
- F. Fasten floor-mounted fixtures to substrate. Fasten fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.
- G. Fasten wall-mounted fittings to reinforcement built into walls.
- H. Fasten counter-mounting plumbing fixtures to casework.
- I. Secure supplies to supports or substrate within pipe space behind fixture.
- J. Set shower receptors and mop basins in leveling bed of cement grout.
- K. Install individual supply inlets, supply stops, supply risers, and tubular brass traps with cleanouts at fixture.
- L. Install water-supply stop valves in accessible locations.
- M. Install traps on fixture outlets. Omit traps on fixtures having integral traps. Omit traps on indirect wastes unless otherwise indicated.
- N. Install hot-water dispensers in back top surface of sink or in counter with spout over sink.
- O. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.
- P. Install piping connections between plumbing fixtures and piping systems and plumbing equipment. Install insulation on supplies and drains of fixtures for people with disabilities.

Q. Ground equipment.

END OF SECTION 224000

## Division\_23 HVAC



## SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

## PART 1 - GENERAL

## 1.1 SUBMITTALS

- A. Product Data.

## PART 2 - PRODUCTS

## 2.1 GENERAL-DUTY VALVES

- A. Valve Sizes: Same as upstream piping unless otherwise indicated.
- B. Valves in Insulated Piping: With 2-inch stem extensions.
- C. End Connections: Threads shall comply with ANSI B1.20.1. Flanges shall comply with ANSI B16.1 for cast-iron valves and with ANSI B16.24 for bronze valves. Solder-joint connections shall comply with ANSI B16.18.
- D. One-Piece, Copper-Alloy Ball Valves: Brass or bronze body with chrome-plated bronze ball, PTFE or TFE seats, and 400-psig minimum CWP rating.
- E. Two-Piece, Copper-Alloy Ball Valves: Brass or bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
- F. Bronze, Swing Check Valves: Class 125, bronze body with bronze disc and seat.
- G. Bronze Gate Valves: Class 125, bronze body with nonrising stem and bronze solid wedge and union-ring bonnet.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Use gate and ball valves for shutoff duty; globe and ball for throttling duty.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves for each fixture and item of equipment.
- D. Install three-valve bypass around each pressure-reducing valve using throttling-type valves.
- E. Install valves in horizontal piping with stem at or above center of pipe.

- F. Install valves in a position to allow full stem movement.
- G. Install check valves for proper direction of flow in horizontal position with hinge pin level.

END OF SECTION 230523



## SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Certified TAB reports.
- B. TAB Firm Qualifications: AABC and NEBB certified.
- C. TAB Report Forms: Standard TAB contractor's forms approved by Architect.
- D. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

## PART 2 - PRODUCTS (Not Used)

## PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine the approved submittals for HVAC systems and equipment.
- C. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- D. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- E. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- F. Examine automatic temperature system components to verify the following:
  - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
  - 2. Dampers and valves are in the position indicated by the controller.
  - 3. Integrity of dampers and valves for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
  - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.

5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
  6. Sensors are located to sense only the intended conditions.
  7. Sequence of operation for control modes is according to the Contract Documents.
  8. Controller set points are set at indicated values.
  9. Interlocked systems are operating.
  10. Changeover from heating to cooling mode occurs according to indicated values.
- G. Report deficiencies discovered before and during performance of test and balance procedures.

### 3.2 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and ASHRAE 111 and NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish.
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

### 3.3 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare schematic diagrams of systems' "as-built" duct layouts.
- B. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- C. Verify that motor starters are equipped with properly sized thermal protection.
- D. Check for airflow blockages.
- E. Check condensate drains for proper connections and functioning.
- F. Check for proper sealing of air-handling unit components.
- G. Check for proper sealing of air duct system.

### 3.4 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data; number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate.

- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
  - 1. Open all manual valves for maximum flow.
  - 2. Check liquid level in expansion tank.
  - 3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
  - 4. Set system controls so automatic valves are wide open to heat exchangers.
  - 5. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

### 3.5 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
  - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
  - 2. Air Outlets and Inlets: Plus or minus 10 percent.
  - 3. Heating-Water Flow Rate: Plus or minus 10 percent.
  - 4. Cooling-Water Flow Rate: Plus or minus 10 percent.

END OF SECTION 230593

## SECTION 230700 - HVAC INSULATION

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Quality Assurance: Labeled with maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to ASTM E 84.

## PART 2 - PRODUCTS

## 2.1 INSULATION MATERIALS

- A. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- B. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
- C. Mineral-Fiber Blanket Insulation: Comply with ASTM C 553, Type II and ASTM C 1290, Type I.
- D. Mineral-Fiber Board Insulation: Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation with factory-applied ASJ.
- E. Mineral-Fiber, Preformed Pipe Insulation: Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ.
- F. Mineral-Fiber, Pipe and Tank Insulation: Complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB; and having factory-applied ASJ. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.
- G. Polyolefin Insulation: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
- H. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- I. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- J. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

- K. Factory-Applied Jackets: When factory-applied jackets are indicated, comply with the following:
  - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
- L. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

## PART 3 - EXECUTION

### 3.1 INSULATION INSTALLATION

- A. Comply with requirements of the Midwest Insulation Contractors Association's "National Commercial & Industrial Insulation Standards" for insulation installation on pipes and equipment.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Flexible Elastomeric Insulation Installation:
  - 1. Seal longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Mineral-Fiber Insulation Installation:
  - 1. Insulation Installation on Straight Pipes and Tubes: Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  - 2. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
  - 3. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
  - 4. Blanket and Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
  - 5. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier.
- E. Polyolefin Insulation Installation:
  - 1. Seal split-tube longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of polyolefin pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

F. Plenums and Ducts Requiring Insulation:

1. Concealed and exposed supply and outdoor air.
2. Concealed and exposed return air located in nonconditioned space.
3. Concealed and exposed exhaust between isolation damper and penetration of building exterior.

G. Plenums and Ducts Not Insulated:

1. Metal ducts with duct liner.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

H. Piping Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawlspaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

### 3.2 DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed duct insulation shall be **one of** the following:

1. Flexible Elastomeric: 1 inch thick.
2. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
3. Polyolefin: 1 inch thick.

B. Exposed duct insulation shall be **one of** the following:

1. Flexible Elastomeric: 1 inch thick.
2. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.
3. Polyolefin: 1 inch thick.

### 3.3 HVAC PIPING INSULATION SCHEDULE

A. Heating-Hot-Water Supply and Return: Insulation shall be the following:

1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

B. Refrigerant Suction and Hot-Gas Piping: Insulation shall be **[ one of ]** the following:

1. Flexible Elastomeric: 1 inch thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
3. Polyolefin: 1 inch thick.

- C. Refrigerant Suction and Hot-Gas Flexible Tubing: Insulation shall be one of the following:
  - 1. Flexible Elastomeric: 1 inch thick.
  - 2. Polyolefin: 1 inch thick.
- D. Dual-Service Heating and Cooling: Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

END OF SECTION 230700

## SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

## A. Submittals

## B. System Description:

## 1.) Radiant Floor:

The heating system will primarily consist of a radiant floor system. This system will cover steady state loads in the winter and meet the full heating load of the house in the spring and autumn. This system may be supplemented in transient conditions by one or both heat pumps which operate fan coil units placed inside the building envelope. If poor weather conditions such as cloud cover prevail heating will be achieved exclusively by the mini-split systems. Heating through this method is preferred due to the relatively high electrical cost of heating water without a gas boiler system and to conserve hot water for other competitions.

## 2.) Mini-Split Systems:

The cooling load will be met primarily by the two centrally located heat pumps in steady state conditions. The system is designed to maximize efficiency in the extremely variable Ohio climate. In the autumn and spring it is likely that the cooling load will be significantly less than the maximum values calculated for months such as August. Thus, by staging the size of the three systems, the control strategy will be able to consistently run only two at steady state. Furthermore, the individual compressors allow for optimized control of transient conditions, offering greater flexibility in meeting quickly changing climate conditions.

## 3.) Ventilation:

The ventilation requirements of the house will be met through the use of an energy recovery ventilator. The return for the ventilator will be placed near the bedroom area in order to achieve even temperature distribution and ensure a contiguous main space as was intended by the architects. Because of the tight construction of the house load based ventilation is necessary to ensure good indoor air quality.

## C. Operation Sequence: Refer to section 25 11 00 for Controls System details and operation sequence.



## PART 2 - CONTROLS SCHEDULE

### 2.1 Products:

- A. Yamatake Radiant Temperature Sensor TY7321:  
<http://www.yamatake.com/products/bi/ba/ss/AB-5361.pdf>
- B. Kele Type III Thermistor ST-S3EW:  
<http://www.hvacc.net/pdf/kele/ST-S3EW.pdf>
- C. Tekmar 356 Mixing Controller:  
<http://www.advancedhomecomfort.com/PDF%20files/Tekmar%20356.pdf>
- D. FocusPRO Non-Programmable Digital Thermostat:  
[http://www.pexsupply.com/specsheet/Honeywell\\_TH5110D1006\\_Brochure.pdf](http://www.pexsupply.com/specsheet/Honeywell_TH5110D1006_Brochure.pdf)
- E. Siemens Duct CO<sub>2</sub>, Temperature, and Humidity Sensor:  
<http://www.sbt.siemens.com/sbttemplates/library/pdf/CE1N1962.pdf>

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install control wiring concealed, except in mechanical rooms, and according to requirements specified in Division 26 Sections.

END OF SECTION 230900

## SECTION 232123 - HYDRONIC PUMPS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data. Include certified pump-performance curves, furnished specialties, motor horsepower and electrical characteristics.
- B. Comply with UL 778 for motor-operated water pumps.

## PART 2 - PRODUCTS

## 2.1 HYDRONIC PUMPS

- A. Close-Coupled, In-Line Centrifugal Pumps: Factory-assembled and -tested, overhung impeller, designed for installation with pump and motor shafts mounted horizontally or vertically. Rated for 150-psig maximum working pressure and maximum water temperature of 230 deg F.
  - 1. Products:
    - a. Grundfos UPS 15-58FC:  
<http://www.intermountainsales.net/files/SuperBrute%20Family%20Curves.pdf>
    - b. Grundfos Alpha 15-55F:  
[http://net.grundfos.com/doc/webnet/poweredy/pdf/Grundfos\\_HO\\_ALPHA2.pdf](http://net.grundfos.com/doc/webnet/poweredy/pdf/Grundfos_HO_ALPHA2.pdf)
  - 2. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, and threaded companion-flange connections.
  - 3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
  - 4. Pump Shaft: Steel, with copper-alloy shaft sleeve.
  - 5. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.

## 2.2 MOTORS

- A. NEMA MG 1, "Standard for Motors and Generators." Include NEMA listing and labeling.
- B. Less than 1/2 HP: Built-in thermal-overload protection.
- C. 1/2 to 3 HP: Permanently lubricated ball bearings.
- D. 5 HP and Larger: Grease-lubricated ball bearings.

- E. Motor shall be non-overloading within full range of pump performance.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install pumps with access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.
- B. Support pumps and piping so weight of piping is not supported by pump volute.
- C. Install electrical connections for power, controls, and devices.
- D. Suspend in-line pumps independent from piping. Use continuous-thread hanger rods and vibration isolation hangers. Fabricate brackets or supports as required for pumps.
- E. Install vertical in-line pumps on concrete bases.
- F. Connect piping with valves that are at least the same size as piping connecting to pumps.
- G. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- H. Install shutoff valve and strainer on suction side of pumps.
- I. Install nonslam check valve and throttling valve on discharge side of pumps.

END OF SECTION 232123

## SECTION 233100 - HVAC DUCTS AND CASINGS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Shop Drawings detailing duct layout and including locations and types of duct accessories, duct sizes, transitions, radius and vaned elbows, special supports details, and inlets and outlet types and locations.
- B. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- C. Comply with NFPA 96 for ducts connected to commercial kitchen hoods.
- D. Comply with UL 181 for ducts and closures.

## PART 2 - PRODUCTS

## 2.1 DUCTS

- A. Galvanized-Steel Sheet: ASTM A 653/A 653M, with G60 hot-dip galvanized coating.
- B. Carbon-Steel Sheets: ASTM A 1008/A 1008M; with oiled, matte finish for exposed ducts.
- C. Stainless Steel: ASTM A 480/A 480M, Type 304, with a No. 2D finish for concealed ducts and No. 4 finish for exposed ducts.
- D. Joint and Seam Tape, and Sealant: Comply with UL 181A.
- E. Rectangular Metal Duct Fabrication: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- F. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
  - 1. Thickness: 1 inch .
  - 2. Airstream surface coated with an antimicrobial erosion-resistant coating.
  - 3. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
  - 4. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment.

## 2.2 ACCESSORIES

- A. Volume Dampers and Control Dampers: Single-blade and multiple opposed-blade dampers, standard leakage rating, and suitable for horizontal or vertical applications; factory fabricated and complete with required hardware and accessories.

- B. Flexible Connectors: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- C. Flexible Ducts: Spiral-wound steel spring with flameproof vinyl sheathing complying with UL 181, Class 1.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
  - 1. Outdoor, Supply-Air Ducts: Seal Class A.
  - 2. Outdoor, Exhaust Ducts: Seal Class C.
  - 3. Outdoor, Return-Air Ducts: Seal Class C.
  - 4. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
  - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
  - 6. Unconditioned Space, Exhaust Ducts: Seal Class C.
  - 7. Unconditioned Space, Return-Air Ducts: Seal Class B.
  - 8. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
  - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg Seal Class B.
  - 10. Conditioned Space, Exhaust Ducts: Seal Class B.
  - 11. Conditioned Space, Return-Air Ducts: Seal Class C.
- C. Conceal ducts from view in finished and occupied spaces.
- D. Avoid passing through electrical equipment spaces and enclosures.
- E. Support ducts to comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Hangers and Supports."
- F. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- G. Install volume and control dampers in lined duct with methods to avoid damage to liner and to avoid erosion of duct liner.
- H. Clean new duct systems before testing, adjusting, and balancing.

3.2 TESTING, ADJUSTING, AND BALANCING

- A. Balance airflow within distribution systems, including submains, branches, and terminals to indicated quantities.

END OF SECTION 233100

## SECTION 233423 - HVAC POWER VENTILATORS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Products shall be licensed to use the AMCA-Certified Ratings Seal.
- C. Power ventilators shall comply with UL 705.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## PART 2 - PRODUCTS

## 2.1 ENERGY RECOVERY VENTILATORS

- A. Product:
  - 1. UltimateAir RecoupAerator 200DX, energy recovery ventilator:  
[http://www.ultimateair.com/Ulimate\\_Air/pdfs/200DX\\_Brochure.pdf](http://www.ultimateair.com/Ulimate_Air/pdfs/200DX_Brochure.pdf)
- B. Housing: Removable, steel casing, square, one-piece.
- C. Accessories:
  - 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
  - 2. Polymer heat exchanger.
  - 3. Multi-function timer.
  - 4. MERV 12 filtration.
  - 5. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
- D. Capacities and Characteristics:
  - 1. Airflow: 200 cfm.
  - 2. Static Pressure: < 1" inches wg.
  - 3. Volts: 120.
  - 4. Phase: Single.
  - 5. Hertz: 60.

## 2.2 CEILING FAN

- A. Product

1. Broan Model 670 Ceiling/Wall Fan:  
[http://shop.menards.com/media/men001/images/vendor/Broan/productspec/99041842\\_v1\\_m56577569830888303.pdf](http://shop.menards.com/media/men001/images/vendor/Broan/productspec/99041842_v1_m56577569830888303.pdf)
- B. Housing: Compact, 25 gage galvanized steel
- C. Accessories:
  1. White polymeric grille
  2. Motor assembly shall be removable and permanently lubricated
  3. Torsion spring grille mounting
  4. Polymeric duct fitting with tapered sleeve for duct connection
- D. Capacities and Characteristics:
  1. Airflow: 56 cfm
  2. Static Pressure: < .500" inches wg.
  3. Volts: 120.
  4. Phase: Single.
  5. Hertz: 60.
- E.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. In-Line Centrifugal Fans: Suspend units from structural-steel support frame using threaded steel rods and vibration isolation springs.
- B. Ceiling-Mounted Units: Suspend units from structure using steel wire or metal straps.
- C. Ground power ventilators.

END OF SECTION 233423



## SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data and color charts for factory finishes.

### PART 2 - PRODUCTS

#### 2.1 OUTLETS AND INLETS

- A. Slot Diffusers:

1. Products:

- a. Titus model ML-37-NT, modular narrow tee, supply air slot diffuser:  
<http://www.titus-hvac.com/ecatalog/getfile2.aspx?fileid=1218>
- b. Titus model MLR-37-NT, modular narrow tee, return air slot grille:  
<http://www.titus-hvac.com/ecatalog/getfile2.aspx?fileid=1218>

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. Mounting: T-bar.

- B. Stationary Louvers:

1. Products:

- a. Ruskin ELF15J Thin Line Stationary Louver, 6"w x6"h:  
<http://www.ruskin.com/catalog/servefile.aspx?id=299>

2. Material: Aluminum
3. Finish: Baked enamel, white.
4. Mounting: Wood installation.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets & Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Make final locations where indicated, as much as practical. For units installed

in lay-in ceiling panels, locate units in the center of panel unless otherwise indicated. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

- C. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

## SECTION 238119 - SELF-CONTAINED AIR-CONDITIONERS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Comply with ASHRAE 15.
- C. EER: Equal to or greater than that prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Comply with NFPA 70.
- E. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace refrigeration components that fail in materials or workmanship within five years from date of Substantial Completion.
- F. Energy Star Rated.

## PART 2 - PRODUCTS

## 2.1 PACKAGED HEAT PUMP UNITS

- A. Description: Self-contained, factory-assembled, -tested, and -wired unit.
- B. Products:
  - 1. Mitsubishi, Mr. Slim, ductless, split air conditioning and heat pump with remote space thermostat.
    - a. Mitsubishi MSZ/MUZ-FD09:  
[http://www.mrslim.com/UploadedFiles/Resource/MSZ-FD09NA~MUZ-FD09NA\\_Submittal.pdf](http://www.mrslim.com/UploadedFiles/Resource/MSZ-FD09NA~MUZ-FD09NA_Submittal.pdf)
- C. Cabinet: Structural-steel frame and galvanized-steel panels with baked-enamel finish with access doors or panels. Minimum 1/2-inch- thick, acoustic duct liner on cabinet interior and control panel. Stainless-steel drain pan.
- D. Discharge Plenum: Cabinet extension with directional louvers.
- E. Evaporator Fan: Galvanized steel; single-width, single-inlet, forward-curved centrifugal fan; statically and dynamically balanced. Direct drive with fan and motor resiliently mounted. Cast-iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Adjustable pitch selected so required rpm are obtained when set at midposition. Motor, multispeed, PSC type, or single speed, ODP polyphase.

- F. Evaporator and Condenser Coil: Seamless copper tubes expanded into aluminum fins; leak tested to 425 psig.
- G. Remote Air-Cooled Condenser: Factory assembled and tested; consisting of condenser coil, fans and motors, and operating controls. Direct-drive propeller-type fans with permanently lubricated motors and built-in thermal-overload protection. Low-ambient control cycle fans and modulates condenser-fan damper assembly to permit operation down to 0 deg F.
  - 1. Annealed-copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; insulated suction line; appropriate fittings at ends, and service valves for both suction and liquid lines.
- H. Refrigerant Circuits: Separate circuit for each compressor. Minimum two circuits for units larger than five nominal tons. Equalized expansion valve with replaceable thermostatic element, refrigerant filter-dryer, high- and low-pressure safety switches, thermal overload protection, anti-recycle timer, brass service and charging valves installed in hot-gas and liquid lines, and charged with R-410A refrigerant.
- I. Water Coil: Copper tube, with mechanically bonded aluminum fins; two-position control valve; and leak tested to 300 psig underwater.
- J. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and fuses in terminal box for overcurrent protection.
- K. Disposable Filters: 1-inch- thick, glass-fiber, pleated panel filters.
- L. Control Package: Factory wired and tested, including control-circuit transformer.
  - 1. Thermostat: Remote, programmable for occupied/unoccupied periods and temperatures to cycle compressor or heating coil. Provide field wiring for condenser fan operation with compressor.
  - 2. Supply fan runs continuous during occupied periods, and cycles for night setback when unoccupied. Opens outdoor-air damper during occupied periods.
  - 3. Motorized Outside-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outside air; with spring-return, low-voltage damper motor.

## 2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
  - 1. Airflow in CFM: 381 cfm.
  - 2. External Static Pressure: 0.25" static pressure
- B. Cooling:
  - 1. Total Cooling Capacity: 9,000 Btu/h.
  - 2. Ambient-Air Temperature: 95 deg F.
  - 3. Entering-Air Dry-Bulb Temperature: 80 deg F.
  - 4. Entering-Air Wet-Bulb Temperature: 67 deg F.

5. SEER: 25.
- C. Heating:
  1. Heating Capacity: 10,900 Btu/h.
  2. Entering-Air Temperature: 47 deg F.
- D. Single-Point Electrical Connection (Indoor Unit):
  1. Volts: 208.
  2. Phase: Single.
  3. Hertz: 60.
  4. Full-Load Amperes: 0.76.
  5. Minimum Circuit Ampere: 1 amp.
  6. Maximum Overcurrent Protection: 15 amp breaker.
- E. Single-Point Electrical Connection (Outdoor Unit):
  1. Volts: 208.
  2. Phase: Single.
  3. Hertz: 60.
  4. Full-Load Amperes: 0.56.
  5. Minimum Circuit Ampere: 12 amps.

## EXECUTION

### 2.3 INSTALLATION

- A. Isolation: Mount cabinet and remote air-cooled condenser on restrained spring isolators for minimum 1-inch static deflection.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Install refrigerant piping between self-contained air-conditioning unit and remote condenser.
- D. Install condensate piping to indirect drain.

END OF SECTION 238119

## SECTION 238316 - RADIANT-HEATING HYDRONIC PIPING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.

## PART 2 - PRODUCTS

## 2.1 PIPES AND FITTINGS

- A. Oxygen Barrier: Limit oxygen diffusion through tubes to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.
- B. PEX Plastic: ASTM F 876. For service at 100 psig and 180 deg F.
  - 1. Fittings: ASTM F 1807, metal insert and copper crimp rings.
- C. EPDM: Crosslinked EPDM inner and outer tubes with braided-aluminum wire reinforcing and aluminum foil oxygen barrier. For service at 100 psig and 210 deg F.
  - 1. Fittings: ASTM F 1807, copper with stainless-steel crimps or clamps.

## 2.2 PIPING SPECIALTIES

- A. Floor Mounting: 1-1/8" thick 4' x 8' tongue and groove plywood with modular pattern.
- B. Heat-Emission Plates: Pressed aluminum suitable for radiant heating piping, used on topside of wood floor, allowing even heat transfer and enhanced heat exchange.

## 2.3 RADIANT HEATING SPECIALTIES

- A. Distribution Manifolds: modular plastic with three-way mixing valve, main shutoff and balancing valves with thermometers, zone shutoff and balancing valves with flow meter, and identification plate.
  - 1. Mixing Valves: Minimum 125 psig , 230 deg F operating pressure and temperature, brass or cast-bronze body, EPDM seals, and threaded connections.

## 2.4 CONTROLS

- A. Thermostats: 50 to 90 deg F. , standard 24 V, 3 wire for day and night setback and clock program.

- B. Radiant Heating Control Sequence: Flow-through radiant heating piping is modulated to satisfy space thermostat.

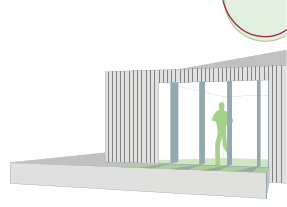
## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install piping downstream from manifolds without joints.
- B. Secure piping at 12 inches o.c. in prefabricated channels and at center of turns or bends.
- C. Install manifolds in accessible locations.

END OF SECTION 238316

## Division\_25 Integrated Automation





## SECTION 25 11 00 - HOME AUTOMATION AND CONTROL SYSTEM (HACS)

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. This section describes the Systems Integration scope of work for the project. This section also coordinates the responsibilities of the Mechanical and Electrical trade contractors pertaining to control products or systems, furnished by each trade, that will be integrated by this Division
- B. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.
- C. It is the owner's goal to implement an open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

#### 1.2 SYSTEM DESCRIPTION

- A. The Home Automation and Control System (HACS) shall be comprised of Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the owner's local or wide area network, depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each NAC shall communicate to LonMark/LonTalk (IDC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices provided under Division 23 or Division 26.
- B. The Home Automation and Control System (HACS) as provided in this Division shall be based on the Niagara Framework (or "Niagara"), a Java-based framework developed by Tridium. Niagara provides an open automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser. Systems not developed on the Niagara Framework platform are unacceptable.

#### 1.3 SPECIFICATION NOMENCLATURE

- A. Acronyms used in this specification are as follows:

HACS	Home Automation and Control System
TCS	Temperature Control System
NAC	Network Area Controller
IDC	Interoperable Digital Controller
IBC	Interoperable BACnet Controller
GUI	Graphical User Interface
WBI	Web Browser Interface
POT	Portable Operator's Terminal
PMI	Power Measurement Interface
DDC	Direct Digital Controls
LAN	Local Area Network
WAN	Wide Area Network

#### 1.4 DIVISION OF WORK

- A. The Division 23 and 26 (if applicable) contractors shall be responsible for all controllers (IDC and IBC), control devices, control panels, controller programming, controller programming software, controller input/output and power wiring and controller network wiring.
- B. The Division 23 contractor shall be responsible for the Network Area Controller(s) (NAC), software and programming of the NAC, graphical user interface software (GUI), development of all graphical screens, Web browser pages, setup of schedules, logs and alarms, LonWorks network management and connection of the NAC to the local or wide area network.

#### 1.5 RELATED WORK SPECIFIED ELSEWHERE

A. Division 23, Mechanical:

- 1. Providing control devices and systems including but not limited to:
  - a. Interoperable Digital Controllers and programming
  - b. Interoperable BACnet Controllers and programming
  - c. Control panels, devices and wiring
  - d. Local controller and control device networks

B. Division 26, Electrical:

- 1. Providing motor starters and disconnect switches (unless otherwise noted).
- 2. Power wiring and conduit (unless otherwise noted).
- 3. Provision, installation and wiring of smoke detectors (unless otherwise noted).
- 4. Other equipment and wiring as specified in Division 26.

#### 1.6 AGENCY AND CODE APPROVALS

- A. All products of the HACs shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided with the submittal package. Systems or products not currently offering the following approvals are not acceptable.
  - 1. UL-916; Energy Management Systems
  - 2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 "signal Equipment"
  - 3. CE
  - 4. FCC, Part 15, Subpart J, Class A Computing Devices

#### 1.7 SOFTWARE LICENSE AGREEMENT

- A. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

- B. It is the owners express goal to implement an open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, HACS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner. The owner shall determine which organizations to be named in the SI organization ID (“orgid”) of all software licenses. Owner shall be free to direct the modification of the “orgid” in any software license, regardless of supplier, by Tridium Inc.

## 1.8 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

## 1.9 JOB CONDITIONS

- A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

# PART 2 MATERIALS

## 2.1 GENERAL

- A. The Home Automation Control System (HACS) shall be comprised of a network of interoperable, stand-alone digital controllers, a computer system, graphical user interface software, printers, network devices and other devices as specified herein.
- B. The installed system shall provide secure password access to all features, functions and data contained in the overall HACS.

## 2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

- A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, LonWorks technology, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135-2001, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification,

the device supplier must provide an XIF file and a resource file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance shall support the ability to support data read and write functionality and those features as specified. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP,) and/or RS-485 (BACnet MSTP) as specified.

- C. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
- D. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
  - 1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
  - 2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

## 2.3 DEVICES AND SOFTWARE

- A. Controller (Also see 2.6 Network Area Controller)
  - 1. Vykon Java Application Control Engine – 200 (JACE-200):  
[http://www.vykon.com/galleries/datasheet\\_pdf/JACE-2-2008-12.pdf](http://www.vykon.com/galleries/datasheet_pdf/JACE-2-2008-12.pdf)
- B. Input/Output Device
  - 1. Vykon IO-16:  
[http://www.blxcentral.com/data/library/IO-16\\_InstallGuide.pdf](http://www.blxcentral.com/data/library/IO-16_InstallGuide.pdf)
  - 2. Vykon IO-34:  
[http://www.blxcentral.com/data/library/IO-34\\_InstallGuide.pdf](http://www.blxcentral.com/data/library/IO-34_InstallGuide.pdf)
- C. Software
  - 1. AX SoftJACE:  
[http://www.tridium.com/galleries/datasheet\\_pdf/SoftJACE\\_1108.pdf](http://www.tridium.com/galleries/datasheet_pdf/SoftJACE_1108.pdf)
- D. Current Sensor
  - 1. F. W. Bell PC-50 AC Current Sensor  
[http://media.fwbell.com/PC\\_PCS.pdf](http://media.fwbell.com/PC_PCS.pdf)

## 2.4 NETWORKS

- A. The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP for maximum flexibility for integration of building data with enterprise

information systems and providing support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE standard 802.3
2. Cable; 100 Base-T, UTP-8 wire, category 5
3. Minimum throughput; 100 Mbps.

## 2.5 NETWORK ACCESS

A. Remote Access.

1. For Local Area Network installations, provide access to the LAN from a remote location, via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's Intranet to a server providing access to an Internet Service Provider (ISP).

## 2.6 NETWORK AREA CONTROLLER (NAC)

- A. The Division 25 contractor shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices provided under Divisions 23 and 26. It is the responsibility of the Division 25 contractor to coordinate with the Division 23 and 26 contractors to determine the quantity and type of devices.
- B. The Network Area Controller (NAC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:
1. Calendar functions
  2. Scheduling
  3. Trending
  4. Alarm monitoring and routing
  5. Time synchronization
  6. Integration of LonWorks controller data, BACnet controller data, and any device connected through an optional software driver installed in the NAC
  7. Network Management functions for all LonWorks based devices
- C. The Network Area Controller (Jace 2 version) must provide the following hardware features as a minimum:
1. One Ethernet Port – 10/100 Mbps
  2. One RS-232 port
  3. One LonWorks Interface Port – 78KB FTT-10A
  4. One RS-485 port (electrically isolated)
  5. Optional auto-dial/answer 56K modem
  6. Battery Backup

7. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
  8. The NAC must be capable of operation over a temperature range of 32 to 122°F
  9. The NAC must be capable of withstanding storage temperatures of between 0 and 158°F
  10. The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing
- D. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.
- E. Event Alarm Notification and actions
1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
  2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
  3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
    - a. To alarm
    - b. Return to normal
    - c. To fault
  4. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
  5. Provide timed (schedule) routing of alarms by class, object, group, or node.
  6. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- F. Control equipment and network failures shall be treated as alarms and annunciated.
- G. Alarms shall be annunciated in any of the following manners as defined by the user:
1. Screen message text
  2. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
    - a. Day of week
    - b. Time of day
    - c. Recipient
  3. Pagers via paging services that initiate a page on receipt of email message
  4. Graphic with flashing alarm object(s)
  5. Printed message, routed directly to a dedicated alarm printer
- H. The following shall be recorded by the NAC for each alarm (at a minimum):
1. Time and date

2. Location (building, floor, zone, office number, etc.)
  3. Equipment (air handler #, accessway, etc.)
  4. Acknowledge time, date, and user who issued acknowledgement.
  5. Number of occurrences since last acknowledgement.
- I. Alarm actions may be initiated by user defined programmable objects created for that purpose.
  - J. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
  - K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.
  - L. Provide a “query” feature to allow review of specific alarms by user defined parameters.
  - M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
  - N. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

## 2.7 Data Collection and Storage

- A. The NAC shall have the ability to collect data for any property of any object and store this data for future use.
- B. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
  1. Designating the log as interval or deviation.
  2. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
  3. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
  4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
  5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
- C. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web browser.
- D. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
- E. All log data shall be available to the user in the following data formats:
  1. HTML
  2. XML
  3. Plain Text
  4. Comma or tab separated values
- F. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.

- G. The NAC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:

1. Archive on time of day
2. Archive on user-defined number of data stores in the log (buffer size)
3. Archive when log has reached it's user-defined capacity of data stores
4. Provide ability to clear logs once archived

## 2.8 AUDIT LOG

- A. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1. Time and date
2. User ID
3. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

## 2.9 DATABASE BACKUP AND STORAGE

- A. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
- B. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.
- C. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

## 2.10 GRAPHICAL USER INTERFACE SOFTWARE

- A. Operating System:

1. The GUI shall run on Microsoft Windows XP Professional.

- B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

- C. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.



3. Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
  4. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
    - a. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
    - b. Holidays shall be set by using a graphical calendar without requiring any keyboard entry from the operator.
  5. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
  6. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.
- D. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
- a. Create, delete or modify control strategies.
  - b. Add/delete objects to the system.
  - c. Tune control loops through the adjustment of control loop parameters.
  - d. Enable or disable control strategies.
  - e. Generate hard copy records or control strategies on a printer.
  - f. Select points to be alarmable and define the alarm state.
  - g. Select points to be trended over a period of time and initiate the recording of values automatically.
- E. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- F. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.
- G. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
- H. Alarm Console
1. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.

2. When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

## 2.11 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Netscape Navigator™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the HACS, shall not be acceptable.
- C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- D. The Web browser client shall support at a minimum, the following functions:
  1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
  2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
  3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
  4. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
  5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
  6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    - a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
      1. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
      2. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    - b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
    - c. View logs and charts

- d. View and acknowledge alarms
  - e. Setup and execute SQL queries on log and archive information
7. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
  8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

## 2.12 SYSTEM PROGRAMMING

- A. The Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the GUI shall be through password access as assigned by the system administrator.
- B. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.
- C. Programming Methods
  1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
  2. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
  3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
  4. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.

5. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

## 2.13 LonWorks NETWORK MANAGEMENT

- A. The Graphical User Interface software (GUI) shall provide a complete set of integrated LonWorks network management tools for working with LonWorks networks. These tools shall manage a database for all LonWorks devices by type and revision, and shall provide a software mechanism for identifying each device on the network. These tools shall also be capable of defining network data connections between LonWorks devices, known as "binding". Systems requiring the use of third party LonWorks network management tools shall not be accepted.
- B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
- C. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.
- D. These tools shall provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.
- E. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times, within the control system, shall not be accepted.

## 2.14 OBJECT LIBRARIES

- A. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
- B. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
- C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.
- D. All control objects shall conform to the control objects specified in the BACnet specification.
- E. The library shall include applications or objects for the following functions, at a minimum:
  1. Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on-off events.
  2. Calendar Object. . The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.

3. Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals
  4. Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.
  5. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.
  6. Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.
- F. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.
1. Analog Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
  2. Analog Output Object - Minimum requirement is to comply with the BACnet standard for data sharing.
  3. Binary Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.
  4. Binary Output Object - Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.

5. PID Control Loop Object - Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.
  6. Comparison Object - Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
  7. Math Object - Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
  8. Custom Programming Objects - Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.
  9. Interlock Object - Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.
  10. Temperature Override Object - Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.
  11. Composite Object - Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphical shell of this container.
- G. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). At a minimum, provide the following as part of the standard library included with the programming software:
1. LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.

2. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file and documentation for the device to facilitate device integration.
3. For BACnet devices, provide the following objects at a minimum:
  - a. Analog In
  - b. Analog Out
  - c. Analog Value
  - d. Binary
  - e. Binary In
  - f. Binary Out
  - g. Binary Value
  - h. Multi-State In
  - i. Multi-State Out
  - j. Multi-State Value
  - k. Schedule Export
  - l. Calendar Export
  - m. Trend Export
  - n. Device
4. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.
5. For BACnet devices, provide the following support at a minimum
  - a. Segmentation
  - b. Segmented Request
  - c. Segmented Response
  - d. Application Services
  - e. Read Property
  - f. Read Property Multiple
  - g. Write Property
  - h. Write Property Multiple
  - i. Confirmed Event Notification
  - j. Unconfirmed Event Notification
  - k. Acknowledge Alarm
  - l. Get Alarm Summary
  - m. Who-has

- n. I-have
- o. Who-is
- p. I-am
- q. Subscribe COV
- r. Confirmed COV notification
- s. Unconfirmed COV notification
- t. Media Types
- u. Ethernet
- v. BACnet IP Annex J
- w. MSTP
- x. BACnet Broadcast Management Device (BBMD) function
- y. Routing

## 2.15 MODBUS SYSTEM INTEGRATION

- A. The Network Area Controller shall support the integration of device data from Modbus RTU, Ascii, or TCP control system devices. The connection to the Modbus system shall be via an RS-232, RS485, or Ethernet IP as required by the device.
- B. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the Modbus system data into the FPMS. Objects provided shall include at a minimum:
  - 1. Read/Write Modbus AI Registers
  - 2. Read/Write Modbus AO Registers
  - 3. Read/Write Modbus BI Registers
  - 4. Read/Write Modbus BO Registers
- C. All scheduling, alarming, logging and global supervisory control functions, of the Modbus system devices, shall be performed by the Network Area Controller.
- D. The HACS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment utilizing Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning

## 2.16 OPC SYSTEM INTEGRATION

- A. The Network Area Controller shall act as an OPC client and shall support the integration of device data from OPC servers. The connection to the OPC server shall be Ethernet IP as required by the device. The OPC client shall support third party OPC servers compatible with the Data Access 1.0 and 2.0 specification.
- B. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the OPC system data into the BAS. Objects provided shall include at a minimum:
  - 1. Read/Write OPC AI Object



2. Read/Write OPC AO Object
3. Read/Write OPC BI Object
4. Read/Write OPC BO Object
5. Read/Write OPC Date/Time Input Object
6. Read/Write OPC Date/Time Output Object
7. Read/Write OPC String Input Object
8. Read/Write OPC String Output Object

- C. All scheduling, alarming, logging and global supervisory control functions, of the OPC system devices, shall be performed by the Network Area Controller.
- D. The HACS supplier shall provide a OPC client communications driver. The equipment system vendor that provided the equipment utilizing OPC shall provide documentation of the system's OPC server interface and shall provide factory support at no charge during system commissioning.

#### 2.17 GRAPHICAL USER INTERFACE COMPUTER HARDWARE (DESKTOP)

- A. The browser workstation shall be an Intel Pentium based computer (minimum processing speed of 2.4 Ghz with 1.0 GB RAM and a 100-gigabyte minimum hard drive). It shall include a DVD-ROM/CD-RW Combination Drive, 2-parallel ports, 2-asynchronous serial ports and 2-USB ports. A minimum 17"flat panel color monitor, 1280 x 1024 optimal preset resolution, 25 ms response time, shall also be included.
- B. Connection to the HACS network shall be via an Ethernet network interface card, 10 Mbps.
- C. A system printer shall be provided. Printer shall be laser type with a minimum 600 x 600-dpi resolution and rated for 12 PPM print speed minimum.

#### 2.18 GRAPHICAL USER INTERFACE COMPUTER HARDWARE (LAPTOP COMPUTER)

- A. The laptop computer shall consist of an Intel Pentium based laptop computer (minimum processing speed of 2 Ghz with 1 GB RAM and a 80-gigabyte minimum hard drive). It shall include a DVD-ROM/CD-RW Combination Drive. Connection to the HACS network shall be via an Ethernet network interface card, 10/100 Mbps.
- B. A system printer shall be provided. Printer shall be laser type with a minimum 600 x 600-dpi resolution and rated for 12 PPM print speed minimum.

### PART 3 EXECUTION

#### 3.1 INSTALLATION

- A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
- B. Drawings of HACS network are diagrammatic only and any apparatus not shown, but required to make the system operative to the complete satisfaction of the architect shall be furnished and installed without additional cost.

### 3.2 WIRING

- A. All electrical control wiring and power wiring to the NAC, computers and network components shall be the responsibility of the HACS contractor.
- B. The electrical contractor (Div. 16) shall furnish all power wiring to NAC, computer and any networking equipment (routers, hubs, switches, etc.).
- C. All wiring shall be in accordance with the Project Electrical Specifications (Division 26), the National Electrical Code and any applicable local codes. All HACS wiring shall be installed in the conduit types specified in the Project Electrical Specifications (Division 26) unless otherwise allowed by the National Electrical Code or applicable local codes. Where HACS plenum rated cable wiring is allowed it shall be run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner.

### 3.3 WARRANTY

- A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.
- B. Within this period, upon notice by the Owner, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by the Division 25 contractor at no expense to the Owner

### 3.4 WARRANTY ACCESS

- A. The Owner shall grant to the Division 25 contractor, reasonable access to the HACS during the warranty period. The owner shall allow the contractor to access the HACS from a remote location for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period.

### 3.5 SOFTWARE LICENSE

- A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). The owner, or his appointed agent, shall determine which organizations to be named in the “orgid” of all Niagara Framework software licenses.
- B. The owner, or his appointed agent, shall be free to direct the modification of the “orgid” in any Niagara Framework software license, regardless of supplier.
- C. The owner, or his appointed agent, shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and /or configured for use within Niagara Framework (Niagara) based controllers and/or servers and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required Ids and passwords for access to any component or software program shall be provided to the owner.

### 3.6 ACCEPTANCE TESTING

- A. Upon completion of the installation, the Division 25 contractor shall load all system software and start-up the system. The Division 23 contractor shall perform all necessary calibration, testing and debugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications. The Division 23 and 25 contractors are to coordinate the checkout of the system such that each Division has a representative present during system checkout.
- B. The Division 23 contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation. The Division 25 contractor shall have a representative present during system checkout by the Division 23 contractor.

- C. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.
- D. System Acceptance: Satisfactory completion is when the Division 23, 25 and 26 contractors have performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

## PART 4 SEQUENCES OF OPERATION

### 4.1 SUMMARY

- A. The Division 25 contractor shall refer to this Item under Division 23 to determine what level of control the Network Area Controller, must provide, which is the responsibility of this Division. It is the responsibility of the Division 25 contractor to coordinate control functions, such as scheduling and supervisory-level global control with the Division 23 contractor.

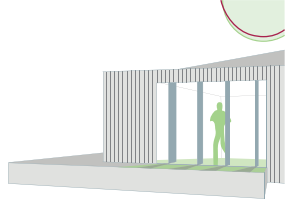
## PART 5 POINT LISTS

### 5.1 SUMMARY

- A. The Division 25 contractor shall refer to this item under Division 23 to determine what data in the local controllers must be integrated into the Network Area Controller, which is the responsibility of this Division. It is the responsibility of the Division 25 contractor to coordinate control functions, such as scheduling and supervisory-level global control with the Division 23 contractor.

END OF SECTION

## Division\_26 Electrical



## SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
  - 1. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
  - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
  - 3. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor five times the applied force.
- B. Seismic-Restraint Loading:
  - 1. Site Class as Defined in the IBC: D.
  - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.
    - a. Component Importance Factor: 1.0.
    - b. Component Response Modification Factor: 1.5.
    - c. Component Amplification Factor: 1.0.
  - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 12%.
  - 4. Design Spectral Response Acceleration at 1.0 Second Period: 6%.
- C. Submittals:
  - 1. Product Data: For sleeve seals.
  - 2. Shop Drawings: For hangers and supports, signed and sealed by a qualified professional engineer. Show fabrication and installation details.
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.1 RACEWAYS

#### A. Raceways:

1. EMT: ANSI C80.3, zinc-coated steel, with setscrew or compression fittings.
2. ENT: NEMA TC 13, complying with UL 1653.
3. FMC: Zinc-coated steel.
4. IMC: ANSI C80.6, zinc-coated steel, with threaded fittings.
5. LFMC: Zinc-coated, flexible steel with sunlight-resistant and mineral-oil-resistant plastic jacket.
6. RNC: NEMA TC 2, with NEMA TC3 fittings.
7. Raceway Fittings: Specifically designed for raceway type used in Project.

#### B. Wireways: Sheet metal sized and shaped, with **[hinged]** **[screw]** covers.

#### C. Surface Raceways:

1. Metal: Galvanized steel with snap-on covers. [Manufacturer's standard enamel finish in color selected by Architect.
2. Plastic: PVC, extruded and fabricated to size and shape indicated in color selected, with snap-on cover and mechanically coupled connections with plastic fasteners.

#### D. Floor Boxes: sheet metal, rectangular.

### 2.2 CONDUCTORS AND CABLES

#### A. Conductors:

1. Conductors, No. 10 AWG and Smaller: Stranded copper.
2. Conductors, Larger Than No. 10 AWG: Stranded copper.
3. Insulation: Thermoplastic, rated at 75 deg C minimum.
4. Wire Connectors and Splices: Units of size, ampacity rating, material, type, and class suitable for service indicated.

#### B. Cable Type NM-B Cable: Comply with UL 719 with Type THHN/THWN conductors complying with UL 83.

#### C. Cable Type SEU: Comply with UL 854 with Type THHN/THWN conductors complying with UL 83 or Type XHHW-2 conductors complying with UL 44.

#### D. Cable Type UF-B: Comply with UL 493 with Type THHN/THWN conductors complying with UL 83.

### 2.3 GROUNDING MATERIALS

#### A. Conductors: Solid for No. 8 AWG and smaller, and stranded for No. 6 AWG and larger unless otherwise indicated.

1. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
  2. Bare, Solid-Copper Conductors: Comply with ASTM B 3.
  3. Bare, Stranded-Copper Conductors: Comply with ASTM B 8.
- B. Ground Rods: Copper-clad steel, sectional type; 5/8 by 96 inches in diameter.
- C. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts with clamp-type pipe connectors sized for pipe.
- D. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

## 2.4 ELECTRICAL IDENTIFICATION MATERIALS

- A. Raceway Identification Materials: Self-adhesive, color-coding vinyl tape; flexible, preprinted, self-adhesive vinyl.
- B. Conductor Identification Materials: Color-Coding Conductor Tape: Self-adhesive vinyl tape 1 to 2 inches wide.
- C. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, polyethylene tape with continuous metallic strip or core.
- D. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with circuit identification legend machine printed by thermal transfer or equivalent process.
- E. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- F. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
- G. Equipment Identification Labels: Engraved, laminated acrylic or melamine label; punched or drilled for screw mounting. White letters on a dark-gray background; red letters for emergency systems.
- H. Fasteners: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## 2.5 SUPPORT AND ANCHORAGE COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly, and provide finish suitable for the environment in which installed.
1. Channel Dimensions: Selected for structural loading.
- B. Raceway and Cable Supports: As described in NECA 1.

- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and fittings.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded malleable-iron body and insulating wedging.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components:
  - 1. Powder-Actuated Fasteners: Threaded-steel stud.
  - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete.
  - 3. Concrete Inserts: Steel or malleable-iron, slotted-support-system units similar to MSS Type 18; complying with MFMA-3 or MSS SP-58.
  - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
  - 5. Through Bolts: Structural type, hex head, high strength; complying with ASTM A 325.
  - 6. Toggle Bolts: All-steel springhead type.
  - 7. Hanger Rods: Threaded steel.

## 2.6 SEISMIC-RESTRAINT COMPONENTS

- A. Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
  - 1. Structural Safety Factor: Strength in tension, shear, and pullout force of components used shall be at least four times the maximum seismic forces to which they will be subjected.
- B. Angle and Channel-Type Brace Assemblies: Steel angles or steel slotted-support-system components; with accessories for attachment to braced component at one end and to building structure at the other end.
- C. Cable Restraints: ASTM A 603, zinc-coated, steel wire rope attached to steel or stainless-steel thimbles, brackets, swivels, and bolts designed for restraining cable service.
  - 1. Seismic Mountings, Anchors, and Attachments: Devices as specified in "Support and Anchorage Components" Article, selected to resist seismic forces.
  - 2. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.
  - 3. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to type and size of anchor bolts and studs used.
  - 4. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to type and size of attachment devices used.



## 2.7 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized-steel sheet.
- D. Sleeve Seals: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Pressure Plates: Carbon steel. Include two for each sealing element.
  - 2. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

## 2.8 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

# PART 3 - EXECUTION

## 3.1 GENERAL ELECTRICAL EQUIPMENT INSTALLATION REQUIREMENTS

- A. Install electrical equipment to allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
- B. Install electrical equipment to provide for ease of disconnecting the equipment with minimum interference to other installations.
- C. Install electrical equipment to allow right of way for piping and conduit installed at required slope.
- D. Install electrical equipment to ensure that connecting raceways, cables, wireways, cable trays, and busways are clear of obstructions and of the working and access space of other equipment.
- E. Install required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Comply with requirements in Division 08 Section "Access Doors and Frames."
- G. Install sleeve and sleeve seals of type and number required for sealing electrical service penetrations of exterior walls.

- H. Comply with NECA 1.

### 3.2 RACEWAY AND CABLE INSTALLATION

#### A. Outdoor Raceways Applications:

1. Exposed or Concealed: IMC.
2. Underground, Single Run: RNC.
3. Connection to Vibrating Equipment: LFMC.
4. Boxes and Enclosures: Metallic, NEMA 250, Type 3R or Type 4.

#### B. Indoor Raceways Applications:

1. Exposed or Concealed: EMT.
2. Connection to Vibrating Equipment: FMC; in wet or damp locations, use LFMC.
3. Damp or Wet Locations: IMC.
4. Boxes and Enclosures: Metallic, NEMA 250, Type 1, unless otherwise indicated.

- C. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.

- D. Install raceways and cables at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Locate horizontal raceway runs above water and steam piping.

- E. Install raceways embedded in slabs in middle third of slab thickness where practical, and leave at least 1-inch- thick concrete cover.

1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Install conduit larger than 1-inch trade size, parallel to or at right angles to main reinforcement. Where conduit is at right angles to reinforcement, place conduit close to slab support.
4. Transition from nonmetallic tubing to Schedule 80 nonmetallic conduit, rigid steel conduit, or IMC before rising above floor.

#### F. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

- G. Install pull wires in empty raceways.

- H. Connect motors and equipment subject to vibration, noise transmission, or movement with a 72-inch maximum length of flexible conduit.

- I. Install raceways and cables conceal within finished walls, ceilings, and floors unless otherwise indicated.
- J. Install raceways and cables at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Locate horizontal raceway runs above water and steam piping.

### 3.3 WIRING METHODS

- A. Service Entrance: Type SE or USE multiconductor cable.
- B. Exposed Feeders, Branch Circuits, and Class 1 Control Circuits, Including in Crawlspace: Nonmetallic-sheathed cable, Type NM or NMC.
- C. Feeders and Branch Circuits Concealed in Ceilings, Walls, Partitions, and Crawlspace: Nonmetallic-sheathed cable, Type NM or NMC.
- D. Feeders and Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.
- E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, and strain relief device at terminations to suit application.
- F. Class 2 Control Circuits: Power-limited cable, concealed in building finishes.

### 3.4 GROUNDING

- A. Underground Grounding Conductors: Install bare copper conductor, #4 AWG minimum. Bury at least 24 inches below grade.
- B. Pipe and Equipment Grounding Conductor Terminations: Bolted.
- C. Underground Connections: Welded.
- D. Connections to Structural Steel: Bolted.
- E. Install grounding conductors routed along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- F. Install ground rods driven into ground until tops are 2 inches below finished floor or final grade unless otherwise indicated.
- G. Make connections without exposing steel or damaging coating if any.
- H. Install bonding straps and jumpers in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
- I. Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

- J. Bond to equipment mounted on vibration isolation hangers and supports so vibration is not transmitted to rigidly mounted equipment.
- K. Grounding and Bonding for Piping:
  - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
  - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
  - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- L. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
  - 1. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
  - 2. Perform tests by fall-of-potential method according to IEEE 81.
  - 3. Report measured ground resistances that exceed the following values:
    - a. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
    - b. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
    - c. Power Distribution Units or Panelboards Serving Electronic Equipment: 5 ohms.
    - d. 5 ohms.
  - 4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

### 3.5 IDENTIFICATION

- A. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive color coding tape-in bands:
  - 1. Fire-Alarm System: Red.
  - 2. Security System: Blue and yellow.
  - 3. Telecommunication System: Green and yellow.
- B. Power-Circuit Conductor Identification: For No. 3 AWG conductors and larger, at each location where observable, identify phase using color-coding conductor tape.

- C. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring.
- D. Warning Labels for Enclosures for Power and Lighting: Comply with 29 CFR 1910.145; identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
- E. Equipment Identification Labels:
  - 1. Labeling Instructions:
    - a. Indoor Equipment: Adhesive film label with clear protective overlay. Provide a single line of text with 1/2-inch- high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
    - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label, drilled for screw attachment.
    - c. Elevated Components: Increase sizes of labels and legend to those appropriate for viewing from the floor.
  - 2. Equipment to Be Labeled:
    - a. Panelboards, electrical cabinets, and enclosures.
    - b. Electrical switchgear and switchboards.
    - c. Transformers.
    - d. Motor-control centers.
    - e. Disconnect switches.
    - f. Enclosed circuit breakers.
    - g. Motor starters.
    - h. Push-button stations.
    - i. Power transfer equipment.
    - j. Contactors.
    - k. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.
- F. Verify identity of each item before installing identification products.
- G. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- H. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- I. Install system identification color banding for raceways and cables at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- J. Color-Coding for Phase Identification, 600 V and Less: Ungrounded service, feeder, and branch-circuit conductors.
  - 1. Colors for 208/120-V Circuits:
    - a. Phase A: Black.

- b. Phase B: Red.
  - c. Phase C: Blue.
2. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points.
- K. Underground-Line Warning Tape: Continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade.

### 3.6 INSTALLATION OF HANGERS AND SUPPORTS

- A. Fasten hangers and supports securely in place, with provisions for thermal and structural movement. Install with concealed fasteners unless otherwise indicated.
- B. Separate dissimilar metals and metal products from contact with wood or cementitious materials, by painting each metal surface in area of contact with a bituminous coating or by other permanent separation.
- C. Raceway Support Methods: In addition to methods described in NECA 1, FMC, and LFMC may be supported by openings through structure members, as permitted in NFPA 70.
- a. Steel flex conduit, FMC
  - b. Liquid tight flexible metal conduit, LFMC.
- D. Multiple Raceways or Cables: Install on trapeze-type supports fabricated with steel slotted channel.
- E. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- F. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods, unless otherwise indicated or required by Code:
- 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Expansion anchor fasteners.
  - 5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
  - 6. To Light Steel: Sheet metal screws.
  - 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount on slotted-channel racks attached to substrate.
- G. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

### 3.7 SEISMIC REQUIREMENTS

- A. Install seismic-restraint components using methods approved by the evaluation service providing required submittals for component.
- B. Install bushing assemblies for anchor bolts for wall- and floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in substrate.
- C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, upper truss chords of bar joists, or at concrete members.
- D. Accommodation of Differential Seismic Motion: Make flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross expansion and seismic-control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to electrical equipment that is anchored to a different structural element than the one supporting them as they approach equipment.

### 3.8 SLEEVE AND SLEEVE-SEALS INSTALLATION

- A. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- B. Cut sleeves to length for mounting flush with both wall surfaces.
- C. Extend sleeves installed in floors 2 inches above finished floor level.
- D. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed.
- E. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- F. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."
- G. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- H. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- I. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.9 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Comply with requirements in Division 07 Section "Penetration Firestopping."

END OF SECTION 260500



## SECTION 260923 - LIGHTING CONTROL DEVICES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. All system components are to be UL listed.
- C. Installation shall be in compliance with the National Electric Code, the 2009 Solar Decathlon Building Code, and all other applicable state and local codes.

## PART 2 - PRODUCTS

## 2.1 DEVICES

- A. Controller
  - 1. The controller shall be used for control of each ballast and relay.
  - 2. The controller shall accept both analog and digital inputs from sensors.
  - 3. Products
    - a. Vykon Java Application Control Engine – 200 (JACE-200):  
[http://www.vykon.com/galleries/datasheet\\_pdf/JACE-2-2008-12.pdf](http://www.vykon.com/galleries/datasheet_pdf/JACE-2-2008-12.pdf)
- B. Analog Dimming Ballast:
  - 1. Analog dimming ballast shall be UL listed, CSA certified, and Class P.
  - 2. Analog dimming ballast shall be for Fluorescent T-5 linear lamps, and shall be of programmed rapid start technology.
  - 3. Analog dimming ballast shall provide continuous flicker-free dimming from 100% to 1% for all lamps.
  - 4. Analog dimming ballast shall operate at 120VAC to 277VAC, 60Hz with sustained variations of +/- 10%.
  - 5. Analog dimming ballast shall be capable of connecting with the JACE.
  - 6. Analog dimming ballast shall have a total harmonic distortion (THD) of less than 10%.
  - 7. Analog dimming ballast shall power factor (PF) shall be 98% or greater.
  - 8. Analog dimming ballast shall not contain polychlorinated biphenyls (PCB's).
  - 9. All analog dimming ballasts shall have colored terminals or wire leads that correlate with the appropriate wires on sensors or controls they will be connected to.
  - 10. The analog dimming ballast shall not be damaged by miswiring line voltage and 0 – 10V controls lines.
  - 11. Products
    - a. Universal Lighting Technologies SuperDim Analog 0 – 10V Dimming Ballast:  
<http://www.universalballast.com/literature/brochures/SuperDimProd.pdf>
- C. Relay

1. Relay will take a digital on/off signal from the JACE and allows or eliminates power from the lighting ballast accordingly
2. Products
  - a. Wattstopper Intelligent Power Pack LC-100:  
<http://www.wattstopper.com/getdoc/334/14703%20LC-100.pdf>

D. Photosensor

1. Photosensor shall be compatible with the JACE.
2. Photosensor shall be designed for ceiling or tabletop mounting. Photosensor shall be rated for indoor use.
3. Products
  - a. WattStopper LS-301:  
<http://www.wattstopper.com/getdoc/269/17505.pdf>
  - b. LI-COR Photometric Sensor LI-210SA:  
<http://www.licor.com/env/PDF/210.pdf>

E. Contact Sensor

1. Contact sensor shall be directly connected to fixtures.
2. Products
  - a. Functional Devices CLC106 Closet Light Contoller:  
<http://www.functionaldevices.com/pdf/CLC106.pdf>

## 2.2 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG, complying with Division 26 Section "Common Work Results for Electrical."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded copper conductors not smaller than No. 22 AWG, complying with Division 26 Section "Common Work Results for Electrical."
- C. Class 1 Control Cable: Multiconductor cable with stranded copper conductors not smaller than No. 18 AWG, complying with Division 26 Section "Common Work Results for Electrical."
- D. UPT Cable: 100 ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
  1. Comply with ICEA S-90-661 for mechanical properties.
  2. Comply with TIA/EIA-568-B.1 for performance specifications.
  3. Comply with TIA/EIA-568-B.2, Category 5e and Category 6.
    - a. Multipurpose: MP or MPG.
    - b. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
    - c. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install and aim sensors in locations to achieve at least 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.
- B. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- C. Label time switches and contactors with a unique designation.
- D. Verify actuation of each sensor and adjust time delays.

END OF SECTION 260923

## SECTION 262416 - PANELBOARDS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA PB 1.
- D. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE.

## PART 2 - PRODUCTS

## 2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Common Work Results for Electrical."
- B. Enclosures: Flush and surface-mounted cabinets; NEMA 250, Type 1.
  - 1. Front: Secured to box with concealed trim clamps.
  - 2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
- C. Incoming Mains Location: Top and bottom.
- D. Phase, Neutral, and Ground Buses: Tin-plated aluminum.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
  - 1. Material: Tin-plated aluminum.
  - 2. Main and Neutral Lugs: Mechanical type.
  - 3. Ground Lugs and Bus Configured Terminators: Mechanical type.
  - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

- H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, and listed and labeled for series-connected short-circuit rating by an NRTL.
- I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

## 2.2 DISTRIBUTION PANELBOARDS

- A. Doors: Omit in fused-switch panelboards.
- B. Mains: Circuit breaker.
- C. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers.
- D. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- E. Branch Overcurrent Protective Devices: Fused switches.

## 2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Mains: Circuit breaker.
- B. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- C. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

## 2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
  - 1. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
  - 2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Receive, inspect, handle, store and install panelboards and accessories according to NEMA PB 1.1.
- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Common Work Results for Electrical."
- C. Mount top of trim 80 inches above finished floor unless otherwise indicated.
- D. Stub four empty 3/4-inch conduits from panelboard into accessible or designated ceiling space; stub four empty conduits into space below floor.
- E. Arrange conductors into groups; bundle and wrap with wire ties.
- F. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory.

END OF SECTION 262416

## SECTION 262713 - ELECTRICITY METERING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data and Shop Drawings.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Coordinate with utility companies for services and components they furnish.

## PART 2 - PRODUCTS

## 2.1 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

- A. Meters will be furnished by utility company.
- B. Current-Transformer Cabinets: Comply with requirements of electrical power utility company.
- C. Meter Sockets: Comply with requirements of electrical power utility company.
- D. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.
- E. Modular Meter Center: Factory-coordinated assembly of a main service terminal box with disconnect device, wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below:
  - 1. Comply with requirements of utility company for meter center.
  - 2. Housing: NEMA 250, Type 3R enclosure.
  - 3. Minimum Short-Circuit Rating: 10,000 A symmetrical at rated voltage.
  - 4. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers.
  - 5. Tenant Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect circuit breakers in downstream tenant and to house loadcenters and panelboards that have 10,000-A interrupting capacity.
    - a. Identification: Provide legend identifying tenant's address.
    - b. Physical Protection: Tamper resistant, with hasp for padlock.
  - 6. Meter Socket: Rating coordinated with indicated tenant feeder circuit rating.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.
- B. Install equipment for utility company metering. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
- C. Install modular meter center according to NECA 400 switchboard installation requirements.

END OF SECTION 262713



## SECTION 262726 - WIRING DEVICES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.

## PART 2 - PRODUCTS

## 2.1 DEVICES

- A. Convenience Receptacles: NEMA WD 1, NEMA WD 6, Configuration 5-20R, and UL 498.
  - 1. Products:
    - a. Pass & Seymour; CR20-W:  
<http://www.passandseymour.com/pdf/U045.pdf>
- B. Duplex GFCI Convenience Receptacles: 125 V, 20 A, straight blade, feed-through type. NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
  - 1. Products:
    - a. Pass & Seymour; 1595-L, 2095-L:  
[http://www.passandseymour.com/spec\\_sheets/pdf/SFG1201R4.pdf](http://www.passandseymour.com/spec_sheets/pdf/SFG1201R4.pdf)
- C. Wall-Box Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
  - 1. Control: button with single-pole or three-way switching to suit connections. Comply with UL 1472.
  - 2. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
  - 3. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.
- D. Wall Plates, Finished Areas: Smooth, high-impact thermoplastic or Satin-finish stainless steel fastened with metal screws having heads matching plate color.

- E. Wall Plates, Unfinished Areas: Smooth, high-impact thermoplastic with metal screws.
- F. Wall Plates, Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet locations.
- G. Floor Service Fittings:
  - 1. Modular, flush-type or flap-type, dual-service units suitable for wiring method used.
  - 2. Compartments: Barrier separates power from voice and data communication cabling.
  - 3. Service Plate: Rectangular with satin finish.
  - 4. Power Receptacle: NEMA WD 6, Configuration 5-20R, gray finish, unless otherwise indicated.
  - 5. Voice and Data Communication Outlet: Blank cover with bushed cable opening.
- H. Finishes:
  - 1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
  - 2. Wiring Devices Connected to Emergency Power System: Red
  - 3. TVSS Devices: Blue.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Install devices and assemblies plumb, level, and square with building lines.
- C. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- D. Install unshared neutral conductors on line and load side of dimmers.
- E. Mount devices flush, with long dimension vertical, and grounding terminal of receptacles on top unless otherwise indicated. Group adjacent devices under single, multigang wall plates.

END OF SECTION 262726

## SECTION 262813 - FUSES

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.

### PART 2 - PRODUCTS

#### 2.1 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

#### 2.2 SPARE-FUSE CABINET

- A. Cabinet: Gray, baked-enamel finish; wall-mounted, steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
  - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.

### PART 3 - EXECUTION

#### 3.1 FUSE APPLICATIONS

- A. Service Entrance: Class RK1, fast acting.
- B. Feeders: Class RK1, fast acting.
- C. Motor Branch Circuits: Class RK5, time delay.
- D. Other Branch Circuits: Class J, fast acting.
- E. Control Circuits: Class CC, fast acting.

### 3.2 INSTALLATION

- A. Install fuses so rating information is readable without removing fuse.
- B. Install labels indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.
- C. Install spare-fuse cabinet(s).

END OF SECTION 262813

## SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## PART 2 - PRODUCTS

## 2.1 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Fusible Switches, 600 A and Smaller: UL 98 and NEMA KS 1, Type GD, that accommodate specified fuses, and with lockable handle interlocked with cover in closed position.
- B. Nonfusible Switches, 600 A and Smaller: UL 98 and NEMA KS 1, Type GD, with lockable handle interlocked with cover in closed position.
- C. Receptacle Nonfusible Switches 240 and 600-V ac, 30 and 60 A: UL 98 and NEMA KS 1, Type GD, with lockable handle interlocked with cover in closed position.
  - 1. Interlocking Linkage: Prevents inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
- D. Shunt Trip Switches: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

## 2.2 MOLDED-CASE CIRCUIT BREAKERS

- A. Description: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers: Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - 2. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with field-adjustable instantaneous trip settings.
  - 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
  - 4. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
  - 5. GFEP Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
- B. Features and Accessories:

1. Lugs: Suitable for number, size, trip ratings, and conductor material.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with ground-fault indicator; relay with adjustable pickup and time-delay settings, and push-to-test feature.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

## 2.3 ENCLOSURES

- A. NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Division 26 Sections "Common work Results for Electrical."
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

### 3.2 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

END OF SECTION 262816

## SECTION 263100 - SOLAR PHOTOVOLTAIC COLLECTORS

## PART 1 - GENERAL

- 1.1 Drawings and General Provisions of the Contract, including General Conditions, General and Trade Specific Scopes of Work and Division 1 Specification Sections apply to this Section.
- 1.2 Materials, design and installation shall comply with Underwriters Laboratories, Inc. requirements and National Electrical Code Article 690.
- 1.3 All electrical work under this Contract shall comply with Specifications Section 26000.
- 1.4 Scope of Work
  - A. Furnish and install all material, equipment and service for a complete, fully operational photovoltaic system; ratings as specified herein.
  - B. The system shall consist of roof mounted photovoltaic solar panels, inverters, and associated disconnects.
  - C. All circuit breakers and fuses, disconnects and wiring connections required for system operation and compliance shall be included.
  - D. The photovoltaic system shall be designed and installed by a factor certified installer of proposed system.
  - E. This contractor shall consult with the photovoltaic system representative and installer for the final system design.
  - F. Coordinate flashing equipment or mounting system to roof with roofing contractor including all roof penetrations and associated weatherproofing and sealing.
  - G. Connect to electrical system provided under Division 26 as indicated on the drawings.

## PART 2 - PRODUCTS

- 2.1 Equipment shall be equal in quality and performance to equipment as specified herein for establishing equipment criteria. All material and/or equipment necessary for proper operation of the system not specified or described herein shall be deemed part of these specifications.
- 2.2 Photovoltaic Modules (Panels)
  - A. The Solar Photovoltaic (SPV) modules shall be provided in an array, which fits within the area of the roof as indicated on the Architectural drawings.

- B. Provide an SPV array consisting of the quantity of modules to achieve a total array output of 6840 DC Watts.
  - C. Module efficiency shall not be less than 15.7 percent. Cell efficiency shall not be less than 18.8 percent. Output power tolerance shall be +10% / -0% to assure the maximum rated output.
  - D. Provide complete racking system at 48 O.C. as manufactured by DPW Solar Corporation or approved equal for support and mounting of the SPV array on the roof. Scope includes all routing of conduits, fasteners and supports, connections and all work associated with the roof structure for support and mounting of the racking system onto the roof. Coordinate this work closely with the roofing Contractor. All roof penetrations shall be by the roofing contractor.
    - 1. <http://power-fab.com/techinfo/roofgroundmounts/InfoSheetRGM.pdf>
  - E. Sanyo HIT Double 190:  
<http://us.sanyo.com/dynamic/product/Downloads/HITPower190DataSheet-28470218.pdf>
- 2.3 Grid Tie Solar Inverters shall meet IEEE 519, UL 1741 and NEC 690 as well as any other requirement of AEP to ensure that the output AC is properly synchronized with the utility grid's AC sine wave.
- A. Provide quantity of continuous output power inverters to accommodate the total array output rating as specified and meet manufacturer's sizing guidelines.
  - B. Inverters shall be as manufactured by PV Powered, SMA America and Sunny Boy. The inverter manufacturer's peak efficiency rating shall not be less than 97.1 percent.
  - C. DC input range shall not exceed 600V. DC operating voltage range shall be 250V-600V with a nominal AC voltage of 240V – 60Hz.
  - D. Inverters shall communicate with BAS and send electrical information via communications lines. Refer to division 26 specifications for wiring requirements. Provide communications lines to local controls/monitoring panel.
  - E. SMA Sunny Boy 7000US Grid Tie Inverter:  
<http://download.sma.de/smaprosa/dateien/4752/SUNNYBOY567-DUS091314W.pdf>
  - F. SMA Sunny Webbox and Sunny Sensor Box shall be installed with the SMA Sunny Boy inverter, and connected as referenced in section 251100
    - 1. Sunny Webbox:  
<http://download.sma.de/smaprosa/dateien/4804/SENSORBOX-DUS084110.pdf>
    - 2. Sunny Sensor Box:  
<http://download.sma.de/smaprosa/dateien/4253/WEBBOX-DUS084110.pdf>



- 2.4 Provide disconnect switches, fused and non-fused, where indicated on the drawings and in the specifications, and where required by the N.E.C.
- A. Disconnect switches shall be listed by Underwriter's Laboratories and shall be manufactured per specification section 26 28 16. All starters and disconnect switches shall be of the same manufacturer unless otherwise approved.

### PART 3 - EXECUTION

- 3.1 The Solar Photovoltaic System Contractor shall submit for approval with shop drawings, schematic and point to point wiring diagrams showing all solar panels and array layouts, inverters, ground fault protection, all Dc and AC disconnect switches, overcurrent protection, combiner boxes as required including all respective branch circuitry, wiring and grounding. **SHOP DRAWINGS WILL BE REJECTED UNLESS THE SUBMITTAL INCLUDES ALL THIS REQUIRED INFORMATION.** At completion of the project, the wiring diagrams shall be revised "as-built" and included as part of the maintenance manuals.
- A. Shop drawing shall include diagram indicating connection of the PV System AC unit to the Division 26 Electric Distribution System; coordinate this with the Electrical Contractor.
- B. Submit catalog cut sheets of all Solar Photovoltaic System equipment for approval by the Engineer.
- C. Submit drawings indicating communication wiring between the inverters and the controls/monitoring panel provided by Division 23.
- 3.2 The complete Solar Photovoltaic System shall be provided in strict accordance with NEC article 690. Installation requirements related to this may be summarized, but not limited to the following:
- A. All Dc and AC circuits shall be installed in conduit. PV source circuits and PV output circuits should not be contained in the same raceway.
- B. The roof mounted photovoltaic arrays shall be provided with Dc ground-fault protection.
- C. Circuit sizing, overcurrent protection and disconnecting means shall be sized for the specific application and equipment provided for this system.
- D. The connection to a module or panels on the roof mounted array shall be arranged to facilitate the removal of a module without interrupting the grounding system or disrupting connection of the remaining modules or panel to the inverter(s).

- 3.3 Upon completion and before acceptance, system performance shall be demonstrated in the presence of the Architect that all specified functions are accomplished and that the complete Solar Photovoltaic System meets the Contract performance criteria.
- 3.4 System shall be tested by and a certificate of inspection shall be furnished by a qualified manufacturer's representative or equipment vendor; submit report indicating results to the Architect.
- 3.5 Provide twenty (20) year warranty from date of Owner acceptance for the solar photovoltaic panels mounted on the roof. Inverter(s) shall be warranted for a period of five (5) years.

END OF SECTION 263100

## SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data.
- B. Installer Qualifications: Certified by UL, trained and approved for installation of units required for this Project.
- C. System Certificate: UL Master Label.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

## PART 2 - PRODUCTS

## 2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96 and NFPA 780.
- B. Main and Bonding Conductors: Copper.
- C. Ground Rods: Zinc-coated; 5/8 inch in diameter by 96 inches long.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A and NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Where indicated, run conductors in nonmetallic raceway.
- C. Conceal the following conductors:
  - 1. System conductors.
  - 2. Down conductors.
  - 3. Interior conductors.
  - 4. Conductors within normal view of exterior locations at grade within 200 feet of building.
- D. Cable Connections: Exothermic-welded connections for conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

- E. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturers' written installation instructions.
- F. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture, unless moisture is permanently excluded from the junction of such materials.
- G. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

### 3.2 FIELD QUALITY CONTROL

- A. UL Inspection: Meet requirements to obtain a UL Master Label for system.
- B. LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

END OF SECTION 264113

## SECTION 265000 - LIGHTING

## PART 1 - GENERAL

## 1.1 SECTION REQUIREMENTS

- A. Submittals: Product Data for each luminaire, including lamps.
- B. Fixtures, Emergency Lighting Units, Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with IEEE C2, "National Electrical Safety Code."
- D. Coordinate ceiling-mounted luminaires with ceiling construction, mechanical work, and security and fire-prevention features mounted in ceiling space and on ceiling.

## PART 2 - PRODUCTS

## 2.1 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
- E. Exterior Luminaires: Comply with UL 1598 and listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- F. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

## 2.2 BALLASTS

- A. Ballasts for Linear Fluorescent Lamps:
  - 1. Electronic: Comply with ANSI C82.11; programmed rapid start type.

- a. Sound Rating: A.
  - b. BF: 1.00 or higher.
  - c. Power Factor: 0.98 or higher.
2. Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) at temperatures 32 deg F (0 deg C) and higher.
3. Dimmer Controlled: Electronic type.
  - a. Dimming Range: 100 to 1 percent of rated lamp lumens.
  - b. Ballast Input Watts: Can be reduced to 20 percent of normal.
  - c. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

## 2.3 LAMPS

- A. T-5 Linear Fluorescent Lamps: Rated 14 W maximum, nominal length 24 inches (60.96 cm), CRI 85 (minimum), color temperature of 6400 K, and average rated life of 10,000 - 20,000 hours unless otherwise indicated.
- B. 25W, 120V Xenon bi-pin lamps.
- C. 75 PAR/R30 Incandescent lamps.
- D. White LED

## 2.4 REQUIREMENTS FOR INDIVIDUAL LIGHTING FIXTURES

- A. Fixture: Slot 2 Series Recessed Fluorescent
  1. Basis-of-Design Product: Subject to compliance with requirements, provide Mark Lighting; Slot2C Series.  
[http://www.marklighting.com/product\\_overview.cfm?ProductID=29](http://www.marklighting.com/product_overview.cfm?ProductID=29)
  2. Voltage: 120V ac.
  3. Mounting: Recessed ceiling
  4. Nominal Dimensions: 24" L, 2" W
  5. Lamps: 1 T-5 Linear fluorescent.
  6. Ballast for Fluorescent Lamps: Electronic dimming
  7. Quantity of Ballasts per Fixture: 1.
  8. Lens: Clear frosted acrylic.
  9. External Finish: Housing and internal components baked enamel.
  10. Minimum CU for typical RCR shall be as follows (typical cavity reflectances are ceiling = 80 percent, wall = 50 percent, and floor = 20 percent): RCR 3
- B. Fixture: 5 inch Incandescent IC Housing
  1. Basis-of-Design Product: Subject to compliance with requirements, provide Pegasus Associates Lighting.  
<http://www.pegasusassociates.com/5inLiVTrimPNT5021C.html>

2. Voltage: 120V ac.
3. Mounting: Recessed ceiling
4. Nominal Dimensions: 10 1/2" L, 7 1/4" W
5. Lamps: 75 PAR/R 30 Incandescent.
6. Lens: High grade frosted dome lens.
7. External Finish: Housing and internal components baked enamel.
8. Minimum CU for typical RCR shall be as follows (typical cavity reflectances are ceiling = 80 percent, wall = 50 percent, and floor = 20 percent): RCR 3

C. Fixture: Stratalume Undercabinet Lighting

1. Basis-of-Design Product: Subject to compliance with requirements, provide Kenall Lighting.  
<http://www.bostonlightsource.com/stuff/contentmgr/files/bd475549a00b86ec93386092f08d22ab/spec/aucled.pdf>
2. Voltage: 120V ac.
3. Mounting: Undercabinet.
4. Nominal Dimensions: 5 1/4" L, 4" W
5. Lamps: 1 T-5 Linear fluorescent.
6. Ballast for Fluorescent Lamps: Electronic.
7. Quantity of Ballasts per Fixture: 1.
8. Lens: High impact extruded wraparound opal diffuser.
9. External Finish: Housing and internal components baked enamel.
10. Minimum CU for typical RCR shall be as follows (typical cavity reflectances are ceiling = 80 percent, wall = 50 percent, and floor = 20 percent): RCR 3

D. Fixture: Tigris Mirror Oval

1. Basis-of-Design Product: Subject to compliance with requirements, provide Tech Lighting LLC.  
<http://www.techlighting.com/default.asp?page=products&subpage=fixturedet&fixid=220&sysid=&cls=12&nme=Bath%20Collection>
2. Voltage: 120V ac.
3. Mounting: Wall mounted.
4. Nominal Dimensions: 28" L, 18" W
5. Lamps: 8 12 Volt Halogen bi pin lamps.
6. Lens: Clear frosted acrylic.
7. External Finish: Chrome satin nickel.
8. Minimum CU for typical RCR shall be as follows (typical cavity reflectances are ceiling = 80 percent, wall = 50 percent, and floor = 20 percent): RCR 3

E. Under Cabinet Xenon Light Bar

1. Basis-of-Design Product: Subject to compliance with requirements, provide WAC Lighting.  
[http://www.creativelighting.com/product\\_p/ba-lix-2.htm](http://www.creativelighting.com/product_p/ba-lix-2.htm)
2. Voltage: 120V ac.
3. Mounting: Under cabinet.

4. Nominal Dimensions: 11 7/8" L, 3 1/8" W
5. Lamps: 2 Xenon bi pin lamps.
6. Lens: Clear.
7. External Finish: Satin nickel.
8. Minimum CU for typical RCR shall be as follows (typical cavity reflectances are ceiling = 80 percent, wall = 50 percent, and floor = 20 percent): RCR 3

F. Outdoor Solar Pathway Walkway Lights

1. Basis-of-Design Product: Subject to compliance with requirements, provide Portfolio Outdoor Lighting.  
<http://www.lowes.com/lowes/lkn?action=productDetail&productId=124700-30383-LV65901BR2&lpage=none>
2. Mounting: Deck.
3. Nominal Dimensions: 4.3" L, 2" W.
4. Lamps: 2 White LEDs.
5. Lens: Plastic.
6. External Finish: Brown Plastic.
7. Minimum CU for typical RCR shall be as follows (typical cavity reflectances are ceiling = 80 percent, wall = 50 percent, and floor = 20 percent): RCR 3

G. Solar Black Flood Set with Panel

1. Basis-of-Design Product: Subject to compliance with requirements, provide Portfolio Outdoor Lighting.  
<http://www.lowes.com/lowes/lkn?action=productDetail&productId=127456-59179-SPS1-BK-PK3&lpage=none>
2. Mounting: Landscape.
3. Nominal Dimensions: 4.6" L, 2.7" W, 8.5" H.
4. Lamps: 2 White LEDs.
5. Lens: Plastic.
6. External Finish: Black Plastic.
7. Minimum CU for typical RCR shall be as follows (typical cavity reflectances are ceiling = 80 percent, wall = 50 percent, and floor = 20 percent): RCR

## PART 3 - EXECUTION

### 3.1 INSTALLATION

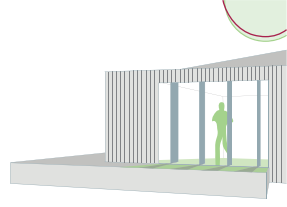
- A. Set units level, plumb, and square with ceiling and walls, and secure.
- B. Support for Recessed and Semirecessed Grid-Type Fluorescent Fixtures:
  1. Install ceiling support system wires at a minimum of four wires for each fixture, located not more than 6 inches from fixture corners.
  2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.



- C. Adjust aimable lighting fixtures to provide required light intensities.
- D. Lamping: Where specific lamp designations are not indicated, lamp units according to manufacturer's written instructions.

END OF SECTION 265000

## Division\_28 Electronic Safety and Security



## SECTION 283100 - FIRE DETECTION AND ALARM

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. System Description: Noncoded, conventional, hardwired, zoned, 24-V dc loop system.
  - 1. Initiating Device Circuits: NFPA 72, Class B, Style B.
  - 2. Notification Appliance Circuits: NFPA 72, Class B, Style Y.
- B. Submittals: Product Data and system operating description.
- C. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals, make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations.
- D. Comply with NFPA 72.
- E. UL listed and labeled.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### PART 2 - PRODUCTS

#### 2.1 FACP

- A. General: Modular, power-limited design with electronic modules, UL 864 listed.
- B. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, trouble, and supervisory signals to a remote alarm station through a digital alarm communicator transmitter and telephone lines.
- C. Secondary Power: 24-V dc supply system with sealed lead calcium batteries and automatic battery charger and an automatic transfer switch.

#### 2.2 ALARM-INITIATING DEVICES

- A. Manual Pull Stations: UL 38 listed, double-action mechanism, red in color with molded, raised-letter operating instructions in contrasting color.
- B. Smoke Detectors: UL 268, 24-V dc, self-restoring, photoelectric type, plug-in arrangement.
- C. Heat Detectors: UL 521 listed, combination 135 deg F fixed-temperature and rate-of-rise unit.

## 2.3 NOTIFICATION APPLIANCES

- A. Bells: Electric-vibrating type, with 94 dBA at 10 feet
- B. Low-Level Chimes: Vibrating type with 75 dBA.
- C. High-Level Chimes: Vibrating type with 81 dBA.
- D. Horns: Electric-vibrating-polarized type, 90 dBA at 10 feet .

## 2.4 WIRE AND CABLE

- A. General: UL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
  - 1. Low-Voltage Circuits: No. 16 AWG, minimum.
  - 2. Line-Voltage Circuits: No. 12 AWG, minimum.

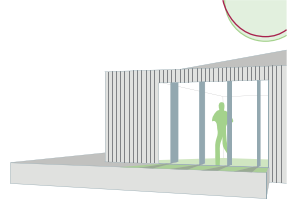
# PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install and test systems according to NFPA 72. Comply with NECA 1.
- B. Wiring Method: Install wiring "fished" in concealed spaces and exposed on ceilings and walls where indicated.
- C. Ground the FACP and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACP.

END OF SECTION 283100

## Division\_32 Exterior Improvements



## SECTION 329300 - PLANTS

### PART 1 - GENERAL

#### 1.1 SECTION REQUIREMENTS

- A. Submittals: Not required
- B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
- C. Planting Restrictions: Plant during the following period:
  - 1. Fall Planting: October 1, 2009 to October 8, 2009
- D. Maintain trees and shrubs until October 18, 2009.
- E. Maintain ground covers and plants until October 18, 2009.

### PART 2 - PRODUCTS

#### 2.1 PLANTING MATERIALS

- A. Tree and Shrub Material: Nursery grown, with healthy root systems, well shaped, fully branched, healthy, and free of insects, eggs, larvae, defects, and disfigurement.
- B. Ground Covers and Plants: Established and well rooted in pots or similar containers.

#### 2.2 SOIL AND AMENDMENTS

- A. Potting soil: ASTM D 5268, with pH range of 5.5 to 7, free of stones 1 inch or larger and other extraneous materials harmful to plant growth.
- B. Compost: Well-composted, stable, and weed-free organic matter; pH range of 5.5 to 8.
- C. Organic Mulch: cocoa-bean shells

#### 2.3 MISCELLANEOUS

- A. Cardboard Tube Planters: Use acrylic sealer to attach a plastic pot liner to a 12" cardboard tube.
- B. Raised Planters: Construct as indicated by drawings.

## 2.4 PLANTING SOIL MIX

- A. Mix potting soil with the following soil amendments in the following quantities:
  - 1. Ratio of Loose Compost to Topsoil by Volume: [1:4]

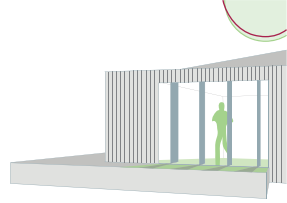
## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Planting Bed Establishment: Fill containers with potting soil mix within 3 inches of the top of the planter but not more than 2 inches from the top of the planter.
- B. Trees and Shrubs: Excavate pits with sides sloped inward and with bottom of excavation slightly raised at center to assist drainage. Excavate approximately three times as wide as ball diameter. Scarify sides of plant pit smeared or smoothed during excavation.
  - 1. Set trees and shrubs plumb and in center of pit with top of ball flush with adjacent finish grades.
  - 2. Remove burlap and wire baskets from tops of balls and partially from sides, but do not remove from under balls. Carefully remove root balls from containers without damaging root ball or plant. Do not use planting stock if ball is cracked or broken before or during planting operation.
  - 3. Place planting soil mix around ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Water again after placing and tamping final layer of planting soil mix.
  - 4. Prune, thin, and shape trees and shrubs after planting.
- C. Plant ground cover and plants as indicated on drawings. Dig holes large enough to allow root spread. Plant stock working soil around roots and leave a slight saucer around plants to hold water. Water after planting. Do not cover plant crowns with wet soil.
- D. Mulching: Apply organic mulch, 1 inch thick and finish level with adjacent finish grades. Do not place mulch against trunks or stems.
- E. Tree and Shrub Maintenance: Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, adjusting and repairing, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
- F. Ground Cover and Plant Maintenance: Maintain and establish plantings by watering, weeding, fertilizing, mulching, and other operations as required to establish healthy, viable plantings.

END OF SECTION 329300

# Structural Calculations\_5



1 of 14  
6/1/09

GRAVITY DESIGN - FLOOR

LIVE LOAD = 50 PSF  
DEAD LOAD = 5 PSF  
TOTAL = 55 PSF

FLOOR BEAMS - WOOD

SPACING = 16" O.C.

LIVE LOAD =  $50 \text{ PSF} \times \frac{16}{12} = 67 \text{ PLF}$   
DEAD LOAD =  $5 \text{ PSF} \times \frac{16}{12} = 7 \text{ PLF}$   
TOTAL = 74 PLF

$\Delta \leq \text{SPAN} / 360$  FOR LIVE LOAD

• IRC TABLE 2308.8(2) w/ TOTAL LOAD OF 60 PSF & SPACING OF 16":

- HEM-FIR #2; 2x8 MAX SPAN = 11'-4" w/ TOTAL  $\Delta \leq L/360$
- MAX SPAN = 10'-0", so A 2x8 IS OK.

FLOOR BEAMS - STEEL

- BEAM COMPRESSION FLANGE IS BRADED @ 16" O.C.
- DESIGN LONG SIDE = 22'-8" (17.67' MAX SPAN)
- FLOOR LOAD =  $60 \text{ PSF} \times (10.67'/2) = 320 \text{ PLF}$
- WALL WEIGHT  $\approx 10 \text{ PSF} \times 11' \text{ HIGH} = 110 \text{ PLF}$
- ROOF LOAD = 20 PSF SNOW + 10 PSF PV + 10 PSF DEAD = 40 PSF  $\times 2' = 80 \text{ PLF}$

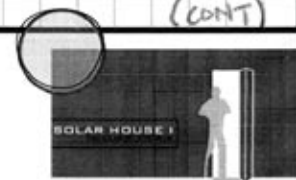
(CONT)



STRUCTURAL CALCULATIONS - OSU SOLAR DECATHLON  
FOR DECKS & BUILDING

date: 1/16/08 scale: N/A

contact info: \_\_\_\_\_





2 of 14

### FLOOR BEAMS - STEEL (CONT)

• TOTAL LOAD = 510 PLF

$$\textcircled{1} \quad \begin{aligned} \text{• MOMENT} &= \frac{WL^2}{8} \\ \text{• MOMENT} &= 510 \text{ PLF} \times \left( \frac{22.67^2}{8} \right) = 32,760 \text{ \#-FT} \\ 32,760 \text{ \#-FT} \times \left( \frac{12 \text{ \"/FT}}{1000 \text{ LB/KIP}} \right) &= 393 \text{ KIP-IN} \end{aligned}$$

- USING ASD DESIGN  $\phi$  A W12X14 BEAM

$$\text{• } M_a \leq M_n / \Omega$$

$$\text{• } \Omega = 1.67$$

$$M_n = F_y Z_x = 50 \text{ KSI} (17.4 \text{ IN}^3) = 870 \text{ KIP-IN}$$

$$M_a = 870 / 1.67 = 520 \text{ KIP-IN} < 393 \text{ KIP-IN}$$

- A W12X14 BEAM IS OK FOR STRENGTH

$$\textcircled{2} \quad \Delta = \frac{5WL^4}{384EI} = \frac{5 \left( 0.510 / 12 \right) (17.67' \times 12)^4}{384 \times 29,000 \times 88.6} = .44''$$

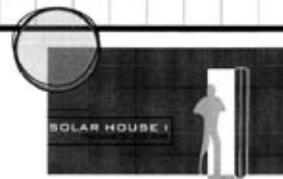
$$\frac{17.67' \times 12 \text{ \"/FT}}{.44''} = 481$$

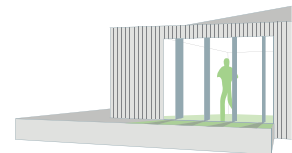
$481 \geq 360$ , so A W12X14 IS OK FOR DEFLECTION

$$\textcircled{3} \quad \text{END REACTION} \propto 510 \text{ \#} \times (17.67' / 2) = 4.5 \text{ K}$$

- SHEAR IS OK BY INSPECTION

☐ date: \_\_\_\_\_ scale: \_\_\_\_\_  
contact info: \_\_\_\_\_





3 of 14

- BEAM COMPRESSION FLANGE IS BRACED @ MIDSPAN
- DESIGN SHORT SIDE = 10'-8" (4'-8" MAX SPAN)

$$\begin{aligned}
 \text{- FLOOR LOAD} &= 60 \text{ PSF} \times \left( \frac{16''}{12''} \right) = 80 \text{ PLF} \\
 \text{- WALL LOAD} &\approx 10 \text{ PSF} \times 1' \text{ H} = 110 \text{ PLF} \\
 \text{- ROOF} &= 40 \text{ PSF} \times (22.67'/2) = 454 \text{ PLF} \\
 \text{TOTAL LOAD} &= 644 \text{ PLF}
 \end{aligned}$$

$$\begin{aligned}
 \textcircled{1} \text{ MOMENT} &= WL^2/8 \\
 &= 644 \text{ PLF} \times (10.67'^2/8) = 9165 \text{ #-FT} \\
 &9165 \text{ #-FT} \times \left( \frac{12''/\text{FT}}{1000\text{#}/\text{KIP}} \right) = 110 \text{ KIP-IN}
 \end{aligned}$$

- USING ASD  $\frac{3}{4}$  A W12X14 BEAM:

$$\begin{aligned}
 \bullet M_a &\leq M_n / \Omega \\
 \bullet \Omega &= 1.67
 \end{aligned}$$

$$\bullet M_a = F_y Z_x = 50 \text{ KSI} (17.4 \text{ IN}^3) = 870 \text{ KIP-IN}$$

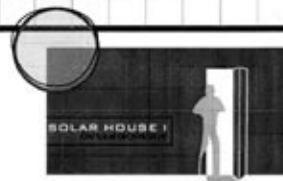
$$\bullet M_a = 870 / 1.67 = 520 \text{ KIP-IN} < 110 \text{ KIP-IN}$$

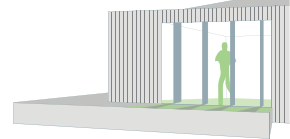
- A W12X14 WORKS FOR STRENGTH.

$$\textcircled{2} \Delta = \frac{5WL^4}{384EI} = \frac{5 \times (.510/12) (4.167 \times 12)^4}{384 \times 29000 \times 88.6} = .002''$$

$$\frac{4.167' \times 12}{.002} = 28020 > 360, \text{ so W12X14 IS OK FOR } \Delta$$

date: \_\_\_\_\_ scale: \_\_\_\_\_  
 contact info: \_\_\_\_\_





4 of 14

③ END REACTION  $\approx 644 \text{ PLF} \times (10.67' / 2) = 3.4 \text{ KIPS}$

- SHEAR IS OK BY INSPECTION

### • ROOF JOISTS - ENGINEERED WOOD

SPACING = 24" O.C.

LIVE LOAD = 30 PSF

DEAD LOAD = 10 PSF

TOTAL = 40 PSF

$\Delta \leq \text{SPAN} / 240$  FOR LIVE LOAD

• CLEAR SPAN = 22'-0"

PER MFR TABLE - LP BUILDING PRODUCTS

SOLID START I-JOISTS

$W = 40 \text{ PSF} \times 2' =$  ROOF SPAN TABLE FOR 6:12 OR LESS SLOPE

$= 80 \text{ PLF} \times (2.15 \text{ PSF ROOF DEAD LOAD}$

• 30 PSF ROOF LIVE LOAD

4040 # - FT X / • LIVE LOAD  $\Delta$  OF  $L/240$  MAX

• 24" O.C. SPACING

PER THE CRITERIA ABOVE, THE FOLLOWING JOIST  
WILL WORK:

- LPI 32 PLUS SERIES, 14" DEEP I-JOIST
- MAX SPAN ALLOWED UNDER ABOVE CRITERIA = 23'-4"
- END BEARING OF 1-3/4" MIN.

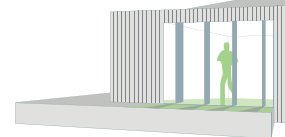


date:

scale:

contact info:





5 of 14

### ROOF JOIST - CONTINUED

- PER MFR RECOMMENDATIONS, CONNECTIONS TO RIM JOISTS ARE TO BE MADE W/ EITHER OF THE FOLLOWING SIMPSON STRONG-TIE CONNECTORS:

TOP MOUNT: MODEL # TH02514Ø  
FACE MOUNT: MODEL # THF2514Ø

- PER MFR RECOMMENDATIONS, ROOF JOISTS ARE TO BE BRAIDED @ MAX 24" O.C. @ PERIMETER CONDITIONS & MAX 48" O.C. @ INTERIOR CONDITIONS.

### RIM JOISTS (1 3/4" x 14" LVL)

- PER MFR LITERATURE, 1 3/4" x 14" LVL (LP LVL 2950F, -2.0E)  
UNFACTORED Δ RESISTANCE =

$$11' \text{ SPAN} = 890 \text{ PLF @ } L/360$$

$$= 1336 \text{ PLF @ } L/240$$

$$\text{ROOF LOAD} = 40 \text{ PSF} \times (22.67'/2) = 453.4 \text{ PLF TOTAL UNFACTORED LOAD}$$

$$\text{ROOF LIVE} = 30 \text{ PSF} \times (22.67'/2) = 340 \text{ PLF}$$

$$\text{ROOF DEAD} = 10 \text{ PSF} \times (22.67'/2) = 114 \text{ PLF}$$

$$\text{FACTORED TOTAL LOAD} = (1.5 \times 340) + (1.25 \times 114) = 652.5 \text{ PLF}$$

$$652.5 \text{ PLF} < 890 \text{ PLF FOR } L/360$$

- A 1 3/4" x 14" LVL WORKS FOR ALL RIM JOISTS

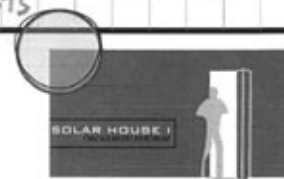
(CONT)



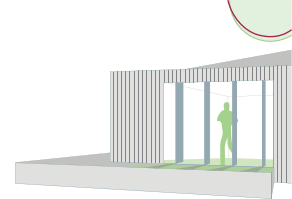
date:

scale:

contact info:







6 of 14

### FLOOR JOIST CONNECTORS

$$R = WL/2$$

$$= 60 \text{ PSF} \times 16' / 2 = 80 \#$$

- B SERIES JOIST HANKERS HAVE MIN 265 # UPLIFT & 2425 # GRAVITY CAPACITY
- LB28 BY SIMPSON STRONG-TIE IS OK

### ROOF JOIST HURRICANE CLIPS

$$0.6 (5 \text{ PSF}) - 19 \text{ PSF} = -16 \text{ PSF}$$

DEAD LOAD  
(WIND UP)

$$16 \text{ PSF} \times (24' / 12') \times (22' / 2) = 352 \#$$

- SIMPSON STRONG-TIE MODEL H2A RESISTS 575 # OF UPLIFT FORCE. AN H2A CLIP WILL BE USED @ EACH STUD TO ROOF JOIST CONNECTION.



date:

scale:

contact info:

SOLAR HOUSE 1



## FOUNDATIONS

- SEE PLAN FOR DIMENSIONS

LIVE LOAD - FLOOR	50 PSF
DEAD LOAD - FLOOR	10 PSF
WALL LOAD	10 PSF
LIVE LOAD - ROOF	30 PSF
DEAD LOAD - ROOF	10 PSF
TOTAL	110 PSF

$$110 \text{ PSF} \times (32' \times 22.67') = 79,800 \text{ LBS}$$

## WORST CASE PIER

$$5.33' \times 4.42' = (23.6 \text{ SF} \times 110 \text{ LBS/SF}) = 2596 \text{ LBS} \quad \text{OK}$$

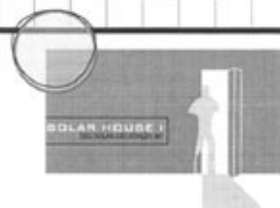
## # OF PIERS

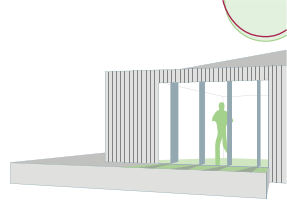
COMPETITION  
GIVEN BEARING  
VALUE

$$\frac{16" \times 16"}{144" / \text{SF}} = 1.78 \text{ SF PER PAD} \rightarrow 1500 \text{ PSF} \times 1.78 \text{ SF} = 2670 \text{ \# / PAD}$$

$$79,800 \text{ LBS} / 2670 = 29.88 = 30 \text{ PIERS TOTAL}$$

☐ date: \_\_\_\_\_ scale: \_\_\_\_\_  
 contact info: \_\_\_\_\_





8 of 14

- FOUNDATIONS CONTINUED

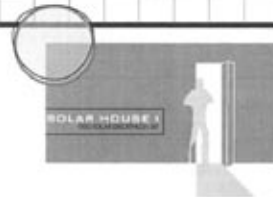
- SEE PROJECT SPECIFICATIONS FOR ADDITIONAL INFORMATION ON STEEL PIERS & BEARING PADS.
- PIERS HAVE A 6000 LB CAPACITY EACH, BUT COMPETITION GUIDELINES SPECIFY AN ASSUMED 1500 PSF BEARING CAPACITY FOR THE SOIL ON THE MALL.

☐

date:

scale:

contact info:



9 of 14

## WOOD STUDS - WALLS

- DESIGN CALLS FOR 2X6 STUDS, 8'-3" OVERALL WALL HEIGHT, SPACED @ 24" O.C.
- CLADDING IS 1/2" PLYWOOD.

PER IRC TABLE R602.3 (5)

### DESIGN

- HEIGHT > 10' w/LATERAL SUPPORT @ 48"
- 24" O.C. SPACING
- SUPPORTING A ROOF ONLY

- ALLOWABLE PER TABLE WORKS FOR A 2X6 STUD.

- HEIGHT - 10' UNBRAIDED
- 24" O.C. SPACING
- SUPPORTS A ROOF ONLY

2X6 @ 24" O.C. IS FINE IN THIS CASE

## SHEATHING - WALLS

• PER IRC TABLE R602.3(3)

- REQUIRES 24/16 RATED, 1/2" THICK @ 24" STUD SPACING
- THIS IS WHAT IS SPECIFIED, SO IT IS OK

## SHEATHING - ROOF/FLOOR - IRC TABLE 503.2.1.1 (1)

- ROOF - 24/16 (MIN 3/8) - TOTAL LOAD 40 PSF
- FLOOR - 24/16 (MIN 7/16) - TOTAL LOAD 50 PSF

→ PROJECT USES 24/16 - 3/4" THICK T&G, SO IT WORKS FOR BOTH



date:

scale:

contact info:



SOLAR HOUSE





10 of 14

## DECK FOUNDATION CALCULATIONS

### EAST SIDE

- LOAD = 100 PSF PER SOLAR DECATHLON RULES
- SOIL CAPACITY = 1500 PSF PER SOLAR DECATHLON RULES

$$100 \text{ PSF} \times 192 \text{ SF} = 19200 \text{ \#}$$

$$19,200 \text{ \#} / 1500 \text{ \#}/\text{SF} = 12.8 \text{ SF OF FOUNDATION BEARING}$$

- ASSUME BEARING AS  $16" \times 16" = 1.78 \text{ SF/PIER}$

$$- 5.5' \times 3.2' = 1.76 \text{ SF/PIER (OLD DESIGN)}$$

$$12.8 \text{ SF} / 1.78 \text{ SF/PIER} = 7.19 \text{ PIERES} \rightarrow 8 \text{ PIERES REQ'D}$$

### WEST SIDE

$$100 \text{ PSF} \times 320 \text{ SF} = 32,000 \text{ \#}$$

$$32,000 \text{ \#} / 1500 \text{ PSF} = 21.33 \text{ SF OF BEARING}$$

$$21.33 \text{ SF} / 1.78 \text{ SF/PIER} = 11.98 \rightarrow 12 \text{ PIERES REQ'D}$$



date:

scale:

contact info:



### DECK JOIST CALCULATIONS

$$\text{SPACING} = 16" \text{ O.C.}$$

$$\text{TOTAL LOAD} = 100 \text{ PSF}$$

$$\Delta \leq \text{SPAN} / 360$$

- WORST CASE

$$\frac{(16/12") \times 100 \text{ PSF}}{6'} = 22.2 \text{ \#/LF}$$

BY INSPECTION, A 2X8 @ 16" O.C. WILL WORK

### DECK 2X12 JOIST CALCULATIONS

SPACING VARIES (CALCULATIONS ARE @ WORST CASE)

$$\text{TOTAL LOAD} = 100 \text{ PSF}$$

$$\text{- WORST CASE} = \frac{24 \text{ SF} \times 100 \text{ PSF}}{8'} = 300 \text{ \#/LF}$$

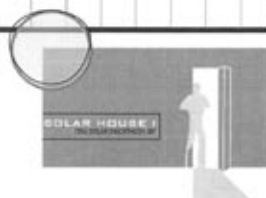
$$\text{DESIGN} = (2) \text{ 2X12 JOISTS W/ EACH } @ 150 \text{ \#/LF EACH.}$$

$$\textcircled{1} \text{ MOMENT} = WL^2/8 = 150 \text{ \#/LF} \times 8'^2/8 = 1200 \text{ \#-FT}$$

$$1200 \text{ \#-FT} \times \left( \frac{12"/\text{FT}}{1000 \text{ \#/K}} \right) = 14.4 \text{ KIP-IN}$$

TABLE 4B - REFERENCE DESIGN VALUES FOR SOUTHERN YELLOW PINE  
IN NDS 2005 (CONT)

☐ date: \_\_\_\_\_ scale: \_\_\_\_\_  
contact info: \_\_\_\_\_



12 of 14

DECK: 2x12 JOISTS CONT

DENSE SELECT STRUCTURAL = 2050 PSI FOR  $F_b$

2050 PSI = 20.5 KSI > 14.4 KSI, SO IT IS OK

WIND DESIGN

- 90 MPH, EXPOSURE 'C' FOR FINAL OHIO LOCATION
  - DESIGNED TO IBC SIMPLIFIED METHOD
    - ROOF SLOPE  $< 5^\circ$
    - BUILDING IS "ENCLOSED"
    - ADJUSTMENT FACTOR FOR EXPOSURE 'C' = 1.21 ( $< 15'$  TALL)  
↑ IBC TABLE R301.2(3)
  - PER FIGURE 6-2 IN ASCE 7-05:
    - MAX HORIZONTAL PRESSURE =  $12.3 \text{ PSF} \times 1.21 = 16 \text{ PSF}$
    - MAX VERTICAL PRESSURE =  $-15.4 \text{ PSF} \times 1.21 = -19 \text{ PSF}$
    - MAX UPLIFT ON OVERHANGS =  $22 \text{ PSF} \times 1.21 = -27 \text{ PSF}$
    - DEAD LOAD =
      - 5 PSF (FLOOR)
      - 10 PSF (WALLS)
      - 10 PSF (ROOF)
- 25 PSF TOTAL

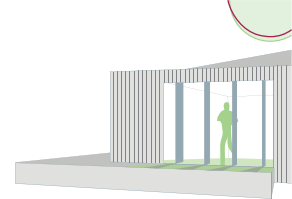


date:

scale:

contact info:





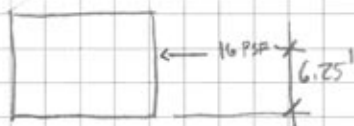
13 of 14

UPLIFT DESIGN

$$\text{UPLIFT} = -19 \text{ PSF} \times (32' \times 22.67') = -13,783 \#$$

$$\text{DEAD LOAD} = 25 \text{ PSF} \times (32' \times 22.67') = 18,136 \#$$

$$\text{OVERTURNING} = -16 \text{ PSF} \times 32' \times 6.25' = -3200 \#$$



$$(-13783 - 3200) + 18136 = 1153 \#$$

BUT WITH A SAFETY FACTOR OF 1.5...

$$(1.5(-13783 - 3200) + 18136) = -7338.5 \# \text{ OF UPLIFT THAT WE NEED TO RESIST.}$$

- LONG EDGE HAS 6 PIERS, EACH W/ 1400# UPLIFT RESISTANCE CAPACITY

$$-7338.5 \# / 6 \text{ PIERS} = 1223 \# / \text{PIER} < 1400 \#, \text{ SO IT IS OK.}$$

NOTE: THIS UPLIFT CALCULATION APPLIES TO THE CONSTRUCTION ON THE WALL. TIE DOWNS ARE USED DURING CONSTRUCTION AT OSU. SEE CALCULATIONS ON NEXT PAGE.



date:

scale:

contact info:



SOLAR HOUSE I



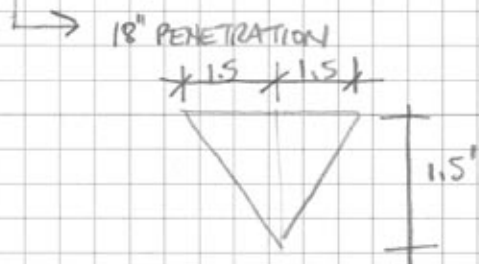
14 of 14

## UPLIFT @ OSU

$$3.5 \text{ CU FT SOIL} \times 80 \text{ \#/CU FT} = 280 \text{ \#/ANCHOR}$$

$$\frac{280 \text{ \#/ANCHOR}}{3070 \text{ \# OF UPLIFT}} = 10.96 \text{ ANCHORS} \rightarrow 12 \text{ ANCHORS}$$

+INSTALL (1) ANCHOR @ EACH TRAILER MODULE CORNER.



$$\text{VOLUME} = \frac{1}{3} \pi r^2 \times h = \frac{1}{3} \pi \times 1.5^2 \times 1.5 = \boxed{3.5 \text{ CU FT}} \text{ SOIL PER ANCHOR}$$



date:

scale:

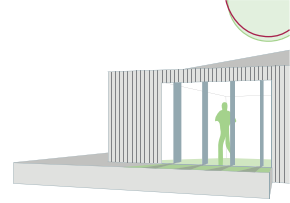
contact info:



SOLAR HOUSE I



# Detailed Water Budget\_6



## Schedule for Water Consuming Contests

**Total Water Consumption** 618.970 gallons

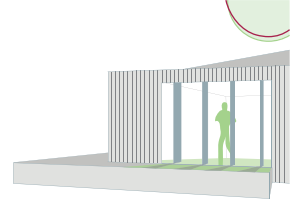
**Max Daily Water Consumption** 60.400 gallons

	Daily # of tasks	Water per task (gallons)	Total Amt of Water (gallons)	Total Daily Amt of Water (gallons)
<b><u>Water Storage Elements</u></b>				
Reflecting Pond		170.200		170.200
Hot Water Tank		80.000		80.000
<b><u>Day 1</u></b>				
Dishwasher	1	2.400	2.400	
Clothes Washer	1	13.000	13.000	
Cooking	1	0.625	0.625	
Hot Water	2	15.000	30.000	
			<b>Day 1 Total</b>	46.025
<b><u>Day 2</u></b>				
Hot Water	3	15.000	45.000	
Clothes Washer**	2	13.000	13.000	
Dinner Party*	1	0.000	0.000	
			<b>Day 2 Total</b>	58.000
<b><u>Day 3</u></b>				
Hot Water	2	15.000	30.000	
Dishwasher	1	2.400	2.400	
Cooking	1	0.625	0.625	
			<b>Day 3 Total</b>	33.025
<b><u>Day 4</u></b>				
Hot Water	3	15.000	45.000	
			<b>Day 4 Total</b>	45.000
<b><u>Day 5</u></b>				
Cooking	1	0.625	0.625	
Hot Water	2	15.000	30.000	
Clothes Washer**	2	13.000	13.000	
Dinner Party*	1	0.000	0.000	
			<b>Day 5 Total</b>	43.625
<b><u>Day 6</u></b>				
Clothes Washer	1	13.000	13.000	
Hot Water	3	15.000	45.000	
Dishwasher	1	2.400	2.400	
			<b>Day 6 Total</b>	60.400
<b><u>Day 7</u></b>				
Clothes Washer**	2	13.000	13.000	
Hot Water	2	15.000	30.000	
Dishwasher	1	2.400	2.400	
Cooking	1	0.625	0.625	
			<b>Day 7 Total</b>	46.025
<b><u>Day 8</u></b>				
Hot Water	3	15.000	45.000	
Clothes Washer**	2	13.000	13.000	
Dishwasher	1	2.400	2.400	
			<b>Day 8 Total</b>	60.400

\*Water used for the dinner party will be from purchased in sealed containers

\*\*Both loads are washed at once when option is available

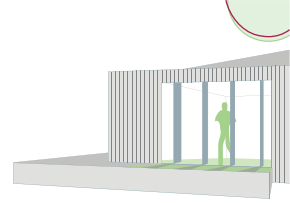
## Summary of Unlisted Electrical Components\_7



There are no unlisted electrical components in Solar House I



# Retail PV Price Quote(s)\_8



## ***Focused Energy, Inc.***

A distributor of renewable energy equipment

320 Aztec Street, Suite F  
Sante Fe, NM 87501  
Phone: (505) 216-7834  
Fax: (888)287-1480  
info@focusedenergy.net  
www.focusedenergy.net

## Quote

Date	Quote #
1/22/2009	QU-1027

Bill To
Ohio State University Scott Laboratory Kara Shell 201 W. 19th Ave. Columbus OH 43210

Ship To
Ohio State University Scott Laboratory Kara Shell 201 W. 19th Ave. Columbus OH 43210

Terms	Expires	Customer PO #	Ship Via	Sales Rep
	2/21/2009		Old Dominion	Buddy Fritz
FOB	Lift Gate Required	Call Ahead Required	Residential Delivery	
Origin	No	Yes	No	

Memo
------

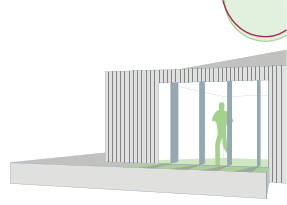
Item	Description	Qty	Rate	Tax	Amount
HIP-190DA3	Sanyo 190W HIT Double PV Module-	1	864.50	Yes	864.50
Shipping	Shipping Fee	1	150.00	Yes	150.00

	<b>Total</b>	<b>\$1,014.50</b>
--	--------------	-------------------

Prices are good for 30 days



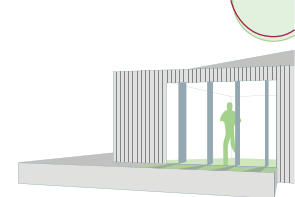
## Summary of Reconfigurable Features\_9



1.) Bed

2.) Exterior Louvers - West Facade

# Interconnection Application Form\_10



04-Dec-2008

## Solar Decathlon 2009 INTERCONNECTION APPLICATION FORM

The Ohio State University 112

**team name and lot number**

### PV SYSTEMS

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
Sanyo HIP-190DA3	6 Modules in series, 6 Series	Voc: 412.8 V, Isc: 4.85 A (string)
		Vmax: 336.6 V, Imax: 29.1A (array)

Total DC power of all arrays is 8.75 kW (in tenths).

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

### INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or kW)	Quantity
SMA	SunnyBoy 7000US	240	7 kW	1

Total AC power of all inverters is 7 kW kVA or kW (in whole numbers).

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Please include the following in the Project Manual:

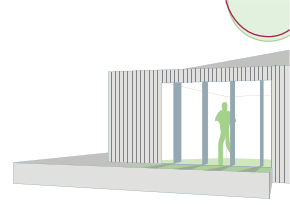
- 1) One-line electrical schematic – the loads do not have to be detailed.
- 2) Calculations of service/feeder net computed load and neutral load (NEC 220)
- 3) Plan view of the lot showing the house, decks, ramps, tour paths and the service point.
- 4) Elevation view(s) showing the terminal box (contains the service point), meter, and other service equipment (such as the distribution panel or load center).

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

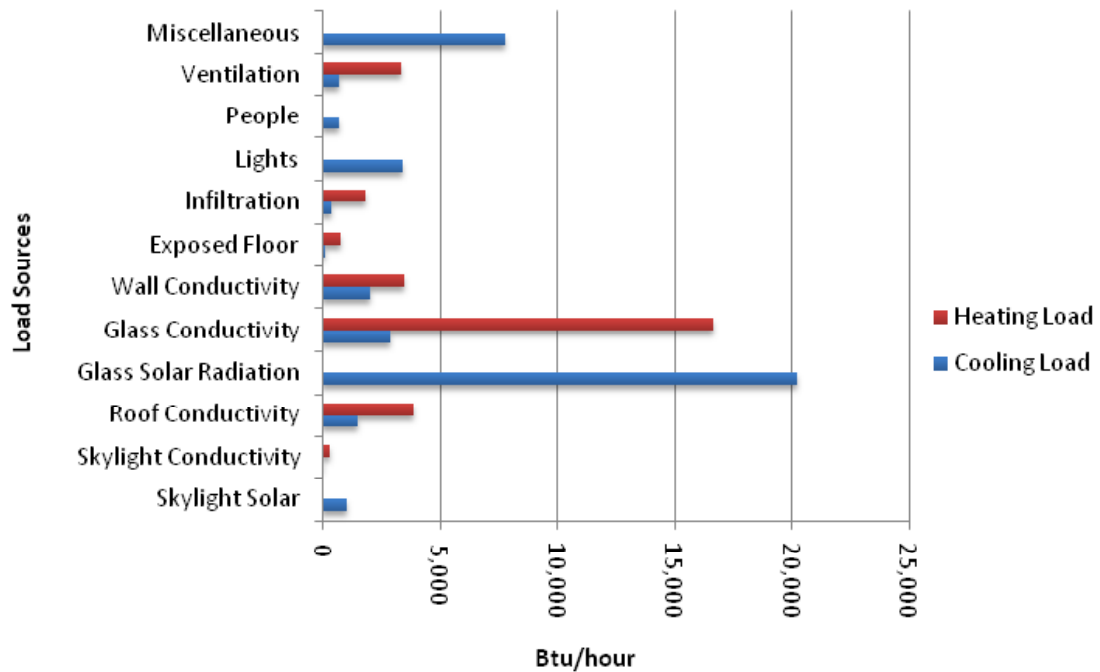
Provide the Team's "Electrical Engineer" contact info in the "Team Officer Contact Info" database on the Yahoo Group. See Rule 3-2.

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.

# Energy Analysis Results and Discussion\_11



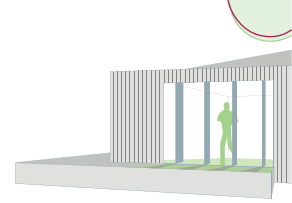
Energy modeling for Solar House I was completed in Trane Trace 700. Trane Trace 700 is a program that is widely used by designers and engineers to determine peak heating and cooling loads of a building. The program also categorizes the heating and cooling loads so that an engineer or architect can determine what improved aspects of the home will result in the most effective energy improvements. Figure 11.1 shows the Trane Trace results for each of the twelve heating and cooling load categories for Solar House I.



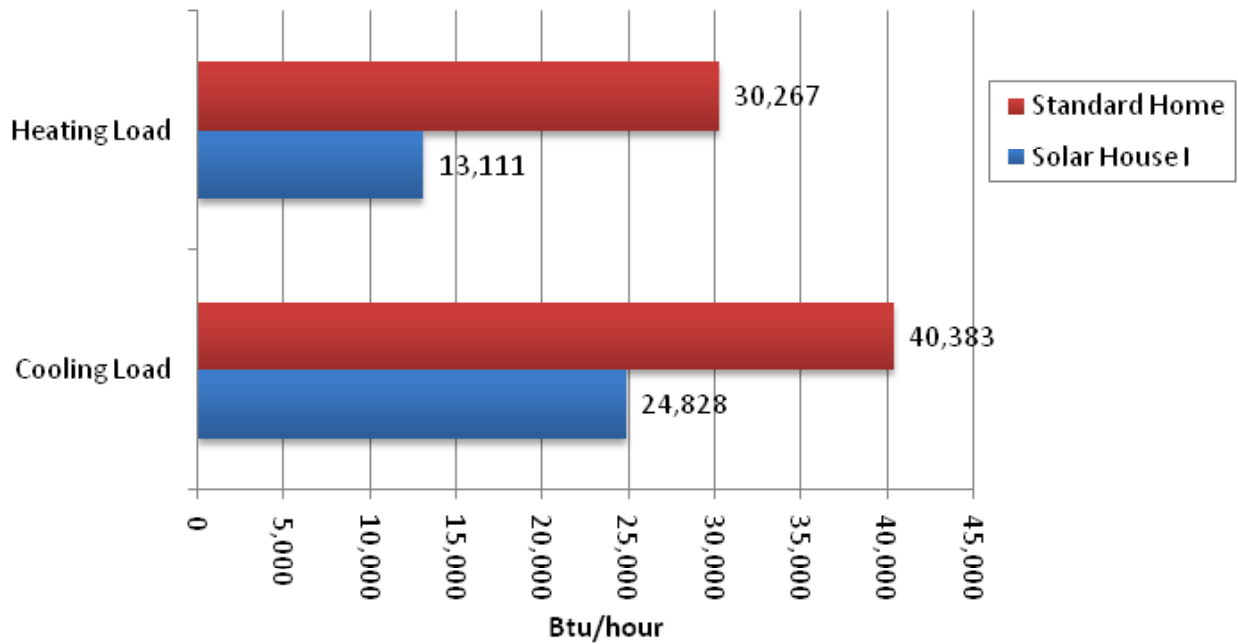
**Figure 11.1: Trane Trace 700 Results for Categorized Heating and Cooling Loads for Solar House I**

To model a building in Trane Trace 700 dimensions and materials are entered into the program. There are material libraries where standard materials for wall construction and windows can be selected and also building libraries where the user enters in the different types of materials including thicknesses and “build” up your wall layer by layer.

The modeling process required several iterations. As construction drawings were completed an analysis would be run on the building. After the results were obtained specific problems could be pinpointed and taken back to the project architects to be fixed. For example, initially the roof was a major factor in the overall heat loss within Solar House I. By sharing this information with the architecture team, a decision was made to increase the insulation thickness within the roof. This resulted in a higher R-value and decreased the overall heat loss of the house. The analysis also pointed out, as shown in Figure 11.1, that the conductivity of glass and the solar gain of glass are the largest contributors to the heating and cooling loads, respectively. This resulted in justification of the extra cost to obtain more efficient windows as well as put forth additional effort into designing intelligent shading systems for the home.



In order to compare the performance of Solar House I to a conventionally constructed home of the same size and layout, a model was created using standard building materials and wall construction. Figure 11.2 below shows the heating and cooling loads for Solar House I as compared to a conventional home. It is seen that Solar House I reduces total cooling energy use by 38% as compared to a standard house of the same size and dimensions. It also reduces the heating loads by 43%.



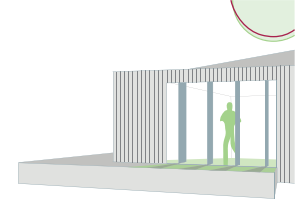
**Figure 11.2: Total Heating and Cooling Load Comparison for Solar House I vs. a Conventional Home**

Attached below are the output reports given within Trane Trace 700.

Project Name: Solar Decathlon  
Dataset Name: C:\Documents and Settings\OSU\Desktop\OSU-SD\Trace\StandardHouse2.trc

[illegible]

TRACE® 700 v6.1.3 calculated at 10:45 AM on 05/21/2009  
Alternative - 1 System Checksums Report Page 1 of 1



# System Checksums

By Trane

## System - 001

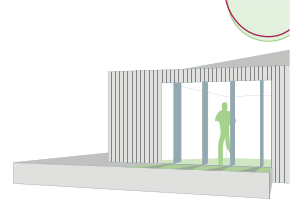
### Incremental Heat Pump

[illegible]

Project Name: Solar Decathlon  
Dataset Name: C:\DOCUMENTS AND SETTINGS\OSUIDESKTOP\OSU-SD\TRACE\13MAY.TRC

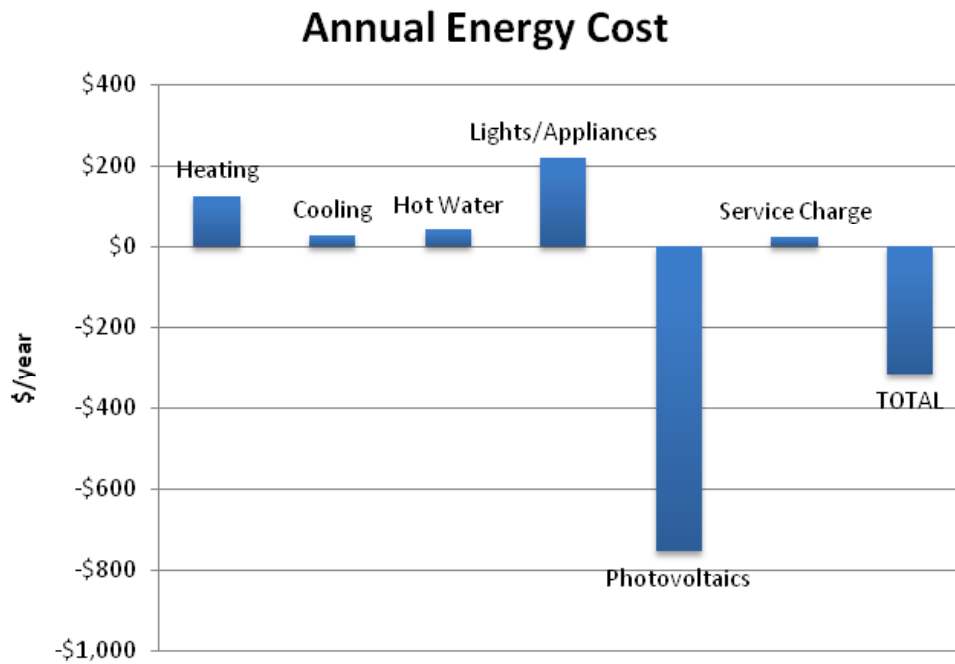
TRACE® 700 v6.1.3 calculated at 11:25 AM on 05/21/2009  
Alternative - 1 System Checksums Report Page 1 of 1

### Figure 11.4: Trane Trace Report for Solar House I



For a comprehensive electrical energy analysis of Solar House I's annual performance, the OSU Solar Decathlon Team partnered with a certified energy rater to evaluate our home based on the Residential Mortgage Industry's Home Energy Rating System (HERS). HERS reports are accepted for earning credit towards Residential LEED certification and Energy Star ratings of buildings. The system compares the annual electrical loads of a given house to a standard house and gives the building a rating of zero to five stars based upon its compared performance.

The HERS report showed that Solar House I was 145% more efficient than a standard home, receiving a HERS index of -45. A rating of zero indicates a net-zero energy home, so the negative HERS index for Solar House I indicates that Solar House I will produce more energy than it consumes. Solar House I earned a 5 stars plus rating overall. Figure 11.5 shows a breakdown of the annual expected energy costs for the home.



**Figure 11.5: Estimated Annual Energy Costs for Solar House 1**

The HERS report shows Solar House I producing an excess of 14.9 MMBtu per year, resulting in a cost savings of \$438 dollars a year in electricity bills. The resulting surplus of energy has a potential profit of \$315 dollars per year, depending on the price per watt the electric company will offer the homeowner.

The Home Energy Rating Certificate is attached below.

# Home Energy Rating Certificate

Columbus, OH



5 Stars Plus

Projected Rating

## Uniform Energy Rating System

1 Star	2 Stars	3 Stars	4 Stars	5 Stars	5 Stars Plus
400-401	300-301	200-201	100-91	85-71	70 or Less

HERS Index: -45 Efficient Home Comparison: 145% Better

## General Information

Conditioned Area: 532 sq. ft. House Type: Single-family detached  
Conditioned Volume: 4389 cubic ft. Foundation: Open crawl space  
Bedrooms: 1

## Mechanical Systems Features

Air-source heat pump: Electric, Htg: 12.5 HSPF, Cig: 25.0 SEER.  
Heating: Ground-source heat pump, Electric, 6.0 COP, w/DSH.  
Water Heating: Conventional, Electric, 0.98 EF, 30.0 Gal.  
Duct Leakage to Outside: 0.00 CFM.  
Ventilation System: Balanced: ERV, 22 cfm, 40.0 watts.  
Programmable Thermostat: Heating: No Cooling: No

## Building Shell Features

Ceiling Flat: R-53 Exposed Floor: U-0.033  
Vaulted Ceiling: NA Window Type: U0.27 SHG 0.24  
Above Grade Walls: R-28 Infiltration: Rate: Htg: 0.20 Cig: 0.18 ACHnat  
Foundation Walls: NA Slab: None Method: Blower door test

## Lights and Appliance Features

Percent Fluorescent Pin-Based: 100.00 Clothes Dryer Fuel: Electric  
Percent Fluorescent CFL: 0.00 Range/Oven Fuel: Electric  
Refrigerator (kWh/yr): 354.00 Ceiling Fan (cfm/Watt): 0.00  
Dishwasher Energy Factor: 0.46

The Home Energy Rating Standard Disclosure for this home is available from the rating provider.

REM/Rate - Residential Energy Analysis and Rating Software v12.6

This information does not constitute any warranty of energy cost or savings.  
© 1985-2008 Architectural Energy Corporation, Boulder, Colorado.

## Rating Number:

Certified Energy Rater: Terry Smith

Rating Date:

Rating Ordered For: OSU

## Estimated Annual Energy Cost

Use	MMBtu	Cost	Percent
Heating	5.7	\$126	-40%
Cooling	1.1	\$26	-8%
Hot Water	1.8	\$41	-13%
Lights/Appliances	9.8	\$221	-70%
Photovoltaics	-33.3	\$-752	239%
Service Charges		\$24	-8%
<b>Total</b>		<b>\$-315</b>	<b>100%</b>

This home meets or exceeds the minimum criteria for all of the following:

## TITLE

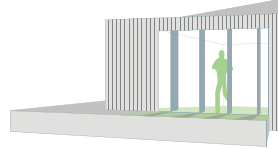
Company

Address

City, State, Zip

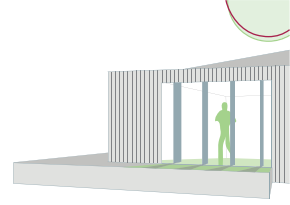
Phone #

Fax #





# Subjective Contest Support Documents\_12



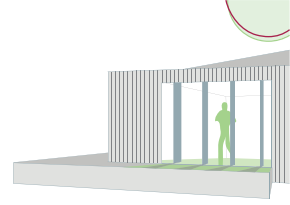
## 12.1 Architecture Design Narrative

Solar House I re-imagines the domestic living experience for Ohio. The house promotes a theme of consolidation, and encourages the average Ohioan to re-consider space within their home. The proposal offers a centralized living space that re-configures to accommodate the users' needs. The house defines two distinct interfaces, one exterior and one interior. The exterior interface is a 'second skin' that allows the user to negotiate between the interior living space and the surrounding environment. This connection to the exterior encourages the individual to employ the house's passive cooling strategies, via an ability to control natural ventilation, views, daylight and privacy. The operable veil, composed of re-claimed Ohio barn siding, creates a rain-screen and draws subtle reference to Ohio's agriculture industry.



The house is organized around a center space. The interior interface is the interactive wall surface that mediates between the user and the house program. Program components are concealed or revealed by the interior interface which adapt the use of the space to the individuals' needs (i.e. space becomes kitchen, space becomes bedroom, space becomes theater for entertaining). Additionally, furniture is designed to be stored behind the interface when not in use. The spaces are designed for the users to live comfortably with their daily routine, and flexible enough to accommodate for entertaining.

Solar House I is sited to optimize passive cooling systems while seamlessly integrating with the landscape. The result is continuity between the interior and exterior environments. The house is canted 10 degrees, encouraging southwest winds to travel over the cooling pond, lowering the temperature before entering the house via ventilation. The drop in wind temperatures entering the house reduces summer cooling loads. The west façade is comprised of operable vertical louvers that facilitate the control of these passive systems. A rainwater catchment system supplies irrigation for the productive gardening components to the north. The living space extends exteriorly to the East, tracing the path of natural ventilation through the house. A translucent insulated window wall system on the South façade, provides filtered light and warms the occupied program spaces (bathroom, bedroom and office) beyond. To the south side of the house the landscape defines a quiet gathering area amongst a field of native-Ohio grasses.



## 12.2 Market Viability Justification

Solar House I is a highly energy-efficient home designed to have market appeal for a selected demographic within the State of Ohio. Using the feedback received from the focus groups during the design process, the house is targeted for the following demographic:

- Location of Permanent Site: Columbus, OH
- Housing Type: Single Family
- Number of Occupants: 2
- Occupant Demographic: College-Educated Professionals, Late 20's
- Homeowners Annual Income: \$80,000
- Number of Bedrooms: 1

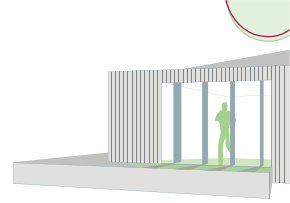
### Occupant Characteristics

The target homeowners are young professionals who to live and work within the Columbus metropolitan area. Doing so allows access to public transportation, green space in the form of public parks, and relatively dense neighborhoods with amenities such as restaurants, bars, and groceries. These things minimize their environmental impact through reduced driving, both in terms of time and distance.

### Location

Recently the urban core of Columbus has been revitalized by new residential developments as well as the rehabilitation of older urban neighborhoods. These neighborhoods offer close proximity to urban shopping and dining areas, museums, parks, and sporting venues, as well as the Ohio State University. Columbus has over 140,000 people aged 25-34 living within the city limits, out of a total population of 747,000. More than 29% of adults in Columbus have obtained at least a bachelor's degree. This is nearly double the national average of 14.96% and provides us with a sizeable and desirable target market.

More specifically, the house will be sited in Columbus' first 'green' neighborhood in the North of Broad community in near east Columbus. The area has undergone revitalization through active participation in the "Get Green Columbus Program" launched by Mayor Coleman in 2005. North of Broad is in walking distance of a robust public bus system with direct access to downtown, as well as a few minutes drive from the airport. Parks and shopping plazas are within a few blocks of the site and the Alum Creek Multi-Use Trail is only a mile away. This trail is often used for walking, running, or biking by community members. In addition to those features, the neighborhood is also home to the first LEED-platinum certified home in Ohio. Solar House 1 will be a good fit for Columbus first "Green Street."

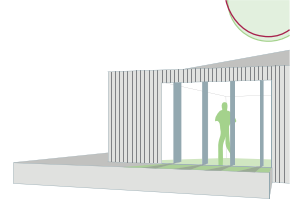


The neighborhood features homes with prices from \$120,000 to the low \$200,000s, ranging in size from 1400 to 1800 sq. ft. Our house costs approximately \$260,000 and is 786 sq. ft.; this makes Solar House I's footprint equal to the existing houses, given that most of these houses are two stories tall. Although our house is slightly more expensive than other homes in the area, it is still a close enough fit with the neighborhood both economically and environmentally. Open lots are available, which are not blocked by trees or neighboring buildings, allowing for unobstructed solar energy production. Many other Ohio cities, including Cleveland, Cincinnati, and Dayton, have similar neighborhoods undergoing urban revitalization. These neighborhoods have similar lot and house sizes and price points, making Solar House I adaptable to other Ohio cities as well.

### Marketability

The design of Solar House I is crisp and clean, with an interior that is reconfigurable to react to the living requirements of the occupant. This allows the inhabitants to effortlessly change the living arrangements to suit their desires, whether it would be opening up the interior space while concealing storage areas when entertaining guests, or closing off sections for a more intimate feeling. Additionally, the house can be set in a more permanent configuration to suit the typical daily needs of the owner. Although the owners are expected to be young professionals without children, the office is capable of being converted to a nursery if a child enters the picture. Space is utilized in an efficient manner and is sufficient to store the average person's belongings, while still being livable. The theme of configuration and usability is continued throughout the house by using home automation technologies which provide customizable settings that enhance the quality of life of the inhabitant while reducing energy consumption.

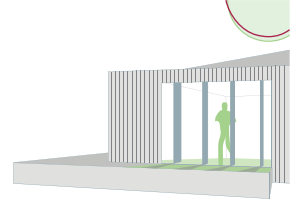
Solar House I has been rated by an experienced energy auditor on the Home Energy Rating Standard (HERS) scale. The house received a rating of -45 on the HERS index, which means that it should exceed net zero energy consumption. The estimated yearly energy bill is \$0; although Ohio electric companies do not pay for electrical generation, they do provide credits for the additional production. Even without the photovoltaic system the house's estimated yearly electricity bill would be \$438, with a monthly cost of \$36.50. Although this does not seem like a substantial savings (electricity in Ohio is 8 cents per kW/hour), electricity prices do not account for the cumulative costs of production in Ohio, which is largely produced through burning coal. When accounting for the impacts upon the environment and global climate change, the value of Solar House I is much greater.



At the estimated price of \$260,000 with a 30-year fixed-rate mortgage at current rates of 5.5% and 20% down payment, our house's monthly mortgage payments would be \$1181. If our homeowners spent no more than 28% of their income on mortgage payments (this is the generally recommended maximum), they could afford \$1,867 each month in mortgage payments. It is recommended that homeowners don't spend more than 28% of their income on mortgage payments. This is only 2/3 of the maximum recommended amount, which leaves financial 'wiggle room' for taxes, insurance, property purchase, and other contingencies.

### Livability

The house encourages our target market to re-consider traditional living conditions by challenging the misconceptions of large spatial needs as an absolute necessity. In fact, we see our house as one that does not sacrifice quality of life, but instead significantly increases it. Our house is designed to promote and encourage the environmentally conscious and active lifestyle of the house's typical inhabitant. Continuity from the interior to the exterior amplifies the perceived interior space, connects the owner with the outdoor environment, and allows natural ventilation during the mild summer and fall months. The compact size of the house allows part of the site to be used for seasonal gardening and outdoor living. The house's reconfigurable nature allows for varying levels of privacy and even though the house is designed for two, it is flexible enough to entertain for eight or more. Although technologically sophisticated, it is simple to operate. The mechanical systems are integrated into a home automation system where the occupant can easily adjust climate and lighting settings on a web enabled device. Altogether, Solar House 1 is able to conform to the user by providing an opportunity for them to lead their desired energy conscious and active lifestyle, without having to sacrifice modern conveniences and perform burdensome tasks.



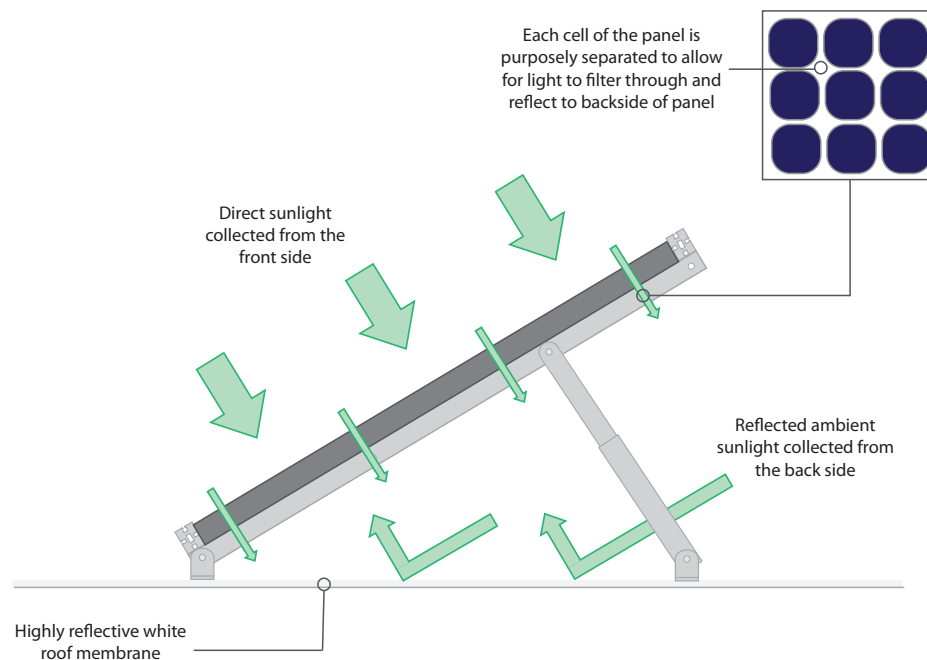
## 12.3 Engineering Design Narrative

Throughout the engineering systems you will find a common theme of adaptability and efficiency. The engineering aspects of Solar House I are designed to maximize occupant comfort and energy efficiency as well as to definitively prove that solar energy production and energy conservation are viable options for Ohio. To achieve these goals, existing technologies are employed in new ways and a special focus is taken to properly size appliances and equipment to maximize occupant comfort while minimizing energy consumption. Highlights of the Solar House I engineering systems include bifacial solar panels with fully adjustable racks; staged heating and cooling methods to maximize efficiency in Ohio's climate; solar hot water heating for both the domestic hot water and radiant floor systems; and a home automation system which not only improves the efficiency of the home, but monitors energy consumption to increase the homeowner's energy awareness.

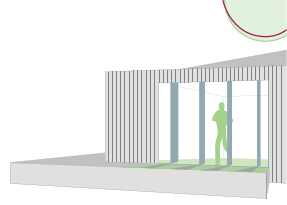
### Power Generation and Use

#### Solar Photovoltaic Panels

Solar House I will employ a 6.84 kW solar panel array consisting of thirty-six 190 Watt Sanyo Bifacial Photovoltaic (PV) Panels. The 190W Sanyo HIT Double panels generate power not only from the front panel face but also from the back panel face. As illustrated in Figure 12.1, ambient light reflected by the high albedo roofing membrane provides additional sunlight to the rear side of the panel. The ability to harvest solar energy from the back face thus increases electricity generation up to 30% per panel. The highly reflective roof surface also reduces cooling loads in summer months.



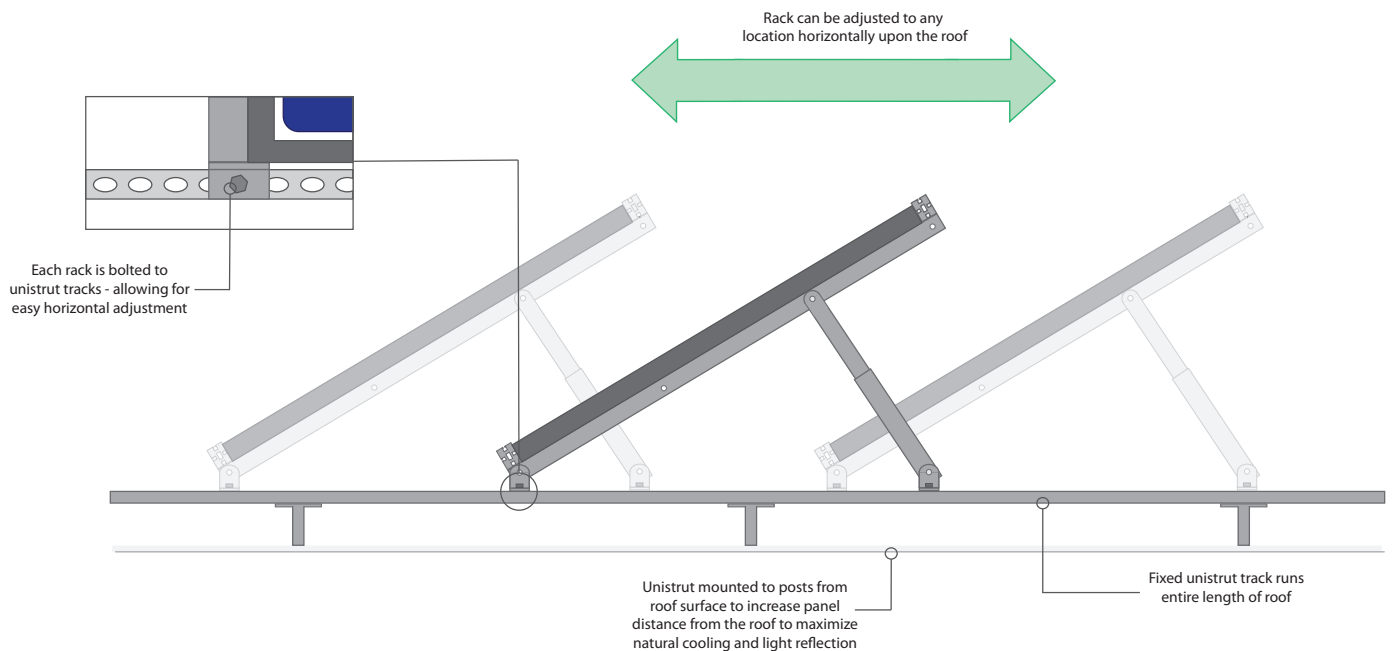
**Figure 12.3.1: Front and Backside Harvesting for Sanyo Bifacial PV Modules**



## PV Rack Selection

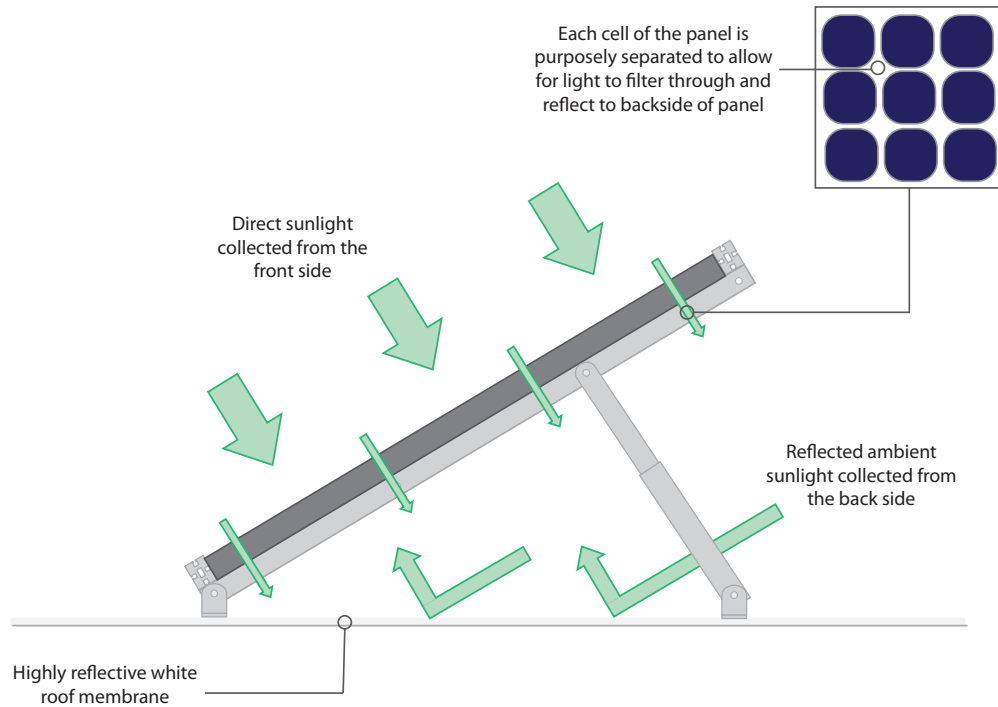
In order to secure the solar panels on the roof and provide the ability to optimize the array orientation, the team researched both in-house designs and commercially available rack systems. A rack system from Direct Power & Water (DPW) Corporation was chosen for its reasonable price and relative adaptability to nearly any mounting application. A total of 12 racks are being used. Each individual rack holds three panels which are then spaced across the roof in four rows.

A key element of this rack system's flexibility is the innovative use of Unistrut® support track on the roof. Each of the three house modules has two Unistrut® tracks running the full length of the roof. The DPW racks can then be mounted at any location along this track. When combined with the angle adjustability of each individual rack, the optimum solar panel configuration in any geographic location and any season can be achieved. The horizontal and angular adjustability of the racking system is illustrated in Figures 12.3.2 and Figure 12.3.3, respectively.



**Figure 12.3.2: Horizontal Adjustability of PV Racking System**



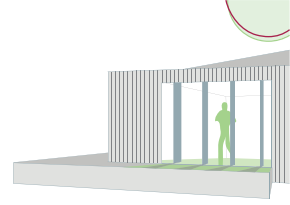


**Figure 12.3.3: Angle Adjustability of PV Racking System**

### DC-AC Power Conversion

The DC power produced will be converted to AC using an SMA SunnyBoy 7000US Inverter. The chosen inverter has a true sine wave conversion with fewer harmonics in the output. Lower quality inverters, often called “modified sine wave” inverters, produce a choppy output sine wave, often with square-like edges on the waveform. The SunnyBoy 7000US inverter has excellent efficiency, resulting in 97% of the power produced being converted into usable AC. Furthermore, the amount of power being produced by the array is maximized with the SMA’s maximum power point tracking technology.

The SunnyBoy 7000US Inverter was also selected because of the available monitoring and control features. A SMA Sunny Webbox and Sunny Sensor Box will be used to provide current and historical system data to the homeowner through Solar House I’s home automation system. The Sunny Webbox records daily, monthly and annual energy yield and transmits the data to the home automation system for analysis and display. The Sunny Sensor Box attaches to the PV Array and monitors both solar insolation and module temperature. This data is sent to the Sunny Webbox for recording. From solar insolation and module temperature it is possible to calculate the expected output of the PV array. This can be compared to the actual inverter output and can thus indicate potential problems in the array.



## Appliances

While maximizing energy production of the PV Array is critical, equally important is minimizing energy consumption within the house. Selection of appliances that are not oversized and are ENERGY STAR rated can have a large effect on the energy consumption of a home. In Solar House I, careful attention was paid to appropriately sizing appliances for a 1-2 person living arrangement. ENERGY STAR appliances are used whenever applicable.

The refrigerator is a compact ENERGY STAR refrigerator, with a total capacity of 14.6 cubic feet. A single drawer dishwasher uses less water, which reduces the energy cost associated with creating hot water. Both the clothes washer and dryer are compact, stackable, front loading units. Front loading clothes washers use significantly less water than top loading washers. The selected washer also has a very high speed spin cycle to remove as much water as possible from laundry, thus reducing subsequent drying time. In the kitchen, a combination microwave and convection oven decrease cooking time. Overall, each of these appliances will integrate seamlessly into the home to maximize comfort while minimizing energy consumption.

## Solar Hot Water Heating and Plumbing

### Solar Hot Water Heating

The free energy of the sun will be used to heat both the domestic hot water and the water circulated in the radiant floor hydronic system. An Apricus 30-tube evacuated tube array with a drain-back manifold will be mounted on Solar House I's southern face. Evacuated tubes are uniquely suited to Ohio's climate because they collect the sun's energy in the form of heat regardless of the ambient temperature. Also, compared to a flat plate collector, the evacuated tube's curved surface absorbs more sunlight from non-optimum angles. Descriptions of the array and evacuated tubes are provided Figure 12.3.4.

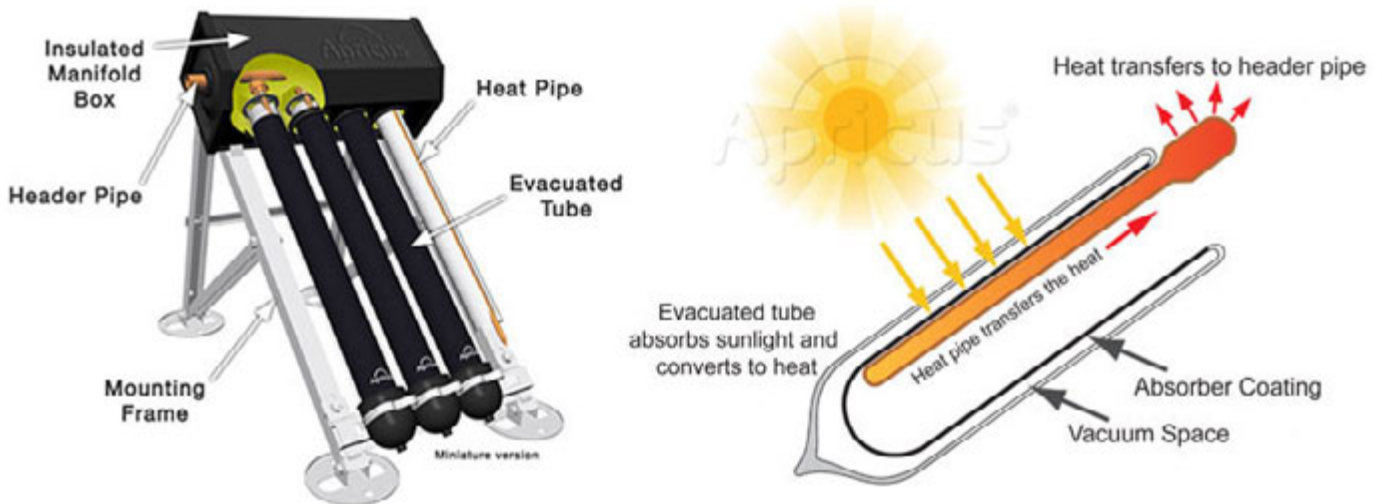
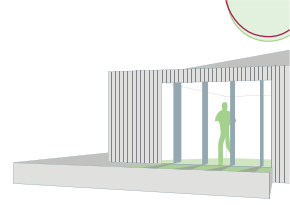


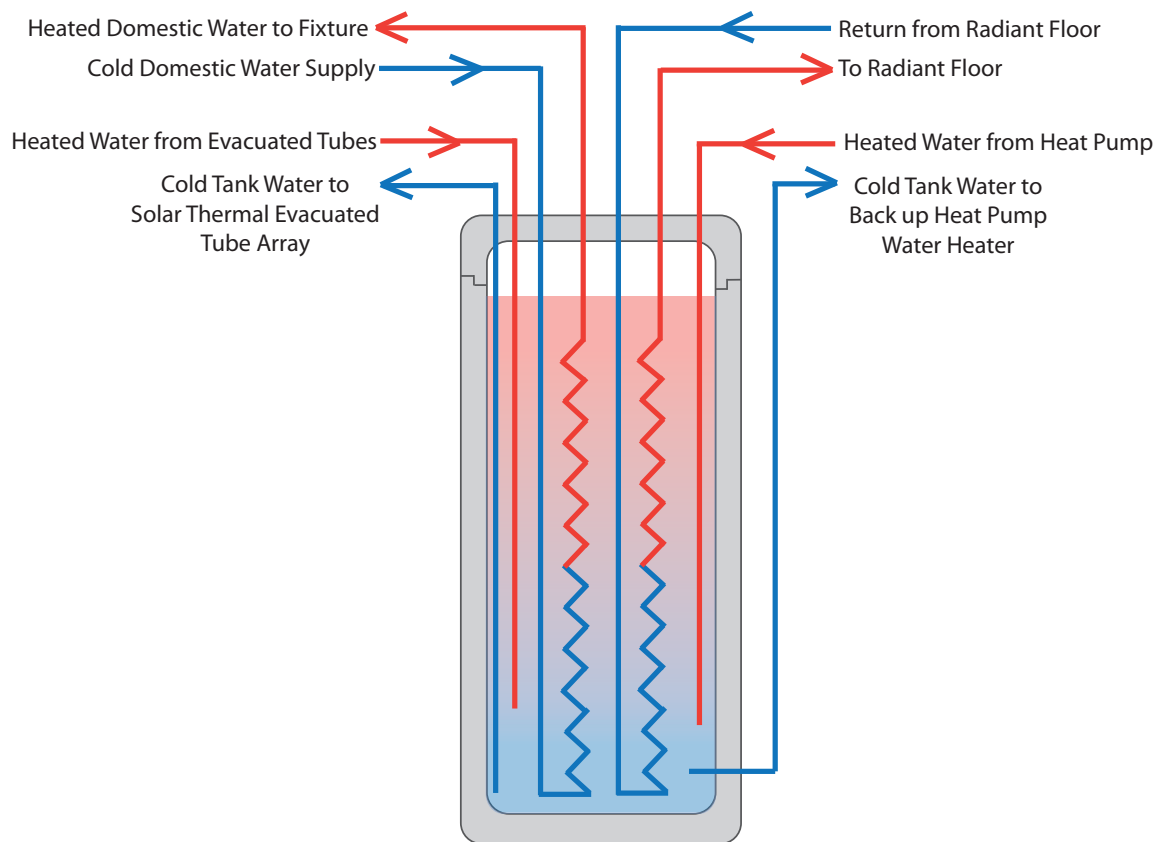
Figure 12.3.4: Description of Apricus Evacuated Tubes and Array



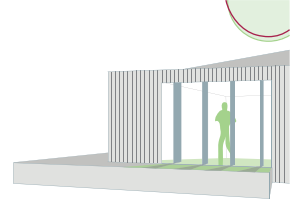


A non-pressurized drain-back system is implemented. The drain-back system employs sensors that recognize when heat is available from the evacuated tube array and then trigger a pump to circulate water through the array. If no thermal energy is available at the evacuated tube array, or if no additional hot water is needed, sensors will turn the pump off and the array will empty ("drain-back"). Drain-back protects the system from freezing and overheating and allows the use of water (versus the less efficient and more caustic glycol) as the circulating medium.

Water pumped to the array is progressively heated to the desired temperature and stored in the well-insulated 80 Gallon Rotex Solaris Sanicube hot water tank. Figure 12.3.5 shows a schematic of the tank and how it is equipped to support the multiple heating sources and loads. The Rotex Solaris Sanicube is revolutionary in that the same 80 gallons of water are always being heated from two heating sources, and it is equipped to support two heating loads. In Solar House I, domestic hot water and radiant floor water go through heat exchangers and are neither exposed to heating elements nor mixed with the tank water. This closed-loop heat exchange system is more sanitary and creates a more efficient, instant-on system that only delivers domestic and radiant floor heated water when called for. The penalty of maintaining 80 gallons of water at temperature is mitigated by the use of evacuated solar tubes and the fact that the well insulated Rotex tank loses only 3.5 °C per day.



**Figure 12.3.5: Rotex Tank Schematic Showing Heating Sources and Loads**



## Plumbing

The plumbing systems for Solar House I are designed as a closed system with a supply source in the form of a 500-gallon potable water pillow tank and 500-gallon grey water tank as a waste collector. These tanks are located under the house on elevated platforms. Pillow tanks were chosen because of their larger capacity and flexibility, simplifying supply and waste to one tank per system. A 1 HP Grundfos pressure booster pump provides 30-60 psi to all water fixtures.

For transportation purposes, Solar House I is broken into three modules. Accordingly, the layout of both plumbing systems is designed to minimize the number of instances where piping crosses modules. To accommodate the necessary crossings, the supply lines are connected with PEX compression fittings, providing airtight pipe connections that can be easily disassembled for transportation. The sanitary system is fitted with rubber flexible couplings with stainless steel clamps. The supply piping is low-cost and flexible PEX tubing and the sanitary piping consists of standard PVC.

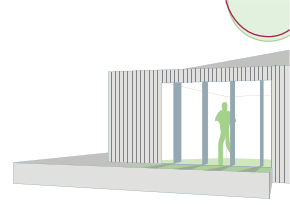
## **Heating, Ventilation and Air Conditioning**

### Radiant Floor Hydronic Heating

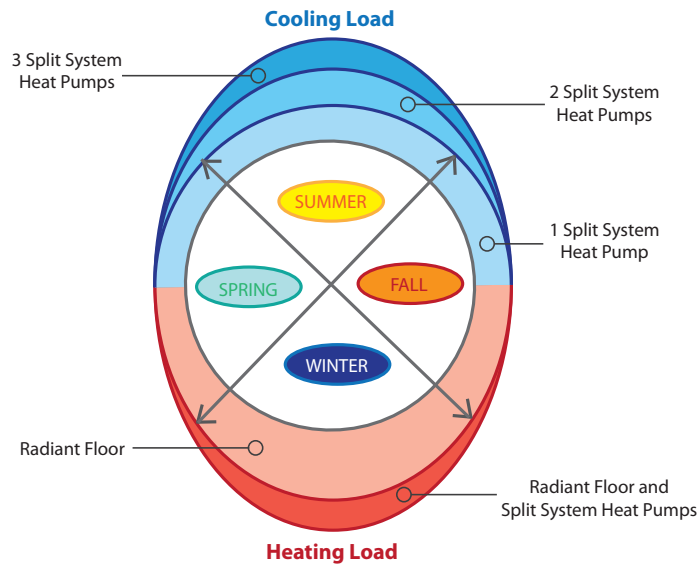
Related to the solar thermal and plumbing systems by the Rotex tank, the heating system consists of a hydronic radiant floor system. The radiant floor heating will cover steady state loads in the winter and meet the full heating load of the house in the spring and autumn. The radiant floor consists of Warm-board™ subflooring with an integrated aluminum plate and channels for increased heat transfer and improved transient response. Three high efficiency Grundfos pumps are used in conjunction with an advanced controller from Tekmar to create an injection mixing system that varies both the temperature of the water and the flow rate to each zone of the radiant floor. Solar House I's radiant floor system is much more complex than a typical flow rate controlled installation; the controller also models its response in conjunction with changes in the outside temperature. This design allows for an efficient and responsive system which generates even and consistent indoor temperatures.

### Mini-Split Heat Pumps for Cooling and Back-up Heating

With three separately controlled mini-split heat pumps operating fan coil units inside the building envelope, the mini-split heat pump system will supplement the radiant floor in extreme heating load and in transient conditions. However, the primary function of the mini split systems is to meet the cooling loads of Solar House I. To maximize efficiency in the extremely variable Ohio climate, instead of one large system that would be designed for the peak cooling load, three small heat pumps are used. In the autumn and spring the cooling load will be significantly less than the maximum summer value. Thus, by using three independently operating fan coils, the control strategy will be able to stage the output of each unit to minimize power consumption and eliminate temperature variability throughout the living space. Furthermore, the separate heat pumps in the system can target problem areas in each zone individually.



Finally, the selected Mitsubishi mini-split systems have SEER ratings of 25. The mini-split system has been designed to effectively cool in the summer as well as support the radiant floor heating loads in the winter. Figure 12.3.6 illustrates the staging strategy of the radiant floor and mini-split system heat pumps.



**Figure 12.3.6: Staging of Heating and Cooling Strategies in Solar House I**

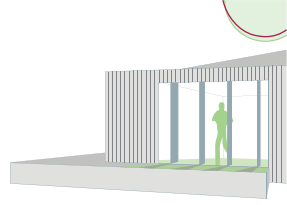
### Hot Water Heat Pump and Point-of-Use Water Heater

In designing the solar thermal collection system and array the team realized that trade-offs had to be made between the size of the PV array and the size of the evacuated tube array. As a result, when several days of cloudy conditions prevail, there may be a significant drop-off in solar hot water production. To maintain the operating temperature of the Rotex hot water storage system, a high efficiency air-to-water heat pump hot water heater was selected to supplement the evacuated tube array.

Household activities such as washing clothes, showering, and doing the dishes are considered essential to daily life. These activities must have an adequate hot water supply. In rare situations, outdoor conditions may not result in sufficient hot water being produced despite the combined contributions of both the evacuated tube array and the heat pump hot water heater. To ensure that hot water is always available, a point-of-use water heater has been included in the mechanical system.

### Energy Recovery Ventilation System

The ventilation requirements of the house will be met through the use of the UltimateAir Recouper-Aerator 200DX energy recovery ventilator. The energy recovery ventilator ensures that any intake air is preheated or cooled, depending on the season, before entering the conditioned space. A CO<sub>2</sub> sensor located in the return vents will determine when mechanical ventilation is necessary. The return for the ventilator will be placed near the bedroom area in order to achieve even temperature distribution and ensure a consistent temperature distribution within the entire conditioned space.



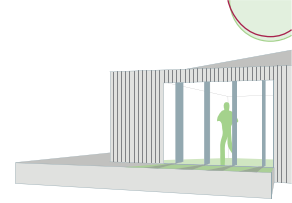
## Home Automation and Controls

### Home Automation

In Solar House I, the home automation system will monitor and control lighting, appliances, HVAC equipment, the photovoltaic array and the solar thermal hot water heating system. The home automation system is based on the BuildingLogiX™ interface and the NiagaraAX Framework®. Using the NiagaraAX Framework®, developers are able to quickly produce web-based applications which support user/computer interaction with smart devices and sensors. In the case of Solar House I, the BuildingLogiX™ interface provides a web-based dashboard panel which presents the user with data on the energy consumption of the building. Figure 12.3.7 shows a month of hourly energy consumption for a current BuildingLogix™ client. The dashboard displays real time or historical data results for electricity use, and breaks the overall consumption into categories. In Figure 12.3.7, these categories are “General Electricity”, “HVAC”, and “Lighting”. The total energy consumption is also shown. The BuildingLogix™ application for Solar House I will have its own set of monitoring categories.

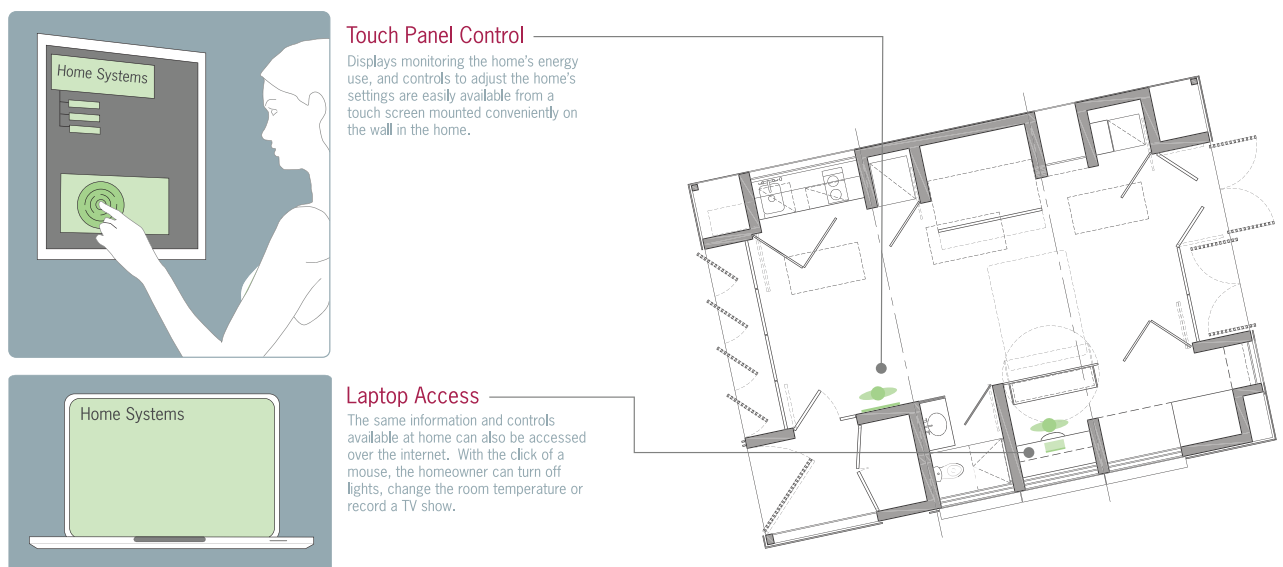


**Figure 12.3.7: BuildingLogiX Online Dashboard Displaying Hourly Electricity Consumption for a Month**

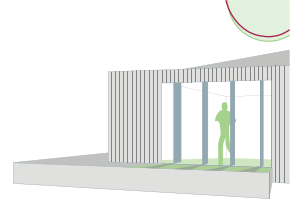


By monitoring the energy consumption of the home and displaying the results in an easy to understand format, the homeowner can make informed decisions on how to improve the overall energy efficiency of their home. Another feature of the home automation system is the ability to use the internet to keep the occupant updated on the status of his or her house from anywhere with an internet connection. The house's online "home page" will display an easy-to-read, real-time graphic showing the house's energy production and consumption, as well as the temperature and humidity. Changes in the settings for the home can quickly and easily be achieved from the same online location. For in-house control, as shown in Figure 12.3.8, the home automation settings in Solar House I, can be adjusted from a touch screen panel located on the wall in the main central space or from the home's computer. Inspired by American Electric Power's GridSmart program, the occupant can view a suggested schedule for daily tasks such as washing clothes or taking a shower that is based on both off-peak electricity rates and future weather conditions. By taking weather predictions into account, the home automation system can suggest to the user that he/she take advantage upcoming weather conditions to reduce energy consumption. For example, if the user wishes to wash clothes using hot water and the current conditions are cloudy, the home automation system may suggest waiting for an upcoming sunny day for optimal hot water production and better air drying conditions. Eventually the house would actually communicate with a so-called "smart grid."

Not only can daily tasks be arranged with the BuildingLogiX™ software, but the homeowner can create pre-set "scenes" which change the home's configuration with the click of a button. For example, one scene could be "dinner party" where all of the main central space lights were dimmed, except for those in the kitchen area, and the temperature was turned down to account for the increased occupancy expected for the evening. Another scene could be "vacation" where all lights were turned off and the HVAC equipment was turned off except for essential functions. The options for pre-set scenes would only be limited by the imagination of the homeowner and the house functions that can be controlled.



**Figure 12.3.8: Locations of Home Automation Accessibility**

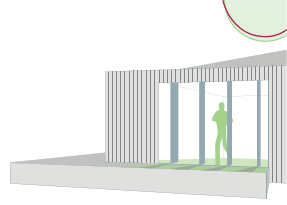


## Sensors and Control

Each zone of the house will be monitored by a variety of sensors connected to the JACE, including those for daylighting, carbon dioxide, temperature, and humidity. Data from the sensors will be used to determine what actions the different systems of the house will take. For example, light sensors will control the light level to save as much energy as possible during daylight hours. HVAC related control is accomplished with carbon dioxide sensors located in the HVAC return vents will determine when mechanical ventilation needs to occur. Temperature and relative humidity sensors, also located in the return vents, will control the various heating and cooling systems of the house. A full listing of monitored and controlled house functions is listed in Table 12.3.1. This list covers controls for lighting, hot water heating and HVAC controls, but all of the energy consuming appliances in the home will be monitored for overall energy consumption as well. An "X" is shown in the locations where a monitored house function controls a corresponding automated function. The resulting controls will result in even greater efficiency gains over the already properly sized and innovatively employed appliances, lighting and HVAC Equipment.

**Table 12.3.1: List of Controlled and Monitored House Functions**

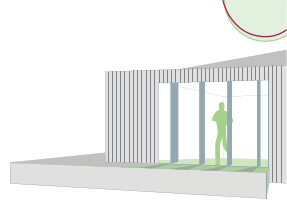
Monitored	Controlled	Light 1 Level	Light 1 (On/Off)	Light 2 Level	Light 2 (On/Off)	Mini-Split 1 (On/Off)	Mini-Split 2 (On/Off)	Mini-Split 3 (On/Off)	Radiant Floor (On/Off)	ERV (On/Off)
Light Sensor 1		x	x							
Light Sensor 2				x	x					
Radiant Temperature Sensor						x	x	x	x	
Duct Sensor 1- Temperature						x	x	x		
Duct Sensor 1- Humidity						x	x	x		
Duct Sensor 1- CO2										x
Duct Sensor 2- Temperature										
Duct Sensor 2- Humidity										
Duct Sensor 2- CO2										x
Mini Split Contact Terminal 1						x				
Mini Split Contact Terminal 2							x			
Mini Split Contact Terminal 3								x		
Radiant Floor On/Off Signal									x	
Rotex Tank Temperature Differential									x	
Forecast- Temperature						x	x	x	x	
Forecast- Cloud Cover						x	x	x	x	
Light Switch 1		x	x							
Light Switch 2				x	x					
Manifold Temperature, Zone 1									x	
Manifold Temperature, Zone 2									x	
Manifold Temperature, Zone 3									x	
Outgoing Tank Temperature									x	



## Summary

The engineering systems incorporated in Solar House I will work together to maximize energy efficiency while improving occupant comfort. The solar photovoltaic array uses innovative Bifacial solar panels and a flexible PV racking system that can easily adjust for improved power collection. The solar thermal hot water heating system uses a unique hot water tank which allows for the support of both domestic hot water and radiant floor hydronic heating loads. An innovative staging system is being employed to meet year round heating and cooling loads as efficiently as possible. Finally, our home automation system encompasses all of the facets of the home, to continuously monitor energy use and improve the homeowners understanding of how they can reduce energy consumption. Overall, the engineering system successfully demonstrates that energy conserving techniques and solar energy production can be successful in Ohio by using efficient, adaptive engineering solutions.





## 12.4 Lighting Design Narrative

The lighting scheme offers a complimentary language to the architectural design. The lighting provides both ambient and task settings set by an over arching theme of individual user control. Energy Star fixtures provide the house with ample light while minimizing the draw to illuminate the space.

Daylight floods the central space and illuminates the translucent insulated window wall to the South throughout the day. Southern exposure provides sufficient light for the occupied program components and reaches into the center space, providing an ambient glow. In the late afternoon and evening hours, the sunlight is controlled with vertical louvers on the West facade. Light reflects off the cooling pond allowing light to filter into the house.

A collection of dimmable linear fixtures is organized according to program zones, and suggest public and private space. The lights are able to respond and be calibrated to different tasks.

To that end, task based lighting is provided with daylight and contact sensors to illuminate specific areas when needed. In the evening, the light within the house percolates through the second skin, emanating a soft lit presence into the surroundings. The integration of day and night lighting schemes works in tandem with the passive and active systems of the house. Conscious of scientific studies regarding Circadian rhythms, night lighting glows with warmer colors which the body associates with night time.

