

MISSOURI S&T  
**CHAMELEON HOUSE**



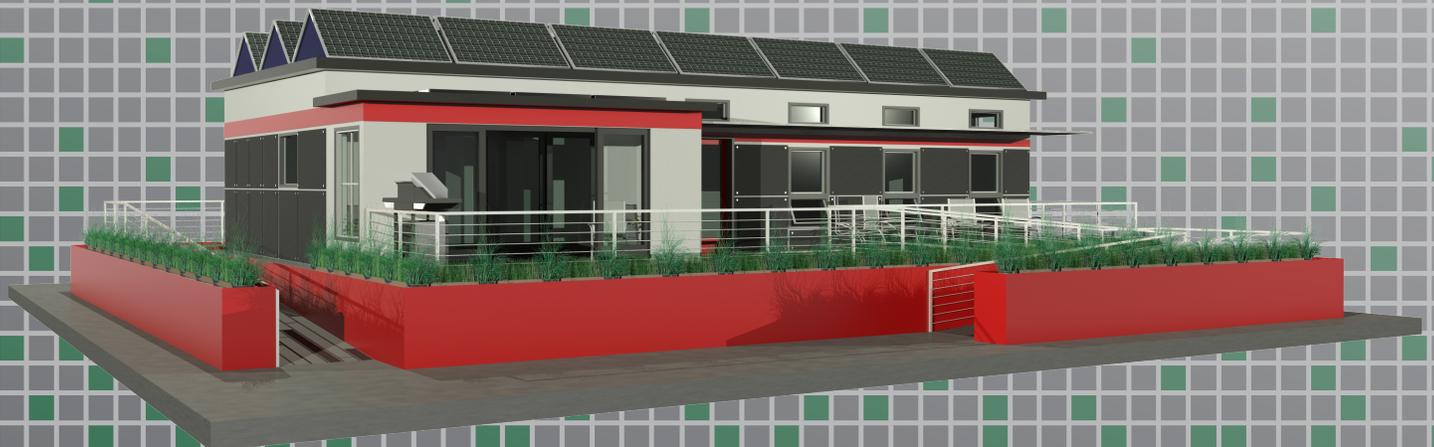
# Project Manual

As-Built Document

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2013  
August 22, 2013

1051 North Bishop Avenue  
116 Kummer Student Design Center  
Rolla, Missouri 65409

[solarhouse.mst.edu](http://solarhouse.mst.edu)  
[solarhouse@mst.edu](mailto:solarhouse@mst.edu)  
(573) 341-7546



# Acronyms

AAMA: American Architectural Manufacturers Association

ACI: American Concrete Institute

AISC: American Institute of Steel Construction

ASTM: ASTM International (previously American Society for Testing and Materials)

CFM: Cubic Feet per Minute

DOT: Department of Transportation

IGMA: Insulating Glass Manufacturers Alliance

NFPA: National Fire Protection Association

NREL: National Renewable Energy Laboratory

NRFC: National Fenestration Ratings Council

O.C.: Over Center

OSHA: Occupational Safety and Health Administration

Pa: Pascal

PSF: Pounds per square foot

PVC: Polyvinylchloride

RCSC: Research Council on Structural Connections

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## Summary of Changes

The Missouri S&T Solar House Team continues to make improvements and develop all aspects of the Chameleon House construction documents. The following Project Manual has been updated and the list of changes from the previous submission is listed below.

### 11.20.2012 Submission

The Rules Compliance Checklist has been filled out for reference to the construction drawings.

Details for the supply and waste water tanks were added in the construction drawings and referenced in the Project Manual

The Summary of Reconfigurable Features was updated to reflect the demonstration of the features to the public as well as the juries.

The Design Narratives were removed.

Water storage tank information including location and typical equipment reference was added.

Structural drawings and calculations were added in the appendix with the NTS report proving Seismic Category D compliance.

### 8.22.2013 Submission

Summary of Reconfigurable Features: the moving cabinet system in the bedroom and kitchen has been removed.

Section 09 29 00 - 2.2 Backer Board was removed.

Section 09 29 00 – 3.2 Backer Board Installation was removed.

Section 09 30 00 – 2.1A.2. changed tile dimensions from 3”x6” to 6”x24”

Section 09 30 00 – 2.1A.4. changed the finish to ceramic.

Section 23 50 00 – 2.2A.1. change 36,000 BTU/h to 18,000 BTU/h

Deleted Section 26 27 29 Car Charger

Section 22 41 00 – 2.2A Product Changes

Section 22 41 00 – 2.2B Product Changes

Section 22 41 00 – 2.3A Product Changes

Section 26 50 00 – 2.2E Product Addition

Section 11 31 00 – 2.1D. Changed Clothes Washer Model

Section 11 31 00 – 2.1E. Changed Clothes Dryer Model

Section 2.1 A 1

## Rules Compliance Checklist

Rule	Rule Description	Location Description	Location
4-2	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy on the competition site	“O” Series
4-2	Construction Equipment	Specifications for heavy machinery	02 43 13
4-3	Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	26 05 26
4-4	Impact Within the Solar Envelope	Drawing(s) showing the location, contact area, and bearing pressure of every component resting directly within the solar envelope	C-104
4-5	Generators	Specifications for generators (including sound rating)	01 50 00
4-6	Spill Containment	Drawing(s) showing the locations of all equipment, containers, and pipes that will contain liquids at any point during the event	H-101, H-102, H-103
4-6	Spill Containment	Specifications for all equipment, containers, and pipes that will contain liquids at any point during the event	Division 22, Division 21
4-7	Lot Conditions	Calculations showing that the structural design remains compliant even if 18 in. of vertical elevation change exists	See Structural Calculations
4-7	Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 18 in. of vertical elevation change exists on the lot	C-501
5-2	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	G-201, G-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 drawing and project manual sheets that have been or will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual	See Structural Calculations
6-2	Finished Square Footage	Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically	G-101
6-2	Finished Square Footage	Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week	N/A
6-3	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route	G-103
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

7-2	Watering Restrictions	Drawing(s) showing the layout and operation of greywater irrigation systems	N/A
8-1	PV Technology	Specifications for photovoltaic components	26 31 00
8-3	Batteries	Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand alone, PV-powered devices	N/A
8-3	Batteries	Specifications for all primary and secondary batteries and stand-alone, PV-powered devices	26 33 13
8-4	Desiccant Systems	Drawing(s) describing the operation of the desiccant system	N/A
8-4	Desiccant Systems	Specifications for desiccant system components	N/A
8-5	Village Grid	Completed interconnection application form	Project Manual, page 51
8-5	Village Grid	Drawing(s) showing the locations of photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	“E” series, C-103
8-5	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means	26 31 00, 48 19 16, 26 05 26, 26 27 13
8-5	Village Grid	One-line electrical diagram	E-601
8-5	Village Grid	Calculation of service/feeder net computed load per NEC 220	E-603
8-5	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box	A-101
8-5	Village Grid	Elevation(s) showing the meter housing, main utility disconnect, and other service equipment	E-201
9-1	Container Locations	Drawing(s) showing the location of all liquid containers relative to the finished square footage	“H” series, “P” series
9-1	Container Locations	Drawing(s) demonstrating that the primary supply water tank(s) is fully shaded from direct solar radiation between 9 am and 5 pm PDT	A-101, G-601
9-2	Team-Provided Liquids	Quantity, characteristics, and delivery date(s) of all team-provided liquids for irrigation, thermal mass, hydronic system pressure testing, and thermodynamic system operation	N/A
9-3	Greywater Reuse	Drawing(s) showing the layout and operation of greywater reuse systems	N/A
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 liquid-based thermal mass systems	N/A
9-6	Thermal Mass	Specifications for components of liquid-based thermal mass systems	N/A
9-7	Greywater Heat Recovery	Drawing(s) showing the layout and operation of greywater heat recovery systems	N/A
9-8	Water Delivery	Drawing(s) showing the complete sequence of water delivery and distribution events	P-101
9-8	Water Delivery	Specifications for the containers to which water will be delivered	22 12 00

9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events	P-101
9-9	Water Removal	Specifications for the containers from which the water will be removed	22 12 00
11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route	G-103

## Detailed Water Budget

Function	Gallons	Events	Total Gallons	Notes
Hot Water Contest	15	15	270	Amount includes extra for waste and spillage.
Water Vaporization	4	1	4	
Dishwasher	3.5	5	17.5	Amount per use according to manufacturer's instructions.
Clothes Washer	14	8	112	Amount per use according to manufacturer's instructions.
Fire Protection	150	1	150	Rough estimate pending final system design.
Testing	50	1	50	50 gallons total for all testing over all days.
Initial System Fill	150	1	150	108 gallon storage tank, solar thermal piping, radiant piping, approximately 1 hour to fill system
Extra	89.2	1	89.2	Extra to fill tank to capacity
		<b>TOTAL</b>	<b>1000.0</b>	

## Summary of Reconfigurable Features

The Chameleon House design concept is “an adaptable living environment”. To create this environment, there are many moving and reconfigurable features in the home. These features will be demonstrated during the public tours and architecture, engineering, and market appeal juries.

### **Chameleon Skin Panels**

Chameleon House is equipped with seasonally transitional exterior siding panels installed on the south and west facades of the house. The Panels are manually hung to the exterior façade of the house. The panels are finished with a light reflective side and a dark absorptive side. The panels are a literal representation of the design concept that aid in controlling heat gain.

### **Folding Glass Walls**

Manually operable full glass doors located in the interior of the structure used to separate the solarium and the kitchen dining area. The doors allow for partial to full access to the solarium depending on the tenants preference. These doors not only regulate the space, but also serve as a passive solar feature. When closed, the solarium becomes a buffer between the house and the outside environment. When opened, the heat collected in the solarium is used to warm up the house. Controlling the environment is a large part of our concept, and the doors are a large part in our efforts in this area.

### **Partition Wall**

The wall that separates the bedroom and the main living area is able to be rolled back in order to create more space in the main living area. In order to open the wall, the wall is collapsed and stored in a closet. Reconfigurable features are used in the bedroom as well in order to allow for a seamless look between the main living area and the bedroom. The wall allows the tenants to customize the space and maximize the usefulness of the house’s limited space.

### **Murphy Bed**

The bed in the Chameleon House is a Murphy bed. This allows the bed to be stored in the wall when the partition wall is open and the bedroom is included in the main living area. The Murphy bed is another example of the bedroom transforming and allowing the space to be used for multiple different uses.

### **Desk**

Like the Murphy bed, the desk also folds up into the wall. This allows the desk to be stored in the wall when the partition wall is open and the bedroom is included in the main living area. The desk is another example of the bedroom transforming and allowing the space to be used for multiple different uses.

### **Grid**

The Grid is an intricate shelving unit spanning the wall between the bathroom and the main living area. Within each shelf is a cube that can be removed and used about the home in a variety of ways. Each cube is different size and can serve a different purpose. Some proposed uses of these cubes include additional seating, temporary tables, and additional storage that can be used around the

home. The removable cubes within the Grid allow the tenant to customize his/her storage needs and adapt the living space to the way he/she needs it.

**Table**

Three small, square tables are used in the Chameleon House in order to accommodate multiple configurations for the tenant's dining needs. The tables can be used alone if only two people are eating, or pushed together to host a large dinner party.

# Interconnection Application Form

Team Missouri S&T, Lot 107

## PV Systems

Module Manufacturer	Short Description of Array	DC Rating of Array (sum of the DC ratings)
tenKsolar Wave XT	21 tenKsolar Model XT-A 410W-P modules, arranged in 3 rows of 7, 11 connected in a parallel string, and 10 connected in second parallel string	8.61 kW
Panasonic	10 Panasonic Model VBHB195DA03 bi-facial modules arranged in 2 series connected row of 5 each as the front overhang	1.95 kW

Total DC power of all arrays is 10.5 kW (in tenths)

## INVERTERS

Inverter Manufacturer	Model Number	Voltage	Rating (kVA or KW)	Quantity
Sustainable Energy Technologies	Sunergy ELV 240	240 VAC	5 kW	2
Kaco	Blueplanet 1502xi	240 VAC	2.5 kW	1

Total AC power of all inverters is 12.5 kW (in tenths)

## REQUIRED INFORMATION

The following information is included in the project manual or construction documents.

	Location
One-Line Electrical Schematic	E-601
Calculations of service/feeder net computed load and neutral load (NEC 220)	E-603
Plan view of the lot showing the house, decks, ramps, tour paths, the service point, and the distribution panel or load center	A-101, G-103, E-104

Team Missouri S&T's Electrical Engineer is Jonathan Kimball. His contact information can be found in the Team Officer Contact Information database on the Solar Decathlon Yahoo Group.

# Wire Calculations

See Appendix A

# Structural Calculations

See Appendix B

## Construction Documents

See Construction Drawings of the Chameleon House submitted to the Solar Decathlon Organizers on August 22, 2013.

DIVISION 00

**PROCUREMENT AND  
CONTRACTING**



**SECTION 00 31 00  
AVAILABLE PROJECT INFORMATION**

**PART 1 GENERAL**

**1.1 PRELIMINARY SCHEDULE BY PHASE**

- |    |                                   |                                       |
|----|-----------------------------------|---------------------------------------|
| A. | Schematic Design                  | January 2012 – April 2012             |
| B. | Design Development Phase          | April 2012 – July 2012                |
| C. | Construction Documents Phase      | June 2012 – October 2012              |
| D. | Construction Phase                | November 2012 – June 2013             |
| E. | System and Building Testing Phase | July 2013 – August 2013               |
| F. | Competition Phase                 | September 22, 2013 – October 18, 2013 |

**1.2 PROJECT BUDGET**

- A. Construction Budget: \$263,000
- B. Total Project Budget: \$361,000

**1.3 CONSTRUCTION FACILITY**

- A. The Chameleon House will be constructed on an outdoor site provided by Missouri S&T.
  - 1. 900 Innovation Drive, Rolla, MO 65401

**END OF SECTION 00 31 00**

DIVISION 01

**GENERAL**

**REQUIREMENTS**



SECTION 01 10 00  
SUMMARY

PART 1 GENERAL

1.1 PROJECT INFORMATION

- A. Project: Chameleon House, S&T Solar Decathlon 2013
  - 1. Construction Location: 900 Innovation Drive, Rolla, MO 65401
  - 2. Competition Location: Orange County Great Park, Irvine, CA
- B. Owner: Missouri S&T Solar House Team
- C. Architect: Missouri S&T Solar House Team
- D. Contractor: Missouri S&T
- E. Work: Design, construction, disassembly, transportation, and reassembly of a 1,000 square foot solar powered house
- F. Work by Owner
  - 1. General Construction
  - 2. Framework
  - 3. Window and Door Installation
  - 4. Drywall Installation
  - 5. Finishing
  - 6. PV Array Installation
  - 7. Wiring and Plumbing
- G. Owner Furnished Items: The following items will be provided by the owner to be installed by the contractor:
  - 1. EZ Floor
  - 2. Honda Generator
  - 3. All materials and products donated to the team for use in the Chameleon House

END OF SECTION 01 10 00

SECTION 01 25 00  
SUBSTITUTION PROCEDURES

PART 1 GENERAL

1.1 DEFINITIONS

- A. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the contract documents and proposed by Contractor.
1. Substitutions for Cause: Changes proposed by Contractor that are required due to changed project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
  2. Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other project requirement but may offer advantage to Contractor or Owner.

1.2 SUBSTITUTION REQUESTS

- A. Submit three (3) copies of each request for consideration. Identify product or fabrication or installation method to be replaced. Include specification section number and title and drawing numbers and titles. Show compliance with requirements for substitution and the following, as applicable:
1. Statement indicated why specified product or fabrication or installation cannot be provided, if applicable.
  2. Coordination information, including a list of changes or modifications needed to other parts of the work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
  3. Detailed comparison of significant qualities of proposed substitution with those of the work specified, include annotated copy of applicable specification section. Significant qualities may include attributes such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated. Indicate deviations, if any, from the work specified.
  4. Product data, including drawings and descriptions of products and fabrication and installation procedures.
  5. Samples, where applicable or requested.
  6. Certificates and qualification data, where applicable or requested
  7. List of similar installations for completed projects with project names and addresses and names and addresses of Architects and Owners.
  8. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated
  9. Research reports evidencing compliance with building codes in effect for project
  10. Detailed comparison of Contractor's construction schedule using proposed substitution with products specified for the work, including effect on the overall contract time. If specified product or method of construction cannot be provided within the contract time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.
  11. Cost information, including a proposal of change, if any, in the contract sum.
  12. Contractor's certification that proposed substitution complies with requirements in the contract documents except as indicated in substitution request, is compatible with related materials, and is appropriate for applications indicated.

13. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.

- B. Architect's Action: If necessary, architect will request additional information or documentation for evaluation within seven days of receipt of a request for substitution, Architect will notify of acceptance or rejection of proposed substitution within 15 days of receipt of request, or seven days of receipt of additional information or documentation, whichever is later.
  - 1. Forms of Acceptance: Change order, construction change directive, or Architect's supplemental instructions for minor changes in the work.
  - 2. Use product specified if Architect does not issue a decision on use of a proposed substitution within time allocated.

### 1.3 QUALITY ASSURANCE

- A. Compatibility of Substitutions: Investigate and document compatibility of proposed substitution with related products and materials. Engage qualified testing agency to perform compatibility tests recommended by manufacturers.

### 1.4 COORDINATION

- A. Modify or adjust affected work as necessary to integrate work of the approved substitutions.

### 1.5 SUBSTITUTIONS

- A. Substitutions for Cause: Submit request for substitution immediately upon discovery of need for change, but not later than 15 days prior to time required for preparation and review of related submittals.
  - 1. Conditions: Architect will consider Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, Architect will return requests without action, except to record noncompliance with these requirements.
  - 2. Requested Substitution is consistent with the contract documents and will produce indicated results.
    - a. Substitution request is fully documented and properly submitted.
    - b. Requested substitution will not adversely affect Contractor's construction schedule.
    - c. Requested substitution has received necessary approvals of authorities having jurisdiction
    - d. Requested substitution is compatible with other portions of the work.
    - e. Requested substitution has been coordinated with other portions of the work.
    - f. Requested substitution provides specified warranty.
    - g. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
- B. Substitutions for Convenience: Architect will consider requests for substitution, when the following conditions have been satisfied, and if received within 60 days after the notice to proceed. Requests received after that time may be considered or rejected at the discretion of architect. If the following conditions are not satisfied,

architect will return requests without action, except to record noncompliance with these requirements:

1. Requested substitution offers Owner a substantial advantage in cost, time, energy conservation, or other considerations, after deducting additional responsibilities owner must assume. Owner's additional responsibilities may include compensation to Architect for redesign and evaluation services, increased cost of other construction by Owner and similar considerations.
2. Requested substitution does not require extensive revisions to the contract documents.
3. Requested substitution is consistent with the contract documents and will produce indicated results.
4. Substitution request is fully documented and properly submitted.
5. Requested substitution will not adversely affect contractor's construction schedule.
6. Requested substitution has received necessary approvals of authorities having jurisdiction.
7. Requested substitution is compatible with other portions of the work.
8. Requested substitution has been coordinated with other portions of the work.
9. Requested substitution provides specified warranty.
10. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

END OF SECTION 01 25 00

**SECTION 01 50 00  
TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS**

**PART 1 GENERAL**

**1.1 SECTION REQUIREMENTS**

- A. Electric Power: Available from a portable generator provided by the team. Connections will also be provided by the team as a part of the site preparation
- B. Electric Service: Comply with NECA and NEMA standards and regulations for temporary electric service.

**PART 2 PRODUCTS**

**2.1 OWNER PROVIDED EQUIPMENT**

- A. Generator
  - 1. Honda EU3000iS Portable Generator
  - 2. AC output: 120V, 3000W max
  - 3. Sound Level:
    - a. Manufacturer's rating: 58 dB(A) @ rated load
    - b. Manufacturer's rating: 49 dB(A) @ ¼ rated load
      - 1) From manufacturer's specifications: "Noise levels at rated load to reflect maximum noise levels possible, measured at 9 Feet (3 Meters) from the control panel side of the generator"
      - 2) From Decathlon rules: "Engine generators shall not exceed 60 dB (A) at 50 ft (15 m) under full load per the manufacturer's listed sound rating."
      - 3) Team supplied generator does not exceed maximum sound rating (60dB(A)) enforced by Decathlon rules. Also, maximum sound rating of team supplied generator was generated under more stringent test conditions than Decathlon requirement (9 ft. test radius in actual test versus 50 feet required radius).

**PART 3 EXECUTION**

**3.1 TEMPORARY UTILITY INSTALLATION**

- A. Owner will provide an array of halogen bulb construction lights to provide adequate illumination for construction operations, observations, and inspections.

**END OF SECTION 01 50 00**

**SECTION 02 43 13  
 BUILDING RELOCATION**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. This section includes the methods, equipment, and schedules necessary for the transportation of The Chameleon House from Rolla, Missouri to Irvine, California and back.

**1.2 SYSTEM DESCRIPTION**

- A. All building components are permanently mounted on custom-built steel members of standard sizes.
- B. The 3 house trailers will be pulled by semi-trucks. The DOT has established these vehicle limits: 102 inches wide, 13.5 feet in height, and 80,000 pounds gross weight. These limits can be exceeded as individual states have the right to issue temporary oversize and/or overweight permits.
- C. The 6 OM trailers will be pulled by any standard Medium Duty 3/4 - 1 ton truck.
- D. Design Requirements:
  - 1. The Chameleon House is designed as a group of connectable parts, each of which shall not exceed the allowable dimensions of a flatbed truck, nor shall it exceed the allowable dimensions for highway transportation under federal highway laws. All components shall not exceed 13 feet 6 inches in height from ground when resting on the bed of the truck[s].
  - 2. The OMs are designed to sit on standard 8' wide trailers, which can legally be pulled by medium duty trucks. All components of the trailer shall not exceed the allowable dimensions for highway transportation under federal highway laws.

**1.3 SUBMITTALS**

- A. Site Operations and Transportation Plan Solar Decathlon 2013 will include trailer specifications, route information, delivery information and site operations.

**1.4 PERFORMANCE REQUIREMENTS**

- A. The Chameleon House as a whole must perform identically before and after transportation and re-construction.
- B. The Chameleon House as a series of parts shall be transported using specified packing and securing methods and no components shall be damaged during transportation.

**PART 2 EXECUTION**

**2.1 QUALITY ASSURANCE**

- A. Ensure that product is in proper and good working order before accepting the delivery of the product.

## 2.2 DELIVERY, STORAGE, & HANDLING

- A. The exact time of delivery to Irvine, California shall be coordinated with the team's and the organizer's schedule.
- B. Additional transportation:
  - 1. Conditioned flower trucks for all plants.
  - 2. Trailer for tools.
  - 3. Moving truck for furnishings
- C. All trailers shall be wrapped with waterproof wrapping to protect the canopy, the decking, and finish surfaces. For the three main house trailers, temporary structure shall be constructed at marriage lines to protect the interior of the trailers.

## 2.3 INSTALLATION

- A. The Chameleon House and all of its components shall be disassembled, reassembled, packed, secured, and shipped by designated individuals in accordance with the specified instructions.

END OF SECTION 02 43 13

DIVISION 03

**CONCRETE**

**SECTION 03 10 00  
 CONCRETE FORMING AND ACCESSORIES**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES**

- A. Layout of formwork
- B. Formwork Construction
- C. Embedded Items and Openings in Concrete
- D. Form Release Materials
- E. Removal of Forms
- F. Field Quality Control
- G. Detection of Movement
- H. Re-use of Forms

**1.2 RELATED SECTIONS**

- A. The following is a list of Specifications which may be related to this section:
  - 1. Section 03 11 00 – Concrete Forming
  - 2. Section 03 15 00 – Concrete Accessories

**1.3 REFERENCES**

- A. American Concrete Institute (ACI):
  - 1. ACI 117 – Standard Specifications for Tolerances for Concrete Construction and Materials.
  - 2. ACI 301 – Specifications for Structural Concrete
  - 3. ACI 318 – Building Code Requirements for Structural Concrete
  - 4. ACI 347 – Guide to Formwork for Concrete

**1.4 SUBMITTALS**

- A. General:
  - 1. Alternate form system configurations require preparation by a licensed Professional Engineer and submittal to Engineer for review and approval.

**1.5 QUALITY ASSURANCE**

- A. Formwork standards in accordance with ACI 117, ACI 301, ACI 318, and ACI 347.

**1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver void forms and installation instructions in manufacturer’s packaging.
- B. Store void forms off ground in ventilated and protected manner to prevent deterioration from moisture.
- C. Storage of release agents and surface retarders: Release agents and surface retarders shall be stored in sealed containers marked to identify the contents and protected

from exposure to conditions that may affect the material. The materials shall be stored in accordance with manufacturer's recommendations and shall not be used after the recommended shelf life has been exceeded.

- D. Lift form panels by methods that will protect panels from damage and distortion.

## 1.7 JOB CONDITIONS

- A. Allow sufficient time between erection of forms and placing of concrete for the various trades to properly install concrete reinforcement, embedded items, sleeves, and blockouts.
- B. Do not apply superimposed loads to the structure until concrete has developed its specified 28-day compressive strength.

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. Lumber: Boards and framing lumber shall be that of Standard Grade lumber.
  1. Boards: Provide either Construction or Standard Grade Boards. Use dressed side of lumber for surface in contact with the concrete and provide boards with dressed or tongue-and-groove edges to provide tight joints to prevent mortar leakage.
  2. Framing Lumber:
    - a. All framing lumber stress-graded.
    - b. Lumber in direct contact with concrete, dressed on at least the contact side, with dressed or tongue-and-groove edges; other lumber may be dressed or rough.
- B. Except for metal forms, use new materials. Materials may be re-used during progress of the work, provided they are completely cleaned and reconditioned, recoated for each use, and capable of producing formwork of the required quality.
- C. Form Release Agent shall not bond with, stain, or adversely affect concrete surfaces, and shall not impair subsequent treatments of concrete surfaces when applied to forms. A ready-to-use water based material formulated to reduce or eliminate surface imperfections, containing no mineral oil or organic solvents. Environmentally safe, meeting local, state, and federal regulations and can be used in potable water facilities.

### 2.2 FABRICATION

- A. Formwork – General: Fabricate forms in accordance with approved Shop Drawings. Maintain forms clean, smooth, and free form imperfections and distortion. Fabricate forms from architectural concrete in accordance with applicable requirements of ACI 301.
- B. Joints:
  1. Arrange form panels in symmetrical patterns conforming to general lines of the structure.
  2. Unless otherwise indicated, orient panels on vertical surfaces with long dimension horizontal, and make horizontal joints level and continuous.
  3. Align form panels on each side of the panel joint with fasteners common to both panels, and in manner which will result in a continuous, unbroken concrete plane surface.

- C. Steel Forms: Use material which is clean, smooth, and free from warps, bends, kinks, rust, cracks, and matter which may stain concrete. Fabricate panels in accordance with approved Shop Drawings. Deflection between form supports from concrete placement shall not exceed 1/240 of the span length.

**PART 3 EXECUTION**

**3.1 FORMWORK**

- A. Erect formwork, shoring and bracing to achieve design requirements, in accordance with requirements of ACI 301.
- B. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.
- C. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.
- D. Arrange form-facing material in an orderly and symmetrical manner with a minimum of seams.
- E. Align joints and make watertight. Keep form joints to a minimum.
- F. Obtain approval before framing openings in structural members that are not indicated on drawings.
- G. Provide chamfer strips on external corners of beams, joists, and columns.
- H. Coordinate this section with other sections of work that require attachment of components to formwork.
- I. If formwork is placed after reinforcement, resulting in insufficient concrete cover over reinforcement, request instructions from SJCF before proceeding.

**3.2 EMBEDDED ITEMS IN CONCRETE**

- A. Set in place and build into the work all anchorage devices and other embedded items required for other work that is attached to, or supported by cast-in-place concrete.
- B. Place accurately all anchor bolts and other embedded items using setting drawings, diagrams, etc., provided by suppliers of the items to be attached.

**3.3 FORM RELEASE AGENT**

- A. Apply form release agent on formwork in accordance with manufacturer's recommendations.
- B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.
- C. Do not apply form release agent where concrete surfaces are indicated to receive special finishes or applied coverings that are affected by agent. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.
- D. Reuse and Coating of Forms: Thoroughly clean forms and reapply form coating before each reuse. For exposed work, do not reuse forms with damaged faces or edges. Apply form coating to forms in accordance with manufacturer's specifications. Do not coat

forms for concrete indicated to receive “scored finish”. Apply form coatings before placing reinforcing steel.

### 3.4 FORMWORK TOLERANCES

- A. Construct formwork to maintain tolerances required by ACI 117.
- B. Camber slabs and beams in accordance with ACI 301.

### 3.5 FIELD QUALITY CONTROL

- A. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and to verify that supports, fastenings, wedges, ties, and items are secure.
- B. Formwork that has been previously used shall be repaired and the edges resealed before it is erected. Formwork that has deteriorated to an extent such that it will not product the specified finish shall not be reused.
- C. Formwork shall not have any splits, cracks or other defects. The faces and edges of formwork shall be clean and formwork faces shall be free of projecting nails.
- D. Retighten forms immediately before, during, or after concrete placement as may be required to eliminate leaks.

### 3.6 REMOVAL OF FORMS

- A. Non-supporting forms (sides of beams, walls, columns, and similar parts of work) may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:
  - 1. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
  - 2. Curing protection operations are maintained.
- B. Elevated Structural Slabs or Beams: In accordance with ACI 318/318R, Chapter 6, and at such time as concrete has reached compressive strength equal to 80 percent of specified 28-day compressive strength as determined by test cylinders.
- C. Wood formwork shall be removed in a manner that allows the contractor to reuse the forms on the project site or for another application. Damaged formwork shall be properly recycled. Disposal of wood forms in solid waste containers will not be permitted.

END OF SECTION 03 10 00

**SECTION 03 11 00  
 CONCRETE FORMING**

**PART 4 GENERAL**

**4.1 SECTION INCLUDES**

- A. Layout of formwork
- B. Formwork Construction
- C. Embedded items in concrete
- D. Form release materials
- E. Removal of forms
- F. Field quality control
- G. Detection of movement
- H. Re-use of forms

**4.2 RELATED SECTIONS**

- A. The following is a list of Specifications which may be related to this section:
  - 1. Section 03 33 00 – Architectural Concrete
  - 2. Section 03 35 00 – Concrete Finishing

**4.3 REFERENCES**

- A. The following is a list of standards which were referenced in this section:
  - 1. American Concrete Institute (ACI):
    - a. ACI 117: Standard Specifications for Tolerances for Concrete Construction and Materials.
    - b. ACI 301: Standard Specifications for Structural Concrete
    - c. ACI 318: Building Code Requirements for Structural Concrete
    - d. ACI 347: Formwork for Concrete

**4.4 SUBMITTALS**

- A. General:
  - 1. Alternate form system configurations require preparation by a licensed Professional Engineer and submittal to Engineer for review and approval.

**4.5 QUALITY ASSURANCE**

- A. Formwork Standards: Unless otherwise indicated, design, construct, erect, maintain, and remove forms and related structures for concrete work in accordance with applicable requirements of ACI 301, ACI 318, and ACI 347.
  - 1. Architectural Concrete: Forms for architectural concrete shall be designed and constructed in accordance with ACI 301.
  - 2. Deflection: Where dead and live loads on forms will be more than 20 percent greater than the weight of the concrete, provide framing lumber of required strength, and comply with ACI 301 and ACI 347 for design of framing members. Deflection shall be kept within the herein specified tolerances.

3. Concrete Mix Design: Design of formwork shall be coordinated with the concrete mix design, as specified in Section 03 05 15 – Portland Cement Concrete, so that form materials, form surfaces, and formwork strength will produce the desired concrete tolerances and finishes.
- B. Formwork Surface Materials: Provide material and work quality which will produce clean and uniform finished surfaces within the allowable tolerances specified and which will conform with the following requirements:
    1. Concrete Finished Flooring: Provide material and work quality that will produce clean, smooth, and uniform concrete surfaces. Refer to Section 03 35 00 – Concrete Finishing and ACI 301 for requirements.
  - C. Chamfered Corners: All external corners shall be chamfered, unless otherwise indicated.
  - D. Removal Features: Design formwork to be readily removable without impact, shock, and damage to concrete surfaces and adjacent materials.
  - E. Tolerances for Formed Surfaces: For buildings and similar structures, comply with the requirements of ACI 301, as applicable. For those items of work or parts of the structure not covered by ACI 301, comply with requirements of ACI 117, as applicable. Coordinate with the requirements specified in Section 03 30 00 – Cast-In-Place Concrete.
    1. The class of surface for offset between adjacent pieces of formwork facing material shall be Class A for surfaces permanently exposed to public view and Class C for surfaces that will be permanently concealed, unless otherwise specified.

#### 4.6 DELIVERY, STORAGE, AND HANDLING

- A. Storage: Store form panels to prevent war-page. Protect panels from damage and contamination which could adversely affect concrete.
- B. Handling: Lift form panels by methods that will protect panels from damage and distortion.

#### 4.7 JOB CONDITIONS

- A. Allow sufficient time between erection of forms and placing of concrete for the various trades to properly install concrete reinforcement, embedded items, sleeves, and blockouts.
- B. Do not apply superimposed loads to the structure until concrete has developed its specified 28-day compressive strength.

### PART 5 PRODUCTS

#### 5.1 MATERIALS

- A. Lumber: Boards and framing lumber shall be that of Standard Grade lumber.
  1. Boards: Provide either Construction or Standard Grade Boards. Use dressed side of lumber for surface in contact with the concrete and provide boards with dressed or tongue-and-groove edges to provide tight joints to prevent mortar leakage.
  2. Framing Lumber:

- a. Light Framing: Provide either Construction or Standard Grade Boards for Light Framing, dressed or rough. Where loads are not a factor, "Utility" Light Framing will be acceptable.
  - b. Where wall is present there will be no need for framing due to the wall acting as the frame to hold the concrete while it is being placed.
- B. Formliners for Exposed and Architectural Concrete: Manufactured to produce finished concrete of design, configuration, and surface texture as specified in Section 03 33 00 - Architectural Concrete. Formliners shall be continuous, one piece. No horizontal joints shall be acceptable unless the applicable height exceeds the available formliner height. Provide formliners with inherent form-release surface. Formliners may be manufactured for single-use or multi-use service as appropriate.
- C. Leakage Control Materials: Provide materials capable of producing flush, watertight, and nonabsorbent surfaces and joints, and compatible with forming material and concrete ingredients. Seal form edges with joining material or sealant placed in the joint in such a way that neither a fin nor groove is made in the face of the cast concrete.
- D. Form Release Agent: Commercial formulation, silicone-free form-release agent, designed for use on all types of forms, which will not bond with, strain, nor adversely affect concrete surfaces, and which will not impair subsequent treatment of concrete surfaces requiring bond or adhesion nor impede wetting of surfaces which will be cured with water, steam, or curing compounds.
- E. Plugged Cone Form Ties: Rod type, with ends or end fasteners which can be removed without spalling the concrete and which leave a hole equal in depth to the required reinforcement clearance. Form ties shall be of a design in which the hole left by the removed end or fastener is easily filled to match the surface of the hardened concrete. Provide removable cones 1-1/4 inches in diameter by 1-1/2 inches deep.
- F. Joint Strips: Preformed strips for reveals, rustications, and similar joints fabricated of wood.

## 5.2 FABRICATION

- A. Formwork – General: Fabricate forms in accordance with approved Shop Drawings. Maintain forms clean, smooth, and free from imperfections and distortion. Fabricate forms from architectural concrete in accordance with applicable requirements of ACI 301.
- B. Joints:
- 1. Arrange form panels in symmetrical patterns conforming to general lines of the structure.
  - 2. Unless otherwise indicated, orient panels on vertical surfaces with long dimension horizontal, and make horizontal joints level and continuous.
  - 3. Align form panels on each side of the panel joint with fasteners common to both panels, and in manner which will result in a continuous, unbroken concrete plane surface.
- C. Steel Forms: Use material which is clean, smooth, and free from warps, bends, kinks, rust, cracks, and matter which may stain concrete. Fabricate panels in accordance with approved Shop Drawings. Deflection between form supports from concrete placement shall not exceed 1/240 of the span length.

## PART 6 EXECUTION

### 6.1 LAYOUT OF FORMWORK

- A. Locate and stake out all forms and establish all lines, levels, and elevations.

### 6.2 CONSTRUCTION

- A. Formwork:
1. Construct formwork in accordance with the approved Shop Drawings and in a manner that will produce finished concrete surfaces conforming to indicated design and within specified tolerances. Formwork for concrete not exposed to view in the finished work may be constructed of any material that will adequately support the weight of the concrete.
  2. Make joints and seams mortar-tight. Install leakage control materials in accordance with the manufacturer's installation instructions and in a manner that will maintain a smooth continuity of plane between abutting form panels and which will resist displacement by concreting operations.
  3. Maintain forms clean and free from indentations and war-page. Do not use rust-stained steel surfaces for forms in contact with concrete. Do not sandblast steel form surfaces to remove rust or mill scale; remove these imperfections by grinding.
  4. Brace temporary closures to prevent war-page or displacement and set tightly against forms in a manner that will prevent loss of concrete mortar.
  5. Support joints with extra studs or girts, and in a manner that will ensure true, square intersections.
  6. Assemble forms in a manner that will facilitate their removal without damage to the concrete.
  7. Construct molding shapes, recesses, and projections with smooth finish materials and install in forms with sealed joints.
  8. Provide camber in formwork, as required, to compensate for deflections caused by weight and pressures of fresh concrete and construction loads and as otherwise indicated. Provide camber strips to compensate for deflections due to permanent loads and long term deflections due to shrinkage and creep as required.
  9. Provide construction openings in forms where required for concrete pour pockets, vibrator access holes, and inspection openings to aid in proper placement and consolidation of concrete, and close up openings during placement of concrete as applicable.
  10. Provide inspection and cleanout openings in forms at bottom of walls and columns and elsewhere as required. Do not close cleanouts until inspected and accepted by the Engineer just before placing concrete.
  11. Drill air escape holes in bottom members of block out.
- B. Edge Forms and Screeds for Slabs: Set edge forms or bulkheads and intermediate screeds for slabs to obtain required elevations and contours in the finished slab surface. Support screeds substantially without penetrating waterproof membranes and vapor barriers.
- C. Corner Treatment: Form chamfers with  $\frac{3}{4}$  inch on each leg, unless otherwise indicated, and accurately shape and surface in a manner which will produce uniformly straight lines and edge joints and which will prevent mortar runs. Extend terminal edges to limits and chamfer strips at changes in direction.

- D. Construction Joints:
  1. Locate joints as indicated. Support forms for joints in concrete so as to rigidly maintain their positions during placement, vibration, and curing of concrete. Install keys in all joints.
  2. Locate and install construction joints, for which locations are not indicated, so as not to impair strength and appearance of the structure and indicate such joints on Shop Drawings. Locations of construction joints require approval of Engineer.
  3. Position joints perpendicular to longitudinal axis of pier, beam, or slab as the case may be.
- E. Load Supports: Formwork loads shall be carried only by structural elements that are supported directly by the footings.

### 6.3 EMBEDDED ITEMS IN CONCRETE

- A. Welded Wire Mesh:
  1. Reinforcing will be that of Grade 60 Steel.
  2. Will be only in use to strengthen against shrinkage and temperature. Not to reinforce for carrying very large heavy loads.

### 6.4 FORM RELEASE MATERIAL

- A. Coat form contact surfaces with approved form release material before reinforcement is placed. Do not allow excess form release material to accumulate in the forms or to come into contact with surfaces that are required to be bonded to fresh concrete such as concrete reinforcement and embedded items. Apply form release material in compliance with manufacturer's application instructions.
- B. Coat steel forms with non-staining, rust-preventive form release material or otherwise protect against rusting.
- C. Apply form release material to bolts and rods that are to be removed or that are to be free to move.

### 6.5 REMOVAL OF FORMS

- A. Remove forms by methods which will not injure, mar, gouge, or chip concrete surfaces, overstress concrete members, or distort formwork. Use air pressure or other approved methods. Do not pry against concrete. Cut off nails flush. Leave surfaces clean and unblemished.
  1. Where early form removal is not necessary and will not impact the Contactor's schedule, leave forms in place at least 72 hours, unless otherwise approved by the Engineer.
- B. When repair of surface defects or finishing is required at an early age, forms may be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations and its own weight.
  1. Concrete work that is damaged by removal operations shall be repaired as specified in Section 03 35 00 - Concrete Finishing. Where exposed surfaces are damaged beyond acceptable repairing measures, the damaged concrete shall be removed and replaced with new concrete.
- C. Forms and shoring in the formwork used to support the weight of all structural members shall remain in place until the concrete has reached adequate strength and stiffness to support itself. Forms shall not be removed before the concrete has reached

a minimum of 70 percent of indicated design compressive strength, unless otherwise approved in writing by the Engineer.

- D. When shores and other vertical supports are so arranged that the non-load-carrying form-facing material may be removed without loosening or disturbing the shores and supports, the facing material may be removed at an earlier age provided the concrete surfaces are not damaged by such earlier removal.
- E. Plan reshoring operations in a manner that will ensure that areas of new construction will not be required to support their own weight. Reshoring shall be in place before shoring is removed. During reshoring, do not permit live loads on new construction. Do not locate reshores in a manner and location that will over stress members or induce tensile stresses where reinforcing bars have not been provided.
- F. When removal of formwork or reshoring is based on the concrete reaching a specified strength, the concrete shall be presumed to have reached its strength when test cylinders, field cured along with the concrete they represent, have reached the strength specified for removal of formwork or reshoring. Except for the field curing and age at test, the cylinders shall be molded and tested as specified in Section 03 05 00 – Common Work Results of Concrete.

#### **6.6 FIELD QUALITY CONTROL**

- A. Before placing concrete, check lines and grades of erected formwork for correctness. Make corrections or adjustments to ensure proper size and location of concrete members and stability of forming systems.
- B. While placing concrete, provide quality control to assure that formwork and related supports have not been displaced, that loss of cement paste through joints is prevented and that completed work will be within specified tolerances.
- C. During form removal, verify that architectural features meet the form and texture requirements of the samples approved by the Engineer.

#### **6.7 DETECTION OF MOVEMENT**

- A. Check movement using methods, such as plumb lines and survey equipment to detect movement of formwork during concrete placement.

#### **6.8 RE-USE OF FORMS**

- A. Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable. Remove such material from the site. Apply form release coating as specified for new formwork.
- B. Align and secure joints in a manner that will preclude offsets. Do not use patched forms for exposed concrete surfaces.

**END OF SECTION 03 11 00**

**SECTION 03 15 00  
CONCRETE ACCESSORIES**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES**

- A. Joint Fillers
- B. Joint Sealing Compound
- C. Elastomeric Joint Seals
- D. Plastic Pads, Spacers, and Fillers

**1.2 RELATED SECTIONS**

- A. The following is a list of SPECIFICATIONS which may be related to this section:
  1. Section 03 10 00 – Concrete Forming and Accessories
  2. Section 03 11 00 – Concrete Forming

**1.3 REFERENCES**

- A. The following is a list of standards which were referenced in this section:
  1. ASTM C272: Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
  2. ASTM C578: Specification for Rigid, Cellular Polystyrene Thermal Insulation
  3. ASTM C920: Specification for Elastomeric Joint Sealant
  4. ASTM D994: Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
  5. ASTM D1190: Specification for Concrete Joint Sealer, Hot-Applied Elastic Type
  6. ASTM D1621: Test Method for Compressive Properties of Rigid Cellular Plastics
  7. ASTM D1622: Test Method for Apparent Density of Rigid Cellular Plastics
  8. ASTM D1751: Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
  9. ASTM D2628: Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
  10. ASTM D3405: Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements
  11. ASTM D3406: Specification for Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements
  12. ASTM D3542: Specification for Preformed Polychloroprene Elastomeric Joint Seals for Bridges
  13. ASTM E84: Test Method for Surface Burning Characteristics of Building Materials

**1.4 SUBMITTALS**

- A. General: Refer to Section 01 33 00 - Submittal Procedures, and Section 01 33 23 – Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.
- B. Shop Drawings: Submit drawings showing locations of all joints to be filled and sealed.

- C. Product Data: Submit manufacturers' product data of joint fillers, sealing compounds, elastomeric joint seals, and plastic materials, verifying compliance with specified requirements.
- D. Samples: Submit 12-inch long sample of joint filler and elastomeric joint seals and one pint can of sealing compound.

## **PART 2 PRODUCTS**

### **2.1 MATERIALS**

- A. Joint Filler: Premolded, of sizes and thickness indicated, conforming to ASTM D994 or ASTM D1751, as applicable.
  - 1. For structural joints and joints subject to movement, provide elastomeric joint seals conforming to ASTM D2628 or ASTM D3542, as applicable.
- B. Joint Sealing Compound: Concrete joint sealant, conforming to ASTM C920 (Type S or M, Class 25, Use T), ASTM D1190, ASTM D3405, or ASTM D3406, as applicable, for sealing of expansion (isolation) and contraction (control) joints in slabs and at junctions of slabs and vertical surfaces.
  - 1. For asphalt pavements, provide ASTM D3405 sealant only. For concrete pavements and roadways, provide ASTM C920 or ASTM D3406 sealant.
  - 2. Color of joint sealant shall be as selected by the Engineer from manufacturer's standards.
- C. Elastomeric Joint Seals: Preformed solid or multi-web design, virgin crystallization-resistant polychloroprene (neoprene) conforming with ASTM D2628 or ASTM D3542, as applicable. Seals shall be designed to function in a compressed installation mode.
  - 1. Lubricant Adhesive: ASTM D2628 or ASTM D3542, as applicable.
- D. Plastic Pads, Spacers, and Fillers: Extruded closed-cell polystyrene rigid board meeting requirements of ASTM C578, Type V, with the following physical properties:
  - 1. Minimum weight and density when tested in accordance with ASTM D1622: 3.0 pounds per cubic foot.
  - 2. Minimum compressive strength when tested in accordance with ASTM D1621: 100 pounds per square inch.
  - 3. Maximum water absorption when tested in accordance with ASTM C272: 0.10 percent by volume.
  - 4. Maximum allowable flame spread when tested in accordance with ASTM E84: 10 flame spread index (UBC Class I).

## **PART 3 EXECUTION**

### **3.1 EXAMINATION**

- A. Verify that joint surfaces are dry to the extent necessary for successful sealant application and long service life as recommended by the sealant manufacturer.
- B. Verify also that ambient and concrete-surface temperatures and humidity are within the ranges recommended by the manufacturer for successful sealant application.

### **3.2 PREPARATION**

- A. Thoroughly clean joints free of dirt, debris, dust, and laitance.
- B. Prime joint surfaces, where required, as recommended by the manufacturer of the joint sealing compound or elastomeric joint seal, as applicable.
- C. Mix multi-component sealing compound as recommended by the manufacturer.

### 3.3 INSTALLATION

- A. Installation/Application Requirements: Joint fillers and sealing compounds shall be installed in accordance with the respective manufacturers' installation and application instructions. Comply also with ASTM D1190, ASTM D3405, Appendix XI., and ASTM D3406, Appendix XI., for application of sealants, as applicable. Coordinate the placement of joint fillers and securing them in position with the work of Section 03 11 00 - Concrete Formwork.
- B. Expansion (Isolation) Joints:
  - 1. Provide premolded joint filler to full depth of slabs, less 1/2 inch. Install joint filler with top edge 1/2 inch below the surface, and tool adjacent concrete edges to a 1/4-inch radius.
  - 2. Use steel pins to hold material in place during placing and floating of concrete.
  - 3. Finished joints shall be tight and leak-proof.
  - 4. After a minimum of 28 days after slabs have been placed and finished, fill expansion joints with joint sealing compound to 1/8 inch below surface of slabs. No traffic shall be permitted to travel over sealed joints until sealing compound has properly cured.
- C. Contraction (Control) Joints: Saw-cut contraction joints and weakened plane joints shall be filled with joint sealing compound in areas and locations indicated. Joints shall be filled and tooled flush to within 1/16 inch of the slab surface.
- D. Roadway and Bridge: Provide elastomeric joint seals as applicable to the conditions. Install as indicated and in accordance with the manufacturer's installation instructions and recommendations.
- E. Plastic Pads, Spacers, and Fillers: Install as indicated over or against clean surfaces. Apply adhesive where required to hold material in place.

END OF SECTION 03 15 00

**SECTION 03 30 00  
 CAST-IN-PLACE CONCRETE**

**PART 2 GENERAL**

**2.1 SECTION INCLUDES**

- A. Conveying and placing concrete
- B. Placement under water
- C. Consolidation
- D. Construction joints
- E. Expansion and contraction joints
- F. Curing and protection

**2.2 RELATED SECTIONS**

- A. Portland cement concrete specified in Section 03 05 15 – Portland Cement Concrete.
- B. Finishing and curing of formed and unformed concrete surfaces, including repair and patching of surface defects, are specified in Section 03 35 00 – Concrete Finishing.

**2.3 REFERENCES**

- A. American Concrete Institute (ACI):
  1. ACI 116R: Cement and Concrete Terminology
  2. ACI 117: Standard Specification for Tolerances for Concrete Construction and Materials
  3. ACI 302.1R: Guide for Concrete Floor and Slab Construction
  4. ACI 303.1: Standard Specification for Cast-In-Place Architectural Concrete
  5. ACI 304R: Guide for Measuring, Mixing, Transporting, and Placing Concrete
  6. ACI 304.2R: Placing Concrete by Pumping Methods
  7. ACI 305R: Hot Weather Concreting
  8. ACI 306.1: Standard Specification for Cold Weather Concreting
  9. ACI 308: Standard Practice for Curing Concrete
  10. ACI 309R: Guide for Consolidation of Concrete
- B. American Society for Testing and Materials (ASTM):
  1. ASTM C31: Standard Practice of Making and Curing Concrete Test Specimens in the Field
  2. ASTM C94: Specification for Ready-Mix Concrete
  3. ASTM C881: Specification for Epoxy-Resin-Base Bonding Systems for Concrete

**2.4 SUBMITTALS**

- A. Shop Drawings
- B. Records and Reports: Report the location in the finished work of each mix design, and the start and completion times of placement of each batch of concrete placed for each date concrete is placed.

**2.5 QUALITY ASSURANCE**

- A. Tolerances:
  - 1. Concrete Tolerances: Comply with the requirements of ACI 117 as applicable. Coordinate with the requirements specified in Section 03 11 00 – Concrete Forming.
  - 2. Tolerances for Slabs and Flatwork: Comply with the requirements specified in Section 03 35 00 –Concrete Finishing.
- B. Architectural Concrete: Where concrete is indicated as architectural concrete exposed to public view, such concrete shall be produced in accordance with applicable requirements of ACI 303.1.
- C. Site Mock-Ups:
  - 1. Construct site mock-ups for all architectural concrete work and formed concrete that will be exposed to the public in the finished work, not less than 4 feet by 6 feet in surface area, for review and acceptance by the Engineer, before starting the placement of concrete.
  - 2. Approved site mock-ups shall set the standard for the various architectural concrete features, formed finishes, and colors of the concrete. Provide as many mock-ups as required to show all the different features and formed surfaces of the concrete.
- D. Cold Joints: Cold joints in concrete will not be permitted unless planned and treated properly as construction joints.
- E. Monitoring of Formwork: Provide monitoring of forms and embedded items to detect movement, or forms and embedded items out-of –alignment, from pressure of concrete placement.

## 2.6 ENVIRONMENTAL REQUIREMENTS

- A. Delivering and placing of concrete in hot weather and cold weather shall conform with applicable requirements of ACI 305R and ACI 306.1 and Section 03 05 15 – Portland Cement Concrete.
- B. Do not place concrete when the rate of evaporation of surface moisture from concrete exceeds 0.2 pounds per square foot per hour as indicated in Figure 2.1.5 of ACI 305R.
- C. Do not place concrete in, or adjacent to, any structure where piles are required until all piles in the structure have been driven or installed.

## PART 3 PRODUCTS

### 3.1 MATERIALS

- A. Formwork: Refer to Section 03 11 00 – Concrete Forming, for requirements.
- B. Joint Fillers and Sealers: Refer to Section 03 15 00 – Concrete Accessories, for requirements.
- C. Waterstops: Refer to Section 03 15 13 – Waterstops, for requirements.
- D. Reinforcing Steel: Refer to Section 03 20 00 – Concrete Reinforcing, for requirements.
- E. Portland Cement Concrete: Refer to Section 03 05 15 – Portland Cement Concrete, for mix designs and other requirements.

- F. Concrete Curing Materials: Refer to Section 03 35 00 – Concrete Finishing, for requirements.

## **PART 3 EXECUTION**

### **3.1 EXAMINATION**

- A. Inspect forms, earth bearing surfaces, reinforcement, and embedded items, and obtain the Engineer's written approval before placing concrete. Complete and sign a pour card on the form supplied by the Engineer. The Engineer shall countersign the card prior to commencing the pour.

### **3.2 PREPARATION**

- A. Place concrete under the observation of the Engineer and with the Contractor's Quality Control Representative present to document requirements and results of the placement.
- B. Whenever possible, place concrete during normal working hours. When concrete – placement schedules require concrete placement at times other than normal working hours, ensure that the Engineer is notified and is present at the time of placement.
- C. Do not place concrete until conditions and facilities for the storage, handling, and transportation of concrete test specimens are in compliance with the requirements of ASTM C31 and Section 03 05 15 – Portland Cement Concrete, and are approved by the Engineer.

### **3.3 TRANSPORTING**

- A. Concrete shall be central-mixed concrete from a central batch plant, transported to the jobsite in a truck mixer, in accordance with the requirements specified in Section 03 05 15 – Portland Cement Concrete, and ASTM C94.
- B. Transport concrete to the jobsite in a manner that will assure efficient delivery of concrete to the point of placement without adversely altering specified properties with regard to water-cement ratio, slump, air entrainment, and homogeneity.

### **3.4 CONVEYING AND PLACING**

- A. Placement Standards: Conveying and placing of concrete shall conform with applicable requirements of ACI 302.1R and ACI 304R.
- B. Handling and Depositing
  1. Concrete placing equipment shall have sufficient capacity to provide a placement rate that will preclude cold joints and shall deposit the concrete without segregation or loss of ingredients.
  2. Concrete placement, once started, shall be carried on as a continuous operation until the section of approved size and shape is completed.
  3. Concrete shall be handled as rapidly as practicable from the mixer to the place of final deposit by methods that prevent the separation or loss of ingredients. Concrete shall be deposited, as nearly as practicable, in its final horizontal position to avoid redistribution or flowing.
  4. Concrete shall not be dropped freely where reinforcing will cause segregation, nor shall it be dropped freely more than 5 feet. Concrete shall be deposited to maintain a plastic surface approximately horizontal.

5. Concrete that has partially hardened shall not be deposited in the work. The discharge of concrete shall be started not later than 60 minutes after the introduction of mixing water. Placing of concrete shall be completed within 90 minutes after the first introduction of water into the mix.

C. Pumping:

1. Concrete may be placed by pumping if the maximum slump can be maintained and if accepted in writing by the Engineer for the location proposed.
2. Placing concrete by pumping methods shall conform with applicable requirements of ACI 304R and ACI 304.2R.
3. Equipment for pumping shall be of such size and design as to ensure a continuous flow of concrete at the delivery end without separation of materials. Concrete from end of hose shall have a free fall of less than 5 feet. Pump hoses shall be supported on horses or similar devices so that reinforcement or post-tensioning ducts or tendons are not moved from their original position.
4. The concrete mix shall be designed to the same requirements as specified in Section 03 05 15 – Portland Cement Concrete, and may be altered for placement purposes with the prior approval of the Engineer.

### 3.5 CONSOLIDATION

- A. Concrete shall be thoroughly consolidated and compacted by mechanical vibration during placement in accordance with the requirements of ACI 309R.
- B. The Engineer will inspect concrete placement to confirm that proper placing methods are being employed, and that special techniques are being used in congested areas and around obstructions such as pipes and other embedded items. Check installation of embedded items for correct location and orientation during concrete placement.
- C. Conduct vibration in a systematic manner by competent, skilled, and experienced workers, with regularly maintained vibrators, and with sufficient back-up unites at the jobsite. Use the largest and most powerful vibrator that can be effectively operated in the given work, with a minimum frequency of 8,000 vibrations or impulses per minute, and of sufficient amplitude to effectively consolidate the concrete.
- D. Insert and withdraw the vibrator vertically at uniform spacing over the entire area of the placement. Space the distance between insertions such that “spheres of influence” of each insertion overlap.
- E. Conduct vibration so as to produce concrete that is of uniform texture and appearance, free of honeycombing, air and rock pockets, streaking, cold joints, and visible lift lines.

### 3.6 CONSTRUCTION JOINTS

- A. Construction joints will be permitted only where indicated or approved by the Engineer.
- B. Provide and prepare construction joints and install waterstops in accordance with the applicable requirements of ACI 304R and as specified in Section 03 11 00 – Concrete Forming.
- C. Make construction joints straight and as inconspicuous as possible, and in exact horizontal alignment with the structure.

- D. Use approved key, at least 1-1/2 inches in depth, at joints unless otherwise indicated or approved by the Engineer.
- E. Thoroughly clean the surface of the concrete at construction joints and remove laitance, loose or defective concrete, coatings, sand, sealing compound and other foreign material. Prepare surfaces of joints by sandblasting or other approved methods to remove laitance and expose aggregate uniformly.
- F. Immediately before new concrete is placed, wet the joint surfaces and remove standing water. To allow for shrinkage, do not place new concrete against the hardened concrete side of a construction joint for a minimum of 72 hours.
- G. Retighten forms and dampen concrete surfaces before concrete placing is continued.
- H. Allow at least 72 hours to elapse before continuing concrete placement at a construction joint. Approval for accelerating the minimum time elapsing between adjacent placements will be based on tests and methods that confirm that a minimum moisture loss at a relatively constant temperature will be maintained for the period as necessary to control the heat of hydration and hardening of concrete and to prevent shrinkage and thermal cracking.

### 3.7 CURING AND PROTECTION

- A. Curing of concrete shall conform with applicable requirements of ACI 308, except that the curing duration shall be a minimum period of ten days. HVFAC shall be cured a minimum of 28 days including an initial 10 days of moist curing. Curing with earth, sand, sawdust, straw and hay will not be permitted.
- B. Keep concrete in a moist condition from the time it is placed until it has cured for at least ten days. Keep forms damp and cool until removal forms.
- C. Immediately upon removal of forms, exposed concrete surfaces shall be kept moist by applying an approved curing compound or by covering with damp curing materials as specified in Section 03 35 00 – Concrete Finishing.
- D. Concrete shall not be permitted to dry during the curing period because of finishing operations.
- E. Finishing and curing of the slabs are specified in Section 03 35 00 – Concrete Finishing.
- F. Protect concrete from injurious action of the elements and defacement of any kind.
- G. Protect concrete during the curing period from mechanical and physical stresses that may be caused by heavy equipment movement, subjecting the concrete to load stress, lead shock, or excessive vibration.

### 3.8 REPAIR OF SURFACE DEFECTS

- A. Refer to Section 03 35 00 – Concrete Finishing, for requirements.

**END OF SECTION 03 30 00**

**SECTION 03 60 00  
 GROUTING**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES**

- A. Information regarding grouting material and installation process
- B. Quality insurance for architectural concrete

**1.2 RELATED SECTIONS**

- A. The following is a list of specifications which may be related to this section:
  1. Section 03 11 00 - Concrete Forming.
  2. Section 03 15 00 - Construction Joints.
  3. Section 03 35 00 - Concrete Finishing.
  4. Section 03 63 00 - Epoxy Grouting.
  5. Section 03 64 00 - Injection Grouting.

**1.3 REFERENCES**

- A. The following is a list of standards which were reference in this section:
  1. ASTM International (ASTM):
    - a. ASTM C33: Specification for Concrete Aggregates.
    - b. ASTM C78: Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
    - c. ASTM C109: Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
    - d. ASTM C469: Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
    - e. Ratio of Concrete in Compression.
    - f. ASTM C579: Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
    - g. ASTM C666: Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
    - h. ASTM C882: Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.
    - i. ASTM C1202: Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

**1.4 SUBMITTALS**

- A. General:
  1. Alternate form system configurations require preparation by a licensed Professional Engineer and submittal to Engineer for review and approval.

**1.5 QUALITY ASSURANCE**

- A. Qualifications:
  1. Grout Testing Laboratory:
    - a. Independent testing laboratory employed for design and testing of grout materials and mixes shall comply with testing laboratory requirements in Section 03 30 00, Cast-in-Place Concrete and other applicable requirements in the Contract Documents.

2. Manufacturer: Shall have a minimum of five years' experience of producing products substantially similar to that required and shall be able to submit documentation of at least five satisfactory installations that have been in successful operation for at least five years each.
  3. Manufacturer's Field Service Technician: When required, provide services of manufacturer's full-time employee, factory-trained in handling, use, and installing the products required, with at least five years of experience in field applications of the products required.
- B. Trial Batch:
1. Each grout fill and construction joint grout mix proportion and design shall be verified by laboratory trial batch or field experience methods. Comply with ACI 211.1 and submit to Engineer a report with the following data:
    - a. Complete identification of aggregate source of supply.
    - b. Tests of aggregates for compliance with specified requirements.
    - c. Scale weight of each aggregate.
    - d. Absorbed water in each aggregate.
    - e. Brand, type, and composition of cement.
    - f. Brand, type, and amount of each admixture.
    - g. Amounts of water used in trial mixes.
    - h. Proportions of each material per cubic yard.
    - i. Unit weight and yield per cubic yard of trial mixtures.
    - j. Measured slump.
    - k. Measured air content.
    - l. Compressive strength developed at seven days and 28 days, from not less than three test specimens cast for each seven-day and 28-day test, and for each design mix.
  2. Laboratory Trial Batches: When laboratory trial batches are used to select grout proportions, prepare test specimens and conduct strength tests as specified in ACI 301.
  3. Field Experience Method: When field experience methods are used to select grout proportions, establish proportions as specified in ACI 301.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Cement based mortar shall be delivered and stored in manufacturer's packaging until it is ready to be mixed and placed. Mortar bags shall be stored off the ground and protected from water and all other substances that may penetrate packaging.

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. General: Materials for grouts (other than non-shrink grouts) shall be in accordance with Section 03 30 00, Cast-In-Place Concrete, except as otherwise specified in this Section.
- B. Grout Fill:
1. Grout fill shall be comprised of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed in accordance with this Section.
    - a. Minimum Compressive Strength: 4,000 psi at 28 days.
    - b. Maximum Water-Cement Ratio: 0.45 by weight.
    - c. Coarse Aggregate: ASTM C33/C33M, No. 8 size.

- d. Fine Aggregate: ASTM C33/C33M, approximately 60 percent by weight of total aggregate.
  - e. Air Content: Seven percent (plus or minus one percent).
  - f. Minimum Cement Content: 564 pounds per cubic yard.
  - g. Slump for grout fill shall be adjusted to match placing and finishing conditions, and shall not exceed four inches.
- C. Construction Joint Grout:
- 1. Construction joint grout shall be comprised of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned with similar cementitious characteristics as Class “A” concrete specified in Section 03 30 00, Cast-In-Place Concrete. Mix design shall result in grout that is flowable with high mortar content. Mix requirements are:
    - a. Minimum Compressive Strength: 4,500 psi at 28 days.
    - b. Maximum Water-Cement Ratio: 0.42 by weight.
    - c. Coarse Aggregate: ASTM C33/C33M, No. 8 size.
    - d. Fine Aggregate: ASTM C33/C33M, approximately 60 percent by weight of total aggregate.
    - e. Air Content: Seven percent (plus or minus one percent).
    - f. Minimum Cement Content: 752 pounds per cubic yard.
    - g. Slump for Construction Joint Grout: Seven inches (plus or minute one inch).

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Preparation:
  - 1. Thoroughly clean the roughened surface and any exposed reinforcement of rust, dirt, loose chips, and dust. Maintain substrate in a saturated, surface-dry condition.
  - 2. Where applicable, coat exposed reinforcing steel with EMACO P22 reinforcing steel bar protection coating prior to patching
- B. Mixing: Comply with mortar manufacturer’s recommendations for water quantity. Mechanically mix with a slow speed drill (four hundred to six hundred [400 to600] rpm) and Jiffler-type paddle. Pour approximately ninety percent (90%) of the mix water into the mixing container; then add the bagged material while continuing to mix. Add remaining water as needed. Mix time shall not exceed five (5) minutes.
- C. Application:
  - 1. Apply bonding adhesive such as Concesive Liquid LPL or Concesive Standard Liquid.
  - 2. Place and finish with trowel or screed. In hot, windy, or dry conditions, where rapid surface evaporation may occur, apply evaporation reducer.
- D. Curing: Apply Masterkure 200 W curing compound in accordance with label instructions.

### 3.2 FIELD QUALITY CONTROL

- A. Field Tests:
  - 1. When prescribed in the drawings or by the specifications, length change test specimens will be taken during construction from the first placement of each type of mortar, and at intervals thereafter as selected to ensure continued compliance with these specifications.

2. When required, length change tests and fabrication of specimens for cement-based mortar shall be performed as specified in ASTM C1012 at intervals during construction as selected. A set of three (3) specimens will be made for testing at seven (7) and twenty eight (28) days.
- B. Quality Control Testing During Construction:
1. Grout Fill: Perform sampling and testing for field quality control during grout fill placing as follows:
    - a. Sampling Fresh Grout Fill: ASTM C172.
    - b. Slump: ASTM C143; one test for each load of grout at point of discharge.
    - c. Air Content: ASTM C231; one sample for every two grout loads at point of discharge, and when a change in the grout is observed.
    - d. Compression Test Specimens:
      - 1) In accordance with ASTM C109/C109M; make one set of compression cubes for each 50 cubic yards of grout, or fraction thereof, of each mix design placed each day. Each set shall be four standard cubes, unless otherwise directed by Engineer.
- C. Evaluation of Field Quality Control Tests:
1. Do not use grout, delivered to final point of placement, having slump or total air content that does not comply with the Contract Documents.
  2. Compressive strength tests for laboratory-cured cubes will be acceptable if averages of all sets of three consecutive compressive strength test results equal or exceed the required 28-day design compressive strength of the associated type of grout.
  3. If the compressive strength tests do not comply with the requirements in the Contract Documents, the grout represented by such tests will be considered defective and shall be removed and replaced, or subject to other action required by Engineer, at Contractor's expense.

**END OF SECTION 03 60 00**

**SECTION 03 63 00  
 EPOXY GROUTING**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES**

- A. Surface preparation.
- B. Application of a three-component multi-purpose epoxy grout.

**1.2 RELATED SECTIONS**

- A. Section 03 10 00 – Concrete Forming and Accessories
- B. Section 03 30 00 – Cast-in-Place Concrete.
- C. Section 03 60 00– Grouting

**1.3 REFERENCES**

- A. The following is a list of standards which were referenced in this section:
  - 1. **ASTM International (ASTM):**
    - a. ASTM C882 : Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.
    - b. ASTM D570: Standard Test Method for Water Absorption of Plastics.
    - c. ASTM D695: Standard Test Method for Compressive Properties of Rigid Plastics.
    - d. ASTM D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

**1.4 QUALITY ASSURANCE**

- A. Team will provide the proper equipment, manpower, and supervision at the jobsite to install the epoxy grout in compliance with the project plans and specifications.
- B. Installation will be carried out by members of the team. There will be an adequate number of members helping with the application of the epoxy grout.

**1.5 SUBMITTALS**

- A. Comply with Section 01 33 00 - Submittal Procedures.
- B. Submit manufacturer's product data and application instructions.

**1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.
- B. Store materials in a clean, dry area in accordance with manufacturer's instructions.
- C. Condition materials to 60-85° F (15°C-30°C) for at least 24 hours prior to mixing.
- D. Keep product from freezing.

- E. Protect materials during handling and application to prevent damage or contamination.
- F. Mix complete units only.
- G. Do not add water to the epoxy grout.

## **PART 2 PRODUCTS**

### **2.1 MATERIALS**

- A. Performance Based Specification: Epoxy grout shall be a three component moisture-insensitive kit consisting of an epoxy resin, activator and selected graded premixed aggregates and possess the following characteristics:
  - 1. Compressive Strength, ASTM D695:
    - a. 1 day: 8,000 psi (55 MPa)
    - b. 3 days: 11,000 psi (75MPa)
    - c. 7 days: 13,000 psi (89 MPa)
  - 2. Flexural Strength, ASTM D790
    - a. 7 days: 4,065 psi (28.05 MPa)
  - 3. Water Absorption, ASTM D570
    - a. 24 hours: 0.09%
  - 4. Bond Strength, ASTM C882
    - a. 7 day bond strength to concrete: 4,034 psi (27.84 MPa).

## **PART 3 EXECUTION**

### **3.1 EXAMINATION**

- A. Examine surfaces to receive epoxy grout. Notify Architect or Engineer if surfaces are not acceptable. Do not begin surface preparation or application until unacceptable conditions have been corrected.

### **3.2 SURFACE PREPARATION**

- A. Mechanically abrade all concrete to a sound surface.
- B. Ensure all surfaces are free of standing water and completely clean of dirt, rust, curing compounds, grease, oil, paint and unsound materials.
- C. Vacuum or blow dust away with oil-free, compressed air.

### **3.3 FORMING**

- A. Seal all forms to prevent leakage.
- B. Coat forms with wax or cover with polyethylene to prevent grout adhesion.
- C. Construct forms to allow a 50 mm (2") minimum head on the pouring side and material to rise slightly above the underside of the base on other sides.

### **3.4 MIXING**

- A. Condition all components to 60-85° F (15°C-30°C) for 24 hours prior to use.

- B. Premix epoxy resin and activator separately to an even consistency prior to combining components.
- C. Mechanically mix at slow speed (600-900rpm) using a drill and Jiffy Blade or drum mixer for three minutes or until completely mixed.
- D. Scrape sides of the container to ensure complete blending of the components.
- E. Ensure mixed product is uniform grey color with no streaks.
- F. Steadily add aggregate while continuing to mix.
- G. Continue mixing for 3-5 minutes upon completion of adding the aggregate.
- H. Mix only the amount of epoxy that can be applied within the product's pot life.
- I. Ensure mixed product is uniform grey color with no streaks.

### 3.5 APPLICATION

- A. Pour the prepared grout into the forms from 1 or 2 sides to avoid air entrapment.
- B. Maintain a liquid head to ensure complete contact with the base plate.
- C. Ensure a minimum 1" (25.4 mm) minimum grout head is maintained.
- D. Place enough material to allow the grout to rise slightly above the underside of the base plate.

### 3.6 CURING

- A. Maintain an ambient temperature between 50 - 90° F (10 - 32° C) until the grout has cured completely.

END OF SECTION 03 63 00

**SECTION 03 64 00  
 INJECTION GROUTING**

**PART 1 GENERAL**

**1.1 RELATED SECTIONS**

- A. The following is a list of Specifications which may be related to this section:
  1. Section 03 60 00 – Grouting
  2. Section 03 63 00 – Epoxy Grouting

**1.2 REFERENCES**

- A. The following is a list of standards which may be referenced in this section:
  1. American Association of State Highway and Transportation Officials (AASHTO): T237, Standard Method of Test for Testing Epoxy Resin Adhesive.
  2. American National Standards Institute (ANSI).
  3. ASTM International (ASTM):
    - a. ASTM C882: Standard Specification for Test Method for Bond Strength of Epoxy-Resin System Used with Concrete by Slant Shear.
    - b. ASTM D570: Standard Test Method for Water Absorption of Plastics.
    - c. ASTM D638: Standard Test Method for Tensile Properties of Plastics.
    - d. ASTM D648: Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position.
    - e. ASTM D695: Standard Test Method for Compressive Properties of Rigid Plastics.
    - f. ASTM D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

**1.3 SUBMITTALS**

- A. Action submittals:
  1. Physical and chemical properties for epoxy adhesives.
  2. Technical data for metering, mixing, and injection equipment.

**1.4 QUALITY ASSURANCE**

- A. Codes and Regulatory Agencies. Perform all work in compliance with all federal, state, and local codes and regulatory agencies.
- B. Comply with provisions of the following standards:
  1. ASTM – American Society for Testing and Materials.
  2. NSF – National Sanitation Foundation.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Material must be brought to the job site in unopened containers and clearly marked by manufacturer with the following information:
  1. Manufacturer’s name.
  2. Product name and lot number.
  3. ANSI Hazard Classification.
  4. ANSI Recommended Precautions for handling.
  5. Mix ratio by volume.

**1.6 JOB CONDITIONS**

- A. Coordinate concrete work with all other trades to prevent delays, errors, or omissions.

## **PART 2 PRODUCTS**

### **2.1 MATERIALS**

- A. The grouting material shall be a hydrophobic polyurethane liquid with catalyst developed to stop highly active leaks. The grout shall be non-toxic after curing. The polyurethane liquid shall react with water to foam and expand to form a flexible, tough, gasket that stops water. The catalyst is added to the grout to determine the reaction time with the water.
- B. Packers are required for injection. Packers for injection shall be supplied from the manufacturer.
- C. Hoses must be moisture impermeable and are required for use where grout material is being pumped.
- D. Expansion Joint Backer Rod: The expansion joint backer rod shall be cross linked open cell polyurethane foam with a rectangular or circular cross section as manufactured. The cross section of the cross linked open cell polyurethane foam shall be a minimum of 150% of the width of the joint as measured between the cleaned concrete surfaces.
- E. Surface Sealant: The surface sealant for the expansion joints shall be a silicone joint compound.

## **PART 3 EXECUTION**

### **3.1 PREPARATION**

- A. Free any loose mater, dirt, oil, grease, and other contaminants from the application site.
- B. Clean the area in accordance with manufacturer's instructions.
- C. Do not use acids and corrosives for cleaning, unless neutralized prior to injection.

### **3.2 EXAMINATION**

- A. Equipment
  1. Demonstrate equipment's ability to pump and dispense the grout at sufficient pressures to fully seal all size joints and cracks. Use proper grouting equipment designed for the application of the specified materials.
  2. Demonstrate that pumping equipment can maintain this pressure for five minutes with no leaks or drop in pressure.
  3. Pumps
    - a. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
    - b. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
    - c. Capable of immediate compensation for changes in resins.
    - d. Do not use batch mix pumps.

4. Automatic Shutoff Control: Provide sensors on both Component A and B reservoirs for stopping machine automatically when one component is being pumped to mixing head.
5. Proportioning Ratio Tolerance: Maintain epoxy adhesive manufacturer's prescribed mix ratio within a tolerance of plus or minus five percent by volume at discharge pressure up to 160 psi.

### 3.3 INSTALLATION

- A. Injection: Use procedure in accordance with manufacturer's written instructions and, in general, include the following steps as needed for the injection grouting.
  1. Store grout at a minimum of 70 degrees F.
  2. Start injection into each crack at lowest elevation entry port.
  3. Continue injection at first port until grout begins to flow out of port at next highest elevation.
  4. Plug first port and start injection at second port until adhesive flows from next port.
  5. Inject entire crack with same sequence.
- B. Cleanup
  1. After injection grout has cured, remove excess polyurethane group from side of wall.

END OF SECTION 03 64 00

DIVISION 05

**METAL**

**SECTION 05 10 00  
 STRUCTURAL METAL FRAMING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. This Section includes:
  1. Structural Steel

**1.2 SUBMITTALS**

- A. Product Data
  1. Recycled Content
    - a. Percentage of recycled material, pre-consumer and post-consumer
    - b. Value of content
  2. Local/Regional Materials
    - a. Source Location
    - b. Manufacturing Location
    - c. Value of components
  
- B. Certifications and Registrations
  1. Environmental Management Systems: show evidence of EMS for the manufacturer's provision of material for work.
  2. Chain of Custody Certification: Submit manufacturer's certification that no open hearth furnaces were used in the manufacturing of any provided steel.
    - a. Bill of Lading, CO2 emissions certificate, or energy efficiency certificate
    - b. Include process of energy efficient methods or Participation in CO2 Breakthrough Program.

**1.3 QUALITY ASSURANCE**

- A. Toxicity/IEQ
  1. Carbon Dioxide Emissions: not to exceed 1.6 tons per ton of crude steel produced.

**PART 2 PRODUCTS**

**2.1 MATERIALS**

- A. Structural Steel
  1. Up to 80 % Recycled Content

**2.2 FACTORY FINISHING**

- A. Finishing System
  1. Toxicity
  2. Anti-corrosive paint
  3. Comply with GS11

**PART 3 EXECUTION**

**3.1 SITE ENVIRONMENTAL PROCEDURES**

- A. Project will be handled according to local codes

**END OF SECTION 05 10 00**

**SECTION 05 12 00  
 STRUCTURAL STEEL FRAMING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  - 1. Section 04 40 00 "Cold-Formed Metal Framing"

**1.2 REFERENCE STANDARDS**

- A. American Institute of Steel Construction (AISC), Steel Construction Manual, 14<sup>th</sup> Edition.
- B. Minimum Design Loads for Buildings and other Structures, ASCE 7-10.
- C. Cold-Formed Steel Design, 14<sup>th</sup> Edition.
- D. "Specifications for Structural Joints Using ASTM Rated Bolts" approved by The Research Council on Structural Connections.

**1.3 SUBMITTALS**

- A. Shop Drawings
  - 1. Drawings depicting all erection and shop details, including cuts, connections, holes, splices, fasteners, welds, and other connection and fabrication details.
  - 2. All welds, necessary in both shop and field.
  - 3. Indicate all exposed surface and edge preparation.
  - 4. Indicate special tolerances, erection and additional connection requirements.

**1.4 PRODUCT HANDLING**

- A. Structural Steel should be stored at project site above ground on skids or other supports, and covered if possible.
- B. All other material shall be stored in a weather-tight and dry place, until ready for use.

**PART 2 PRODUCTS**

**2.1 MATERIAL**

- A. Structural shapes and plates must meet ASTM A36. Hollow structural shapes shall meet ASTM A53.
- B. Provide products with an average recycled content of steel products that is not less than 25 percent.
- C. Tie Back Anchors:
  - 1. Manufacture according to structural drawings.
  - 2. Tested and Certified according to OSHA requirements for fall prevention system.

## 2.2 FABRICATION

- A. Fabricate structural steel in accordance with AISC 16.1.
- B. Fabricate and assemble in shop as much as possible.
- C. High strength bolts: install according to RCSC's "specification for Structural Joints using ASTM A325 bolts" for type of bolt and type of joint specified.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Examine all structural steel for warping, gouges and other imperfections prior to erecting.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected. Installation constitutes acceptance of existing conditions and responsibility for satisfactory performance.

### 3.02 EXECUTION

- A. Erect structural steel in accordance with the AISC specifications and additional requirements of this section.
- B. Erection Tolerances: Maintain erection tolerances of structural steel within AISC 303-05.
- C. Field Assembly:
  1. Structural steel frames shall be accurately assembled to the lines and elevations indicated in the drawings within specified erection tolerances.
  2. The various members forming parts of a complete frame or structure after being assembled shall be aligned and adjusted accurately before being fastened.
  3. Fastening of splices of compression members shall be done after the abutting surfaces have been brought completely into contact.
  4. Bearing surfaces and surfaces which will be in permanent contact shall be cleaned before members are assembled.

### 3.3 QUALITY CONTROL

- A. Testing: Field bolted connections will be subjected to testing and inspection. Qualified independent testing and inspection agency will perform field tests and report results.
- B. Remove and replace work where test results indicate that it does not comply with specified requirements.
- C. Additional testing will be performed where necessary to determine compliance of replaced or additional work.

END OF SECTION 05 12 00

**SECTION 05 14 13  
 ARCHITECTURALLY EXPOSED STRUCTURAL ALUMINUM FRAMING**

**PART 1 GENERAL**

**1.01 SUMMARY**

- A. Photovoltaic Roof Rack System
- B. Photovoltaic Roof Rack Footing

**1.02 RELATED SECTIONS**

- A. Section 07 53 00 "Elastomeric Membrane Roofing"
- B. Section 07 65 00 "Flexible Flashing"
- C. Section 26 31 00 "Photovoltaic Collector".

**1.03 QUALITY ASSURANCE**

- A. Installer responsibilities:
  1. Inquire and comply with all local and state building codes that apply to installation.
  2. Consult with engineer to inspect and determine that all roofs, rafters, trusses and all structure supports the solar array and live load conditions.

**PART 2 PRODUCTS**

**2.01 MANUFACTURES**

- A. Ten K Solar

**2.02 MATERIALS**

- A. Ten K Solar mounting system

**2.03 ASSESSORIES**

- A. High-Strength Bolts, Nuts, and washers.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A. Follow all installation directions provided by manufacturers.
- 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 the members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
- C. All roofing penetrations shall be done to ensure minimal chance of weathering penetration.

END OF SECTION 05 14 13

**SECTION 05 40 00  
 COLD-FORMED METAL FRAMING**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES**

- A. Steel Framing Members
- B. Screws
- C. Bolts

**1.2 RELATED SECTIONS**

- A. Metal framing of 20, 22, and 25 gage metal studs and joists and metal ceiling suspension systems are specified in Section 09 22 00 – Supports for Plaster and Gypsum Board.

**1.3 REFERENCES**

- A. American Iron and Steel Institute (AISI):
  - 1. AISI SG-673: Specification for the Design of Cold-Formed Steel Structural Members
- B. American Society for Testing and Materials (ASTM):
  - 1. ASTM A570: Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, A570M Structural Quality
  - 2. ASTM A611: Specification for Steel, Sheet, Carbon, Cold-Rolled, Structural Quality
- C. Steel Structures Painting Council (SSPC):
  - 1. SSPC-PA 1: Shop, Field, and Maintenance Painting.

**1.4 SUBMITTALS**

- A. General: Refer to Section 01 33 00 – Submittals, and Section 01 33 23 – Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.
- B. Shop Drawings: Submit detailed shop drawings of steel studs and joists, showing grade, size, and thickness of framing members, layout of framing, installation details, and methods of anchorage and attachment. Indicate strapping, bracing, splices, bridging, and accessories as required for proper installation.
- C. Product Data: Submit manufacturer’s product data of the framing members, along with applicable accessories.

**1.5 DELIVERY AND STORAGE**

- A. Protect metal framing members from corrosion and damage. Deliver to site in manufacturer’s unopened containers or bundles, fully identified by type, size, and grade. Store off the ground in a dry ventilated space.

**PART 2 PRODUCTS**

**2.1 MATERIALS**

- A. Steel: Steel for light gage structural framing, studs, tracks, joists, bridging, sills and headers, shall not conform with ASTM A570/A570M, minimum Grade 33, or ASTM A611, minimum Grade C, with a minimum yield point of 33,000 psi. Light gage structural framing shall conform with applicable requirements of AISI SG-673. Framing members and accessories shall be delivered to the job with manufacturer's standard over-dried coat of corrosion-inhibitive metal primer.
- B. Framing Members:
  - 1. Studs: "C" studs or standard channel studs of sizes indicated. Studs shall be 12 gage steel. Studs shall be unpunched where required to be bolted.
  - 2. Tracks: Unpunched channels, of same size, type, and gage as studs, for floor and ceiling tracks.
  - 3. Joists: Punched channel joists of sizes indicated. Joists shall be 16 gage steel as indicated. Short lengths may be 18 gage steel. Joists shall be unpunched where required to be bolted. Provide joists for floors, ceilings, and soffits as indicated.
  - 4. Heavier Members: Where studs or joists are required to be heavier steel because of long lengths or heavy loads, provide 12 or 14 gage components as indicated or required.
- C. Screws: Self-drilling, self-tapping hardened steel screws manufactured specifically for the purposes and capable of penetrating 12 gage or heavier sheet steel of structural quality. Provide screws with corrosion-inhibitive coating.
- D. Bolts: ½ -inch diameter steel bolts provide connection for building. These stated bolts do not provide structural load transfer.

### **PART 3 EXECUTION**

#### **3.1 INSTALLATION**

- A. Install steel studs and joists as indicated and in accordance with the approved submittals and the manufacturer's installation instructions by skilled installers experienced in the type of work involved.
- B. Provide bridging for studs and joists in accordance with the framing manufacturer's instructions.
- C. Erection technique shall result in plumb and straight walls and level ceilings and soffits with no waves or buckles or unevenness at joints.

#### **3.2 FIELD PAINTING**

- A. After erection and installation, spot paint and touch up all field bolts, field welds, and abrasions to the shop coat in accordance with SSPC-PA 1. Shop, Field, and Maintenance Painting. Clean surfaces for paint adherence and as required to prevent corrosion. Provide same paint as was used for shop painting.

**END OF SECTION 05 40 00**

**SECTION 05 50 00  
 METAL FABRICATIONS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 01 53 00 "Temporary Foundations"
  2. Section 06 10 00 "Rough Carpentry"
  3. Section 06 60 00 "Plastic Fabrications"
  4. Section 08 43 13 "Aluminum-Framed Storefronts"

**1.2 SUBMITTALS**

- A. Submit shop drawings indicating all shop and erection details including cuts, connections, holes, threaded fasteners, welds, connections to adjacent construction, elevations, etc.
- B. Shop Drawings shall at least meet all applicable codes and regulations.
- C. No Fabrication shall commence until shop drawings are approved.

**1.3 AGENCY STANDARDS**

- A. Comply with applicable portions of the standards set by The American Society for Testing Materials (ASTM).

**PART 2 PRODUCTS**

**2.1 GENERAL**

- A. All materials shall be new and shall conform to the following requirements, latest edition:
  1. Structural Steel Shapes: as per ASTM A992
  2. Steel Plates, channels, and angles: as per ASTM A36.
- B. Fastenings shall be indicated in drawings and specifications.

**2.2 CONNECTION PLATE AT DECK FOOTINGS**

- A. Fabricated per drawings.
- B. Steel to be 12-gauge and galvanized.

**2.3 PLATE AT BASE OF RAMP**

- A. Fabricated per drawings.
- B. 1/8" Aluminum Diamond Plate
- C. Connect to ramp with Sierra Pacific 1/4" x 0.40" x 18" continuous hinge.

## 2.4 AWNING SUPPORT

- A. Fabricated per drawings.
- B. All steel to be galvanized.

## PART 3 EXECUTION

### 3.1 INSTALLATION, GENERAL

- A. All work performed as per standard practices of AISC
- B. Provide all bolts, anchors, screws, shop and field connections, and miscellaneous fasteners required to make installation complete.
- C. Wherever dissimilar metals come into contact, neoprene washers, spacers, gaskets or other approved materials shall be inserted between them to provide insulation against electrolytic action.
- D. The fabricator shall verify all dimensions of work. Measurements of adjoining work shall be obtained so that work shall fit closely to space provided.
- F. Do not field cut or alter structural members.
- G. At exposed steel components, grind welds smooth and flush prior to finishing.

END OF SECTION 05 50 00

DIVISION 08  
**OPENINGS**

**SECTION 08 35 13  
 ACCORDION FOLDING GLASS DOORS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes
  - 1. Interior Folding Door Track
  - 2. Interior Folding Door Hardware
- B. Related Sections
  - 1. Section 08 80 00

**PART 2 PRODUCTS**

**2.1 FOLDING DOOR TRACK**

- A. Multi-Slide Door System: TS-83 Thermally Broken
  - 1. Four multi-sliding doors
  - 2. Glass Thickness: 8mm

**2.2 FOLDING DOOR HARDWARE**

- A. Model: Allegro
- B. Finish: Polished Chrome

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Set doors level, plumb, and true to line, without warp or rack of frames and panels. Provide proper support 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. Clean aluminum surfaces and glass immediately after installing folding glass door system. Remove nonpermanent labels from glass surfaces.
- D. Installation should follow the manufacturer's instructions.

**END OF SECTION 08 35 13**

**SECTION 08 42 00  
 ALUMINUM FRAMED ENTRANCES**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes
  1. Wood Door Frame
  2. Fiberglass entry door

**1.2 SECTION REQUIREMENTS**

- A. Entrance performance Requirements:
  1. Air Infiltration: For single acting offset pivot or butt hung entrances in the closed and locked position, the test specimen shall be tested in accordance with ASTM E 283 at a pressure differential of 6.24 psf (300 Pa) for single doors. A single 3'0" x 7'0" entrance door and frame shall not exceed 0.5 cfm per square foot.
  2. Structural: Corner strength shall be tested per the Pella dual moment load test procedure and certified by an independent testing laboratory to ensure weld compliance and corner integrity.
  3. Thermal performance: computer simulation testing shall be in accordance with NFRC 100/200/500 and AAMA 507-03.

**1.3 SUBMITTALS**

- A. General:
  1. Prepare, review, and submit specified submittals in accordance with the "Conditions of the Contract" and Submittals Sections.

**1.4 WARRANTY**

- A. Manufacturer's Warranty: Submit for owner's acceptance, manufacturer's standard warranty.
  1. Warranty period: Two (2) years from date of sale or refund the original purchase price to client.

**PART 2 PRODUCTS**

**2.1 MANUFACTURES**

- A. Manufacturers:
  1. Therma-Tru Doors

**2.2 MATERIALS**

- A. Wood Frame
  1. Aluminum Clad Coating
- B. Fiberglass Entry Door
  1. Smooth Star
  2. Finish: Smooth fiberglass in Real Red
  3. Glass: Low-E non-decorative glass

**PART 3 EXECUTION**

**3.1 HANDLING**

- A. Handling and Unloading
  - 1. Observe manufacturers recommendations and handle accordingly to prevent breakage or damage
  - 2. Do not allow door to move during transportation

**3.2 INSTALLATION**

- A. Install according to manufacturer's recommendation to avoid any damages.

**END OF SECTION 08 42 00**

**SECTION 08 53 13  
 VINYL WINDOWS**

**PART 1 GENERAL**

**1.1 SCOPE OF WORK**

- A. Furnish and install vinyl windows as shown in drawings and as per specifications stipulated in this section.
- B. Factory-installed glass and glazing.

**1.2 RELATED SECTIONS**

- A. Section 07 90 00 – “Joint Protection.”
- B. Section 08 41 00 – “Entrances and Storefronts.”
- C. Section 08 70 00 – “Hardware.”

**1.3 REFERENCES**

- A. AAMA - American Architectural Manufacturers Association:
  1. AAMA/WDMA/CSA 101/I.S.2/A440-08 "North American Fenestration Standard/Specification for Windows, Doors, and Skylights"
  2. AAMA/WDMA/CSA 101/I.S.2/A440-05 "Standard/Specification for Windows, Doors, and Unit Skylights"
  3. AAMA 502-08 - Voluntary Specification for Field Testing of Newly Installed Fenestration Products.
  4. AAMA 611-98 - Voluntary Specification for Anodized Architectural Aluminum
  5. AAMA 701/702-04 - Voluntary Specification for Pile Weatherstripping and Replaceable Fenestration Weatherseals.
  6. AAMA 800-07 - Voluntary Specifications and Test Methods for Sealants.
  7. AAMA 902-07 - Voluntary Specification for Sash Balances.
  8. AAMA 910-93 - Voluntary Life Cycle' Specifications and Test Methods for Architectural Grade Windows and Sliding Glass Doors.
  9. AAMA 1503-98 - Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors, and Glazed Wall Sections.
  10. AAMA 2603-02 - Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels.
  11. AAMA 2604-05 - Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels.
  12. AAMA 2605-05 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
- B. ASTM – American Society for Testing and Materials:
  1. ASTM E 283-04 - Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.

2. ASTM E 330-02 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Uniform Static Air Pressure Difference.
  3. ASTM E 331-00 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.
  4. ASTM E 547-00 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Differential.
  5. ASTM F 588; 1997 - Standard Test Methods for Measuring the Forced Entry Resistance of Window Assemblies, Excluding Glazing Impact.
  6. ASTM E 2190-02 - Standard Specification for Insulating Glass Unit Performance and Evaluation.
- C. NFRC - National Fenestration Rating Council.
1. NFRC 100-04 - Procedure for Determining Fenestration Product U Factors.
  2. NFRC 102-04 - Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems.
  3. NFRC 500-04 - Procedure for Determining Fenestration Product Condensation Resistance Values.
- D. IGCC - Insulating Glass Certification Council.
- E. SGCC - Safety Glazing Certification Council.
1. Z97.1-04 American National Standard for Safety Glazing Materials used in Buildings - Safety Performance Specifications and Methods of Test.
  2. 16 CFR 1201 Consumer Product Safety Commission Safety Standard for Architectural Glazing Materials - codified at Title 16, Part 1201 of the Code of Federal Regulations.
- F. ANSI Z97.1 - American National Standard For Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test/Consumer Products Safety Commission CPSC 16 CFR 1201.
- G. LEED: The Leadership in Energy & Environmental Design; U.S. Green Building Council (USGBC).

#### 1.4 SUBMITTALS

- A. Submit administrative requirements under provisions of Section 01 30 00.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
1. Preparation instructions and recommendations.
  2. Storage and handling requirements and recommendations.
  3. Installation methods.
- C. Shop Drawings:
1. Elevation for each style window specified indicating its size, glazing type, mounting type and design.
  2. Manufacturer's head, jamb and sill details and section views for each window type specified.
- D. Schedules:

1. Provide a window schedule indicating the type, size, color, and operation of each unit specified. Coordinate with window mark types found in the Contract Drawings.
- E. Selection Samples: For each finish product specified, two complete sets of color chips representing manufacturer's full range of available colors and patterns.
- F. Verification Samples: For each finish product specified, samples may be subsequently installed on the project.
- G. Test Reports: Submit certified independent testing agency reports indicating window units meet or exceed specified performance requirements.

#### 1.5 SYSTEM DESCRIPTION

- A. Operation: FIXED
- B. Construction: 3 1/4" frame depth. Wall thickness: 0.080"/0.080" frame/sill. Factory finished VY Vinyl frame and sash members with integral structural polyurethane thermal break.
- C. Glazing: 1" insulating glass; set on double-sided adhesive glazing foam tape on the frame glazing leg, and secured in the interior with snap-in glazing beads and bulb gaskets.

#### 1.6 WEATHERSTRIPPING:

- A. Compression type bulb gasket on the interior glazing bead.

#### 1.7 PERFORMANCE REQUIREMENTS

- A. Air, Water and Structural Performance Requirements: When tested in accordance with cited test procedures, windows shall meet or exceed the following performance criteria, as well as those indicated in AAMA 101 and 101/I.S.2/A440-08 for performance grade of unit specified unless otherwise noted herein.
  1. Air Test Performance Requirements:
    - a. Performance: Air infiltration maximum 0.10 cfm per square foot at 6.2 psf pressure differential when tested in accordance with ASTM E283 for sliding sealed products.
  2. Water Test Performance Requirements:
    - a. No uncontrolled water leakage at 12 psf static pressure differential when tested in accordance with ASTM E331 and ASTM E547.
  3. Structural Test Performance Requirements:
    - a. Uniform Load Deflection Test
      - 1) No deflection of any unsupported span L of test unit (framing rails, muntins, mullions, etc.) in excess of L/150 at both a positive and negative load of design test pressure when tested in accordance with ASTM E330.
      - 2) Structural reinforcing that is not standard on units being furnished is not allowed.
    - b. Uniform Load Structural Test:
      - 1) Unit to be tested at 1.5 x design test pressure, both positive and negative, acting normal to plane of wall in accordance with ASTM E330.

- 2) No glass breakage; permanent damage to fasteners, hardware parts, or anchors; damage to make windows inoperable; or permanent deformation of any main frame or ventilator member in excess of 0.2% of its clear span.
- B. Forced Entry Resistance Test: ASTM F 588, type and grade as indicated for each product.
- C. Thermal Performance Requirements
  - 1. Perform thermal computer simulation in accordance with the configuration specified in NFRC 100.
  - 2. Computed Thermal Transmittance (U-Value) shall not exceed 0.2 BTU/hr/sq.ft.°F for the whole window assembly.

## 1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: All windows specified in this section shall be supplied by a manufacturer which has been fabricating/manufacturing commercial grade aluminum windows of similar quality and performance for a minimum of ten (10) years.
- B. Installer Qualifications: All products listed in this section are to be installed by a single installer with a minimum of five (5) years demonstrated experience in installing windows of the same type and scope as specified, preferably AAMA certified installers.
- C. Provide test reports from AAMA accredited laboratory certifying that window units are found to be in compliance with AAMA/WDMA/CSA 101/I.S.2/A440-08 and performance standards listed above.
  - 1. Test reports shall be accompanied by the window manufacturer's letter of certification stating that the tested window meets or exceeds criteria for the appropriate AAMA/WDMA/CSA 101/I.S.2/A440 test.

## 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation in accordance with manufacturer's recommendations.
- B. Protect units against damage from the elements, construction activities and other hazards before, during, and after installation.

## 1.10 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

## 1.11 WARRANTY

- A. Refer to Crystal Window & Door Systems, Ltd. standard warranty.
- B. Optional Extended Warranty (contact your Crystal sales representative).

## PART 2 PRODUCTS

## 2.1 MANUFACTURER

- A. Acceptable Manufacturer: Crystal Window & Door Systems, Ltd., located at 31-10 Whitestone Expressway, Flushing, NY 11354; Tel: 718. 961.7300; Tel: 800. 472.9988; Fax: 718.460.4594; Web: [www.crystalwindows.com](http://www.crystalwindows.com)
- B. Requests for substitutions will be considered in accordance with provisions of Section 01 60 00.

## 2.2 VINYL

- A. VY Vinyl:
  - 1. All vinyl extrusions shall be rigid 100% virgin PVC. The frame, mullion, sash rails shall have a main wall thickness of 0.075". Frame section shall have seven tubular hollows for strength and thermal efficiency. Sash profiles shall contain ten tubular hollows.

## 2.3 THERMAL BARRIER

- A. Structural Thermal Barrier:
  - 1. Structural thermal barrier shall consist of poured-in-place polyurethane polymer that shall transfer shear during bending and provide composite action between frame components.
- B. Non Structural Thermal Barriers:
  - 1. Non structural thermal barriers are used only in conjunction with structural thermal barriers. The purpose of non structural thermal barriers is to enhance thermal performance of the primary structural thermal barriers (polyamide struts) by inhibiting heat transfer through thermal radiation and convection. Non structural thermal barriers shall not be used as primary load carrying members.
  - 2. Rigid non structural thermal barriers shall be constructed of extruded polyvinylchloride (PVC).

## 2.4 GLASS

- A. Glazing Materials:
  - 1. Vertical Glazing: For glass surfaces sloped 15 degrees or less from vertical. Design glass to resist design wind pressure based on glass type factors for short-duration load.
  - 2. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass lites in thicknesses as needed to comply with requirements indicated.
  - 3. Strength: Where float glass is indicated, provide annealed float glass. Where fully tempered glass is indicated, provide Kind FT heat-treated float glass.
  - 4. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated.
    - a. U-Factors: Total-glazing values, according to NFRC 100 and based on LBL's WINDOW 5.2 computer program, expressed as BTU/sq.ft x h x deg F (W/sq. m x K).
    - b. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL's WINDOW 5.2 computer program.
    - c. Visible Reflectance: Center-of-glazing values, according to NFRC 300.

- A. Insulating Glass Units:
  - 1. Factory-assemble units consisting of sealed lites of glass separated by a PPG Intercept Spacer system consisting of a one-piece, metallic, U-channel design that creates an effective thermal barrier to help reduce conducted heat loss through the window.
  - 2. Insulating glass units shall be sealed with an integral desiccant matrix and a butyl sealant extruded around the entire perimeter of the spacer to achieve a seal. The sealant applied is to be Dual Seal Equivalent (DSE). Interspace to be filled with air or argon gas as required by thermal computer simulation.
  - 3. Insulating Glass Types: Low-E coated, insulating glass units.
    - a. Overall Unit Thickness: 23.625"
    - b. Thickness of Each Glass Lite: 3/32", 1/8" or 1/4".
    - c. Interspace Content: Air or Argon Gas.
    - d. Low-E Coating: Sputtered on second or third surface.
    - e. U-Value: 0.23
    - f. Solar Heat Gain Coefficient: 0.19
    - g. Provide safety glazing labeling, if necessary.

## 2.5 WINDOW ACCESSORIES

- B. Provide the following accessories as specified in the contract drawings. Finish to match window frames or as selected by the Architect.
  - 1. Wrap Around Panning
  - 2. Preset Panning
  - 3. Snap Trim/Clips
  - 4. Expanders
  - 5. Receptors
  - 6. Subsills and Subsill Anchors.
  - 7. Mullions and Mullion Covers.
  - 8. Exterior Sills.
  - 9. Interior Stools.
  - 10. Muntins.

## 2.6 FINISHES

- A. Conforming to AAMA 2604-05 specification, finish on all extruded aluminum shall consist of zero or near-zero VOC, organic POWDER COAT with a baked on super-durable thermosetting polyester resin, electro-statically applied on five-stage pre-treated aluminum surface. Equivalent to 50% Kynar polyvinylidene fluoride liquid paint finishes. Powder coat material to be as manufactured by Sherwin Williams or PPG Powder Coatings.
- B. Color to be selected from Manufacturer's Standard Color Chart (or custom-matched as required by project Architect/Owner).

## 2.7 INSECT SCREENS

- A. Screen frames shall consist of tubular extruded aluminum profiles with finish to match window frames.
- B. Fiberglass mesh (18 X 16) with PVC spline.

- C. Steel components including attachment fasteners shall be 300 series stainless steel except as noted.
- D. Thermoplastic or thermo-set plastic caps, housings and other components shall be injection-molded nylon, extruded PVC, or other suitable compound.

**2.8 SEALENTS**

- A. Sealants shall comply with applicable provisions of AAMA 800 and/or Federal Specifications FS-TT-001 and 002 Series.
- B. Frame joinery sealants shall be suitable for application specified and as tested and approved by window manufacturer.

**PART 3 EXECUTION**

**3.1 EXAMINATION**

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

**3.2 PREPERATION**

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

**3.3 INSTALLATION**

- A. Install in accordance with manufacturer's instructions.

**3.4 ANCHORAGE**

- A. Anchor window units and/or assemblies sufficiently to maintain permanent positions when subjected to normal thermal movement, specified building movement and specified wind loads.

**3.5 PROTECTION**

- A. Protect installed products until completion of project.
- B. Final operating adjustment shall be made after glazing work is complete. Operating sash and ventilator shall operate smoothly and shall be weather tight when in locked position.
- C. Touch-up, repair or replace damaged products before Substantial Completion.

**3.6 DISPOSAL OF DEBRIS**

- A. Remove all garbage off site and legally dispose of existing windows and debris generated from the installation of the new windows.

### 3.7 OPTIONAL FIELD TESTING

- A. At the discretion and expense of Owner or Owner's representative, perform on-site testing of installed units in conformance with AAMA 502 - Voluntary Specification for Field Testing of Windows and Sliding Glass Doors. Conduct air and water infiltration testing with the window manufacturer, contractor, and owner present.
- B. An AAMA accredited lab will be hired by the owner to perform the required testing.

### 3.8 ADJUSTMENT AND CLEAN UP

- A. Adjust all products, sash, vents, and hardware after installation, as necessary to provide proper operation and a weather tight installation.
- B. Remove any labels and dirt from the window.

END OF SECTION 08 53 13

**SECTION 08 70 00  
 DOOR HARDWARE**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Door Hardware at exterior doors
- B. Related Sections
  - 1. Section 08 42 00 "Aluminum Framed Fiberglass Entrances"

**1.2 WARRANTY**

- A. Manufacturer's ten-year [10- year] limited warranty

**PART 2 PRODUCTS**

**2.1 MATERIAL**

- A. Manufacturer
  - 1. Schlage Century Satin Nickel Residential Single-Lock Door Handleset
- B. Finish of Hardware to be as Follows:
  - 1. Satin Nickel

**2.2 KEYS AND KEYING**

- A. All locksets shall be keyed as directed by owner, as part of its sergeant master system.
- B. Supply two (2) keys for each lock.

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Install and adjust hardware so that:
  - 1. Hinges function freely without binding or dragging
  - 2. Locksets, latch sets and panic hardware function perfectly with bolts or pins fitting perfectly into strikes

**END OF SECTION 08 70 00**

SECTION 08 80 00  
**GLAZING**

**PART 1 GENERAL**

**1.1 SUMMARY**

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

**1.2 SUBMITTALS**

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

**1.3 QUALITY ASSURANCE**

- A. Comply with provisions of the consumer product safety standard for architectural glazing materials (16 CFR 1201)
- B. The glazier must examine the framing and glazing channel surfaces, backing, removable stop design, and the conditions under which the glazing is to be performed, and notify the contractor in writing of conditions detrimental to proper and timely completion of the work. Do not proceed with glazing until unsatisfactory conditions have been corrected in a manner acceptable to the glazier.
- C. Environmental requirements: installation of glass products at ambient air temperature below 40 degrees Fahrenheit is prohibited. Do not proceed with installation of liquid sealants under adverse weather conditions, or when temperatures are below or above manufacturer's recommended limitations for installation.
- D. Glazing contractor shall obtain compatibility and adhesion test reports from sealant manufacturer. Indicating that glazing materials were tested for compatibility and adhesion with glazing sealant, as well as other glazing materials including insulating units.

**1.4 WARRANTY**

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

**PART 2 PRODUCTS**

**2.1 GLASS PRODUCTS**

- A. Glass at Panda TS.83 Thermally Broken Multi-Slide Doors
  1. Panda Windows & Doors - Glass
    - a. Clear LoE Tempered 1 3/8" insulated glass
    - b. Minimum 1/4" single pane glass
    - c. Maximum 1 1/2" hurricane insulated glass
    - d. Unique (blinds between) glass 1 1/2" insulated glass
    - e. Options: Frosted, Tinted, Argon/Krypton filled.

- f. SDLs or TDLs may also be integrated
- B. Glass at Exterior Wall Systems
  - 1. AGC Flat Glass: Single Pane, tempered
    - a. Thickness: 9/16"
    - b. Coating: low-e at interior face
- C. Glass at Exterior Doors
  - 1. ACG Flat Glass: U4 Insulated Glass Unit, tempered
    - a. Acid etched
- D. Glass at Interior Doors
  - 1. ACG Flat Glass: single pane, tempered
    - a. Thickness: 8mm

### **PART 3 EXECUTION**

#### **3.1 STANDARDS AND PERFORMANCE**

- A. Skilled glaziers shall set all glass in strict accordance with glass and frame manufacturer's printed instructions.
- B. Watertight and airtight installation of each piece of glass is required, except as otherwise shown. Each installation must withstand normal temperature changes, wind loading, impact loading (for operating sash and doors) without failure of any kind, including loss or breakage of glass, failure of sealants or gaskets to remain watertight and airtight, deterioration of glazing materials and other defects in the work.
- C. Protect glass from edge damage at all time during handling, installation and operation of the building.
- D. Glazing channel dimensions as shown are intended to provide for necessary minimum bite on the glass, minimum edge clearance and adequate sealant thicknesses, with reasonable tolerances. The glazier is responsible for providing correct glass size for each opening, within the tolerances and necessary dimensions established.
- E. Comply with combined recommendations of glass manufacturer and manufacturer of sealants and other materials used in glazing, except where more stringent requirements are shown or specified, and except where manufacturer's technical representative directs otherwise.
- F. Comply with "glazing manual" by flat glass marketing association except as shown and specified otherwise, and excepts as specifically recommended otherwise by the manufacturers of the glass and glazing materials.
- G. Inspect each piece of glass immediately before installation, and eliminate any, which have observable edge damage or face imperfections.
- H. Unify appearance of each series of lights by setting each piece to match others as nearly as possible. Inspect each piece and set with pattern, draw and bow oriented in the same direction as other pieces.

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

### 3.2 PREPARATION FOR GLAZING

- A. Verify that site conditions are acceptable for installation of the glass.
- B. Verify openings for glazing are correctly sized and within tolerance.
- C. Verify that a functioning weep system is present.
- D. Verify that the minimum required face and edge clearances are being followed.
- E. Clean the glazing channel, or other framing members to receive glass, immediately before glazing. Remove coatings not firmly bonded to the substrate. Remove lacquer from metal surfaces wherever elastomeric sealants are used.
- F. Apply primer or sealer to joint surfaces wherever recommended by sealant manufacturer.
- G. Do not proceed with glazing until unsatisfactory conditions have been corrected.

### 3.3 GLAZING

- A. Install products using the recommendations of manufacturers of glass, sealants, gaskets and other glazing materials, except where more stringent requirements are indicated, including those in the "Gana Glazing Manual"
- B. Verify that insulating glass (IG) unit secondary seal is compatible with glazing sealants.
- C. Install glass in prepared glazing channels and other framing members
- D. Install setting blocks in rabbets as recommended by referenced glazing standards in Gana Glazing Manual and IGMA Glazing Guidelines
- E. Provide bite on glass, minimum edge and face clearances and glazing material tolerances recommended by GANA Glazing Manual
- F. Provide weep system as recommended by Gana Glazing Manual
- G. Set glass lites in each series with uniform pattern, draw, bow and similar characteristics
- H. Distribute the weight of the glass unit along the edge rather than at the corner
- I. Comply with manufacturer's and referenced industry recommendations on expansion joints and anchors, accommodating thermal movement, glass openings, use of setting blocks, edge, face and bite clearances, use of glass spacers, edge blocks and installation of weep systems.

- J. Don not attempt to cut, seam, nip or abrade glass that is tempered, heat strengthened or coated
- K. Clean and trim excess materials from the glass and stops or frames promptly after installation, and eliminate stains and discolorations.
- L. Gasket glazing. Miter cut and bond ends together at corners where gaskets are used for channel glazing, so that gaskets will not pull away from corners and results in voids or leaks in the glazing system.
- M. Provide bite, face clearance and edge clearance as recommended by glass and framing manufacturers.
- N. Protect glass from edge damage during handling and installation
- O. Prevent glass form contact with contaminating substances that result for construction operations, such as weld splatter, fireproofing or plaster.

**3.4 CURE, PROTECTION AND CLEANING**

- A. Protect exterior glass from breakage immediately upon installation, by attachment of crossed streamers to framing held away from glass. Do not apply markers of any type to surface of glass.
- B. Remove or replace glass which is broken, chipped, scratched, marred, pitted obscured, abraded or damaged in other ways during the construction period, including natural causes, accidents, and vandalism.
- C. Maintain glass in a reasonably clean condition during construction, so that it will not be damaged by corrosive action and will not contribute (by wash off) to the deterioration of glazing materials and other work.
- D. Clean excess sealant or compound from glass and framing members immediately after application, using solvents or cleaners recommended by manufacturers.
- E. Glass to be cleaned according to:
  - 1. Serious materials
  - 2. AGC
- F. Do not use scrapers or other metal tools to clean glass.

**END OF SECTION 08 80 00**

DIVISION 09

**FINISHES**

**SECTION 09 29 00  
 GYPSUM BOARD**

**PART 1 GENERAL**

**1.1 SECTION REQUIREMENTS**

- A. Submittals: Product Data
- B. Product Certificate for GREENGUARD indoor Air Quality for products and materials required to comply with requirements for minimum chemical emission.
- C. ASTM C 1396 standards pertinent.

**PART 2 PRODUCTS**

**2.1 GYPSUM BOARD**

- A. Standard Gypsum Board
  - 1. Core: Regular
  - 2. Surface Paper: 100% recycled content paper on front, back and edges.
  - 3. Overall thickness: 1/2"
- B. Mold and Moisture Resistant Gypsum Board
  - 1. Core: Mold and moisture resistant core
  - 2. Surface paper: 100% recycled content moisture, mold and mildew resistant paper on front, back, and edges.
  - 3. Overall thickness: 5/8"
  - 4. Mold and Mildew Resistance: 10 when tested in accordance with ASTM D 3273 Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coating in an Environment Chamber.
  - 5. Environmental Requirements: Provide products that comply with testing and product requirements for low emitting materials.
- C. Accessory Products
  - 1. Tape:
    - a. Paper Tape: 2- 1/16 inches wide
    - b. Paper Tape: 2 inches wide with metal strips along center crease to form inside and outside corners
    - c. Fiberglass Tape: normal 2 inches wide self adhering tape
  - 2. Trims and Beads" material: Zinc Coated steel; 26 gauge minimum, ASTM C 10472
    - a. Corner Bead: Use at outside corners
    - b. Control Joint: Use when indicated and specified
    - c. J-Bead: Use where indicated and specified
  - 3. Drying Tape Compound
    - a. Ready Mix vinyl base compound
    - b. Ready Mix vinyl base compound formulated for enhanced mold and mildew resistance
    - c. Ready Mix Vinyl base compound formulated to reduce airborne dust during sanding
    - d. Ready Mix Vinyl base topping compound for finish coating

- e. Ready Mix vinyl base compound for embedding joint tape, corner beads, or other accessories
  - f. Field Mix vinyl base compound.
4. Setting Compound:
- a. Field mixed hardening compound
  - b. Field mixed hardening compound for fire resistance rated construction and penetrations

**PART 3 EXECUTION**

**3.1 INSTALLATION: GYPSUM BOARD**

- A. Prepare substrate by cleaning, removing projections, filling voids, sealing joints, and as otherwise recommended in manufactures instructions.
  - 1. Single Layer- 5 ½ inch wood stud construction
    - a. Apply ½ inch gypsum panel to SIP and/or stud wall.
    - b. Space screw 16" in field and along abutting end joints.
    - c. Parallel application, space screws 16" in field of panels and along vertical abutting edges.

**END OF SECTION 09 29 00**

**SECTION 09 30 00  
 TILING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes
  - 1. Bathroom Wall Tile
  - 2. Kitchen Backsplash Tile

**PART 2 PRODUCTS**

**2.1 BATHROOM TILE**

- A. Ceramic Subway Tile
  - 1. Thickness: 8mm
  - 2. Size: 6"x 24"
  - 3. Color(s): Dark Slate, Black, Shell White
  - 4. Finish: Ceramic
- B. Glass Mosaic Tile 1"x1" or equivalent
  - 1. Thickness: 3/16"
  - 2. Size: 12.5"x12.5"
  - 3. Color(s): Fog Dark Grey

**2.2 KITCHEN TILE**

- A. White Gray Tones Wall Tile
  - 1. Thickness: 8mm
  - 2. Size: 12"x14"
  - 3. Color(s): Gray/Silver

**PART 3 EXECUTION**

**3.1 EXAMINATION**

- A. Examine areas and substrates with installer present, for compliance with requirements and other conditions affecting performance.
- B. Examine tiles before installation. Reject broken or cracked tiles.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.2 INSTALLATION**

- A. Installation shall comply with manufacturer's instructions

**END OF SECTION 09 30 00**

**SECTION 09 51 33  
 CEILING PANEL SYSTEM**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes
  - 1. Ceiling System

**1.2 DELIVERY, STORAGE, AND HANDLING**

- A. The ceiling panels shall be stored in a dry interior location and shall remain in cartons prior to installation to avoid damage. The cartons shall be stored in a vertical position.

**PART 2 PRODUCTS**

**2.1 CEILING PANEL SYSTEM**

- A. Armstrong METALWORKS Vector or equivalent
  - 1. Size: 2'x2'
  - 2. Thickness: 5/16"
  - 3. Color: White

**PART 3 EXECUTION**

**3.1 EXAMINATION**

- A. Examine areas with installer present, for compliance with installation conditions.
- B. Examine Panels before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.2 INSTALLATION**

- A. Installation shall comply with manufacturer's instructions.

**END OF SECTION 09 15 33**

**SECTION 09 91 00  
 PAINTING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Sections Include:
  1. The work of this section includes, but is not limited to, painting of all exposed steel at interior of building.
- B. Related Sections
  1. Section 05 12 00 "Structural Steel Framing"

**1.2 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination
- B. LEED Submittals:
  1. This work shall be scheduled and coordinated with other trades and shall not proceed until other work and or job conditions are as required to achieve satisfactory results.
  2. The contractor shall examine the specifications for the various other trades and shall thoroughly familiarize himself with all their provisions regarding painting.

**1.3 ACTION SUBMITALS**

- A. Samples: Submitted for approval not less than two weeks before any painting will start. Rejected samples shall be resubmitted until approval. Obtain approval in writing before delivering materials.

**1.4 DELIVERY, STORAGE, AND HANDLING**

- A. All materials used on the job shall be stored in a single place designated by the architect. Such storage place shall be kept neat and clean and all damage thereto or its surroundings shall be made good. Any soiled or used rags, wasted, and trash must be removed from the building every night and every precaution taken to avoid the danger or a fire.

**1.5 FIELD OR SITE CONDITIONS**

**PART 2 PRODUCTS**

**2.1 ACCEPTABLE MANUFACTURES**

- A. Provide products of one of the following manufacturers that meet or exceed specified requirements.
  1. Benjamin Moore and Co.
  2. Pittsburgh Paints

**2.2 PAINT MATERIALS**

- A. All paints, varnishes, enamel, lacquers, stains, paste fillers, and similar materials must be delivered in the original containers with the seals unbroken and labels intact, and with the manufacturer's instructions printed without disturbance.
- B. Solvents shall be pure and of highest quality, and shall be approved by the architect. They shall bear identifying labels on the containers, with the manufacturer's instructions printed without disturbance.
- C. Paint shall arrive on the job ready-mixed, except for tinting or undercoats and possible thinning.

### 2.3 ACCESSORY MATERIALS

- A. This work shall include all required ladder, scaffolding, drop cloths, masking, scrapers, tools, sandpaper, dusters, cleaning solvents, etc. as required to perform the work and achieve the results herein specified.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Before starting any work, surfaces to receive paint finishes shall be examined carefully for defects which cannot be corrected by the procedures specified herein under "Preparation of Surfaces" and which might prevent satisfactory painting results. Work shall not proceed until such damages are corrected.
- B. The commencing of work in a specific area shall be construed as acceptance of the surfaces, and thereafter the contractor shall be fully responsible for satisfactory work as requires herein.

### 3.2 PREPARATION

- A. Preparation of Surfaces:
  1. Surfaces shall be clean, dry, and adequately protected from dampness
  2. Surface shall be free of any foreign material which will adversely affect adhesion or appearance of applied coating.
  3. Mildew shall be removed and the surface neutralized
  4. Efflorescence on any area shall be corrected before painting.

### 3.3 APPLICATION

- A. All materials shall be mixed, thinned, modified and applied only as specified by the manufacturer's directions.
- B. All priming coats and undercoats shall be tinted to the approximate shade of the final coat.
- C. The contractor not only shall protect his work at all times, but shall also protect all adjacent work and materials by suitable covering or other method during progress of his work. Upon completion of the work, he shall remove all paint spatters from the floors, glass and other surfaces. He shall remove from the premises all rubbish and accumulated materials of whatever nature not caused by others and shall leave his part of the work in clean, orderly and acceptable condition.

- D. Remove and protect hardware, accessories, device plates, lighting fixtures, factory finished work, and similar items, or provide ample in place protection. Upon completion of each space, carefully replace all removed items.
- E. All materials shall be applied under adequate illumination, evenly spread and smoothly flowed on to avoid runs, sags, holidays, brush marks, air bubbles, and roller stipple.
- F. Coverage and hide shall be complete. When color or undercoats show through final coat of paint, the surface shall be covered by additional coats until the paint film is of uniform finish, color, appearance, and coverage at no additional cost to the owner.
- G. All coats shall be thoroughly dry before applying succeeding coats.

### 3.4 PAINT SCHEDULE

- A. Steel
  - 1. Two coats of QUICK- DRY ENAMEL satin
  - 2. Color: White

END OF SECTION 09 91 00

DIVISION 10  
**SPECIALTIES**



SECTION 10 22 26  
OPERABLE PARTITIONS

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes
  - 1. Manually operated paired panel partitions

**PART 2 PRODUCTS**

**2.1 OPERABLE WALL**

- A. Manufacturer: Panelfold
- B. Moduflex Series 400 Model
  - 1. Panels
    - a. Thickness: 3 1/4"
    - b. Width: 48 5/8"
    - c. Weight: shall not exceed 8 lbs/SF
    - d. Acoustical Rating: tested in accordance with ASM E90-85
  - 2. Track
    - a. Aluminum track
    - b. Steel ball bearing wheels

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Installer shall conform to the manufactures installation instruction sheets
- B. Apply primer caulking and trim as required.

END SECTION 10 22 26

DIVISION 11  
**EQUIPMENT**



**SECTION 11 31 00  
 RESIDENTIAL APPLIANCES**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  - 1. Section 25 11 00 “Home Automation and Control Systems”

**1.2 SECTION REQUIREMENTS**

- A. 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. NAECA: Provide residential appliances that comply with NAECA standards.
- B. Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with the US Architecture and Transportation Barriers Compliance’s ADA-ABA Accessibility Guidelines.
- C. Energy Ratings: Provide appliances that quantify for the EPA/DOE Energy Star product labeling program.

**PART 2 PRODUCTS**

**2.1 RESIDENTIAL APPLIANCES**

- A. Range
  - 1. Frigidaire FPIF3093L
    - a. Energy Source: Electric
    - b. Number of Cooktop Burners: 4
    - c. Number of Electric zones: 5
    - d. Cooktop Watts: 3,400
    - e. Oven Capacity: 6.0 Cu. Ft
    - f. Oven Amps/Watts: 40/ 3,900
    - g. Volts: 208-240 V
- B. Refrigerator/Freezer
  - 1. Frigidaire FFHT1513L
    - a. Energy Star Rated
    - b. Volts: 120V
    - c. Hertz: 60Hz
    - d. Draw: 15-20A
- C. Dishwasher
  - 1. Frigidaire FPHD2491KF
    - a. Tub Material: Stainless Steel
    - b. Volts: 120V

- c. Hertz: 60Hz
- d. Current: 15A
- e. Number of Cycles: 6
  
- D. Clothes Washer
  - 1. LG (Model#: WM2650HRA Item#: 02645539000)
    - a. Capacity: 4.4 Cu. Ft
    - b. Max. Spin Speed: 1200 RPM
  
- E. Clothes Dryer
  - 1. LG (Model#: WM2650HRA Item#: 02685539000)
    - a. Capacity: 7 Cu. Ft
    - b. Dry Cycles: 13
    - c. Fuel Type: Electric

### **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 are. 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 11 31 00**

**SECTION 11 52 00  
 AUDIO-VISUAL EQUIPMENT**

**PART 1 GENERAL**

**1.1 SECTION REQUIREMENTS**

- A. 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.
- B. 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 BY OWNER**

- A. Television: Wall Mounted Flat Screen Television
- B. Audio System

**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 functions and rough openings are completely concealed.

**3.2 RESIDENTIAL APPLIANCES**

- A. Freestanding Equipment: Place in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
- B. Test each item of audio-visual equipment to verify proper operation. Make necessary adjustments.
- C. Verify that accessories required have been furnished and installed.

**END OF SECTION 11 52 00**

DIVISION 12

**FURNISHINGS**



**SECTION 12 32 00  
 MANUFACTURED WOOD CASEWORK**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes
  - 1. Manufactured Wood Casework
    - a. Acrylic Faced Kitchen Cabinets

**PART 2 PRODUCTS**

**2.1 CASEWORK**

- A. Manufacturer: Crystal Cabinets
- B. Cabinetry
  - 1. Model: Quest
  - 2. Style: Frameless
  - 3. Door and Drawer Fronts: Acrylic
    - a. Color: Red
  - 4. Door and Drawer Base: Green-Core plywood
    - a. Thickness: 3/4"
    - b. Dovetail joints
    - c. Color: White
    - d. FSC Certified
  - 5. Guides: self closing zinc coated steel

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Install cabinets with no variations in flushness of adjoining surface 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. Fasten each cabinet to adjacent unit and to SIP. Fasten wall cabinets through back, near top and bottom, at ends, and not less than 24 inches o.c.

**3.2 WARRANTY**

- A. Warranty covers defects in material and workmanship from normal home use and service.
- B. Lifetime warranty lasts for as long as the purchaser owns the product at the original site of installation.

**END OF SECTION 12 32 00**

**SECTION 12 36 61  
SIMULATED STONE COUNTERTOP**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes
  - 1. Counter tops
    - a. Templates showing cutouts required for installation of items installed on or penetrating through quartz surfacing shall be provided under Sections where items are specified.

**1.2 REFERENCES**

- A. ASTM International
  - 1. ASTM C97- Absorption and Bulk Specific Gravity of Dimension Stone
  - 2. ASTM C170- Compressive Strength of Dimension Stone

**1.3 QUALITY ASSURANCE**

- A. Applicable Standards
  - 1. Standards of the following, as referenced herein:
    - a. American National Standards Institute (ANSI)
    - b. American Society for Testing Materials (ASTM)
    - c. National Electrical Manufacturers Association (NEMA)
    - d. NSF International
    - e. International Organization for Standardization (ISO)
- B. Allowable Tolerances
  - 1. Variation in component size  $\pm 1/8"$  (3mm) over a ten (10) foot length
  - 2. Location of openings:  $\pm 1/8"$  (3mm) from indicated location
  - 3. Maximum  $1/8"$  (3mm) clearance between quartz surfaces and each wall

**1.4 DELIVERY, STORAGE, AND HANDLING**

- A. Packaging, Shipping, Handling, and Unloading
  - 1. Observe manufacturer's recommendations and handle accordingly in order to prevent breakage or damage.
  - 2. Brace parts if necessary.
  - 3. Transport in the near-vertical position with finished face turned toward finished face.
  - 4. Do not allow finished surfaces to rub during shipping or handling
- B. Storage and Protection
  - 1. Store in racks in near-vertical position.
  - 2. Prevent warpage and breakage.
  - 3. Store inside away from direct exposure to sun.
  - 4. Store between 25°F and 130°F (-4°C and 54°C).
  - 5. Store with finished face turned toward finished face.

**1.5 WARRANTY**

- A. Residential: Provide manufacturer's Residential Lifetime Warranty against product defects when fabricated and installed by a CaesarStone certified fabricator.

## PART 2 PRODUCTS

### 2.1 ENGINEERED STONE COUNTER TOPS

- A. Composition: 93 percent crushed quartz aggregate combined with resins and pigments and fabricated into slabs using a vacuum vibro-compaction process.
- B. Dimensions:
  - 1. Thickness: Nominal [3/4" (20mm)] [1- 1/4" (30 mm)] [As shown on drawings.]
  - 2. Size: Slabs shall be not less than [56.5 x 120" (1.44 x 3.05 m)] to minimize the number of joints used in installation.
- C. Identification: Materials shall be labeled with a batch number and imprinted with a manufacturer's identifying mark on the back.
- D. Finish
  - 1. Smoky Ash
  - 2. Finish
    - a. Polished surface shall have gloss greater than or equal to 35% at 50°

### 2.2 INSTALLATION

- A. General
  - 1. Install materials in accordance to manufacturer's recommendations.
  - 2. Lift and place carefully to avoid breakage.

END OF SECTION 12 36 61

DIVISION 21

**FIRE SUPPRESSION**



**SECTION 21 13 00  
 FIRE SUPPRESSION SPRINKLER SYSTEM**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 21 30 00 "Fire Pumps"
  2. Section 21 40 00 "Fire-Suppression Water Storage"

**1.2 SCOPE**

- A. Furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation, complete, of all fire protection systems. All material shall be new, unused, and of first class construction, designed and guaranteed to perform the service required.
- B. The local authority having jurisdiction shall approve all work and material. The fire protection/fire detection and alarm systems shall use UL listed materials and equipment, and shall be installed in accordance with manufacturer's specifications, the insurance carrier and NFPA R13D.
- C. The fire protection drawings contained within the construction documents are for concept only. The installing sprinkler contractor shall submit directly to the fire marshal's office, or other inspection agencies, for review detailed drawings and hydraulic calculations. The drawings and calculations shall be signed by a responsible managing employee and submitted by a registered fire protection contractor. The sprinkler contractor shall submit approved installation drawings to the architect prior to commencing the work. The sprinkler contractor's installation drawings, especially sprinkler head locations, shall be coordinated with the architectural reflected ceiling plans and other architectural or structural drawings of the building. The system shall be installed according to the approved drawings.

**PART 2 PRODUCTS**

**2.1 FIRE LINES**

- A. The fire line shall be installed by a licensed sprinkler contractor.
- B. The fire line shall be hydrostatically tested for leakage at normal system operating pressures and thoroughly flushed out in accordance with NFPA R13D.

**2.2 PIPE HANGERS**

- A. Space pipe hangers in accordance with requirements of NFPA. Hanger rods, inserts and clamps shall be constructed as approved by NFPA.

**2.3 INSPECTOR'S TEST**

- A. Install an approved inspector's test connection at the end of the branch line that is most remote from the system supply, and at the highest point on the system. The discharge from the inspector's test must be unobstructed and visible and located in a manner approved by the NFPA.

## 2.4 VALVES

- A. Maintenance and check valves shall be approved by NFPA. Test valves shall be approved and conform to requirements of NFPA.

## 2.5 SPRINKLER HEADS

- A. All sprinkler head shall be the quick response type and carry both the UL listing and factory mutual approval. All sprinkler heads shall be of type and operating temperature as required by specific location of installation.
- B. Spare heads of every type used on the project shall be included in the spare head cabinet. A sprinkler wrench specifically adapted for removal and replacement of every type of head used on the project shall be included in the spare head cabinet.

## PART 3 EXECUTION

### 3.1 CODES AND STANDARDS

- A. The sprinkler system shall comply with all codes, requirements, regulations, and provisions of the law of the state of Missouri and NFPA R13D.
- B. The contractor must hold a state of Missouri certification in cross connection.

### 3.2 INSTALLATION

- A. The installed system shall be complete in every respect and shall include but not be limited to the following: heads, check valves with detector or backflow preventer (if required by authority having jurisdiction), heat actuated devices, fittings, piping, valves, test valve, maintenance valve, hangers and all other required items.
- B. Install the fire line complete and make arrangements for the connection to the fire safety tank.
- C. Refer to architectural reflected ceiling plan for exact location of heads.

### 3.3 TESTS AND INSPECTIONS

- A. Work included herein shall include all tests and inspections by the inspecting agencies and any permits or inspection fees connected therewith. The use of waterglass shall not be permitted. Following all testing, the system shall be returned to functional and operational condition at no extra cost to the owner. After approval, the contractor shall obtain the approval certificates and deliver them to the architect.

END OF SECTION 21 13 00

SECTION 21 24 16  
DRY CHEMICAL FIRE EXTINGUISHING EQUIPMENT

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Fire Extinguisher.

**1.2 SUBMITTALS**

- A. Qualification: The product exceeds the minimum UL rating of 2A-10BC.

**1.3 PRODUCTS**

- A. Manufacturers
  - 1. First Alert.
- B. Product
  - 1. Home 2 First Alert Fire Extinguisher.

**PART 2 EXECUTION**

**2.1 INSPECTIONS**

- A. Inspect products upon arrival for damage or misuse.
- B. Product should be stored in appropriate locations for easy access.

END OF SECTION 21 24 16

SECTION 21 30 00  
FIRE PUMPS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes:
  - 1. Pumps serving the sprinkler system
- B. Related Sections:
  - 1. Section 21 13 00 "Fire-Suppression Sprinkler Systems".

1.2 SUBMITTALS

- A. Installation Instructions

1.3 QUALITY ASSURANCE

- A. Use only approved liquids by manufacturer's recommendations.

PART 2 PRODUCTS

2.1 PUMPS

- A. SPD Inc. R13D certified fire sprinkler pump
  - 1. Model: G3000
  - 2. Mounting: Floor Mounted
  - 3. Horse power: 2HP
  - 4. Flow: 55 GPM
  - 5. Pressure: 35 PSI

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install according to manufacturer's instructions.

END OF SECTION 21 30 00

DIVISION 22  
**PLUMBING**

**SECTION 22 05 00  
COMMON WORK RESULTS FOR PLUMBING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  - 1. Section 22 11 16 “Domestic Water Piping”
  - 2. Section 22 11 23 “Domestic Water Pumps”
  - 3. Section 22 12 00 “Facility Potable-Water Storage Tanks”
  - 4. Section 22 13 16 “Sanitary Waste and Vent Piping”
  - 5. Section 22 13 53 “Facility Septic Tanks”
  - 6. Section 22 14 00 “Facility Storm Drainage”
  - 7. Section 22 33 00 “Electric Domestic Water Heaters”
  - 8. Section 22 41 00 “Residential Plumbing Fixtures”

**PART 2 PRODUCTS**

**2.1 PIPE**

- A. PVC Pipe: ASTM D 1785, Schedule 40

**2.2 PUMPS**

- A. TACO 007 Variable Speed Delta-T Cast Iron Circulator Pump
  - 1. Type: Variable Speed Pump
  - 2. Applications: Heating
  - 3. Material: Cast Iron
  - 4. RPM: Variable
  - 5. Power: 1/25 HP
  - 6. Voltage: 115 V (single phase)
  - 7. Hertz: 60
  
- B. TACO 009-VTF5 Cartridge Variable Speed Solar Thermal Circulator Pump
  - 1. Type: Variable Speed Pump
  - 2. Applications: Solar Thermal Circulator Pump
  - 3. Material: Cast Iron
  - 4. RPM: Variable
  - 5. Power: 1/8 HP
  - 6. Voltage: 115 V (single phase)
  - 7. Hertz: 60

**2.3 HANGERS AND SUPPORTS**

- A. Hanger and Pipe attachments: factory fabricated with galvanized coatings; nonmetallic coated for hangers in direct contact with copper tubing.

**PART 3 EXECUTION**

**3.1 GENERAL PIPING INSTALLATIONS**

- A. Install piping free of sags and bends.

- B. Install fittings for changes in direction and branch connections.
- C. Floor, pipe penetrations: mechanical sleeve seals installed in steel or cast-iron pipes for wall sleeves.
- D. Install unions at final connections to each piece of equipment.
- E. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in water piping.

### 3.2 GENERAL EQUIPMENTS INSTALLATIONS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are 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.
- D. Install equipment to allow right of way for piping installed at required slope.

### 3.3 HANGERS AND SUPPORTS

- A. Comply with MSS SP-69 and MSS SP-89. Install building attachments to structural steel.
- B. Install hangers and supports to allow controlled thermal and seismic movements of piping systems.
- C. Load distribution: install hangers and supports so piping live and dead loading and stresses from movements will not be transmitted to connected equipment.

END OF SECTION 22 05 00

**SECTION 22 11 16  
 DOMESTIC WATER PIPING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 22 05 00 “Common Work Results for Plumbing”
  2. Section 22 11 23 “Domestic Water Pumps”
  3. Section 22 33 00 “Electric Domestic Water Heaters”
  4. Section 22 41 00 “Residential Plumbing Fixtures”

**1.2 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 FITTING, GENERAL**

- A. PEX Tube and Fittings: ASTM 877, SDR 9 PEX tubing and ASTM 1807, metal insert-type fittings with copper or stainless steel crimp rings.
  1. Manufacturer: Watts Radiant
  2. Manifold: MANABLOC 14 port Compression manifold
- B. Radiant Piping and Fittings: ASTM F-1281-05 cross-linked polyethylene tubing
  1. Manufacturer: Watts Radiant
  2. Pipe: Radiant PEX-AL, cross-linked polyethylene tubing with aluminum layer
- C. Valves:
  1. Water Heater SH Valve: Sioux Chief ¾” FIP Swivel x 1/8” full-slip FSWT Water Heater Connector.
  2. Main Shut Off Valve: Sioux Chief Replace-A-Valve ¾” Full-Port Ball Valve, sweat connection.
  3. Maintenance shut off valve: Sioux Chief Replace-A-Valve ¾” and ½” Full-Port Ball Valve, sweat connection.
  4. Ball Check Valves: Apollo ¾” Ball Check Valve
    - a. Model: 6110401
    - b. .5 Cracking PSI
    - c. Material: Bronze
- D. 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.
- E. Cleanouts
  1. Install cleanouts in accessible locations at intersection of soil and waste lines beneath the structure ahead of the wastewater pumps as indicated on the drawings.
  2. Cleanouts shall be full size of trap or pipe. Full size Y or T branches shall be provided for cleanouts as required at the building.

## 2.2 EXPANSION TANK

- A. Utilitech 2-gallon Expansion Pressure Tank
  1. Volume: 2.0 Gallons
  2. Diameter: 8.0 inches
  3. Height: 12.5 inches
  4. Discharge Size: ¾"

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Comply with requirements in Division 22 Section “Commons Work Results for Plumbing” for basic piping installation requirements.
- B. Install wall penetration system at each service pipe penetrations through exterior wall. Make installation watertight. Comply with requirements in Division 22 Section “Commons Work Results for Plumbing” for wall penetration systems.
- C. Install shutoff valve, drain valve, strainer, pressure gauge, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section “Commons Work Results for Plumbing” for pressure gauges.
- D. Install domestic water piping without pitch for horizontal piping and plumb for vertical piping.
- E. Comply with requirements Division 22 Section “Common Work Results for Plumbing” for pipe hanger and support devices.
- F. Support vertical piping.
- G. 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 INSPECTION 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 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. Above Ground Exterior Piping: PVC Pipes

- B. Interior Distribution Piping: PEX piping

### 3.4 VALVE SCHEDULE

- A. Above Ground Exterior Piping: PVC Pipes.
- B. Interior Distribution Piping: PEX piping.
- C. Install ball valves close to main on each branch and riser serving two or more plumbing fixtures or equipment connections and where indicated.
- D. Install 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.
- E. Install drain valve at base of each rise, at low points of horizontal runs and where required to drain water distribution piping system.

END OF SECTION 22 11 16

**SECTION 22 11 23  
 DOMESTIC WATER PUMP**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  1. Section 22 11 16 "Domestic Water Piping"

**1.2 SECTION REQUIREMENTS**

- A. Comply with UL 778 for motor-operated water pumps.

**PART 2 PRODUCTS**

**2.1 DOMESTIC WATER PUMPS**

- A. FloJet 4300-501
  1. Pre-Set Constant Pressure: 45 PSI
  2. Nominal Capacity: 3.5 GPM
  3. Voltage: 115 Volt
  4. Pressure Switch controllable
- B. Website
  1. <http://flojet-pump.net/04300-501.html>

**2.2 MOTORS**

- A. NEMA MG 1, "Standards 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. Controller, 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. Connect piping with valves that are at least the same size as piping connections to pumps.

- F. Install suction and discharge pipe sizes equal to or greater than diameter or pump nozzles.
- G. Install shutoff valve and throttling valve on discharge side of pumps.
- H. Install non-slam check valves and throttling valve on discharge side of pumps.
- I. Install thermostats in hot-water return piping.
- J. Install pressure gauges on suction and discharge of each. Install integral pressure gauge tapings at each.

END OF SECTION 22 11 23

**SECTION 22 12 00  
 FACILITY POTABLE-WATER STORAGE TANKS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  1. Section 22 05 00 "Common Work Results for Plumbing"
  2. Section 22 11 16 "Domestic Water Piping"

**PART 2 PRODUCTS**

**2.1 POTABLE -WATER STORAGE TANKS**

- A. 1000 Gallon Vertical Plastic Storage Tank (1 for storage, 1 for waste)
  1. MDPE
  2. 1000 gallon capacity
  3. 64" Diameter x 80" Height
  4. Translucent White
  5. 174 lbs Weight
  6. 16" Manway
  7. 2" female threaded npt bulkhead fittings outlet
  8. Provide
    - a. Fill: 6" or greater with vented lid
    - b. Water outlet: 1"
    - c. Drain: 2"
- B. Website
  1. <http://www.plastic-mart.com/product/732/1000-gallon-vertical-plastic-storage-tank-40152>

**2.2 DISTRIBUTION PIPES AND FITTINGS**

- A. PEX Pipes and Fittings: Refer to Section 22 11 16.

**PART 3 EXECUTION**

**3.1 FACILITY POTABLE-WATER STORAGE TANK INSTALLATION**

- A. Install potable-water storage tanks level.
- B. Install potable-water storage tanks according to guidelines.
  1. Accessibility, ease of maintenance, and removal should be taken into consideration when installing tanks.
  2. Adequately support all pipes and valves. Do not apply excess weight on water tanks.
  3. Tanks are not designed for storage of fluid in vacuum conditions or higher pressure above atmospheric.
  4. Use caution when handling all tanks.
- C. Fill potable-water storage tank with water

END OF SECTION 22 12 00

**SECTION 22 13 16  
 SANITARY WASTE AND VENT PIPING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  1. Section 22 05 00 "Common Work Results for Plumbing"
  2. Section 22 13 52 "Facility Septic Tanks"

**1.2 SECTION REQUIREMENTS**

- A. Minimum Pressure Requirements 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 connections

**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

**2.2 FLOOR DRAINS**

- A. Sioux Chief Manufacturing: 1 ½ in PVC Solvent Weld Module Drain

**2.3 DRAINAGE FLOOR MEMBRANE**

- A. Sheet Waterproofing: Waterproof, mildew resistance membrane

**PART 3 EXECUTION**

**3.1 PIPING INSTALLATION**

- A. Install floor penetration system at each pipe penetration through floor. Make installation watertight. Comply with requirements in Division 22 Section "Common Work Results for Plumbing" for floor penetration systems.
- B. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends and long-sweep bends. Sanitary tee 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 drainpipe. 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.

- C. Install required gaskets according to manufacturer’s written instruction for use of lubricants and other requirements. Maintain swab in piping and pull past each joint as completed.
- D. 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.
- E. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- F. Do not enclose, cover or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- G. Comply with requirements in Division 22 Section “Common Work Results for Plumbing” for pipe hanger and support devices.

### 3.2 PIPE SCHEDULE

- A. Install drainage floor membrane per manufacturer’s installation instructions and drawings.

END OF SECTION 22 13 16

**SECTION 22 13 36  
 PACKAGED, WASTEWATER PUMP UNITS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  - 1. Section 22 13 16 "Sanitary Waste and Vent Piping"

**1.2 SECTION REQUIREMENTS**

- A. Comply with UL 778 for motor-operated water pumps

**PART 2 PRODUCTS**

**2.1 PACKAGED, WASTEWATER PUMP UNIT**

**2.2 MOTORS**

- A. NEMA MG 1, "Standard for Motors and Generators." Include NEMA listing and labeling.

**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. Connect piping with valves that are at least the same size as piping connections to pumps.
- F. Install suction and discharge sizes equal to or greater than diameter of pump nozzles.
- G. Install shutoff valve and strainer on suction side of pumps.
- H. Install nonslam check valve and throttling valve on discharge side of pumps.
- I. Install thermostats in hot-water return piping.
- J. Install pressure gauges on suction and discharge of each pump. Install at integral pressure gauge tappings where provided.

**END OF SECTION 22 13 36**

**SECTION 22 33 00  
 DOMESTIC WATER HEATERS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  - 1. Section 22 10 00 "Domestic Water Piping"
  - 2. Section 22 11 16 "Domestic Water Piping"

**1.2 SECTION REQUIREMENTS**

- A. Comply with requirements of applicable NSF, AWWA, or FDA and EPA regulatory standards for tasteless and odorless, potable-water-tank linings.
- B. Comply with performance efficiencies prescribed in ASHRAE 90.2, "Energy Efficient Design or New Low-Rise Residential Buildings."

**PART 2 PRODUCTS**

**2.1 WATER HEATER, GENERAL**

- A. Insulation: suitable for operating temperature and required insulating value. Include insulation material that surround 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 WATER HEATERS**

- A. Product
  - 1. StorMaxx Ptec Water Storage Tank with dual heat exchanges
    - a. Model: Ptec 802HX
    - b. Capacity: 80 gallons
    - c. Insulation: 2 inches
    - d. Height: 66.8 inches
    - e. Heat Area (top/bottom): 8.6/12.9 ft<sup>2</sup>
    - f. Maximum Temperature: 200 F
    - g. Maximum Pressure: 145 psi
    - h. Circulation Port Sizes: 3/4"
    - i. Heat Exchanger Port Sizes: 3/4"
  - 2. Rheem RTE 18 Instantaneous Electric Water Heater
    - a. Voltage: 240 V
    - b. Amps: 40 amps
    - c. AWG connection wire size: 8
    - d. Minimum Activation Flow Rate: 0.4 GPM

- e. Maximum Flow Rate: 5 GPM

### PART 3 EXECUTION

#### 3.1 INSTALLATION

- A. Locate water heater in a clean dry area as near as practical to the area of greatest heated water demand.
- B. Recommended to install an expansion tank between the water heater and the check valve to relieve thermal expansions.
- C. Install hot and cold water supply connections in accordance with GE recommendations. Install shut-off valve in the cold water line.
- D. Drain line completely installed per local code.
- E. Install electrical connections: all wiring must comply to local codes or National Electrical Code ANSI/NFPA 70.

END OF SECTION 22 33 00

**SECTION 22 41 00  
 RESIDENTIAL PLUMBING FIXTURES**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 22 05 00 "Common Work Results for Plumbing"
  2. Section 22 11 00 "Domestic Water Piping"

**1.2 ACTION SUBMITTALS**

- A. Product Data: Submit samples for all finishes as selected by architect.

**1.3 DELIVERY, STORAGE AND HANDLING**

- A. Deliver items in manufacturer's original unopened protective packaging.
- B. Store materials in original protective packaging to prevent soiling, physical damage, or wetting.
- C. Handle so as to prevent damage to finished surfaces.

**1.4 WARRANTY**

- A. Provide standard manufacturer's warranty for each product listed.

**PART 2 PRODUCTS**

**2.1 TOILET**

- A. American Standard Toilet
  1. 1.28 gallon per flush
  2. Finishes: Gloss White

**2.2 BATHROOM SINK**

- A. Porcelain White Vessel Bath Sink
  1. Width: 16.25 inches
  2. Length: 16.25 inches
  3. Depth of bowl: 5 inches
  4. Thickness: 5/8 inch
- B. Roma 11 Bathroom Single Hole Sink Faucet
  1. 6 inch length of spout
  2. Single hole installation
  3. Finish: Polished Chrome

**2.3 KITCHEN SINK**

- A. Kindred 18 Gauge Double Basin Dual Mount Kitchen Sink
  1. Model: C2233R/9
  2. Width: 33.25 inches
  3. Length: 22 inches

4. Depth of Bowl 1: 9 inches
5. Depth of Bowl 2: 8 inches
6. Material: 18 gauge Stainless Steel
7. Weight: 31 lbs

- B. Design House Single Handle Kitchen Faucet with Side Spray
  1. Single hole mount
  2. Flow Rate: 1.9 GPM @ 60 psi
  3. Spout Reach: 9.4 inches

## 2.4 SHOWER HEAD

- A. Delta Showerhead

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Reference drawings for configuration and locations.
- B. Use concealed fasteners wherever possible.
- C. Provide anchors, bolts and other necessary fasteners, and attach accessories securely to walls and partitions in locations as show or directed.
- D. Install exposed mounting devices and fasteners finished to match the accessories.
- E. Secure bathroom accessories in accordance with manufacturer's instructions for each item and each type of substrate.
- F. Mounting heights shall be as recommended for handicapped access and at the locations indicated on drawings.
- G. Recessed units shall have adequate lintels or headers installed as appropriated to the wall construction in which installed.

### 3.2 PROTECTION

- A. Maintain protective covers on all units until installation is complete.
- B. Remove protective covers at final cleanup of installation.

END OF SECTION 22 41 00

DIVISION 23

**HEATING, VENTILATING,  
AND AIR CONDITIONING  
(HVAC)**



**SECTION 23 00 00  
 HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  1. The work required under this specification consists of all air conditioning and ventilation systems (HVAC).
  2. Heating, Ventilating, and air conditioning shall include all materials, equipment accessories, tools and labor required to install the following systems:
    - a. Electric Heating and Cooling System
    - b. Exhaust and Ventilation System
  
- B. Related Sections:
  1. Section 23 05 00- "Common Work Results for HVAC"
  2. Section 23 07 00- "HVAC Insulations"
  3. Section 23 31 00- "HVAC Ducts and Castings"
  4. Section 23 37 00- "Air Outlets and Inlets"
  5. Section 23 72 00- "Air to Air Energy Recovery Ventilator"
  6. Section 23 81 00- "Decentralize Unitary HVAC Equipment"

**1.2 ACTIVE SUBMITTALS: ELECTRICAL WIRING**

- A. Provide electrical power wiring for mechanical equipment from load side of disconnect switch (provided by electrical) to unit terminals. In addition, provide and install all control devices and wiring. All electrical work shall be in accordance with the requirements of electrical specifications.
  
- B. All electrical components and materials shall be UL listed and bear the UL label.

**1.3 FURNISH ITEMS FOR INSTALLATION**

- A. Field verify electrical characteristics before ordering equipment

**1.4 CONNECTING FOR EQUIPMENT FURNISHED BY OTHERS**

- A. Where drawings indicate utility rough-in for owner-furnished equipment, terminate utilities with caps, plugs, or valves as indicated to insure convenient final connection.

**1.5 PERMITS, CODES AND STANDARDS**

- A. Obtain and deliver to the Architect certification of inspection issued by authorities having jurisdiction. Perform work in accordance with standards listed below except where specifications or State and Local Codes are more stringent.
  1. American Society of Mechanical Engineers (ASME)
  2. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
  3. American Society for Testing and Material (ASTM)
  4. Sheet Metal and Air Conditioning Contractors Association (SMACNA)
  5. Underwriters' Laboratory (UL)
  6. Air Conditioning and Refrigeration Institute (ARI)

7. International Mechanical Code (IMC)
8. International Gas Code (IGC)

## PART 2 PRODUCTS

### 2.1 MATERIALS

- A. Capacities, sizes, and other conditions specified and indicated on drawings are not minimums. Any deviation from capacities, sizing or other conditions must be approved by the HVAC Engineer.

END OF SECTION 23 00 00

**SECTION 23 05 00  
COMMON WORK RESULTS FOR HVAC**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  1. Equipment nameplate data requirements
  2. Labeling and identifying mechanical systems and equipment
  3. Installation requirements common to equipment specification sections
  
- B. Related Sections:
  1. Section 23 00 00 "Heating, Ventilating, and Air Conditioning (HVAC)"
  2. Section 23 31 00 "HVAC Ducts and Casings"
  3. Section 23 37 00 "Air Outlets and Inlets"
  4. Section 23 50 00 "Central Heating Equipment"
  5. Section 23 60 00 "Central Cooling Equipment"
  6. Section 23 72 00 "Air to Air Energy Recovery Ventilator"

**1.2 SUBMITTALS:**

- A. Construction drawings detailing fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment
  
- B. Construction drawings for access panel and door locations
  
- C. As part of the Construction Drawings Set, all of the following will be provided:
  1. Planned duct systems layout, including elbows radii and duct accessories.
  2. Clearances for servicing and maintaining equipment, including space for equipment disassembly required for periodic maintenance
  3. Equipment service connections and support details.
  4. Exterior wall and floor penetrations
  5. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
  6. Reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers and other ceiling-mounted items.

**1.3 SEQUENCING AND SCHEDULING**

- A. Coordinate mechanical equipment installation with other building components
  
- B. Arrange for chases, slots and openings in building structure during progress of construction to allow for mechanical installations.
  
- C. Sequence, coordinate and integrate installations of mechanical materials and equipment for efficient flow of the work.

**PART 2 PRODUCTS**

**2.1 JOINING MATERIALS**

- A. Brazing Filler Metals: AWS A5.8
  - 1. BCuP Series: Copper-phosphorus alloys
  - 2. Bag1: Silver Alloy
  
- B. Solvent Cements: Manufacturer's standard solvents complying with the following:
  - 1. Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235.
  - 2. Chlorinated Poly (Vinyl Chloride) (CPVC): ASTM F 493
  - 3. Poly (Vinyl Chloride) (PVC): ASTM D 2564

**PART 3 EXECUTION**

**3.1 EQUIPMENT INSTALLATION – COMMON REQUIREMENTS**

- A. Install equipment to provide the maximum possible headroom, where mounting heights are not indicated.
  
- B. Install equipment according to approved Construction Drawings.
  
- C. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
  
- D. Install equipment giving right-of-way to piping systems installed at a required slope.

**END OF SECTION 23 05 00**

**SECTION 23 31 00  
HVAC DUCTS AND CASINGS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 23 00 00 "Heating, Ventilating, and Air Conditioning (HVAC)"
  2. Section 23 37 00 "Air Outlets and Inlets"
  3. Section 23 50 00 "Central Heating Equipment"
  4. Section 23 60 00 "Central Cooling Equipment"
  5. Section 23 72 00 "Air to Air Energy Recovery Ventilator"

**1.2 SECTION REQUIREMENTS**

- A. ASHRAE design guidelines and standards must be followed except where superseded or negated by local code.
- B. ACCA Manual J and ACCA Manual D are the standard for building loads and duct sizing estimation.

**PART 2 PRODUCT**

**2.1 DUCT**

- A. Unico Supply Duct
  1. Model: UPC-25
  2. Aluminized mylar outer wrap
  3. Two-Ply aluminum core
  4. Fully insulated (R 4.2 equivalent)
  5. Certified per UL181
- B. Unico Return Air Duct
  1. Model: UPC-04-1218
  2. Aluminized outer mylar wrap
  3. Spun-bonded nylon and helical wire core
  4. 1" fiberglass insulation (R 4.2)
  5. 10 ft. lengths

**2.2 ACCESSORIES**

- A. Unico Sound Attenuator Tube
  1. Model: UPC-26
  2. Aluminized mylar outer wrap
  3. Spun-bonded nylon and helical wire core
  4. Fully insulated
  5. Certified per UL181
  6. 12' lengths
- B. Unico Return Air Adapter M1218
  1. UPC-104-1218
  2. Duct diameter: 12.0"
  3. 15.5" x 10" x 4.5"

4. Mates directly to air handler
5. Can be used in horizontal or vertical configurations

### **PART 3 EXECUTION**

#### **3.1 INSTALLATION**

- A. Install duct and accessories per Unico instructions.
- B. Do not crush the flexible duct.
- C. Avoid sharp bends in flexible duct whenever possible.
- D. Install duct to be connected to outlets per approved construction drawings and/or the building model.

**END OF SECTION 23 31 00**

SECTION 23 37 00  
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SUMMARY

- A. Related Sections
  - 1. Section 23 00 00 "Heating Ventilation and Air Conditioning"
  - 2. Section 23 05 00 "Common Work Results for HVAC"
  - 3. Section 23 31 00 "HVAC Duct and Casings"

PART 2 PRODUCTS

2.1 OUTLETS

- A. Unico Supply Outlet Terminator
  - 1. Model: UPC-56B
  - 2. Finish: White

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install outlets in drop ceiling panels.
  - 1. Refer to user's manual for ceiling mounting instructions.
  - 2. Refer to ceiling panel user's manual for cutting instructions.
- B. Position outlets per approved construction drawings.
- C. Deviations in duct placement from construction drawings must be approved by HVAC engineer and architect.

END OF SECTION 21 37 00

**SECTION 23 50 00  
 CENTRAL HEATING EQUIPMENT**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
  1. Section 23 00 00 "Heating, Ventilating, and Air Conditioning (HVAC)"
  2. Section 23 31 00 "HVAC Ducts and Casings"
  3. Section 23 37 00 "Air Outlets and Inlets"
  4. Section 23 60 00 "Central Cooling Equipment"
  5. Section 23 72 00 "Air to Air Energy Recovery Ventilator"
  
- B. Regulatory Requirements
  1. 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.
  
- C. Energy Ratings: Provide equipment that qualifies for the EPA/DOE Energy Star product labeling program where possible.

**PART 2 PRODUCTS**

**2.1 AIR HANDLER**

- A. Unico Model 1218 Ventilator (Green Series)
  1. Dimensions: 12" x 20" x 38"
  2. Weight: 92 lbs
  3. Nominal Capacity: 1.5 tons
  4. Cabinet Type: Galvanized
  5. Motor:
    - a. Size: ½ HP
    - b. RPM: 1800 Max, Variable
    - c. Bearing: permanently lubricated

**2.2 OUTDOOR UNIT**

- A. Unico UniChiller RC
  1. Nominal Capacity: 18,000 Btu/hr.
  2. Sound Level: 69 dB
  3. Min. Circuit Amp: 29.1 A
  4. Max Circuit Breaker: 45 A
  5. Voltage: 208/230 V
  6. Frequency: 60 Hz
  7. Phase: Single
  8. Amps @ 230 V: 19
  9. Refrigerant:
    - a. Type: R-22
    - b. Charge: 5.1 lbs
  10. Ship Weight: 310 lbs

**PART 3 EXECUTION**

### 3.1 INSTALLATION

- A. Outdoor Unit:
  - 1. Install per manufacturer's instructions.
  - 2. Placement must satisfy all stand-off and/or clearance requirements per building code.
  - 3. Temporary Installation:
    - a. Masonry or properly treated lumber platform must be created to manufacturer's specifications.
    - b. Platform must be transportable.
    - c. Shipping materials should be kept to facilitate the repackaging and transportation of the outdoor unit.
  - 4. Permanent Installation:
    - a. Permanent concrete pad should be poured in conjunction with the foundation of the house.
  - 5. Connection of outdoor unit to air handler:
    - a. Regular residential water plumbing methods and materials should be used to make the connection.
    - b. Weather resistant plumbing materials must be selected to avoid weather/UV damage.
    - c. All pipe runs should be thoroughly insulated using foil backed pipe wrap or equivalent.
    - d. System must be filled with distilled water, per manufacturer's instructions once all connections have been made.
    - e. Once the system is charged with water, all connection should be checked for leaks.
    - f. If detected, leaks must be repaired.
    - g. This system does not need to be charged with refrigerant! The outdoor unit contains a pre-charged closed refrigerant loop. Water is used in place of the "refrigerant" between the outdoor unit and the air handler.

END OF SECTION 23 50 00

SECTION 23 60 00  
CENTRAL COOLING EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Related Sections: 23 50 00 “Central Heating Equipment”
- B. Please see section 23 50 00. The outdoor unit and air handler function as both central heating and central cooling equipment. Upon completion of 23 50 00, central cooling equipment will also be completely installed.

PART 2 PRODUCTS

2.1 SEE SECTION 23 50 00

PART 3 EXECUTION

3.1 SEE SECTION 23 50 00

END OF SECTION 23 60 00

**SECTION 23 72 00  
 AIR TO AIR ENERGY RECOVERY VENTILATOR**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 23 00 00 "Heating, Ventilating, and Air Conditioning (HVAC)"
  2. Section 23 31 00 "HVAC Ducts and Casings"
  3. Section 23 37 00 "Air Outlets and Inlets"
  4. Section 23 50 00 "Central Heating Equipment"
  5. Section 23 60 00 "Central Cooling Equipment"

**PART 2 PRODUCTS**

**2.1 VENTILATOR UNIT**

- A. Constructo 1.0 Energy Recovery Ventilator
  1. Air flow: 45-105 CFM
  2. Type of Recovery: ERV
  3. Filter Type: Washable foam
  4. Voltage: 120 V
  5. Power: 104 W
  6. Current: 1.0 A
  7. Dimensions: 23" x 13" x 20"
  8. Weight: 45 lbs
  9. Home Ventilation Institute (HVI) certified
  10. UL listed

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Ventilator will be attached to the ceiling in the mechanical space.
- B. Fabricated shelving/brackets must comply with structural codes and seismic design requirements.
- C. Manufacturer's guidelines must be following during installation. Including:
  1. Satisfying minimum head-room
  2. Satisfying minimum clearances
- D. Placement must allow accessibility for routine maintenance (filter changes, etc.).

**END OF SECTION 23 72 00**

DIVISION 25  
**INTEGRATED  
AUTOMATION**



**SECTION 25 11 00  
 HOME AUTOMATION AND CONTROL SYSTEMS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. System Description
  - 1. HVAC control: The Chameleon Automation system will control all of the heating, cooling and ventilation of the house via pumps, valves and the Unico System.
  - 2. Lighting control: The Chameleon Automation system will control lights throughout the house using the C-Bus protocol.
  - 3. Power monitoring: The Chameleon Automation system will monitor the power consumed and produced in the house using a Schneider Electric PowerLogic Branch Current Monitor then display the information to the user.
  - 4. Passive control: The Chameleon Automation system will control the windows and shades in the house with motors.
  
- B. Related Sections:
  - 1. Plumbing
  - 2. HVAC
  - 3. Electrical
  - 4. Windows
  - 5. Shades
  - 6. Lighting
  - 7. Power
  - 8. Entertainment

**1.2 SECTION REQUIREMENTS**

- A. The installer is to ensure that all work meets all specifications.

**1.3 DEFINITIONS**

- A. IEEE 802.11 - The standard for implementing wireless local area network computer communication.
- B. C-Bus – communications protocol developed by Shneider Electric to control lighting and shades in buildings.

**PART 2 PRODUCTS**

**2.1 GENERAL**

- A. Fully operational controls system and monitoring, such as
  - 1. Sensors
  - 2. Control Devices
  - 3. Communication components
  - 4. Software/Hardware components with documentation
  - 5. Operating and maintenance manuals
  
- B. Product List
  - 1. General

- a. back-ups
- b. tablet mounts (pactab)
2. Central Server
  - a. Foxconn Intel based Mini PC
3. Modules
  - a. PoE Arduino Modules
4. Interactive Display
  - a. Nexus 7
5. Enclosure
  - a. Chameleon Enclosure
  - b. Chameleon Faceplate
6. Design Requirements
  - a. Design wiring and conduit for power to all elements of the system.
  - b. Design communication wiring for hardwired components of the system.
  - c. Supply programmable controllers to meet project requirements.
  - d. Review module locations.
7. Language Requirements
  - a. Provide an English user interface.
  - b. Provide software documentation in English.
  - c. Provide user manuals in English.
8. Product Requirements
  - a. System to use IEEE 802.3af communication protocol.
  - b. Products to be installed in wall cavities.
  - c. Central server to be installed into Chameleon Enclosure.
9. Installation
  - a. Modules to be installed into cavities in the SIPs.
  - b. Central server to be mounted in the Mechanical Closet.
  - c. All installations carried out according to the supplied manufacturer's data.
10. Personal Computer
  - a. Intel DC3217IYE Next Unit of Computing.
  - b. Asus 24" Full HD Monitor
  - c. USB RF wireless ergonomic wave combo

## **PART 3 EXECUTION**

### **3.1 INSTALLATION**

- A. Run ethernet lines to wall cavities.
- B. Install modules into wall cavities.
- C. Run sensor/device lines to module.
- D. Debug system software if necessary.
- E. Demonstrate functionality of control system.

**END OF SECTION 25 11 00**

DIVISION 26

**ELECTRICAL**



**SECTION 26 05 00  
COMMON WORK RESULTS FOR ELECTRICAL**

**PART 1 GENERAL**

**1.1 SECTION REQUIREMENTS**

- A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application
- B. Comply with 2011 NFPA 70, and all applicable local codes.

**PART 2 PRODUCTS**

**2.1 CONDUCTOR AND CABLES**

- A. Conductors:
  1. Conductors, No. 12 AWG and Smaller: Solid copper
  2. Conductors, No. 10 AWG and larger: 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.
  5. Products: Furnish products listed as classified by Underwriters' Laboratories Inc or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and 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.

**2.2 GROUNDING MATERIALS**

- A. Conductors: Solid for No. 12 AWG and smaller, and stranded for No. 8 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. 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.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

**2.3 ELECTRICAL IDENTIFICATION MATERIALS**

- A. Conductor Identification Materials: Color-Coding Conductor Tape: Self-adhesive vinyl tape 1/2 to 2 inches wide.
- B. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with circuit identification legend machine printed by thermal transfer or equivalent process
- C. 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.
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396 inch galvanized steel backing; and with colors, legend and size required for application
- E. 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
- F. Fasteners: Self-tapping, stainless steel screws or stainless steel machining screws with nuts and flat and lock washers

#### 2.4 SUPPORT AND ANCHORAGE COMPONENTS

- A. Raceway and Cable Supports: As described in NECA 1
- B. Conduit and Cable Devices: Steel and malleable iron hangers, clamps and fittings
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded malleable iron body and insulating wedging
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates shapes and bars; black and galvanized
- E. Mounting, Anchoring and Attachment Components:
  1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement concrete.
  2. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural Element
  3. Through Bolts: Structural type, hex head, high strength; complying with ASTM A 325.
  4. Toggle Bolts: All-steel springhead type
  5. Hanger Rods: Threaded steel

#### 2.5 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 elements
  - 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 element.

### **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 cable and wireways are clear of obstructions and of the working and access space of other equipment.
- E. Install sleeve and sleeve seals of type and number required for sealing electrical service penetrations of exterior walls.
- F. Comply with NECA 1.

#### **3.2 RACWAYS AND CABLE INSTALLATION**

- A. Conceal cables, unless otherwise indicated, within finished walls, ceilings and floors
- B. Install cables at least 6 inches away from parallel runs of water pipes. Locate horizontal raceway runs above water piping.
- C. Connect motors and equipment subject to vibration, noise transmission, or movement with a 72-inch maximum length of flexible conduit.

#### **3.3 WIRING METHODS**

- A. Service Entrance: Type SE or USE-2 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. 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
- E. Class 2 Control Circuits: Power-limited cable, concealed in building finishes.

### 3.4 GROUNDING

- A. Grounding Conductors: Install bare copper conductor, #4 AWG minimum.
- B. Pipe and Equipment Grounding Conductor Terminations: Bolted
- C. Connections to Structural Steel: 2 hole compression lug. All structural steel shall be grounded.
- D. 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.
- E. Install ground rod driven into ground according to ground rod manufacturer's instructions.
- F. Make Connections without exposing steel or damaging coating.
- G. Install bonding straps and jumpers in locations accessible for inspection and maintenance, except where routed through short lengths of conduit
- H. Bond straps directly to basic structure, take care not to penetrate any adjacent parts
- I. Test completed grounding system at each location where a maximum ground-resistance level is specified at service disconnect enclosure grounding terminal.
  - 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 Distribution Units or panelboards Serving Electronic Equipment: 5 ohms.
  - 4. Excessive Ground Resistance: If resistance to ground exceeds specified values, include recommendations to reduce ground resistance

### 3.5 IDENTIFICATION

- A. Power-Circuit Conductor Identification: For No. 8 AWG conductors and larger, at each location where observable, identify phase using color-coding conductor tape
- B. 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
- C. Equipment Identification Labels
  - 1. Labeling Instructions:
    - a. Indoor Equipment: Adhesive film label with clear protective overlay. Provide a single line of text with ½ inch high letters on 1 ½ 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. Motor-control centers
    - c. Disconnect switches
    - d. Enclosed circuit breakers
    - e. Motor starters
    - f. Power transfer equipment
    - g. Contactors
- D. Verify identity of each item before installing identification products
- E. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment
- F. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate
- G. 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
- H. Color Coding for Phase Identification, 600 V and Less: Underground service, feeder and branch-circuit conductors
  - 1. Colors for 240/120-V Circuits
    - a. Phase A: Black
    - b. Phase B: Red
    - c. Neutral: White
  - 2. Field Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points

### 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. Multiple Cables: Install on trapeze-type supports fabricated with steel slotted channel
- D. 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 from strength determination shall be weight of supported components plus 200 lb
- E. 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 steel: beam clamps (MSS Type 19. 21. 23. 25. Or 27) complying with MSS SP-69 or Spring tension clamps
3. To light steel: sheet metal screws
4. Items mounted on hollow walls and nonstructural building surfaces: mount on slotted channel racks attached to substrate

### 3.7 SLEEVE AND SLEEVE-SEALS INSTALLATION

- A. Cut sleeves to length for mounting flush with both wall surfaces
- B. Extend sleeves installed in floors 2 inches above finished floor level
- C. Size pipe sleeves to provide ¼ inch annular clear space between sleeve and cable unless sleeve seal is to be installed
- D. Interior Penetrations of Non-Fire Rated Wall 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 Penetration”
- E. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work
- F. Aboveground Exterior Floor 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

END OF SECTION 26 05 00

**SECTION 26 05 19  
 LOW-VOLTAGE ELECTRICAL CONDUCTORS AND CABLES**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES**

- A. Wire and cable for 600 volts and less
- B. Wiring connectors and connections

**1.2 RELATED SECTIONS**

- A. Section 26 05 00 “Common Work Results for Electrical”
- B. Section 26 05 33 “Raceway and Boxes for Electrical Systems”
- C. Section 26 24 16 “Panelboards”
- D. Section 26 27 13 “Electricity Metering”
- E. Section 26 27 26 “Wiring Devices”

**1.3 REFERENCES**

- A. NECA 1- Standard Practices for Good Workmanship in Electrical Contracting; National Electrical Contractors Association; 2006
- B. NETA STD ATS- Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems; International Electrical Testing Association; 2009.
- C. NFPA 70- National Electrical Code; National Fire Protection Association; 2011.

**1.4 QUALITY ASSURANCE**

- A. Conform to requirements of 2011 NFPA 70.
- B. Products: Furnish products listed as classified by Underwriters Laboratories Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

**PART 2 PRODUCTS**

**2.1 WIRING REQUIREMENTS**

- A. Dry Locations: Use only building wire with Type THHN insulation
- B. Wet or Damp Interior Locations: Use only building wire with Type THHN-2/THWN-2 or XHHW-2 insulation in raceway.
- C. Exterior Locations: Use only building wire with Type THHN/THWN or XHW insulation in raceway. Exception: rooftop PV modules to use USE-2 in free air.

- D. Use 2 AWG aluminum wire with USE-2 insulation for rooftop PV interconnection.
- E. Use stranded conductor for feeders and branch circuits 10 AWG and larger
- F. Use conductor not smaller than 14 AWG for power and lighting circuits.
- G. Use conductor not smaller than 24 AWG for control circuits
- H. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet.
- I. Shall have designated ground conductor. Ground path via armor jacket shall not be acceptable

## 2.2 BUILDING WIRE

- A. Description: Single conductor insulated wire.
- B. Conductor: Copper
- C. Insulation Voltage Rating: 600 volts
- D. Insulation: NFPA 70, Type THHN
- E. Insulation Color: Conductor sizes AWG and smaller shall have solid color insulation as required for phasing. Conductors sizes 8 AWG and larger may be black in color.

## 2.3 METAL CLAD CABLE

- A. Description: NFPA 70, Type MC
- B. Conductor: Copper
- C. Insulation Voltage Rating: 600 volts
- D. Insulation Temperature Rating: 60 degrees C
- E. Insulation Material: Thermoplastic
- F. Armor Material: Thermoplastic
- G. Armor Design: Interlock metal type

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Verify that interior of building has been protected from weather
- B. Verify that mechanical work likely to damage wire and cable has been completed
- C. Verify that raceway installation is completed and supported

### 3.2 INSTALLATION

- A. Install wire and cable securely, in a neat and workmanlike manner, as specified in NECA
- B. Routine wire and cable as required to meet project conditions
  - 1. Wire and cable routing indicated is approximate unless dimensioned
  - 2. Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.
- C. Use wiring methods indicated
- D. Pull all conductors into raceway at same time
- E. Use suitable wire pulling lubricant as required.
- F. Support cables above accessible ceiling, using spring metal clips or metal cable ties to support cables from structure. Do not support cables from ceiling suspension system or rest cable on ceiling panels.
- G. Use suitable cable fittings and connectors
- H. Neatly train and lace wiring inside boxes, equipment and panelboards
- I. Clean conductor surfaces before installing lugs and connectors
- J. Make splices, taps and terminations to carry full ampacity of conductors with no perceptible temperature rise.
- K. Use split bolt connectors for copper conductor splices and taps, 6 AWG and larger. Tape un-insulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor.
- L. Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
- M. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller
- N. Identify and color code wire and cable under provisions of Section 26 05 00. Identify each conductor with its circuit number or other designation indicated.

### 3.3 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA STD ATS, except Section 4.
- B. Perform inspections and tests listed in NETA STD ATS, Section 7.3.2.

**END OF SECTION 26 05 19**

**SECTION 26 05 26  
 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 26 05 00 "Common Work Results for Electrical"
  2. Section 26 05 19 "Low-Voltage Electrical Conducts and Cables"
  3. Section 26 24 16 "Panel Boards"
  4. Section 26 27 13 "Electrical Metering"

**1.2 DESCRIPTION**

- A. This section specifies general grounding requirements of electrical equipment operations and to provide a low impedance path for possible ground fault currents.

**PART 2 PRODUCTS**

**2.1 GROUNDING ELECTRODES**

- A. Ground Rod
  1. 5/8 in diameter by 8 feet long zinc or copper-coated steel rod
- B. Quantity: One (1) ground electrodes
- C. Electrode plates shall be bonded to each other with an uninsulated 4 AWG minimum stranded bare copper conductor attached to the grounding plate rod with a listed connector device (clamp) or via exothermic weld. Bonding conductors should be in contact with the ground and placed in order to avoid trip hazards

**PART 3 EXECUTION**

**3.1 GENERAL**

- A. Ground in accordance with the NEC, as shown on drawings and as hereinafter specified.
  1. Reference Section 26 05 00 "Common Work Results for Electrical"
- B. System Grounding:
  1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means.
- C. Equipment Grounding: Metallic structures including (ductwork, and building steel), enclosures raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be grounded.

**3.2 WIREWAY GROUNDING**

- A. Ground and bond Metallic Wireway Systems as follows
  1. Bond the metallic structures of wireway to provide 100 percent electrical continuity throughout the wireway system by connecting a 16 mm, 6 AWG,

bonding jumper at all intermediate metallic enclosures and across all section junctions.

2. Install insulated 16 mm, 6 AWG, bonding jumpers between the wireway system bonded as required in paragraph 1 above, and the closest building ground at each end and approximately every 16 meters (50 feet).
3. Use insulated 16 mm, 6 AWG, bonding jumpers to ground or bond metallic wireway at each end at all intermediate metallic enclosures and cross all section junctions.
4. Use insulated 16 mm, 6 AWG, bonding jumpers to ground cable tray to column mounted building ground plates at each end and approximately every 15 meters (50 feet).

### 3.3 INSTALLATION

- A. Reference drawings for location.
- B. Drive each rod vertically in the earth.

END OF SECTION 26 05 26

**SECTION 26 05 33**  
**RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 GENERAL**

**I.1 GENERAL**

- A. Furnish outlet boxes for lighting fixtures, wall receptacles, switches, and other boxes as required. Also, pull boxes and junction boxes shall be furnished as required.

**I.2 RELATED WORK**

- A. General provisions of the contract general and supplementary conditions, and Division 01 specification sections, general requirements, apply to this section.

**PART 2 PRODUCTS**

**2.1 MATERIALS**

- A. Ceiling boxes: Ceiling outlet boxes shall be 4-inch octagon and 2-1/8" deep. Provide extension rings where additional volume is required. All ceiling outlet boxes shall have fixture stud of no bolt, self-locking type installed if required to hang fixture specified at that outlet.
- B. Wall boxes: Light wall switch boxes shall be a minimum size of 4" high by 2-1/8" wide by 2-1/8" deep. Where more than one gang occurs, 4" square boxes or additional larger boxes shall be used with device ring attached.
- C. Manufactures: Boxes and fittings shall be Appleton, Steel City, Raco, Efcor, Crouse-Hinds, or equal.
- D. Pull and junction boxes shall be galvanized or sherardized sheet metal or code thickness with lapped and welded joints and with 3/4" flange. They shall be rigidly supported on ceiling or wall conduit runs entering a box shall not be considered as adequate support.

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Install pull and/or junction boxes in conduit lines wherever necessary to avoid excessive length of runs or number of bends in run. No run shall exceed 100 feet without a pull box.
- B. Pull and junction boxes shall be accessible and sized in accordance with provisions of Article No 370-18 of 2011 National Electrical Code.
- C. Pull and junction boxes shall be installed so that cover shall be accessible at all times.

**END OF SECTION 26 05 33**

## SECTION 26 24 16 PANELBOARDS

### PART 1 GENERAL

#### I.1 SUMMARY

- A. Related Sections:
1. Section 26 05 00 "Common Work Results for Electrical"
  2. Section 26 05 19 "Low-Voltage Electrical Conductors and Cables"
  3. Section 26 27 26 "Electricity Metering"
  4. Section 26 28 16 "Enclosed Switches and Circuit Breakers"

#### I.2 SECTION REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in 2011 NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA PB 1.

### PART 2 PRODUCTS

#### 2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. 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.
- B. Phase, Neutral, and Ground Buses: Tin plated aluminum.
- C. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Tin plated aluminum.
  2. Phase and Neutral Lugs: Mechanical type.
  3. Ground Lugs and Bus Configured Terminators: Mechanical Type.
- D. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.
- E. 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.
- F. Circuit Breakers: Reference section 26 28 16.

#### 2.2 DISTRIBUTION PANELBOARD

- A. Product: Square D Load Center
1. Single phase load center
  2. Main Lug Only
  3. Bus Rating: 225 amp, 120/240 VAC
  4. Max Branch circuits: 42
  5. Provide with ground bar
  6. Provide with branch breakers as indicated on drawings.

## 2.3 SOLAR LOAD CENTER

- A. Product: Square D
  - 1. Single Phase Load Center
  - 2. Main Lugs Only
  - 3. Rating: 125A; 120/240 VAC
  - 4. Enclosure Box: NEMA 1
  - 5. Two 30A Double Pole Breakers
  - 6. Max Branch Circuits: 8

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Receive, inspect, handle, store and install panelboards and accessories according to NEMA PB 1.1.
- B. Stub four empty ¾ inch conduits from panelboard into accessible or designated ceiling space; stub one empty conduits into space below floor, as well as others as indicated on drawings.
- C. Arrange conductors into groups, bundle and wrap with wire ties.
- D. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer to create directory. Directory shall be installed under plastic.

END OF SECTION 26 24 16

**SECTION 26 27 13  
 ELECTRICITY METERING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 26 05 00 "Common Work Results for Electrical."
  2. Section 26 05 19 "Low-Voltage Electrical Conductors and Cables."

**1.2 SECTIONS 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 locations and application.
- C. Coordinate NREC for services and components they furnish.

**PART 2 PRODUCTS**

**2.1 EQUIPMENT FOR ELECTRICITY METERING BY COMPETITION ORGANIZERS**

- A. Meters will be furnished by NREL.
- B. Current-Transformer Cabinets: Comply with requirements of electrical power utility company.
- C. Meter Sockets: Steady-state and short circuit current ratings shall meet indicated circuit ratings.
  1. Square D. URTRS213 B METER SOCKET
    - a. Ringed
    - b. 200 amp
    - c. Enclosure: NEMA 3R

**2.2 EQUIPMENT FOR ELECTRICITY METERING BY HOMEOWNER**

- A. Meter Socket:
  1. Square D: QC816F200CH Meter Socket
    - a. Ringless
    - b. 200 amp
    - c. Enclosure: NEMA 3R
- B. Main Disconnect Circuit Breaker
  1. Square D: QOM2200VH
    - a. 120/240V
    - b. 200 amp
    - c. Fault Rating: 22KAIC

**PART 3 EXECUTION**

### 3.1 INSTALLATION

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

END OF SECTION 26 27 13

**SECTION 26 27 26  
 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. 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.
- B. Wall Plates, Finished Areas: Smooth, high-impact thermoplastic or Satin-finish stainless steel fastened with metal screws having heads matching plate color
- C. Wall Plates, Unfinished Areas: Smooth, high-impact thermoplastic with metal screws.
- D. Wall Plates, Damp Locations: Thermoplastic with spring-loaded lift cover and listed and labeled for use in wet locations.
- E. Floor Service Fittings:
  - 1. Floor Mounted Convenience Receptacles: NEMA WD 1, NEMA WD 6, Configuration 5-20R, and UL 498.
  - 2. Manufacturer: Hubbell
  - 3. Product: RACO Floor Box Kit ((6239NI)
  - 4. Nickel Plated Concealed Receptacle
- F. Exterior Receptacles:
  - 1. Weather-resistant , in compliance with NEC 406.8(8)(1)
  - 2. Housing Finish: To be selected by team architecture group
- G. Finishes: To be selected by team architecture group

**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. 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 26 27 26**

**SECTION 26 28 16**  
**ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections
1. Division 26 24 16 "Panel Boards"

**1.2 SECTION REQUIREMENTS**

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

**PART 2 PRODUCTS**

**2.1 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: Square D QO Circuit Breakers: Single and two-pole configurations with 10,000 Amperes RMS-UL listed interrupting rating.
  2. GFCI Circuit Breakers: Square D QO Ground Fault Circuit Interrupter. Single and two-pole configurations with 6-mA trip sensitivity
  3. AFCI Circuit Breakers: Square D QO Arc-D-TECT Arc Fault Circuit Interrupter. Single pole configurations with arc fault protection in accordance with UL 1699.
- 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.

**2.2 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

**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 NECA 1.

### 3.2 FIELD QUALITY CONTROL

A. Perform the following fielded 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 26 28 16**

**SECTION 26 31 00  
 PHOTOVOLTAIC COLLECTOR**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES**

- A. Photovoltaic Collectors

**1.2 RELATED SECTIONS**

- A. Section 05 14 13 “Architecturally-Exposed Structural Aluminum Framing.”
- B. Section 07 72 00 “Roof Accessories.”
- C. Section 26 05 19 “Low-Voltage Electrical Conductors and Cables.”
- D. Section 26 24 16 “Panelboards.”
- E. Section 48 19 16 “Electrical Power Generation Inverters.”

**1.3 REFERENCES**

- A. 2011 National Electrical Code (NEC) – NEC Article 690.

**1.4 SCOPE OF WORK**

- A. Furnish and install all materials, equipment and service for a complete, fully operational photovoltaic system; ratings as specified herein.
- B. All routing of conduits, fasteners and supports, connections and all work associated with mounting array to racking system on roof shall be included.
- C. Connect to electrical system provided under Division 26 as indicated on the drawings.

**1.5 COORDINATION**

- A. Coordinate flashing equipment or mounting system to roof with roofing contractor including all roof penetrations and associated weatherproofing and sealing.

**PART 2 PRODUCTS**

**2.1 PHOTOVOLTAIC PANELS BY OWNER**

- A. tenKsolar RAIS WAVE System - Model XT-A 410W-P modules
  - 1. 410 Watt Solar Panel.
  - 2. Maximum power voltage/current: 57V/9.1A
  - 3. The Solar Photovoltaic (SPV) panels shall be provided in an array, as indicated on the architectural drawings.
  - 4. Reference drawings and section 05 14 13 for racking system.
- B. Sanyo Model HIT-195DA3 bi-facial module
  - 1. 195 Watt Solar Panel
  - 2. Maximum power voltage/current: 55.8V/3.5A

3. The Solar Photovoltaic (SPV) panels shall be provided in an array, as indicated on the architectural drawings.
4. Reference drawings for integral solarium mounting.

### **PART 3 EXECUTION**

#### **3.1 INSTALLATION**

- A. The photovoltaic system shall be designed and installed by Solar House electrical team, in consultation with factory representatives of proposed system and team university electrical engineer/advisor.
- B. 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:
  1. All AC and high voltage DC circuits shall be installed in conduit. PV source circuits and PV output circuits should not be contained in the same raceway.
  2. The roof mounted photovoltaic arrays shall be provided with DC ground-fault protection.
  3. Circuit sizing, overcurrent protection and disconnecting means shall be sized for the specific application and equipment provided for this system.
  4. 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 inverters.

#### **3.2 EXAMINATION**

- A. Upon completion and before acceptance, system performance shall be demonstrated in the presence of the Team that all specified functions are accomplished and that the complete solar photovoltaic system meets the contract performance criteria. Provide seven calendar days minimum notice to Team prior to demonstration so that all interested parties may attend.
- B. 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 Team.

**END OF SECTION 26 31 00**

**SECTION 26 33 13  
 BATTERIES**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  1. Batteries for Television Remote Control
  2. Batteries for Stereo Remote Control
  3. Batteries for Computer
  4. Batteries for Smoke Detector Battery Back Up
  
- B. Related Sections:
  1. Section 11 28 13 "Computers"
  2. Section 11 52 00 "Audio-Visual Equipment"
  3. Section 12 38 00 "Residential Furniture"

**PART 2 PRODUCTS**

**2.1 BATTERIES FOR TELEVISION, STEREO AND DUCTLESS MINI SPLIT UNIT REMOTE CONTROLS**

- A. Product: Energizer NHIZ-850
  1. Classification: Rechargeable
  2. Chemical System: Nickel-Metal Hydride
  3. Designation: ANSI- 1.2H1
  4. Nominal Voltage: 1.2 volts

**2.2 BATTERIES FOR COMPUTER**

- A. Product: Dell Distributed 29 watt-hour 4 cell rechargeable battery

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Install batteries in equipment according to manufacturer's instructions

**END OF SECTION 26 33 13**

**SECTION 26 50 00  
 LIGHTING**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Section Requirements:
  1. Submittals: Product Data for each luminaire, including lamps.
  2. Fixtures, 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.
  3. Comply with IEEC C2, "National Electrical Safety Code."
  4. Coordinate ceiling-mounted luminaires with ceiling construction, mechanical work and security and fire-prevention features mounted in ceiling space and on ceiling.
  
- B. Related Sections:
  1. Section 08 80 00 "Glazing"
  2. Section 09 54 00 "Specialty Ceiling"
  3. Section 09 62 00 "Sheet Metal Flashing and Trim"
  4. Section 21 13 00 "Fire-Suppression Sprinkler Systems"
  5. Section 25 11 00 "Home Automation and Control Systems"
  6. Section 26 05 00 "Common Work Results for Electrical"
  7. Section 26 05 19 "Low-Voltage Electrical Conductors and Cables"
  8. Section 26 05 33 "Raceways and Boxes for Electrical Systems"
  9. Section 26 27 26 "Panelboards"

**PART 2 PRODUCTS**

**2.1 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. Exterior Luminaires: Comply with UL 1598 and listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- D. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- E. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

**2.2 INDOOR FIXTURES**

- A. Track Lighting in Main Living Area:
  1. Juno Trac-Master System: TU4, TU8, and TU12
  2. Lengths: 4', 8', and 12'
  3. Voltage: 120VAC
    - a. AVIO™ TRAC MOUNTED SERIES XT16101

- b. HALO LF5061620
  - c. ART GLASS PENDANTS P95 - LONG CONE
- B. Ceiling Fixture for Troughs:
- 1. Tubular Fluorescent
  - 2. Manufacturer: HE Williams
  - 3. Product: SM76-4-132-120V
  - 4. Stepped Dimming Ballast, 0/10/40/100%
  - 5. Ballast Type: Electronic T8, Side Mounted
  - 6. No. Lamps: 1
  - 7. Length: 4'
  - 8. Baffle:
    - a. Parasquare 1 – Small Cell Low Glare Parabolic Louver
    - b. Manufacturer: SLP
    - c. Thickness: .4"
    - d. Blade Spacing: .625"
    - e. Width: 9 ½"
    - f. Finish: Glossy Black
- C. Linear Fixture (Mechanical Room)
- 1. 4' Linear Tubular Fluorescent
  - 2. Product: LaMar Lighting WN Series
  - 3. Model Number: WN-132-E8-U
- D. Bathroom Can Light Fixture
- 1. 4" LED IC/Airtight New Construction Housing with Lens
  - 2. Product: Nora Lighting
  - 3. Mounting: Recessed ceiling with platinum diffused reflector and flange
  - 4. Housing: NHIC-5 LED AT
  - 5. UL Wet Location Listed
- E. Bathroom Vanity Light
- 1. 20.5 inch Cylindrical LED Wall Sconce
  - 2. Product: George Kovacs
  - 3. Model Number: P5044-077-L
  - 4. UL Listed Damp Location
  - 5. Width: 20.5 inches
  - 6. Height: 4.75 inches

## 2.3 EXTERIOR FIXTURES

- A. Wall-mounted Powered Lantern, LED
- 1. Product: Hampton Bay
  - 2. Model: HB7054-35
  - 3. Voltage: 120 VAC
  - 4. Dimensions: 7.13" x 6.08" x 9.38"
  - 5. Exterior Finish: Brushed Nickel

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Set units level, plumb, and square with ceiling, walls, and floors and secure.

- B. Adequate support for all Fixtures. Conduit shall not be used for support.
- C. Adjust aim able lighting fixtures to provide required light intensities.

END OF SECTION 26 50 00

## DIVISION 28

# **ELECTRONIC SAFETY**

**SECTION 28 31 46  
 SMOKE DETECTION SENSOR**

**PART 1 GENERAL**

**1.1 SUMMARY**

- A. Related Sections:
  1. Section 26 05 19 “Low-Voltage Electrical Conductors and Cables.”

**1.2 SECTION REQUIREMENTS**

- A. System Description: Non-coded, 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 DIVISION
- 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 ALARM-INITIATING DEVICES**

- A. Smoke Detector: First Alert
  1. Model: SC120B
  2. UL 1971, 120 V ac, self-restoring, hard-wired electric type.
  3. Finished: White
  4. 9V battery backup

**2.2 WIRE AND CABLE**

- A. General: UL listed and labeled as complying with NFPA 70, Article 760.
- B. Signal Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
- C. Non-Power-Limited Circuits: Solid copper conductors with 600 V rated, 75 degree 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.

**END OF SECTION 28 31 46**

DIVISION 48

**ELECTRICAL POWER  
GENERATION**

**SECTION 48 19 16  
 ELECTRICAL POWER GENERATION INVERTERS**

**PART 1 GENERAL**

**3.2 SUMMARY**

- A. Section Includes
  - 1. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application
- B. Related Sections
  - 1. Section 26 05 00 “Common Work Results for Electrical”
  - 2. Section 26 05 19 “Low-Voltage Electrical Conductors and Cables”
  - 3. Section 26 31 00 “Photovoltaic Collector”

**PART 2 PRODUCTS**

**2.1 DC-AC INVERTERS**

- A. TenKsolar RAIS WAVE System
  - 1. TenK 240 Extra Low Voltage inverter for parallel operation
    - a. Network number of phases: single phase
    - b. Nominal output power: 5kW AC-240V
    - c. Output current: 21 A-240V
  - 2. INV-SUST-MBUS - communications gateway
    - a. Communication network type: Ethernet
    - b. Communication port protocol: Modbus RS-485
    - c. Port Ethernet: 10/100 B56-T
- B. KACO blueplanet series
  - 1. KACO blueplanet 2502xi
    - a. Network number of phases: single phase
    - b. Nominal output power: 2.5kW AC-240V
    - c. Output current: 12 A-240V
    - d. Integrated communication network type: Ethernet
    - e. Communication port protocol: RS-485
    - f. Port Ethernet: 10/100 B56-T

**PART 3 EXECUTION**

**3.1 INSTALLATION**

- A. Roof-mounted Inverters: Install in PV racking per manufacturer’s instructions.
- B. Wall-mounted Inverter: Securely anchor wall-mounting bracket to manufacturer’s specifications before attaching inverter. Verify all clearances for adequate ventilation.
- C. Before testing any inverters ensure that all wires are properly connected and adequate circuit protection has been taken in accordance with NEC 690.

**END OF SECTION 48 19 16**

# Appendix

## Quantity Takeoff

Product Name	Quantity
<b>Structures:</b>	
Steel Members	1
Plywood (Subfloor)	50
Insulation	1
Concrete	1
Concrete Finish	1
Mesh	3
Steel Footing	1
Binkley Jacks	32
Wooden Footing	45
2x4 Boards	40
SIPs	1
<b>Wall Sytems:</b>	
Gutters (Gutter Supply)	1
Basic Materials (drywall, compound, tape)	1
Exterior Doors	1
Interior Doors	1
Interior Paint	1
Exterior Paint	1
Roof/Ceiling:	
Primary Roof Material	1
<b>Kitchen:</b>	
Sink (Giagni) GSS250	1
Cabinets (Crystal Cabinets, Acrylic)	1
Faucet- CHROME (Design House, 526756)	1
Countertop (CeasarStone, smokey ash)	1
Handles (Linnea Hardware, 2 1/8" center)	1
Tiles	1
Cabinet Sliding Tracks (Johnson Hardware 200SD)	1
Cabinet Hanger (Jonson Hardware 200SD)	1
<b>Bathroom:</b>	
Duravit KT6634 Ketho Vanity Wall Mount 39 3/8" W x 19 5/8" H with 2 Drawers	1
Pfister Polished Chrome F-042-BN	1
Toilet, American Standard	1
Sink	1
Countertop	1
Mirror (Gardner Glass Products)	1

Shower Tile Grey Mosaic	1
Shower Tile White	1
Tile Subway Black	1
Tile Subway Grey	1
Shower Door/System	1
Shower Head (DELTA)	1
Bathroom Caulking	1
<b>Bedroom:</b>	
Murphy Bed	1
Cabinet System	1
Operable Wall	1
<b>Deck:</b>	
Deck System	1
<b>Grid Wall:</b>	
3/4" Plywood	1
1/8" Luann Plywood	1
Cabinet Hinges	1
2x4 Stud	1
Canvas (door covering)	1
<b>Solarium:</b>	
Nana Wall - Folding Glass Wall (4L4R\SL60L)	2
<b>Wall Systems:</b>	
HardiePanels 4'x9'	1
HardiePanels 4'x10'	1
Dupont Tyvek 10'x150'	1
Stud Wall	1
3.5 in fiberglass roll	1
Air-infiltration wrap	1
Gypsum	1
Interior Paint (2 coats)	1
<b>Windows:</b>	
Crystal Windows	1
<b>Automation:</b>	
Chameleon Enclosure	1
Chameleon Faceplate	1
PoE Arduino Module	3
Tablet Mounting	1
Nexus 7- 16 GB	1
Intel DC3217IYE Next Unit of Computing	1
<b>Entertainment:</b>	

Asus 24" W Full HD Monitor with LED	1
USB RF Wireless Ergonomic Wave Combo	1
5.1 Speakers	1
2.1 Speakers	1
VLock	1
Stereo Jack	1
Blank Wall Plate	1
Speaker Wire	1
Stereo Jack Wires	1
<b>PV:</b>	
PV Modules (Price for 195W)	6
Inverter	1
Switch, DC	1
TenKSolar System (19 Panels, 2 Inv.)	1
TenKSolar Ballast	1
Balance	1
<b>Distribution:</b>	
Load Center (1" spacing)	1
Circuit Breaker (GFI)	3
Circuit Breaker (Arc Fault)	4
Circuit Breaker (20A DP)	4
Circuit Breaker (30A DP)	3
Circuit Breaker (40A DP)	2
Circuit Breaker (50A DP)	2
Circuit Breaker (20A SP)	20
PowerLogic® Branch Current Monitor	1
Conduit	1
Conduit	1
J-Box	1
Sw/Rcp Box	1
Switch	1
Outlet, Tamper Resistant	30
Outlet, GFI	4
Wire 14-2 w/gnd, 1000ft roll	1
Wire 12-2 w/gnd, 1000ft roll	1
Balance	1
<b>Appliances:</b>	
Refrigerator	1
Dishwasher	1
Range	1
Vent Hood	1

Microwave	1
Washer	1
Dryer	1
<b>Heating:</b>	
2-Branch Stainless Steel Radiant Manifold	3
TACO 009 SF5 Stainless Steel Single Speed Circulator	1
3/4" PEX-Al-PEX Piping (300' coil)	1
TACO 005 SF2-IFC	3
Taco Z075C2 3/4" Sweat Motorized Zone Sentry Zone Valve	1
Dwyer Immersion Temperature Sensor	1
Sparkfun Temperature Sensor	1
ESBE Diverter Valve	1
Isolator Flange with Drain	1
Freedom Flange	1
3/4" Copper 10' Section	1
3/4" Copper Elbow	1
3/4" Copper Tee	1
<b>Solar:</b>	
Oventrop 105 gallon Solar Hot Water Tank	1
10 Gallon Sav'N Sun Drainback Resevior Solar Tank	1
Heliodyne GOBI 406 Collector	1
<b>Ventilation:</b>	
Venmar Constructo 1.0 ERV	1
Unico Unichiller RC UCHR0364-1C0	1
Unico Model 1218 Green Series	1
<b>Plumbing:</b>	
3/4" Brass Check Valve	1
3/4" Relief Valve	1
3/4" Boiler Drain	1
MANABLOC 14 Port Compression PEX Manifold	1
3/8" PEX 300' Coil	1
Wax Ring	1
2" Schedule 40 PVC 10' Section	1
2" Schedule 40 PVC Elbow	1
2" PVC Wye	1
Eastman 2-pack 6' Stainless Steel Washing Machine Connectors	1
1 1/2" P-Trap	1
Quarter-Turn Ball valve PEX Washing Machine Outlet Box	1

# Wire Calculations for Bi-Facial Panels

## Ratings

$V_{oc}$  : 67.8V

$I_{sc}$  : 3.73A

Temperature Coefficients ( $V_{oc}$ ) :  $-0.192 \frac{V}{^{\circ}C}$

Temperature Coefficients ( $I_{sc}$ ) :  $1.70 \frac{mA}{^{\circ}C}$

Lowest Recorded Temperature :  $-30^{\circ}C$

Highest Recorded Temperature:  $46.11^{\circ}C$

## Voltage Calculations

$$\Delta T = 25 - (-30) = 55$$

Voltage change in  $V_{oc}$  resulting from temperature change:

$$\Delta V = 0.192 \frac{V}{^{\circ}C} \cdot 55^{\circ}C = 10.56V$$

Applying  $\Delta V$  to  $V_{oc}$

$$V_{oc(\Delta T)} = 10.56V + 68.7V = 79.26V$$

Five panels in parallel would result in a voltage of:

$$V_{total} = 5 \cdot 79.26 = 396.3V$$

## Current Calculations

Current change in  $I_{sc}$  resulting from  $\Delta T$ :

$$\Delta I = 1.70 \frac{mA}{^{\circ}C} \cdot 55^{\circ}C = 93.5mA$$

Applying  $\Delta I$  to  $I_{sc}$

$$I_{sc(\Delta T)} = 0.0935A + 3.73A = 3.8235A$$

Combining two strings of five in parallel

$$I_{sc(\Delta T)TOTAL} = 2 \cdot I_{sc(\Delta T)} = 7.647A$$

Max circuit current calculated in accordance with NEC 690.8(A)(1) and 690.8(B)(1)

$$I_{sc(max)} = 1.56 \cdot 7.647 = 11.93A$$

## Wire Selection

Ambient temperature correction factor in accordance with NEC 310.15(B)(2)(A):

$$I' = I \sqrt{\frac{T_c - T'_a}{T_c - T_a}} = I \sqrt{\frac{90 - 46.11}{90 - 30}} = I \cdot 0.85527$$

I' = ampacity corrected for ambient temperature

I = ampacity shown in the tables

T<sub>c</sub> = temperature rating of conductor (°C)

T'<sub>a</sub> = new ambient temperature (°C)

T<sub>a</sub> = ambient temperature used in the table (°C)

Wire from Kaco inverter to AC combiner:

I	I·1.25	I·1.56	Wire Size	30°C Ampacity	Ambient Temp	Ambient Derate	Conduit Fill	Fill Derate	Derated Ampacity
12	15	18.72	12	30	46.11	0.85527	3	1.0	25.658

Overcurrent circuit breaker size: 20A

This was chosen because it was the next standard size above 18.72A.

Wire from Bi-facial array to Kaco inverter:

I <sub>sc</sub>	I <sub>sc</sub> ·1.25	I <sub>sc</sub> ·1.56	Wire Size	30°C Ampacity	Ambient Temp	Ambient Derate	Conduit Fill	Fill Derate	Derated Ampacity
7.647	9.559	11.93	10	40	46.11	0.85527	2	1.0	34.211

### Conduit Sizing

Conduit run from bi-facial array to inverter:

5 - #10 conductors require a ¾" conduit according to NEC Table C.1

Conduit run from Kaco inverter to AC combiner:

4 - #12 conductors require ¾" conduit according to NEC Table C.1

# Wire Calculations for tenKsolar array

## Ratings

$V_{max} : 57V$

$I_{max} : 9.1A$

## Wire Selection

Ambient temperature correction factor in accordance with NEC 310.15(B)(2)(A):

$$I'_{free\ air} = I \sqrt{\frac{T_c - T'_a}{T_c - T_a}} = I \sqrt{\frac{90 - 50}{90 - 30}} = I \cdot 0.82$$

$$I'_{conduit} = I \sqrt{\frac{T_c - T'_a}{T_c - T_a}} = I \sqrt{\frac{90 - 65}{90 - 30}} = I \cdot 0.65$$

$I'$  = ampacity corrected for ambient temperature

$I$  = ampacity shown in the tables

$T_c$  = temperature rating of conductor (°C)

$T'_a$  = new ambient temperature (°C)

$T_a$  = ambient temperature used in the table (°C)

Wire from panels to DC disconnect (Free Air):

I	I-1.25	I-1.56	Wire Size	30°C Ampacity	Ambient Temp	Ambient Derate	Conduit Fill	Fill Derate	Derated Ampacity
9.1.7	80	99	2 AL	150	50	0.82	NA	NA	123

Wire from DC disconnect to inverter (Free Air):

I	I-1.25	I-1.56	Wire Size	30°C Ampacity	Ambient Temp	Ambient Derate	Conduit Fill	Fill Derate	Derated Ampacity
100*	125	156	1 CU	190	50	0.82	NA	NA	156

\*See tenKsolar white paper dated July 27, 2012 rev 2 (text provided below)

Wire from inverter to AC disconnect (Free Air):

I	I-1.25	I-1.56	Wire Size	30°C Ampacity	Ambient Temp	Ambient Derate	Conduit Fill	Fill Derate	Derated Ampacity
21	26	33	8	80	50	0.82	NA	NA	66

Wire from AC disconnect to AC combiner:

I	I-1.25	I-1.56	Wire Size	30°C Ampacity	Ambient Temp	Ambient Derate	Conduit Fill	Fill Derate	Derated Ampacity
21	26	33	8	80	65	0.65	3	1.0	52

Overcurrent circuit breaker size: 30A

This was chosen because it was the next standard size above 26A.

Wire from AC combiner to Main PV disconnect and from disconnect to Main Service Panel:

I	I-1.25	I-1.56	Wire Size	30°C Ampacity	Ambient Temp	Ambient Derate	Conduit Fill	Fill Derate	Derated Ampacity
54	67.5	84.24	4	80	65	0.65	3	1.0	91

Overcurrent circuit breaker size: 70A

This was chosen because it was the next standard size above 67.5A.

### Conduit Sizing

Conduit run from bi-facial array to inverter:

4 - #8 conductors require a 1" conduit according to NEC Table C.1

Conduit run from AC combiner to PV disconnect and from disconnect to Main Service Panel:

4 - #14 conductors require 1¼" conduit according to NEC Table C.1

### **System Ground conductor sizing**

Ground conductors selected in accordance with NEC 690.47(C)(3) and NEC Table 250.122

Bi-facial array to Kaco inverter	10 AWG
Kaco inverter to AC combiner	10 AWG
AC disconnect to AC combiner	10 AWG
AC combiner to Main PV disconnect and from disconnect to Main Service Panel	8 AWG
Main service panel to ground rod and meter	6 AWG

# tenKsolar White Paper on Inverter Hyperloading

July 27, 2012 rev 2

The integration between tenKsolar RAIS solar modules and the Sustainable Energy Technologies ELV inverter series allows hyperloading of modules over the inverter's nameplate due to the elegant nature of the integration. This hyperloading trend is market-driven, and varies widely from location to location, but it is not unreasonable to see 5400 W nameplate (7860 W peak reflected ) feeding a 5000 W inverter.

Facts that contribute:

- The inverter's DC input is hard-limited to its AC output limit.
- The RAIS module's upper production limit is 57 VDC.
- All RAIS modules are connected in parallel.
- DC bus voltage is set by the inverter, not by the solar modules.
- MPPT is built into each module, and is disabled in the inverter.

How this works:

As the sun gets higher, when the inverter's output limit is reached, for example, 24 A for the ELV-208, or 21 A for the ELV-240, any excess current being sent from the RAIS modules to the DC input will cause the DC bus voltage to rise. The inverter does this automatically. As the DC bus voltage rises, modules will begin to reach their upper limit of production, which is 57 VDC. The first module that approaches this hard limit (usually the one furthest from the inverter) will automatically reduce its output until it reaches zero at 57 VDC. Other modules in turn will do this as needed, resulting in a flat 24 A output from the inverter's AC terminals, and presents no threat to the inverter. All components are working as designed in this scenario.

The result:

The system designer is free to balance the energy lost at peak production hours with the AC equipment saved by hyperloading the inverters. Typically in Minnesota, a 5000 watt inverter can be loaded up with 7000 peak watts of RAIS modules, and lose at most 1.5% annual kWh production.

Another example, in Providence, Rhode Island, it was determined that the best combination for overall return-on-investment was 30 fully-reflected 180 W modules per 5000-watt inverter.

DC combiner current:

With module hyperloading, the question comes up regarding how to size the inverter's input conductors. There are two main factors which determine the ampacity required for these conductors:

1. The inverter's maximum input is limited by its output rating. For example, with an ELV-240, which is limited to 5000 W, on a peak sun day the input will be  $5000 \text{ W} / 0.96 = 5208 \text{ W}$ , or around 99.2 A on the DC input. This is the design current.
2. If the inverter is hyperloaded, there is no physical way for the sum total of all modules' current output at peak conditions to flow toward the inverter. If there were a positive-to-negative short circuit in these conductors, the current would drop to zero, due to the RAIS module short-circuit current value of zero. If there were a positive-to-ground or negative-to-ground short in these conductors (a ground-fault), all RAIS modules would stop production and go into ground-fault mode.

# ***Structural Engineering Calculations***

***For***

***The Chameleon House***

***Colin Polleys & Shayne Heskin***

***Missouri S&T Solar House Team***

***Rolla, Missouri***

***August 2013***

***THHinc # ----***

This Certification applies to the attached Structural Engineering Calculations only and is not intended to imply or otherwise indicate that the referenced structure has been designed according to any state-specific criterion, Codes or other related standards. The purpose of this Certification is to comply with the requirements of the US Department of Energy Solar Decathlon competition submittal requirements only. As such this document shall not become attached to, or otherwise survive with, this modular residential structure beyond the temporary installation in California.

I am a Professional Engineer in good standing in the State of California.



Kris L. Bezenek, P.E.

California Registration C79776

**THHinc**

**Trabue, Hansen & Hinshaw, Inc.**

1901 Pennsylvania Avenue  
Columbia, MO 65202

(573) 814-1568  
Corp. Reg. # MO E-1454-D

MISSOURI S&T SOLAR HOUSE TEAM

# STRUCTURAL DESIGN

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## CALCULATIONS

COLIN POLLEYS & SHAYNE HESKIN

8/21/2013



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THIS DOCUMENT CONTAINS THE  
INFORMATION REQUIRED BY THE US  
DEPARTMENT OF ENERGY SOLAR  
DECATHALON 2013 TO HAVE A  
PROFESSIONAL ENGINEER'S STAMPED  
APPROVAL ON THE STRUCTURAL  
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## **1. GENERAL**

### **1.1 - ARCHITECTURE**

#### **1.1.1 ISOMETRIC VIEW**

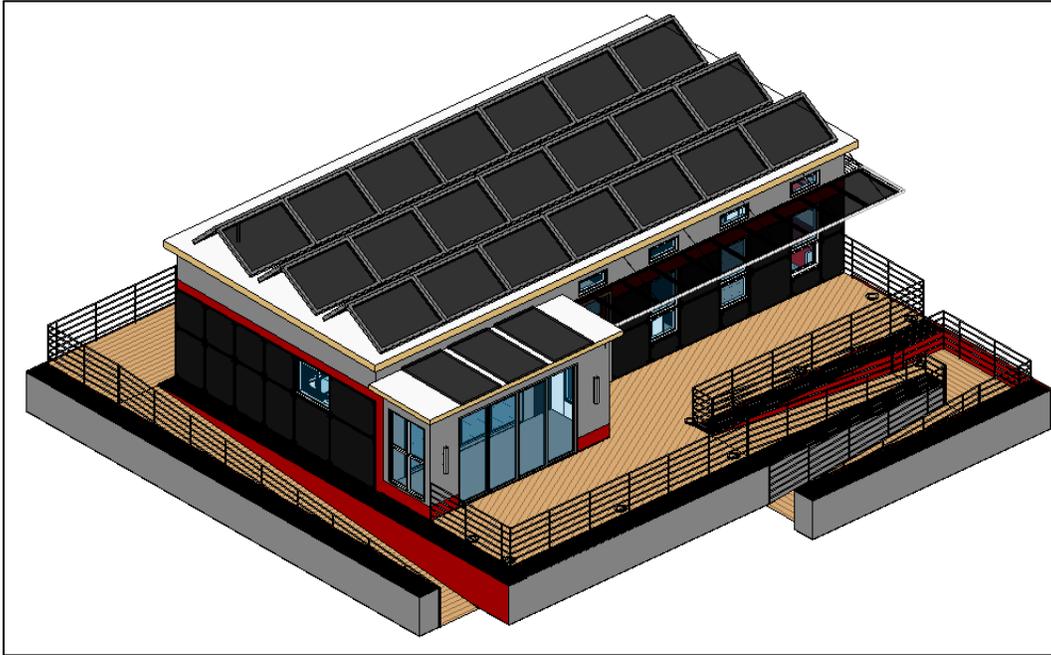


FIGURE 1.1.1

#### **1.1.2 FLOOR PLAN**

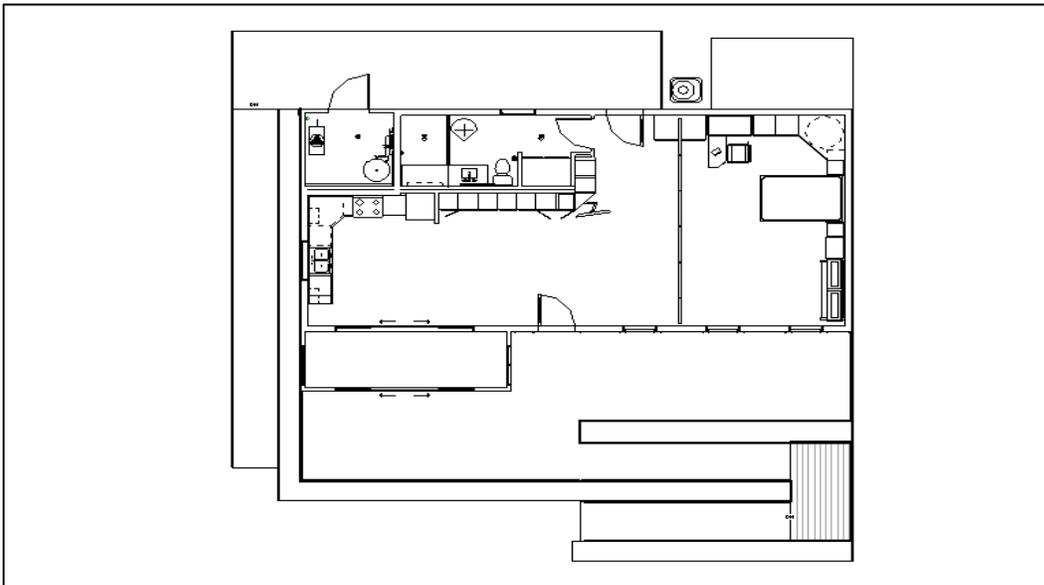


FIGURE 1.1.2

JOB \_\_\_\_\_  
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CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

### 1.1.3 ROOF PLAN

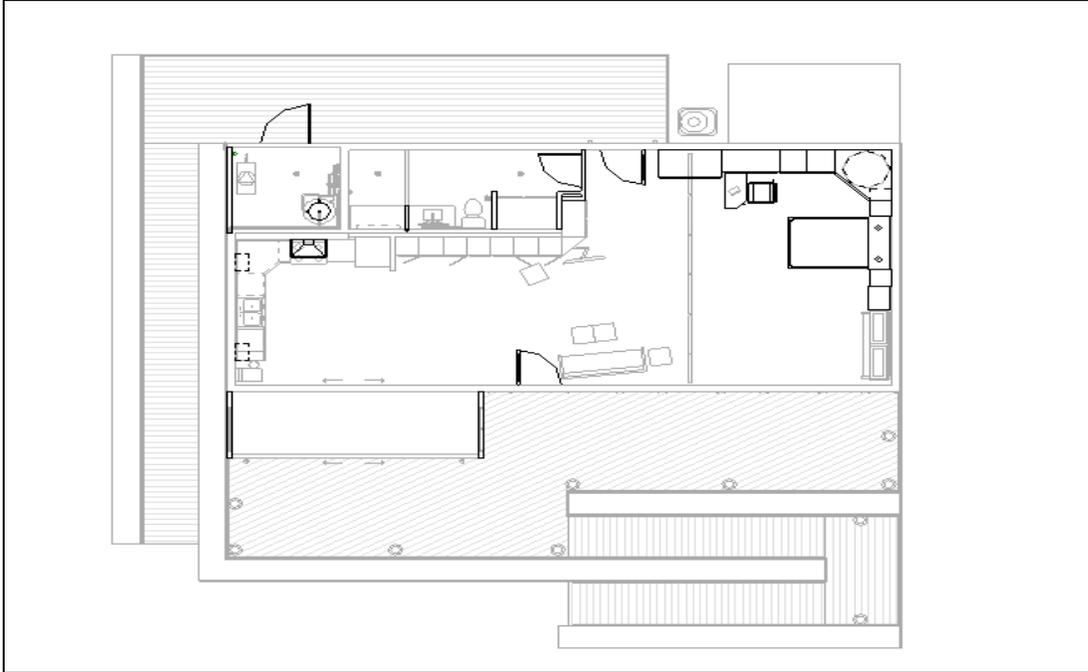


FIGURE 1.1.3

### 1.1.4 NORTH ELEVATION

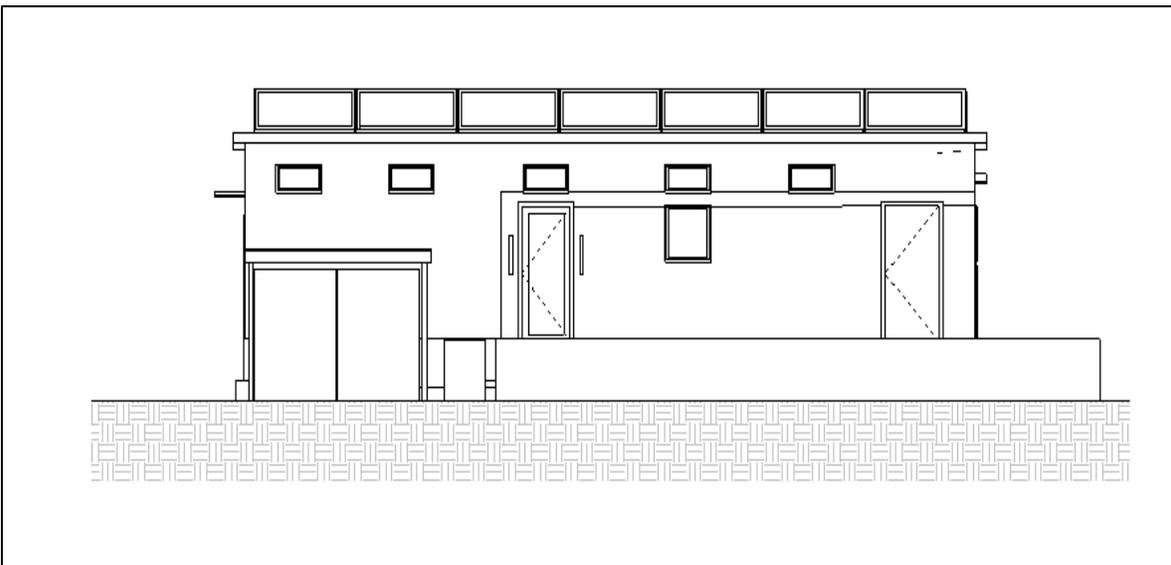


FIGURE 1.1.4

JOB \_\_\_\_\_  
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### 1.1.5 EAST ELEVATION



FIGURE 1.1.5

### 1.1.6 SOUTH ELEVATION

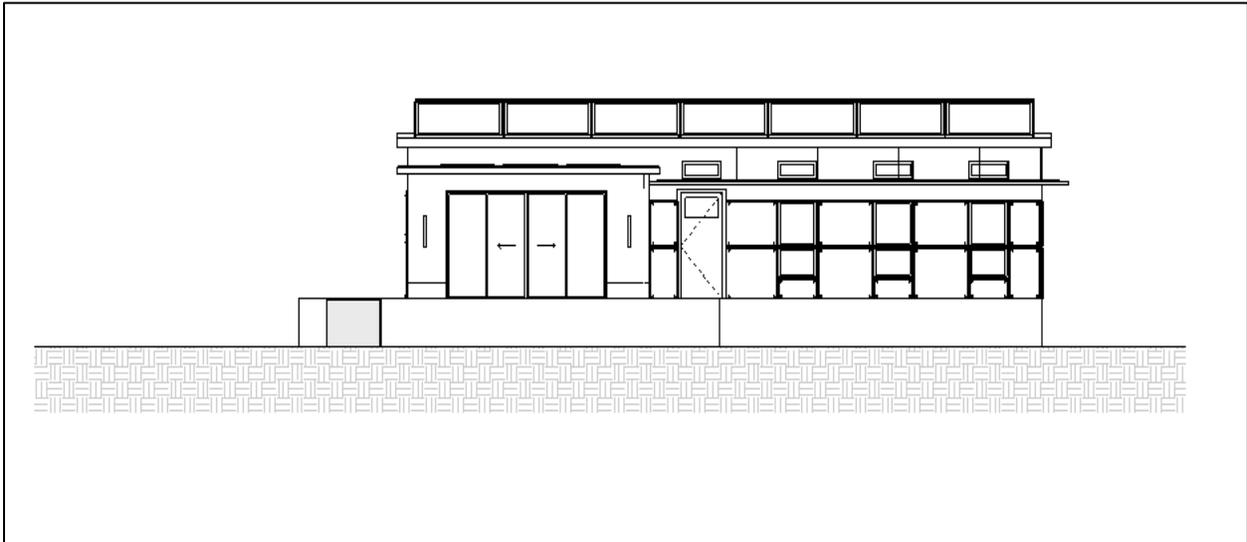


FIGURE 1.1.6

JOB \_\_\_\_\_  
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**1.1.7 WEST ELEVATION**

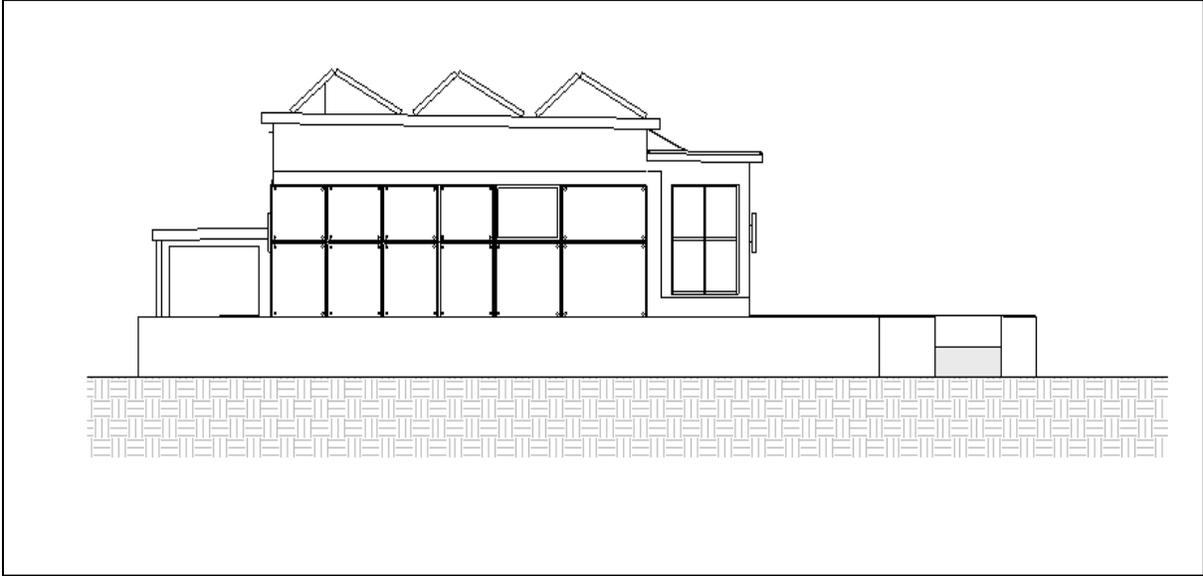


FIGURE 1.1.7

**1.2 – LOADS**

**1.2.1 ITEM WEIGHTS**

Figure 1.2.1 is an itemized list of the expected weights and quantities of loads applied to the house.

TABLE 1.2.1

	Item	Quantity	Weight	Units	Notes	Load	Weight	Unit
Roof	6" SIPs		4.8	psf		Floor Live Loads	50	psf
	Evacuated Tubes and Racks	2	120	lbs	Estimated	Tour Live Load	50	psf
	Heat Recovery System		5	psf		Egress Componets	100	psf
	Mono-crystalline Panels	24	43	lbs		Snow Roof Live Load	20	psf
	PV Racks	24	6.45	lbs		Roof Load	20	psf
	Roofing Material		3	psf				
	Drywall (5/8")		2.5	psf				
						Wind Loads		
Walls	6" SIPs		4.8	psf		85 mph 3 second gusts		
	Doors	3	100	lbs				
	Bedroom Cabinets		80	lbs				
	Clerestory Windows (18" X 36") 17 psf	14	76.50	lbs	Triple Pane			
	Exterior Façade (panels, plastic wrap)		2.5	psf				
	Kitchen Appliances				In LL			
	Kitchen Cabinets		40	lbs				
	Kitchen Windows (36" X 48") 17 psf	2	204	lbs	Triple Pane			
	Murphy Bed (80" long)		300	lbs				
	South Wall Windows (36" X 59.5") 17 psf	3	252.88	lbs				
	"Glass Mechanical Wall"		526.5	lbs	Double Pane			
	2X4 Stud Wall (16" O.C.)		9.75	plf				
	Solarium Door		233.33	lbs				
Drywall (5/8")		2.5	psf					
Floor	Concrete Floor (3.5" @ 110 pcf)*		32.083	psf				
	Insulation (2") & EZ Floor (2")		3.6	psf				
	Plywood Floor (1")		2.250	psf				

\* Wind loads are based upon competition requirements specified in appendix c.

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## 1.2.2 GRAVITY LOADS

### 1.2.2.1 BEDROOM

TABLE 1.2.2.1A

DEAD LOADS: CRANE, TRUCK, AND COMPETITION							
<b>Bedroom Roof (15' x 22.25')</b>		Length	22.25 ft				
		Width	15 ft				
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>				
Mono-crystalline Panels	5	43 lbs					
PV Racks	5	6.45 lbs					
6" SIPs		4.8 psf					
Roofing Material		3 psf					
Drywall (5/8")		2.5 psf					
Heat Recovery System	5	psf					
<b>Bedroom Overhang 9' Wide</b>		NS Length	23.75 ft				
		EW Length	15 ft				
		Width	0.75 ft				
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>				
Mono-crystalline Panels	5	43 lbs					
PV Racks	5	6.45 lbs					
8" SIPs		4.8 psf					
Roofing Material		3 psf					
				Area (ft <sup>2</sup> )	Weight (psf)	Peak Load (plf)	Factored Load (plf)
				North	56.25	17.06	63.97
				South	56.25	17.06	63.97
				East	166.88	15.89	119.19
				West	166.88	15.89	119.19
							1.2
<b>Bedroom North Wall</b>		Area	153.75 ft <sup>2</sup>				
		Length	15 ft				
		Height	10.25 ft				
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>				
6" SIPs		4.8 psf					
Clerestory Windows (14" X 36") .375 psf	2	76.50 lbs					
Exterior Façade (panels, plastic wrap)		2.5 psf					
Drywall (5/8")		2.5 psf					
Bedroom Cabinets	4	80 lbs					
				Total	12.88 psf		
				Safety Factor	1.2		
				Factored	15.45 psf		
				UF - Dist	131.98 plf		
				<b>Distributed</b>	<b>158.38 plf</b>		
<b>Bedroom South Wall</b>		Area	153.75 ft <sup>2</sup>				
		Length	15 ft				
		Height	10.25 ft				
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>				
6" SIPs		4.8 psf					
Exterior Façade (panels, plastic wrap)		2.5 psf					
Drywall (5/8")		2.5 psf					
Clerestory Windows (14" X 36") .375 psf	2	76.50 lbs					
South Wall Windows (36" X 54") .375 psf	2	252.88 lbs					
				Total	14.08 psf		
				Safety Factor	1.2		
				Factored	16.90 psf		
				UF - Dist	144.37 plf		
				<b>Distributed</b>	<b>173.24 plf</b>		
<b>Bedroom East Wall</b>		Area	228.06 ft <sup>2</sup>				
		Length	22.25 ft				
		Height	10.25 ft				
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>				
6" SIPs		4.8 psf					
Exterior Façade (panels, plastic wrap)		2.5 psf					
Drywall (5/8")		2.5 psf					
Clerestory Windows (14" X 36") .375 psf	3	76.50 lbs					
Bedroom Cabinets (7)	5	80 lbs					
Murphy Bed (80" long)		300 lbs					
				Total	13.88 psf		
				Safety Factor	1.2		
				Factored	16.65 psf		
				UF - Dist	142.23 plf		
				<b>Distributed</b>	<b>170.67 plf</b>		
<b>Bedroom West Wall</b>		Area	228.06 ft <sup>2</sup>				
		Length	22.25 ft				
		Height	10.25 ft				
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>				
2X4 Stud Wall (16" O.C.)		9.75 plf					
				Total	0.95 psf		
				Safety Factor	1.2		
				Factored	1.14 psf		
				UF - Dist	9.75 plf		
				<b>Distributed</b>	<b>11.70 plf</b>		

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 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 1.2.2.1B

**LIVE LOADS: COMPETITION**

Bedroom Roof (15' x 22' 3")							1.6
Load Type	Size	Units		Area (ft <sup>2</sup> )	Weight (psf)	Peak Load (plf)	Factored Load
Snow	20	psf	North	56.25	20.00	50.56	80.90
Roof Load	20	psf	South	56.25	20.00	50.56	80.90
			East	166.88	20.00	222.50	356.00
			West	166.88	20.00	222.50	356.00
Bedroom Overhang 9" Wide							1.6
Load Type	Size	Units		Area (ft <sup>2</sup> )	Weight (psf)	Peak Load (plf)	Factored Load
Snow	20	psf	North	11.25	20.00	15.00	24.00
Roof Load	20	psf	South	11.25	20.00	15.00	24.00
			East	17.81	20.00	15.00	24.00

TABLE 1.2.2.1C

**FLOOR LOADS: CRANE**

Dead Loads				16 in.	
Item	Thickness (in)	Weigh	Units	Beam Spacing	
Concrete Floor	3	32.08	psf	Beam Spacing	16 in
Insulation (2") & EZ Floor (2")	3	3.6	psf	DL	1.33 ft
Plywood Floor	1	2.25	psf	DL	50.58 plf
Live Loads				Factor	1.2
Item	Thickness (in)	Weigh	Units	F DL	60.69 plf
Tour Live Load		0	psf	LL	66.67 plf
Typical Floor Load		50	psf	Factor	1.6
				F LL	106.67 plf

TABLE 1.2.2.1D

**FLOOR LOADS: TRUCK**

Dead Loads				16 in.	
Item	Thickness (in)	Weigh	Units	Trib. Spacing	
Concrete Floor	3	32.08	psf	Trib. Spacing	16 in
Insulation (2") & EZ Floor (2")	3	3.6	psf	DL	1.33 ft
Plywood Floor	1	2.25	psf	DL	50.58 plf
Live Loads				Factor	1.2
Item	Thickness (in)	Weigh	Units	F DL	60.69 plf
Tour Live Load		50	psf	LL	133.33 plf
Typical Floor Load		50	psf	Factor	1.6
				F LL	213.33 plf

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
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**1.2.2.2 LIVING ROOM**

TABLE 1.2.2.2A

DEAD LOAD: CRANE, TRUCK, COMPETITION					
<b>Living Room Roof (14'3" X 32' 3")</b>					
	Length	32.25 ft			
	Width	14.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>		
Mono-crystalline Panels	9	43 lbs		1.2	
PV Racks	9	6.45 lbs			
6" SIPs		4.8 psf			
Roofing Material		3 psf			
Drywall (5/8")		2.5 psf			
Heat Recovery System (4" thick plaster)		5 psf			
<b>Bedroom Overhang 9" Wide</b>					
	NS Length	15.00 ft			
	EW Length	32.25 ft			
	Width	0.75 ft		1.2	
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>		
8" SIPs		4.8 psf			
Roofing Material		3 psf			
<b>Living Room North Wall</b>					
	Area	330.56 sft			
	Length	32.25 ft			
	Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>		
6" SIPs		4.8 psf		1.2	
Drywall (5/8")		2.5 psf			
Kitchen Cabinets	3	40 lbs			
2X4 Stud Wall (16" O.C.)		9.75 plf			
<b>Living Room South Wall</b>					
	Area	330.56 sft			
	Length	32.250 ft			
	Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>		
6" SIPs		4.8 psf			
Clerestory Windows (14" X 36") .375 psf	2	76.50 lbs			
South Wall Windows (36" X 54") .375 psf	3	252.88 lbs			
Doors	1	100 lbs			
Exterior Façade (panels, plastic wrap)		2.5 psf			
Drywall (5/8")		2.5 psf			
Solarium Door	6	200.00 lbs			
<b>Living Room West Wall</b>					
	Area	153.75 sft			
	Length	15.000 ft			
	Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>		
6" SIPs		4.8 psf			
Drywall (5/8")		2.5 psf			
Kitchen Cabinets	6	40 lbs			
West Wall Window (36" x 60")	1	150 lbs			
<b>Living Room East Wall (Shipping)</b>					
	Area	153.75 sft			
	Length	15.00 ft			
	Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>		
2X4 Stud Wall (16" O.C.)		9.75 plf		1.2	

	Area sft	Weight (psf)	Peak Load (plf)	F - Load (plf)
North	179.02	15.30	84.93	101.91
South	179.02	17.79	98.73	118.47
East	50.77	16.27	25.62	30.74
West	50.77	16.27	25.62	30.74

	Area (ft2)	Weight (psf)	Peak Load (plf)	F - Load (plf)
East	11.25	7.80	5.85	7.02
South	24.19	7.80	5.85	7.02

Length	Load	Factored Load	Units
0' - 9'	88.16	105.79	plf
9' - 22'	35.38	42.45	plf
22' - 32.25'	9.75	11.7	plf

Total	16.49 psf
SF	1.2
Factored	19.79 psf
UF - Dist	169.03 plf
<b>Distributed</b>	<b>202.83 plf</b>

Total	89 plf
1.2 Factored	106.8 plf

Total	9.75 plf
1.2 Factored	11.7 plf

JOB \_\_\_\_\_  
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TABLE 1.2.2.2B

LIVE LOAD: COMPETITION							
Living Room Roof (15' x 32.33')		Length	32.25 ft				1.6
		Width	14.25 ft		Area sft	Weight (psf)	Peak Load (plf)
Load Type	Weight	Units		North	179.02	20.00	177.63
Snow	20	psf		South	179.02	20.00	177.63
Roof Load	20	psf		East	50.77	20.00	114.00
				West	50.77	20.00	114.00
				East Overhang	11.25	20.00	11.16
				South Overhang	24.19	20.00	24.00

TABLE 1.2.2.2C

FLOOR LOADS: CRANE							
<b>Dead Loads</b>				Trib. Spacing	16 in		
<b>Item</b>	<b>Thickness (in)</b>	<b>Weight</b>	<b>Units</b>	Trib. Spacing	1.33 ft		
Concrete Floor (3" @ 110 pcf)	3	32.08	psf	DL	50.58 plf		
Insulation (3")	3	3.60	psf	Factor	1.2		
Plywood Floor (1")	1	2.25	psf	F DL	60.69 plf		
<b>Live Loads</b>				LL	66.67 plf		
<b>Item</b>	<b>Thickness (in)</b>	<b>Weight</b>	<b>Units</b>	Factor	1.6		
Floor Load (Competition)		0	psf	F LL	106.67 plf		
Typical Floor Load		50	psf				

TABLE 1.2.2.2D

FLOOR LOADS: TRUCK							
<b>Dead Loads</b>				Trib. Spacing	16 in		
<b>Item</b>	<b>Thickness (in)</b>	<b>Weight</b>	<b>Units</b>	Trib. Spacing	1.33 ft		
Concrete Floor (3" @ 110 pcf)	3	32.08	psf	DL	50.58 plf		
Insulation (3")	3	3.60	psf	Factor	1.2		
Plywood Floor (1")	1	2.25	psf	F DL	60.69 plf		
<b>Live Loads</b>				LL	133.33 plf		
<b>Item</b>	<b>Thickness (in)</b>	<b>Weight</b>	<b>Units</b>	Factor	1.6		
Floor Load (Competition)		50	psf	F LL	213.33 plf		
Typical Floor Load		50	psf				

JOB \_\_\_\_\_  
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**1.2.2.3 BATHROOM**

**TABLE 1.2.2.3A**

DEAD LOAD: CRANE, TRUCK, COMPETITION						
<b>Bathroom Roof (8' X 32' 3")</b>		Length	8 ft			
		Width	32.25 ft			
		Overhang Width	0.75 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>			
Mono-crystalline Panels	5	43	lbs			
PV Racks	5	6.45	lbs			
6" SIPs		4.8	psf			
Roofing Material		3	psf			
Drywall (5/8")		2.5	psf			
Evacuated Tubes and Racks	2	120	lbs			
				Area sft	Weight (psf)	Peak Load (plf)
				North	129.00	12.19
				South	129.00	12.19
				North Overhang	24.19	7.80
						48.75
						58.51
						58.51
						301.86
						1.2
<b>Bathroom North Wall</b>		Area	330.5625 sft			
		Length	32.25 ft			
		Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>			
6" SIPs		4.8	psf			
Drywall (5/8")		2.5	psf			
Exterior Façade (panels, plastic wrap)		2.5	psf			
Mechanical Door	1	150	lbs			
Clerestory Windows	3	76.50	lbs			
Door	1	100	lbs			
				Area sft	Weight (psf)	Peak Load (plf)
				0-8		0
				8-32.25	9.8	100.45
						0
						120.54
						1.2
<b>Bathroom South Wall</b>		Area	330.5625 sft			
		Length	32.25 ft			
		Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>			
6" SIPs		4.8	psf			
Drywall (5/8")		2.5	psf			
Interior Finish		2.5	psf			
Doors	1	100	lbs			
2X4 Stud Wall (16" O.C.)		9.75	plf			
				Area sft	Weight (psf)	Peak Load (plf)
				0 to 9	9.8	100.45
				9 to 26	5.951219512	61
				26 to 32.25	0	9.75
						120.54
						73.2
						11.7
<b>Bathroom West Wall (Mechanical Room)</b>		Area	82 sft			
		Length	8.000 ft			
		Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>			
2X4 Stud Wall (16" O.C.)		9.75	plf			
Exterior Façade (panels, plastic wrap)		2.5	psf			
				Total	3.25	plf
				Factored	3.9	plf
<b>Bathroom West Wall (SIP Wall)</b>		Area	82 sft			
		Length	8.000 ft			
		Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>			
6" SIPs		4.8	psf			
Drywall (5/8")		2.5	psf			
				Total	9.125	plf
				Factored	10.95	plf
<b>Bathroom EastWall (Shipping)</b>		Area	82 sft			
		Length	8.000 ft			
		Height	10.25 ft			
<b>Item</b>	<b>Quantity</b>	<b>Weight</b>	<b>Units</b>			
2X4 Stud Wall (16" O.C.)		9.75	plf			
				Total	9.75	plf
				Factored	11.7	plf

JOB \_\_\_\_\_  
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TABLE 1.2.2.3B

LIVE LOAD: COMPETITION						
<b>Living Room Roof (15' x 32.33')</b>		Length	8 ft			
		Width	32.25 ft			
		Overhang Length	40.25 ft			
			Area sft	Weight (psf)	Peak Load (plf)	Factored Load (plf)
<b>Load Type</b>	<b>Size</b>	<b>Units</b>				1.6
Snow	20	psf	North	129.00	20.000	80.000
Roof Load	20	psf	South	129.00	20.000	80.000
			North Ove	24.19	20.000	12.019
						19.230

TABLE 1.2.2.3C

**FLOOR LOADS: CRANE**

<b>Dead Loads</b>				Trib. Spacing	16 in
Item	Thickness (in)	Weight	Units	Trib. Spacing	1.333 ft
Concrete Floor (3" @ 110 pcf)	3.5	32.08	psf	DL	50.578 plf
Insulation (4")	4	3.6	psf	Factor	1.2
Plywood Floor (0.75")	1	2.25	psf	F DL	60.693 plf
<b>Live Loads</b>				LL	133.333 plf
Item	Thickness (in)	Weight	Units	Factor	1.6
Floor Load (Competition)		50	psf	F LL	213.333 plf
Typical Floor Load		50	psf		

TABLE 1.2.2.3D

**FLOOR LOADS: TRUCK**

<b>Dead Loads</b>				Trib. Spacing	16 in
Item	Thickness (in)	Weight	Units	Trib. Spacing	1.33 ft
Concrete Floor (3" @ 110 pcf)	3	32.08	psf	DL	50.58 plf
Insulation (3")	3	3.6	psf	Factor	1.2
Plywood Floor (1")	1	2.25	psf	F DL	60.69 plf
<b>Live Loads</b>				LL	133.333 plf
Item	Thickness (in)	Weight	Units	Factor	1.6
Floor Load (Competition)		50	psf	F LL	213.333 plf
Typical Floor Load		50	psf		

**1.2.2.4 SOLARIUM**

An engineering judgment was made that the solarium roof, wall, and floor loads are similar enough to the living room section that as long as the structure system was similar the smaller area, and smaller joist spacing would be more than enough.

### 1.2.3 LATERAL

#### 1.2.3.1 EARTHQUAKE

Table 1.2.3.1a illustrates the seismic weights based on the dead loads of each section. Figure 1.2.3.1 illustrates the variables used in determining the ground lateral load based on ASCE 7-10. Table 1.2.3.1b illustrates the distribution the lateral load to the levels of the house. Table 1.2.3.1c shows the summary of the earthquake loads dispersed to the lateral support system. Seismic concerns were based off of appendix C, calling for a design that meets all code requirements for a seismic design category D2 based upon the IRC.

TABLE 1.2.3.1A

<b>Seismic Weight Calculations</b>			
<b>Bedroom Section</b>			
	Floor Area (SF)		Weight (lbs)
1	333.75	First Floor	21492.26
Roof	333.75	Roof	7834.36
<b>Total Building Weight</b>		W=	29327 lb
		W=	29.33 k
<b>Living Room Section</b>			
	Floor Area (SF)		Weight (lbs)
1	459.56	First Floor	26976.85
Roof	459.56	Roof	7851.67
<b>Total Building Weight</b>		W=	34829 lb
		W=	34.83 k
<b>Bathroom Section</b>			
	Floor Area (SF)		Weight (lbs)
1	258	First Floor	18863.19
Roof	258	Roof	3333.31
<b>Total Building Weight</b>		W=	22197 lb
		W=	22.20 k
<b>Estimated Solarium Room</b>			
	Floor Area (SF)		Weight (lbs)
1	108	First Floor	7584.80
Roof	108	Roof	2160.00
<b>Total Building Weight</b>		W=	9745 lb
		W=	9.74 k
*Estimated based on 2, 14' glass windows, and 2X4 walls on edge with typical flooring based on house			

**Seismic Forces**

**ASCE 7-10 Seismic Design**

**Site Spectrum**

Input values below from map or CD:

		<u>Code Reference</u>
Spectral Response Acceleration, Short Period	$S_s = 1.493$ g	11.4.1
Spectral Response Acceleration, 1-Sec. Period	$S_1 = 0.554$ g	11.4.1

Input value below from soils report:

Site Class	<b>Class = D</b>	Table 1: Site Parameters
------------	------------------	--------------------------

Value of Coefficients based on SPA periods:

Site Coefficient for Short Period	$F_a = 1.00$	Table 11.4-1
Site Coefficient for 1-sec. Period	$F_v = 1.50$	Table 11.4-2

Determine Maximum Considered Earthquake (MCE) Parameters:

MCE Spectral Response Acceleration, Short T	$S_{MS} = 1.493$ g	11.4.3
MCE Spectral Response Acceleration, 1-Sec. T	$S_{M1} = 0.831$ g	11.4.3

Determine Design Base Earthquake (DBE) parameters:

DBE Spectral Response Acceleration, Short T	$S_{DS} = 0.995$ g	11.4.4
DBE Spectral Response Acceleration, 1-Sec. T	$S_{D1} = 0.554$ g	11.4.4

**Building Response**

Input Building Properties:

Structure Type	All Other Structural Systems	
Response Modification Factor	$R = 6.5$	Table 12.2-1
System Overstrength Factor	$\Omega_0 = 3.0$	Table 12.2-1
Deflection Amplification Factor	$C_d = 4.0$	Table 12.2-1
Occupancy Category	<b>Category = II</b>	Table 1-1
Period Parameters	$C_t = 0.02$	Table 12.8-2
Period Parameters	$x = 0.75$	Table 12.8-2
Long Period Transition Period	$T_L = 8.00$ sec.	Figure 22-12
Effective Height	$h_n = 13.1$ ft.	12.8.2.1

Determine Period for Base Shear:

Seismic Design Category	<b>Cat. = D</b>	11.6 & Tables 11.6-1 & 11.6-2
Occupancy Importance Factor	$I = 1.0$	11.5.1 & Table 11.5-1
Coefficient for Upper Limit on Calculated Period	$C_U = 1.40$	Table 12.8-1
Approximate Fundamental Period	$T_a = 0.138$ sec.	12.8.2.1
Design Fundamental Period Limit	$T_{LIM} = 0.193$ sec.	12.8.2
Period $T_0$	$T_0 = 0.111$ sec.	11.4.4
Period $T_s$	$T_s = 0.557$ sec.	11.4.5
Design Period	$T = 0.557$ sec.	12.8.2

Determine Base Shear:

Seismic Response Coefficient $T_0 \leq T < T_s$	$C_s = N/A$	12.8-2
Seismic Response Coefficient $T \leq T_L$	$C_s = 0.153$	12.8-3
Seismic Response Coefficient $T > T_L$	$C_s = N/A$	12.8-4
Min. Allowable Seismic Response Coefficient	$C_{s, min\_Allowable} = 0.01$	12.8-5
	$C_{s, min\_Allowable} = N/A$	12.8-6
	$C_s = 0.153$	

Seismic Base Shear (Equivalent Lateral Force Procedure)	$C_s = 0.153 * W$	12.8-1
	$W = 96.10$ k	
	$V = 14.72$ k	

FIGURE 1.2.3.1

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 1.2.3.1B

Floor	$w_i$ (lb)	$w_i$ (k)	$h_i$ (ft)	$k$	$w_i h_i^k$ (k-ft)	$w_x h_x^k$ (k-ft)	$C_v$	$V$ (k)	$F_x$ (k)
1	74917	74.92	2.31	1	173.25	173.25	0.39	14.72	<b>5.73</b>
Roof	21179	21.18	12.84	1	272.02	272.02	0.61	14.72	<b>8.99</b>
$\Sigma w_i h_i^k$					<b>445.27 k-ft</b>				

TABLE 1.2.3.1C

Seismic Frame Story Shear						
Level	Story Shear	1 & 2	3	Story Shear	A	B & C
Roof	8.99	202.02	202.02	8.99	95.13	95.13
Level	Story Shear	f1	f2	Story Shear	a	b
1st Floor	5.73	140.64	116.68	5.73	66.23	54.95

**1.2.3.2 WIND**

Wind was calculated at a wind velocity of 85 miles per hour in 3 second gusts us solar decathlon building code seen in appendix C. Table 1.2.3.2 shows the summary of the wind loads on the lateral resistant system.

TABLE 1.2.3.2

Wind Frame Story Shear						
Level	Story Shear	1 & 2	3	Story Shear	A	B & C
Roof	7.2	161.80	161.80	3.9	41.27	49.68
Level	Story Shear	f1	f2	Story Shear	a	b
1st Floor	8.3	160.58	169.15	4.5	52.05	43.19

## **2. SPECIFIC DESIGN ITEMS**

### **2.1 SOLAR PANELS**

Manufacturer: tenK solar

product: wave system

Watts: 410w panels, 3 rows of 7 panels

Angle of panel: 26°

Angle of reflector: 45°

A PE stamp is necessary ensure the ballast weight applied to this solar system is adequate in weight. Appendix e and f provide testing data from tenK solar to facilitate the wind uplift. Appendix g shows provided drawings from tenK solar regarding dimensions and angles.

### **2.2 DROP CEILING**

A drop ceiling is incorporated with the design. The ceiling provides a significant danger to occupants during a seismic event and thus must be designed according to specific codes.

The ceiling is designed to comply with e580 for seismic design categories d,e, and f. All

Vertical support will be provided by 12 gauge hanger wire.

At locations requiring both lateral and vertical support, vertical support will be provided by two separate members. Typical vertical support (tension) will be provided by hanger wire just as in a plain vertical support. Additional vertical support (compression or resistance to uplift) will be provided by a 1/2" diameter electrical metal tubing compression post.

Lateral support will be provided by four separate 12 gauge hanger wires splayed 90° from each other (when measured in plan view) and each oriented at an angle not more than 45° upward (measured from the ceiling plane).

Hanger wires (vertical supports) must be positioned every 4'. Compression posts must be positioned every 12'. Splay wires (lateral supports) must be positioned every 12'.

Figure 7.0a shows the design of the support ceiling and figure 7.0b shows a cross-section of a lateral support.

## 2.3 - WIND

### 2.3.1 SUMMARY

Based upon competition rules and building codes, as well as local orange county building requirements, the design wind load used was 85 mph 3 second gusts. A summary of the calculated loads applied to the solar home is provided in table 1.2.3.2. Calculations to support this loading can be seen in section 2.3.2.

### 2.3.2 CALCULATIONS

Calculations performed on wind loading per ASCE 7-10.

HEIGHT ABOVE GROUND LEVEL	$K_z$ FOR EXPOSURE B	$q_z$ (PSF)
0 - 15	0.85	22.4
18	0.88	23.2

WALL PRESSURE COEFFICIENTS, $C_p$			
SURFACE	L/B	$C_p$	USE WITH
WINDWARD WALL	ALL VALUES	0.8	$Q_z$
LEEWARD WALL	0.6	-0.5	$Q_z$
	1.68	-0.37	$Q_z$
SIDE WALL	ALL VALUES	-0.7	$Q_z$

WINDWARD WALL PRESSURES				COMBINED WW + LW	
Z (FT)	$q_z GC_p$ (PSF)	$W/ + q_i GC_{pi}$ (PSF)	$W/ - q_i GC_{pi}$ (PSF)	47.25' WALL	28.25' WALL
0 - 15	15.22	11.1	19.4	25.1	22.5
18	15.76	11.6	19.9	25.6	23.0

ROOF PRESSURE				
HORIZONTAL DISTANCE	$C_p$	$q_H GC_p$ (PSF)	$W/ + q_i GC_{pi}$ (PSF)	$W/ - q_H GC_{pi}$ (PSF)
0 TO $h/2$ 0' TO 6.5'	-0.9	-26.7	-13.5	-21.9
$h/2$ TO $h$ 6.5' TO 13'	-0.9	-26.7	-13.5	-21.9
$h$ TO $2h$ 13' TO 26'	-0.5	-14.9	-5.6	-14
> $2h$ > 26'	-0.3	-8.9	-1.7	-10.1

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

AGAINST 28.25' AT 1ST FLOOR					AGAINST 47.25' AT 1ST FLOOR				
V	4.5 KIP				V	8.3 KIP			
FRAME	A <sub>T</sub> (ft <sup>2</sup> )	Length (ft)	DIRECT SHEAR (kip)	V (plf)	FRAME	A <sub>T</sub> (ft <sup>2</sup> )	Length (ft)	CT SHEAR	V (plf)
a	634	47.25	2.46	52.05	a	634	47.25		0.00
b	526	47.25	2.04	43.19	b	526	47.25		0.00
f1	634	<u>22.25</u>		0.00	f1	634	<u>22.25</u>	4.54	203.88
f2	526	22.25		0.00	f2	526	22.25	3.76	169.15
AGAINST 28.25' AT ROOF					AGAINST 47.25' AT ROOF				
V	3.9 KIP				V	7.2 KIP			
FRAME	A <sub>T</sub> (ft <sup>2</sup> )	Length (ft)	DIRECT SHEAR (kip)	V (plf)	FRAME	A <sub>T</sub> (ft <sup>2</sup> )	Length (ft)	CT SHEAR	V (plf)
1 & 2	579	22.25		0.00	1 & 2	579	22.25	3.60	161.80
3	579	22.25		0.00	3	579	22.25	3.60	161.80
A	579	47.25	1.95	41.27	A	579	47.25		0.00
B & C	579	39.25	1.95	49.68	B & C	579	39.25		0.00

## 2.4- STRUCTURALLY INSULATED PANELS (SIPS)

### 2.4.1 SPECIFICATIONS

Energy panel systems will engineer and design the wall panel system. See appendix A for the product specs, appendix D for the complete design, and appendix D for the calculations.

## 2.5 – LATERAL SEISMIC DESIGN CHECK

### 2.5.1 SIPS

See appendix D for energy panel solutions lateral seismic design checks.

### 2.5.2 DIAPHRAM

The diaphragm that is being used is a wood product manufactured by Advantech. The product we are using is a 23/32” tongue and groove, weather resistant and stiff material.

## 2.6 – STEEL FLOOR JOIST SYSTEM

### 2.6.1 MEMBER SPECIFICATION

Steel will be purchased from NCI building systems. 3 different member profiles will be used, a 10x2.5c12 (joist), 12x3.5c12 (roof beam), and a 10.25x2.5ch12 (channel). The joist will be used in both single and built-up sections; the built up section would consist of two joists back-to-back. The roof beam will be only used as a built-up section placed back-to-back.

### 2.6.2 LOAD SUMMARY

See load summary in section 2.6.8.1 in table 2.6.8.1. Loads were assumed to be the same as at competition to allow for storage in sections during shipment. These loads were also used for competition checks.

### 2.6.3 DEFLECTION

The deflection was designed to stay under an 1/480 safety factor. This was to reduce the probability of the concrete floor supported by the steel member's tendency to crack during loading at competition. See section 2.6.8.2 for deflection checks. During competition, channel sections have a smaller unbraced length then during craning, and as each member passes during craning it was assumed that it would pass during competition loading and support.

### 2.6.4 STRENGTH

Strength was checked with a phi factor of 0.9 based on AISI code standards. The members were checked in a competition loading to ensure that failure would not occur. See section 2.6.8.3 for strength checks. During competition, channel sections have a smaller unbraced length then during craning and as each member passes during craning so it was assumed that it would pass during competition loading and support.

### 2.6.5 DESIGN

The design shown in figure 2.6.5 consists of 4 main sections that contain both the track and studs. Each section has a channel beam that receives the joist in to them and a screw is placed in the top and bottom of the member. The inside pieces are either composite joists or single joists. The purple color denotes a track steel member. The red denotes a single joist while the green denotes a composite joist.

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

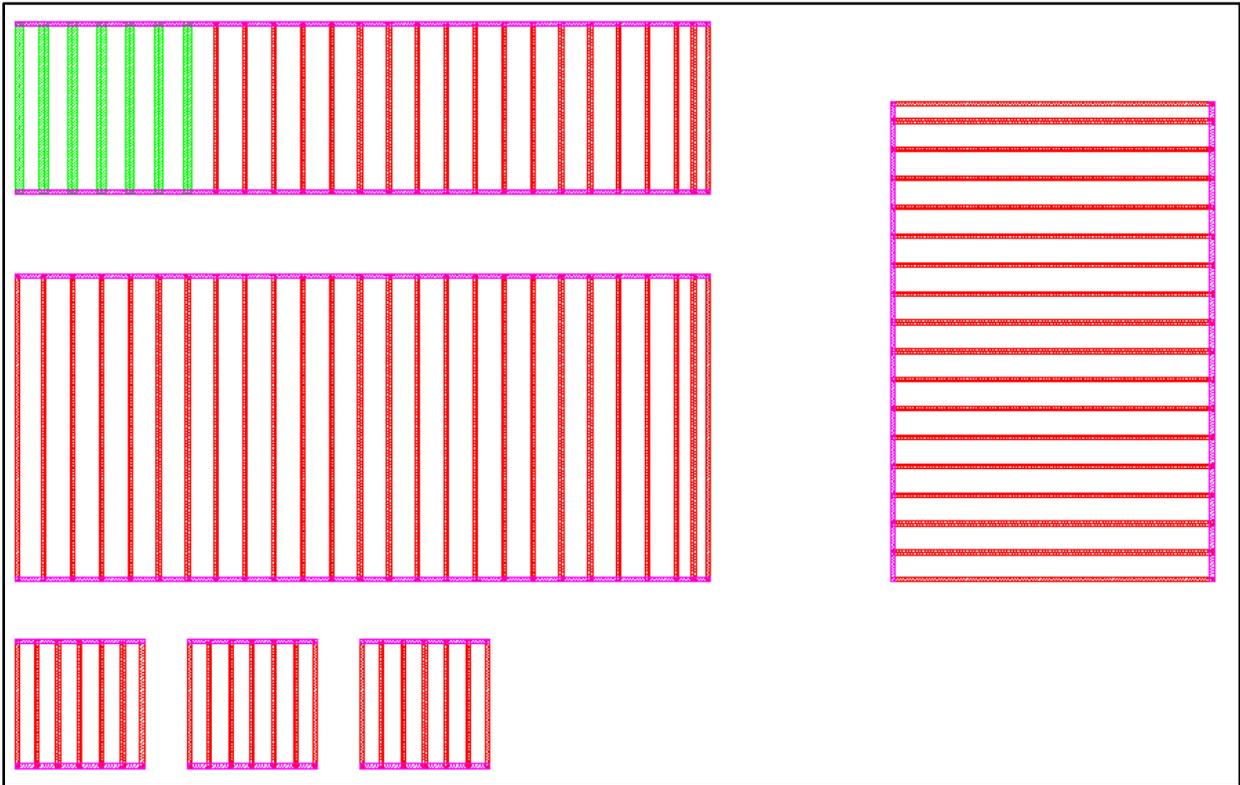


FIGURE 2.6.5

### 2.6.6 CONNECTION DETAIL

Figure 2.6.6a illustrates the connection of two joists to create a built-up section. Figure 2.6.6b illustrates the bolting of the channel members when bringing the sections together. The built-up joist are held together by two 12x 1 ¼ self-tapping screws spaced at 1' o.c., and 6" from the end. This calculation and a technical note used in calculation can be seen in figure 2.6.6c. Where the joist come together, ¾" 12 gage bolts are used to help line up the sections as well as hold the pieces together. Out of safety, the connection between channels are spaced at the upper limit for built-up sections, 1/6. For the 33.25 members this spacing is 5'4" o.c., for the 22.25' long member this spacing is 3'8" o.c., with 8 inches from the end of the members.

The Advantech sheets will be anchored to the steel with self-tapping 12 gage 1 ½" screws designed to go through steel. The sheets will be offset from row to row and the screws will be placed 6" apart around the edges of the diaphragm and 12" apart on the intermediate joists. Figure 2.6.6d shows the typical blocking diagram of the Advantech board and the spacing on the screws on specific beams.

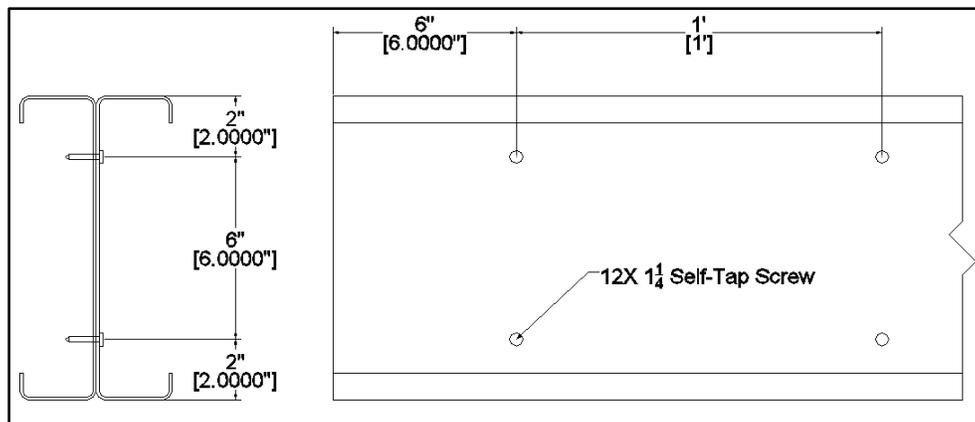


FIGURE 2.6.6A

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

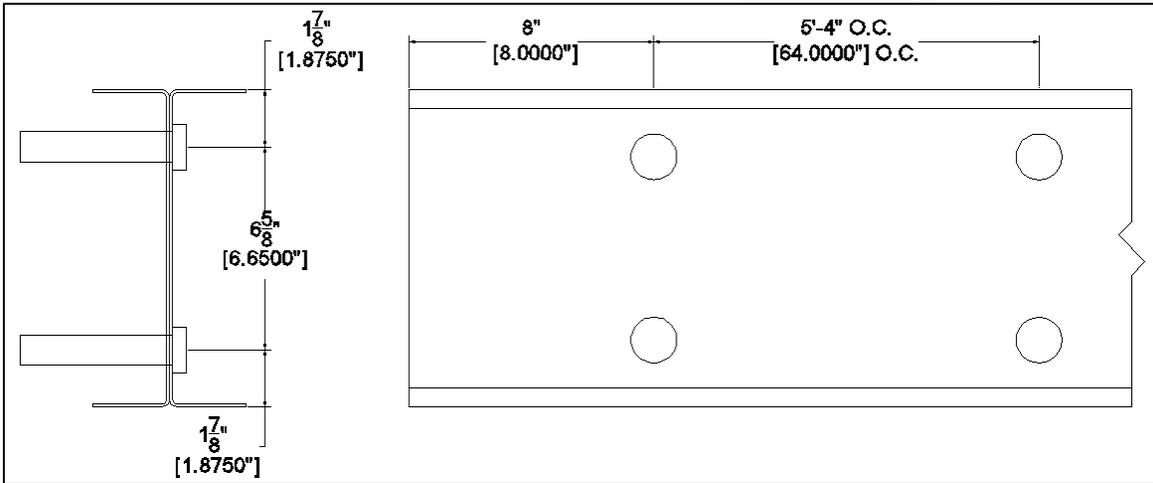
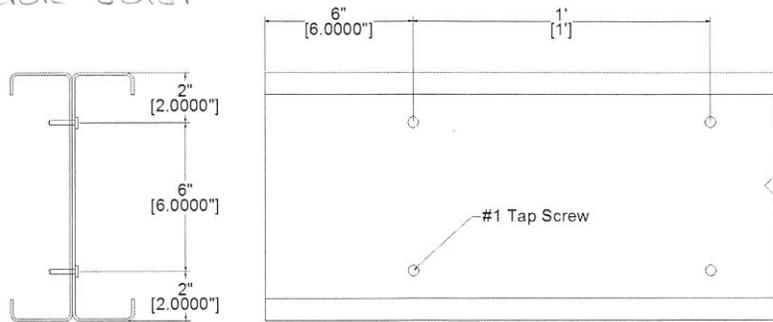


FIGURE 2.6.6B

Built-Up Joist Calculations

INTERIOR JOIST



$$S_{max} = \frac{L}{6} \leq \frac{2gT_s}{mcb} \quad (Eq. D1.1-1)$$

$L = 8' = 96"$   
 $g = 6"$   
 $m = 0.5702" \text{ (CFS 7.0)}$   
 $q = 3 \times LC$

LOADS (16" O.C JOISTS)

$DL = 38.0 \text{ PSF} \times \frac{16"}{12} = 50.7 \text{ PLF}$   
 $LL = 100 \text{ PSF} \times \frac{16"}{12} = 133.3 \text{ PLF}$

LOAD COMBINATION

$$1.2 DL + 1.6 L = 1.2(50.7 \text{ PLF}) + 1.6(133.3) = 275 \text{ PLF}$$

$$q_b = 3 \times 275 \text{ PLF} = 825 \text{ PLF} = 68.75 \text{ lb/in} = 0.069 \text{ 1/in}$$

T<sub>s</sub>

PULL-OUT =  $0.85 t_c d F_{u2}$   
 $= 0.85 (0.105") (0.156") (55 \text{ ksi})$   
 $= 0.766 \text{ kips}$

PULL-OVER =  $1.5 t_w d_w F_{u1}$   
 $= 1.5 (0.105") (\frac{7}{16}) (55 \text{ ksi})$   
 $= 3.79 \text{ kips}$

SCREW TENSILE STRENGTH

TBL 2 (TECH NOTE F701-12)  
 #12 SCREW  
 $P_{TS} = 3520 \text{ lb (nominal)}$   $FS = 30$

DESIGN  $T_S = \frac{3520 \text{ lb}}{3.0} = 1173 \text{ lb/screw}$   
 $1173 \text{ lb} > 766 \text{ lb}$  **OK**

CHECK

$$\frac{96"}{6} = 16" \leq \frac{2(6")(0.766 \text{ k})}{(0.5702")(0.069 \text{ 1/in})} = 237"$$

\* 16" maximum

\* USE 12" FOR CONSTRUCTABILITY

FIGURE 2.6.6C

 <p><b>CFSEI</b> COLD-FORMED STEEL ENGINEERS INSTITUTE</p>	<p><b>TECHNICAL NOTE</b> <span style="float: right;">\$5.00</span>  <i>On Cold-Formed Steel Construction</i></p> <p>Cold-Formed Steel Engineers Institute • Washington, DC • www.cfsei.org • 866-465-4732</p>
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## Evaluation of Screw Strength

**Summary:** The design provisions for screw connections contained in the *North American Specification for the Design of Cold-Formed Steel Structural Members*, AISI S100-07 with 2010 Addendum, contains specific limit states equations that pertain to the design strength of the connecting elements, i.e. sheets. In addition to sheet related design limit states, AISI S100 also provides design provisions for the screw when subjected to either pure shear or pure tension. However, the screw design provisions require that the screw capacity be defined by tests. In the absence of test data, the design engineer is at a loss for evaluating the strength of the screw. This Tech Note provides design guidance for the evaluation of the screw when subjected to pure shear, pure tension and combined shear and tension.

**Disclaimer:** Designs cited herein are not intended to preclude the use of other materials, assemblies, structures or designs when these other designs and materials demonstrate equivalent performance for the intended use; CFSEI documents are not intended to exclude the use and implementation of any other design or construction technique.

### INTRODUCTION

The design provisions for screw connections, Section E4, in the *North American Specification for the Design of Cold-Formed Steel Structural Members*, AISI S100-07 with 2010 Addendum, contains specific design equations for the following design limit states:

- Shear strength of the sheet parallel to the direction of the applied load (Section E4.3.2)
- Shear strength of the sheet resulting from either bearing or tilting of the screw on the sheet (Section E4.3.1)
- Tension pull-out of the screw from the sheet not in contact with the screw head (Section E4.4.1)
- Tension pull-over of the sheet in contact with the screw head (Section E4.4.2)
- Combined shear and tension pull-over of the sheet in contact with the screw head (Section E4.5)
- Combined shear and tension pull-out of the sheet not in contact with the screw head (Section E4.5 of AISI S100-12).

The above limit states pertain to the design strength of the connecting elements. In addition to the above sheet related design limit states, AISI S100 also provides design provisions for the screw when subjected to either pure shear or pure tension. However the screw design provisions require that the screw capacity be defined by tests. AISI S904-08 *Standard Test Method for Determining the Tensile and Shear Strength of Screws* is the recognized test protocol for determining the nominal shear and tension capacity for a screw.

In the absence of test data, the design engineer is at a loss for evaluating the strength of the screw. This Tech Note provides design guidance for the evaluation of the screw when subjected to pure shear, pure tension and combined shear and tension. The design guidance is based on the evaluation of published screw shear and tension nominal strength values as summarized in Table 2. The outside diameter for the array of screws is listed in Tables 1a and 1b.

### PURE SHEAR STRENGTH

Manufacturer's data for the pure shear strength for the array of screw diameters reveals that an average nominal shear strength,  $P_{ss}$ , may be assumed as summarized by Table 2. The safety factor and phi factor are stipulated by Section E4.3.3 of AISI S100 as 3.0 and 0.5.

### PURE TENSION STRENGTH

Manufacturer's published data for the pure tension strength for the array of screws reveals that an average nominal tension strength may be taken as summarized by Table 2. The safety factor and phi factor are stipulated by Section E4.4.3 of AISI S100 as 3.0 and 0.5.

### COMBINED SHEAR AND TENSION STRENGTH

The interaction of shear and tension strength has not been extensively studied and a design relationship does not currently exist in AISI S100. In the absence of a definite relationship that defines the interaction of shear and tension stresses on a screw the following linear equation is suggested:

$$Q/P_{ss} + T/P_{ts} \leq 1.0$$

Cold-

**TECH NOTE F701-12**

**July 2012**

FIGURE 2.6.6C

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

For Allowable Strength Design apply a safety factor of 3.0:

$$Q/P_{ss} + T/P_{ts} \leq 1/3$$

For Load and Resistance Factor Design apply a resistance factor of 0.5:

$$Q/P_{ss} + T/P_{ts} \leq 0.5$$

Where Q = required shear strength per screw and T = required tension strength per screw.

**TEST VS. COMPUTED CONNECTION STRENGTH**

Section E4 of AISI S100 permits the use of tested values for the strength of a screw connection. Tested values will provide a more accurate assessment of the performance of a screw connection when used as stipulated by the manufacturer's design information. Tested values may be provided by the individual manufacturer or listed by an evaluation service. When tested values are used the safety factor and resistance factor must be determined in accordance with Chapter F of AISI S100. For guidance on the application of Chapter F refer to CFSEI Tech Note G100-07, Using Chapter F of the North American Specification for the Design of Cold-Formed Steel Structural Members.

**MANUFACTURER'S PUBLISHED DATA**

The following is a list of the ICC-ES Reports and manufacturer's published product data pertaining to screws or screw connections:

Product data	Simpson Strong-Tie Company, Inc.
ESR-5280	John Wagner Assoc Grabber Division and Hitachi Koki USA LTD
ESR-1408	Primesource Building Products, Inc.
ESR-1730	Global Fasteners LTD and Hilti Corp
ESR-1976	ITW Buildex
ESR-2196	Hilti, Inc
ESR-3231	Porteous Fastener

**DESIGN APPLICATION**

The suggested design values,  $P_{ss}$  and  $P_{ts}$ , are average values as presented by Table 2. The design engineer may opt to choose different, i.e. higher values, or refer to a specific manufacturer's product data or Evaluation Report.

To eliminate potential confusion regarding the required  $P_{ss}$  and  $P_{ts}$  values, as well as the required corresponding

safety or phi factors it is recommended that the design documents define the available strength for the screw that was used in the design. The available strength should be given for each screw size (diameter) and each steel thickness.

For example:

54 mils; No. 10 screw; allowable shear strength 500 lbs.; allowable tension strength 750 lbs.

68 mils; No. 14 screw; allowable shear strength 750 lbs.; allowable tension strength 1100 lbs.

**TABLE 1a Nominal Body Diameter for Screws**

NUMBER DESIGNATION	NOMINAL DIAMETER FOR SCREWS	
	IN.	MM
0	0.060	1.52
1	0.073	1.85
2	0.086	2.18
3	0.099	2.51
4	0.112	2.84
5	0.125	3.18
6	0.138	3.51
7	0.151	3.84
8	0.164	4.17
10	0.190	4.83
12	0.216	5.49
1/4"	0.250	6.35

**TABLE 1b Hex Head Diameter**

Number Designation	Head Diameter (in.)
6	0.272
8	0.272
10	0.340
12	0.340
1/4"	0.409

FIGURE 2.6.6C

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**TABLE 2 Published Data**

The following data was derived from the listed ICC-ES reports and manufacturer's published data.

Screw	Diameter	$P_{ts}$	$P_{ss}$		
8	0.164	1000	1170		
		2179	1392		
		1457	1326		
		586	1007		
		1810	1495		
		<u>Average</u>	<u>1406</u>	<u>1278</u>	
		Std. Dev.	633	192	
		COV	0.450	0.150	
		10	0.190	2170	1645
				1370	1215
1390	1845				
1158	1484				
1857	1883				
2645	1718				
1783	1222				
2215	1710				
2120	1885				
2885	1835				
<u>Average</u>	<u>1959</u>	<u>1644</u>			
Std. Dev.	560	256			
COV	0.286	0.156			
12	0.216	2325	1880		
		3900	2285		
		2603	2077		
		3602	2553		
		3551	2171		
		4750	2654		
		3380	2535		
		4045	2485		
		<u>Average</u>	<u>3520</u>	<u>2330</u>	
		Std. Dev.	777	271	
COV	0.221	0.116			
1/4"	0.25	4580	2440		
		3201	2772		
		3852	3309		
		4816	2970		
		5767	3925		
		4419	2871		
		<u>Average</u>	<u>4439</u>	<u>3048</u>	
		Std. Dev.	872	514	
		COV	0.196	0.169	

FIGURE 2.6.6C

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

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**References**

1. AISI S100-07, *North American Specification for the Design of Cold-Formed Steel Structural Members*, American Iron and Steel Institute, Washington, D.C., 2007
2. AISI S100-12, *North American Specification for the Design of Cold-Formed Steel Structural Members*, American Iron and Steel Institute, Washington, D.C., 2012 (to be published)
3. AISI S904-08, *Standard Test Method for Determining the Tensile and Shear Strength of Screws*, American Iron and Steel Institute, Washington, D.C., 2008

*Primary author of original Tech Note:*  
Roger LaBoube, Ph.D., P.E., Wei-Wen Yu Center for Cold-Formed Steel Structures

*Technical Review:*  
Randy Daudet, P.E., S.E. Simpson Strong-Tie, Co.  
Maribeth Rizzuto, CFSEI

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**FIGURE 2.6.6C**

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

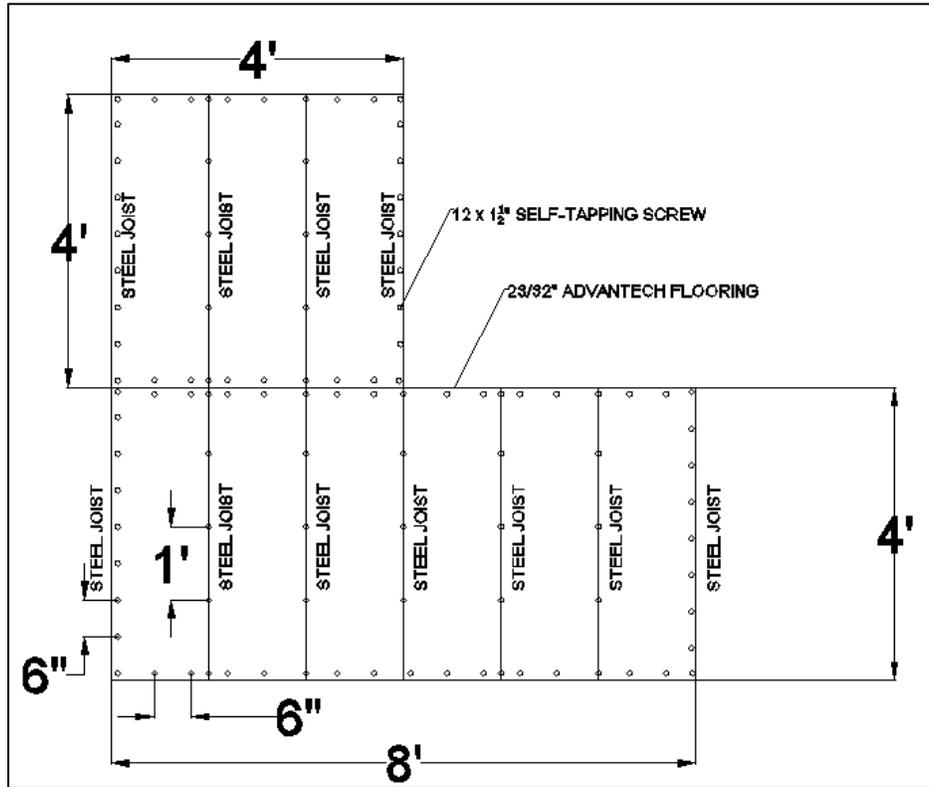


FIGURE 2.6.6D

**2.6.7 CALCULATIONS AND CODE**

Wind Frame Story Shear						
Level	Story Shear	1 & 2	3	Story Shear	A	B & C
Roof	7.2	161.80	161.80	3.9	41.27	49.68
Level	Story Shear	f1	f2	Story Shear	a	b
1st Floor	8.3	203.88	169.15	4.5	52.05	43.19

Wind Load at Beams	
Beams	Shear (plf)
A26, C20	93.32
B27, C3	92.87
A1, B1	365.68
B7	161.80
A27, B28	49.68
C2	330.95

Seismic Frame Story Shear						
Level	Story Shear	1 & 2	3	Story Shear	A	B & C
Roof	8.99	202.02	202.02	8.99	95.13	95.13
Level	Story Shear	f1	f2	Story Shear	a	b
1st Floor	5.73	140.64	116.68	5.73	66.23	54.95

Wind Load at Beams	
Beams	Shear (plf)
A26, C20	161.36
B27, C3	150.08
A1, B1	342.66
B7	202.02
A27, B28	95.13
C2	318.70

SHEAR WALLS 1 & 2 ARE THE WEST SIP WALLS

SHEAR WALL 3 IS THE EAST SIP WAL

SHEAR WALL A IS THE SOUTH SIP WALL

SHEAR WALL B IS THE NORTH SIP WALL

SHEAR WALL F1 IS THE STEEL BEAMS ALONG THE WEST PERIMETER

SHEAR WALL F2 IS THE STEAL BEAMS RUNNING ALONG THE EAST PERIMETER

SHEAR WALL A IS THE STEEL BEAMS RUNNING ALONG THE SOUTH PERIMETER

SHEAR WALL B IS THE STEAL BEAMS RUNNING ALONG THE NORTH PERIMETER

- WIND CONTROLS AS COMBINED SHEAR IS THE HIGHEST.

-BEAM C2 CONTROL CONTROLS WITHIN WIND

- TABLE D2-1

- UNBLOCKED

- STRUCTURAL L MEMBRANE MATERIAL

- ALL OTHER CONFIGURATIONS [LOADS APPLIED PARALLEL]

- 7/16" THICKNESS = 565 PLF

- FOR WIND,  $\Phi = 0.65$  [D2.2 WOOD DIAPHRAMS]

$565 \text{ PSF} * 0.65 = 367.25 \text{ PLF} > 365.68 \text{ PLF}$  OK

-OUR MEMBER THICKNESS IS 23/32" > 7/16 OK

- DIAPHRAM ASPECT RATIO = 2.12:1 < 3:1 OK

- USE NO. 10 SCREWS (MINIMUM) [FRAMING MEMBERS 97 MILS]

- SCREWS SPACED AT 6" MAXIMUM AROUND ALL SUPPORTED EDGES

- SCREWS SPACED 12" MAXIMUM AT INTERMEDIATE SUPPORTS ALONG FRAMING

SEE FIGURE 2.3.2.1

**D. DIAPHRAGMS**

*In the United States and Mexico:* The design of *diaphragms* that resist wind, seismic or other in-plane lateral loads shall comply with the requirements of this section.

**D1 General**

The *diaphragm* sheathing shall consist of sheet steel, concrete, or wood structural panel sheathing or other *approved* materials.

**D1.1 Seismic Requirements for Diaphragms**

Where permitted by the *applicable building code*, when the seismic response modification coefficient, *R*, (for steel systems) is taken equal to or less than 3, the design shall comply with these provisions exclusive of those in Section D3.

Where the seismic response modification coefficient, *R*, is taken greater than 3, the design shall comply with these provisions inclusive of those in Section D3.

**D2 Diaphragm Design**

**D2.1 Available Shear Strength**

The *available strength* of *diaphragms* shall be determined in accordance with Section B2. Alternatively for *diaphragms* sheathed with wood structural panels the *available strength* is permitted to be determined by the Section D2.2.

**D2.1.1 Design Deflection**

The deflection of a blocked wood structural panel *diaphragm* is permitted to be calculated by the use of the following formulas:

$$\delta = \frac{5vL^3}{8E_s A_c b} + \omega_1 \omega_2 \frac{vL}{\rho G t_{\text{sheathing}}} + \omega_1^{5/4} \omega_2 \left( \frac{v}{2\beta} \right)^2 + \frac{\sum_{j=1}^n \Delta_{ci} X_i}{2b} \quad (\text{Eq. D2.1-1})$$

$$\text{For SI: } \delta = \frac{0.052vL^3}{E_s A_c b} + \omega_1 \omega_2 \frac{vL}{\rho G t_{\text{sheathing}}} + \omega_1^{5/4} \omega_2 \left( \frac{v}{0.00579\beta} \right)^2 + \frac{\sum_{j=1}^n \Delta_{ci} X_i}{2b} \quad (\text{Eq. D2.1-2})$$

where:

- $A_c$  = Gross cross-sectional area of *chord* member, in square inches (mm<sup>2</sup>)
- $b$  = *Diaphragm* depth parallel to direction of load, in feet (mm)
- $E_s$  = Modulus of elasticity of steel = 29,500,000 psi (203,000 MPa)
- $G$  = Shear modulus of sheathing material, in pounds per square inch (MPa)
- $L$  = *Diaphragm* length perpendicular to direction of load, in feet (mm)
- $n$  = Number of *chord* splices in the *diaphragm* (considering both *diaphragm chords*)
- $s$  = Maximum fastener spacing at panel edges, in inches (mm)
- $t_{\text{sheathing}}$  = Nominal panel thickness, in inches (mm)
- $t_{\text{stud}}$  = Nominal framing thickness, in inches (mm)
- $v$  = Shear demand ( $V/2b$ ), in pounds per linear foot (N/mm)

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

- V = Total lateral load applied to the *diaphragm*, in pounds (N)
- $X_i$  = Distance between the "ith" *chord*-splice and the nearest support (braced wall line), in feet (mm)
- $\alpha$  = Ratio of the average load per fastener based on a non-uniform fastener pattern to the average load per fastener based on a uniform fastener pattern (= 1 for a uniformly fastened *diaphragm*)
- $\beta$  = 810 for plywood and 660 for OSB
- $\delta$  = Calculated deflection, in inches (mm)
- $\Delta_{ci}$  = Deformation value associated with "ith" *chord* splice, in inches (mm)
- $\rho$  = 1.85 for plywood and 1.05 for OSB
- $\omega_1$  =  $s/6$  (for  $s$  in inches)  
 =  $s/152.4$  (for  $s$  in mm)
- $\omega_2$  =  $0.033/t_{stud}$  (for  $t_{stud}$  in inches)  
 =  $0.838/t_{stud}$  (for  $t_{stud}$  in mm)

For unblocked *diaphragms*,  $\delta$  shall be multiplied by 2.50.

**D2.2 Wood Diaphragms**

The *nominal strength* of wood structural panel *diaphragms*, used to determine the *available strength*, is permitted to be taken from Table D2-1 subject to the requirements of this section. Sheathing material in wood *diaphragms* shall conform to DOC PS-1 and PS-2. Wood structural panel *diaphragms* shall be designed as either blocked or unblocked.

Where *allowable strength design (ASD)* is used, the *allowable strength* shall be determined by dividing the *nominal strength*, shown in Table D2-1, by a *safety factor* ( $\Omega$ ) of 2.5 for assemblies resisting seismic loads and 2.0 for assemblies resisting wind or other in-plane lateral loads.

Where *load and resistance factor design (LRFD)* is used, the *design strength* shall be determined by multiplying the *nominal strength*, shown in Table D2-1, by a *resistance factor* ( $\phi$ ) of 0.60 for assemblies resisting seismic loads and 0.65 for assemblies resisting wind or other in-plane lateral loads.

**Table D2-1**  
**United States and Mexico**  
**Nominal Shear Strength ( $R_n$ ) for Diaphragms with Wood Sheathing<sup>1, 4</sup>**  
**(Pounds Per Foot)**

Membrane Material	Screw Size	Thickness (in)	Blocked				Unblocked					
			Screw spacing at diaphragm boundary edges and at all continuous panel edges				Screws spaced maximum of 6" on all supported edges					
			6	4	2.5	2	Load perpendicular to unblocked edges and continuous panel joints			All other configurations (parallel)		
			Screw spacing at all other panel edges									
6	6	4	3	0.6	0.65							
Structural I	See note 2	3/8	768	1022	1660	2045	411	685	445	306	510	331
		7/16	768	1127	1800	2255	453	755	490	339	565	367
		15/32	925	1232	1970	2465	495	825	536	369	615	399
C-D, C-C and other graded wood structural panels <sup>3</sup>	See note 2	3/8	690	920	1470	1840	615			460		
		7/16	760	1015	1620	2030	680			505		
		15/32	832	1110	1770	2215	740			555		

- 1 For SI: 1" = 25.4 mm, 1 foot = 0.305 m, 1 lb = 4.45 N
- 2 No. 8 screws (minimum) shall be used when framing members have a *designation thickness* of 54 mils or less and No. 10 screws (minimum) shall be used when framing members have a *designation thickness* greater than 54 mils.
- 3 Wood structural panels shall conform to DOC PS-1 and PS-2
- 4 For wood structural panel sheathed diaphragms, tabulated  $R_n$  values shall be applicable for short-term load duration (wind or seismic loads). For other in-plane lateral loads of normal or permanent load duration as defined by the AF&PA NDS, the values in the table above for wood structural panel sheathed diaphragms shall be multiplied by 0.75 (normal) or 0.67 (permanent).

**D2.2.1 Diaphragm Aspect Ratio**

The aspect ratio (length/ width) of wood *diaphragms* shall not exceed 4:1 for blocked *diaphragms* and 3:1 for unblocked *diaphragms*. ✓

**D2.2.3 Framing**

The minimum *designation thickness* of framing members shall be 33.

**D2.2.4 Attachment of the Sheathing to Framing**

Panel edges of sheathing shall be attached to framing as indicated in Table D2-1 with minimum #8 countersunk tapping screws in accordance with ASTM C1513. Screws in the field of the panel shall be attached to intermediate supports at a maximum 12-inch (305 mm) spacing along the framing.

**D2.2.5 Blocking**

Where *diaphragms* are designed as blocked, all panel edges shall be attached to framing members or *blocking*. Where used as *blocking*, flat strapping shall be a minimum

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thickness of 33-mils with a minimum width of 1½ inches (38.1 mm) and shall be either installed on top of or below sheathing. For other than steel sheathing, the screws shall be installed through the sheathing to the *blocking*.

**D3 Special Seismic Requirements**

**D3.1 General**

Where the seismic response modification coefficient, R, used to determine the lateral forces is taken greater than 3, the requirements of this section shall apply in addition to the requirements of Sections D1 and D2.

*Diaphragms* shall be defined as flexible or rigid, in accordance with the *applicable building code*.

**D3.2 Wood Diaphragms**

The aspect ratio (length/width) of a *diaphragm* sheathed with wood structural sheathing shall be limited to 4:1 where all edges of the wood structural panel sheathing are attached to framing members or to intermittent *blocking*. Where there is no intermittent *blocking* the aspect ratio shall be limited to 3:1. Wood structural panel sheathing shall be arranged so that the minimum panel width is not less than 24 inches (610 mm) unless further limited elsewhere in these provisions.

Open front structures with rigid wood *diaphragms* resulting in torsional force distribution shall be limited by the following:

1. The length of the *diaphragm* normal to the open side shall not exceed 25 feet (7.62 m), and the aspect ratio (l/w) shall be less than 1:1 for one-story structures or 2:3 for structures over one story in height, where the length dimension of the *diaphragm* is parallel to the opening.
2. Where calculations show that *diaphragm* deflections can be tolerated, the length normal to the opening shall be permitted to be increased to an aspect ratio (l/w) not greater than 3:2.

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## 2.6.8 - STEEL CHECKS FOR CRANING

### 2.6.8.1 LOADS

TABLE 2.6.8.1

Crane Loads Summary									
Bedroom									
Dead Load			Live Load			Joists			
Section	Peak Load (plf)	F-Peak Load (plf)	Section	Peak Load (plf)	F-Peak Load (plf)	Load Type	Peak Load (plf)	F-Peak Load (plf)	Units
Roof: North	76.41	91.69	Roof: North	65.56	104.90	Dead Load	50.58	60.69	plf
Roof: South	76.41	91.69	Roof: South	65.56	104.90	Live Load	66.67	106.7	plf
Roof: East	129.21	155.05	Roof: East	237.50	380.00				
Roof: West	119.19	143.03	Roof: West	222.50	356.00				
Wall: North	231.98	278.38							
Wall: South	144.37	173.24							
Wall: East	142.23	170.67							
Wall: West	9.75	11.70							
Living Room									
Dead Load			Live Load			Joists			
Section	Peak Load (plf)	F-Peak Load (plf)	Section	Peak Load (plf)	F-Peak Load (plf)	Load Type	Peak Load (plf)	F-Peak Load (plf)	Units
Roof: North	84.93	101.91	Roof: North	111.02	177.63	Dead Load	50.58	60.69	plf
Roof: South	98.73	118.47	Roof: South	111.02	177.63	Live Load	66.67	106.67	plf
Roof: East	25.62	30.74	Roof: East	78.23	114.00				
Roof: West	25.62	30.74	Roof: West	86.25	114.00				
Wall: North	88.16	105.79							
Wall: South	144.22	173.07							
Wall: East	9.75	11.70							
Wall: West	89.00	106.80							
Bathroom									
Dead Load			Live Load			Joists			
Section	Peak Load (plf)	F-Peak Load (plf)	Section	Peak Load (plf)	F-Peak Load (plf)	Load Type	Peak Load (plf)	F-Peak Load (plf)	Units
Roof: North	48.75	58.51	Roof: North	92.02	128.00	Dead Load	50.58	60.69	plf
Roof: South	48.75	58.51	Roof: South	80.00	128.00	Live Load	133.33	213.33	plf
Wall: North	100.45	120.54							
Wall: South	61.00	73.20							
Wall: East	9.75	11.70							
Wall: West (SIP)	9.13	10.95							

JOB \_\_\_\_\_  
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**2.6.8.2 DEFLECTION**

Table 2.6.8.2a shows the properties of the steel members as well as the safety factor check table to ensure members passed the deflection requirements. The members were designed for a deflection of less than or equal to  $l/480$  to try and prevent the concrete from cracking. Table 2.6.8.2b calculates the deflection in the control members in the section and checks against the design standard. Figure 2.6.8.2 shows a sample calculation of a deflection check.

TABLE 2.6.8.2A

STEEL MEMBER PROPERTIES - CRANE DEFLECTION											
Properties				Capacity			Check				
Name	Shape	Fy (ksi)	Se (in <sup>3</sup> )	E (psi)	I (in <sup>4</sup> )	(plf)	Length (ft)	MIN L/240	MIN L/360	MIN L/480	NO GOOD
Joists (Single)	1000S250-97	50.00	4.181	29500000.00	21.827	5.360	7.616	0.381	0.254	0.190	
Track	1000T250-97	50.00	7.347	29500000.00	40.00	10.537	13.866	0.693	0.462	0.347	
Double Joist (F2F)	1000S250-97 BB	50.00	8.427	29500000.00	42.706	10.715	14.616	0.731	0.487	0.365	
							** 22.250	0.278	0.278	0.371	
							** 33.250	0.416	0.416	0.554	

\*\*4 crane supports spaced evenly across girder

Crane Situation - Deflectoin Checks

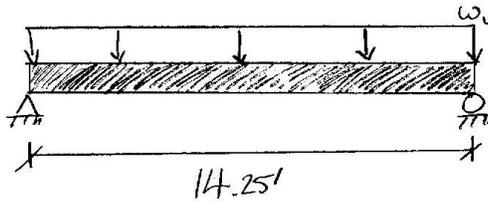
Joists	Girder N (Dbl Joist)	Girder S (Dbl Joist)	Girder E (Track)	Girder W (Track)
Bedroom	Length (ft) 15.00 Unbraced Length (ft) 15.00 Tributary Area (in) 8.00 ASTM Table 3-23. 19.22 Floor wd (plf) 50.58 Floor wl (plf) 142.23 Wall wd <sub>s</sub> (plf) 231.98 Wall wd <sub>w</sub> (plf) 76.41 Roof wd (plf) 129.21 w total (plf) 55.94 w total (lbs) 361.91 Defl. (in) 0.0990	Length (ft) 15.00 Unbraced Length (ft) 15.00 Tributary Area (in) 8.00 ASTM Table 3-23. 19.22 Floor wd (plf) 50.58 Floor wl (plf) 144.37 Wall wd <sub>s</sub> (plf) 142.23 Wall wd <sub>w</sub> (plf) 129.21 Roof wd (plf) 324.15 w total (plf) 94.82 p total (lbs) 0.2931 Defl. (in) 0.3343	Length (ft) 22.25 Unbraced Length (ft) 7.42 Tributary Area (in) 16.00 ASTM Table 3-23. 50.58 Floor wd (plf) 142.23 Floor wl (plf) 144.37 Wall wd <sub>s</sub> (plf) 129.21 Roof wd (plf) 332.55 w total (plf) 192.49 p total (lbs) 0.0192 Defl. (in) 0.0186	Length (ft) 22.25 Unbraced Length (ft) 7.42 Tributary Area (in) 16.00 ASTM Table 3-23. 50.58 Floor wd (plf) 142.23 Floor wl (plf) 144.37 Wall wd <sub>s</sub> (plf) 129.21 Roof wd (plf) 332.55 w total (plf) 192.49 p total (lbs) 0.0192 Defl. (in) 0.0186
Living Room	Length (ft) 14.25 Unbraced Length (ft) 14.25 Tributary Area (in) 16.00 ASTM Table 3-23. 19.22 Floor wd (plf) 50.58 Floor wl (plf) 144.22 Wall wd <sub>s</sub> (plf) 89.00 Wall wd <sub>w</sub> (plf) 84.93 Roof wd (plf) 55.94 w total (plf) 323.93 p total (lbs) 0.0806 Defl. (in) 0.0806	Length (ft) 32.25 Unbraced Length (ft) 10.75 Tributary Area (in) 16.00 ASTM Table 3-23. 50.58 Floor wd (plf) 88.16 Floor wl (plf) 89.00 Wall wd <sub>s</sub> (plf) 84.93 Wall wd <sub>w</sub> (plf) 234.20 Roof wd (plf) 118.67 w total (plf) 0.0596 p total (lbs) 0.0774 Defl. (in) 0.0774	Length (ft) 14.25 Unbraced Length (ft) 8.00 Tributary Area (in) 16.00 ASTM Table 3-23. 19.22 Floor wd (plf) 50.58 Floor wl (plf) 9.75 Wall wd <sub>s</sub> (plf) 144.22 Wall wd <sub>w</sub> (plf) 25.62 Roof wd (plf) 60.87 w total (plf) 96.15 p total (lbs) 0.0877 Defl. (in) 0.1295	Length (ft) 14.25 Unbraced Length (ft) 8.00 Tributary Area (in) 16.00 ASTM Table 3-23. 19.22 Floor wd (plf) 50.58 Floor wl (plf) 9.75 Wall wd <sub>s</sub> (plf) 144.22 Wall wd <sub>w</sub> (plf) 25.62 Roof wd (plf) 60.87 w total (plf) 96.15 p total (lbs) 0.0877 Defl. (in) 0.1295
Bathroom	Length (ft) 8.00 Unbraced Length (ft) 8.00 Tributary Area (in) 16.00 ASTM Table 3-23. 19.22 Floor wd (plf) 50.58 Floor wl (plf) 100.45 Wall wd <sub>s</sub> (plf) 9.13 Wall wd <sub>w</sub> (plf) 48.75 Roof wd (plf) 55.94 w total (plf) 198.94 p total (lbs) 0.0080 Defl. (in) 0.0080	Length (ft) 32.25 Unbraced Length (ft) 10.75 Tributary Area (in) 16.00 ASTM Table 3-23. 50.58 Floor wd (plf) 100.45 Floor wl (plf) 9.13 Wall wd <sub>s</sub> (plf) 48.75 Wall wd <sub>w</sub> (plf) 199.78 Roof wd (plf) 12.17 w total (plf) 0.0509 p total (lbs) 0.0408 Defl. (in) 0.0408	Length (ft) 14.25 Unbraced Length (ft) 14.25 Tributary Area (in) 16.00 ASTM Table 3-23. 50.58 Floor wd (plf) 9.13 Floor wl (plf) 100.45 Wall wd <sub>s</sub> (plf) 154.52 Wall wd <sub>w</sub> (plf) 133.93 Roof wd (plf) 65.69 w total (plf) 133.93 p total (lbs) 0.0916 Defl. (in) 0.1138	Length (ft) 14.25 Unbraced Length (ft) 14.25 Tributary Area (in) 16.00 ASTM Table 3-23. 50.58 Floor wd (plf) 9.13 Floor wl (plf) 100.45 Wall wd <sub>s</sub> (plf) 154.52 Wall wd <sub>w</sub> (plf) 133.93 Roof wd (plf) 65.69 w total (plf) 133.93 p total (lbs) 0.0916 Defl. (in) 0.1138

MISSOURI STATE HOUSE TEAM

Bedroom House

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Deflection - Crane | Living Room | Joist (single)



$F_y = 50 \text{ ksi}$   
 Tributary Area = 16"

Previously Calculated

Floor :  $w_b = 50.58 \text{ plf}$   
 Wall :  $w_b = 144.22 \text{ plf}$   
 Roof :  $w_b = 98.73 \text{ plf}$   
 selfweight :  $w_b = 5.36 \text{ plf}$

$$w_u = 50.58 \text{ plf} + 5.36 \text{ plf}$$

$$w_u = 55.94 \text{ plf}$$

Deflection:

$$\delta = \frac{5(w_u)(l)^4}{384 EI}$$

$$= \frac{5(55.94 \text{ plf})(14.25')^4 [(12'')^3]}{384(29,500,000 \text{ psi})(21.827 \text{ in}^4)}$$

$$\delta = 0.0806''$$

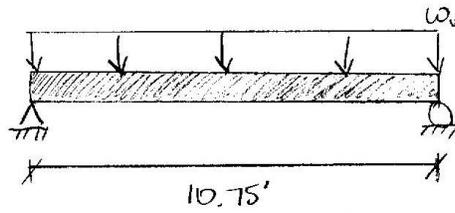
Check:

$$\frac{l}{480} = 0.356''$$

$$0.0806'' < 0.356'' \quad \checkmark \text{ OK}$$

FIGURE 2.6.8.2

Deflection - Crane Living Room Girder N (Track)



$F_y = 50 \text{ ksi}$   
 Tributary Area =  $16''$   
 Total Length =  $32.25'$   
 Unbraced Length =  $10.75'$

Previously calculated:

Floor:  $w_D = 50.58 \text{ plf}$   
 Wall:  $w_{DN} = 88.16 \text{ plf}$ ;  $w_{DW} = 89.00 \text{ plf}$   
 Roof:  $w_D = 84.93 \text{ plf}$   
 Self weight:  $w_D = 10.537 \text{ plf}$

$$w_u = 50.58 \text{ plf} + 88.16 \text{ plf} + 84.93 \text{ plf} + 10.537 \text{ plf}$$

$$w_u = 234.20 \text{ plf}$$

$$P_u = (89.00 \text{ plf}) \left( \frac{16''}{12} \right)$$

$$P_u = 118.67 \text{ lbs}$$

Deflection:

$$\delta = \frac{5(w_u L)^4}{384 E I}$$

$$= \frac{5(234.20 \text{ plf})(10.75')^4 [(12'')^3]}{384(29,500,000 \text{ ps})(40.00 \text{ in}^4)}$$

$$\delta = 0.0596''$$

Check:

$$\frac{l}{480} = 0.269''$$

$$0.0596'' < 0.269'' \quad \checkmark \text{ OK}$$

FIGURE 2.6.8.2

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

### 2.6.8.3 STRENGTH

Table 2.6.8.3a shows the properties of the steel members as well as the safety factor check table to check if members passed the strength requirements. Figure 2.6.8.3 shows a sample calculation for strength during the craning scenario.

TABLE 2.6.8.3A

Crane Situation - Strength Checks						
Member Type	Properties			Capacity		
	Shape	Fy (ksi)	Se (in <sup>3</sup> )	Mn (k-ft)	φ	Mu (k-ft)
Joists	1000S250-97	55.00	4.663	21.37	0.9	19.23
Track	1000T250-97	55.00	3.155	14.46	0.9	13.01
Double Joist (F2F)	1000S250-97 BB	55.00	9.326	42.74	0.9	38.47

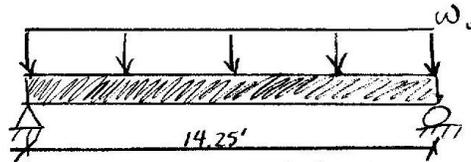
JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 2.6.8.3B

Crane Situation - Strength Checks

		Bedroom											
		Joists		Girder N (Dbl Joist)		Girder S (Dbl Joist)		Girder E (Track)		Girder W (Track)			
Demand	Floor	L (ft)	15.00	L (ft)	15.00	L (ft)	15.00	L (ft)	7.42	L (ft)	7.42		
		s (ft)	1.3333	w <sub>d</sub> (plf)	278.38	w <sub>d</sub> (plf)	201.47	w <sub>d</sub> (plf)	170.67	w <sub>d</sub> (plf)	11.70		
		w <sub>d</sub> (plf)	60.69	Walls	w <sub>1</sub> (plf)	0.00	Walls	w <sub>1</sub> (plf)	0.00	Walls	w <sub>1</sub> (plf)	0.00	
		w <sub>1</sub> (plf)	106.67	Roof	M <sub>n</sub> (k-ft)	7.83	Roof	M <sub>n</sub> (k-ft)	5.67	Roof	M <sub>n</sub> (k-ft)	0.08	
		M <sub>n</sub> (k-ft)	4.71	Roof	w <sub>d</sub> (plf)	91.69	Roof	w <sub>d</sub> (plf)	91.69	Roof	w <sub>d</sub> (plf)	143.03	
				w <sub>1</sub> (plf)	104.90		w <sub>1</sub> (plf)	104.90		w <sub>1</sub> (plf)	356.00		
				M <sub>n</sub> (k-ft)	5.53		M <sub>n</sub> (k-ft)	5.53	Joist	R (lb)	1,255.20		
									Joist	w <sub>1</sub> (plf)	941.40		
										w <sub>T</sub> (plf)	1,452.13		
				M <sub>n</sub> (k-ft)	4.71	M <sub>n</sub> (k-ft)	13.36	M <sub>n</sub> (k-ft)	11.20	M <sub>n</sub> (k-ft)	9.07	M <sub>n</sub> (k-ft)	7.99
Living Room													
		Joists		Girder N (Track)		Girder S (Track)		Girder E (Single)		Girder W (Dbl Joist)			
		L (ft)	14.25	L (ft)	10.75	L (ft)	10.75	L (ft)	14.25	L (ft)	14.25		
Demand	Floor	s (ft)	1.3333	w <sub>d</sub> (plf)	105.79	w <sub>d</sub> (plf)	173.07	w <sub>d</sub> (plf)	11.70	w <sub>d</sub> (plf)	106.80		
		w <sub>d</sub> (plf)	60.69	Walls	w <sub>1</sub> (plf)	0.00	Walls	w <sub>1</sub> (plf)	0.00	Walls	w <sub>1</sub> (plf)	0.00	
		w <sub>1</sub> (plf)	106.67	Roof	M <sub>n</sub> (k-ft)	1.53	Roof	M <sub>n</sub> (k-ft)	2.50	Roof	M <sub>n</sub> (k-ft)	2.71	
		M <sub>n</sub> (k-ft)	4.25	Roof	w <sub>d</sub> (plf)	101.91	Roof	w <sub>d</sub> (plf)	118.47	Roof	w <sub>d</sub> (plf)	30.74	
					w <sub>1</sub> (plf)	177.63		w <sub>1</sub> (plf)	177.63		w <sub>1</sub> (plf)	114.00	
				M <sub>n</sub> (k-ft)	4.04		M <sub>n</sub> (k-ft)	4.28	Joist	R (lb)	1,192.44		
									Joist	w <sub>1</sub> (plf)	894.33		
										w <sub>T</sub> (plf)	1,102.03		
				M <sub>n</sub> (k-ft)	4.25	M <sub>n</sub> (k-ft)	12.74	M <sub>n</sub> (k-ft)	13.70	M <sub>n</sub> (k-ft)	2.75	M <sub>n</sub> (k-ft)	5.16
	Bathroom												
		Joists		Girder N (Track)		Girder S (Track)		Girder E (Single)		Girder W (Dbl Joist)			
		L (ft)	8.00	L (ft)	10.75	L (ft)	10.75	L (ft)	8.00	L (ft)	8.00		
Demand	Floor	s (ft)	1.3333	w <sub>d</sub> (plf)	120.54	w <sub>d</sub> (plf)	73.20	w <sub>d</sub> (plf)	11.70	w <sub>d</sub> (plf)	10.95		
		w <sub>d</sub> (plf)	60.69	Walls	w <sub>1</sub> (plf)	0.00	Walls	w <sub>1</sub> (plf)	0.00	Walls	w <sub>1</sub> (plf)	0.00	
		w <sub>1</sub> (plf)	106.67	Roof	M <sub>n</sub> (k-ft)	1.74	Roof	M <sub>n</sub> (k-ft)	1.06	Roof	M <sub>n</sub> (k-ft)	0.09	
		M <sub>n</sub> (k-ft)	1.34	Roof	w <sub>d</sub> (plf)	58.51	Roof	w <sub>d</sub> (plf)	58.51	Roof	w <sub>d</sub> (plf)	0.00	
					w <sub>1</sub> (plf)	128.00		w <sub>1</sub> (plf)	128.00		w <sub>1</sub> (plf)	0.00	
				M <sub>n</sub> (k-ft)	2.69		M <sub>n</sub> (k-ft)	2.69	Joist	R (lb)	1,192.44		
									Joist	w <sub>1</sub> (plf)	894.33		
										w <sub>T</sub> (plf)	1,026.04		
				M <sub>n</sub> (k-ft)	1.34	M <sub>n</sub> (k-ft)	7.87	M <sub>n</sub> (k-ft)	3.75	M <sub>n</sub> (k-ft)	0.09	M <sub>n</sub> (k-ft)	0.09

Strength Check - Crane | Living Room | Joist



$F_y = 55 \text{ ksi}$   
 $S_c = 4.663 \text{ in}^3$

Previously factored loads:

$w_D = 60.69 \text{ plf}$   
 $w_L = 106.67 \text{ plf}$

$w_u = w_D + w_L$   
 $= 60.69 \text{ plf} + 106.67 \text{ plf}$   
 $= 167.36 \text{ plf}$

$M_N = \frac{w_u (L)^2}{8} \left( \frac{1}{1000} \right)$   
 $= \frac{(167.36 \text{ plf}) (14.25')^2}{8} \left( \frac{1}{1000} \right)$   
 $M_N = 4.25 \text{ k-ft}$

Capacity:

$M_n = \frac{F_y S_c}{12}$   
 $= \frac{(55 \text{ ksi})(4.663 \text{ in}^3)}{12}$

$M_n = 21.37 \text{ k-ft}$

$\phi = 0.9$

$M_u = 19.23 \text{ k-ft}$

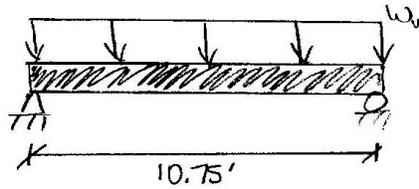
Check.

$M_N < M_u$

$4.25 \text{ k-ft} < 19.23 \text{ k-ft} \quad \checkmark \text{OK}$

FIGURE 2.6.8.3

Strength Check-Crane Living Room Girder N (Track)



$F_y = 55 \text{ ksi}$   
 $S_x = 3.155 \text{ in}^3$

Previously factored loads:

walls:  $w_D = 105.79 \text{ plf}$  —  $w_u = w_{DW} + w_{DR} + w_j$   
 $w_u = 1,102.03 \text{ plf}$   
 Roof:  $w_D = 101.91 \text{ plf}$   
 $w_E = 177.63 \text{ plf}$   
 weight of joist on track:  $w_j = 894.33 \text{ plf}$

$$M_{N \text{ wall}} = \frac{(w_{D \text{ wall}})(l)^2}{8} \left( \frac{1}{1000} \right)$$

$$= \frac{(105.79 \text{ plf})(10.75)^2}{8} \left( \frac{1}{1000} \right)$$

$M_{N \text{ wall}} = 1.53 \text{ k-ft}$

$$M_{N \text{ roof}} = \frac{(w_{DR} + w_{ER})(l)^2}{8} \left( \frac{1}{1000} \right)$$

$$= \frac{(101.91 \text{ plf} + 177.63 \text{ plf})(10.75)^2}{8} \left( \frac{1}{1000} \right)$$

$M_{N \text{ r}} = 4.04 \text{ k-ft}$

$$M_N = \frac{w_u(l)^2}{1000}$$

$$= \frac{(1102.03)(10.75)^2}{1000}$$

$M_N = 12.74 \text{ k-ft}$

Capacity:

$$M_N = \frac{F_y S_x}{12}$$

$$= \frac{(55 \text{ ksi})(3.155 \text{ in}^3)}{12}$$

$M_N = 14.46 \text{ k-ft}$

$\phi = 0.9$

$M_u = 13.01 \text{ k-ft}$

Check:

$M_N < M_u$  ✓ OK

$12.74 \text{ k-ft} < 13.01 \text{ k-ft}$

FIGURE 2.6.8.3

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

## 2.6.9 - STEEL CHECKS FOR TRUCK

### 2.6.9.1 LOADS

TABLE 2.6.9.1

Truck Loads Summary									
<b>Bedroom</b>									
Dead Load			Live Load			Joists			
Section	Peak Load (plf)	F-Peak Load (plf)	Section	Peak Load (plf)	F-Peak Load (plf)	Load Type	Peak Load (plf)	F-Peak Load (plf)	Units
Roof: North	76.41	91.69	Roof: North	65.56	0.00	Dead Load	50.58	60.69	plf
Roof: South	76.41	91.69	Roof: South	65.56	0.00	Live Load	133.33	213.33	plf
Roof: East	129.21	155.05	Roof: East	237.50	0.00				
Roof: West	119.19	143.03	Roof: West	222.50	0.00				
Wall: North	231.98	278.38							
Wall: South	144.37	173.24							
Wall: East	142.23	170.67							
Wall: West	9.75	11.70							
<b>Living Room</b>									
Dead Load			Live Load			Joists			
Section	Peak Load (plf)	F-Peak Load (plf)	Section	Peak Load (plf)	F-Peak Load (plf)	Load Type	Peak Load (plf)	F-Peak Load (plf)	Units
Roof: North	84.93	101.91	Roof: North	111.02	0.00	Dead Load	50.58	60.69	plf
Roof: South	98.73	118.47	Roof: South	111.02	0.00	Live Load	133.33	213.33	plf
Roof: East	25.62	30.74	Roof: East	78.23	0.00				
Roof: West	25.62	30.74	Roof: West	86.25	0.00				
Wall: North	88.16	105.79							
Wall: South	144.22	173.07							
Wall: East	9.75	11.70							
Wall: West	89.00	106.80							
<b>Bathroom</b>									
Dead Load			Live Load			Joists			
Section	Peak Load (plf)	F-Peak Load (plf)	Section	Peak Load (plf)	F-Peak Load (plf)	Load Type	Peak Load (plf)	F-Peak Load (plf)	Units
Roof: North	48.75	58.51	Roof: North	92.02	0.00	Dead Load	50.58	60.69	plf
Roof: South	48.75	58.51	Roof: South	80.00	0.00	Live Load	133.33	213.33	plf
Wall: North	100.45	120.54							
Wall: South	61.00	73.20							
Wall: East	9.75	11.70							
Wall: West (SIP)	9.13	10.95							

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

### 2.6.9.2 DEFLECTION

Table 2.6.9.2a shows the properties of the steel members as well as the safety factor check table to ensure members passed the deflection requirements. The members were designed for a deflection of less than or equal to  $l/480$  to try and prevent the concrete from cracking. Table 2.6.9.2b calculates the deflection on the control members in the section and checks against the design standard. Figure 2.6.9.2 shows a sample calculation for deflection during a trucking situation.

TABLE 2.6.9.2A

Truck Situation - Deflection Checks											
Properties				Capacity			Length (ft)	Check (in)			
Name	Shape	Fy (ksi)	Se (in <sup>3</sup> )	E (psi)	I (in <sup>4</sup> )	(plf)		NO GOOD	MIN L/240	MIN L/360	MIN L/480
Joists (Single)	1000S250-97	55.00	4.663	29500000.00	23.317	5.690	3.25		0.1625	0.1625	0.1625
Track	1000T250-97	55.00	3.155	29500000.00	19.38	4.976	2.875		0.1438	0.1438	0.1438
Double Joist (F2F)	1000S250-97 BB	55.00	9.326	29500000.00	46.634	11.38					

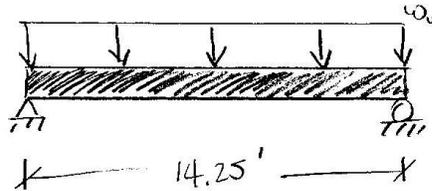
TABLE 2.6.9.2B

TRUCK SITUATION - DEFLECTION CHECKS																																				
DEMAND	Joists				Girder N (Dbl Joist)				Girder S (Dbl Joist)				Girder E (Track)				Girder W (Track)																			
	Length (ft)	Unbraced Length (ft)	Tributary Area (sq ft)	ASTM Table 3-23	Dynamic Amp	wd (plf)	wl (plf)	wd <sub>s</sub> (plf)	wl <sub>s</sub> (plf)	w total (plf)	p total (lbs)	Defl. (in)	Length (ft)	Unbraced Length (ft)	Tributary Area (sq ft)	ASTM Table 3-23	Dynamic Amp	wd (plf)	wl (plf)	wd <sub>s</sub> (plf)	wl <sub>s</sub> (plf)	w total (plf)	p total (lbs)	Defl. (in)	Length (ft)	Unbraced Length (ft)	Tributary Area (sq ft)	ASTM Table 3-23	Dynamic Amp	wd (plf)	wl (plf)	wd <sub>s</sub> (plf)	wl <sub>s</sub> (plf)	w total (plf)	p total (lbs)	Defl. (in)
Bedroom	15.00	3.25	16.00	19.22	1.50	50.58	142.23	231.98	76.41	555.53	142.23	0.0186	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095
	16.00	3.25	16.00	19.22	1.50	50.58	142.23	231.98	76.41	555.53	142.23	0.0186	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095
	16.00	3.25	16.00	19.22	1.50	50.58	142.23	231.98	76.41	555.53	142.23	0.0186	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095
	16.00	3.25	16.00	19.22	1.50	50.58	142.23	231.98	76.41	555.53	142.23	0.0186	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095	15.00	3.25	8.00	19.22	1.50	50.58	144.37	142.23	76.41	424.10	142.23	0.0095
Living Room	14.25	2.88	16.00	19.22	1.50	50.58	144.37	144.22	76.41	84.40	441.56	0.0106	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043
	16.00	2.88	16.00	19.22	1.50	50.58	144.37	144.22	76.41	84.40	441.56	0.0106	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043
	16.00	2.88	16.00	19.22	1.50	50.58	144.37	144.22	76.41	84.40	441.56	0.0106	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043
	16.00	2.88	16.00	19.22	1.50	50.58	144.37	144.22	76.41	84.40	441.56	0.0106	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043
Bathroom	14.25	2.88	16.00	19.22	1.50	50.58	144.37	144.22	76.41	84.40	441.56	0.0106	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043
	16.00	2.88	16.00	19.22	1.50	50.58	144.37	144.22	76.41	84.40	441.56	0.0106	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043	14.25	2.88	8.00	19.22	1.50	50.58	89.00	144.22	25.62	264.86	144.22	0.0043

Fully supported by truck, does not need deflection calculations

\* Section not calculated because not supported fully by anything but framing members and are only spaced 16" apart. Will not control.

Deflection - Truck Living Room Joist (single)



Tributary area = 16"  
 Dynamic Amp = 1.5  
 $l_{ub}$  = unbraced length = 2.88'

Previously Calculated:

Floor:  $w_D = 50.58$  plf  
 Wall:  $w_D = 144.37$  plf  
 Roof:  $w_D = 76.41$  plf  
 Self weight:  $w_D = 5.69$  plf

$$W_{total} = (50.58 \text{ plf} + 5.69 \text{ plf}) 1.5$$

$$W_T = 84.40 \text{ plf}$$

$$P_{total} = (144.37 + 76.41) \left( \frac{16''}{12} \right) 1.5$$

$$P_T = 441.56 \text{ lbs}$$

Deflection:

$$\begin{aligned} \delta &= \frac{W_T (l_{ub})^4}{8EI} \left( \frac{12}{1} \right)^3 + \frac{P_T (l_{ub})^3}{3EI} \left( \frac{12}{1} \right)^3 \\ &= \frac{84.40 (2.88)^4}{8 (29,500 \text{ ksi}) (23.317 \text{ in}^4)} \left( \frac{12}{1} \right)^3 + \frac{441.56 (2.88)^3}{3 (29,500) (23.32)} \left( \frac{12}{1} \right)^3 \\ \delta &= 0.0106'' \end{aligned}$$

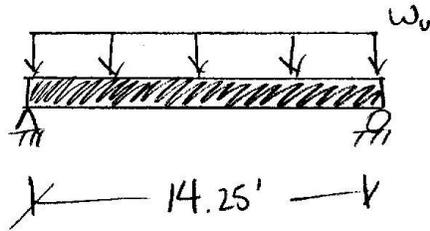
Check:

$$\frac{l}{480} = 0.0297''$$

$$0.0106'' < 0.0297'' \quad \checkmark \text{ OK}$$

FIGURE 2.6.9.2

Deflection - Truck Living Room Girder E (Single)



Tributary Area = 8"  
 Dynamic Amp = 1.5  
 $l_{UB} = \text{unbraced length} = 2.88'$

Floor:  $w_D = 50.58 \text{ plf}$   
 Wall:  $w_{DE} = 9.75 \text{ plf}$   
 $w_{DS} = 144.22 \text{ plf}$   
 Roof:  $w_P = 25.62 \text{ plf}$   
 Self weight:  $w_D = 5.69 \text{ plf}$

$$w_T = (50.58 \text{ plf} + 9.75 \text{ plf} + 25.62 \text{ plf} + 5.69 \text{ plf}) 1.5$$

$$w_T = 137.45 \text{ plf}$$

$$P_T = \left[ 144.22 \left( \frac{8''}{12} \right) \right] 1.5$$

$$P_T = 144.22 \text{ lbs}$$

Deflection:

$$\delta = \frac{w_T (l_{UB})^4}{8EI} \left( \frac{12}{1} \right)^3 + \frac{P_T (l_{UB})^3}{3EI} \left( \frac{12}{1} \right)^3$$

$$= \frac{(137.45 \text{ plf}) (2.88)^4}{8 \cdot 29,500 (23.317)} \frac{(12)^3}{1} + \frac{144.22 (2.88)^3}{3 \cdot 29,500 (23.317)} \frac{(12)^3}{1}$$

$$\delta = 0.0059''$$

Check -

$$\frac{l}{480} = 0.0297''$$

$$0.0059'' < 0.0297'' \quad \text{OK}$$

FIGURE 2.6.9.2

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

### 2.6.9.3 STRENGTH

Table 2.6.9.3a shows the properties of the steel members as well as the safety factor check table to ensure members passed the strength requirements. The members were designed with a phi factor of 0.9. Table 2.6.9.3b calculates the strength on the control members in the section and checks against the member's capacity. Figure 2.6.9.3 shows a sample calculation for strength checks during a trucking situation.

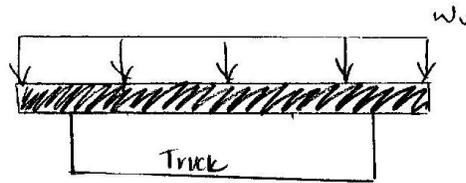
TABLE 2.6.9.3A

Truck Situation - Strength Checks						
Member Type	Properties			Capacity		
	Shape	Fy (ksi)	Sxe (in <sup>3</sup> )	Mn (k-ft)	φ	Mu (k-ft)
Joists	1000S250-97	55.00	4.663	21.37	0.9	19.23
Track	1000T250-97	55.00	3.155	14.46	0.9	13.01
Double Joist (F2F)	1000S250-97 BB	55.00	9.326	42.74	0.9	38.47

TABLE 2.6.9.3B

Truck Situation - Strength Checks															
Bedroom - East Cantilever				Bedroom - West Cantilever				Living Room - North Cantilever				Living Room - South Cantilever			
Joists				Joists				Joists				Joists			
L (ft)	3.25	Girder N - C3 (Dbl Joist)	3.25	L (ft)	3.25	Girder S - C20 (Dbl Joist)	3.25	L (ft)	2.88	Girder E (Single) (Smaller)	2.88	L (ft)	2.88	Girder W (Dbl Joist)	2.88
s (ft)	1.33	Dynamic Amp	1.5	s (ft)	1.33	Dynamic Amp	1.5	s (ft)	1.33	Dynamic Amp	1.5	s (ft)	1.33	Dynamic Amp	1.5
w <sub>d</sub> (plf)	60.69	Walls	278.38	w <sub>d</sub> (plf)	60.69	Walls	173.24	w <sub>d</sub> (plf)	60.69	Walls	106.80	w <sub>d</sub> (plf)	60.69	Walls	106.80
w <sub>1</sub> (plf)	213.33	Roof	0.00	w <sub>1</sub> (plf)	213.33	Roof	0.00	w <sub>1</sub> (plf)	213.33	Roof	0.00	w <sub>1</sub> (plf)	213.33	Roof	0.00
P <sub>2</sub> (k)	0.65	Floor	91.69	P <sub>1</sub> (k)	0.02	Floor	91.69	P <sub>1</sub> (k)	0.58	Floor	30.74	P <sub>1</sub> (k)	0.00	Floor	30.74
R <sub>2</sub> (k)	1.99		0.00	R <sub>1</sub> (k)	1.36		0.00	R <sub>1</sub> (k)	1.76		0.21	R <sub>1</sub> (k)	0.00		0.21
			0.16				0.16		0.80		0.80				0.39
M <sub>n</sub> (k-ft)	4.29		3.44	M <sub>n</sub> (k-ft)	2.25		2.60	M <sub>n</sub> (k-ft)	3.38		1.45	M <sub>n</sub> (k-ft)	0.86		2.89
Demand				Demand				Demand				Demand			
Bathroom (Continually Supported by Truck - No Cantilever)				Bathroom (Continually Supported by Truck - No Cantilever)				Bathroom (Continually Supported by Truck - No Cantilever)				Bathroom (Continually Supported by Truck - No Cantilever)			

Strength Check - truck | Living Room - North | Joists



$L = 2.88'$   
 $S = 1.33'$   
 Dynamic Amp = 1.5

Floor:  $w_D = 60.69 \text{ plf}$   
 $w_L = 213.3 \text{ plf}$   
 $P = 0.42 \text{ k}$

$F_y = 55 \text{ ksi}$   
 $S_x = 4.67 \text{ in}^3$

$$R = \frac{(60.69 \text{ plf} + 213.3 \text{ plf}) \cdot 1.5 \cdot (2.88)}{1000} + 0.42 \text{ k}$$

$$R = 1.60 \text{ k}$$

$$M_N = PL + 0.5(L)(R - P)$$

$$= (0.42 \text{ k})(2.88') + 0.5(2.88')(1.60 - 0.42)$$

$$M_N = 2.89 \text{ k'}$$

Capacity

$$M_u = \frac{F_y S_x}{12}$$

$$= 21.37 \text{ k'}$$

$\phi = 0.9$

$$M_u = 19.23 \text{ k'}$$

Check:  $M_N < M_u \quad \checkmark \text{ OK}$   
 $2.89 \text{ k'} < 19.23 \text{ k'}$

FIGURE 2.6.9.3

## 2.7 – FOOTING CONSTRUCTION AND COMPETITION DESIGN

### 2.7.1 DRAWING

Figure 2.7.1a illustrates the location and labels the footings based on size. Figure 2.7.1b labels the footings per section and in conjunction with table 2.7.2a and table 2.7.2b, the calculation on the load applied per footing is illustrated.

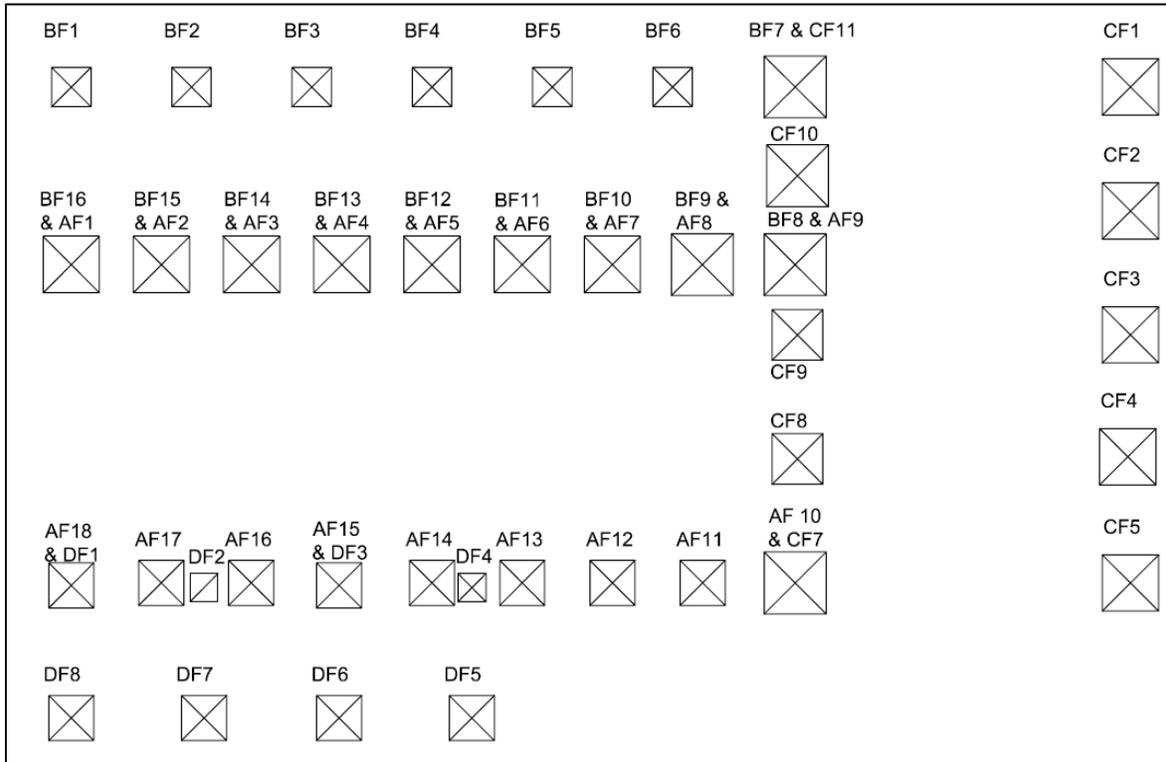


FIGURE 2.7.1A

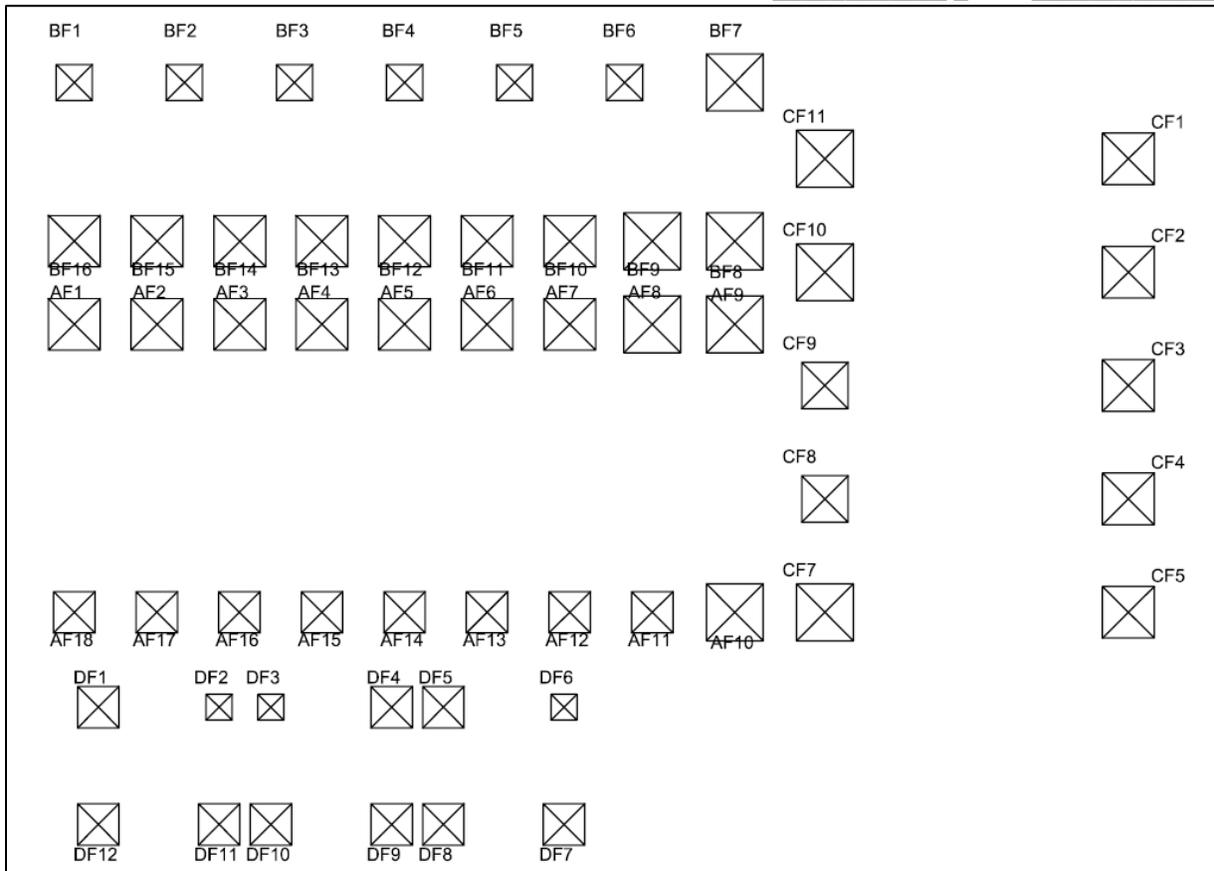


FIGURE 2.7.1B

## 2.7.2 SIZING CALCULATIONS

Footing load calculations are based off of loads calculated in section 1.2-loads. These were used in table 2.7.2a to calculate the total load applied at each location. Table 2.7.2b illustrates the final footing sizes for the competition and construction sites. Figure 2.7.2 shows a sample hand calculation for the sizing of a footing.

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 2.7.2A

		Individual Footing Calculations																		Case Load
		Dead Loads										Live								
		Footing	Roof North	Roof South	Roof East	Roof West	Wall North	Wall South	Wall East	Wall West	Joist	Total DL	Roof North	Roof South	Roof East	Roof West	LLR	Joist	LL	
Living Room Section	AF1	171.18	0.00	0.00	182.52	177.69	0.00	0.00	634.13	544.77	1710.30	223.77	0.00	0.00	614.53	838.30	1436.13	1436.13	4769.32	
	AF2	342.37	0.00	0.00	0.00	355.39	0.00	0.00	0.00	1089.55	1787.30	447.54	0.00	0.00	0.00	447.54	2872.27	2872.27	6964.16	
	AF3	342.37	0.00	0.00	0.00	355.39	0.00	0.00	0.00	1089.55	1787.30	447.54	0.00	0.00	0.00	447.54	2872.27	2872.27	6964.16	
	AF4	342.37	0.00	0.00	0.00	355.39	0.00	0.00	0.00	1089.55	1787.30	447.54	0.00	0.00	0.00	447.54	2872.27	2872.27	6964.16	
	AF5	342.37	0.00	0.00	0.00	355.39	0.00	0.00	0.00	1089.55	1787.30	447.54	0.00	0.00	0.00	447.54	2872.27	2872.27	6964.16	
	AF6	342.37	0.00	0.00	0.00	355.39	0.00	0.00	0.00	1089.55	1787.30	447.54	0.00	0.00	0.00	447.54	2872.27	2872.27	6964.16	
	AF7	342.37	0.00	0.00	0.00	355.39	0.00	0.00	0.00	1089.55	1787.30	447.54	0.00	0.00	0.00	447.54	2872.27	2872.27	6964.16	
	AF8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1089.55	1089.55	0.00	0.00	0.00	0.00	0.00	2872.27	2872.27	5903.08	
	AF9	171.18	0.00	182.52	0.00	177.69	0.00	69.47	0.00	544.77	1145.64	223.77	0.00	557.37	0.00	781.14	1436.13	1436.13	4063.15	
	AF10	0.00	199.00	182.52	0.00	0.00	290.70	69.47	0.00	544.77	1286.46	0.00	223.77	557.37	0.00	781.14	1436.13	1436.13	4232.13	
	AF11	0.00	398.00	0.00	0.00	0.00	581.39	0.00	0.00	1089.55	2068.94	0.00	447.54	0.00	0.00	447.54	2872.27	2872.27	7302.12	
	AF12	0.00	398.00	0.00	0.00	0.00	581.39	0.00	0.00	1089.55	2068.94	0.00	447.54	0.00	0.00	447.54	2872.27	2872.27	7302.12	
	AF13	0.00	398.00	0.00	0.00	0.00	581.39	0.00	0.00	1089.55	2068.94	0.00	447.54	0.00	0.00	447.54	2872.27	2872.27	7302.12	
	AF14	0.00	398.00	0.00	0.00	0.00	581.39	0.00	0.00	1089.55	2068.94	0.00	447.54	0.00	0.00	447.54	2872.27	2872.27	7302.12	
	AF15	0.00	398.00	0.00	0.00	0.00	581.39	0.00	0.00	1089.55	2068.94	0.00	447.54	0.00	0.00	447.54	2872.27	2872.27	7302.12	
	AF16	0.00	398.00	0.00	0.00	0.00	581.39	0.00	0.00	1089.55	2068.94	0.00	447.54	0.00	0.00	447.54	2872.27	2872.27	7302.12	
	AF17	0.00	398.00	0.00	0.00	0.00	581.39	0.00	0.00	1089.55	2068.94	0.00	447.54	0.00	0.00	447.54	2872.27	2872.27	7302.12	
	AF18	0.00	199.00	0.00	182.52	0.00	290.70	0.00	634.13	544.77	1851.12	0.00	223.77	0.00	614.53	838.30	1436.13	1436.13	4938.30	
Bathroom Section	BF1	131.03	0.00	0.00	0.00	269.96	0.00	39.00	0.00	407.78	847.77	247.30	0.00	0.00	0.00	247.30	1075.00	1075.00	2860.97	
	BF2	262.05	0.00	0.00	0.00	539.92	0.00	0.00	0.00	815.57	1617.54	494.60	0.00	0.00	0.00	494.60	2150.00	2150.00	5628.35	
	BF3	262.05	0.00	0.00	0.00	539.92	0.00	0.00	0.00	815.57	1617.54	494.60	0.00	0.00	0.00	494.60	2150.00	2150.00	5628.35	
	BF4	262.05	0.00	0.00	0.00	539.92	0.00	0.00	0.00	815.57	1617.54	494.60	0.00	0.00	0.00	494.60	2150.00	2150.00	5628.35	
	BF5	262.05	0.00	0.00	0.00	539.92	0.00	0.00	0.00	815.57	1617.54	494.60	0.00	0.00	0.00	494.60	2150.00	2150.00	5628.35	
	BF6	262.05	0.00	0.00	0.00	539.92	0.00	0.00	0.00	815.57	1617.54	494.60	0.00	0.00	0.00	494.60	2150.00	2150.00	5628.35	
	BF7	131.03	0.00	0.00	0.00	269.96	0.00	0.00	0.00	407.78	808.77	247.30	0.00	0.00	0.00	247.30	1075.00	1075.00	2814.17	
	BF8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	305.84	305.84	0.00	161.25	0.00	0.00	161.25	806.25	806.25	1737.63	
	BF9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	611.68	611.68	0.00	322.50	0.00	0.00	322.50	1612.50	1612.50	3475.26	
	BF10	0.00	196.54	0.00	0.00	0.00	245.91	0.00	0.00	611.68	1054.12	0.00	322.50	0.00	0.00	322.50	1612.50	1612.50	4006.20	
	BF11	0.00	196.54	0.00	0.00	0.00	245.91	0.00	0.00	611.68	1054.12	0.00	322.50	0.00	0.00	322.50	1612.50	1612.50	4006.20	
	BF12	0.00	196.54	0.00	0.00	0.00	245.91	0.00	0.00	611.68	1054.12	0.00	322.50	0.00	0.00	322.50	1612.50	1612.50	4006.20	
	BF13	0.00	196.54	0.00	0.00	0.00	245.91	0.00	0.00	611.68	1054.12	0.00	322.50	0.00	0.00	322.50	1612.50	1612.50	4006.20	
	BF14	0.00	196.54	0.00	0.00	0.00	245.91	0.00	0.00	611.68	1054.12	0.00	322.50	0.00	0.00	322.50	1612.50	1612.50	4006.20	
	BF15	0.00	196.54	0.00	0.00	0.00	245.91	0.00	0.00	611.68	1054.12	0.00	322.50	0.00	0.00	322.50	1612.50	1612.50	4006.20	
	BF16	0.00	98.27	0.00	0.00	0.00	122.95	39.00	0.00	305.84	566.06	0.00	161.25	0.00	0.00	161.25	806.25	806.25	2049.90	
Bedroom Section	CF1	573.09	0.00	359.36	0.00	1739.88	0.00	395.56	0.00	791.27	3859.16	491.71	0.00	660.55	0.00	1152.26	2085.94	2085.94	8544.62	
	CF2	0.00	0.00	718.73	0.00	0.00	0.00	791.13	0.00	1582.53	3092.39	0.00	0.00	1321.09	0.00	1321.09	4171.88	4171.88	11046.41	
	CF3	0.00	0.00	718.73	0.00	0.00	0.00	791.13	0.00	1582.53	3092.39	0.00	0.00	1321.09	0.00	1321.09	4171.88	4171.88	11046.41	
	CF4	0.00	0.00	718.73	0.00	0.00	0.00	791.13	0.00	1582.53	3092.39	0.00	0.00	1321.09	0.00	1321.09	4171.88	4171.88	11046.41	
	CF5	0.00	573.09	359.36	0.00	0.00	1082.75	395.56	0.00	791.27	3202.03	0.00	491.71	0.00	0.00	491.71	2085.94	2085.94	7425.79	
	CF6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	CF7	0.00	573.0875	0.00	1326.04	0.00	1082.75	0.00	0.00	791.27	5273.15	0.00	491.71	0.00	2475.31	2967.03	2085.94	2085.94	11148.79	
	CF8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1582.53	1582.53	0.00	0.00	0.00	0.00	0.00	4171.88	4171.88	8574.04	
	CF9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1582.53	1582.53	0.00	0.00	0.00	0.00	0.00	4171.88	4171.88	8574.04	
	CF10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1582.53	1582.53	0.00	0.00	0.00	0.00	0.00	4171.88	4171.88	8574.04	
	CF11	573.09	0.00	0.00	1326.04	1739.88	0.00	0.00	0.00	791.27	5930.27	0.00	491.71	0.00	2475.31	2967.03	2085.94	2085.94	11937.34	
	CF12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Solarium section was estimated using a hand calculation because an engineering judgment was made when determining the loads on the section from the living room section. After inspection the sizes meet all requirements previous sections met.

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 2.7.2B

Individual Footing Information					Bearing Capacity (psf)		2000	3000		
Footing	Length (ft)	Width (ft)	Tributary Area (ft <sup>2</sup> )	Footing Weight (lb)	Combined Footing (lbs)		Area of Footing (ft <sup>2</sup> )	Dimension of Footing (ft)	Competition Area of Footing	Competition Dimension of Footing
AF1	2.02	7.13	14.36	4769.32	AF1 & BF16	6819.22	3.41	1.85	2.27	1.51
AF2	4.03	7.13	28.72	6964.16	AF2 & BF15	10970.35	5.49	2.34	3.66	1.91
AF3	4.03	7.13	28.72	6964.16	AF3 & BF14	10970.35	5.49	2.34	3.66	1.91
AF4	4.03	7.13	28.72	6964.16	AF4 & BF13	10970.35	5.49	2.34	3.66	1.91
AF5	4.03	7.13	28.72	6964.16	AF5 & BF12	10970.35	5.49	2.34	3.66	1.91
AF6	4.03	7.13	28.72	6964.16	AF6 & BF11	10970.35	5.49	2.34	3.66	1.91
AF7	4.03	7.13	28.72	6964.16	AF7 & BF10	10970.35	5.49	2.34	3.66	1.91
AF8	4.03	7.13	28.72	5903.08	AF8 & BF9	9378.34	4.69	2.17	3.13	1.77
AF9	2.02	7.13	14.36	4063.15	AF9 & BF8 & CF10	14374.82	7.19	2.68	4.79	2.19
AF10	2.02	7.13	14.36	4232.13	AF10 & CF7	15380.92	7.69	2.77	5.13	2.26
AF11	4.03	7.13	28.72	7302.12	AF11	7302.12	3.65	1.91	2.43	1.56
AF12	4.03	7.13	28.72	7302.12	AF12	7302.12	3.65	1.91	2.43	1.56
AF13	4.03	7.13	28.72	7302.12	AF13	7302.12	3.65	1.91	2.43	1.56
AF14	4.03	7.13	28.72	7302.12	AF14	7302.12	3.65	1.91	2.43	1.56
AF15	4.03	7.13	28.72	7302.12	AF15	7302.12	3.65	1.91	2.43	1.56
AF16	4.03	7.13	28.72	7302.12	AF16	7302.12	3.65	1.91	2.43	1.56
AF17	4.03	7.13	28.72	7302.12	AF17	7302.12	3.65	1.91	2.43	1.56
AF18	2.02	7.13	14.36	4938.30	AF18	4938.30	2.47	1.57	1.65	1.28
BF1	2.69	4.00	10.75	2860.97	BF1	2860.97	1.43	1.20	0.95	0.98
BF2	5.38	4.00	21.50	5628.35	BF2	5628.35	2.81	1.68	1.88	1.37
BF3	5.38	4.00	21.50	5628.35	BF3	5628.35	2.81	1.68	1.88	1.37
BF4	5.38	4.00	21.50	5628.35	BF4	5628.35	2.81	1.68	1.88	1.37
BF5	5.38	4.00	21.50	5628.35	BF5	5628.35	2.81	1.68	1.88	1.37
BF6	5.38	4.00	21.50	5628.35	BF6	5628.35	2.81	1.68	1.88	1.37
BF7	2.69	4.00	10.75	2814.17	BF7 & CF11	14751.51	7.38	2.72	4.92	2.22
BF8	2.02	4.00	8.06	1737.63	CF1	8544.62	4.27	2.07	2.85	1.69
BF9	4.03	4.00	16.13	3475.26	CF2	11046.41	5.52	2.35	3.68	1.92
BF10	4.03	4.00	16.13	4006.20	CF3	11046.41	5.52	2.35	3.68	1.92
BF11	4.03	4.00	16.13	4006.20	CF4	11046.41	5.52	2.35	3.68	1.92
BF12	4.03	4.00	16.13	4006.20	CF5	7425.79	3.71	1.93	2.48	1.57
BF13	4.03	4.00	16.13	4006.20	CF6	0.00	0.00	0.00	0.00	0.00
BF14	4.03	4.00	16.13	4006.20	CF8	8574.04	4.29	2.07	2.86	1.69
BF15	4.03	4.00	16.13	4006.20	CF9	8574.04	4.29	2.07	2.86	1.69
BF16	2.02	4.00	8.06	2049.90	CF12	0.00	0.00	0.00	0.00	0.00
CF1	2.78	7.50	20.86	8544.62	DF1	3211.20	1.61	1.27	1.07	1.03
CF2	5.56	7.50	41.72	11046.41	DF2	6422.40	3.21	1.79	2.14	1.46
CF3	5.56	7.50	41.72	11046.41	DF3	6422.40	3.21	1.79	2.14	1.46
CF4	5.56	7.50	41.72	11046.41	DF4	3211.20	1.61	1.27	1.07	1.03
CF5	2.78	7.50	20.86	7425.79	DF5	3211.20	1.61	1.27	1.07	1.03
CF6	0.00	0.00	0.00	0.00	DF6	6422.40	3.21	1.79	2.14	1.46
CF7	2.78	7.50	20.86	11148.79	DF7	6422.40	3.21	1.79	2.14	1.46
CF8	5.56	7.50	41.72	8574.04	DF8	3211.20	1.61	1.27	1.07	1.03
CF9	5.56	7.50	41.72	8574.04						
CF10	5.56	7.50	41.72	8574.04						
CF11	2.78	7.50	20.86	11937.34						
CF12	0.00	0.00	0.00	0.00						
DF1	3.00	3.00	9.00	3211.20						
DF2	6.00	3.00	18.00	6422.40						
DF3	6.00	3.00	18.00	6422.40						
DF4	3.00	3.00	9.00	3211.20						
DF5	3.00	3.00	9.00	3211.20						
DF6	6.00	3.00	18.00	6422.40						
DF7	6.00	3.00	18.00	6422.40						
DF8	3.00	3.00	9.00	3211.20						

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**TRIBUTARY AREA**

$$A_T = (2.02 \text{ FT}) (7.13 \text{ FT}) = 14.40 \text{ FT}^2$$

**DEAD LOADS**

ROOF WEST – 25.62 LB/FT.

$$\text{DEAD ROOF WEST} = (25.62 \text{ LB/FT}) * (7.13 \text{ FT}) = 182.67 \text{ LB}$$

ROOF NORTH – 84.93 LB/FT

$$\text{DEAD ROOF NORTH} = (84.93 \text{ LB/FT}) * (2.02 \text{ FT}) = 171.56 \text{ LB}$$

WALL NORTH – 88.16 LB/FT

$$\text{DEAD WALL NORTH} = (88.16 \text{ LB/FT}) * (2.02 \text{ FT}) = 178.08 \text{ LB}$$

WALL WEST – 89.00 LB/FT

$$\text{DEAD WALL WEST} = (89.00 \text{ LB/FT}) * (7.13 \text{ FT}) = 634.57 \text{ LB}$$

JOIST – 37.93 LB/FT<sup>2</sup>

$$\text{DEAD JOIST} = (37.93 \text{ LB/FT}^2) * (14.40 \text{ FT}^2) = 546.19 \text{ LB}$$

**DEAD LOAD TOTAL (D<sub>L</sub>) = 1553.07 LB**

**LIVE LOAD**

ROOF NORTH – 111.02 LB/FT

$$\text{LIVE ROOF NORTH} = (111.02 \text{ LB/FT}) * (2.02 \text{ FT}) = 224.26 \text{ LB}$$

ROOF WEST – 86.25 LB/FT

$$\text{LIVE ROOF WEST} = (86.25 \text{ LB/FT}) * (7.13 \text{ FT}) = 614.96 \text{ LB}$$

**TOTAL LIVE LOAD ROOF (LL<sub>R</sub>) = 839.22 LB**

JOIST- 100.00 LB/FT<sup>2</sup>

$$\text{LIVE JOIST} = (100.00 \text{ LB/FT}^2) * (14.40 \text{ FT}^2) = 1440 \text{ LB}$$

**TOTAL LIVE LOAD (LL) = 1440 LB**

**LOAD CASE**

$$1.2(D_L) + 1.6(LL) + 0.5(LL_R)$$

$$1.2(1553.07 \text{ LB}) + 1.6(1440 \text{ LB}) + 0.5(839.22 \text{ LB}) = \mathbf{4587.29 \text{ LB}}$$

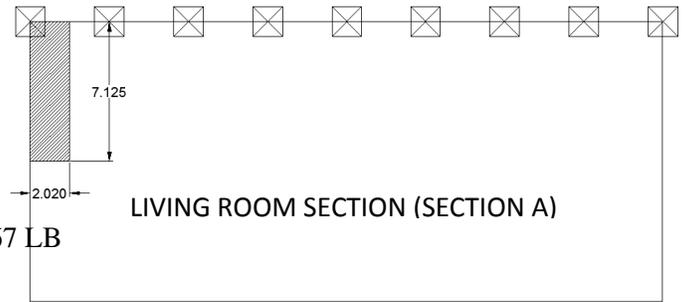


FIGURE 2.7.2 SAMPLE CALCULATION

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

Figure 2.7.2 shows a sample calculation of how the footings were sized. This method was used for all footings. Once each footing for each section was determined, the footing loads were added together and divided by the bearing capacity at each footing location. This gave a square footage, and a square footing was assumed and the dimensions were rounded off to the nearest quarter of a foot for constructability. This type of calculation determined the contents of table 2.7.2a and table 2.7.2b.

## 2.7.3 GRAVITY FOOTINGS

### 2.7.3.1 SIZE

The footing dimensions are listed in Table 2.7.3.1.

TABLE 2.7.3.1

FOOTING LABEL	LENGTH	WIDTH	AREA (FT <sup>2</sup> )
C	2'	2'	4.00
D	2'-3"	2'-3"	5.06

### 2.7.3.2 MATERIAL SPECIFICATION

Footings will be constructed out of typical 2 x 4 dimensional lumber. The 2 x 4 will be placed between 5/8" plywood. The fasteners for material will be 16p nails.

### 2.7.3.3 DESIGN

Figure 2.7.3.3a illustrates a cross-section view and a plan view of the foundation footings. The footings are made of 2x4 timber boards set on edge. The plywood serves as a layer to keep the 2x4 lumber connected, acts as a beam to distribute the load throughout the entire footing.

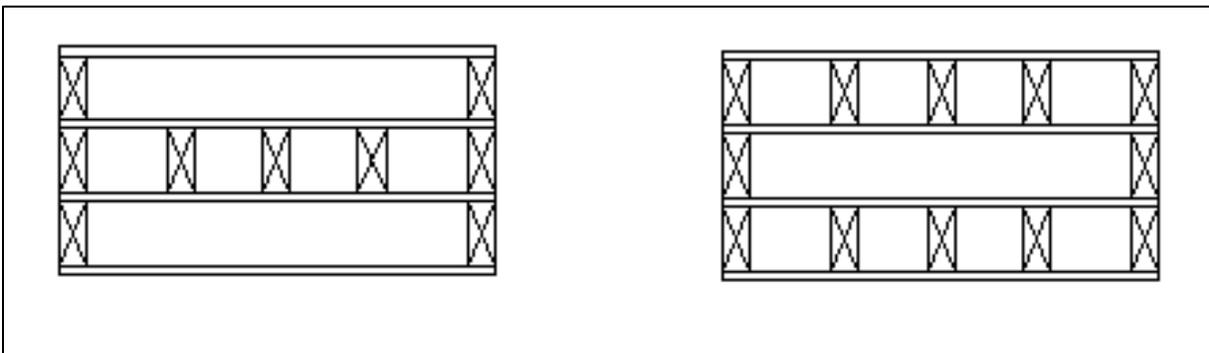


FIGURE 2.7.3.3A

The steel will rest directly on top of the footings. Figure 2.7.3.3b is a drawing of how the steel sits on the footing.

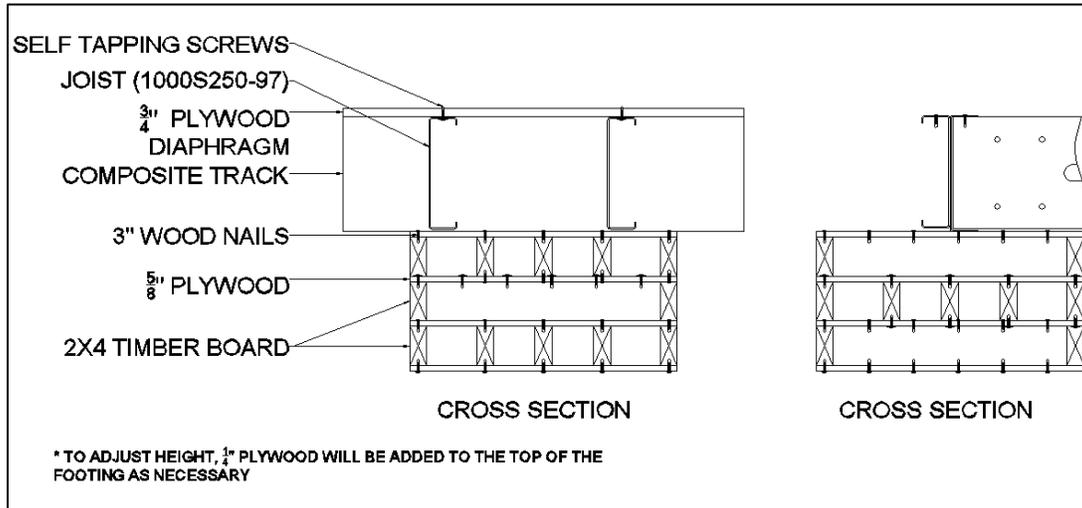


FIGURE 2.7.3.3B

#### 2.7.3.4 LATERAL CHECK

Calculations to determine the number of screws per layer in the footing are shown below. These calculations are to check lateral and pull out values based on expected loads on the footings.

\* From Text "Wood Engineering & Construction Handbook 3rd Edition"  
 yield modes for wood screws in single shear are I<sub>s</sub>, III<sub>s</sub>, & IV  
 for lateral design.

Lateral Design (NDS 11.3)

• Yield Mode I<sub>s</sub>:

$$Z = \frac{D_s F_{es}}{R_d} \quad (11.3-2)$$

$D = 0.216 \text{ in}$  (#12 wood screw)  
 $l_s = 0.468 \text{ in}$  (#12" plywood)  
 $F_{es} = 3350 \text{ psi}$  (Table 11.3.3  $\rightarrow C_1 = 0.42$  from Table 11.3.3B)  
 $R_d = K_d = 10D + 0.5$  (Table 11.3.1B)  
 $= 10(0.216) + 0.5$   
 $R_d = 2.66$

$$Z = \frac{(0.216 \text{ in})(0.468 \text{ in})(3350 \text{ psi})}{2.66}$$

$$Z = 127.3 \text{ lb}$$

• Yield Mode III<sub>s</sub>:

$$Z = \frac{k_s D_s F_{em}}{(2 + R_c) R_d} \quad (11.3-5)$$

$D = 0.216 \text{ in}$   
 $l_s = 0.468 \text{ in}$   
 $F_{em} = 2550 \text{ psi}$  (Table 11.3.3  $\rightarrow C_1 = 0.36 \rightarrow$  Assumed SPF(s))  
 $R_d = 2.66$   
 $R_c = F_{em} / F_{es} = 2550 \text{ psi} / 3350 \text{ psi}$   
 $R_c = 0.76$

$$k_s = -1 + \sqrt{\frac{2(1+R_c)}{R_c} + \frac{2F_{yw}(2+R_c)D^2}{3F_{em}l_s^2}}, \text{ where } F_{yw} = 80,000 \text{ psi} \text{ (NDS Appendix I, Table I1)}$$

$$= -1 + \sqrt{\frac{2(1+0.76)}{0.76} + \frac{2(80,000 \text{ psi})(2+0.76)(0.216 \text{ in})^2}{3(2550 \text{ psi})(0.468 \text{ in})^2}}$$

$$k_s = 3.11$$

$$Z = \frac{(3.11)(0.216 \text{ in})(0.468 \text{ in})(2550 \text{ psi})}{(2+0.76)(2.66)}$$

$$Z = 109.4 \text{ lb}$$

Lateral design (cont'd)

• Yield Mode III

$$Z = \frac{D^3}{Pd} \sqrt{\frac{2 F_{cm} F_{fw}}{3(1+R_c)}}$$

$$D = 0.216m$$

$$P_d = 2.66$$

$$F_{cm} = 2550psi$$

$$F_{fw} = 80,000psi$$

$$R_c = 0.76$$

$$Z = \frac{(0.216m)^3}{2.66} \sqrt{\frac{2(2550psi \times 80,000psi)}{3(1+0.76)}}$$

$$Z = 154.2 lb$$

\* Yield Mode III's Controls \*

$$Z = 109.4 lb$$

\* Determine Adjustment Factors per 10.3.1 \*

$$Z' = Z \times C_m \times C_t \times C_g \times C_a \times C_{cp} \times C_{cl} \times C_{cm} \times K_F \times \Phi \times \lambda$$

$$C_m = 0.7 \quad (\text{Table 10.3.3} \rightarrow \text{consecutive, Fabrication} \rightarrow \text{any, In-service} \rightarrow 71\%)$$

$$C_t = 1.0 \quad (\text{Table 10.3.4} \rightarrow T \leq 100^\circ F)$$

$$C_g = 1.0 \quad (10.3.6 \rightarrow \text{dowel fastener with } D \leq 0.25")$$

$$C_a = 1.0 \quad (11.5.1 \rightarrow \text{dowel fastener with } D \leq 0.25")$$

$$C_{cp} = 1.0 \quad (11.5.2)$$

$$C_{cl} = 1.0 \quad (11.5.3)$$

$$C_{cm} = 1.0 \quad (11.5.4)$$

$$K_F = 3.32 \quad (10.3.1)$$

$$\Phi = 0.65 \quad (10.3.1)$$

$$\lambda = 0.8 \quad (\text{Appendix N.3.3})$$

$$Z' = 109.4 lb (0.7)(1.0)(1.0)(1.0)(1.0)(1.0)(1.0)(3.32)(0.65)(0.8)$$

$$Z' = 132 lb$$

Withdrawal Design (NDS 11.2)

$$W = 2850 G^2 D \quad (\text{lb/in of penetration})$$

$$G = 0.36$$
$$D = 0.216 \text{ in}$$

$$W = 2850 (0.36)^2 (0.216 \text{ in})$$
$$W = 79.8 \text{ lb/in of penetration}$$

\* Assume 2" penetration

\* Determine Adjustment Factors per 10.3.1 \*

$$W' = W \times C_m^2 C_t C_{eg} C_{en} K_F \phi \lambda$$

$$C_m = 0.7$$
$$C_t = 1.0$$
$$C_{eg} = 1.0$$
$$C_{en} = 1.0$$
$$K_F = 3.32$$
$$\phi = 0.65$$
$$\lambda = 0.8$$

$$W' = (79.8 \text{ lb/in})(2 \text{ in})(0.7)^2 (1.0)(1.0)(1.0)(3.32)(0.65)(0.8)$$
$$W' = 135 \text{ lb}$$

Lateral Force Design

• Footing A1

$$\frac{V}{Z'} = \frac{1432.2 \text{ lbs}}{132 \text{ lb}} = 10.85$$

\* Needs 11 screws per layer

• Footing A4

$$\frac{V}{Z'} = \frac{2407.5 \text{ lbs}}{132 \text{ lb}} = 18.2$$

\* Needs 19 screws per layer

• Footing E1

$$\frac{V}{Z'} = \frac{2822.5 \text{ lbs}}{132 \text{ lb}} = 17.6$$

\* Needs 18 screws per layer

• Footing E3

$$\frac{V}{Z'} = \frac{2498.4 \text{ lbs}}{132 \text{ lb}} = 18.9$$

\* Needs 19 screws per layer

• Footing D8

$$\frac{V}{Z'} = \frac{1814.7 \text{ lbs}}{132 \text{ lb}} = 13.7$$

\* Needs 14 screws per layer

• Footing D12

$$\frac{V}{Z'} = \frac{1814.7 \text{ lbs}}{132 \text{ lb}} = 13.7$$

\* Needs 14 screws per layer

• Footing D1

$$\frac{V}{Z'} = \frac{4037.7 \text{ lbs}}{132 \text{ lb}} = 30.6$$

\* Needs 31 screws per layer

• Footing D10

$$\frac{V}{Z'} = \frac{3626.7 \text{ lbs}}{132 \text{ lb}} = 27.5$$

\* Needs 28 screws per layer

• Footing B1

$$\frac{V}{Z'} = \frac{2609.5 \text{ lbs}}{132 \text{ lb}} = 19.7$$

\* Needs 20 screws per layer

• Footing B5

$$\frac{V}{Z'} = \frac{2588.5 \text{ lbs}}{132 \text{ lb}} = 19.6$$

\* Needs 20 screws per layer

## 2.7.4 SEISMIC FOOTINGS

### 2.7.4.1 MATERIAL SPECIFICATION

Each footing will be constructed out of a bottom plate of 1/8" steel plate, five pieces of 4" x 4" x 5/16" steel angle, and four pieces of 2" x 2" x 1/8" hollow steel post. The steel will be welded and the completed pier will be fastened to floor joist groove welds.

### 2.7.4.2 DESIGN

Figure 2.7.4.2a illustrates a cross-section view and a plan view of the foundation footings. The footings are made of 2x2 steel posts with 4x4 steel angles spanning in between posts. The steel plate acts as a beam to distribute the load throughout the entire footing. The steel will rest directly on top of the footings. Figure 2.7.4.2a also shows how the steel sits on the footing. The thicknesses of the steel plates are shown in the table 2.7.4.2b for all of the footings and the completed sample calculations are shown in Figure 2.7.4.2c.

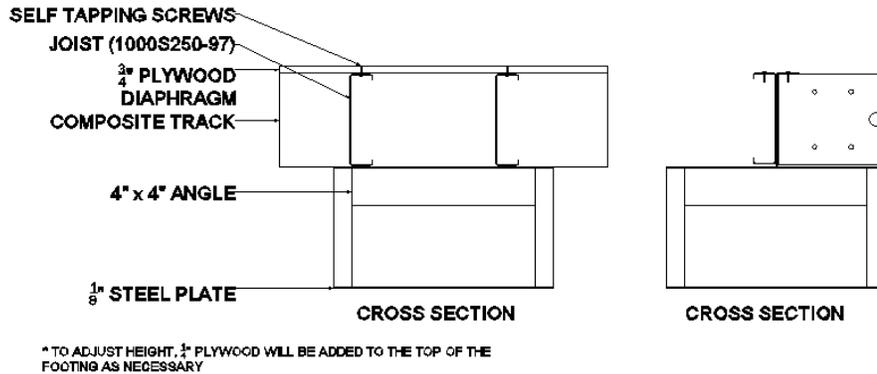


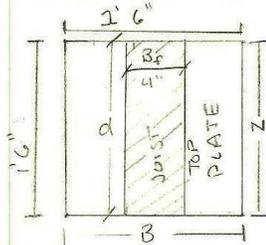
FIGURE 2.7.4.2A

Shear Footings									Plate Thickness		
Shear Footings	Force on Footing	Competition Dimension of Footing (ft)	Competition Dimension of Footing	Competition Dimension of Footing (in)	in <sup>2</sup>	Shear (lb)	psi	l	t <sub>min</sub> (in)	F <sub>y</sub>	36000
D1	6819.22	1.5	1' 6"	18	324	4037.7	12.46209	2.12132	0.076462		
E3	15380.92	2.25	2'3"	27	729	2498.4	3.427148	2.598076	0.093761		
B5	7302.12	1.75	1'9"	21	441	2588.5	5.869577	2.291288	0.073253		
B1	4938.30	1.5	1'6"	18	324	2605.5	8.041574	2.12132	0.065068		
A1	2860.97	1	1'	12	144	1432.2	9.946157	1.732051	0.060657		
A4	5628.35	1.5	1'6"	18	324	2407.5	7.430658	2.12132	0.069465		
E1	14751.51	2.25	2'3"	27	729	2322.5	3.185855	2.598076	0.091822		
D8	8544.62	1.75	1'9"	21	441	1814.7	4.114987	2.291288	0.079241		
D10	11046.41	2	2'	24	576	3626.7	6.296285	2.44949	0.084279		
D12	7425.79	1.75	1'9"	21	441	1814.7	4.114987	2.291288	0.073871		

Table 2.7.4.2B

SHEAR FOOTING  
 PLATE THICKNESS CALCULATION

SHEAR FOOTING D1



LRFD

EQN 14-7a

$$t_{min} = l \sqrt{\frac{2 P_u}{0.9 F_y B N}}$$

A36 STEEL  $\therefore F_y = 36 \text{ ksi}$

TOP PLATE ANALYSIS

$$P_u = 6819.77 \text{ lb}$$

$$B + N = 1.5' = 18''$$

$$l = \lambda n'$$

$$\lambda = 1$$

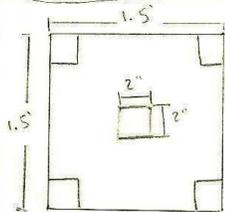
$$n' = \frac{\sqrt{d b_p}}{4} = \frac{\sqrt{(1.5')(0.33')}}{4} = 0.176 \text{ FT}$$

$$d = 1.5'$$

$$b_p = 4'' = 0.33'$$

$$l = (1)(0.176 \text{ FT}) = 0.176 \text{ FT} = 2.11 \text{ IN}$$

$$t_{min} = (2.11 \text{ IN}) \sqrt{\frac{2(6819.77 \text{ lb})}{(0.9)(36,000 \text{ psi})(18'')^2}} = 0.076 \text{ IN}$$



BOTTOM PLATE ANALYSIS

ASSUME ALL FORCE IS GOING THROUGH CENTER POST

$$t_{min} = l \sqrt{\frac{2 P_u}{0.9 F_y B N}}$$

A36 STEEL  $\therefore F_y = 36 \text{ ksi}$

$$P_u = 6819.77 \text{ lb}$$

$$B = N = 18''$$

$$l = \lambda n'$$

$$\lambda = 1$$

$$n' = \frac{\sqrt{d b_p}}{4} = \frac{\sqrt{(2'')(2'')}}{4} = 0.5 \text{ IN}$$

$$l = (1)(0.5 \text{ IN}) = 0.5 \text{ IN}$$

$$d = b_p = 2''$$

$$t_{min} = (0.5 \text{ IN}) \sqrt{\frac{2(6819.77 \text{ lb})}{(0.9)(36,000 \text{ psi})(18'')^2}}$$

$$t_{min} = 0.018 \text{ IN}$$

FIGURE 2.7.4.2C

E2.5 AISI FOR GROVE WELDS

MAX SHEAR = 4.037 KIPS

$P_N = 0.75 \epsilon L F_u$   
 $\phi = 0.55$   
 $\epsilon = .102''$   
 $F_u = 65 \text{ KSI}$

$\phi P_N = \text{MAX SHEAR}$   
 $.55 P_N = 4.037 \text{ KIPS}$   
 $P_N = 7.34 \text{ KIPS}$

$7.34 \text{ KIPS} = .75 (102'') L (65 \text{ KSI})$

$L = 1.48 \text{ INCHES}$

WELD CHECK

$P_N = .75 \epsilon_w L F_{xx}$   
 $\phi = 0.6$   
 $\epsilon_w = \frac{5}{16} (R) = .078''$   
 $R = \frac{1}{4}''$   
 $F_{xx} = 60 \text{ KSI}$   
 $6.73 \text{ KIPS} = .75 (.078'') L (60 \text{ KSI})$

$\phi P_N = 4.037 \text{ KIPS}$   
 $P_N = 6.73 \text{ KIPS}$

$L = 1.91'' \text{ INCHES}$  CONTROLS

FIGURE 2.7.4.2C

## 2.8 - TIE DOWNS

### 2.8.1 MATERIALS AND SPECIFICATIONS

A 36", 1" diameter, steel, double head, anchor stake will be used to hold the house to the ground. Competition advisors have provided assumed values for the ground resistance on a 1" diameter stake, these values are: 1,250 lb pullout design capacity, 1,500 lb shear design capacity. The quantity and placement of anchors shall be such that the combination of actual pullout load/1,250 + actual shear load/1,500 shall be less than or equal to 1.

The shear footing design calls for anchors to be placed in the bottom steel plate to transfer lateral forces and resist uplift forces. This footing will be anchored to the asphalt using the above mentioned stake. Figure 1.4.1 calls out these locations.

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

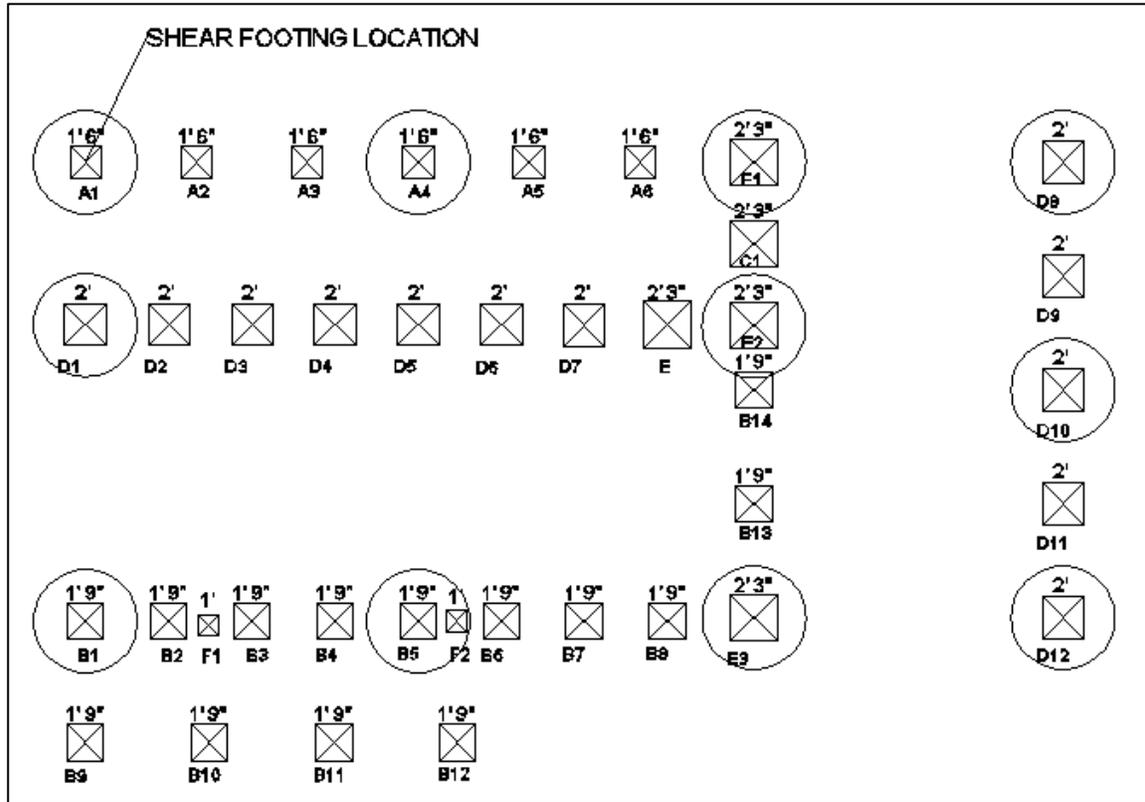


FIGURE 2.8.1

## 2.8.2 DRAWINGS

Figure 2.8.2 illustrates a flat bottom plate design of the steel footing.

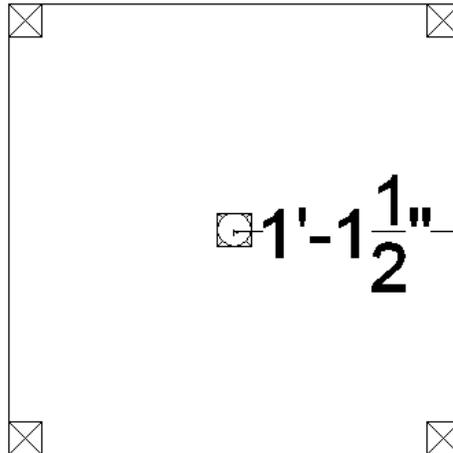


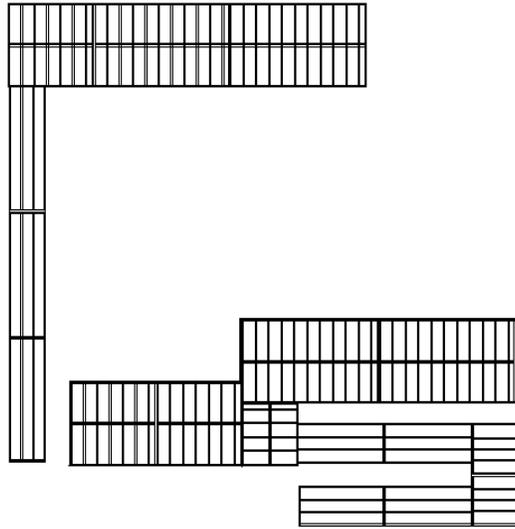
FIGURE 2.8.2

## 2.9 DECK

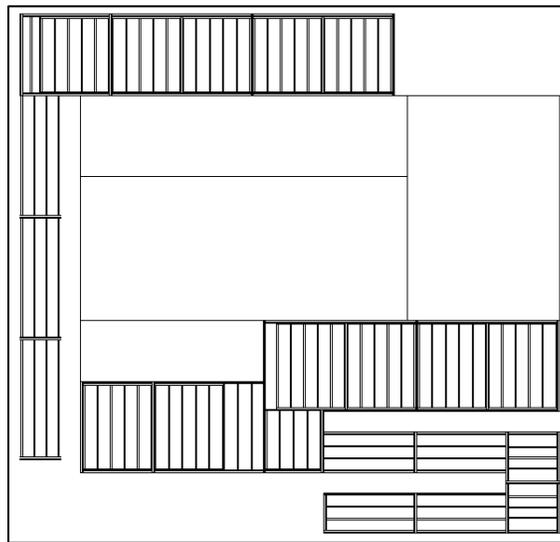
The deck design will consist of joist systems and a girder system. The girders will be made of 2 2x10 weather treated lumber boards screwed together to make a composite member. The joists will be made of 2x6 weather treated lumber assembled in smaller assemblies. The joist assemblies will slide into pockets in the girder system and bolt to the girders. This is over engineered but it is done so to provide a quick assembly process for the deck. The deck top will be made of bamboo decking provided by Cali-Bambo. The posts consist of 4x4 treated southern pine and are spaced every 7 foot. The calculations for the spacing can be seen in Figure 2.9C

The following diagrams illustrate the girder, joist and all together system.

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_



GIRDERS AND JOISTS



DECK SYSTEM WITH HOUSE OUTLINE





JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

POST SPACING

IN ACCORDANCE WITH TABLE 3.26 H OF THE WFCM

A PAIR OF 2x4s AT 24" JOIST SPACING REQUIRES A SUPPORT EVERY 10' 2"

∴ AT 48" JOIST SPACING

$$\frac{wL^2}{8} = MA \quad L = \sqrt{\frac{8M}{w}} \quad 2w = \sqrt{\frac{1}{4}} L \quad \therefore .707(L)$$

$$\therefore (10' 2") (.707) = \boxed{7' \text{ FOR "A PAIR OF 2x4"}}$$

POSTS WILL CONSIST OF 4x4 TREATED SOUTHERN PINE

FIGURE 2.9C

**2.10- BIFACIAL RACKING**

The Bifacial racking system consists of an outside frame constructed of 2x8 treated southern pine and the inside supports are constructed of 2x6 treated southern pine. The posts supporting the structure are 4x4 treated southern pine and are spaced every 12 foot. The calculations can be found in Figure 2.10a. Figure 2.10b shows both the plan and profile views of the structure.

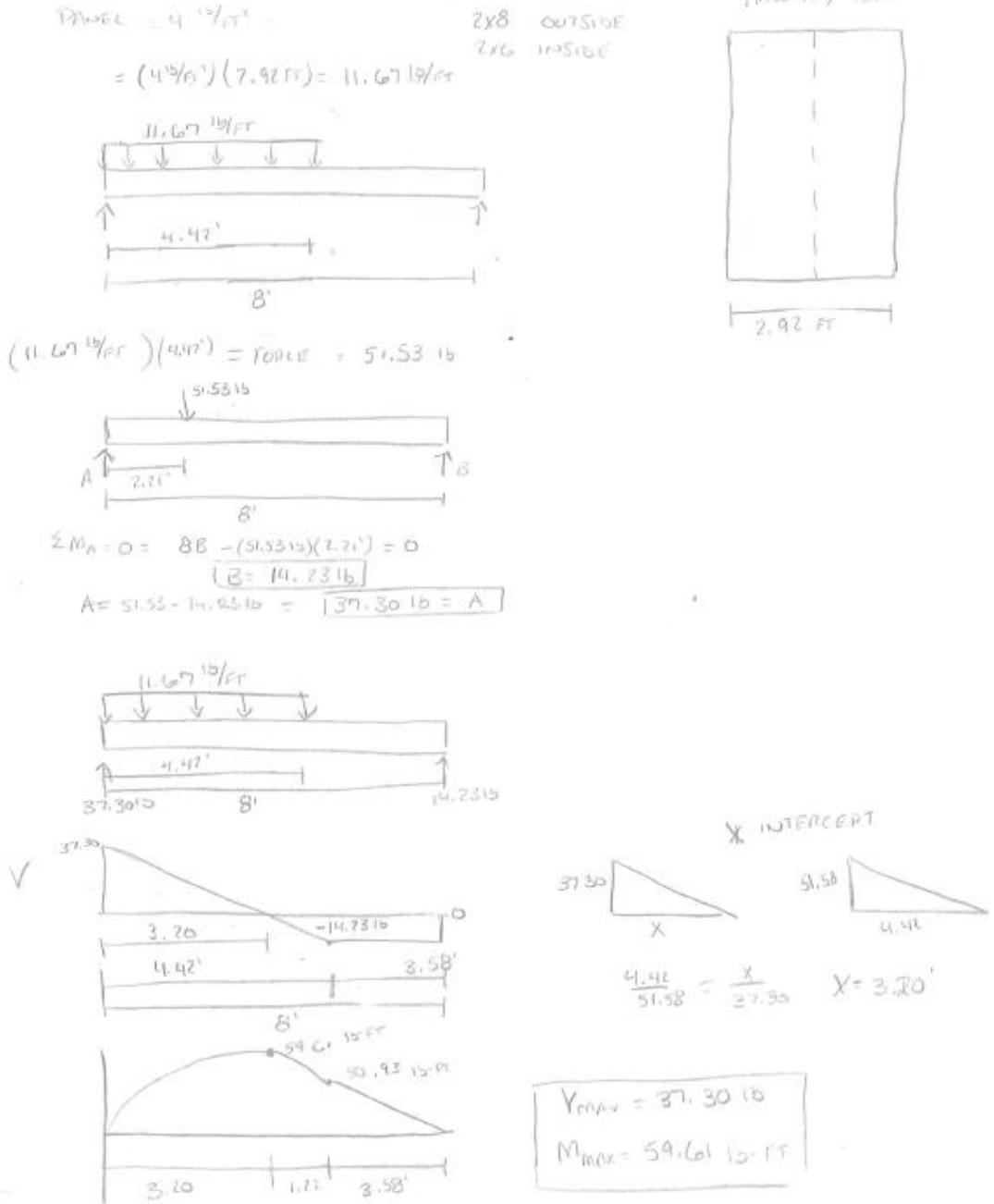


FIGURE 2.10A

MEMBER CHECK

IN ACCORDANCE TO TABLE 3.26B OF THE LDFCM

2x6" @ 12" A SOUTHERN PINE 2x6 CAN BE 16'1" IN LENGTH  
 $M_n = \sqrt{\frac{wL^2}{8}}$      $L = \sqrt{\frac{M_n^2}{w}}$      $\therefore 3w = \sqrt{\frac{1}{8}} L = .577L$   
 $\therefore (16'1")(.577) = 9'$  SPACING  
 MEMBERS ARE ACTUALLY 8' ✓

2x8"

TABLE 3.26B

@ 12" A SOUTHERN PINE 2x8 CAN BE 21'2" IN LENGTH

$M_n = \frac{wL^2}{8}$      $L = \sqrt{\frac{M_n^2}{w}}$      $\therefore 3w = \sqrt{\frac{1}{8}} L = .577L$

$\therefore (21'2")(.577) = 12'$  SPACING

MAXIMUM SPACING PERMITTED = 12' SPACING ✓

FIGURE 2.10A

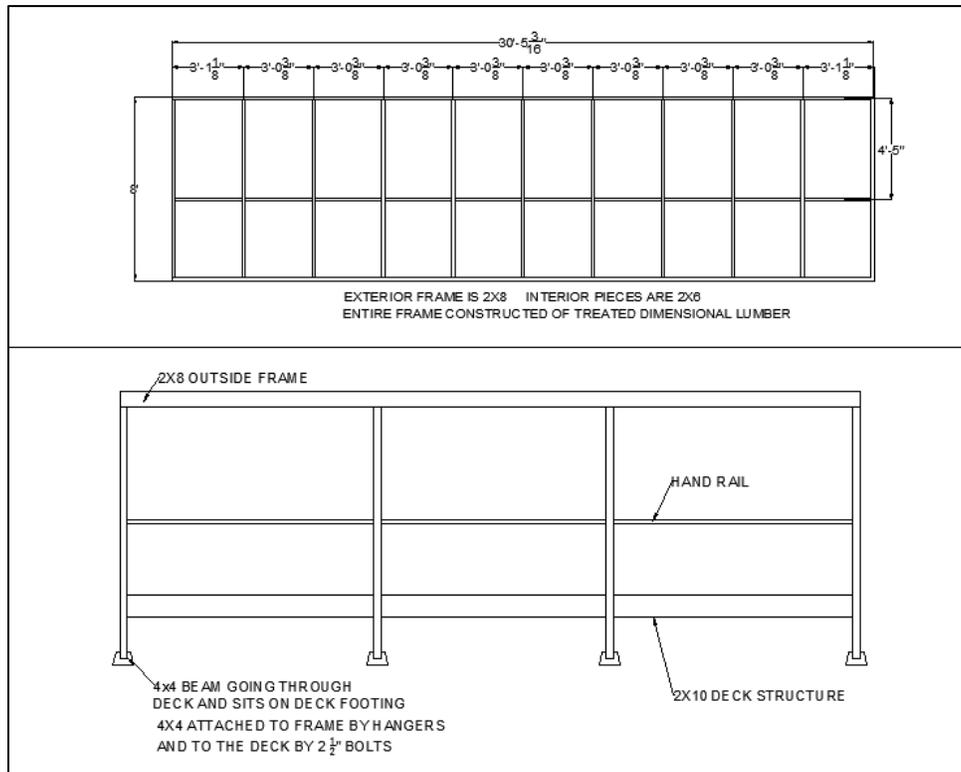


FIGURE 2.10B

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

### 3 CRANING

#### 3.1 - WEIGHT CALCULATIONS

Table 3.1A is a summary of the loads from each section. This table is just a summary of tables 3.1b -3.1e which show a breakdown of the expected weights.

TABLE 3.1A

<b>CRANE LOAD SUMMARY</b>		
<b>SECTION</b>	<b>WT. (LBS)</b>	<b>WT. (TONS)</b>
1 (BEDROOM)	25257.33	12.63
2 (LIVING ROOM)	31452.76	15.73
3 (BATHROOM)	19526.11	9.76
4 (SOLARIUM)	3601.80	1.80
<b>TOTAL</b>	<b>79838.00</b>	<b>39.92</b>

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 3.1B

BEDROOM CRANE WEIGHT CALCULATIONS						
Item	Quantity	Weight	Units	Total	Units	Grand Total (lb)
<b>Bedroom Roof</b>						
Area with Overhang	486.5625 sqft					
Area without Overhang	446.25 sqft					
6" SIPs		4.8 psf		2335.5 lbs		
Roofing Material		3 psf		1459.6875 lbs		
Drywall (5/8")		2.5 psf		1115.625 lbs	<b>Bedroom Roof</b>	
Heat Recovery System		5 psf		2231.25 lbs		<b>7142.0625</b>
<b>North Wall</b>						
Area	153.75 sqft					
Length	15 ft					
Height	10.25 ft					
6" SIPs		4.8 psf		738 lbs		
Drywall (5/8")		2.5 psf		384.375 lbs		
Clear Story Windows (14" X 36")	.375 psf	2	76.5 lbs	153 lbs		
Exterior Façade (panels, plastic wrap)		2.5 psf		384.375 lbs		
Bedroom Cabinets	4	80 lbs		320 lbs	<b>North Wall</b>	
Murphy Bed (80" Long)	1	300 plf		300 lbs		<b>2279.75</b>
<b>South Wall</b>						
Area	153.75 sqft					
Length	15 ft					
Height	10.25 ft					
6" SIPs		4.8 psf		738 lbs		
Clear Story Windows (14" X 36")	.375 psf	2	76.5 lbs	153 lbs		
South Wall Windows (36" X 54")	.375 psf	3	252.88 lbs	758.64 lbs		
Doors	1	100 lbs		100 lbs		
Exterior Façade (panels, plastic wrap)		2.5 psf		384.375 lbs	<b>South Wall</b>	
Drywall (5/8")		2.5 psf		384.375 lbs		<b>2518.39</b>
<b>East Wall</b>						
Area	153.75 sqft					
Length	15 ft					
Height	10.25 ft					
6" SIPs		4.8 psf		738 lbs		
Drywall (5/8")		2.5 psf		384.375 lbs		
Exterior Façade (panels, plastic wrap)		2.5 psf		384.375 lbs		
Clear Story Windows (14" X 36")	.375 psf	2	76.5 lbs	153 lbs	<b>West Wall</b>	
Bedroom Cabinets	7	80 lbs		560 lbs		<b>2219.75</b>
<b>Temp. Shipping Wall</b>						
Length of West Section	22.25 ft					
2X4 Stud Wall (16" O.C.)		9.75 plf		216.9375 lbs		<b>216.9375</b>
<b>Bedroom Floor</b>						
Area	326.25					
Length (Total - .5ft)	22.5					
Width (Total - .5ft)	14.5					
Concrete Floor (3" @ 110 pcf)		27.5 psf		8971.875 lbs		
Insulation (3")		3.6 psf		1174.5 lbs	Floor	
Plywood Floor (1")		2.25 psf		734.0625 lbs		10880.4375
					<b>Bedroom Section</b>	<b>25257.3275</b>

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 3.1C

**LIVING ROOM CRANE WEIGHT CALCULATIONS**

Item	Quantity	Weight	Units	Total	Units	Grand Total (lb)
<b>Living Room Roof</b>						
Area with Overhang	495.00 sqft					
Area without Overhang	459.56 sqft					
6" SIPs		4.8 psf		2376.00 lbs		
Roofing Material		3 psf		1485.00 lbs		
Drywall (5/8")		2.5 psf		1148.91 lbs		<b>Living Room Roof</b>
Heat Recovery System (4" thick plaster)		5 psf		2297.81 lbs		<b>7307.72</b>
<b>North Wall</b>						
Area	330.56 sqft					
Length	32.25 ft					
Height	10.25 ft					
6" SIPs		4.8 psf		1586.70 lbs		
Drywall (5/8")		2.5 psf		826.41 lbs		<b>North Wall</b>
Kitchen Cabinets	6	40 lbs		240.00 lbs		<b>2653.11</b>
<b>South Wall</b>						
Area	330.56 sqft					
Length	32.25 ft					
Height	10.25 ft					
6" SIPs		4.8 psf		1586.70 lbs		
Clear Story Windows (14" X 36") .375 psf	4	76.5 lbs		306.00 lbs		
South Wall Windows (36" X 54") .375 psf	3	252.88 lbs		758.64 lbs		
Doors	1	100 lbs		100.00 lbs		
Exterior Façade (panels, plastic wrap)		2.5 psf		826.41 lbs		
Drywall (5/8")		2.5 psf		826.41 lbs		<b>South Wall</b>
Solarium Door	4	233.33 lbs		933.32 lbs		<b>5337.47</b>
<b>West Wall</b>						
Area	153.75 sqft					
Length	15 ft					
Height	10.25 ft					
6" SIPs		4.8 psf		738.00 lbs		
Drywall (5/8")		2.5 psf		384.38 lbs		<b>West Wall</b>
Kitchen Cabinets	6	40 lbs		240.00 lbs		<b>1362.38</b>
<b>Temp. Shipping Wall</b>						
Length of East Section	15 ft					
Length of North Section	8.87 ft					
2X4 Stud Wall (16" O.C.)		9.75 plf		146.25 lbs		<b>Shipping Wall</b>
2X4 Stud Wall (16" O.C.)		9.75 plf		86.48 lbs		<b>232.73</b>
<b>Living Room Floor</b>						
Area	436.56					
Length (Total - .5ft)	31.75					
Width (Total - .5ft)	13.75					
Concrete Floor (3" @ 110 pcf)		27.5 psf		12005.47 lbs		
Insulation (3")		3.6 psf		1571.63 lbs		<b>Floor</b>
Plywood Floor (1")		2.25 psf		982.27 lbs		<b>14559.36</b>
						<b>Living Room Section</b>
						<b>31452.76</b>

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 3.1D

BATHROOM CRANE WEIGHT CALCULATIONS						
Item	Quantity	Weight	Units	Total	Units	Grand Total (lb)
<b>Bathroom Roof</b>						
Area with Overhang	282.19 sqft					
Area without Overhang	258 sqft					
6" SIPs			4.8 psf	1354.50 lbs		
Roofing Material			3 psf	846.56 lbs		
Drywall (5/8")			2.5 psf	645.00 lbs		<b>Bathroom Roof</b>
Evacuated Tubes and Racks	2		120 lbs	240.00 lbs		<b>3086.06</b>
<b>North Wall</b>						
Area	330.56 sqft					
Length	32.25 ft					
Height	10.25 ft					
6" SIPs			4.8 psf	1586.70 lbs		
Drywall (5/8")			2.5 psf	826.41 lbs		
Exterior Façade (panels, plastic wrap)			2.5 psf	826.41 lbs		<b>North Wall</b>
Glass Wall	1		526.5 lbs	526.50 lbs		<b>3766.01</b>
<b>South Wall</b>						
Area	323.30 sqft					
Length	32.33 ft					
Height	10 ft					
6" SIPs			4.8 psf	1551.84 lbs		
Doors	1		100 lbs	100.00 lbs		
Interior Finish			2.5 psf	808.25 lbs		<b>South Wall</b>
Drywall (5/8")			2.5 psf	808.25 lbs		<b>3268.34</b>
<b>West Wall (Mechanical)</b>						
Area	150 sqft					
Length	15 ft					
Height	10 ft					
Glass Wall	1		526.5 lbs	526.50 lbs		
Water Heater Tank	1		400 lbs	400.00		
Mechanical Equipment	1		143 lbs	143.00		
Venmar Constructo	1		42 lbs	42.00		
Unico Ventilator	1		92 lbs	92.00		
10 Gallon Resevior	1		28 lbs	28.00		<b>West Wall (Mec)</b>
						<b>1231.50</b>
<b>West Wall (SIP Wall)</b>						
Area	150 sqft					
Length	15 ft					
Height	10 ft					
6" SIPs			4.8 psf	720.00 lbs		<b>West Wall (SIP)</b>
Drywall (5/8")			2.5 psf	375.00 lbs		<b>1095.00</b>
<b>Temp. Shipping Wall</b>						
Length of East Section	15 ft					
Length of South Section	8.87 ft					
2X4 Stud Wall (16" O.C.)			9.75 plf	146.25 lbs		<b>Shipping Wall</b>
2X4 Stud Wall (16" O.C.)			9.75 plf	86.48 lbs		<b>232.73</b>
<b>Bathroom Floor</b>						
Area	238.13					
Length (Total - .5ft)	31.75					
Width (Total - .5ft)	7.5					
Concrete Floor (3" @ 110 pcf)			27.5 psf	6548.44 lbs		
Insulation (3")			3.6 psf	857.25 lbs		<b>Floor</b>
Plywood Floor (1")			2.25 psf	535.78 lbs		<b>7941.47</b>
						<b>Living Room Section</b>
						<b>19526.11</b>

JOB \_\_\_\_\_  
 SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
 CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
 CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

TABLE 3.1E

SOLARIUM CRANE WEIGHT CALCULATIONS						
Item	Quantity	Weight	Units	Total	Units	Grand Total
<b>Solarium Floor</b>						
Area	108 sqft					
Length	18 ft					
Width	6 ft					
Concrete Floor (3" @ 110 pcf)		27.5 psf		2970 lbs		
Insulation (3")		3.6 psf		388.8 lbs		<b>Solarium Floor</b>
Plywood Floor (1")		2.25 psf		243 lbs		<b>3601.80</b>
					<b>Solarium*</b>	<b>3601.80</b>
					<b>Solarium Section*</b>	<b>1200.6</b>

\*Solarium breaks into three equal sections

### 3.1.2 - LIFT POINTS

#### 3.1.2.1 SPECIFICATIONS

The house will be lifted in sections by using straps specified by the craning company. These straps will span underneath each section along the steel floor joists to prevent buckling.

#### 3.1.2.2 LOADS

Table 3.1A shows the expected loads for each section. Each section will be picked up with two to three craning straps. These straps will then connect to the cables. As is noticeable from the table, the largest expected load at any section is 15.73 tons. This is the design load we will use sizing the craning straps.

#### 3.1.2.3 DIAGRAM

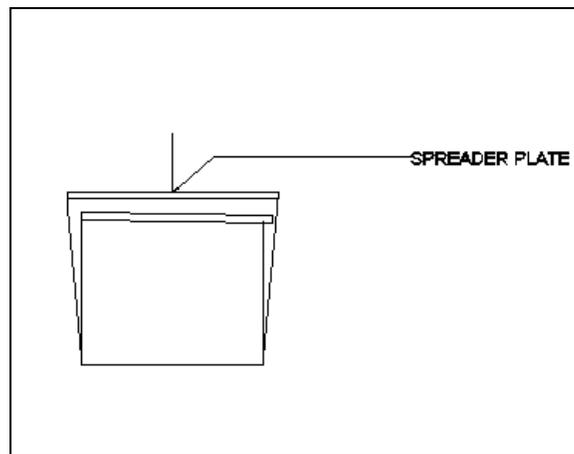
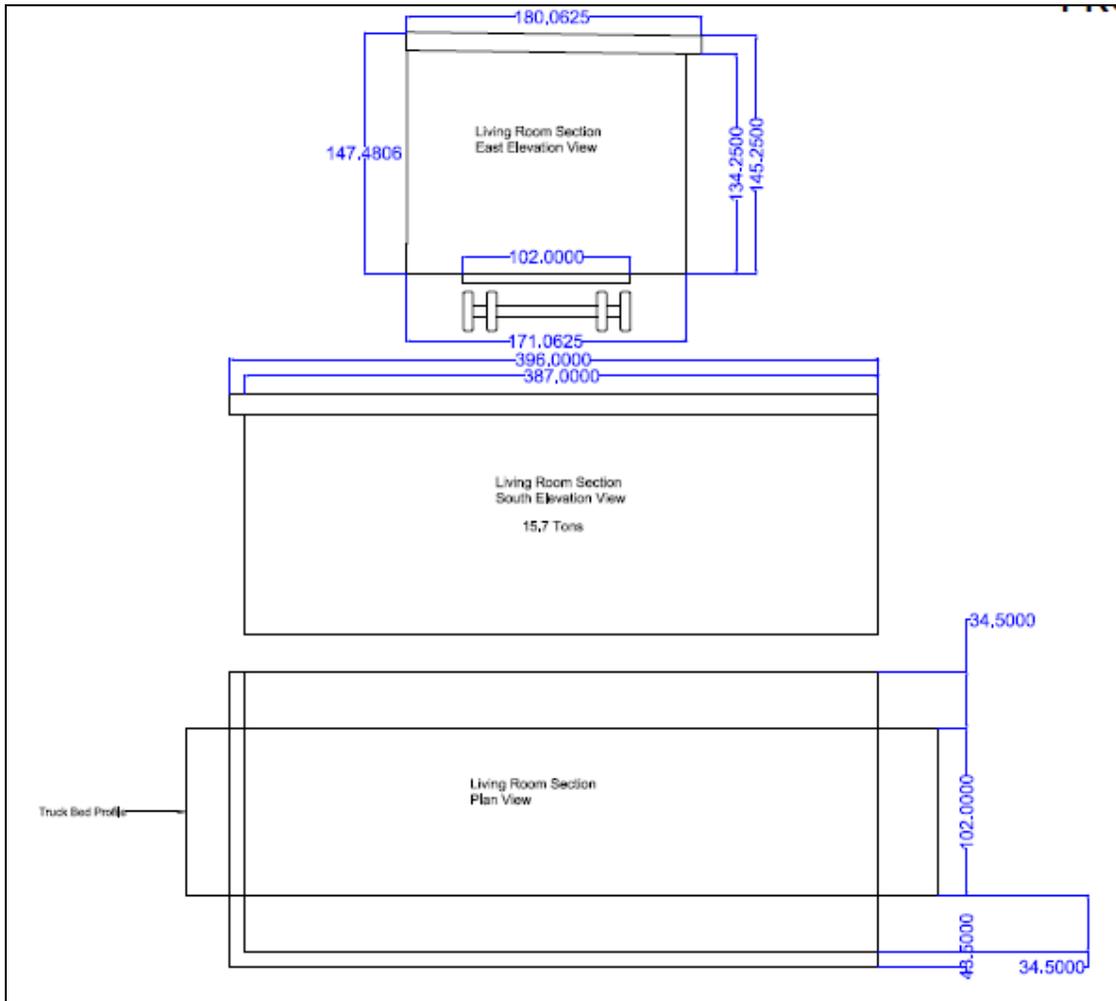


FIGURE 3.1.2.3A

## 4. TRUCKING

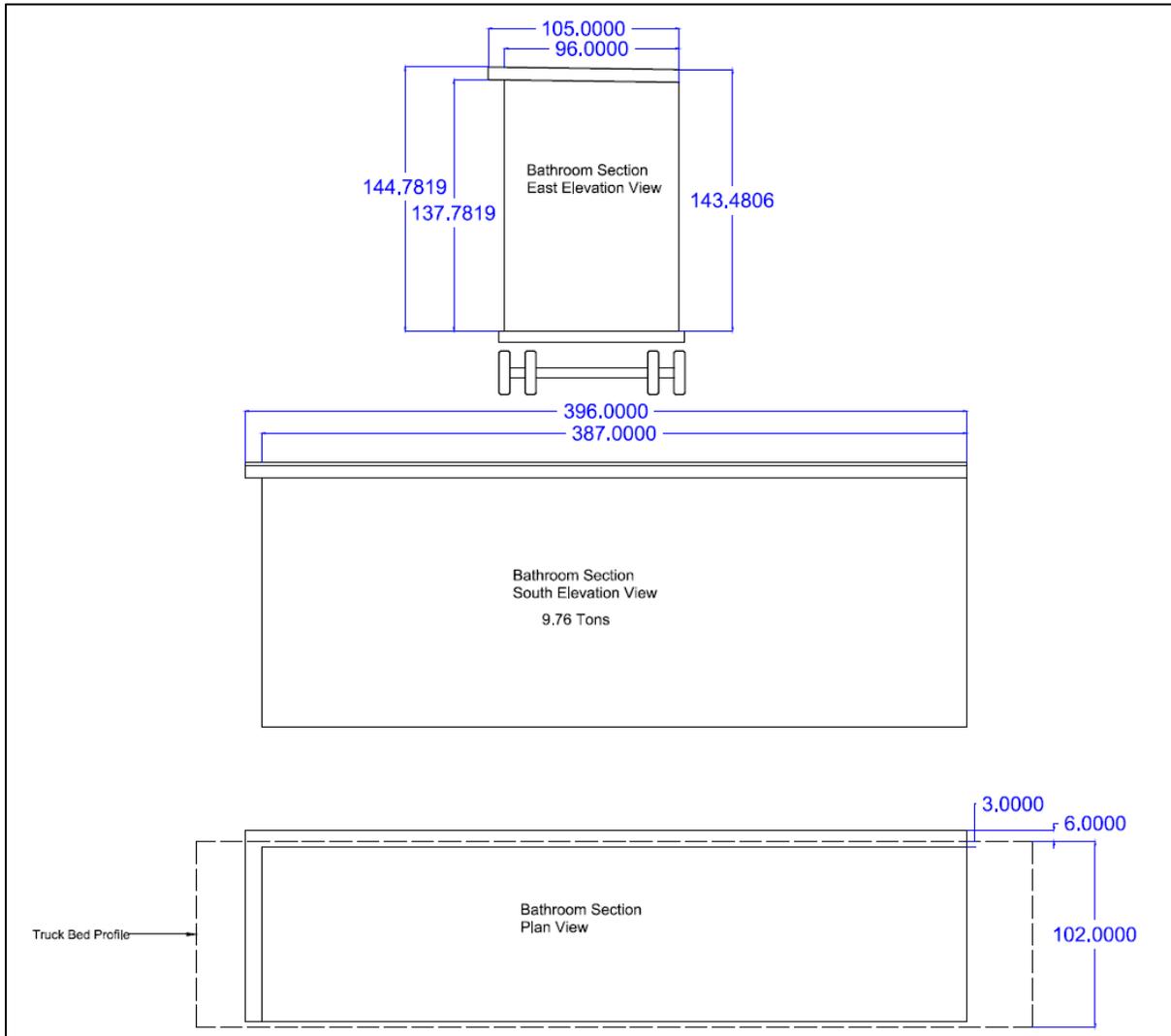
### 4.1 - SECTION DIAGRAM LIVING ROOM SECTION

TABLE 4.1A



BATHROOM SECTION

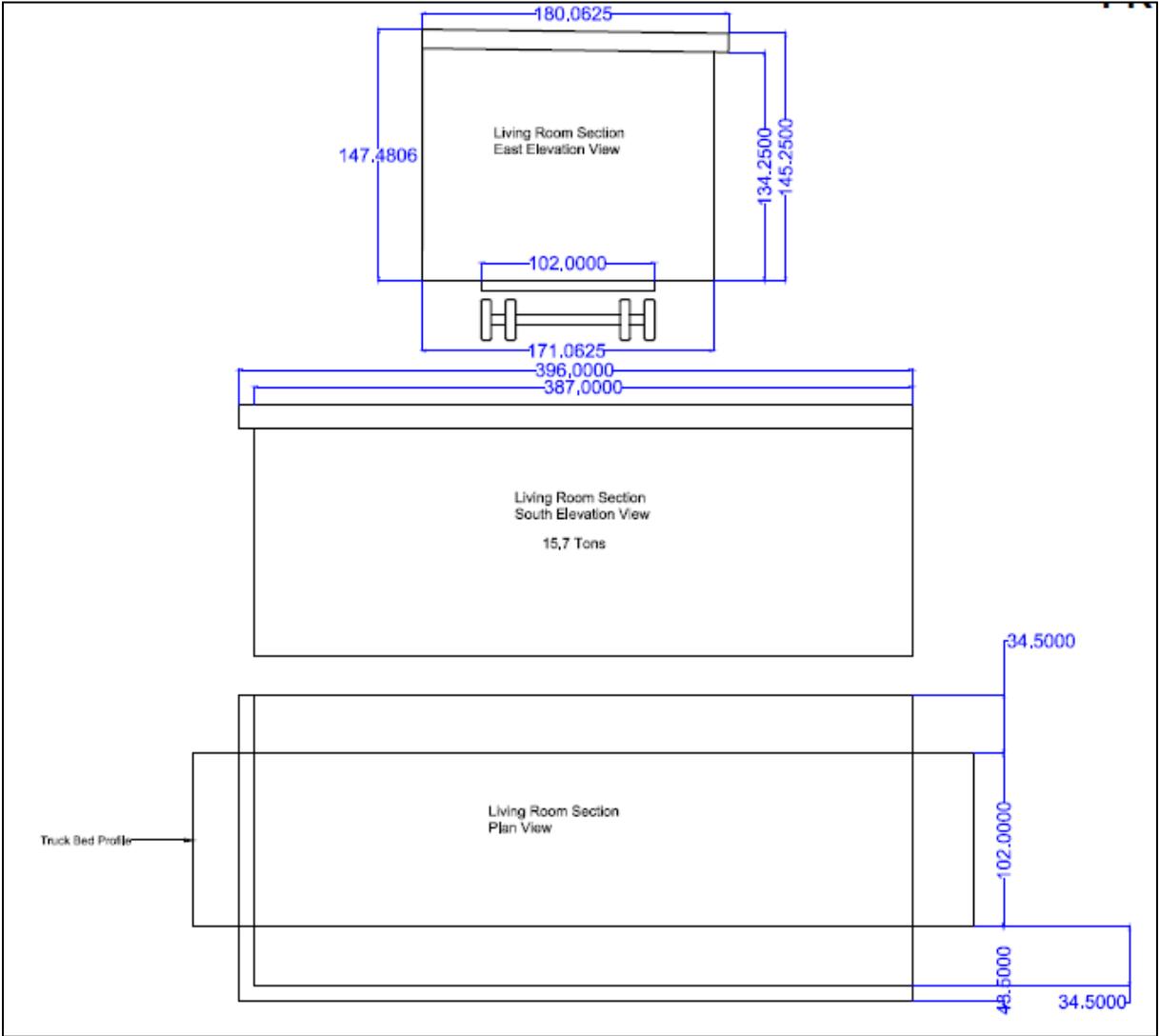
TABLE 4.1B



JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

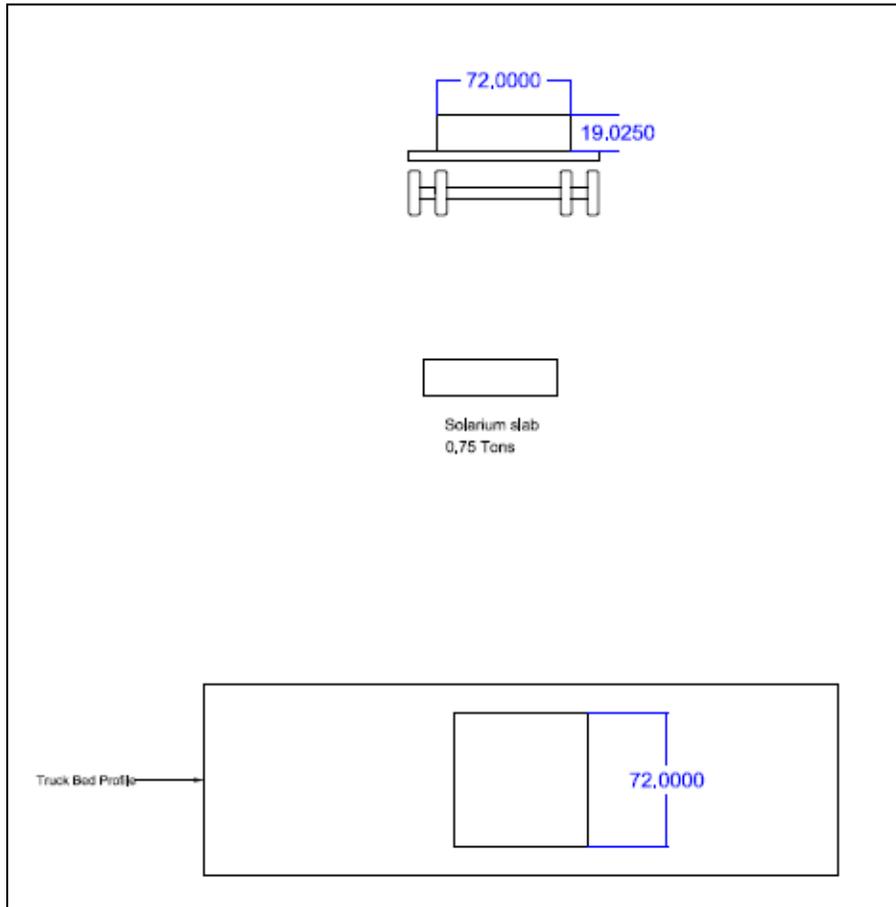
BEDROOM SECTION

TABLE 4.1C



SOLARIUM SLAB PIECE

TABLE 4.1D



**5.4 - TIE DOWNS**

The house will be tied down at the locations as the lift points used for the crane straps. There will be four quarter inch steel edge guards on each section that will act as reinforcement for the tie downs. These will each run four feet along each section of the house which will then be tied down to the truck. The sections will be tied down with the crane anchor points. An engineering judgment was made to assume that the anchor points can support the weight of the house then will be able to support the applied loads during transportation.

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

## **6. APPENDICIES**

- A. ENERGY PANEL SOLUTIONS' NTA LISTING REPORT
- B. US SOLAR DECATHALON 2013 RULES
- C. US SOLAR DECATHALON BUILDING CODE
- D. ENERGY PANEL SOLUTIONS' DESIGN REPORT AND CALCULATIONS
- E. SUMMARY OF TENK SOLAR WIND TUNNEL FORCE COEFFICIENTS
- F. SCALING WIND TUNNEL RESULTS FROM JUPITER TO NEPTUNE
- G. TENK SOLAR PANEL DIMENSIONS AND ANGLES
- H. SEISMIC FOOTING CALCULATIONS
- I. STEEL STRAPPING CALCULATIONS
- J. GABRIEL CRANE INFORMATION
- K. WOOD FRAME CONSTRUCTION MANUAL REFERNCE

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**A. ENERGY PANEL SOLUTIONS' NTA LISTING REPORT**



**PRODUCT:** Structural Insulated Panels (SIPs)  
**DIVISION:** Wood and Plastics (06)  
**SECTION:** Structural Panels (06 12 16)

**Report Holder**  
Structural Insulated Panel Association (SIPA)  
PO Box 1699  
Gig Harbor, WA 98335

#### Manufacturing Locations

**Energy Panel Structures, Inc. (NTA Plant #549)**  
102 East Industrial Park  
Graettinger, IA 51342

#### 1. SUBJECT

**Energy Panel Structures Structural Insulated Panels. Wall and Roof Panels 8 ft. to 20 ft. long, 4-5/8 in. to 12-1/4 in. thick.**

#### 2. SCOPE

2.1. NTA, Inc. has evaluated the above product(s) for compliance with the applicable sections of the following codes:

- 2.1.1. 2006, 2009 International Building Code (IBC)
- 2.1.2. 2006, 2009 International Residential Code (IRC)

2.2. NTA, Inc. has evaluated the above product(s) in accordance with:

- 2.2.1. NTA IM 014 Structural Insulated Panel Evaluation
- 2.2.2. NTA IM 036 Quality System Requirements

2.3. NTA, Inc. has evaluated the following properties of the above product(s):

- 2.3.1. Structural performance under axial, transverse and racking loads.

To obtain the most current NTA Listing Report visit [www.ntainc.com/product-certification/](http://www.ntainc.com/product-certification/).

#### 3. USES

**3.1. General.** *Energy Panel Structures Structural Insulated Panels* are used as structural insulated roof and wall panels capable of resisting transverse, axial and in-plane shear loads.

**3.2. Construction Types.** *Energy Panel Structures Structural Insulated Panels* shall be considered combustible building elements when determining the Type of Construction in accordance with 2009 IBC Chapter 6. <sup>(IM 014 NACU1)</sup>

**3.3. Fire Resistive Assemblies.** *Energy Panel Structures Structural Insulated Panels* shall not be used as part of a fire-rated assembly unless suitable evidence and details are submitted and approved by the authority having jurisdiction. <sup>(IM 014 ACU14)</sup>

#### 4. DESCRIPTION

**4.1. General.** *Energy Panel Structures Structural Insulated Panels* are factory-assembled, engineered-wood-faced, structural insulated panels (SIPs) with an expanded polystyrene (EPS) foam core. The panels are intended for use as load-bearing or non-load bearing wall and roof panels. Panels are available in 4-5/8 in. through 12-1/4 in. overall thicknesses. The panels are custom made to the specifications for each use and are assembled under factory-controlled conditions. The maximum panel size is 8 ft. wide and up to 20 ft. in length.

#### 4.2. Materials

**4.2.1. Facing.** The facing consists of two single-ply oriented strand board (OSB) facings a minimum of 7/16 in. thick conforming to 2009 IRC Table 613.3.2 and DOC PS 2-04, Exposure 1, Rated Sheathing with a span index of 24/16. Panels may be manufactured with the facing strength axis oriented in either direction with respect to the direction of SIP bending provided the appropriate strength values are used.

**4.2.2. Core.** The core material is EPS Foam conforming to the Type I specification defined in ASTM C578. The foam core, up to 11-3/8 in. thickness, has a flame spread rating not exceeding 75 and a smoke-developed rating not exceeding 450 in compliance with 2009 IBC Section 2603.3 Exception 4.

**4.2.3. Adhesive.** Facing materials are adhered to the core material using a structural adhesive. The adhesive is applied during the lamination process in accordance with the in-plant quality system documentation.

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NTA, INC. • 305 NORTH OAKLAND AVENUE • P.O. BOX 490 • NAPPANEE, INDIANA 46550  
WEB: WWW.NTAINC.COM

PHONE: 574-773-7975  
FAX: 574-773-2260

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Issue/Revision Date: 04/05/2012  
This report is subject to annual renewal.

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**4.2.4. Material Sources.** The facing, core and adhesive used in the construction of *Energy Panel Structures Structural Insulated Panels* shall be composed only of materials from approved sources as identified in the in-plant quality system documentation. A list of material suppliers is provided in Table 9.

**4.2.5. Splines.** *Energy Panel Structures Structural Insulated Panels* are interconnected with surface splines or block splines (Figure 1). Connections using dimensional lumber splines or engineered structural splines are not specifically addressed in this report and must be designed in accordance with accepted engineering practice to meet applicable code requirements. <sup>(IM 014 ACU 20)</sup>

**4.2.5.1. Surface Splines.** Surface splines (Figure 1) consist of 3 in. wide by 7/16 in. thick or thicker OSB. At each panel joint, one surface spline is inserted into each of two tight-fitting slots in the core. The slots in the core are located just inside the facing.

**4.2.5.2. Block Splines.** Block splines (Figure 1) are manufactured in the same manner as the SIP except with an overall thickness that is 1 in. less than the overall thickness of the panel to be joined.

## 5. DESIGN

**5.1. Overall Structural System.** The scope of this report is limited to the evaluation of the SIP component. Panel connections and other details related to incorporation of the panel into the overall structural system of a building are beyond the scope of this report. <sup>(IM 014 NACU3)</sup>

**5.2. Design Approval.** Where required by the authority having jurisdiction, structures using *Energy Panel Structures Structural Insulated Panels* shall be designed by a registered design professional. Construction documents, including engineering calculations and drawings providing floor plans, window details, door details and connector details, shall be submitted to the code official when application is made for a permit. The individual preparing such documents shall possess the necessary qualifications as required by the applicable code and the professional registration laws of the state where the construction is undertaken. Approved construction documents shall be available at all times on the jobsite during installation. <sup>(IM 014 NACU4)</sup>

**5.3. Design Loads.** Design loads to be resisted by the SIPs shall be as required under the applicable building code. Loads on the panels shall not exceed the loads noted in this report.

**5.4. Allowable Loads.** Allowable axial, transverse, and racking loads may be calculated using the panel properties provided in Tables 1 and 2 or may be selected from Tables 3 through 7. Maximum and minimum panel heights, spans and thicknesses are limited as provided in Table 2 through 7. Unless otherwise noted, all properties and allowable loads apply to panels joined with surface or block splines. Allowable loads for reinforced panel capacities shall be designed by a registered professional. Calculations demonstrating that the loads applied are less than the allowable loads described in this report shall be submitted to the code official for approval. <sup>(IM 014 NACU5)</sup> For loading conditions not specifically addressed herein, structural members designed in accordance with accepted engineering practice shall be provided to meet applicable code requirements.

**5.5. Concentrated Loads.** Axial loads shall be applied to the SIP through continuous members such as structural insulated roof or floor panels or repetitive members such as joists, trusses or rafters spaced at regular intervals of 24 in. on center or less. Such members shall be fastened to a rim board or similar member to distribute the load to the SIP. For other loading conditions, reinforcement shall be provided. This reinforcement shall be designed in accordance with accepted engineering practice. <sup>(IM 014 ACU12)</sup>

**5.6. Eccentric and Side Loads.** Axial loads shall be applied concentrically to the top of the SIP. Loads shall not be applied eccentrically or through framing attached to one side of the panel (such as balloon framing) except where additional engineering documentation is provided. <sup>(IM 014 ACU13)</sup>

**5.7. Openings.** Openings in panels shall be reinforced with wood or steel designed in accordance with accepted engineering practice to resist all loads applied to the opening as required by the adopted code. Details for door and window openings shall be provided to clarify the manner of supporting axial, transverse and/or racking shear loads at openings. Such details shall be shown on approved design documents and subject to approval by the local authority having jurisdiction. <sup>(IM 014 ACU8)</sup>

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**5.8. In-Plane Shear Design.** Shear walls utilizing block or surface splines shall be sized to resist all code required wind and seismic loads without exceeding the allowable loads provided in Tables 6 and 7. Shear wall chords, hold-downs and connections to transfer shear forces between the wall and surrounding structure shall be designed in accordance with accepted engineering practice. Allowable strengths for shear walls with structural splines along each panel edge shall be designed in accordance with accepted engineering practice and subject to the limitations for wood sheathed shear walls.

**5.8.1. Seismic Design Categories A, B and C.** The use of the shear wall configurations in Table 6 is limited to structures in Seismic Design Categories A, B and C. Where SIPs are used to resist seismic forces the following factors shall be used for design: Response Modification Coefficient,  $R = 2.0$ ; System Overstrength Factor,  $\Omega_D = 2.5$ ; Deflection Amplification Factor,  $C_d = 2.0$ . <sup>(IM 014 ACU16)</sup> The maximum panel height-to-width ratio shall be 2:1. <sup>(IM 014 ACU17)</sup>

**5.8.2. Seismic Design Categories D, E, and F.** The shear wall configurations in Table 7 are permitted in Seismic Design Categories D, E and F. Such walls shall be designed using the seismic design coefficients and limitations provided in ASCE 7-05 for light-framed walls sheathed with wood structural panels rated for shear resistance (SFRS A13). These SIPs shall use the following factors for design: Response Modification Coefficient,  $R = 6.5$ ; System Overstrength Factor,  $\Omega_D = 3.0$ ; Deflection Amplification Factor,  $C_d = 4.0$ . <sup>(IM 014 ACU16)</sup> The maximum panel height-to-width ratio shall be 1:1. <sup>(IM 014 ACU17)</sup>

**5.8.3. Adhesives and Sealants.** Adhesives and sealants shall not be applied at wood-to-wood or spline-to-facing interfaces in shear walls in Seismic Design Categories D, E and F <sup>(IM 014 NACU10)</sup>. Adhesives and sealants may be applied to wood-to-foam or facing-to-foam interfaces. Flexible SIP tape may be applied over panel joints.

**5.9. Horizontal Diaphragms.** Horizontal diaphragms shall be sized to resist all code required wind and seismic loads without exceeding the allowable loads provided in Table 8. Diaphragm chords and connections to transfer shear forces between the diaphragm and surrounding structure shall be designed in accordance with accepted engineering practice. The maximum diaphragm length-to-width ratio shall not exceed 3:1. <sup>(IM 014 ACU18)</sup>

**5.10. Combined Loads.** Panels subjected to any combination of transverse, axial or in-plane shear loads shall be analyzed utilizing a straight line interaction in accordance with *NTA IM014 TIP 01 SIP Design Guide*.

## 6. INSTALLATION

**6.1. General.** *Energy Panel Structures Structural Insulated Panels* shall be fabricated, identified and erected in accordance with this report, the approved construction documents and the applicable code. In the event of a conflict between the manufacturer's published installation instructions and this report, this report shall govern. Approved construction documents shall be available at all times on the jobsite during installation. <sup>(IM 014 NACU7)</sup>

**6.2. Splines.** *Energy Panel Structures Structural Insulated Panels* are interconnected at the panel edges through the use of a spline. The spline type may be of any configuration listed in Section 4.2.5 as required by the specific design. The spline shall be secured in place with not less than 0.131 in. x 2-1/2 in. nails, spaced 6 in. on center on both sides of the panel, or an approved equivalent fastener. All joints shall be sealed in accordance with the SIP manufacturer's installation instructions. Alternate spline connections may be required for panels subjected to in-plane racking forces. Such panels shall be interconnected exactly as required in Table 6 or 7 or as directed by the designer.

**6.3. Plates.** The top and bottom plates of the panels shall be dimensional or engineered lumber sized to match the core thickness of the panel. The plates shall be secured using not less than 0.131 in. x 2-1/2 in. nails, spaced 6 in. on center on both sides of the panel, or an approved equivalent fastener.

A second plate composed of 1-1/8 in. minimum thickness dimensional or engineered lumber with a specific gravity of 0.42 that is cut to the full thickness of the panel shall be secured to the first top plate using 0.131 in. x 3 in. nails or an approved equivalent fastener.

**6.4. Cutting and Notching.** No field cutting or routing of the panels shall be permitted except as shown on approved drawings. <sup>(IM 014 NACU6)</sup>

**6.5. Protection from Decay.** SIPs that rest on exterior foundation walls shall not be located within 8 in. of exposed earth. SIPs supported by concrete or masonry that is in direct contact with earth shall be protected from the concrete or masonry by a moisture barrier. <sup>(IM 014 ACU6)</sup>

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**6.6. Protection from Termites.** In areas subject to damage from termites, SIPs shall be protected from termites using an approved method. Panels shall not be installed below grade or in contact with earth. <sup>(IM 014 ACU7)</sup>

**6.7. Heat-Producing Fixtures.** Heat-producing fixtures shall not be installed in the panels unless protected by a method approved by the code official or documented in test reports. This limitation shall not be interpreted to prohibit heat-producing elements with suitable protection. <sup>(IM 014 NACU9)</sup>

#### **6.8. Voids and Holes**

**6.8.1 Voids in Core.** In lieu of openings designed in accordance with section 5.7, the following voids are permitted. Voids may be provided in the panel core during fabrication at predetermined locations only. Voids parallel to the panel span shall be limited to a single 1 in. maximum diameter hole. Such voids shall be spaced a minimum of 4 ft. on center measured perpendicular to the panel span. Two 1/2 in. diameter holes may be substituted for the single 1 in. hole provided they are maintained parallel and within 2 in. of each other. <sup>(IM 014 ACU11)</sup>

Voids perpendicular to the panel span shall be limited to a single 1 in. maximum diameter hole placed not closer than 16 in. from the support. Additional voids in the same direction shall be spaced not less than 28 in. on center.

**6.8.2 Holes in Panels.** Holes may be placed in panels during fabrication at predetermined locations only. Holes shall be limited to 4 in. x 4 in. square. The minimum distance between holes shall not be less than 4 ft. on center measured perpendicular to the panel span and 24 in. on center measured parallel to the panel span. Not more than three holes shall be permitted in a single line parallel to the panel span. The holes may intersect voids permitted elsewhere in this report. <sup>(IM 014 ACU15)</sup>

#### **6.9. Panel Cladding**

**6.9.1 Roof Covering.** The roof covering, underlayment and flashing shall comply with the applicable code(s). All roofing materials must be installed in accordance with the manufacturer's installation instructions. The use of roof coverings requiring the application of heat during installation shall be reviewed and approved by a registered design professional.

**6.9.2 Exterior Wall Covering.** Panels shall be covered on the exterior by a water-resistive barrier as required by the applicable code. The water-resistive barrier shall be attached with flashing in such a manner as to provide a continuous water-resistive barrier behind the exterior wall veneer. <sup>(IM 014 ACU9)</sup> The exterior facing of the SIP wall shall be covered with weather protection as required by the adopted building code or other approved materials. <sup>(IM 014 ACU10)</sup>

**6.9.3 Interior Finish.** The SIP foam plastic core shall be separated from the interior of the building by an approved thermal barrier of 1/2 in. gypsum wallboard or equivalent thermal barrier where required by 2009 IBC Section 2603.4.

### **7. CONDITIONS OF USE**

*Energy Panel Structures Structural Insulated Panels* as described in this report comply with the codes listed in Section 2.0, subject to the following conditions:

- 7.1.** Installation complies with this report and the approved construction documents.
- 7.2.** This report applies only to the panel thicknesses specifically listed herein. <sup>(IM 014 ACU3)</sup>
- 7.3.** In-use panel heights/spans shall not exceed the values listed herein. Extrapolation beyond the values listed herein is not permitted. <sup>(IM 014 ACU2)</sup>
- 7.4.** The panels are manufactured in the production facilities noted in this report. <sup>(IM 014 NACU8)</sup>

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**8. EVIDENCE SUBMITTED**

NTA, Inc. has examined the following evidence to evaluate this product:

- 8.1. Review of each manufacturing facility's quality system documentation for conformance to NTA IM 036.
- 8.2. Qualification test data in accordance with NTA IM 14 *Standard Evaluation Plan 01* (IM 014 SEP 01).
- 8.3. Periodic quality system audits of the production facilities.
- 8.4. Periodic testing in accordance with NTA IM 014.

Evaluation evidence and data are on file with NTA, Inc. NTA, Inc. is accredited by the International Accreditation Service (IAS) as follows:

*ISO17020 Inspection Agency (AA-682)*  
*ISO17025 Testing Laboratory (TL-259)*  
*ISO Guide 65 Product Certification Agency (PCA-102)*

The scope of accreditation related to testing, inspection or product certification pertain only to the test methods and/or standard referenced therein. Design parameters and the application of building code requirements, such as special inspection, have not been reviewed by IAS and are not covered in the accreditation. Product evaluations are performed under the direct supervision of Professional Engineers licensed in all jurisdictions within the United States as required by the building code and state engineering board rules.

**9. FINDINGS**

**All products referenced herein are manufactured under an in-plant quality assurance program to insure that the production quality meets or exceeds the requirements of the codes noted herein and the criteria as established by NTA, Inc. Furthermore, panels must comply with the conditions of this report.**

***This report is subject to annual renewal.***

**10. IDENTIFICATION**

Each eligible panel shall be permanently marked to provide the following information:

- a) The NTA, Inc. listing mark, shown below
- b) NTA's Listing No. EPS102108-21
- c) In-plant quality assurance stamp
- d) Identifier for production facility
- e) Project or batch number.



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**Table 1: Basic Properties<sup>1,2</sup>**

Property	Weak-Axis Bending	Strong-Axis Bending
Allowable Tensile Stress, $F_t$ (psi)	245	495
Allowable Compressive Stress, $F_c$ (psi)	340	580
Elastic Modulus (Bending), $E_b$ (psi)	738900	658800
Shear Modulus, $G$ (psi)	270	405
Allowable Core Shear Stress, $F_v$ (psi)	4.5	5.0
Core Compressive Modulus, $E_c$ (psi)	360	360
Reference Depth, $h_o$ (in.)	4.625	4.625
Shear Depth Factor Exponent, $m$	0.84	0.86

<sup>1</sup> All properties are based on a minimum panel width of 24 in.

<sup>2</sup> Refer to NTA IM14 TIP 01 SIP Design Guide for details on engineered design using basic panel properties.

**Table 2: Section Properties**

Panel Thickness, $h$ (in.)	Core Thickness, $c$ (in.)	Dead Weight, $w_d$ (psf)	Facing Area, $A_f$ (in. <sup>2</sup> /ft)	Shear Area, $A_v$ (in. <sup>2</sup> /ft)	Moment of Inertia, $I$ (in. <sup>4</sup> /ft)	Section Modulus, $S$ (in. <sup>3</sup> /ft)	Radius of Gyration, $r$ (in.)	Centroid-to-Facing Dist., $y_c$ (in.)
4.625	3.75	3.2	10.5	50.3	46.0	19.9	2.09	2.31
6.50	5.625	3.3	10.5	72.8	96.5	29.7	3.03	3.25
8.25	7.375	3.5	10.5	93.8	160.2	38.8	3.91	4.13
10.25	9.375	3.6	10.5	117.8	252.7	49.3	--	--
12.25	11.375	3.8	10.5	141.8	366.3	59.8	--	--



**Figure 1: SIP Spline Types**

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**Table 3: Allowable Uniform Transverse Loads<sup>1,4</sup>**

Panel Length (ft)	4-5/8 inch Thick SIP			6-1/2 inch Thick SIP		
	Deflection Limit <sup>2</sup>			Deflection Limit <sup>2</sup>		
	L/180	L/240	L/360	L/180	L/240	L/360
8 WAB <sup>3</sup>	50.8	40.9	27.3	73.8	64.7	43.1
8	68.8	51.6	34.4	80.6	80.6	56.6
10	45.1	33.8	22.5	62.0	57.9	38.6
12	30.8	23.1	15.4	50.4	40.9	27.3
14	21.7	16.3	--	39.6	29.7	19.8
16	--	--	--	29.4	22.1	14.7
18	--	--	--	22.4	16.8	--

See Table 4 for notes.

**Table 4: Allowable Uniform Transverse Loads (continued)<sup>1,4</sup>**

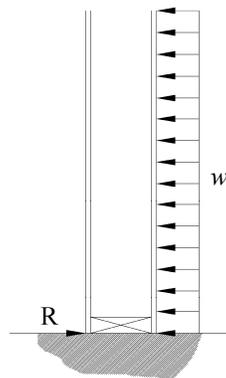
Panel Length (ft)	8-1/4 inch Thick SIP			10-1/4 inch Thick SIP			12-1/4 inch Thick SIP		
	Deflection Limit <sup>2</sup>			Deflection Limit <sup>2</sup>			Deflection Limit <sup>2</sup>		
	L/180	L/240	L/360	L/180	L/240	L/360	L/180	L/240	L/360
8 WAB <sup>3</sup>	81.4	81.4	58.3	89.9	89.9	75.9	98.6	98.6	93.6
8	88.5	88.5	78.4	97.3	97.3	97.3	106.4	106.4	106.4
10	67.4	67.4	54.8	73.1	73.1	73.1	78.8	78.8	78.8
12	54.4	54.4	39.6	58.6	58.6	54.6	62.5	62.5	62.5
14	45.6	43.9	29.3	48.8	48.8	41.1	51.9	51.9	51.9
16	39.3	33.2	22.1	41.9	41.9	31.5	44.3	44.3	41.7
18	34.1	25.6	17.1	36.7	36.7	24.6	38.7	38.7	32.9
20	26.7	20.0	13.4	32.6	29.2	19.5	34.3	34.3	26.3

<sup>1</sup> Table values assume a simply supported panel with 1.5 in. of continuous bearing on facing at supports ( $C_v = 1.0$ ) with solid wood plates at bearing locations. Values do not include the dead weight of the panel. For wall panel capacities utilizing a zero bearing configuration, shown in Figure 2, multiply the allowable uniform load shown by  $C_v = 0.4$ .

<sup>2</sup> Deflection limit shall be selected by building designer based on the serviceability requirements of the structure and the requirements of adopted building code. Values are based on loads of short duration only and do not consider the effects of creep.

<sup>3</sup> Tabulated values are based on the strong-axis of the facing material oriented parallel to the direction of panel bending. WAB indicates weak-axis bending of the facing material; the strong-axis of the facing material is oriented perpendicular to the direction of panel bending.

<sup>4</sup> Permanent loads, such as dead load, shall not exceed 0.50 times the tabulated load.



**Figure 2: Zero Bearing Support**

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**Table 5: Allowable Axial Loads (plf)<sup>1,2,3,4</sup>**

Lateral Brace Spacing (ft)	Panel Thickness		
	4-5/8 inch	6-1/2 inch	8-1/4 inch
8 WAB <sup>5</sup>	2320	2470	2530
8	3630	4070	4240
10	3260	3890	4130
12	2810	3660	4000
14	--	3390	3830
16	--	3090	3640
18	--	2790	3430
20	--	--	3190

- Permanent loads, such as dead load, shall not exceed 0.50 times the tabulated load.
- All values are for normal duration and may not be increased for other durations.
- Axial loads shall be applied concentrically to the top of the panel through repetitive members spaced not more than 24 in. on center. Such members shall be fastened to a rim board or similar member to distribute along the top of the SIP.
- The ends of both facings must bear on the supporting foundation or structure to achieve the tabulated axial loads.
- Tabulated values are based on the strong-axis of the facing material oriented parallel to the direction of panel bending. WAB indicates weak-axis bending of the facing material; the strong-axis of the facing material is oriented perpendicular to the direction of panel bending.

**Table 6: Allowable In-Plane Shear Strength (Pounds per Foot) for SIP Shear Walls (Wind and Seismic Loads in Seismic Design Categories A, B and C)<sup>1,3</sup>**

Spline Type <sup>4</sup>	Nominal SIP Thickness (in.)	Minimum Facing Connections <sup>3,5</sup>			Shear Strength (plf)
		Chord <sup>3</sup>	Plate <sup>3</sup>	Spline <sup>4</sup>	
Block or Surface Spline	4.625	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	380
	6.625	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	380
	8.375	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	400

See Table 7 for notes.

**Table 7: Allowable In-Plane Shear Strength (Pounds per Foot) for SIP Shear Walls (Wind and Seismic Loads in Seismic Design Categories D, E and F)<sup>2,3</sup>**

Spline Type <sup>4</sup>	Nominal SIP Thickness (in.)	Minimum Facing Connections <sup>3,5</sup>			Shear Strength (plf)
		Chord <sup>3</sup>	Plate <sup>3</sup>	Spline <sup>4</sup>	
Block or Surface Spline	6.5	0.131"x 2-1/2" nails, 3" oc (3/8" edge distance)	0.131"x 2-1/2" nails, 3" oc (3/8" edge distance)	0.131"x 2-1/2" nails, 3" oc (23/32" thick, 3" wide spline)	900

- Maximum shear wall dimensions ratio shall not exceed 2:1 (height: width) for resisting wind or seismic loads.
- Maximum shear wall dimension ratio shall not exceed 1:1 (height: width) for resisting wind or seismic loads.
- Chords, hold downs and connections to other structural elements must be designed by a registered design professional in accordance with accepted engineering practice.
- Spline type at interior panel-to-panel joints only. Solid chord members are required at each end of each shear wall segment.
- Required connections must be made on each side of the panel. Dimensional or engineered lumber shall have an equivalent specific gravity of 0.42 or greater.

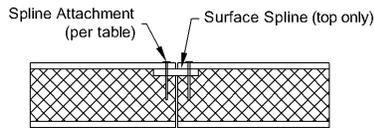
*This listing report is intended to indicate that NTA Inc. has evaluated product described and has found it to be eligible for labeling. Product not labeled as specified herein is not covered by this report. NTA Inc. makes no warranty, either expressed or implied, regarding the product covered by this report.*

**Table 8: Allowable In-Plane Shear Strength (Pounds per Foot)  
for Horizontal Diaphragms Subjected to Wind or Seismic Loading**

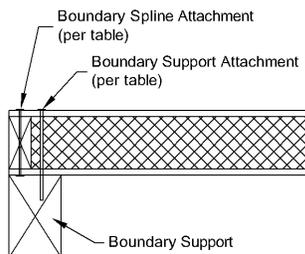
Nominal SIP Thickness (in.)	Minimum Connections		Shear Strength (plf)	Max. Aspect Ratio	
	Block Spline <sup>1</sup> (Figure 3a)	Boundary <sup>2</sup> (Figure 3b)			
		Support			Spline
8.25	0.131" x 2-1/2" nails, 6" oc 7/16" x 3" x 7-3/8" OSB Surface Spline	10" Length, 0.190" shank diameter, 0.255" thread o.d., 2.750" thread length 0.625" head diameter SIP Screw 6" oc	0.131" x 2-1/2" nails, 6" oc	265	3:1
	0.131" x 2-1/2" nails, 4" oc 7/16" x 3" x 7-3/8" OSB Surface Spline	10" Length, 0.190" shank diameter, 0.255" thread o.d., 2.750" thread length 0.625" head diameter SIP Screw 4" oc	0.131" x 2-1/2" nails, 4" oc	330	3:1
	0.131" x 2-1/2" nails, 2" oc staggered 3/8" (Figure 3c) 7/16" x 3" x 7-3/8" OSB Surface Spline	10" Length, 0.190" shank diameter, 0.255" thread o.d., 2.750" thread length 0.625" head diameter SIP Screw 3" oc	0.131" x 2-1/2" nails, 2" oc staggered 3/8" (Figure 3c)	575	3:1

<sup>1</sup> Top spline or block spline only at interior panel-to-panel joints. Specified fasteners are required on both sides of panel joint through the top surface only, as shown in Figure 3a.

<sup>2</sup> Boundary spline shall be solid lumber 1.5 in. wide minimum and have a specific gravity of 0.42 or greater. Specified fasteners are required through both facings as shown in Figure 3b.

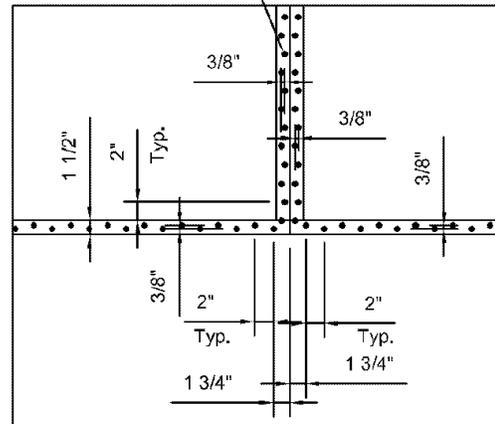


**Figure 3a: Surface Spline**



**Figure 3b: Boundary**

0.131" x 2 1/2" Nails, 2" O.C. (Staggered 3/8"),  
Fasteners Applied to Both Sides at SPF  
Members and Only One Side (the Side Opposite  
of Load Application) at All Block Splines



**Figure 3c: Boundary Spline**

**Figure 3: Diaphragm Connection Types**

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**Table 9: Component Material Sources**

Facing	Core	Adhesive
<p>Ainsworth Group of Companies Suite 3194 Bentall 4 1055 Dunsmuir Street Vancouver BC, Canada V7X 1L3</p>	<p>ACH Corporation Plant U-37 - Fond du Lac, WI</p>	<p>Ashland Specialty Chemical Company 5200 Blazer Parkway Dublin, OH 43017</p>
<p>Georgia-Pacific 9918 Buford Bridge Road Fairfax, SC 29827</p>	<p>Atlas EPS, A Division of Atlas Roofing Corporation 8240 Byron Center Road SW Byron Center, MI 49315</p>	<p>Foam Supplies, Inc. 4387 N. Rider Trail Earth City, MO 63045</p>
<p>Huber Engineered Woods 1000 Chaney Lane Crystal Hill, VA 24539</p>	<p>Iowa EPS Products, Inc. 5554 N.E. 16<sup>th</sup> Street Des Moines, IA 50313</p>	<p>Rohm and Haas Company 5005 Barnard Mill Road Ringwood, IL 60072</p>
<p>Louisiana-Pacific Corporation Sagola, MI  Sales and Marketing by: Affiliated Resources, Inc. River Forum 1 4380 SW Macadam Avenue, Suite 200 Portland, OR 97239</p>	<p>Northwest Foam Products, Inc. 2390 Rostron Circle Twin Falls, ID 83301</p>	
<p>Tolko Industries, Ltd. 3203 30<sup>th</sup> Avenue Vernon BC, Canada V1T 6M1</p>	<p>OPCO, Inc. P.O. Box 101 Latrobe, PA 15650</p>	
	<p>Plymouth Foam 1 Southern Gateway Drive Gnadenhutten, OH 44629</p>	
	<p>Polar Industries, Inc. 32 Gramar Avenue Prospect, CT 06712</p>	
	<p>Powerfoam Insulation 550 Murray Street/Highway 287 Midlothian, TX 76065</p>	

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JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**B. US DEPARTMENT OF ENERGY SOLAR DECATHALON 2013 RULES**



U.S. DEPARTMENT OF ENERGY  
**SOLAR DECATHLON**

**RULES**

Last Updated: September 24, 2012

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## SECTION I: DEFINITIONS

### **Assembly**

The period of time between the arrival of trucks and the beginning of the [contests](#) on the [competition](#) site

### **Communications manager**

The [organizer](#) responsible for the [project's](#) public outreach and communications activities

### **Communications materials**

All printed or electronic publications designed to convey information to the public

### **Competition**

All aspects of the Solar Decathlon related to the [contests](#) and the scoring of those [contests](#)

### **Competition manager**

The [organizer](#) responsible for writing and enforcing the [rules](#) and conducting a fair and compelling [competition](#)

### **Competition prototype**

The complete assembly of physical components installed within the [solar envelope](#)

### **Competition site**

The area provided by the organizers containing all [solar envelopes](#), pedestrian walkways, and associated organizer equipment, structures, and infrastructure

### **Contest**

The Solar Decathlon [competition](#) consists of 10 separately scored contests, each containing one or more [subcontests](#)

### **Contest official**

An individual selected by the [competition manager](#) to officiate one or more of the [contests](#); a contest official is only authorized to interpret the [rules](#) of the [contest\(s\)](#) to which he or she is assigned

### **Contest week**

The 9-day period on the [competition](#) site when some or all [contests](#) are in progress

### **Decathlete**

A [team member](#) who meets the decathlete eligibility rules outlined in the file posted in the "/Files/Rules" folder on the [Yahoo Group](#)

### **Decision**

The [rules officials'](#) interpretation or clarification of a [rule](#)

### **Decisions on the Solar Decathlon Rules**

The compilation of all [decisions](#) made by the [rules officials](#) during the [project](#)

### **Director**

The [organizer](#) representing the U.S. Department of Energy with final decision-making authority regarding all aspects of the [project](#)

### **Disassembly**

The period of time between the closing of the public exhibit and the completion of [competition](#) site cleanup; Rule 8-2 does not apply during disassembly

### **Event**

The activities that take place on the [competition](#) site including, but not limited to, registration, [assembly](#), inspections, [contests](#), special events, public exhibits, and [disassembly](#)

**Event production manager**

The [organizer](#) responsible for the [project's](#) special events and volunteer activities

**Event sponsor**

An entity selected by the [director](#) to support the Solar Decathlon—a project of the U.S. Department of Energy (DOE), which partners with other institutions, such as its National Renewable Energy Laboratory (NREL), to help ensure the success of the [project](#)

**Faculty advisor**

A [team member](#) who is the lead faculty member and primary representative of a participating school in the [project](#); also provides guidance to the team on an as-needed basis throughout the [project](#)

**Grid-tie assembly**

The period of time during [assembly](#) after the house has been connected to the village grid (interconnected); Rule 8-2 applies during grid-tie assembly

**Interconnection application**

Submitted in the project manual by the team's [electrical engineer](#), this form provides the technical details needed to determine the suitability of the team's electrical system for interconnection to the [village grid](#)

**Juried subcontest**

A [subcontest](#) based on a [jury](#) evaluation

**Juror**

An individual selected by the [organizers](#) to make subjective evaluations of the [projects](#)

**Jury**

A group of [jurors](#) evaluating a specific aspect of each team's [competition prototype](#)

**Measured subcontest**

A [subcontest](#) based on task completion or monitored performance

**Observer**

Assigned by the [competition manager](#) to observe team activities during [contest week](#), an [observer](#) reports observed [rules](#) infractions to the [rules officials](#) and records the results of specific [contest](#) tasks, but does not provide interpretations of the Solar Decathlon Rules

**Organizer**

A DOE or NREL employee, subcontractor, or [observer](#) working on the [project](#) and having the authority described in Rule 1-4

**Project**

All activities related to the U.S. Department of Energy Solar Decathlon 2013—from the issuance of the request for proposals through the closing of subcontracts

**Protest resolution committee**

A group of individuals selected by the [organizers](#) to resolve team protests during the [competition](#)

**Public exhibit**

Areas of the competition site open to the public during designated hours

**Rule**

A principle or regulation governing conduct, action, procedure, arrangement, etc., for the duration of the [project](#)

**Rules official**

An [organizer](#) authorized to interpret the [rules](#); the [competition manager](#) is the lead rules official

## **Safety officer**

An organizer whose primary responsibilities are to evaluate the teams' construction documents and the teams' competition site activities for compliance with Rule 3-3

## **Scored period**

Any 15-minute period beginning at 0, 15, 30, or 45 minutes after the hour, during which a particular monitored [contest](#) is in progress

## **Scorekeeper**

The individual selected by the [organizers](#) to operate the [scoring server](#) during the [competition](#)

## **Scoring server**

A server that collects data from the central datalogger server; includes forms for manually entering juried and task-based measured [contest](#) results, and calculates composite scores

## **Site operations manager**

The [organizer](#) responsible for all [event](#) site operations except those listed as responsibilities of the [competition manager](#) and [event production manager](#)

## **Solar Decathlon Building Code**

A set of design and construction standards set forth and enforced by the [Solar Decathlon building official](#) for the protection of public health and safety during the [event](#)

## **Solar Decathlon building official**

The [rules official](#) responsible for writing, interpreting, and enforcing the [Solar Decathlon Building Code](#)

## **Solar envelope**

The area, as defined by [Rule 5](#), containing the [competition prototype](#)

## **Stand-alone assembly**

The period of time during [assembly](#) before the house has been interconnected to the village grid; Rule 8-2 does not apply during stand-alone assembly

## **Staff**

Individuals working for the [organizers](#) on the [project](#), including volunteers

## **Subcontest**

An individually scored element within a [contest](#)

## **Team**

The combination of [team members](#), including [team crew](#) and [decathletes](#), representing a single entry to the [competition](#)

## **Team crew**

A person who is integrally involved with a team's [project](#) but is unaffiliated with a participating school; contractors, volunteers, team media, and sponsors represent team crew examples

## **Team member**

An enrolled student, recent graduate, faculty member, or other person who is affiliated with one of the participating schools and is integrally involved with a team's [project](#) activities; [decathletes](#), [faculty advisors](#), and involved staff from a participating school are all considered team members

## **Village grid**

The bi-directional, AC electrical network on the [competition](#) site to which each house has an individually metered connection

## **Yahoo Group**

A community website that includes official communications suitable for viewing by all [teams](#) and [organizers](#)

## SECTION II: GENERAL RULES

### *Rule 1. Authority*

#### **1-1. Director**

The director represents the U.S. Department of Energy and has the final decision-making authority in all aspects of the project.

#### **1-2. Competition Manager**

The competition manager is the only rules official authorized to write and modify the rules.

#### **1-3. Rules Officials**

The rules officials are the only organizers authorized to interpret the rules.

- a. If there is any doubt or ambiguity as to the wording or intent of these rules, the decision of the rules officials shall prevail.
- b. Printed, electronic, and verbal communications from the rules officials shall be considered part of, and shall have the same validity as, these rules.

#### **1-4. Organizers**

Occasionally, a rules official may not be immediately available to make an extremely time-sensitive decision. In these rare cases, organizers are authorized to revise the project schedule, change a team's score, or enforce the rules in any manner that is, in their sole judgment, required for the fair and efficient operation or safety of the competition.

#### **1-5. Staff**

Solar Decathlon staff are not authorized to revise the project schedule, change a team's score, or enforce the rules under any circumstances.

### *Rule 2. Administration*

#### **2-1. Precedence**

If there is a conflict between two or more rules, the rule having the later date takes precedence.

#### **2-2. Violations of Intent**

A violation of the intent of a rule is considered a violation of the rule itself.

#### **2-3. Effective Date**

The latest version of the Rules posted in the "/Files/Rules" folder on the Yahoo Group<sup>1</sup> and dated for the year of the event represents the Rules in effect.

#### **2-4. Official Communications**

It is the team's responsibility to stay current with official project communications. Official communications between the teams and the organizers occur through, but are not limited to, one or more of the following:

- a. **Yahoo Group** (<http://groups.yahoo.com/group/SD2013>): Official communications suitable for viewing by all teams and organizers are posted on the Yahoo Group message board. The Yahoo Group includes a section

<sup>1</sup> Members of the public without access to the Yahoo Group who are interested in receiving this information may email a request to the competition manager at [sdrules@nrel.gov](mailto:sdrules@nrel.gov).

for posting files. If files are too large for the Yahoo Group, they are posted on the FTP site or in the dropbox, and the teams are notified of the exact location of file(s) via the Yahoo Group. Other Yahoo Group features are used for various purposes. Instructions for joining the Yahoo Group are provided to each team immediately following the selection of teams.

- b. **Competition manager's email** ([sdrules@nrel.gov](mailto:sdrules@nrel.gov)): For confidential communications or the transfer of small (<5 MB), confidential files, teams may email the competition manager. The content of communications sent to this email address remains confidential, unless the team grants permission to the competition manager to divulge the content of these communications to the other teams. See the exception in Rule 2-5 for more information about confidentiality.
- c. **Dropbox** (<http://dropbox.yousendit.com/SolarDecathlon>): The dropbox is used by the organizers and teams to transfer large or confidential files. Notification of or requests for file transfers are made via the Yahoo Group or email.
- d. **Conference calls**: Teams are strongly encouraged to participate in regularly scheduled conference calls with the organizers. Invitations and instructions for participation in conference calls are provided via the Yahoo Group.
- e. **Meetings**: Before the event, the teams and organizers have one or more in-person meetings. Notification of the date(s) and agenda(s) for these meetings is made via the Yahoo Group. A meeting is held the day before assembly begins. Meetings are also held on a daily basis throughout the event.
- f. **Email**: For expediency and to protect confidentiality, the organizers may choose to communicate with teams via team members' email addresses listed in the Yahoo Group database. However, most official communication occurs via the Yahoo Group message board.

## 2-5. Decisions on the Rules

The Decisions on the Rules offers interpretations of the rules contained in this document, the Solar Decathlon Rules.

After the rules officials make a decision that may, in their opinion, directly or indirectly affect the strategies of all teams, the rules officials add the decision to the Decisions on the Rules and notify the teams of the addition via the Yahoo Group.

**Exception:** If such a notification would unfairly reveal the strategies of one or more individual teams, the organizers may, depending on the circumstances, refrain from notifying all teams of the decision.

## 2-6. Self-Reporting

Teams shall self-report obvious or suspected rules infractions that have occurred or may occur.

- a. The Solar Decathlon Rules do not address every possible scenario that may arise during the competition. Therefore, a team considering an action that is not explicitly permitted by the rules should ask the rules officials for a decision before proceeding with the action. If the team does not ask for an official decision, it puts itself at risk of incurring a penalty.
- b. The rules officials and director exercise discretion when determining the penalty for a rules infraction. Rules infractions observed by rules officials, organizers, or other teams, i.e., not self-reported by the team committing the infraction, may be subject to more severe penalties than self-reported rules infractions.

## 2-7. Penalties

Teams committing rules infractions are subject to one or more of the following penalties, depending on the severity of the infraction: 1) point penalty applied to one or more contests; 2) disqualification from part, or all, of one or more subcontests; or 3) disqualification from the competition.

- a. The rules officials shall determine the severity of rules infractions and classify them as **minor** or **major**.
- b. The rules officials are authorized to apply point penalties and disqualify a team from part, or all, of one or more subcontests as a consequence of **minor** rules infractions.

- c. The rules officials shall report to the director all **major** rules infractions. The director is solely authorized to apply point penalties or disqualify a team from the competition or from part, or all, of one or more subcontests for **major** rules infractions.
- d. Disqualification from the competition requires prior notice to the team and an opportunity for the team to make an oral or written statement on its behalf.
- e. The competition manager shall notify all teams via the scoring server when a penalty has been assessed against any team. The notification shall include the identity of the team receiving the penalty; a brief description of the infraction, including its severity, i.e., minor or major; and a brief description of the penalty.

## 2-8. Protests

Official written protests may be filed by a team for any reason during the contest week. A filing fee of up to 10 points may be assessed to the team filing the protest if the protest is deemed by the protest resolution committee to be frivolous.

- a. Teams are encouraged to communicate with the rules officials to resolve issues and complaints before resorting to the protest process. Protests should be filed only if a) the team and the rules officials are unable to resolve the dispute themselves; or b) the team or the rules officials are too busy to engage in discussions that may result in resolution of the dispute without a protest.
- b. Protests shall be submitted between 8 a.m. and 6 p.m., and within 24 hours of the action being protested. The final opportunity to file a protest is 5 minutes following the conclusion of the final subcontest on the final day of contest week.

**Exception:** The results of one or more subcontests may be announced during the final awards ceremony. The results of contests or subcontests announced during the final awards ceremony may not be protested.

- c. The protest shall be submitted to the competition manager in a sealed envelope. It shall include the name and signature of a decathlete, the date of the protest submission, an acknowledgment that a 10-point filing fee may be assessed, and a clear description of the action being protested.
- d. Following the receipt of a protest, the protest resolution procedure will occur as follows:
  - (i). The competition manager convenes the protest resolution committee.
  - (ii). The competition manager submits the sealed envelope containing the team's written protest to the committee. Unless the competition manager is called by the committee to testify, the competition manager is not permitted to read the protest until after the protest resolution committee has submitted its written decision.
  - (iii). The committee opens the envelope and reads the protest in private. No appearance by organizers or team members is authorized during the committee's private deliberations. No right to counsel by organizers or team members is authorized.
  - (iv). The committee notifies the competition manager if it would like to call any individuals for testimony. The competition manager notifies individuals called for testimony. The committee may call the competition manager for testimony.
  - (v). Testimony is provided by individuals called by the committee.
  - (vi). The committee notifies the competition manager of its decision in writing and indicates how many points shall be assessed as a filing fee. The decision of the committee is final and no further appeals are allowed.
  - (vii). If the decision involves changes to a team's score or the assessment of a filing fee, the competition manager notifies the scorekeeper of the changes, and the scorekeeper applies the changes to the scoring server.
  - (viii). The competition manager posts a copy of the written protest and decision on the Yahoo Group.

## **Rule 3. Participation**

### **3-1. Entry**

The project is open to colleges, universities, and other post-secondary educational institutions. Entry is determined through a proposal process. All proposals are reviewed, scored, and ranked. Subject to the quantity and quality of proposals, a limited number of teams will be selected for entry.

### **3-2. Contact Information**

Each team shall provide contact information for the team officers listed in Table 1 and shall keep the contact information current for the duration of the project.

- a. If a team’s internal officer titles do not exactly match those listed in Table 1, each team shall still provide the contact information for the person fulfilling each of the areas of responsibility described in the second column.
- b. Teams shall provide the contact information for one and only one person in each officer position; these individuals are responsible for forwarding information to any “co-officers,” as necessary.
- c. An individual may have multiple officer titles, however the same individual may not fulfill the project manager, construction manager, or health and safety officer roles.
- d. Teams shall enter required contact information into the “Team Officer Contact Info” Yahoo Group database.
- e. Faculty members are only eligible to fill the “faculty advisor” team officer position. Eligible decathletes must fill all other team officer positions.

**Table 1: Team officers**

<b>Title</b>	<b>Responsibilities</b>
Primary student contact	Ensures that official communications from the organizers are routed to the appropriate team member(s)
Project manager	Responsible for planning and executing the project and ultimately responsible for the overall health and safety of the project
Public relations contact	Works in conjunction with DOE’s Public Affairs office to coordinate the team’s interactions with the media
Construction manager	Responsible for planning and executing the construction, transport, assembly, and disassembly of the house, including providing the necessary oversight on construction activities to ensure that construction work is performed in compliance with the Health and Safety Plan
Architecture project manager	Responsible for the architectural design effort; license not required
Project engineer	Responsible for the engineering design effort; license not required
Measured contest captain	Serves as the primary strategist and coordinator of tasks in Contests 6 through 10; is responsible for demonstrating the compliance of appliances with the Rules
Health and safety officer	Responsible for developing the team’s Health and Safety Plan, for providing health and safety oversight to the project and advising the project manager and construction manager, as necessary, on project health and safety issues
Life safety captain	Responsible for the team’s life safety during the event, including the fire watch, public safety within the team’s solar envelope, and evacuation procedures
Instrumentation contact	Collaborates with the organizers’ instrumentation team and the team’s construction manager to accommodate the organizer’s equipment
Electrical engineer	Completes the Interconnection Application and works in conjunction with the site operations manager to interconnect the house to the micro-grid on the competition site; license not required
Faculty advisor	Serves as the lead faculty member and primary representative of a participating school in the project; also provides guidance to the team throughout the project
Sponsorship manager	Responsible for recruiting team sponsors and for team compliance with Rule 10-3

### 3-3. Safety

Each team is responsible for the safety of its operations.

- a. Each team member and team crew member shall work in a safe manner at all times during the project in accordance with the requirements identified in the rules and approved team Health and Safety Plan.
- b. Each team shall supply all necessary personal protective equipment (PPE) and safety equipment for all of the team's workers during the project.
- c. During assembly and disassembly, a minimum level of PPE—hard hat (ANSI Z89.1 or equivalent, Type I, Class G or better), safety glasses with side shields (ANSI Z87.1 or equivalent), shirt with sleeves at least 3 in. (7.6 cm) long, long pants (the bottoms of the pant legs shall, at a minimum, touch the top of the boots when standing), and safety boots (ANSI Z41 PT99 or equivalent) with ankle support—shall be used by each team member and team crew member. Additional PPE or safety equipment shall be used if required for the task being performed.
- d. Children under the age of 18 are not permitted to be on the competition site during assembly and disassembly.
- e. Smoking is not permitted within the competition site at any time during assembly or disassembly.
- f. Pets and other animals are not permitted on the competition site during assembly or disassembly with the exception of registered service animals.
- g. Organizers may issue a stop work order at any time during the project if a hazardous condition is identified.
- h. Failure to follow the procedures and requirements outlined in each team's Health and Safety Plan is considered a rule violation subject to Rule 2-7. All electrical work on the competition site shall meet electrical lockout/tagout requirements indicated in each team's approved Health and Safety Plan.

### 3-4. Conduct

Improper conduct or the use of alcohol or illegal substances will not be tolerated. Improper conduct may include, but is not limited to, improper language, unsportsmanlike conduct, unsafe behavior, distribution of inappropriate media, or cheating.

### 3-5. Use of Likeness, Content, and Images

Team members and crew agree to the use of their names, likenesses, content, graphics, and photos in any communications materials issued by the organizers and event sponsors.

- a. Content and images (graphics and photos), and any publications in which the content and images appear, may be viewable and made available to the general public via DOE's, NREL's, and the event sponsors' websites with unrestricted use.
- b. The organizers and event sponsors will make all reasonable efforts to credit the sources of content and images, although they may be published without credit. To ensure proper usage of and credit for images, teams should submit photos and graphics by following the instructions for submitting images located in Appendix F.

**Exception:** The deliverable status sheet posted in the "/Files/Deliverable Status Sheet" folder on the Yahoo Group indicates which deliverables will remain confidential through the completion of the project. All other competition and contract deliverables may be made publicly available any time after their receipt by the organizers.

### 3-6. Withdrawals

Any team wishing to withdraw from the project must notify the competition manager in writing. All written withdrawals signed by a faculty advisor are final.

## ***Rule 4. Site Operations***

### 4-1. Damage Liability

Each team is financially responsible for any damage it causes to the competition site.

#### **4-2. Construction Equipment**

- a. Truck-mounted cranes, trailers, semi-trailer trucks, etc., are limited to the paved surfaces of the competition site.
- b. Track-mounted equipment, such as vehicles, cranes, and forklifts, are prohibited at all times.
- c. Teams shall not permit the use of any equipment or tools on the competition site that are not safe and/or do not comply with applicable requirements of the Occupational Safety and Health Administration (OSHA) and/or other related regulatory standards.

#### **4-3. Ground Penetration**

Ground penetration is permitted only for the installation of tie-downs needed to meet wind loading and seismic requirements and for the installation of grounding means for the house's electrical system. Ground penetrations should be minimized and must be approved by the organizers prior to arrival at the competition site.

- a. Prior to assembly, a qualified utilities locator will identify any locations near each house where grounding means shall be installed. Grounding means shall be installed in accordance with the Solar Decathlon Building Code.

#### **4-4. Impact on the Competition Site**

Low-impact footings shall be used to support all house and site components.

- a. Properly designed footings comply with the bearing pressure criteria specified in the Solar Decathlon Building Code.

#### **4-5. Generators**

Generators are permitted to power tools and construction lights during stand-alone assembly and stand-alone disassembly.

- a. Engine generators shall not exceed 60 dB (A) at 50 ft (15 m) under full load per the manufacturer's listed sound rating. Operation and refueling of generators are limited to times approved by the organizers.

#### **4-6. Spill Containment**

- a. Generators must be equipped with secondary containment systems that can accommodate all of the oil, fuel, and coolant that the generator contains at maximum capacities.
- b. The release of water or other liquids onto the competition site or into nearby storm drains is prohibited.

#### **4-7. Lot Conditions**

Up to 12 in. (30.48 cm) of vertical elevation change may exist across a lot. Design and plan accordingly.

#### **4-8. Electric Vehicles**

Teams are permitted, but not required, to locate an electric vehicle on the competition site during contest week.

- a. The vehicle must be electric. Hybrid vehicles and non-electric vehicles are not permitted.
- b. Movement of the vehicle on and off the competition site is prohibited one hour prior, one hour after, and throughout all public exhibit periods.
- c. If a vehicle is demonstrated, the competition prototype must include the infrastructure required to charge the vehicle.
- d. The vehicle is not permitted to be connected to the competition prototype's electrical system at any time.
- e. Any vehicle displayed must be commercially available to all teams at the beginning of contest week.

## Rule 5. The Solar Envelope

### 5-1. Lot Size

Lots are 78 ft (23.8 m) east to west by 60 ft (18.3 m) north to south.

### 5-2. Solar Envelope Dimensions

The house and all site components on a team's lot must stay within the 18-foot-high (5.486 m) solar envelope shown in Figure 1. The north and south planes of the solar envelope are vertical, i.e., slope of 90 degrees from horizontal. The east and west planes of the solar envelope have slopes of about 52 degrees from horizontal as defined by the dimensions provided in Figure 1.

- The official height of a site component or set of contiguous site components is the vertical distance from the point of highest grade along the outside perimeter of the site component(s) to the highest point of the site component(s).
- Small weather stations, antennas, air vents, and other similar components may be specifically exempted from Rule 5-2 if all of the following conditions are met:
  - The team makes a request to the competition manager for an exemption.
  - The team can prove to the competition manager's satisfaction that the component is not significantly restricting a neighbor's right to the sun.
  - The competition manager determines that the component is sufficiently unique in function and small in size to warrant an exemption.
- Moveable or convertible house or site components shall not extend beyond the solar envelope during live demonstrations or in printed or electronic media presented by the team during jury visits, public exhibit hours, or contests.
- Any vehicle presented on the competition site shall not extend beyond the solar envelope during live demonstrations or in printed or electronic media presented by the team during jury visits, public exhibit hours, or contests.

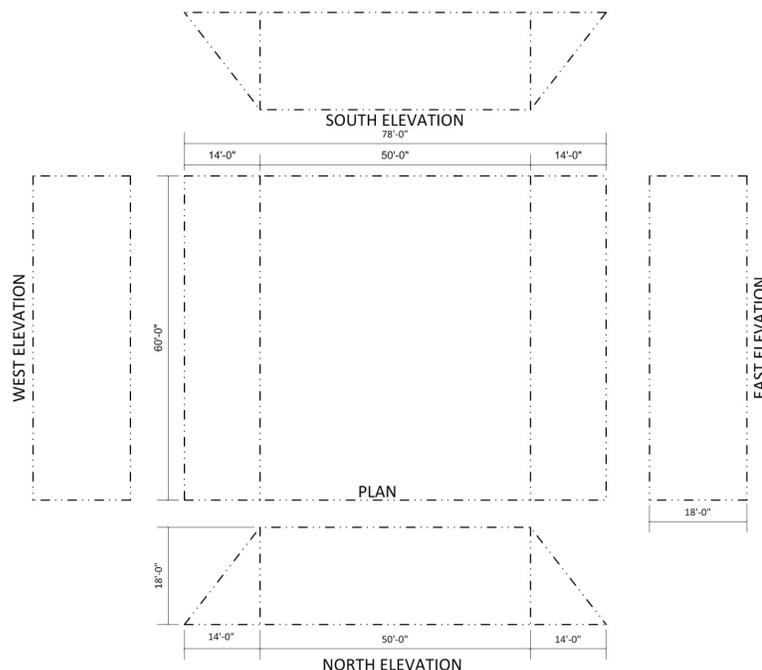


Figure 1: Solar envelope dimensions

## Rule 6. The House

### 6-1. Structural Design Approval

Each team shall submit structural drawings and calculations that have been stamped by a qualified, licensed design professional registered in the State of California or be eligible for California registration reciprocity.

- a. By stamping the structural drawings and calculations, the licensed professional certifies that the structural provisions of the Solar Decathlon Building Code have been met by the design, and that the structure is safe for the public to enter if it has been built as designed.
- b. The licensed professional shall stamp the structural drawings and calculations of the house and all site components that might pose a threat to public safety if they fail.

### 6-2. Finished Square Footage

The finished square footage, as defined by ANSI Z765-2003, “Square Footage—Method for Calculating,” shall be at least 600 ft<sup>2</sup> (55.7 m<sup>2</sup>), but shall not exceed 1000 ft<sup>2</sup> (92.9 m<sup>2</sup>).

- a. If the building has convertible or moveable components, the maximum and minimum square footages observed during live demonstrations or shown in printed or electronic media presented by the team during jury visits, public exhibit hours, or contests count as the maximum and minimum square footages of record, respectively.

### 6-3. Entrance and Exit Routes

- a. The main house entrance may be placed on any side of the house. However, an accessible route leading from the main street of the solar village to the main house entrance shall be provided.
- b. The house exit route shall lead from the main house exit to the main street of the solar village or to the east/west side of the solar envelope accessible to the public.
- c. Teams shall clearly illustrate and label the entrance and exit routes between solar envelope “property lines” and house entrance/exit in the construction drawings.

### 6-4. Competition Prototype Alternates

Alternates to the competition prototype shall not be proposed in materials intended for consideration by the Architecture, Market Appeal, and Engineering juries. Team websites and public exhibit communications materials, including signage, handouts and public display information, are not subject to this rule.

- a. Renderings and other graphical representations may only show the competition prototype house and the associated competition prototype site components on a featureless 78 ft (23.8 m) east to west by 60 ft (18.3 m) north to south lot. The featureless lot has a flat, uniform ground covering to be specified by the team.
- b. Natural and man-made features, including adjacent competition prototypes, located near the target client's site may be depicted, as long as the depicted features are located outside of the solar envelope.
- c. Teams shall not propose alternates to address local building code provisions and site restrictions at the target client's site. The juries will be instructed to assume that the Solar Decathlon Rules and Building Code also apply at the target client's site.
- d. Public exhibit communications materials are not considered part of the competition prototype and, therefore, shall not be shown in renderings and other graphical representations.

**Exception:** The cost estimator and juries will disregard all containers and associated equipment, such as pressure pumps, that would be unnecessary if city water and sewer services were available on the competition site. Therefore, these components shall be noted as “Temporary for Competition Purposes” in drawings and other graphical representations. Note that all structures and surfaces that surround the containers will be evaluated by the cost estimator and juries.

The cost estimator and juries will disregard any vehicle on display on the competition site. Note that any infrastructure provided to support the vehicle will be evaluated by the cost estimator and juries.

## ***Rule 7. Vegetation***

The use of potted vegetation is permitted. All potted vegetation shall comply with Rules 4-4 and 4-6.

### **7-1. Placement**

Vegetation may be moved around the solar envelope until the beginning of contest week, after which it shall remain stationary until the conclusion of contest week unless the drawings clearly show how some or all vegetation is designed to be moved as part of an integrated system.

### **7-2. Watering Restrictions**

Greywater that may possibly contain organisms that could go septic shall not be used to water vegetation.

## ***Rule 8. Energy***

### **8-1. PV Technology Limitations**

- a. Bare photovoltaic cells and encapsulated photovoltaic modules must be commercially available to all teams by the beginning of the event.
- b. Substantial modification of the crystal structure, junction, or metallization constitutes manufacture of a new cell and is not allowed.

### **8-2. Energy Sources**

After the conclusion of stand-alone assembly (see Rule 8-5c for details) and until the conclusion of the Energy Balance Contest (see Appendix A for the detailed event schedule), global solar radiation incident upon the lot and the energy in small primary batteries (see Rule 8-3 for limitations) are the only sources of energy that may be consumed in the operation of the house without the requirement of subsequent energy offsets.

**Exception:** Teams may use organizer-supplied microgrid power that is exempt from the Energy Balance Contest during grid-tie assembly for construction equipment, site lighting, and task lighting located outside the finished square footage only. Teams may use generators during grid-tie assembly for nighttime construction lighting only.

- a. All other energy sources, such as AC grid energy, consumed in the operation of the house must be offset by an equal or greater amount of energy produced, or “regenerated,” by the house.
- b. Fireplaces, fire pits, candles, and other devices using non-solar fuels are not permitted in the designs.

**Exception:** The limited use of batteries is permitted by Rule 8-3.

### **8-3. Batteries**

Hard-wired battery banks and large plug-in uninterruptable power supplies (UPS) are not permitted.

- a. The use of primary (non-rechargeable) batteries (no larger than “9V” size) is limited to smoke detectors, remote controls, thermostats, alarm clock backups, and other small devices that typically use small primary batteries.
- b. “Plug-in” (non-hard-wired) devices with small secondary (rechargeable) batteries that are designed to be recharged by the house’s electrical system (e.g., a laptop computer), shall be connected, or “plugged into,” the house’s electrical system whenever the devices are located in the house or within the solar envelope.

**Exception:** If not used in the operation of the house at any time during contest week, portable electronic devices used for mobile communications, such as cell phones and PDAs, are permitted within the solar envelope without having to be plugged into the house’s electrical system.

Electric vehicles with integrated batteries are permitted to be located within the solar envelope, but may not be connected to the competition prototype’s electrical system at any time.

- c. Stand-alone, PV-powered devices with small secondary batteries are permitted, but the aggregate battery capacity of these devices may not exceed 100 Wh.

- d. Batteries include most commercially available energy storage devices, such as electrochemical batteries and capacitors.

#### 8-4. Desiccant Systems

If a desiccant system is used, it must be regenerative.

- a. To ensure that the desiccant has been fully regenerated by the conclusion of the Energy Balance Contest, the desiccant material or device must be easily measurable.
- b. In most cases, the material or device will be measured prior to and at the conclusion of the Energy Balance Contest. In some cases, a measurement at the conclusion of the Energy Balance Contest may not be necessary.
- c. At the conclusion of the Energy Balance Contest, the weight of the desiccant material or device shall be less than or equal to its initial weight.
- d. Some desiccant systems with very low moisture storage capacities may be exempt from this requirement. Exemptions will be granted on a case-by-case basis by the competition manager.

#### 8-5. Village Grid

The organizers shall provide the village with an electric power grid that provides AC power to and accepts AC power from the houses.

- a. The organizers shall provide the necessary service conductors and connect the conductors at the utility intertie point.
- b. A team shall notify the organizers if its house operates with an AC service other than 60 Hz, 120/240V split-phase with neutral.
- c. At a date and time specified in Appendix A, teams have the option to switch from stand-alone assembly to grid-tie assembly if all relevant inspections have been passed and the village grid is available. Teams shall not switch back to stand-alone assembly after switching to grid-tie assembly. At a later date and time specified in Appendix A, all teams shall have switched to grid-tie assembly.

#### 8-6. Net Metering Rules

- a. When a team switches from stand-alone assembly to grid-tie assembly, its bidirectional meter resets to zero.
- b. If the meter reading indicates net energy production at the start of the Energy Balance Contest, the meter is reset to zero. If the meter reading indicates net energy consumption at the start of the Energy Balance Contest, the meter is not reset and the team begins the Energy Balance Contest with an energy deficit.

### *Rule 9. Liquids*

#### 9-1. Container Locations

- a. Primary supply water and greywater containers shall be located outside of the finished square footage as defined by Rule 6-2. These containers may not be located below the finished square footage.  
**Exception:** Teams may utilize one or more small tanks to accept wastewater discharge in preparation for delivery to the main wastewater tank(s) up to a maximum aggregate volume of 20 gallons.
- b. Solar storage, hot water, or other thermal storage containers may be located within the finished square footage.
- c. The primary supply water tank(s) shall be fully shaded from direct solar radiation between 9 a.m. and 5 p.m. Pacific Daylight Time (PDT) or between 8 a.m. and 4 p.m. solar time on October 1.

#### 9-2. Team-Provided Liquids

A team may provide its own liquids for the following purposes:

- a. Personal hydration
- b. Irrigation [one-time delivery before water delivery day, 50 gallon (189 L) limit, water only]

- c. Thermal mass (quantity limited by bearing pressure limit and Rule 4-4; see Rule 9-6 for restrictions)
- d. Food preparation
- e. Hydronic system pressure testing<sup>2</sup>
- f. Small volumes of glycol, deionized water, or other working fluids for thermodynamic systems using working fluids other than non-potable water
- g. Assembly (e.g., hydraulic fluid), finishing (e.g., paint), and cleaning (e.g., mineral spirits).

### **9-3. Greywater Reuse**

A team may reuse greywater for irrigation only.

- a. Greywater reuse systems shall comply with Rule 7-2.

### **9-4. Rainwater Collection**

A team may collect rainwater that falls on its site and use it in, or as, any of the following:

- a. Irrigation source
- b. Water feature
- c. Heat sink or heat source

### **9-5. Evaporation**

Water may be used for evaporation purposes.

### **9-6. Thermal Mass**

Teams may use liquids as thermal mass.

- a. The thermal storage containers shall be filled and sealed before their arrival on the competition site and shall remain sealed until they are removed from the competition site by the teams.
- b. The thermal storage containers shall be isolated, i.e., the contained liquid shall not circulate to other containers or systems.

### **9-7. Greywater Heat Recovery**

Heat may be recovered from greywater as it flows from the drain to the waste tank.

- a. “Batch”-type greywater heat recovery is prohibited.

### **9-8. Water Delivery**

A team may request up to 1500 gallons of water from the organizers in its detailed water budget.<sup>3</sup>

The procedure and associated requirements for water delivery follow.

- a. On water delivery day, two water trucks begin at the southeast and northwest corners of the competition site in the morning and proceed to service each house. Each truck will be equipped with a pump to aid in water supply.
- b. Teams shall provide a minimum of six people, on command, to help move the water hose to their house from the previously serviced house.
- c. After the two trucks have serviced all houses once, they will circle the village again to service any house needing additional water.
- d. Teams that delay the water supply process or request additional water after the trucks complete their second circle around the village are subject to a penalty and a delay in receiving their water. Instead of or in addition to a penalty, these teams may be required to pay for their own water. Teams required to pay for their own water supply shall use a company approved by the organizers.

<sup>2</sup> The water may only fill isolated loops; it shall not enter tanks.

<sup>3</sup> The detailed water budget shall be included in the Project Manual (see *Content Requirements* in Appendix D-5).

- e. The design deliverables shall clearly indicate the fill location(s), quantity of water requested at each fill location, container dimensions, diameter of the opening(s) (minimum 4 in., or 10 cm), and clearance above the container(s) fill location(s) (minimum 12 in., or 30.48 cm). All openings shall be easily accessible.
- f. Teams are responsible for distributing water within their houses. This includes all necessary pumps, containers, lines, valves, etc. All pumping power to distribute water must be delivered by an AC circuit.

## 9-9. Water Removal

The procedure and associated requirements for water removal follow.

- a. On water removal day, two water trucks begin at the middle of the village and proceed toward the northwest and southeast to service each house. Each truck will be equipped with a pump to aid in water removal.
- b. Teams shall supply a minimum of six people, on command, to help move the water hose to their house from the previously serviced house.
- c. After the two trucks have serviced all houses once, they will circle the village again to service any house needing remaining water removed.
- d. Teams that delay the water removal process may be required to pay for their own water removal. Teams required to pay for their own water removal shall use a company approved by the organizers.
- e. The design deliverables shall clearly indicate the removal location(s), quantity of water to be removed from each removal location, container dimensions, diameter of the opening(s) (minimum 4 in., or 10 cm), and clearance above the container(s) fill location(s) (minimum 12 in., or 30.48 cm). All openings shall be easily accessible.
- f. Teams are responsible for either removing remaining water from the site or moving remaining water to the designated removal locations.

## *Rule 10. The Event*

### 10-1. Registration

All Solar Decathlon event participants must register either through the online registration site, which will be available closer to the event, or on the competition site.

- a. The following rules apply to **all registrants**:
  - (i). Each event participant must register individually. Group registrations are not allowed.
  - (ii). Online registration is encouraged for all event participants, because on-site registration could cause delays in gaining event access.
  - (iii). When registering, event participants must complete all required information and forms before access to the event is allowed.
- b. **Organizers, team members, jurors, and staff** are required to provide a photo that will be kept on file and used for security purposes. Participants should use the online registration site to submit completed forms, information, and photos prior to the event. Once all information, forms, and photos are received, the organizers will issue an event security ID that must be visible at all times while on the competition site.
- c. **Team crew** members are not required to submit a photo. Due to safety concerns, site access for team crew members may be restricted.
- d. **Visiting media** will not be required to submit forms or photos, but must check in at event headquarters. Due to safety concerns, site access for visiting media may be restricted.

### 10-2. Event Sponsor Recognition

All communications materials produced by the teams concerning or referring to the project (including team websites) shall refer prominently to the project as the “U.S. Department of Energy Solar Decathlon.”

- a. Teams are required to use the Solar Decathlon logo, the DOE wordmark, and the NREL logo on all communications materials visible at the Orange County Great Park. The DOE wordmark and NREL logo

shall be a maximum of one-third the size of the Solar Decathlon logo as outlined in the Solar Decathlon identity guidelines<sup>4</sup>.

- b. The Solar Decathlon logo, the DOE wordmark, and NREL logo are the only required graphic elements teams must use.
- c. Team websites shall comply with Rule 10-2 with the exception of the one-third size rule for team sponsor text and logos.
- d. Team uniforms are exempt from Rule 10-2. See Rule 11-5 for specifics.

### **10-3. Team Sponsor Recognition**

Team sponsors may be recognized with text, logos, or both, but the text and logos must appear in conjunction with the Solar Decathlon text and logo and be a maximum of one-third of the size of the Solar Decathlon text and logo, as outlined in the Solar Decathlon identity guidelines.

- a. Team websites shall comply with Rules 10-2 and 10-3, with the exception of the one-third size rule for team sponsor text and logos.
- b. Rule 10-3 applies but is not limited to all communications materials that will be on display or distributed on the competition site.
- c. Communications materials or other products that exist largely for the recognition of sponsors are limited to 10 square feet (0.93 square meters), in aggregate within the solar envelope. “Other products” include but are not limited to signs, exhibits, posters, plaques, photos, wall art, and furnishings.
- d. For multimedia or audio presentations shown on the competition site, no more than 20% of the total time, 1 minute, or whichever is less may be dedicated to recognition of team sponsors.
- e. Off-the-shelf components that feature a built-in manufacturer’s logo are acceptable and need not be accompanied by the Solar Decathlon text and logo.
- f. Team uniforms are exempt from Rule 10-3. See Rule 11-5 for specifics.

### **10-4. Logistics**

- a. Each team is responsible for the transport of its house, the house’s contents, and all necessary tools and equipment, and shall be responsible for any damage to or loss of such items.
- b. Each team is responsible for procuring all necessary equipment, tools, and supplies.
- c. Each team is responsible for transportation, accommodations, lodging, food, and beverages
  - (i). The organizers will make drinking water available on the competition site to all team members for the duration of the event.
- d. Each team is responsible for making its own reservations and arrangements and for covering all necessary costs.

### **10-5. Inspections**

Each project shall be inspected for compliance with the Solar Decathlon Rules and the Solar Decathlon Building Code.

- a. A team shall notify the appropriate inspector when it is ready for an inspection. When two or more teams request an inspection simultaneously, the order of inspections shall be determined in a drawing.
- b. Additional random inspections for compliance shall take place throughout contest week.
- c. The competition manager shall check each team’s inspection status, as indicated on the team’s official inspection card, to determine which houses are eligible to participate in the contests. All final inspections shall be passed by the conclusion of last-chance final inspections. Failure to pass inspections by the required deadline will be considered a rules violation. A team must have passed inspections by the conclusion of the inspector’s work day for a team to be eligible to participate in the following day’s contests, which officially start at midnight.

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<sup>4</sup> Solar Decathlon identity guidelines are available at: <http://www.solardecathlon.gov/commstandards>.

**Exception:** Jury visits will proceed as scheduled regardless of a team's inspection status. However, jurors will be made aware of the team's inspection status and may consider it in their evaluations.

- d. Because open, partially functioning houses are preferable to closed, fully functioning houses, the organizers will direct the inspectors to require that an unsafe condition be corrected so that public visits can occur—even if, as a consequence, the house is ineligible for participation in one or more contests.

## **10-6. Communications Materials**

All communications materials shall support the goal of Contest 4: Communications, which is to educate consumers about the project and topics relevant to the project.

# ***Rule 11. Contest Week***

## **11-1. House Occupancy**

Under normal circumstances, no more than six people may be located in the house at any one time.

- a. Toward the end of each day of contest week, the competition manager shall post a message on the Yahoo Group message board indicating the hours during which rule 11-1 is in effect the following day.
- b. Rule 11-1 is automatically suspended whenever the Comfort Zone Contest measurements are suspended. See Appendix A-3 for the Comfort Zone Contest schedule.
- c. Jurors, observers, official organizer-provided competition photographers, media, writers, and others with authority to enter a house as an organizer are not counted toward the number of house occupants.
- d. Up to 10 people may be located in the house during dinner parties. At least six of the people in the house during dinner parties shall be the two decathletes from each of the three guest teams. No more than two of the remaining people in the house may be VIP guests.

## **11-2. House Operators**

Only decathletes are permitted to operate the house and participate in the contests during contest week.

- a. All competition-related communications on the competition site shall be between the organizers and decathletes. Non-decathlete team members and team crew are not permitted to participate in or listen to competition-related communications.

## **11-3. Late Design Changes**

The final project assembled on the competition site shall be consistent with the design and specifications presented in the as-built drawings and project manual.

- a. If there are known inconsistencies between the final project and the as-built drawings and project manual, the team shall document these inconsistencies and submit the documentation to the competition manager as soon as possible after the inconsistency is known. The competition manager will then submit this documentation or a summary of the documented inconsistencies to the respective juries and inspectors at the appropriate time.
- b. The competition manager will compile a summary of all undocumented inconsistencies discovered during the inspections process and submit the summary to the respective juries at the appropriate time.

## **11-4. Public Exhibit**

- a. Teams are required to provide an accessible route to all areas of the house and site that are available to the public during exhibit hours.
- b. Teams are permitted to produce and distribute only one informational brochure or handout on the competition site.
- c. Teams shall develop signage that complements public exhibit tours by informing visitors about the team project and engaging visitors waiting in line.
- d. Teams are prohibited from selling items to the general public on the competition site.

- e. Only organizer-approved vendors may provide food and beverage to the general public on the competition site.

### **11-5. Team Uniforms**

- a. During contest week and special events specified by the organizers, all team members present on the competition site or the site of a special event shall wear uniforms representing their team.
- b. Team uniforms are exempt from Rules 10-2 and 10-3.
- c. Team sponsor logos are approved to be visible ONLY on the back of the team uniform (jacket, shirt, hat, or other wearable item).
- d. The only information or graphics that are approved to be visible from the front of the team uniform (jacket, shirt, hat, or other wearable item) shall be the institution and its logo, the team name and logo, the Solar Decathlon logo, and event sponsor logos.
- e. A built-in clothing manufacturer logo may be visible on the front or back of the team uniform, or both.

### **11-6. Impound**

Each house shall be impounded on specified nights as indicated in Appendix A under the direct supervision of the organizers or staff. Team members and team crew shall not occupy the competition site during impound hours. There is a 10-minute impound grace period.



## SECTION III: CONTEST CRITERIA

The Solar Decathlon competition consists of 10 separately scored contests. Each contest contains one or more subcontests. For example, Contest 8: Appliances consists of five separately scored subcontests. The team with the highest total points at the end of the competition wins. Table 2 shows the competition structure.

**Table 2: Competition structure**

Contest Number	Subcontest Number	Contest Name	Available Points	Subcontest Name	Available Points	Subcontest Type	Brief Description
1	n/a	Architecture <sup>5</sup>	100	n/a	n/a	Juried	Architecture Jury reviews and evaluates the drawings, construction specifications, audiovisual presentation, architecture narrative, and final constructed project
2	n/a	Market Appeal	100	n/a	n/a	Juried	Market Appeal Jury reviews and evaluates the drawings, construction specifications, audiovisual presentation, market appeal narrative, and final constructed project
3	n/a	Engineering	100	n/a	n/a	Juried	Engineering Jury reviews and evaluates the drawings, construction specs, energy analysis results and discussion, audiovisual presentation, engineering narrative and final constructed project
4	n/a	Communications	100	n/a	n/a	Juried	Communications Jury reviews and evaluates the team website, audiovisual presentation, communications narrative, onsite public exhibit, and public exhibit materials
5	n/a	Affordability	100	n/a	n/a	Juried	Cost estimator reviews the drawings, construction specifications, and final constructed project to estimate construction costs
6	6-1	Comfort Zone	100	Temperature	75	Measured   Monitored	Keep zone temperature in 71°F – 76°F (22°C – 24°C) range
	6-2			Humidity	25	Measured   Monitored	Keep zone relative humidity below 60%
7	n/a	Hot Water	100	n/a	n/a	Measured   Task	Deliver 15 gallons of water at average 110°F (43°C) temperature within 10 minutes; 16 water draws during contest week
8	8-1	Appliances	100	Refrigerator	10	Measured   Monitored	Keep refrigerator temperature in 34°F – 40°F (1°C - 4°C) range
	8-2			Freezer	10	Measured   Monitored	Keep freezer temperature in -20°F – 5°F (-29°C to -15°C) range
	8-3			Clothes Washer	20	Measured   Task	Successfully wash 8 loads of laundry (one load = six bath towels) during contest week
	8-4			Clothes Dryer	40	Measured   Task	Return 8 loads of laundry to their original weight (one load = six bath towels) during contest week
	8-5			Dishwasher	20	Measured   Task	Successfully wash five loads of dishes (one load = eight place settings) during contest week
9	9-1	Home Entertainment	100	Lighting	40	Measured   Task	All interior and exterior lights on at full levels at night
	9-2			Cooking	20	Measured   Task	Successfully perform six cooking tasks (one task = vaporize 5 lb of water in less than 2 hours) during contest week
	9-3			Dinner Party	10	Juried	Host two dinner parties for up 8 guests; teams score each other
	9-4			Home Electronics	25	Measured   Task	Operate a TV and computer during specified hours
	9-5			Movie Night	5	Juried	Invite neighbors to watch a movie on the home theater system; teams score each other
10	n/a	Energy Balance	100	n/a	100	Measured   Monitored	Produce at least as much electrical energy (kWh) as is consumed during contest week
<b>TOTALS</b>			<b>1,000</b>	<b>515 total juried points and 485 total measured points from 19 individually scored contest elements</b>			

<sup>5</sup> Lighting quality and lighting control evaluations are conducted by the Architecture, Market Appeal, and Engineering juries.

There are three ways to earn points:

- Task completion
- Monitored performance
- Jury evaluation.

Subcontests based on task completion or monitored performance are called measured subcontests; subcontests based on a jury evaluation are called juried subcontests.

Points for task completion are awarded as a function of “closeness to completion.” Points for measured performance are either awarded at the end of each scored period throughout contest week or at the conclusion of contest week when performance requirements are met or partially met.

The scoring of the juried subcontests is more flexible than the scoring of the measured subcontests described above. However, for the sake of fairness, consistency is important. To increase the consistency of the scoring in juried subcontests, the jurors shall use the evaluation method described in Appendix B-1.

## ***Contest 1. Architecture***

A jury of architects shall assign an overall score for the design’s architectural merit and implementation by reviewing the team’s drawings, construction specifications, audiovisual presentation, and architecture narrative (see Appendix D), and by performing an on-site evaluation of the competition prototype (see Appendix B).

The jury shall consider the following specific criteria in its evaluation:

### ***Design and implementation***

- Was the team effective in its use of architectural elements including, but not limited to: scale and proportion of room and facade features, indoor/outdoor connections, composition, and linking of various house elements?
- Did the team create a holistic design that will be comfortable for occupants and compatible with the surrounding environment?
- Are the lighted spaces rich and varied? Do they have adequate light for tasks? Do they have good color rendition? Do the luminaires properly distribute light? Is the admission of direct and diffuse sunlight effectively controlled?
- Will the overall architectural design offer a sense of inspiration and delight to Solar Decathlon visitors?
- Did the competition prototype demonstrate quality design, detailing, and architectural implementation?

### ***Documentation***

- Did the drawings, construction specifications, audiovisual presentation, and architecture narrative enable the jury to conduct a preliminary evaluation of the design prior to its arrival at the competition site?
- Did the drawings, construction specifications, and audiovisual presentation accurately reflect the constructed project as assembled on the competition site?

## ***Contest 2. Market Appeal***

A jury of professionals from the homebuilding industry shall assign an overall score for the house’s market appeal by reviewing the team’s drawings, construction specifications, audiovisual presentation, and market appeal narrative (see Appendix D), and by performing an on-site evaluation of the competition prototype (see Appendix B).

The jury shall consider the following specific criteria in its evaluation of the responsiveness of the design to the characteristics and requirements of a team-defined target client (see Table 3 for examples of target client characteristics and requirements, which shall be included in the project manual).

### ***Livability***

- Does the design offer the occupant(s) a safe, functional, convenient, comfortable, and enjoyable place to live?

- Is the operation of the house’s lighting, entertainment, and other controls intuitive?
- Are the unique needs and desires of the target client met by the design?

**Marketability**

- Does the house demonstrate curb appeal, interior appeal, and quality craftsmanship?
- Do the house’s sustainability features and strategies make a positive contribution to its marketability?
- Does the house offer a good value to potential homebuyers?

**Buildability**

- Are the drawings and construction specifications of sufficient quality and detail to enable a contractor to generate an accurate, detailed construction cost estimate?
- Are the drawings and construction specifications of sufficient quality and detail to enable a contractor to construct the building as the design team intended it to be built?
- Are all the house’s materials and equipment commercially available, such that the house can be immediately built in the private sector?

**Table 3: Examples of target client characteristics and requirements**

Characteristic or Requirement	Example #1	Example #2	Example #3
Location of permanent site	New Orleans, LA	Folsom, CA	Boston, MA
Housing type	Emergency relief	Single family	Investment property in an urban college setting
# of occupants	2	3	1
Client demographic	Middle-aged married couple	Mid-30s married couple with infant	Graduate student
Client annual income	\$35,000	\$100,000	\$75,000
# of bedrooms	1	2	1

Notes:

1. These examples show the *minimum* required level of detail for the target client characteristics and requirements.
2. The target client characteristics and requirements shall be included in the project manual and market appeal narrative (see Appendix D).
3. Other examples of housing types include, but are not limited to, the following: retirement cottage, vacation retreat, university housing, home office/studio, studio apartment, mobile home, barracks, penthouse, and loft.

**Contest 3. Engineering**

A jury of engineers shall assign an overall score for the design’s engineering merit and implementation by reviewing the team’s drawings, construction specifications, energy analysis results and discussion, audiovisual presentation, and engineering narrative (see Appendix D), and by performing an on-site evaluation of the competition prototype (see Appendix B).

The jury shall consider the following specific criteria in its evaluation:

**Functionality**

- Do the house systems function as intended?
- Does the HVAC system maintain indoor air quality via contaminant control, fresh air ventilation, or both?
- Does the HVAC system maintain uniform thermal comfort conditions via temperature control, humidity control, air movement, and a successful distribution system design?

**Efficiency**

- Relative to conventional systems, how much energy will the systems save over the course of an entire year?
- Do house controls facilitate a reduction in energy consumption during an entire year of operation?
- Is the design effective, efficient and practical in its engineering approach?

### ***Innovation***

- Were any unique approaches used to solve engineering design challenges?
- Do the proposed innovations have true market potential?

### ***Reliability***

- How long are the systems expected to operate at a high level of performance?
- How much maintenance is required to keep them operating at a high level?

### ***Documentation***

- Did the drawings, construction specifications, energy analysis results and discussion, and audiovisual engineering presentation enable the jury to conduct a preliminary evaluation of the design prior to its arrival at the competition site?
- Did the drawings, construction specifications, energy analysis results and discussion, and audiovisual engineering presentation accurately reflect the constructed project as assembled on the competition site?

## ***Contest 4. Communications***

A jury of communications professionals will evaluate and assign an overall score for the team's communications by reviewing the team's final website, public exhibit materials, communications narrative, audiovisual presentations (see Appendix D), and by evaluating the public exhibit presentations and communications summary presentation onsite (see Appendix B).

For each product evaluated, the jury will consider the following specific criteria:

### ***Final website***

- Was the website submitted by the deadline?
- Is the design appealing (graphics, photos, colors, and typography)?
- Is the information architecture easy to use, consistent, and comprehensible? Does it present a logical hierarchy of information?
- Are graphical elements easy to use, consistent, and well integrated with content and design?
- Does the website meet minimum coding requirements?
- Is the website usable by people of all abilities?
- Does the team communicate its messages appropriately to online audiences?
- Does the team employ original and creative methods to capture users' interests and engage online visitors?
- Does the website comply with Rules 10-2 and 10-3?
- Does the team employ a comprehensive and successful social media strategy?

### ***Public exhibit materials***

- Does the on-site signage comply with Rules 10-2 and 10-3?
- Does the team handout comply with Rules 10-2 and 10-3?
- Do the on-site communications materials follow the team's communications strategy?
- Are messages communicated successfully?
- Do materials use correct spelling and grammar?
- Does the handout demonstrate originality?
- Does the signage demonstrate originality?
- Are the materials educational?

### ***Public exhibit presentation***

- Did the team present a 10-minute comprehensive, personalized "tour" appropriate for times when visitors are sparse?

- Did the team present a 5-minute fast-yet-informative “tour” that accommodates large crowds and long lines successfully?
- Did the team present a 5-minute summary of all communications strategies, impacts, approaches, and goals for the project?
- Are both onsite presentations for the public informative? Interesting? Accessible by people of all abilities?
- Has the team planned original and creative methods to control lines and wait times and to engage visitors waiting in line during public hours? Are these methods effective?
- Are the team messages appropriate for the public?

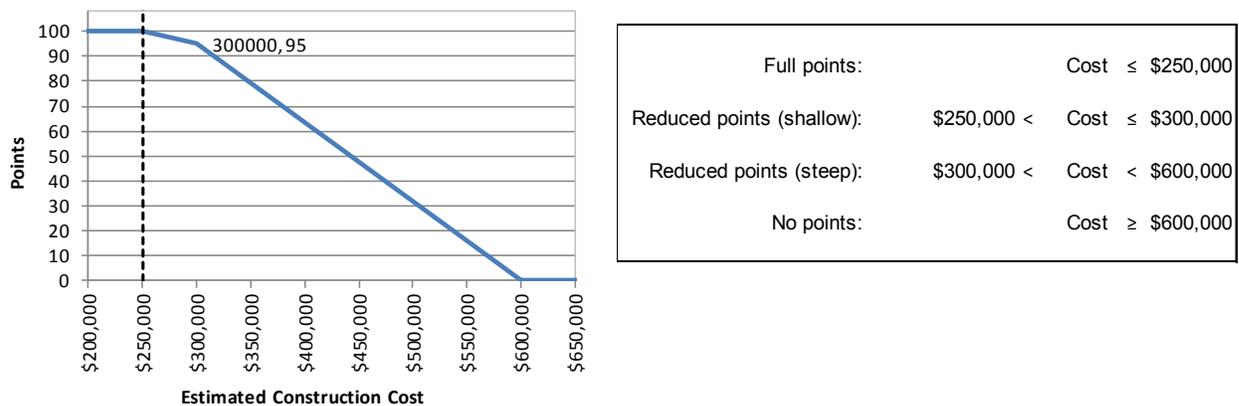
***Audiovisual presentation***

- Does the audiovisual presentation provide viewers with interesting and informative video of the team’s house?
- Does the audiovisual presentation include an audio narrative that explains to viewers what they’re seeing and describes the philosophy behind the design?
- Does the audio narrative correspond appropriately with the visual presentation?
- Is the audio quality good?
- Does the audiovisual presentation showcase the completed as-built house to be presented on the competition site?
- Did the team follow formatting requirements?
- Did the team provide a verbatim transcript to meet Section 508 Accessibility standards?

***Contest 5. Affordability***

A professional cost estimator shall assign an estimated construction cost to each project. All available points are earned for achieving an estimated construction cost of \$250,000 or less.

- Reduced points are earned for an estimated construction cost between \$250,000 and \$600,000. No points are earned for an estimated construction cost at or above \$600,000. Reduced points are scaled linearly, as shown in Figure 2.
- When information necessary for completing a thorough, accurate estimate is missing, the estimators will err on the high side to accommodate for uncertainty.
- Each team is required to declare the target construction cost of its design by a specified deadline. The team’s target construction cost shall be within  $\pm 20\%$  of the professional cost estimator’s final estimated construction cost.
- A file describing the methodology is posted in the “/Files/Rules/Affordability Contest” folder on the Yahoo Group.



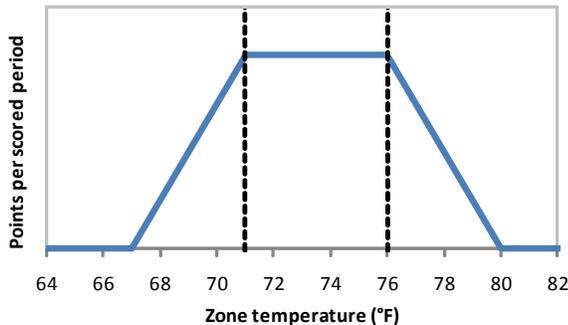
**Figure 2: Scoring function for the Affordability Contest**

## Contest 6. Comfort Zone

### 6-1. Temperature

All available points are earned at the conclusion of each scored period by keeping the time-averaged interior dry-bulb temperature between 71.0°F (21.7°C) and 76.0°F (24.4°C) during the scored period. See Appendix A-3 for the schedule of scored periods and for the number of available points per scored period.

- a. Reduced points are earned if the time-averaged interior dry-bulb temperature is between 67.0°F (19.4°C) and 71.0°F (21.7°C) or between 76.0°F (24.4°C) and 80.0°F (26.7°C). Reduced point values are scaled linearly, as shown in Figure 3.
- b. The zone temperature deviating farthest from the target temperature range is the zone temperature of record. The organizers will identify at least two thermal zones in each house and measure the temperature of each zone.



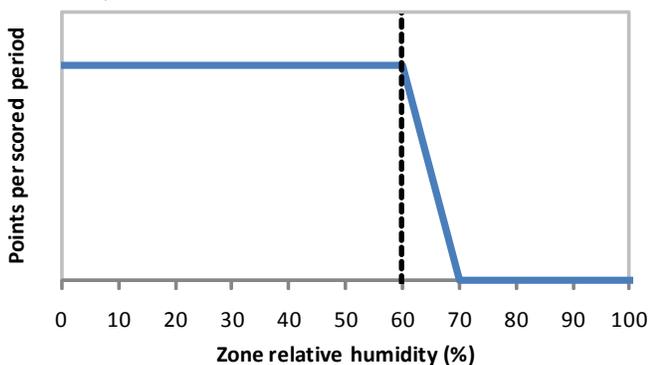
Full points:	$71\text{ }^{\circ}\text{F}\text{ (}22\text{ }^{\circ}\text{C)} \leq \text{Temperature} \leq 76\text{ }^{\circ}\text{F}\text{ (}24\text{ }^{\circ}\text{C)}$
Reduced points:	$67\text{ }^{\circ}\text{F}\text{ (}19\text{ }^{\circ}\text{C)} < \text{Temperature} < 71\text{ }^{\circ}\text{F}\text{ (}22\text{ }^{\circ}\text{C)}$
	or $76\text{ }^{\circ}\text{F}\text{ (}24\text{ }^{\circ}\text{C)} < \text{Temperature} < 80\text{ }^{\circ}\text{F}\text{ (}27\text{ }^{\circ}\text{C)}$
No points:	$\text{Temperature} \leq 67\text{ }^{\circ}\text{F}\text{ (}19\text{ }^{\circ}\text{C)}$
	or $\text{Temperature} \geq 80\text{ }^{\circ}\text{F}\text{ (}27\text{ }^{\circ}\text{C)}$

**Figure 3: Scoring function for the Temperature Subcontest**

### 6-2. Humidity

All available points are earned at the conclusion of each scored period by keeping the time-averaged interior relative humidity below 60.0% during the scored period. See Appendix A-3 for the schedule of scored periods and for the number of available points per scored period.

- a. Reduced points are earned if the time-averaged interior relative humidity is between 60.0% and 70.0%. Reduced point values are scaled linearly, as shown in Figure 4.
- b. In multi-zone houses, the zone humidity deviating farthest from the target humidity range is the zone humidity of record.



Full points:	$\text{Relative humidity} \leq 60\%$
Reduced points:	$60\% < \text{Relative humidity} < 70\%$
No points:	$\text{Relative humidity} \geq 70\%$

**Figure 4: Scoring function for the Humidity Subcontest**

## Contest 7. Hot Water

Hot water draws will occur at the approximate times specified in Appendix A-3. For each draw, at least 15 gal (56.8 L) of hot water shall be delivered in no more than 10 minutes to qualify for points. All available points are earned by delivering an average temperature of at least 110°F (43.3°C). An average temperature below 100°F

(37.8°C) earns no points. For temperatures between 100°F (37.8°C) and 110°F (43.3°C), points are scaled linearly, as shown in Figure 5.

- These hot water draws are designed to simulate most of the washing and bathing tasks that would take place in a typical day. *Note: The dishwashing task is not simulated by these hot water draws because it belongs to a different contest.*
- The schedule for hot water draws will most likely vary from one day to the next, just as it does in a typical home.
- The maximum number of hot water draws for one day will not exceed three, but they may occur consecutively.
- For fairness, all teams will be drawing hot water on nearly identical schedules.
- Hot water will be drawn from the shower. Teams shall replace their showerhead with an organizer-supplied fitting prior to the start of the contest. If a house has multiple showers, the shower expected to be used most frequently by the occupants will be used for the hot water draws.
- Teams shall provide a male ½” National Pipe Thread Tapered Thread (NPT) to accept the Organizer equipment.

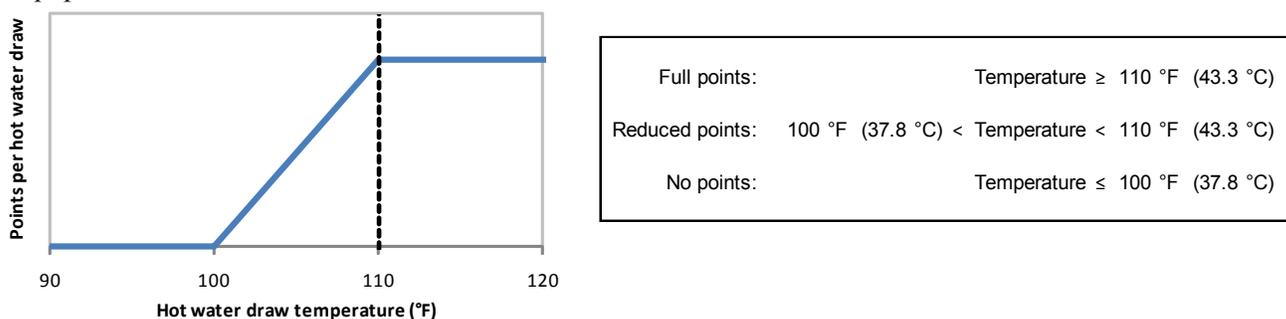


Figure 5: Scoring function for the Hot Water Contest

## Contest 8. Appliances

### 8-1. Refrigerator

All available points are earned at the conclusion of each scored period by keeping the time-averaged interior temperature of a refrigerator between 34.0°F (1.11°C) and 40.0°F (4.44°C) during the scored period. See Appendix A-3 for the schedule of scored periods and for the number of available points per scored period.

- Reduced points are earned if the time-averaged interior refrigerator temperature is between 32.0°F (0.00°C) and 34.0°F (1.11°C) or between 40.0°F (4.44°C) and 42.0°F (5.56°C). Reduced point values are scaled linearly, as shown in Figure 6.
- The refrigerator volume published in the manufacturer’s specifications shall be a minimum of 6.0 ft<sup>3</sup> (170 L).
- The refrigerator may be used to store food and beverages.

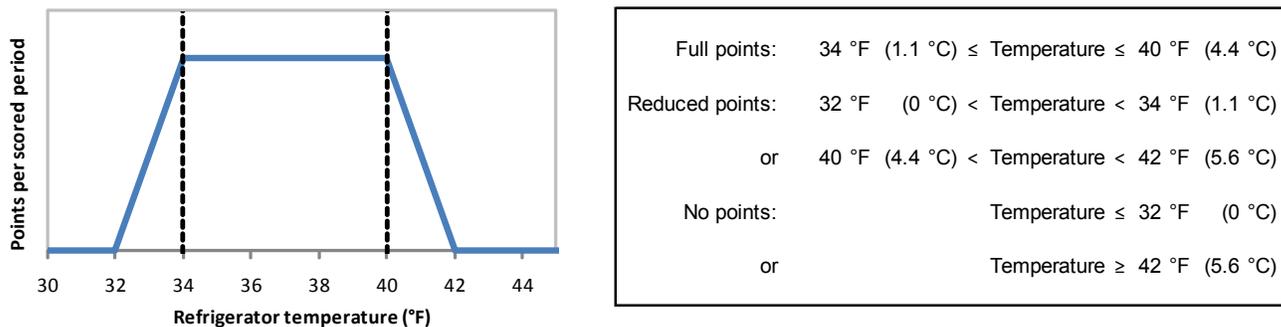


Figure 6: Scoring function for the Refrigerator Subcontest

## 8-2. Freezer

All available points are earned at the conclusion of each scored period by keeping the time-averaged interior temperature of a freezer between  $-20.0^{\circ}\text{F}$  ( $-28.9^{\circ}\text{C}$ ) and  $5.0^{\circ}\text{F}$  ( $-15.0^{\circ}\text{C}$ ) during the scored period. See Appendix A-3 for the schedule of scored periods and for the number of available points per scored period.

- Reduced points are earned if the time-averaged interior freezer temperature is between  $-30.0^{\circ}\text{F}$  ( $-34.4^{\circ}\text{C}$ ) and  $-20.0^{\circ}\text{F}$  ( $-28.9^{\circ}\text{C}$ ) or between  $5.0^{\circ}\text{F}$  ( $-15.0^{\circ}\text{C}$ ) and  $15.0^{\circ}\text{F}$  ( $-9.44^{\circ}\text{C}$ ). Reduced points are scaled linearly, as shown in Figure 7.
- The freezer volume published in the manufacturer's specifications shall be a minimum of  $2.0\text{ ft}^3$  (57 L).
- The automatic defrost function may be disabled.
- The freezer may be used to store food and only enough ice to fill the freezer's ice bin (or equivalent).

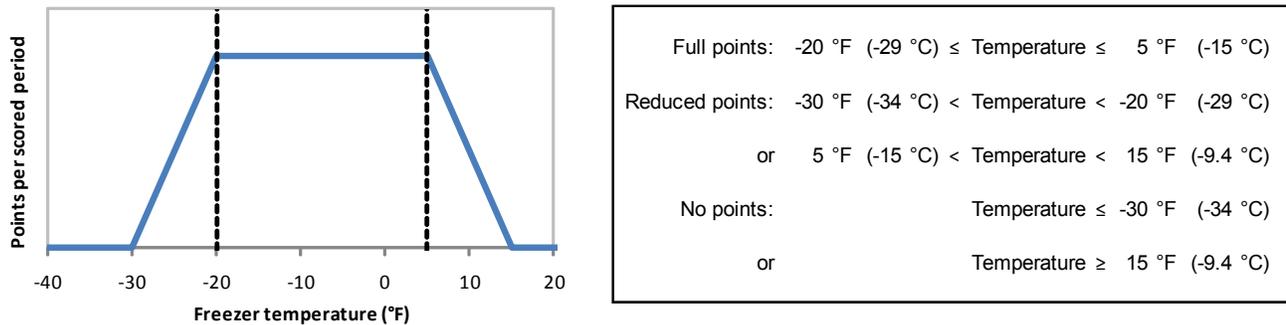


Figure 7: Scoring function for the Freezer Subcontest

## 8-3. Clothes Washer

All available points are earned for washing laundry by running a clothes washer through one or more complete, uninterrupted, “normal” (or equivalent) cycle(s) within a specified period of time. See Appendix A-3 for specific details regarding the number of points per clothes-washing task and the time periods designated for clothes-washing tasks.

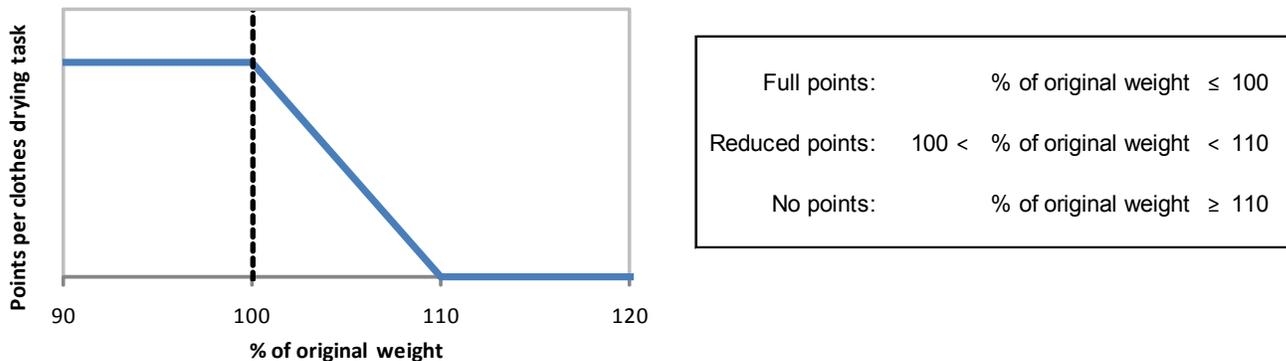
- A load of laundry is defined as six organizer-supplied bath towels.
- The clothes washer shall operate automatically and have at least one wash and rinse cycle.
- One or more complete, uninterrupted, “normal” (or equivalent) cycle(s) in an automatic clothes washer shall be used to wash the laundry.
- On several days during contest week, two loads of laundry are required to be washed. Teams have the option to combine double loads and wash them in one clothes washer cycle.
- The drying function in a combination washer/dryer shall be disabled until the observer can verify that the laundry is wet after the completion of the wash and rinse cycle.
- Cycle “interruption” includes the adjustment of supply temperature or flow in a manner not anticipated by the manufacturer or addressed in its operation manual.
- Cycle completion shall be confirmed by the observance of an audible or visible signal.
- The organizers will consult the operation manual to identify appropriate cycle settings. “Normal” or “regular” settings shall be selected, if available. Otherwise, settings most closely resembling typical “normal” or “regular” settings shall be selected.

## 8-4. Clothes Dryer

All available points are earned by returning a load of laundry (defined as six organizer-supplied bath towels) to a total weight less than or equal to the towels' total weight before washing. Clothes drying shall be completed within a specified period of time. See Appendix A-3 for specific details regarding the number of points per clothes drying task and the time periods designated for laundry tasks.

- Reduced points are earned if the “dry” towel weight is between 100.0% and 110.0% of the original towel weight. Reduced point values are scaled linearly, as shown in Figure 8.

- b. A load of laundry is eligible for clothes-drying points only if the load experienced a complete, uninterrupted cycle (see Contest 8-3h for required cycle settings) in an automatic clothes washer.
- c. The drying method may include active drying (e.g., machine drying), passive drying, (e.g., on a clothes line), or any combination of active and passive drying. All drying methods that require the towels to be visible (such as on a clothes line) must be demonstrated to the architecture and market appeal juries as they visit the houses.
- d. On several days during contest week, two loads of laundry are required to be dried. Teams have the option to combine double loads and dry them in one clothes-drying cycle, but each load will be scored separately.



**Figure 8: Scoring function for the Clothes Dryer Subcontest**

## 8-5. Dishwasher

All available points are earned by running a dishwasher through a complete, uninterrupted, “normal” (or equivalent) cycle within a specified period of time, during which a temperature sensor placed in the dishwasher must reach 120°F (48.9°C) at some point during the cycle. See Appendix A-3 for specific details regarding the number of points per dishwashing task and the time periods designated for dishwashing tasks.

- a. Half of the available points are earned if the temperature sensor reaches 115°F (46.1°C), but does not reach 120°F (48.9°C).
- b. For redundancy, two temperature sensors shall be placed in the dishwasher for each test. The higher of the two readings is the temperature of record, unless it is determined that the sensor with the higher reading is defective, in which case the lower of the two readings is the temperature of record.
- c. The dishwasher shall operate automatically, have at least one wash and rinse cycle, and have a minimum capacity of eight place settings according to the manufacturer’s specifications.
- d. If the dishwasher has a heated drying option, this option shall be disabled.
- e. Cycle “interruption” includes the adjustment of supply temperature or flow in a manner not anticipated by the manufacturer or addressed in its operation manual, including the disruption of an ordinary cycle due to user interaction.
- f. Cycle completion shall be confirmed by the observance of an audible or visible signal.
- g. The organizers will consult the operation manual to identify appropriate cycle settings. “Normal” or “regular” settings shall be selected, if available. Otherwise, settings most closely resembling typical “normal” or “regular” settings shall be selected.
- h. The dishwasher may be run empty, partially loaded, or fully loaded; the load may be soiled or clean.

## *Contest 9. Home Entertainment*

### 9-1. Lighting

All available points are earned for keeping all interior and exterior house lights on during specified periods of time. See Appendix A-3 for specific details regarding the number of points per lighting task and the time periods designated for lighting tasks.

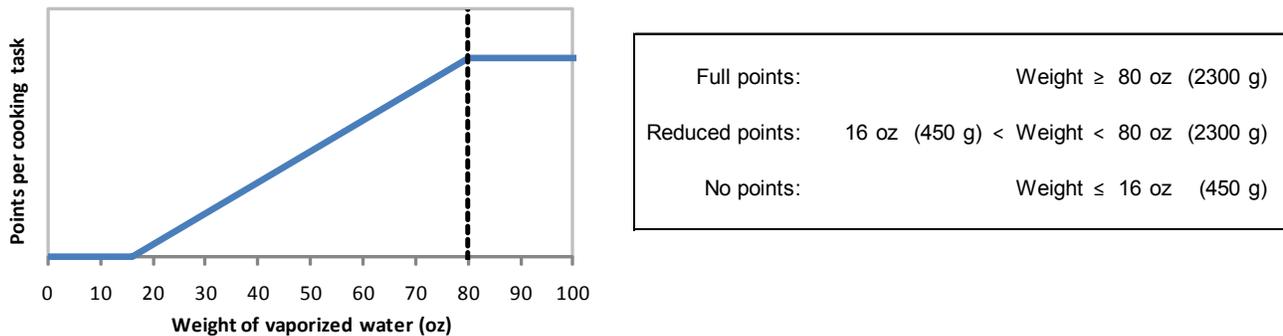
**Exception:** Lights located within manufactured residential appliances such as a refrigerator, clothes dryer, microwave, and oven that are intended to illuminate the interior of the appliance are not required to be illuminated. Lights that are not designed to be connected to the house electrical system are not required to be illuminated.

- a. All dimmers shall be adjusted to their highest positions and all other lighting control equipment shall be disabled or overridden so that the controlled lamps are fully and continuously on during the specified periods.
- b. Partial credit will be awarded for partial compliance.

## 9-2. Cooking

All available points are earned by using a kitchen appliance to vaporize 5.000 lb (80.00 oz or 2.268 kg) of water within a specified period of time. See Appendix A-3 for specific details regarding the number of points per cooking task and the time periods designated for cooking tasks.

- a. Reduced points are earned if between 1.000 lb (16.00 oz or 0.454 kg) and 5.000 lb (80.00 oz or 2.268 kg) are vaporized. Reduced point values are scaled linearly, as shown in Figure 9.
- b. Any kitchen appliance may be used, but it must operate in its normal configuration as it is vaporizing the water.
- c. The water shall be vaporized in a single container and the starting water weight shall be at least 96.00 oz (2.721 kg).



**Figure 9: Scoring function for the Cooking Subcontest**

## 9-3. Dinner Party

Each team shall host two dinner parties for its neighbors during contest week. See Appendix A-3 for the dinner party schedule and the number of available points per dinner party. Dinner parties will feature a pair of guest decathletes from each of three competing teams, and each pair of guest decathletes shall assign a score to the host team after each dinner party. The quality of the meal, ambiance, and overall experience shall be considered in the evaluation.

- a. To maintain consistency among the juried contests and subcontests, guest teams shall use the scoring methodology described in the “Phase 3: Deliberation” section of Appendix B-1. Each of the three pairs of guest decathletes shall submit three percentage integer scores, i.e., one score for quality of the meal, one score for ambiance, and one score for overall experience, to the contest officials by 11 p.m. These nine scores will be averaged and multiplied by the maximum available points in the scoring server to generate a final score for each dinner party. Percentage integer scores may range from 0% (lowest possible score) to 100% (highest possible score).
- b. The village will be organized into five small “neighborhoods.” Each neighborhood consists of four neighboring houses. The guest list for the dinner party shall be limited to eight people—two people from each of the three neighboring houses and up to two VIP guests. VIP guests may include organizers, media, government employees, family members, or other individuals approved by the organizers to attend the dinner parties.
- c. See Rule 11-1d for house occupancy rules during the dinner party.

- d. Each host team shall prepare dinner for exactly eight people—six decathlete guests and two host team members or VIP guests. Guest decathletes are encouraged to deduct points if too much or too little food is prepared. Teams are not permitted to serve the same meal at each dinner party.
- e. Host team decathletes in the house during the dinner party must be performing one or more of the following three functions: 1) eating the meal; 2) cooking/preparing the food; 3) operating the house during scheduled Contest 7, 8, or 9 activities.
- f. Non-decathletes are prohibited from preparing the meal or instructing decathletes in any way on the competition site.
- g. Teams shall prepare and cook all food and beverages in the house during the period of time indicated in Appendix A-3. A file describing eligible and ineligible ingredients is posted in the “/Files/Rules/Dinner Party” folder on the Yahoo Group.
- h. The meal shall be served and eaten in the finished square footage at the eating area designated in the drawings.
- i. Before and after the dinner portion of the party, the host team is permitted, but not required, to serve hors d’oeuvres and/or beverages, which may be served outside.
- j. Teams are required to submit detailed dinner party menus, recipes, and ingredient lists to the organizers.
  - (i). Guest decathletes are encouraged to deduct points for inconsistencies between the meal served for each dinner party and the dinner party information submitted prior to contest week.
- k. Teams hosting dinner parties shall comply with the following safety requirements:
  - (i). The use of flames, including candle flames, is prohibited during contest week (see Rule 8-2b).
  - (ii). No alcoholic beverages may be stored in the house, used in meal preparation, served, or part of a meal in any way.
  - (iii). All water used for cooking and drinking shall be drinking water purchased in sealed containers.
  - (iv). All dishes and cookware shall be washed with hot water and soap and rinsed prior to use.
  - (v). Normal domestic wastewater may go into the wastewater tank.
  - (vi). All beverages and food must be stored properly and according to the instructions on the packaging, e.g., beverages and foods marked “refrigerate after opening” must be refrigerated appropriately after opening.
  - (vii). To help prevent allergic reactions among dinner party guests, teams shall create a list of ingredients for each of the items being served at each meal. Common food allergies include milk/dairy products, eggs, peanuts, tree nuts (walnuts, cashews, pecans), fish, shellfish, soy, and wheat.
  - (viii). Outdoor cooking and grilling equipment may be incorporated into the competition prototype, but the use of such equipment is prohibited on the competition site.
  - (ix). The use of coolers to store food, beverages, or ice associated with the dinner party on site is not permitted. Coolers may be used for transporting food to the competition site only.

#### **9-4. Home Electronics**

All available points are earned for operating a television (TV) and computer during specified periods of time. See Appendix A-3 for specific details regarding the number of points per home electronics task and the time periods designated for home electronics tasks.

- a. The TV display shall be a minimum of 27 in. (68.6 cm) according to the manufacturer’s stated display size. The computer display shall be a minimum of 15 in. (38.1 cm) according to the manufacturer’s stated display size. The computer may be a laptop or desktop computer. The TV and computer displays shall be able to be operated simultaneously and controlled independently of each other.
- b. The organizers will supply content that must be shown on the TV display during the home electronics tasks. There is no required volume setting, but the brightness of the display shall be set to at least 75% of maximum. Observers will conduct spot checks to verify that the TV is showing the supplied content and that the brightness is at the required level.
- c. The organizers will supply content that must be shown on the computer display during the scored periods. A decathlete may temporarily suspend the supplied content to use the computer for other practical purposes, but

the display of supplied content shall be resumed whenever the computer is not being used for other practical purposes. The brightness of the display shall be set to at least 75% of maximum. Observers will conduct spot checks to verify that the computer is either showing the supplied content or is being used by a decathlete, and that the brightness is at the required level.

## 9-5. Movie Night

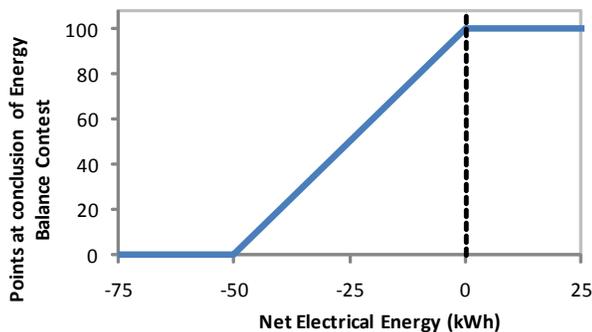
Each team shall host a movie night for its neighbors during contest week. See Appendix A-3 for the movie night schedule and the number of available points for movie night. Each guest team shall assign a score to each host team. The quality and design of the home theater system, ambiance, and overall experience shall be considered in the evaluation.

- To maintain consistency among the juried contests and subcontests, guest teams shall use the scoring methodology described in the “Phase 3: Deliberation” section of Appendix B-1. Each of the three guest teams shall submit three percentage integer scores, i.e., one score for the quality and design of the home theater system, one score for ambiance, and one score for overall experience, to the contest officials by 10:30 p.m. These nine scores will be averaged and multiplied by the maximum available points in the scoring server to generate a final score for movie night. Percentage integer scores may range from 0% (lowest possible score) to 100% (highest possible score).
- The village will be organized into five small “neighborhoods.” Each neighborhood consists of four neighboring houses. One or more decathletes from each neighboring house shall spend at least 15 minutes during the movie in each of their neighbors’ houses.
- The Comfort Zone Contest is suspended during movie night. Therefore, the occupancy rule, Rule 11-1, is not in effect on movie night.
- Prior to the event, team members signed up for the Yahoo Group will have the option to vote for one of three movies selected by the organizers. The movie receiving the most votes shall be provided by the organizers on the day of movie night and shall be the movie shown in all houses on movie night. The selected movie shall be available in several of the most popular video formats, so that each team may request the format most suitable for its home theater system.
- The audio/visual equipment settings to be used on movie night shall be declared to a designated organizer prior to movie night. Observers or a small team of organizers, or both, will verify that these settings are maintained on movie night. Guests are encouraged to evaluate the usability of the home theater system and its controls, but the host team is responsible for returning the equipment back to the declared settings after the guests have finished their evaluation(s).

## Contest 10. Energy Balance

All available points are earned at the conclusion of the specified energy balance period (see Appendix A-3 for the energy balance schedule) for a net electrical energy balance of at least 0 kWh. A positive net electrical energy balance indicates net production; a negative net electrical energy balance indicates net consumption.

- Reduced points are earned for a net electrical energy balance between -50 kWh and 0 kWh. Reduced points are scaled linearly, as shown in Figure 10.



Full points:	Net electrical energy $\geq$ 0 kWh
Reduced points:	-50 kWh < Net electrical energy < 0 kWh
No points:	Net electrical energy $\leq$ -50 kWh

Figure 10: Scoring function for the Energy Balance Contest

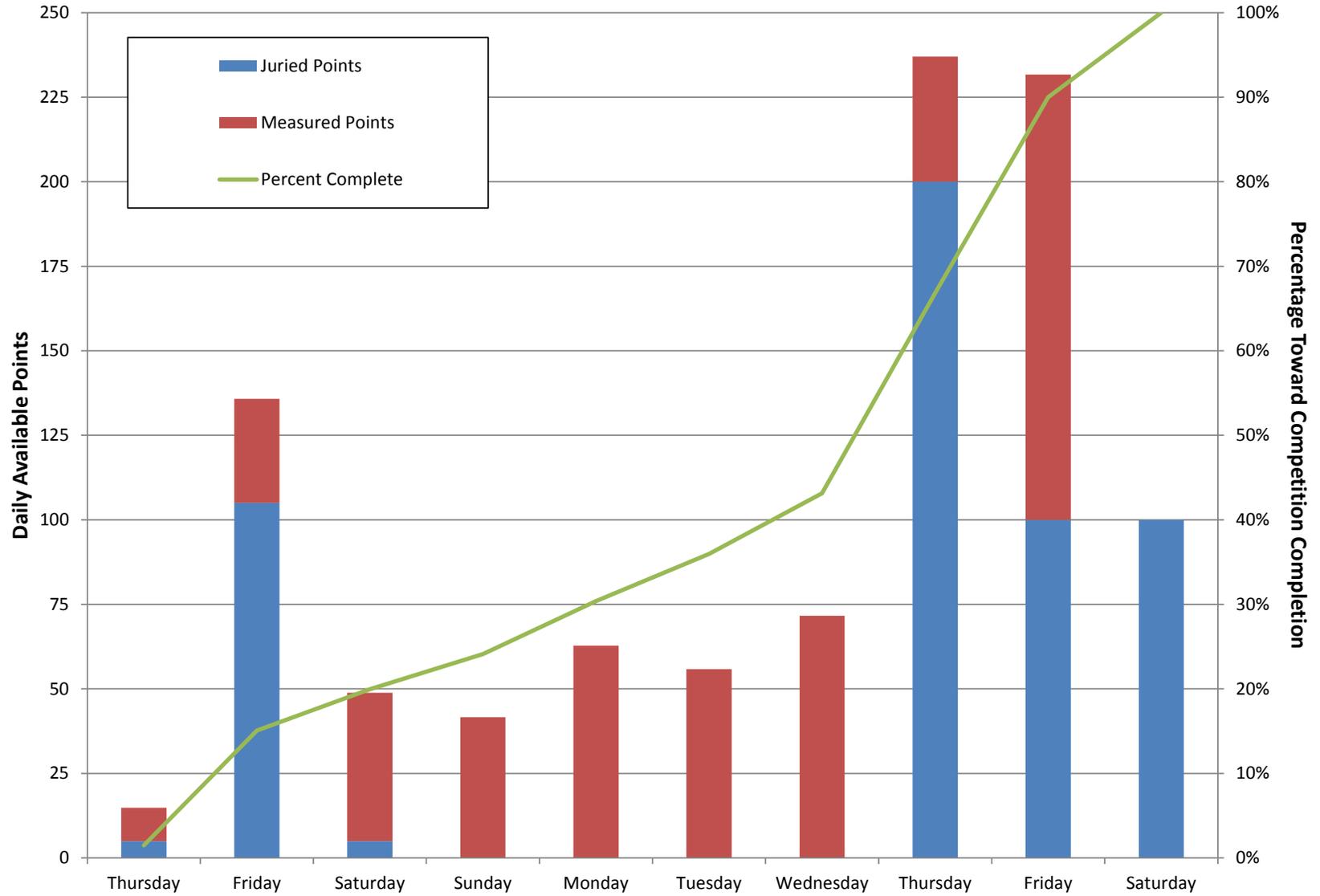
## Appendix A Event Schedules

### A-1. Overview Event Calendar

This calendar provides an overview of daily activities. Refer to the Detailed Event Schedule (Appendix A-3) for a complete list and schedule of daily activities.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
DAY 0 - September 22, 2013	DAY 1 - September 23, 2013	DAY 2 - September 24, 2013	DAY 3 - September 25, 2013	DAY 4 - September 26, 2013	DAY 5 - September 27, 2013	DAY 6 - September 28, 2013
<b>REGISTRATION</b> (12 p.m. - 2 p.m.; 4 p.m. on)	<b>STAND-ALONE ASSEMBLY</b> (Begins at 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)
<b>ALL-TEAM MEETING</b> (2 p.m. - 4 p.m.)		<b>STAND-ALONE ASSEMBLY</b>	<b>STAND-ALONE ASSEMBLY</b>	<b>STAND-ALONE ASSEMBLY</b>	<b>STAND-ALONE ASSEMBLY</b>	<b>STAND-ALONE or GRID-TIE ASSEMBLY</b> (Grid available at 12:00 p.m.)
<b>VEHICLE STAGING</b> (Begins at 7 p.m.)						<b>GRID-TIE ASSEMBLY</b> (Grid available at 12:00 p.m.)
DAY 7 - September 29, 2013	DAY 8 - September 30, 2013	DAY 9 - October 1, 2013	DAY 10 - October 2, 2013	DAY 11 - October 3, 2013	DAY 12 - October 4, 2013	DAY 13 - October 5, 2013
<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)
<b>STAND-ALONE or GRID-TIE ASSEMBLY</b>	<b>STAND-ALONE or GRID-TIE ASSEMBLY</b> (Until 12 p.m.)	<b>GRID-TIE ASSEMBLY</b>	<b>REST DAY</b>	<b>CONTESTS</b> (11:00 a.m. - Midnight)	<b>CONTESTS</b> (24 hours)	<b>CONTESTS</b> (24 hours)
<b>WATER DELIVERY</b> (8 a.m. - 5 p.m.)	<b>GRID-TIE ASSEMBLY</b> (After 12 p.m.)	<b>STOP WORK FOR LAST-CHANCE FINAL INSPECTIONS*</b> (12 p.m.)	<b>HOUSE PHOTOGRAPHY</b> (8 a.m. - 6 p.m.)	<b>OPENING CEREMONY</b> (10 a.m. - 11 a.m.)	<b>AFFORDABILITY RESULTS</b> (10:30 a.m. - 11 a.m.)	
			<b>OPENING RECEPTION</b> (6 p.m. - 8:30 p.m.)	<b>PUBLIC EXHIBIT</b> (11 a.m. - 7 p.m.)	<b>PUBLIC EXHIBIT</b> (11 a.m. - 7 p.m.)	<b>PUBLIC EXHIBIT</b> (11 a.m. - 7 p.m.)
			<b>TEAM OPEN HOUSE</b> (8:30 p.m. - 11 p.m.)			
DAY 14 - October 6, 2013	DAY 15 - October 7, 2013	DAY 16 - October 8, 2013	DAY 17 - October 9, 2013	DAY 18 - October 10, 2013	DAY 19 - October 11, 2013	DAY 20 - October 12, 2013
<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)	<b>IMPOUND</b> (12 a.m. - 7 a.m. & 11 p.m. - 12 a.m.)
<b>CONTESTS</b> (24 hours)	<b>CONTESTS</b> (24 hours)	<b>CONTESTS</b> (24 hours)	<b>CONTESTS</b> (24 hours)	<b>CONTESTS</b> (24 hours)	<b>CONTESTS</b> (Midnight - 11a.m.)	<b>ENGINEERING RESULTS &amp; AWARDS CEREMONY</b> (10:00 a.m. - 11 a.m.)
<b>PUBLIC EXHIBIT</b> (11 a.m. - 7 p.m.)	<b>JURY WALKTHROUGHS</b> (7:30 a.m. - 12:30 p.m.) and ( 7:30 p.m. - 9:30 p.m.)	<b>JURY WALKTHROUGHS</b> (7:30 a.m. - 12:30 p.m.) and ( 7:30 p.m. - 9:30 p.m.)	<b>JURY WALKTHROUGHS</b> (7:30 a.m. - 10:00 a.m.) and (7:30 p.m. to 8:30 p.m.)	<b>COMMUNICATIONS &amp; MARKET APPEAL RESULTS</b> (10:30 a.m. - 11 a.m.)	<b>ARCHITECTURE RESULTS</b> (10:30 a.m. - 11 a.m.)	<b>PUBLIC EXHIBIT</b> (11 a.m. - 7 p.m.)
				<b>PUBLIC EXHIBIT</b> (11 a.m. - 7 p.m.)	<b>TEAM OPEN HOUSE</b> (7:30 p.m. - 11 p.m.)	<b>VICTORY CELEBRATION</b> (7:30 p.m. - 11 p.m.)
DAY 21 - October 13, 2013	DAY 22 - October 14, 2013	DAY 23 - October 15, 2013	DAY 24 - October 16, 2013	DAY 25 - October 17, 2013	DAY 26 - October 18, 2013	<b>Last Updated On:</b> <b>09-24-2012</b>  * Significant precipitation or the occurrence of an unforeseen circumstance that equally affects all teams' progress during the assembly phase may result in a postponement of the last-chance final inspections. The remainder of the schedule will remain unchanged.
<b>IMPOUND</b> (12 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	<b>IMPOUND</b> (2 a.m. - 7 a.m.)	
<b>PUBLIC EXHIBIT</b> (11 a.m. - 7 p.m.)	<b>DISASSEMBLY</b>	<b>DISASSEMBLY</b>	<b>DISASSEMBLY</b>	<b>DISASSEMBLY</b>	<b>DISASSEMBLY</b>	
<b>DISASSEMBLY</b> (Begins at 7 p.m.)					<b>FINAL DISASSEMBLY INSPECTIONS</b> (7 p.m.)	
					<b>ALL TEAMS OFF SITE</b> (9 p.m.)	

## A-2. Scoring Chronology









## Sun (Day 14)

Rules Section	Contest Type	Total Pts Available	Total # of tasks or periods	Daily # of tasks or periods	Daily Points Available	12:00 AM	12:30 AM	1:00 AM	1:30 AM	2:00 AM	2:30 AM	3:00 AM	3:30 AM	4:00 AM	4:30 AM	5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 AM							
Temperature	C6-1	MEAS	75,000	576	60	7,813																															
Humidity	C6-2	MEAS	25,000	576	60	2,604																															
Refrigerator	C8-1	MEAS	10,000	766	96	1,253																															
Freezer	C8-2	MEAS	10,000	766	96	1,253																															
Clothes Washer	C8-3	TASK	20,000	8	1	2,500																															
Clothes Dryer	C8-4	TASK	40,000	8	1	5,000																															
Home Electronics	C9-4	TASK	25,000	34	3	2,206																															
Dishwasher	C8-5	TASK	20,000	5	1	4,000																															
Cooking	C9-2	TASK	20,000	6	1	3,333																															
Hot Water	C7	TASK	100,000	16	1	6,250																															
Lighting	C9-1	TASK	40,000	52	7	5,385																															
<b>DAILY AVAILABLE POINTS</b>					<b>41,597</b>																																
<b>CUMULATIVE AVAILABLE POINTS</b>					<b>241,107</b>																																
Team/organizer meeting																																					

## Mon (Day 15)

Rules Section	Contest Type	Total Pts Available	Total # of tasks or periods	Daily # of tasks or periods	Daily Points Available	12:00 AM	12:30 AM	1:00 AM	1:30 AM	2:00 AM	2:30 AM	3:00 AM	3:30 AM	4:00 AM	4:30 AM	5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 AM							
Temperature	C6-1	MEAS	75,000	576	96	12,500																															
Humidity	C6-2	MEAS	25,000	576	96	4,167																															
Refrigerator	C8-1	MEAS	10,000	766	96	1,253																															
Freezer	C8-2	MEAS	10,000	766	96	1,253																															
Jury Walkthroughs	C1,2,3,4	JURIED	-	-	-	-																															
Clothes Washer	C8-3	TASK	20,000	8	2	5,000																															
Clothes Dryer	C8-4	TASK	40,000	8	2	10,000																															
Home Electronics	C9-4	TASK	25,000	34	5	3,676																															
Hot Water	C7	TASK	100,000	16	3	18,750																															
Lighting	C9-1	TASK	40,000	52	8	6,154																															
<b>DAILY AVAILABLE POINTS</b>					<b>62,754</b>																																
<b>CUMULATIVE AVAILABLE POINTS</b>					<b>303,861</b>																																
Team/organizer meeting																																					

## Tues (Day 16)

Rules Section	Contest Type	Total Pts Available	Total # of tasks or periods	Daily # of tasks or periods	Daily Points Available	12:00 AM	12:30 AM	1:00 AM	1:30 AM	2:00 AM	2:30 AM	3:00 AM	3:30 AM	4:00 AM	4:30 AM	5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 AM							
Temperature	C6-1	MEAS	75,000	576	96	12,500																															
Humidity	C6-2	MEAS	25,000	576	96	4,167																															
Refrigerator	C8-1	MEAS	10,000	766	96	1,253																															
Freezer	C8-2	MEAS	10,000	766	96	1,253																															
Jury Walkthroughs	C1,2,3,4	JURIED	-	-	-	-																															
Home Electronics	C9-4	TASK	25,000	34	6	4,412																															
Dishwasher	C8-5	TASK	20,000	5	1	4,000																															
Hot Water	C7	TASK	100,000	16	3	18,750																															
Cooking	C9-2	TASK	20,000	6	1	3,333																															
Lighting	C9-1	TASK	40,000	52	8	6,154																															
<b>DAILY AVAILABLE POINTS</b>					<b>55,822</b>																																
<b>CUMULATIVE AVAILABLE POINTS</b>					<b>359,683</b>																																
Team/organizer meeting																																					

Impound period
  Task Period
  Event/Activity
  Public exhibit hours
  Juried contest results
  Tasks requiring observer
  Food preparation and cooking
  Jury walkthroughs





## Appendix B Juried Subcontest Guidelines

### B-1. Juror Guidelines

A jury's evaluation of each team's project consists of the following three phases:

1. Deliverables review
2. On-site walkthroughs
3. Deliberation

**Table 4: Juror time commitments for deliverables review and on-site walkthroughs**

Jury	Time Commitment for Deliverables Review (per team)	Relevant Deliverables for Review	Time Commitment for On-site Walkthrough (per team)
Architecture	30-45 minutes	<ol style="list-style-type: none"> <li>1. Drawings<sup>6</sup></li> <li>2. Construction specifications<sup>7</sup></li> <li>3. Audiovisual presentation<sup>8</sup></li> <li>4. Architecture narrative<sup>9</sup></li> </ol>	30 minutes
Market Appeal	1 to 2 hours	<ol style="list-style-type: none"> <li>1. Drawings<sup>6</sup></li> <li>2. Construction specifications<sup>7</sup></li> <li>3. Audiovisual presentation<sup>8</sup></li> <li>4. Market appeal narrative<sup>9</sup></li> </ol>	30 minutes
Engineering	1 to 2 hours	<ol style="list-style-type: none"> <li>1. Drawings<sup>6</sup></li> <li>2. Construction specifications<sup>7</sup></li> <li>3. Energy analysis results and discussion<sup>10</sup></li> <li>4. Audiovisual presentation<sup>8</sup></li> <li>5. Engineering narrative<sup>9</sup></li> </ol>	30 minutes
Communications	1 to 2 hours	<ol style="list-style-type: none"> <li>1. Website<sup>11</sup></li> <li>2. Audiovisual presentation<sup>8</sup></li> <li>3. Public exhibit presentation and materials<sup>12</sup></li> <li>4. Communications narrative<sup>9</sup></li> </ol>	30 minutes

#### ***Phase 1: Deliverables Review***

Each juror will review the deliverables outlined in Table 4 to explore the relevant details of each team's project. If questions arise during the deliverables review phase, jurors may address those questions to the appropriate contest official before or during the event.

#### ***Phase 2: On-site Walkthroughs***

The on-site walkthroughs take place on the competition site and offer the jurors an opportunity to make visual verifications of information presented in the deliverables and to ask the decathletes for clarification of questions that may have arisen during the deliverables review. The logistical details of the on-site walkthroughs will be provided to each juror by the contest official prior to the juror's arrival on the competition site.

<sup>6</sup> See Appendix D-4 for drawings requirements.

<sup>7</sup> The construction specifications are located in the project manual. See Appendix D-5 for project manual requirements.

<sup>8</sup> See Appendix D-7 for audiovisual presentation requirements.

<sup>9</sup> See Appendix D-6 for jury narrative requirements.

<sup>10</sup> The energy analysis results and discussion is located in the project manual. See Appendix D-5 for project manual requirements.

<sup>11</sup> See Appendix D-8 for website requirements.

<sup>12</sup> See Appendix B-3 for public exhibit presentation requirements and Appendix D-10 for public exhibit materials requirements.

### ***Phase 3: Deliberation***

#### ***STEP #1***

During the deliberation phase, which takes place after the completion of on-site walkthroughs, the jury is encouraged to place each team into one of four classes based on each team's performance relative to the contest criteria. The four classes are:

Class #1: ECLIPSES contest criteria 91% – 100% of available points

Class #2: EXCEEDS contest criteria 81% – 90% of available points

Class #3: EQUALS contest criteria 61% – 80% of available points

Class #4: APPROACHES contest criteria 0% – 60% of available points

Juries are not required to place a uniform number of teams in all classes or to place at least one team in every class. For example, if a jury determines that no teams are worthy of Class #1, there would be no teams with scores greater than 90%. Note that placing teams into classes (as a first step toward assigning an eventual percentage integer) is encouraged to ease the process of evaluating so many teams at one time.

If it is possible to further separate teams within a particular class, assigning different percentage integers within the allowed range of the particular class is encouraged. The assigned percentage integer may fall anywhere within the range associated with the class. If it is not possible to further separate teams within a particular class, it may be appropriate to assign each team in a particular class the same percentage integer.

#### ***STEP #2***

After assigning each team a percentage integer from 0% to 100%, the jury shall submit its percentage integers to the contest official. The contest official will then submit the percentages to the competition manager, who will convert them into a score based on the total number of available points for the contest being judged. The competition manager will round off any noninteger percentage scores to the nearest integer. Prior to posting scores in the scoring server, the scorekeeper will apply any applicable penalties that may have been incurred.

#### ***STEP #3***

The three highest-scoring teams (plus ties) will be given awards during a scheduled media announcement during contest week (see Appendix A for announcement schedule). Pending the jurors' availability, the organizers will invite the jurors to make the announcement. The scores for all of the teams will be posted immediately following the announcement.

#### ***STEP #4***

The jury shall submit written or recorded scoring justifications for each team to the contest official. The jury's scoring justifications will be provided as feedback to each team so it might better understand why the jury evaluated the team as it did. The justifications may be posted on the Solar Decathlon website.

## **B-2. Team Guidelines**

- a. It is ultimately the team's responsibility to be ready for the arrival of juries at the times indicated in the jury walkthrough schedule, which is available in the "/Files/Rules/Rules Reference Documents" folder on the Yahoo Group. A Solar Decathlon organizer or staff person called a "runner" will deliver a warning 30 to 60 minutes prior to the arrival of the jury.
- b. Teams shall show all possible configurations of the house during the walkthroughs of the Architecture, Market Appeal, and Engineering juries. House configurations that could affect the outcome of contests and that were not demonstrated to the juries are prohibited during contest week. Some examples of reconfigurable features include:
  - A significant moveable component, such as a room, wall, or bed (safety plan must also be in place)
  - Significant shading devices, such as retractable awnings or operable shutters
  - Towel-drying locations
  - Window coverings that may obstruct views or reduce light levels.

If a team does not have time to do a live reconfiguration during the jury walkthroughs, the team must use some other method, such as photographs or video, to show all reconfigurable features in their various configurations. If a team is not planning to actually reconfigure qualifying features at any time during contest week and has not shown or described the reconfiguration in the drawings, project manual, audiovisual presentation, or video walkthrough, that team does not have to show the reconfiguration to the juries.

All plug-in or portable appliances that may be used during contest week must be in their fully deployed locations and configurations during the Architecture, Engineering, or Market Appeal jury walkthroughs. Also be aware that the Architecture, Engineering or Market Appeal juries may request plug-in, portable, or hard-wired appliances to be turned on so they can evaluate noise levels or other characteristics of the appliances that may not be apparent when the appliances are off.

- c. Rule 11-1, “House Occupancy,” applies during jury walkthroughs. Non-decathlete team members and team crew shall not be present during the walkthroughs.
- d. The jury walkthroughs will be held to a very strict schedule for each of the houses. The importance of following this schedule is twofold: 1) To ensure each team receives equal visitation time by the juries to maintain a sense of fairness among all the teams; and 2) Any deviation from the schedule will have an immediate effect on other events planned during the days the juries will be evaluating houses. A small deviation in the defined schedule for the juries could result in a very difficult situation to resolve in another component of the competition. If a team is not ready for a jury to begin its evaluation at the scheduled time, then the total time the jury spends in that team’s house will be reduced.
- e. During daytime jury walkthroughs, the jury will have 30 minutes to visit each house, followed by a 5-minute period to travel to the next house. During the 30-minute walkthrough, 20 minutes will be allocated for the team to lead the jury through the house and answer any questions the jury may have. After 20 minutes, the team shall leave the house so that the jury can hold a private, 10-minute discussion about the house it has just visited.
- f. The Architecture Jury will visit each house a second time at night. During the nighttime walkthrough, the Architecture Jury will have 10 minutes to visit each house followed by a 5-minute period to travel to the next house. During the 10-minute walkthrough, 5 minutes will be allocated for the team to answer any questions the jury may have. Teams are permitted to adjust the house lighting during the Architecture Jury visit without consequence on the score for the Lighting Subcontest. After 5 minutes, the team shall leave the house so that the jury can hold a private, 5-minute discussion about the house it has just visited.
- g. Presentation boards or other visual media summarizing information in the “Relevant Deliverables” (see the third column in Table 4) are permitted to be on display during jury walkthroughs. The team website, public exhibit handout, and public exhibit materials may only be viewed by the Communications Jury.
- h. One or more of the eligible house occupants (see Rule 11-1 and item c above) may audiotape or videotape the jury walkthrough as it is happening, but taping of the private jury discussion period is prohibited.
- i. Areas of the house excluded from the accessible exhibit route may be accessed by the juries and considered in their evaluations.
- j. The organizers will provide all juries with summaries of important rule and code violations for each team so that juries are aware of violations before giving credit for aspects of the project that are not in compliance.
- k. The organizers may provide juries with contents of the organizers’ reviews of relevant deliverables.

### **B-3. Public Exhibit Requirements**

The team shall present two versions of its public tour. Both versions will be evaluated by the Communications Jury.

#### ***Version #1: 10-Minute Personalized Tour***

- The personalized tour is a comprehensive tour that addresses individual visitors’ needs and questions and is appropriate for times when wait lines are short or nonexistent.
- Each team will be allowed 10 minutes to present the personalized tour to the Communications Jury.
- The version of the personalized tour presented to the Communications Jury must represent the personalized tour presented to the public throughout the competition week.

### ***Version #2: 5-Minute Fast Tour***

- The 5-minute fast tour is a fast-yet-informative tour that allows visitors to move through the house on their own and accommodates large crowds and long lines.
- Each team will be allowed 5 minutes to present the fast-yet-informative tour to the Communications Jury.
- The version of the fast tour presented to the Communications Jury must represent the fast tour presented to the public throughout the competition week.

### ***Common Requirements***

- Both versions of the public tours shall be informative, interesting, and accessible by people of all abilities.
- In addition to the two tours described above, teams will be allowed 5 minutes to present the team communications strategy to the Communications Jury.
- Teams are encouraged to employ effective and creative methods to control wait times and engage visitors waiting in line during public hours.
- Power-consuming devices, such as LCD displays, house lighting, mobile electronics, etc., shall not be used during the fast tour presented to the Communication Jury. Any power-consuming devices used during the personalized tour must be plugged into the house at all times when not in use.
- For additional information, see Rule 11-4.

## Appendix C Measured Subcontest Guidelines

### C-1. Monitored Performance Subcontests

Table 5 lists sensors used<sup>13</sup> in the “monitored performance” subcontests for which points are automatically awarded based on measurements made by each home’s datalogger. Purchasing information is provided for teams intending to practice the contests before the competition using the same equipment that will be used by the organizers.

**Table 5: Sensors used in “measured performance” subcontests**

Subcontest(s)	Sensor Type	Vendor	Model Number	Approx. Price
6-1. Temperature 6-2. Humidity	Temperature/humidity probe	Campbell Scientific (probe)	<a href="#">HMP50</a> probe	\$425
8-1. Refrigerator	Thermocouple wire	Omega Engineering	<a href="#">TT-T-24S-TWSH-SLE-100</a>	\$141
8-2. Freezer	Thermocouple wire	Omega Engineering	<a href="#">TT-T-24S-TWSH-SLE-100</a>	\$141
Contest 10. Energy Balance	Utility revenue-grade meter	GE	<a href="#">kV2c Encompass</a> electronic meter family with KYZ output	\$150

Table 6 lists the central data acquisition equipment and associated accessories that collect sensor readings and transmit the data to the scoring server. Please refer to the documents<sup>14</sup> in the “/Files/Rules/Rules Reference Documents” folder on the Yahoo Group for detailed policies and procedures for accommodating competition instruments.

**Table 6: Central data acquisition equipment**

Equipment Description	Vendor	Model Number	Approx. Price
Datalogger enclosure	Hubbell-Wiegmann	<a href="#">ENC12/14-DC-NM</a>	\$235
Datalogger	Campbell Scientific	<a href="#">CR1000</a>	\$1,400
Power supply	Campbell Scientific	<a href="#">PS100</a>	\$225
Transformer	Campbell Scientific	9591	\$50
Ethernet interface	Campbell Scientific	<a href="#">NL120</a>	\$220
Sensor wire and miscellaneous parts	Various	Various	\$125

<sup>13</sup> The sensors and equipment listed here represent the expected solution, but may change as procedures are further developed.

<sup>14</sup> These documents are expected to be posted to the Yahoo Group in fall 2012.

## C-2. Task Completion Subcontests

The “task completion” subcontests listed in Table 7 are classified as such because teams earn points by successfully completing a task that is observed by, and the results of which are recorded by, an observer in the “observer logs”:

**Table 7: Instruments and sensors used in “task completion” subcontests**

Subcontest(s)	Instrument or Sensor Type	Vendor	Model Number	Approx. Price
Contest 7. Hot Water	Multiple Components <sup>15</sup>	Constructed	None	\$600
8-3. Clothes Washer	Visual/audible inspection	n/a	n/a	n/a
8-4. Clothes Dryer	Scale	Acculab	<a href="#">SVI-50C</a>	\$350
8-5. Dishwasher	Nonreversible temperature label	Omega	<a href="#">TL-5-105-10</a>	\$10 (pkg of 10)
9-1. Lighting	Visual inspection	n/a	n/a	n/a
9-2. Cooking	Kitchen scale	Salton	1008	\$50
9-4. Home Electronics	Visual inspection	n/a	n/a	n/a

Please refer to the “Measured Contest Procedures” slideshow<sup>16</sup> in the “/Files/Rules/Rules Reference Documents” folder on the Yahoo Group for detailed task completion subcontest policies and procedures as well as examples of observer logs.

<sup>15</sup> A detailed component list is expected to be posted to the Yahoo Group in spring 2013.

<sup>16</sup> This slideshow is expected to be posted in spring 2013.

## Appendix D Competition Deliverables

The design deliverables consist of the schematic design summary, building information model, drawings, project manual, and audiovisual presentations. These design deliverables serve the following important functions:

- In its **schematic design summary**, the team shall disclose to the organizers all non-standard design features, communications strategies, site operations plans, and health and safety considerations that require further review prior to the continuation of the project into the design development phase.
- All the drawings shall be generated in an Autodesk Revit **building information model** compatible format.
- The **drawings and project manual** shall demonstrate compliance with the Solar Decathlon Building Code and the Solar Decathlon Rules so that the inspectors will be able to grant final on-site approval by verifying that the constructed project on the competition site was accurately represented by the approved drawings and project manual.
- The **drawings and project manual** shall clearly describe a team's proposed assembly and disassembly procedures. The site operations manager will review the teams' procedures to identify and address potential conflicts among the teams. Each team is encouraged to consult with the site operations manager as the relevant sections of the drawings and project manual are being developed.
- The **drawings and project manual** shall provide a residential contractor with all the information needed to generate an accurate, detailed cost estimate and to efficiently construct the building as the design team intended it to be built. The drawings and project manual must be comprehensive because the design team shall assume that the contractor has had no prior communication with the design team, has no prior knowledge of the design, and has little or no experience building high-performance residences.
- Because the juries have a very limited opportunity to evaluate the constructed projects on the competition site, the **drawings, project manual, audiovisual presentation, and jury narratives** provide the only means for a team to provide a detailed presentation of its project to the juries. In the weeks leading up to contest week, each juror shall evaluate the audiovisual presentation and sections of the teams' drawings and project manual relevant to the juror's respective area of expertise. The primary purpose of the juries' walkthroughs on the competition site is twofold: 1) to verify that the project, as assembled on the competition site, was accurately represented in the drawings, project manual, audiovisual presentations and narratives; and 2) to ask the decathletes any clarifying questions that arose during the evaluation of the design via the drawings, project manual, and audiovisual presentations.

Additional competition deliverables provided the information required to allow the organizers, juries, and public to develop a comprehensive understanding of each team's competition prototype.

### D-1. Schematic Design Summary

The schematic design proposal will be reviewed by the organizers and discussed in detail during the schematic design review. It will not be reviewed by any juries and will not be made publicly available until after the completion of the competition.

### ***Format Requirements***

<input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements)
<input type="checkbox"/> Intent of figures shouldn't be lost if printed in black & white
<input type="checkbox"/> ANSI "A" (8.5 in. X 11 in.) sheet size and ANSI "D" (22 in. X 34 in.) sheet size
<input type="checkbox"/> 20 to 30 pages, including figures and tables; cover sheet, table of contents, and appendices do not count toward page limit
<input type="checkbox"/> 11-point body text
<input type="checkbox"/> Maximum 14-point heading text
<input type="checkbox"/> One-inch margins on top, bottom, left, and right
<input type="checkbox"/> Include page numbers and numbered captions for figures and tables for easy navigation through document

### ***Content Requirements***

<input type="checkbox"/> Team mission statement (1 paragraph)
<input type="checkbox"/> Detailed strategy for winning the competition including a realistic contest-by-contest breakdown of points the team expects to earn (2 to 3 pages)
<input type="checkbox"/> Narrative describing the architectural and engineering design approaches (1 to 2 pages)
<input type="checkbox"/> Design drawings and written description of the following systems and components, with a focus on unique systems and components that may not be addressed by model building codes (12 to 17 pages): <ul style="list-style-type: none"><li>• Temporary foundations and anchors</li><li>• Exterior building structures, such as including decks, outbuildings, overhead structures, etc.</li><li>• Ramps, railings, and guards</li><li>• Glazing types and location</li><li>• Interior finishes</li><li>• Fire protection</li><li>• DC electrical</li><li>• AC electrical</li><li>• Water storage/service</li><li>• Plumbing</li><li>• Mechanical (includes HVAC)</li><li>• Solar mechanical</li></ul>
<input type="checkbox"/> Description of and proposed location(s) for utility meter and organizer dataloggers (1 to 2 pages)
<input type="checkbox"/> Description of public exhibit, communications, and outreach strategy (1 to 2 pages)
<input type="checkbox"/> Drawings showing proposed interior and exterior accessible tour routes (2 to 3 pages)
<input type="checkbox"/> Computer-generated renderings of competition prototype (5-6 pages, images to be minimum 3000 px by 2400 px)
<input type="checkbox"/> Health and Safety Plan outline including approach to meeting OSHA training requirement (1 to 2 pages)
<input type="checkbox"/> Identification of and summary of qualifications for the licensed design professional who will be stamping the structural drawings and calculations (1 page)

## D-2. Computer-Animated Walkthrough and Computer-Generated Renderings

### Computer-Animated Walkthrough

Each team shall provide a computer-animated walkthrough of its house for the following purposes:

1. To be included in a compilation video of all Solar Decathlon 2013 walkthroughs that will be presented to the public and used in marketing materials associated with the project.
2. To be posted on the Solar Decathlon website as an introduction to each house.

#### Format Requirements

<input type="checkbox"/> Packaged into a single Quicktime .mov or H.264 compressed MP4 (MPEG-4) file type using 720 x 480 resolution and 16:9 aspect ratio
<input type="checkbox"/> Runtime between 3 and 3.5 minutes
<input type="checkbox"/> Shall be accompanied by a verbatim transcript in a Microsoft Word-compatible format to meet Section 508 Accessibility standards.

#### Content Requirements

<input type="checkbox"/> Composed of animated computer renderings that demonstrate all aspects of the house
<input type="checkbox"/> Includes an audio narrative that explains to viewers what they're seeing and describes the philosophy behind the design
<input type="checkbox"/> Does not include elements that are inherently inaccessible to those with visual disabilities
<input type="checkbox"/> Does not contain background music that violates U.S. copyright laws. All incorporated music must be an original or royalty-free composition. Proof of licensing shall be submitted with the final file and transcript.

### Computer-Generated Renderings

The computer-generated renderings will be posted to the Solar Decathlon website and used in various communications materials to introduce the public to each competition prototype.

#### Format Requirements

<input type="checkbox"/> Minimum resolution of each image shall be 3000 px wide by 2400 px
<input type="checkbox"/> Composed of image files (JPEG, TIFF, etc.) packaged as one Zip (.zip) file

#### Content Requirements

<input type="checkbox"/> Includes, at a minimum: <ul style="list-style-type: none"><li>• Two (2) elevation views of the competition prototype</li><li>• One (1) Birds-eye perspective views of the competition prototype</li><li>• Two (2) Interior views of the competition prototype</li></ul>
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## D-3. Building Information Model

The BIM is a contractual deliverable that is due at the conclusion of the design development phase, at the conclusion of the construction documentation phase, and again just prior to the competition. Each iteration of the BIM shall include an increasing level of detail and refinement as the project progresses. It will be used by the organizers for several purposes outlined in the Appendix D introduction above. The BIM will not be reviewed by any juries and may be made publicly available following each submission.

#### Format Requirements

<input type="checkbox"/> One (1) Autodesk Revit (.rvt)-compatible file or one (1) Autodesk Revit Architecture (.rvt)-compatible file with relative references to additional Revit (.rvt)-compatible files as required. If multiple Autodesk Revit-compatible files are submitted, they should be packaged as one Zip (.zip) file.
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| <input type="checkbox"/> Extensive use of the Revit template (.rvt) file <sup>17</sup> available for download in the “/Files/Rules/Resources” folder on the Yahoo Group; limited minor modifications to the template are allowed, but must be approved by competition management |
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**Content Requirements**

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| <input type="checkbox"/> House model   |
| <input type="checkbox"/> Site model including all exterior site components   |
| <input type="checkbox"/> Drawing set sheet views matching submitted drawings<br>Notes:<br>1) Shop drawings submitted by subcontractors need not be recreated from scratch in the BIM unless they contain information that is required to make the BIM complete<br>2) Even if shop drawings aren’t recreated in the BIM, they shall be imported into the BIM file and included in sheet views for inclusion in the drawing set. |
| <input type="checkbox"/> Sufficient detail to enable the organizers to develop detailed cost estimates and a product directory using only the information included in the BIM; the sample BIM <sup>18</sup> posted for download in the “/Files/Rules/Resources” folder on the Yahoo Group includes the minimum required level of detail  |

**D-4. Drawings**

The drawings shall be generated from sheet views in the BIM file. Each iteration of the drawings shall include an increasing level of detail and refinement as the project progresses. The drawings may be made publicly available after each submission.

**Format Requirements**

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| <input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements) using NCSv4-compliant order and formatting.  |
| <input type="checkbox"/> Compliant with <a href="#">United States National CAD Standard® – Version 5.0</a><br>EXCEPTION: The use of keynotes is not required.  |
| <input type="checkbox"/> ANSI “D” (22 in. X 34 in.) sheet size   |
| <input type="checkbox"/> Graphic scales included to allow users to reduce or enlarge printed sheets  |
| <input type="checkbox"/> Very similar formatting as the sample drawings <sup>19</sup> generated from the sample BIM; limited minor modifications to the sample drawings format are allowed, but must be approved by competition management |

**Content Requirements**

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| <input type="checkbox"/> Sufficient detail to enable the organizers to develop detailed cost estimates and a product directory using only the information included in the drawings and project manual; sample drawings posted <sup>19</sup> for download in the “/Files/Rules/Resources” folder on the Yahoo Group include the minimum required level of detail |
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**D-5. Project Manual**

The project manual is a contractual and competition deliverable that is due at the conclusion of the design development phase, at the conclusion of the construction documentation phase, and again just prior to the competition. Each iteration of the project manual shall include an increasing level of detail and refinement as the project progresses. The project manual may be made publicly available following each submission.

<sup>17</sup> The Revit template was posted in summer 2012

<sup>18</sup> A first version of the sample BIM was posted for download in summer 2012.

<sup>19</sup> A first version of the sample drawings was posted for download in summer 2012.

### Format Requirements

<input type="checkbox"/>	ANSI “A” (8.5 in. X 11 in.) sheet size
<input type="checkbox"/>	Organization and formatting of construction specifications in compliance with the Construction Specifications Institute’s <a href="#">MasterFormat 2004 Edition</a> , <a href="#">SectionFormat</a> , and <a href="#">PageFormat</a> standards
<input type="checkbox"/>	Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements)
<input type="checkbox"/>	Extensive use of the Word template (.dotx) file <sup>20</sup> available for download in the “/Files/Rules/Resources” folder on the Yahoo Group; limited minor modifications to the template are allowed, but must be approved by competition management

### Content Requirements

<input type="checkbox"/>	Complete set of construction specifications (including links to manufacturers’ data sheets)
<input type="checkbox"/>	Rules compliance checklist <sup>21</sup> (see content requirements below)
<input type="checkbox"/>	Structural calculations
<input type="checkbox"/>	Detailed water budget
<input type="checkbox"/>	Summary of unlisted electrical components
<input type="checkbox"/>	Summary of reconfigurable features (see Appendix B-2b)
<input type="checkbox"/>	Interconnection application form
<input type="checkbox"/>	Complete quantity take-offs of entire competition prototype

### Content Requirements for Rules Compliance Checklist

Rule #	Rule Description	Content Requirement(s)
<input type="checkbox"/>	4-2 Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site
<input type="checkbox"/>	4-2 Construction Equipment	Specifications for heavy machinery
<input type="checkbox"/>	4-3 Ground Penetration	Drawing(s) showing the locations and depths of all ground penetrations on the competition site
<input type="checkbox"/>	4-4 Impact within the Solar Envelope	Drawing(s) showing the location, contact area, and bearing pressure of every component resting directly within the solar envelope
<input type="checkbox"/>	4-5 Generators	Specifications for generators (including sound rating)
<input type="checkbox"/>	4-6 Spill Containment	Drawing(s) showing the locations of all equipment, containers, and pipes that will contain liquids at any point during the event
<input type="checkbox"/>	4-6 Spill Containment	Specifications for all equipment, containers, and pipes that will contain liquids at any point during the event
<input type="checkbox"/>	4-7 Lot Conditions	Calculations showing that the structural design remains compliant even if 12 in. (30.48 cm) of vertical elevation change exists
<input type="checkbox"/>	4-7 Lot Conditions	Drawing(s) showing shimming methods and materials to be used if 12 in. (30.48 cm) of vertical elevation change exists on the lot
<input type="checkbox"/>	5-2 Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope
<input type="checkbox"/>	5-2 Solar Envelope Dimensions	List of solar envelope exemption requests accompanied by justifications and drawing references
<input type="checkbox"/>	6-1 Structural Design Approval	List of, or marking on, all drawing and project manual sheets that have been or will be stamped by the qualified, licensed design professional in the stamped structural submission; the stamped submission shall consist entirely of sheets that also appear in the drawings and project manual

<sup>20</sup> A first version of the project manual template was posted for download in summer 2012.

<sup>21</sup> A template version of the rules compliance checklist was included in the project manual template.

<b>Rule #</b>	<b>Rule Description</b>	<b>Content Requirement(s)</b>
<input type="checkbox"/> 6-2	Finished Square Footage	Drawing(s) showing all information needed by the rules officials to measure the finished square footage electronically
<input type="checkbox"/> 6-2	Finished Square Footage	Drawing(s) showing all movable components that may increase the finished square footage if operated during contest week
<input type="checkbox"/> 6-3	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route
<input type="checkbox"/> 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
<input type="checkbox"/> 7-2	Watering Restrictions	Drawing(s) showing the layout and operation of greywater irrigation systems
<input type="checkbox"/> 8-1	PV Technology Limitations	Specifications for photovoltaic components
<input type="checkbox"/> 8-3	Batteries	Drawing(s) showing the location(s) and quantity of all primary and secondary batteries and stand-alone, PV-powered devices
<input type="checkbox"/> 8-3	Batteries	Specifications for all primary and secondary batteries and stand-alone, PV-powered devices
<input type="checkbox"/> 8-4	Desiccant Systems	Drawing(s) describing the operation of the desiccant system
<input type="checkbox"/> 8-4	Desiccant Systems	Specifications for desiccant system components
<input type="checkbox"/> 8-5	Village Grid	Completed interconnection application form
<input type="checkbox"/> 8-5	Village Grid	Drawing(s) showing the locations of the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means
<input type="checkbox"/> 8-5	Village Grid	Specifications for the photovoltaics, inverter(s), terminal box, meter housing, service equipment, and grounding means
<input type="checkbox"/> 8-5	Village Grid	One-line electrical diagram
<input type="checkbox"/> 8-5	Village Grid	Calculation of service/feeder net computed load per NEC 220
<input type="checkbox"/> 8-5	Village Grid	Site plan showing the house, decks, ramps, tour paths, and terminal box
<input type="checkbox"/> 8-5	Village Grid	Elevation(s) showing the meter housing, main utility disconnect, and other service equipment
<input type="checkbox"/> 9-1	Container Locations	Drawing(s) showing the location of all liquid containers relative to the finished square footage
<input type="checkbox"/> 9-1	Container Locations	Drawing(s) demonstrating that the primary supply water tank(s) is fully shaded from direct solar radiation between 9 a.m. and 5 p.m. PDT or between 8 a.m. and 4 p.m. solar time on October 1
<input type="checkbox"/> 9-2	Team-Provided Liquids	Quantity, characteristics, and delivery date(s) of all team-provided liquids for irrigation, thermal mass, hydronic system pressure testing, and thermodynamic system operation
<input type="checkbox"/> 9-3	Greywater Reuse	Drawing(s) showing the layout and operation of greywater reuse systems
<input type="checkbox"/> 9-4	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems
<input type="checkbox"/> 9-6	Thermal Mass	Drawing(s) showing the locations of liquid-based thermal mass systems
<input type="checkbox"/> 9-6	Thermal Mass	Specifications for components of liquid-based thermal mass systems
<input type="checkbox"/> 9-7	Greywater Heat Recovery	Drawing(s) showing the layout and operation of greywater heat recovery systems
<input type="checkbox"/> 9-8	Water Delivery	Drawing(s) showing the complete sequence of water delivery and distribution events
<input type="checkbox"/> 9-8	Water Delivery	Specifications for the containers to which water will be delivered
<input type="checkbox"/> 9-9	Water Removal	Drawing(s) showing the complete sequence of water consolidation and removal events
<input type="checkbox"/> 9-9	Water Removal	Specifications for the containers from which water will be removed
<input type="checkbox"/> 11-4	Public Exhibit	Interior and exterior plans showing entire accessible tour route

## D-6. Jury Narratives

The jury narratives are written documents that provide a summary of each team’s approach to meeting the contest requirements for the Architecture, Market Appeal, Engineering, and Communications contests. The narratives will be reviewed by the respective jury prior to the competition in accordance with Table 4. The narratives will not be made public prior to the release of the respective contest results.

### *Format Requirements*

<input type="checkbox"/> ANSI “A” (8.5 in. X 11 in.) sheet size
<input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements)

### *Content Requirements*

<input type="checkbox"/> Architecture Narrative (5 pages, maximum)
<input type="checkbox"/> Market Appeal Narrative (5 pages, maximum)
<input type="checkbox"/> Engineering Narrative (5 pages, maximum)
<input type="checkbox"/> Communications Narrative (2 pages, maximum) The narrative should present the team’s communications goals, objectives, 2-3 high-level strategies/tactics for meeting these goals and objectives, target audiences, key messages, and metrics for success (e.g., how will the team know if its communications succeeded?).

## D-7. Audiovisual Presentation

The audiovisual presentation is a competition deliverable that is due just prior to the competition. The juries will review the audiovisual presentation prior to the competition in accordance with Table 4. The presentation will be made publicly available soon after the submission as an update to the Computer-Animated Walkthrough.

### *Format Requirements*

The format requirements for the audiovisual presentation are outlined below.

- .MOV or H.264 compressed.MP4 (MPEG-4) file type
- 3–3.5 minute runtime
- 16:9 aspect ratio
- 720 x 480 resolution
- Accompanied by a verbatim transcript of the audio narrative to meet Section 508 Accessibility standards. Transcript should be submitted in a Microsoft Word-compatible format. For an example of a text version script, see the [Wind Power Animation \(Text Version\)](#).

### *Content Requirements*

<input type="checkbox"/> Must include video footage of the actual constructed house
<input type="checkbox"/> May contain still photos and graphics
<input type="checkbox"/> Gives the jurors a realistic preview of what they will experience during the on-site walkthroughs
<input type="checkbox"/> Explains how the project meets the criteria <sup>22</sup> listed in the relevant contest section of the rules
<input type="checkbox"/> Includes an audio narrative that explains to viewers what they’re seeing and describes the underlying philosophy
<input type="checkbox"/> Contains only originally created or properly credited work that does not violate U.S. copyright laws
<input type="checkbox"/> Does not contain background music that violates U.S. copyright laws. All incorporated music must be an original or royalty-free composition. Proof of licensing shall be submitted with the final file and transcript.

<sup>22</sup> The audiovisual presentation shall address the design and implementation criteria for architecture; the livability and marketability criteria for market appeal; and the functionality, efficiency, innovation, and reliability criteria for engineering.

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|---|
| <input type="checkbox"/> Follows guidelines for logos as described in Rules 10-2 and 10-3   |
| <input type="checkbox"/> Does not contain interactive elements that are inherently inaccessible to those with visual disabilities |

## D-8. Website

The website is a contractual and competition deliverable that is due near the beginning of the project as a preliminary website and again just prior to the competition. The website serves as part of each team's communications strategy and will be reviewed by the communications jury in accordance with Table 4.

### Preliminary Website

A preliminary website consisting of at least three pages shall be evaluated by communications professionals at NREL to ensure compliance with the Minimum Website Coding Standards document available on the Yahoo Group<sup>23</sup>.

### Final Website

The final website shall be evaluated by the Communications Jury. The final website shall consist of considerably more content than the preliminary website.

Each team may request up to two courtesy reviews of the final website prior to submission. Teams shall request a courtesy review by contacting [sdrules@nrel.gov](mailto:sdrules@nrel.gov). After each courtesy review, each team shall be notified of required changes it should make to achieve compliance.

The Communications Jury shall begin evaluations of team websites at the same time as the as-built deliverable submission. Communications professionals at NREL will also evaluate each final website for compliance with the Minimum Website Coding Standards document posted in the Yahoo Group. The organizers will provide the Communications Jury with a summary of aspects that are not in compliance for each team so that the jury is aware of any violations.

The Communications Jury will re-evaluate the website following the on-site walkthrough to determine effective use of project updates, photographs, social media, and other communications efforts.

## D-9. Project Summary

Important to many communications-related aspects of the Solar Decathlon, project summaries:

- Provide essential content for the organizers to use while developing various event materials (e.g., the website, event program, media kit, and village signage)
- Prepare teams to answer questions from visitors to their construction sites and to the competition site at Orange County Great Park.
- Help organizers and teams respond effectively to media inquiries.

All project summary materials (narrative, photograph, computer-generated house rendering, and logos) shall be saved in the formats indicated and submitted to organizers packaged as a single .zip file.

## Overview

### Format Requirements

- |   |
|---|
| <input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements) |
| <input type="checkbox"/> 10 pages maximum   |
| <input type="checkbox"/> 11-pt. type, double spaced, 1-in. (or metric equivalent) margins   |

### Content Requirements

- |  |
|--|
| <input type="checkbox"/> A 100-word or less description of your team house. (1 paragraph)  |
| <input type="checkbox"/> Design philosophy and house design. What is the team trying to portray or accomplish with this design? What will the house look like? What are some of the key features? (1 page) |

<sup>23</sup> The Minimum Website Coding Standards document was posted for download in spring 2012

<input type="checkbox"/> Unique house features. What makes the house unlike any other? (1 page)
<input type="checkbox"/> Technological innovations. Summarize the unique or unusual technologies incorporated into your house. (1-2 pages)
<input type="checkbox"/> Define the target client for the team house. How does the design accommodate the needs and desires of this client? (1 paragraph)
<input type="checkbox"/> Team organization and contacts. Indicate how your team is organized and approximately how many students, faculty, and others (e.g., sponsors, volunteers, family members) are involved in the project. (1 page)
<input type="checkbox"/> Future plans for your house, if known. Where will it go after the competition? (1 paragraph)

### **Team Photograph**

For use in the event program, media kit, and Solar Decathlon website, the team photo is an important conveyance of your team's personality.

#### **Format Requirements**

<input type="checkbox"/> Native format of the camera, such as JPEG or RAW, if available
<input type="checkbox"/> 2048 × 1080 minimum pixel dimensions
<input type="checkbox"/> RGB, 8-bit color, not black and white

#### **Content Requirements**

<input type="checkbox"/> Include all team members (if possible) and strive for creativity. For examples of past team photos, visit the <a href="#">History section</a> of the Solar Decathlon website.
<input type="checkbox"/> For a photograph to be properly credited, the following information shall be included in a Microsoft Word-compatible text file accompanying the photograph file: <ul style="list-style-type: none"> <li>• Name, phone number, and email of person submitting the photograph</li> <li>• Photograph date and location</li> <li>• Photographer's name and affiliation.</li> </ul>

### **Team Logo**

The team logo is used by organizers in village signage, the event program, media kit, and Solar Decathlon website.

#### **Format Requirements**

<input type="checkbox"/> Submit two versions of your logo: <ul style="list-style-type: none"> <li>• One for Web (GIF or JPG, at least 200 px wide). GIF is preferred for simple flat-color logos. JPG is preferred for complex logos.</li> <li>• One for print (high-resolution or vector format; EPS preferred).</li> </ul>
--

#### **Content Requirements**

<input type="checkbox"/> Include a text file containing the following additional information: <ul style="list-style-type: none"> <li>• Name, phone number, and email of person submitting the logo</li> <li>• A list of all Pantone (PMS) or CMYK numbers used in the logo. Please consult the graphic designer of your logo if you need help providing these specific color requirements.</li> </ul>
---

### **Computer-Generated Renderings**

The computer-generated renderings will be posted to the Solar Decathlon website and used in various communications materials to introduce the public to each competition prototype.

#### **Format Requirements**

- |   |
|---|
| <input type="checkbox"/> Minimum resolution of each image shall be 3000 px wide by 2400 px          |
| <input type="checkbox"/> Composed of image files (JPEG, TIFF, etc.) packaged as one Zip (.zip) file |

***Content Requirements***

- |   |
|---|
| <input type="checkbox"/> Includes, at a minimum: <ul style="list-style-type: none"> <li>• North Elevation View of the competition prototype</li> <li>• South Elevation View of the competition prototype</li> <li>• East Elevation View of the competition prototype</li> <li>• West Elevation View of the competition prototype</li> <li>• Two (2) Birds-eye perspective views of the competition prototype</li> <li>• Four (4) Interior views of the competition prototype</li> </ul> |
|---|

**Dinner Party Menus and Recipes**

The dinner party information will be provided to visiting teams for review prior to participation in the dinner party subcontest and will be posted to the Solar Decathlon website.

***Format Requirements***

- |   |
|---|
| <input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements) |
|---|

***Content Requirements***

- |  |
|--|
| <input type="checkbox"/> Restaurant-style dinner party menu for each dinner party  |
| <input type="checkbox"/> Cookbook-style recipes for all components of dinner party |
| <input type="checkbox"/> Comprehensive ingredient list for each dinner party       |

**D-10. Public Exhibit Materials**

All team communications materials on the competition site shall support the goal of Contest 4: Communications, which is to educate consumers about the project and topics relevant to the project.

- Teams shall submit all public exhibit materials to organizers for review. Organizers will determine whether materials meet competition guidelines.
- Public exhibit materials shall be evaluated by Communications Jury members.

***Format Requirements***

- |   |
|---|
| <input type="checkbox"/> Packaged into a single, bookmarked PDF file (see Appendix F for PDF formatting and file-naming requirements)   |
| <input type="checkbox"/> Each public exhibit material shall be represented at its full scale within the PDF. Therefore, it is expected that the PDF may contain sheets at several different scales. |

***Content Requirements***

- |   |
|---|
| <input type="checkbox"/> Team handout (shall abide by Rules 10-2, 10-3, and 11-4b)  |
| <input type="checkbox"/> Signage (shall abide by Rules 10-2, 10-3, and 11-4c)   |
| <input type="checkbox"/> Team uniform design (shall abide by Rule 11-5)   |
| <input type="checkbox"/> Plan drawing of team site depicting public exhibit material locations and tour route at 1:48 scale |

**D-11. Final Report**

The Final Report shall reflect the results of the team’s Solar Decathlon project.

***Format Requirements***

<input type="checkbox"/> Packaged into a single PDF file (see Appendix F for PDF formatting and file-naming requirements)
<input type="checkbox"/> Intent of figures shouldn't be lost if printed in black & white
<input type="checkbox"/> ANSI "A" (8.5 in. X 11 in.) sheet size
<input type="checkbox"/> 20 pages maximum, including figures, tables, and appendices; cover sheet and table of contents do not count toward page limit
<input type="checkbox"/> 11-point body text minimum, maximum 14-point heading text
<input type="checkbox"/> One-inch margins on top, bottom, left, and right
<input type="checkbox"/> Include page numbers and numbered captions for figures and tables for easy navigation through document

***Content Requirements***

<input type="checkbox"/> Results of fundraising activities—final quantity of contributions (cash and in-kind); final project budget and accounting; lessons learned—what went well, what didn't, and what you would do differently.
<input type="checkbox"/> Results of media-outreach activities—include statistics.
<input type="checkbox"/> Results of on-site exhibition activities—estimates of the number of visitors to the house (justify estimates); assessment of visitor experiences (include qualitative data); and lessons learned—what went well, what didn't, and what you would do differently.
<input type="checkbox"/> Evaluation of the team's website—number of hits, unique visits, and any other user statistics; lessons learned—what went well, what didn't, and what you would do differently.
<input type="checkbox"/> Team perspective on the effectiveness of the organizers' communications efforts with both the teams and the public.
<input type="checkbox"/> Description of future plans for the house, including a statement indicating whether the participating institution(s) would be interested in partnering with NREL to use the house for follow-up collaborative research and outreach projects.
<input type="checkbox"/> Short description of each team officer's future plans for employment, continued study, or other endeavors. NREL requests this information for possible inclusion in publications and presentations describing how the Solar Decathlon serves as an effective workforce development and university research project.
<input type="checkbox"/> Suggested competition improvements.
<input type="checkbox"/> Any other information you feel would be helpful to the organizers or future teams.

## Appendix E Health and Safety Plan

The overall success of the Solar Decathlon competition is dependent on the health and safety of all members, volunteers, organizers, and the public. To achieve this objective, each team is required to submit a Health and Safety Plan that identifies the following elements:

- How you will be minimizing risk
- How you will address major hazards that may be encountered during assembly and disassembly activities on the competition site
- How you will control these hazards to prevent injury to team members, volunteers, organizers and the public.
- Areas of high risk such as electrical safety, working at elevated heights/fall protection, hoisting and rigging activities and safe equipment operations shall include the necessary level of detail to ensure the health and safety of all site personnel.
- How you will ensure that you are in compliance with applicable regulations.
- The roles and responsibilities for the health and safety officer(s) throughout the event.

### E-1. Plan Development

A Health and Safety Plan template is available in the “/Files/Site Ops and Safety”<sup>24</sup> folder of the Yahoo Group. The template identifies major topics to address, the level of detail required, performance expectations, and requirements such as minimum levels of training needed for various team positions. The format of each team’s submitted plan can deviate slightly from the recommended template as long as the information and level of detail is equivalent.

Teams are encouraged to work or consult with your school’s environment, safety and health department during the development process. They can be an excellent resource when developing your Health and Safety Plans, while also ensuring that school-specific requirements are addressed.

### E-2. Required Training

To ensure a minimum knowledge base regarding health and safety issues during construction activities, the team’s project manager, construction manager, and health and safety officer are required to complete the OSHA 30-hour Construction Safety Training course. Each role must be filled by a different individual. Proof of course completion for the OSHA 30-hour Construction Safety Training shall be included in the final Health and Safety Plan.

### E-3. Submission and Approval

Teams are required to submit their Health and Safety Plan to NREL for acceptance. Teams are responsible to update the Health and Safety Plans, both before and after acceptance, to reflect changes in construction parameters. For example, if a team did not plan to use a crane to place their house when the plan was submitted but later decide that a crane will be necessary, then the team is required to update the plan accordingly.

During the event, a current copy of each team’s Health and Safety Plan shall be posted on their site in a prominent location. Individuals working on your site shall be briefed on the final, approved plan and should know the expectations regarding safety, hazards, and controls.

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<sup>24</sup> The template was posted to the Yahoo Group in spring 2012

## Appendix F Deliverable Submission Instructions

Deliverables are considered to be on time if they are received by the competition manager by 5 p.m. Mountain time on the respective due date. Refer to the “Deliverable Status Sheet” in the “/Files/Deliverable status sheets” folder on the Yahoo Group for deliverable due dates and required file formats for each of the respective deliverables.

### F-1. Website URL

Website URLs shall be emailed to the competition manager at [sdrules@nrel.gov](mailto:sdrules@nrel.gov).

### F-2. PDF Requirements

- a. Files submitted as a PDF shall meet the following criteria:
  - (i). Embed all fonts.
  - (ii). Maintain a minimum resolution of 300 dpi.
- b. If an application does not support a direct-to-PDF function, create a postscript file by printing to a postscript printer with the “print to file” option selected. Use this postscript (.ps or .prn) file to create a PDF using Acrobat Distiller’s high-resolution job settings.
  - (i). Creating a PDF from scans, or by outputting the content into a raster image format (.jpg, .tiff, .png, .gif, etc.) and then creating a PDF from the images, is NOT ACCEPTABLE.
  - (ii). All-raster PDFs are large files at 300dpi, are of unacceptable quality at lower resolutions, and are not scalable without degradation.

### F-3. Electronic File-Naming Instructions

The required file-naming convention for all electronic files follows:

[TEAM ABBREVIATION]\_[DELIVERABLE ABBREVIATION]\_[SUBMISSION DATE (YYYY-MM-DD)].[EXTENSION]

See Table 8 for a list of team name and deliverable abbreviations.

Example: A building information model submitted by West Virginia on April 5, 2013 would have the following file name:

WVU\_BIM\_2013-04-05.rvt

**Table 8: Team and deliverable abbreviations**

Team Name	TEAM ABBREVIATION	Deliverable Name	DELIVERABLE ABBREVIATION <sup>25</sup>
AZ State/New Mexico	ASUNM	Schematic Design Summary	SCHEMATIC
Czech Republic	CTU	Building Information Model	BIM
Kentucky/Indiana	KEN	Project Manual	MANUAL
Las Vegas	UNLV	Health and Safety Plan	SAFETY
Middlebury College	MIDD	Computer-Animated Walkthrough	ANIMATION
Missouri S&T	MST	Stamped Structural Drawings	DRAWINGS
North Carolina	UNCC	Stamped Structural Calculations	CALCS
Norwich	NU	Project Summary ZIP file	SUMMARY
Santa Clara	SCU	Jury Narratives	NARRATIVE
SCI-Arc/Caltech	SCICAL	Audiovisual Presentation	AV
Stanford	SU	Overview	OVERVIEW
Stevens	SIT	Team Photograph	PHOTO
Team Alberta	CALG	Team logo	LOGO
Team Austria	VUT	Computer-Generated Renderings	RENDER
Team Capitol DC	DC	Dinner Party Menus and Recipes	DINNER
Team Ontario	ONT	Public Exhibit Materials	EXHIBIT
Team Texas	TEX	Final Report	FINALREPORT
Tidewater Virginia	VA		
U of So Cal	USC		
West Virginia	WVU		

#### **F-4. Electronic File Submission Options**

All electronic files shall be uploaded to the [Solar Decathlon dropbox](#). Teams wishing to reduce file upload times may archive electronic files in ZIP files. Please verify that files in ZIP archives can be extracted using [WinZip](#).

<sup>25</sup> Accompanying files, such as text transcripts for videos and metadata files for photos and logos, should also use the appropriate abbreviation from this list.

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**C. US SOLAR DECATHALON BUILDING CODE**



U.S. DEPARTMENT OF ENERGY

**SOLAR DECATHLON**

# **DRAFT BUILDING CODE**

Last Updated: March 8, 2012

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DRAFT

## *Section 1. Introduction*

Although there is some degree of overlap between the two, it is important to note some crucial distinctions between the Solar Decathlon Rules and the Solar Decathlon Building Code. The Rules exist primarily to promote a fair and interesting competition. The Building Code exists primarily to protect public health and ensure safety. Failure to comply with the Rules may result in official warnings, point penalties, or disqualification from the competition. Failure to comply with the Building Code may prohibit the participation of your house in any aspect of the overall competition. Therefore, compliance with the Building Code is a prerequisite for participation in the competition.

## *Section 2. Adopted Codes*

The 2012 International Residential Code (IRC) of the International Code Council with amendments and the 2011 National Electric Code (NEC) of the National Fire Protection Agency (NFPA) have been adopted by reference as the Solar Decathlon Building Code and have the same force and effect as though fully set forth in the Solar Decathlon Rules, except as specifically amended by provisions that follow.

## *Section 3. Building Planning and Construction*

The building is intended to be representative of a single-family dwelling constructed in accordance with the provisions contained in the IRC. Because portions of the building will be open to viewing by the general public, the IRC is amended with specific provisions of the International Building Code (IBC) and the Architectural Barriers Act as appropriate.

### **3-1. Fire Protection and Prevention**

#### a. Fire Protection Plan

Each team shall provide a fire protection plan. This plan should indicate the location of fire extinguishers, how egress will be made from the unit, and who will be responsible for public tour life safety (the team's "life-safety captain") during the event. Include a written operations plan for orderly and quick evacuation and fire mitigation. Successful demonstration of the plan will be required before any public tour of the building will be permitted.

- b. Each house will be required to have smoke alarms per IRC requirements and a fire extinguisher with a minimum Underwriters Laboratory (UL) rating of 2A-10BC. Smoke alarms shall be connected to the AC voltage side of the inverter and provided with independent, e.g., integral with the alarm, battery backup. All alarms shall be interconnected and all shall sound when one is activated (IRC, Sec. R314).

### **3-2. Means of Egress**

The following means of egress components accessible to the public shall comply with Chapter 10 of the International Building Code.

#### a. Stairs

**Exterior stairs are prohibited.** All changes in elevation used as part of the public tour, accessible route, or means of egress shall be provided with sloped walking surfaces or ramps. Demonstration or mechanical equipment access stairs located within the interior of the dwelling and excluded from use by the public or any other individual during the public tours may be provided in accordance with IRC Section 311.4. Ladders or stairs that are not IRC compliant may be provided as "demonstrators" but the design team should be aware that United States building codes typically do not permit their use for access to habitable spaces.

#### b. Handrails

Handrails shall be provided on both sides of ramps (sloped walking surfaces in excess of 5% in the direction of travel) used by the public during the display. All handrails shall be designed in accordance with ICC-A117.1 2009 Section 505

### 3-3. Interior Finishes

Interior finishes must comply with IRC Section R302.9.

### 3-4. Glazing

The following hazardous locations are subject to human impact and require safety glazing. See IRC Section 308 for specific details and exceptions.

- a. Photovoltaic modules containing glazing materials and placed within any of the locations listed in Items b through g below
- b. Glazing in doors
- c. Glazing in doors, surrounds, and walls enclosing or facing bathtubs or showers where not located more than 60 inches (152cm) above the finished floor.
- d. Glazing in windows within a 24 in. (61.0 cm) arc of either vertical edge of a door and less than 60 in. (152.4 cm) above the floor
- e. Glazing within 36 in. (91.4 cm) of stairways and/or within 60 in. (152.4 cm) of the bottom edge of stair treads when the bottom edge of the glazing is less than 60 in. (152.4 cm) above a walking surface
- f. Glazing in overhead panels (including skylights and glazed solar panels) placed where glazing is not separated from the occupants by a solid surface such as a roof
- g. Glazing in panels located with all the following conditions present:
  - (i). Pane of glazing is greater than 9 ft<sup>2</sup> (0.836 m<sup>2</sup>)
  - (ii). Bottom edge of glazing is less than 18 in. (45.7 cm) above the floor
  - (iii). Top edge of glazing is greater than 36 in. (91.4 cm) above the floor
  - (iv). Walking surface is located within 36 in. (91.4 cm) of the glazing (IRC, Sec. 308.4).

### 3-5. Roofing

All roofing materials shall comply with IRC Chapter 9. Photovoltaic modules and shingles modules must be evaluated in accordance with UL 1703 and be designed for design wind loads.

### 3-6. Foam Plastic Insulation

Foam plastics used for building construction shall only be permitted if the foam plastic is isolated from the interior of the building with gypsum board 0.5 in. (1.3 cm) thick. This applies to foams typically used in structural insulated panel wall, floor, and roof systems. Provide documentation to demonstrate compliance (IRC, Sec. R316).

- a. Gypsum board containing phase-change materials and other flammable performance enhancements may not qualify as the required thermal barrier unless specifically approved.
- b. The thermal barrier specified in Section R316.4 is not required to be installed on the walking surface of a structural floor system that contains foam plastic insulation where the foam plastic is covered by a minimum nominal 0.5 inch (1.3 cm) thick wood structural panel or equivalent.
- c. Exposed foam plastic located in attics or crawlspaces (interstitial space between the floor assembly and the competition site surface) shall be covered with an ignition barrier consisting of 1.5 in. (3.81 cm) thick mineral fiber insulation, 0.25 in. (0.64 cm) thick wood structural panels, 0.375 in. (0.95 cm) thick particleboard, 0.25 in. (0.64 cm) hardboard, 0.375 in. (0.95 cm) gypsum board, or corrosion-resistant steel having a base metal thickness of 0.016 inch (0.41 mm).

### 3-7. Exterior Envelope

Provide section details of proposed wall assembly showing framing, sheathing, water-resistive barrier, flashing, and exterior cladding as applicable (IRC, Sec. R703).

### **3-8. Ceiling Height**

Ceiling height shall provide a minimum of 7 ft (213.4 cm) of headroom (IRC, Sec. R305).

### **3-9. Skylights**

IRC Section R308.6 regulates skylight glazing. Glazing is limited to certain types, and screening under the glazing may be required. Indicate which glazing products are to be used and provide sufficient details in the submitted plans to ensure compliance (IRC, Sec. 308.6). Glass PV or hydronic solar collectors used overhead without a solid surface underneath (such as a roof) will be regulated as skylights.

### **3-10. Energy Conservation**

Design and construction for energy conservation shall be in accordance with the 2012 International Residential Code. Buildings shall be designed using the Climate Zone specified at the final location for the structure following the public exhibit in Irvine, California at the Orange County Great Park. For areas outside of the United States, determination of climate zone equivalency shall be provided in accordance with IRC Section N1101.10. Teams will be required to demonstrate compliance by using either the prescriptive method, UA Trade Off approach, or by performance modeling using RESNET or other approved software.

### **3-11. Fire Sprinkler System**

2012 IRC Section R313 requires fire suppression sprinkler systems in all single-family dwellings. All buildings shall be provided with fire sprinklers designed in accordance with IRC Section P2904 or NFPA 13D. Such systems shall be fully operational during the public exhibit and competition. Each dwelling will be individually required to provide site-stored fire water for sprinkler operations based on the design demand. Each dwelling's sprinkler will be required to be provided with a pump capable of the pressure and volume required for the fire sprinkler design.

## ***Section 4. Accessibility***

### **4-1. Accessible Route – Interior**

An accessible route shall be provided within the unit to all spaces accessible to the public as part of the tour. Other accessible features may be included in rooms such as kitchens and bathrooms at the discretion of the designers. If any of the features are intended for use by the public, they shall be accessible in accordance with 2012 IBC Chapter 11 and ICC/ANSI A117.1-2009 for the level of accessibility desired.

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

Solar Decathlon competition houses are intended to demonstrate single-family dwellings that would not normally be regulated by federal accessibility standards. However, these buildings are open to the public for educational purposes and must be accessible in all primary function areas. Therefore, any portion of the building where the public is permitted must provide an accessible route.

- a. The Americans with Disabilities Act (ADA) requires an elevator to be installed in buildings (funded pursuant to Title II) where an accessible route is required to stories above the first floor (such as the roof deck, second floor, or loft). The 3,000 ft<sup>2</sup> (278.7 m<sup>2</sup>) exception located in IBC Section 1104.4 Exc. 1 is superseded by this Federal regulation.
- b. The ADA Technical Assistance Center has stated that it is acceptable to “demonstrate” a roof deck, loft, or upper level accessed via stairs, or other means of inaccessible access, as long as no member of the public, organizers, or competing teams is allowed to access the space during public exhibit periods. Any provided means of access shall be fully gated or cordoned off to inhibit entry. Adherence to these guidelines should remove any perception that the upper level is being used as a primary function and therefore subject to the accessibility provisions of the ADA.
- c. Please note that the construction of buildings using U.S. Federal Funds requires compliance with the Architectural Barriers Act. Scoping and technical criteria can be found in the ADA-ABA Accessibility

Guidelines: <http://www.access-board.gov/ada-aba/final.cfm>. Technical provisions in the Guidelines are similar to those contained in ICC A117.1-2009.

### **4-3. Accessibility – Ramps**

The following are the most important regulations regarding ramps:

- a. A “ramp” is any sloping surface used as part of the circulation path that has a slope in excess of 1:20. Sloping surfaces less than 1:20 shall comply with ICC A117.1-2009 and ADA-ABA Accessibility Guidelines Section 403.
- b. The slope of a ramp cannot exceed 1:12.
- c. At the top and bottom of any ramp, a landing 60 in. (152.4 cm) long is required.
- d. A 60 in. by 60 in. (152.4 cm by 152.4 cm) landing is required at any point where a ramp changes directions.
- e. Handrails are required if the ramp’s rise exceeds 6 in. (15 cm) ADA-ABA Accessibility Guidelines, and ICC A117.1-2003 Section 405).
- f. Teams must design and provide a metal plate transition component between the access ramp and the walking surface of the competition site. Such plate shall be no greater than 1/2 inch (12.7mm) thick at the edge contacting the walking surface of the competition site. If the edge exceeds 1/4 inch (6.3mm) thickness, it shall be provided with a 1:2 bevel. If the connected ramp exceeds 5% slope, the transition plate and the ramp must be provided with handrails and edge protection. Both shall extend onto the transition plate with the handrails extending 12 inches (305mm) beyond the termination of the transition plate.

### **4-4. Changes in Elevation**

All changes in elevation (including even minor changes in areas such as door thresholds) must be considered along an accessible route. Changes not exceeding 0.25 in. (0.64 cm) are acceptable.

- a. Elevation changes between 0.25 in. and 0.5 in. (0.64 cm and 1.3 cm) shall be beveled at a maximum of 1:2 slope
- b. Any change in elevation exceeding 0.5 in. (1.3 cm) shall be by a ramp with a maximum slope of 1:12 (ADA-ABA Accessibility Guidelines and ICC A117.1 Section 405).
- c. Sloped walking surfaces complying with ADA-ABA Accessibility Guidelines and ICC A117.1 Section 403 shall be permitted.

### **4-5. Doors and Door Approaches**

All doors shall comply with ADA-ABA Accessibility Guidelines and ANSI A117.1-2003 Section 404.

- a. Doors that can be fixed in an open position may be accepted as part of the accessible route if 32 in. (81.3 cm) minimum clearance is provided through the door opening with the door secured in the fully open position.
- b. Doors without required maneuvering clearances that are intended to remain open during the public tour must be clearly identified on the plans and approved by the Solar Decathlon Building Official.

## ***Section 5. Structural***

The structural drawings and calculations shall be stamped by a qualified, licensed professional engineer. Such engineer shall be registered in the State of California or be eligible for California registration reciprocity. Obtaining the stamp is the responsibility of the teams, not the organizers. The organizers will submit stamped structural drawings and calculations to the City of Irvine, California for final approval. It is strongly recommended that teams involve a qualified, licensed professional throughout the design process because he or she could require structural design changes that could affect other aspects of the house. In addition to meeting applicable IRC requirements, special attention must be given to the structural design challenges unique to the temporary exhibit. These challenges include, but are not limited to, the following:

- a. Increased live loads because of public access to houses
- b. Necessity for non-earth-embedded foundations employing post installed concrete anchor embedment tie-down because of the lack of a permanent foundation Unique wind-loading conditions because of roof-mounted solar systems
- c. Increased dead loads because of unusual or concentrated mechanical and electrical equipment.

### 5-1. Prescriptive Requirements

- a. Structural systems shall be designed in accordance with the appropriate prescriptive provisions of the IRC where practical. Engineered design may be employed using accepted engineering practice in accordance with the International Building Code. Alternate materials and methods shall comply with IRC Section 104.11 and Sec. CC2.6.
- b. Structural framing: A detailed one-line structural plan view drawing is required at a minimum. Successive plan sheets shall be provided and shall include foundation footings, anchorage details, floor framing, wall locations, and roof framing. All structural components shall be listed including sizes, species and grade, orientation of the structural components, and repetitive spacing (on-center distances). Include details on connections between joists and beams, floor systems and foundations, walls and floors, rafters and beams, etc. Specify proprietary hangers or other mechanical connections (IRC, Sec. R301.1).

### 5-2. Design Loads

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

- a. Wind: 85 mph (38.0 m/s) (3-second gust), exposure category C (if anchorage design is not employed, the design must show that there is no overturning, uplifting, or sliding with a safety factor of 2)
- b. Seismic: IRC Seismic Design Category (SDC) D<sub>2</sub> See IRC Section R301.2.2
- c. Railings: 200 lb (890 N) concentrated load applied in any direction at any point at the top of the rail
- d. Interior floor, decks, ramps: 50 psf (2.39 kPa) live load
- e. Exterior floor, decks, ramps used for tour staging and egress purposes: 100psf (4.79 kPa) live load
- f. Roof: 20 psf (0.958 kPa) live load
- g. Temporary Paved Surface: 6,000 psf (287 kPa) maximum load-bearing pressure Additional structural design requirements at the post-event house location (to be determined by the licensed professional of record).

Structural plans shall indicate the design live loads [e.g., 40 psf (1.92 kPa) floors, 100 psf (4.79 kPa) means of egress components (ramps), 20 psf (0.958 kPa) snow roof live load] and the location, size, and weight of special loads such as liquid storage tanks and mass or trombe walls. These loads are considered minimums for the temporary event competition. Higher design loads may be mandated by the local authority having jurisdiction in the location where the house will be permanently sited. The design should accommodate the higher of the design values required by the Solar Decathlon Building Code or the local Authority Having Jurisdiction (AHJ).

### 5-3. Exterior Construction

Structural plans shall include design details for any exterior appurtenances such as decks, stairs, ramps, awnings, canopies, and roof projections (IRC, Sec. R301.1). Deck structural framing shall include full details for house ledger connections, joist-to-beam connections, and beam-to-column/footing connections. Special design attention shall be paid to load path for deck foundation systems for concealed footing systems.

### 5-4. Specific Point Loads

Provide wind-analysis calculations for point-load connections demonstrating the components' abilities to withstand 85 mph (38.0 m/s) (3 second gust), exposure category C wind conditions. Provide point-load connection details for all solar panel connections to demonstrate that the connections will resist uplift (IRC, Sec. R301.1 and R905.16).

## 5-5. Foundation

Provide a foundation plan for temporary setup on the competition site. Plans shall include location and size of all pad footings and required tie-down anchors (e.g., type, number, and installation configuration) to prevent wind uplift or overturning (IRC, Sec. R401.1 and R401.2) and to provide adequate lateral load transference for SDC D<sub>2</sub> design seismic forces. Please provide consideration for sloping or variable site conditions. General Requirements

- a. All houses, decks, and other structures shall be provided with foundations sufficient to safely transmit gravity, lateral, and uplift loads. For purposes of design, the presumptive paved surface bearing capacity shall be 6,000 psf (287 kPa). Design wind speed shall be 85 mph (38.0 m/s) (3-second gust) with a C exposure. Uplift Design
- b. Uplift design may employ uplift anchorage, dead-load analysis, or a combination of both. Anchorage embedment in the site concrete will be limited to the 6" of reported concrete depth for post installed embedment anchors. Through concrete earth anchor design values must be approved by the Solar Decathlon Building Official. Teams are encouraged to configure their structures to take advantage of dead loads to resist wind uplift, and seismic and wind generated overturning, and sliding. All designs shall be supported by calculations demonstrating the efficacy of the system. Foundation designs and calculations shall be approved prior to placement of the structure on the Orange County Great Park competition site in Irvine, California.

## 5-6. Alternate Materials

Alternate materials are permitted as follows.

- a. Engineered lumber (e.g., TJI, LPIs, and BCIs) pursuant to specific manufacturer's design data. The product selected must carry a current ICC Evaluation Services report. See <http://www.icc-es.org/>.
- b. Structurally insulated panel systems pursuant to specific manufacturer's design data. The product selected must carry a current ICC Evaluation Services report. Also be advised that foam plastics must be thermally isolated from the interior of the dwelling (see Section 3-6 for more details).
- c. Engineered trusses (floor or roof) must be designed in accordance with IRC Sections R502.11 or R802.10 as appropriate. Individual truss reports shall be provided for review and shall bear the seal of a registered design professional.
- d. Alternate materials may be permitted if approved pursuant to approval by written request under IRC Section 104.11. It is the responsibility of the applicant to provide adequate proof to document the alternate as meeting the intent of the prescriptive code requirements. The organizers reserve the right to deny any alternate for failure to clearly demonstrate code equivalence.
- e. Phase-change materials included within building components must be identified on the plans. Specifications for the material composition must be provided with fire-performance testing data. Be advised that phase-change embedment in gypsum board or interior wall or ceiling finishes may affect the ability of these materials to pass IRC required fire tests.
- f. Unlisted electrical components intended to be used must be fully disclosed no later than 12 months prior to the start of the competition. Such unlisted components will be limited to 60 volts. Such components shall be fully described in a written proposal format with competent technical substantiation provided. The proposal is subject to approval by the event organizers subject to stipulated minimum testing to ensure safe operation during the public event.

## 5-7. Structural Steel

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

## Section 6. Electrical

### 6-1. Governing Code

The provisions of the 2011 NEC supersede the limited prescriptive electrical requirements contained in Chapters 33-42 of the IRC.

Exception: Electrical system design methods required by non-US entrants for compliance in the jurisdiction of final placement may be permitted following review and approval by the Solar Decathlon Building Code Official. Such approval will require compliance with an approved national or international electrical code or standard. Teams seeking approval must submit two copies of the referenced code for evaluation prior to approval. If approved, such teams will be required to provide special inspection of the electrical system prior to placement of the structure in Irvine, California. Solar Decathlon temporary site final inspections of the visible electrical system will be performed by Solar Decathlon electrical inspectors using team supplied electrical test equipment suitable for the approved NEC-alternate electrical system.

### 6-2. Drawing Requirements

- a. Electrical plan(s) must include layouts of proposed receptacles, switches, light fixtures, smoke alarms, ceiling fans, etc.
- b. Provide details on the proposed PV system along with a key for symbols used in the drawings. Such details shall include information on the photovoltaic panels, distribution (e.g., wiring, inverters, switch gear, and over-current protection), and storage equipment (IRC, Sec. R106.1.1).
- c. Provide a key for electrical symbols used in the electrical plans (IRC, Sec. R106.1.1).

### 6-3. Tamper-Resistant Receptacles

#### **406.11 Tamper-Resistant Receptacles in Dwelling Units.**

In all areas specified in NEC Article 210.52, all 125-volt, 15- and 20-ampere receptacles shall be listed tamper-resistant receptacles.

**Figure 1: NEC excerpt regarding tamper-resistant receptacles**

### 6-4. Outdoor Receptacles

Any receptacles used on the exterior of the building must be protected with ground fault circuit interrupters (GFCI). Enclosures provided must be suitable for damp locations (IRC, Sec. E3802.3).

## **406.8 Receptacles in Damp or Wet Locations.**

(A) Damp Locations. A receptacle installed outdoors in a location protected from the weather or in other damp locations shall have an enclosure for the receptacle that is weatherproof when the receptacle is covered (attachment plug cap not inserted and receptacle covers closed).

An installation suitable for wet locations shall also be considered suitable for damp locations.

A receptacle shall be considered to be in a location protected from the weather where located under roofed open porches, canopies, marquees, and the like, and will not be subjected to a beating rain or water runoff. All 15- and 20-ampere, 125- and 250-volt nonlocking receptacles shall be a listed weather-resistant type.

FPN: The types of receptacles covered by this requirement are identified as 5-15, 5-20, 6-15, and 6-20 in ANSI/NEMA WD 6-2002, National Electrical Manufacturers Association Standard for Dimensions of Attachment Plugs and Receptacles.

(B) Wet Locations.

(1) 15- and 20-Ampere Receptacles in a Wet Location. 15- and 20-ampere, 125- and 250-volt receptacles installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. All 15- and 20-ampere, 125- and 250-volt nonlocking receptacles shall be listed weather-resistant type.

FPN: The types of receptacles covered by this requirement are identified as 5-15, 5-20, 6-15, and 6-20 in ANSI/NEMA WD 6-2002, National Electrical Manufacturers Association Standard for Dimensions of Attachment Plugs and Receptacles.]

Exception: 15- and 20-ampere, 125- through 250-volt receptacles installed in a wet location and subject to routine high-pressure spray washing shall be permitted to have an enclosure that is weatherproof when the attachment plug is removed.

**Figure 2: NEC excerpt regarding receptacles in damp or wet locations**

## **6-5. Arc-Fault Circuit Protection**

### **210.12 Arc-Fault Circuit-Interrupter Protection.**

(A) Definition: Arc-Fault Circuit Interrupter (AFCI). A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.

(B) Dwelling Units. All 120-volt, single phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas shall be protected by a listed arc-fault circuit interrupter, combination-type, installed to provide protection of the branch circuit.

Exception No. 1: Where RMC, IMC, EMT or steel armored cable, Type AC, meeting the requirements of 250.118 using metal outlet and junction boxes is installed for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a combination AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

Exception No. 2: Where a branch circuit to a fire alarm system installed in accordance with 760.41(B) and 760.121(B) is installed in RMC, IMC, EMT, or steel armored cable, Type AC, meeting the requirements of 250.118, with metal outlet and junction boxes, AFCI protection shall be permitted to be omitted.

**Figure 3: NEC excerpt regarding arc-fault circuit protection**

## **6-6. Ground-Fault Circuit Protection**

Any AC receptacles located in kitchens or bathrooms shall be GFCI protected (IRC, Sec. 3802.1 and 3802.6).

## 210.8 Ground-Fault Circuit-Interrupter Protection for Personnel.

(A) Dwelling Units. All 125-volt, single-phase, 15- and 20-ampere receptacles installed in the locations specified in (1) through (8) shall have ground-fault circuit-interrupter protection for personnel.

(1) Bathrooms

(2) Garages, and also accessory buildings that have a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use

(3) Outdoors

Exception to (3): Receptacles that are not readily accessible and are supplied by a dedicated branch circuit for electric snow-melting or deicing equipment shall be permitted to be installed in accordance with 426.28.

(4) Crawl spaces — at or below grade level

(5) Unfinished basements — for purposes of this section, unfinished basements are defined as portions or areas of the basement not intended as habitable rooms and limited to storage areas, work areas, and the like

Exception to (5): A receptacle supplying only a permanently installed fire alarm or burglar alarm system shall not be required to have ground-fault circuit-interrupter protection.

FPN: See 760.41(B) and 760.121(B) for power supply requirements for fire alarm systems.

Receptacles installed under the exception to 210.8(A)(5) shall not be considered as meeting the requirements of 210.52(G).

(6) Kitchens — where the receptacles are installed to serve the countertop surfaces

(7) Laundry, utility, and wet bar sinks — where the receptacles are installed within 1.8 m (6 ft) of the outside edge of the sink.

**Figure 4: NEC excerpt regarding ground-fault circuit protection**

## 6-7. Equipment Listings

All electrical equipment shall carry an approved testing agency's listing or shall have been approved by the Solar Decathlon Building Official and Solar Decathlon electrical inspectors for temporary use during the event in accordance with Section 104.11 of the IRC and Section 110.2 of the NEC (IRC, Sec. E3303.3).

- a. Unlisted PV modules may be used in a system with a DC bus voltage of no greater than 60 volts (open-circuit) at 32°F (0°C) if, and only if, such equipment has been evaluated and approved by the Solar Decathlon Building Official and Solar Decathlon electrical inspectors. PV cell and module mounting means are subject to increased scrutiny in custom, unlisted, building-integrated PV applications.
- b. The use of unlisted PV modules and the installation of listed PV modules in an unapproved manner in a system with a DC bus voltage of greater than 60 volts (open-circuit) at 32°F (0°C) are prohibited. Listings shall be to United States UL Standards and shall be granted by an OSHA approved, accredited testing laboratory.
- c. The attachment of PV modules to any material where the PV module is not listed for such an application is prohibited, regardless of the bus voltage.
- d. All DC to AC utility-interactive inverters must be fully listed to UL Standard 1741.

## 6-8. Photovoltaics

Particular attention should be paid to Articles 690, 480, 445, 250, 310, 400, and 240 of the NEC, which refer to photovoltaic system design, storage batteries, generators, grounding, conductors for general wiring, flexible cords and cables, and over-current protection devices, respectively. Teams are also encouraged to follow the guidelines in the following publication: Wiles, John C. *Photovoltaic Power Systems and the 2005 National Electric Code: Suggested Practices*, Southwest Technology Development Institute, New Mexico State University, 2008. This publication can be downloaded for free at <http://www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/PVnecSugPract.html>.

## **6-9. Grounding**

Each dwelling shall be provided with grounding electrodes in accordance with IRC E3608.1.4 Rod and pipe electrodes. The length of the ground rod shall be exactly 8 feet (2438 mm) in length.

# ***Section 7. Mechanical***

## **7-1. Drawing Requirements**

Provide a key for symbols used in the drawings (IRC, Sec. R106.1.1).

## **7-2. Return Air**

Return air shall not be taken from a bathroom, kitchen, mechanical, or furnace room. (IRC, Sec. M1602.2).

## **7-3. Outside and Exhaust Air**

### **a. Outside Air**

Outside air shall not be taken closer than 10 ft (304.8 cm) from an appliance or plumbing vent, or discharge outlet of an exhaust fan [unless the intake is located at least 3 ft (91.4 cm) below the vent or fan discharge] (IRC, Sec. M1602.2, Item 1).

### **b. Screens**

Outside air inlets shall be equipped with a screen with openings 0.25 in. to 0.5 in. (0.64 cm to 1.3 cm) (IRC, Sec. M1602.3).

c. Exhaust hood systems capable of exhausting in excess of 400 cubic feet per minute (0.19 m<sup>3</sup>/s) shall be provided with makeup air at a rate approximately equal to the exhaust air rate. Such makeup air systems shall be equipped with a means of closure and shall be automatically controlled to start and operate simultaneously with the exhaust system. (IRC Sec. M1503.4)

## **7-4. Bathroom Ventilation**

Bathrooms shall be provided with mechanical ventilation systems capable of providing 50 cfm (23.6 L/s) for intermittent ventilation or 20 cfm (9.4 L/s) for continuous ventilation, or with windows allowing a 1.5 ft<sup>2</sup> (0.14 m<sup>2</sup>) opening for natural ventilation (IRC, Sec. R303.3).

# ***Section 8. Solar Mechanical***

## **8-1. Drawing Requirements**

Provide plan details for any proposed solar mechanical systems. Provide details on collectors, fluid distribution, heat exchangers, etc., along with a key for symbols used in the drawings (IRC, Sec. 106.1.1). Plans should emphasize compliance with IRC M2301.

## **8-2. Cross Connection**

Provide details for the solar hot-water system. Provide details indicating if potable water or other heat transfer liquids will be employed. If other than potable water is used, an approved heat exchanger shall be employed to isolate potable water from transfer fluids (IRC Section R106.1.1).

## **8-3. Access**

Solar collectors, controls, dampers, fans, and pumps shall be accessible for inspection, maintenance, repair, and replacement (IRC, Sec. M2301.2.1).

#### **8-4. Roof-Mounted Collectors**

The roof shall be constructed to support all loads imposed by the collectors. If collectors are intended to serve as the roof covering, documentation shall be provided to determine compliance with the roofing provisions in IRC, Chapter 9. If the collectors will be placed over the roof covering, the collectors and supporting structure shall be constructed of noncombustible material or fire-retardant-treated wood equivalent to that required for the roof covering (IRC, Sec. M2301.2.2).

#### **8-5. Pressure and Temperature Relief**

Pressure- and temperature-relief valves shall be provided for components under pressure. Relief devices shall be installed in sections of the system so that a section cannot be valved off or isolated from a relief device (IRC, Sec. M2301.2.3). Pressure and temperature relief devices shall have the capacity to be removed and capped prior to inspection to accommodate the required 100 psi (690 kPa) system pressure test required by Section 8-13.

#### **8-6. Vacuum Relief**

A vacuum relief valve shall protect system components that might be subjected to pressure drops below atmospheric pressure during operation or shutdown. Plans shall indicate if this system is subject to vacuum conditions (IRC, Sec. M2301.2.4).

#### **8-7. Expansion Tanks**

Expansion tanks in solar systems shall be installed in accordance with IRC, Section M2301 in closed-fluid loops that contain heat-transfer fluid (IRC, Sec. M2301.2.6).

#### **8-8. Solar Loop Isolation**

Valves shall be installed to allow isolation of the solar collectors from the remainder of the system (IRC, Sec. M2301.2.8).

#### **8-9. Maximum Temperature Limitation**

Systems shall be equipped with means to limit the maximum water temperature of the system fluid entering or exchanging heat with any pressurized vessel inside the dwelling to 180°F (82°C). This protection is required in addition to required temperature and pressure relief valves stated in IRC, Section M2301.2.3 (IRC, Sec. M2301.2.9).

#### **8-10. Collector and Thermal Storage Unit Labeling**

- a. Collectors and storage units shall be listed and labeled to show the manufacturer's name, model number, serial number, collector weight, collector maximum allowable temperatures and pressures, and the type of heat transfer fluids that are compatible with the collector and storage units (IRC, Sec. 2301.3).
- b. Identification of system components. All components of the solar hydronic system shall be identified with permanent identification labels. Such labels shall indicate the function of the component (i.e. panel loop supply or return, heat exchanger, domestic loop, etc.) and flow direction.

Exception: Domestic plumbing fixture supply and in-floor radiant heat loops.

#### **8-11. Prohibited Heat-Transfer Media**

Flammable gasses and liquids shall not be used as heat-transfer fluids (IRC, Sec. M2301.4).

#### **8-12. Backflow Prevention**

All connections from the potable water supply to solar systems shall comply with IRC, Section P2902.4.5 (IRC, Sec. M2301.5).

## **8-13. Pressure Test**

All solar hydronic piping shall be tested hydrostatically at a pressure of not less than 100 psi (690 kPa) for no fewer than 15 minutes. Temperature and pressure relief devices that operate at or less than 100 psi (690 kPa) shall be isolated during the test by removal and capping.

Exception: Systems designed for pressures under 100psi (690kPa) may be tested at lower pressures when approved by the Solar Decathlon Building Official. Such testing must be approved prior to transportation of the structure to the competition site.

# **Section 9. Plumbing**

## **9-1. Drawing Requirements**

- a. Provide a labeled isometric diagram of the proposed plumbing system for review. Clearly indicate waste lines, vent lines, potable water supply, heat exchange equipment, and the type of any heat transferring fluid used other than potable water.
- b. Provide a key for symbols used in the drawings (IRC, Sec. 106.1.1).

## **9-2. Water Closet Demonstration**

Water closets are installed for demonstration only and shall not be connected to any portion of the sewage disposal system. The water closet shall be attached to a PVC or ABS 4 in. to 3 in. (10.2 cm to 7.7 cm) water-closet flange provided with a capped end. The cap shall be located as close as possible to the flange fitting. No structural member shall be cut or otherwise damaged to accommodate the water-closet flange assembly. No water supply shall be extended to the water closet unless otherwise approved by the Solar Decathlon Building Official.

## **9-3. Plumbing Wall – Structural**

Recommendation: Create a dedicated plumbing wall with thickness sufficient to allow pipe penetrations within the studs not exceeding 60% of the stud width in nonbearing walls (IRC, Sec. 602.6).

## **9-4. Shower Mixing Valves**

Shower mixing valves shall be pressure balanced, thermostatic mixing, or a combination of the two, with the high limit set at 120°F (48.9°C) to prevent scalding (IRC, Sec. P2708.3).

## **9-5. Backflow Prevention**

Backflow prevention is required to isolate the potable water supply from the solar systems. See IRC Section P2902.2 for permissible devices. Because this project uses supply tanks for potable water, the use of a separate and isolated fill system for the solar component may be deemed acceptable backflow prevention (IRC, Sec. P2902.2).

## **9-6. Water Heater and Heated Storage Vessel Seismic Support**

Water heaters and other heated fluid storage vessels shall be anchored or strapped in the upper one-third and in the lower one-third of the appliance to resist a horizontal force equal to one-third of the operating weight of the water heater, acting in any horizontal direction, or in accordance with the appliance manufacturer's recommendations.

## **9-7. Supply**

No additives of any kind may be added to the water in the team's supply tank. This water is not for consumption at any time. Teams will be required to provide the tank and support this tank so that it does not damage the competition site turf.

## 9-8. Waste

All substances used in combination with water to clean the house, dishes, utensils, etc., must be nontoxic and preferably biodegradable. Teams may incur a point penalty for any toxic substances that are found in the wastewater tank.

## 9-9. Water Feature Safety

- a. Water features shall not exceed a depth of 2 ft (61 cm).
- b. For water features >1 ft but <2 ft (>30.5 cm but <61 cm), there shall be a representative from the team positioned at the water feature when open to the public to monitor the area and act as a lifeguard if necessary. During times when the area is not open to the public, the water feature shall be covered or guarded in a manner to prevent access.
- c. To ensure safe access, a 44 in. (111.8 cm) accessible surface shall be maintained all around the water feature.
- d. Visitor flow patterns shall be considered in the placement of the water feature.
- e. The water feature should have sufficient circulation/treatment/measures taken to ensure the water does not become stagnant and a nuisance hazard.

# Section 10. Material Safety

## 10-1. Thermal Storage

All thermal storage devices (“mass”) must be made of stable, nontoxic materials. For all heat-transfer fluids, Material Safety Data Sheets (MSDS) must be submitted for approval. All liquid-based thermal storage systems must be marked with the NFPA’s hazard warning diamond appropriate to the technology.

## 10-2. Paint Disposal

Teams are not permitted to dispose of paint on the competition site. Teams may either take unused paint home or find a local facility that disposes of or recycles paint.

## 10-3. Material Safety Data Sheets (MSDS)

MSDS are required for all potentially hazardous materials to be used at the event, such as cleaning solvents, glycol, rubber cement, rubbing alcohol, etc.

# Section 11. Moveable Features

Teams planning to move or transform major components of their houses beyond the assembly and disassembly phases are required to obtain special approval from a Solar Decathlon safety officer. Possible design features meeting this description include large, unusual, and potentially dangerous features such as moveable rooms and walls, changeable façades, collapsible spaces, and folding beds. This requirement does not apply to smaller, more typical house features that may be reconfigured, such as awnings, operable windows and window coverings, and doors. The following rules apply to qualifying features:

- a. After the houses are assembled on the competition site, the safety officer will inspect every house and inform each team whether it has any qualifying features.
- b. Teams wanting to determine before the event whether their house has any qualifying features should contact [sdrules@nrel.gov](mailto:sdrules@nrel.gov).
- c. The safety officer cannot thoroughly evaluate the safety of a particular house feature until it is seen in operation; however, the safety officer will try to indicate with a reasonable degree of confidence whether certain features are subject to these rules.
- d. Qualifying features shall not be reconfigured during impound.

- e. Qualifying features shall not be reconfigured during public exhibit hours unless approved by the Solar Decathlon safety officer. To receive approval, a team must:
  - (i). Include in its Health and Safety Plan an explanation of how it will ensure safety during the movement of qualifying features
  - (ii). Demonstrate the successful execution of the safety plan for qualifying features at some point before public exhibit hours begin
  - (iii). Continue to demonstrate the successful execution of the safety plan for qualifying features during public exhibit hours.
- f. If, at any time, the safety officer witnesses unsafe conditions, the movement of qualifying features during public tours may be prohibited for the duration of the event.

DRAFT

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**D. ENERGY PANEL SOLUTIONS' DESIGN REPORT AND CALCULATIONS**



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*Energy Panel Structures, Inc.*

4/24/2013

## **SIP PANEL STRUCTURAL CALCULATIONS**

Project: 89539 / BBL Buildings / MO S&T Solar House  
EPS Engineer: David Mensing, P.E.

Attached are the structural calculations (23 Sheets, not including this sheet), of the above referenced project. These calculations cover the EPS building package only. All other design is by others. All loading information used was provided by others.

## Summary of Provided Loadings by MO S&amp;T Students

- Assume ASCE 7-10
- ASD Load Combinations
- Pages 7-13

## Max Seismic Shear

- EW  $\rightarrow 202 \text{ plf} \rightarrow 4495 \text{ lbs total}$  (Walls 1, 2 & 3)
- SW  $\rightarrow 96 \text{ plf} \rightarrow 4536 \text{ lbs total}$  (Walls A, B & C)

## Max Wind

- Pressures for Wall Design  
Max  $19.4 \text{ psf}$

## - Shear

- EW  $\rightarrow 162 \text{ plf} \rightarrow 3604 \text{ lbs total}$
- SW  $\rightarrow 50 \text{ plf} \rightarrow 2362 \text{ lbs total}$

\* By Inspection Seismic Shear controls design.

Roof  $\rightarrow$   
Live Load -  $20 \text{ psf}$   
Dead Load -  $18 \text{ psf}$

### Roof Panels

7/16" OSB / 9 3/2" EPS / 1/16" OSB "A-40"

Max Span = 14'-1" @ Roofplane "1"

Total Load = 38 psf

Per Table 4 of NTA listing report allowable transverse load for 14' span @ 4/360 = 41.1 psf. ∴ OK

1 3/4" x 9 1/2" LVL spline 4' o.c. used for extra rigidity.

### Wall Panels

Max Vertical Load @ Wall "2"

$$8.5' \times 38 \text{ psf} = 323 \text{ plf} \quad (170 \text{ plf LL} + 153 \text{ plf DL})$$

NTA Table 5 Allowable 12' Panel = 3660 plf.

Max Transverse = 19.4 psf

NTA Table 3 12' Allowable = 27.3 x 0.4 L<sub>v</sub> = 11 psf Allowable

Load Comb. 6A

Trans.  $\Delta + .75L + .75(.6W) = .75 \times .6 \times 19.4 = 8.73 \text{ psf}$

Axial  $= 153 + .75 \times 170 = 280.5 \text{ plf}$

Unity Equation

$$\frac{8.73}{11} + \frac{280.5}{3660} = .872 \leq 1.0 \quad \therefore \text{OK}$$

### Roof Diaphragm

NTA Table 8

Seismic Comb #8  $0.6\Delta + 0.7E = 3146 \text{ lbs}$

$$\frac{3146 \text{ lbs}}{22.25 \text{ ft}} = 142 \text{ plf} < 265 \text{ Allowable}$$

8d @ Seams 6" O.C. SIP Screws 6" O.C. @ Perimeter

### Seismic Load Combinations

Worst case  $\Rightarrow$  Comb. #8  $\Rightarrow 0.6D + 0.7E$

Per NTA Section 5.8 Shear walls with structural splines are to be designed with accepted engineering practice.

American Wood Council SDPWS-08 used.

$V_s = 480 \text{ plf}$  for  $7/16''$  OSB w/ 8d Edge nails 6" o.c.  
\*Due to SIP assume blocked values  
\*Table 4.3A

S.G. Adjustment  $\Rightarrow 1 - (.5 - .6) = 1 - (.5 - .42) = .92$  for SAF

ASD Factor = 2.0.

$V_{ub} = \frac{480}{2.0} \times 2 \text{ Layers} \times .92 = 441 \text{ plf}$  Allowable.

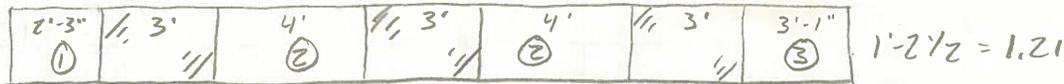
Shear Wall 3 (EPS Wall "Z")

- Wall Pier - Force Transfer.

Comb #8  $0.6D + 1.7E = 3147 \text{ lbs}$

Total width of Piers =  $2'-3" + (2)3'-11\frac{1}{2}" + 3'-1" = 13'-3"$

$v = \frac{3147}{13'-3} = 238 \text{ p/ft} \leq 441 \text{ p/ft Allowable} \therefore \text{OK}$



①  $\sum M_o = (238 \times 2.25) \times 1.21 - (0.6 \times 8' \times 18 \text{ psf} \times 2.25) \times 1.21 - T \times 2.25 = 0$   
 Roof DL  
 $T = 191 \text{ lbs}$   
 OSB OK

②  $T = 116 \text{ lbs}$   
 OSB OK

③ SIM to ① by Inspection

Overall Overturning

$\sum M_o = 3147 \times 10.5 - (0.6 \times 8 \times 18 \times 22.25) \times \frac{22.25}{2} - T \times 22.25 = 0$   
 $T = 524 \text{ lbs}$

Shear Wall 1.2 As Built - Perforated Shear Wall (EPS wall "6")

$$C_o = \left( \frac{r}{3-2r} \right) \left( \frac{L_{tot}}{\sum L_i} \right) = \left( \frac{0.94}{3-2 \times 0.94} \right) \left( \frac{22.25}{18.25} \right) = 1.02 \Rightarrow 1.0$$

$$r = \frac{1}{1 + \frac{A_o}{h \sum L_i}} = \frac{1}{1 + \frac{12}{10.25 \times 18.25}} = 0.94$$

Load Comb #8

$$0.6D + 0.7E = 3147 \text{ lbs}$$

$$L_{tot} = 22.25 \text{ ft}$$

$$\sum L_i = 13.25 + 5 = 18.25$$

$$h = 10.25$$

$$A_o = 12 \text{ ft}^2$$

$$U_{max} = \frac{V}{C_o \sum L_i} = \frac{3147}{1.0 \times 18.25} = 173 \text{ plf} < 441 \text{ plf allowable} \therefore \text{OK}$$

Overturning

$$\sum M_o = 3147 \times 10.25 - 0.6(2 \times 18 \times 22.25)11.2 - T \times 22.25 = 0$$

$$T = 1207$$

### Shear Wall A (EPS Wall "1")

- Perforated Shear Wall

↳ Edge of (001) to Edge of W1-17

$$V = 0.6D \times 0.7E = 0.7 \times 4536 = 3175 \text{ lbs}$$

$$L_{tot} = 27'$$

$$\sum L_i = 17'-10"$$

$$h = 10'-3"$$

$$A_0 = 63.2 \text{ ft}^2$$

$$r = \frac{1}{1 + \frac{63.2}{10.25 \times 17.8}} = 0.74$$

$$C_0 = \left( \frac{.74}{3 - 2 \times .74} \right) \left( \frac{27'}{17.8'} \right) = 0.74$$

$$V_{max} = \frac{3175 \text{ lbs}}{0.74 \times 17.8 \text{ ft}} = 241 \text{ plf} < 441 \text{ plf} \therefore \text{OK}$$

Overturning

$$\sum M_o = 3175 \times 10.25 - .6(7.5' \times 17.25' \times 18) \times 8.4'$$

$$.6(2' \times 9.7' \times 18) \times 22.3' - T \times 27'$$

$$T = 598 \text{ lbs}$$

### Shear Wall B (EPS Wall 3)

- Similar to Wall A by Inspection

- Shear wall assumed from W3-4 to W3-16

Wind Frame Story Shear						
Level	Story Shear	1 & 2	3	Story Shear	A	B & C
Roof	7.2	161.80	161.80	3.9	41.27	49.68
Level	Story Shear	f1	f2	Story Shear	a	b
1st Floor	8.3	203.88	169.15	4.5	52.05	43.19

Wind Load at Beams	
Beams	Shear (plf)
A26, C20	93.32
B27, C3	92.87
A1, B1	365.68
B7	161.80
A27, B28	49.68
C2	330.95

Seismic Frame Story Shear						
Level	Story Shear	1 & 2	3	Story Shear	A	B & C
Roof	8.99	202.02	202.02	8.99	95.13	95.13
Level	Story Shear	f1	f2	Story Shear	a	b
1st Floor	5.73	140.64	116.68	5.73	66.23	54.95

Wind Load at Beams	
Beams	Shear (plf)
A26, C20	161.36
B27, C3	150.08
A1, B1	342.66
B7	202.02
A27, B28	95.13
C2	318.70

SHEAR WALLS 1 & 2 ARE THE WEST SIP WALLS  
 SHEAR WALL 3 IS THE EAST SIP WALL  
 SHEAR WALL A IS THE SOUTH SIP WALL  
 SHEAR WALL B IS THE NORTH SIP WALL  
 SHEAR WALL F1 IS THE STEEL BEAMS ALONG THE WEST PERIMETER  
 SHEAR WALL F2 IS THE STEAL BEAMS RUNNING ALONG THE EAST PERIMETER  
 SHEAR WALL A IS THE STEEL BEAMS RUNNING ALONG THE SOUTH PERIMETER  
 SHEAR WALL B IS THE STEAL BEAMS RUNNING ALONG THE NORTH PERIMETER

Table 12.8-1 Coefficient for Upper Limit on Calculated Period		
	$S_{D1}$	$C_u$
$\geq$	0.4	1.4
	0.3	1.4
	0.2	1.5
	0.15	1.6
$\leq$	0.1	1.7

Table 12.8-2 Values of Approximate Period Parameters $C_t$ and $\alpha$		
Structure Type	$C_t$	$\alpha$
Steel MRF	0.028	0.8
Concrete MRF	0.016	0.9
Steel Eccentrically Braced Frames	0.03	0.75
Steel Buckling-Restrained Braced Frames	0.03	0.75
All Other Structural Systems	0.02	0.75

Table 1: Site Parameters	
Property	Value
Site Class	B
Intended Use	Normal Office Building

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Floor	$w_i$ (lb)	$w_i$ (k)	$h_i$ (ft)	k	$w_i h_i^k$ (k-ft)	$w_x h_x^k$ (k-ft)	$C_v$	V (k)	$F_x$ (k)
1	74917	74.92	2.31	1	173.25	173.25	0.39	14.72	5.73
Roof	21179	21.18	12.84	1	272.02	272.02	0.61	14.72	8.99
$\Sigma w_i h_i^k$					445.27 k-ft				

Frame Shear at Roof		Use in conjunction with Irregularity Table 12.3-1 4 and Section 12.3.3.4					
$V_x$ 8.99 kip							
	Frame	Trib. Area (ft <sup>2</sup> )	Length (ft)	Direct Shear (k)	Torsional Shear (k)	Total V (kip)	Linear Shear (plf)
X Direction	A	579	47.25	4.49	0.00	4.49	95.13
	B/C	579	47.25	4.49	0.00	4.49	95.13
Y Direction	1/2	579	22.25	4.49	0.00	4.49	202.02
	3	579	22.25	4.49	0.00	4.49	202.02
Frame Shear at Level 1							
$V_x$ 5.73 kip							
	Frame	Trib. Area (ft <sup>2</sup> )	Length (ft)	Direct Shear (k)	Torsional Shear (k)	Total V (kip)	Linear Shear (plf)
X Direction	a	634	47.25	3.13	0.00	3.13	66.23
	b	526	47.25	2.60	0.00	2.60	54.95
Y Direction	f1	634	22.25	3.13	0.00	3.13	140.64
	f2	526	22.25	2.60	0.00	2.60	116.68

Seismic Forces			
ASCE 7-10 Seismic Design			
Site Spectrum			
Input values below from map or CD:			Code Reference
Spectral Response Acceleration, Short Period	$S_s =$	1.493 g	11.4.1
Spectral Response Acceleration, 1-Sec. Period	$S_1 =$	0.554 g	11.4.1
Input value below from soils report:			
Site Class	Class =	D	Table 1: Site Parameters
Value of Coefficients based on SPA periods:			
Site Coefficient for Short Period	$F_a =$	1.00	Table 11.4-1
Site Coefficient for 1-sec. Period	$F_v =$	1.50	Table 11.4-2
Determine Maximum Considered Earthquake (MCE) Parameters:			
MCE Spectral Response Acceleration, Short T	$S_{MS} =$	1.493 g	11.4.3
MCE Spectral Response Acceleration, 1-Sec. T	$S_{M1} =$	0.831 g	11.4.3
Determine Design Base Earthquake (DBE) parameters:			
DBE Spectral Response Acceleration, Short T	$S_{DS} =$	0.995 g	11.4.4
DBE Spectral Response Acceleration, 1-Sec. T	$S_{D1} =$	0.554 g	11.4.4
<b>Building Response</b>			
Input Building Properties:			
Structure Type	All Other Structural Systems		
Response Modification Factor	$R =$	6.5	Table 12.2-1
System Overstrength Factor	$\Omega_o =$	3.0	Table 12.2-1
Deflection Amplification Factor	$C_d =$	4.0	Table 12.2-1
Occupancy Category	Category =	II	Table 1-1
Period Parameters	$C_t =$	0.02	Table 12.8-2
Period Parameters	$\alpha =$	0.75	Table 12.8-2
Long Period Transition Period	$T_L =$	8.00 sec.	Figure 22-12
Effective Height	$h_n =$	13.1 ft.	12.8.2.1
Determine Period for Base Shear:			
Seismic Design Category	Cat. =	D	11.6 & Tables 11.6-1 & 11.6-2
Occupancy Importance Factor	$I =$	1.0	11.5.1 & Table 11.5-1
Coefficient for Upper Limit on Calculated Period	$C_U =$	1.40	Table 12.8-1
Approximate Fundamental Period	$T_a =$	0.138 sec.	12.8.2.1
Design Fundamental Period Limit	$T_{UM} =$	0.193 sec.	12.8.2
Period $T_o$	$T_o =$	0.111 sec.	11.4.4
Period $T_s$	$T_s =$	0.557 sec.	11.4.5
Design Period	$T =$	0.557 sec.	12.8.2
Determine Base Shear:			
Seismic Response Coefficient $T_o \leq T < T_s$	$C_s =$	N/A	12.8-2
Seismic Response Coefficient $T \leq T_L$	$C_s =$	0.153	12.8-3
Seismic Response Coefficient $T > T_L$	$C_s =$	N/A	12.8-4
Min. Allowable Seismic Response Coefficient	$C_{s, min\_Allowable} =$	0.01	12.8-5
	$C_{s, min\_Allowable} =$	N/A	12.8-6
	$C_s =$	0.153	
Seismic Base Shear (Equivalent Lateral Force Procedure)	$C_s =$	0.153 *W	12.8-1
	$W =$	96.10 k	
	$V =$	14.72 k	

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AGAINST 28.25' AT 1ST FLOOR				
V 4.5 KIP				
FRAME	A <sub>r</sub> (ft <sup>2</sup> )	Length (ft)	DIRECT SHEAR (kip)	V (plf)
a	634	47.25	2.46	52.05
b	526	47.25	2.04	43.19
f1	634	22.25		0.00
f2	526	22.25		0.00

AGAINST 47.25' AT 1ST FLOOR				
V 8.3 KIP				
FRAME	A <sub>r</sub> (ft <sup>2</sup> )	Length (ft)	DIRECT SHEAR (kip)	V (plf)
a	634	47.25	0.00	0.00
b	526	47.25	0.00	0.00
f1	634	22.25	4.54	203.88
f2	526	22.25	3.76	169.15

AGAINST 28.25' AT ROOF				
V 3.9 KIP				
FRAME	A <sub>r</sub> (ft <sup>2</sup> )	Length (ft)	DIRECT SHEAR (kip)	V (plf)
1 & 2	579	22.25		0.00
3	579	22.25		0.00
A	579	47.25	1.95	41.27
B & C	579	39.25	1.95	49.68

AGAINST 47.25' AT ROOF				
V 7.2 KIP				
FRAME	A <sub>r</sub> (ft <sup>2</sup> )	Length (ft)	DIRECT SHEAR (kip)	V (plf)
1 & 2	579	22.25	3.60	161.80
3	579	22.25	3.60	161.80
A	579	47.25		0.00
B & C	579	39.25		0.00

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HEIGHT ABOVE GROUND LEVEL	K <sub>z</sub> FOR EXPOSURE B	q <sub>z</sub> (PSF)
0 - 15	0.85	22.4
18	0.88	23.2

WALL PRESSURE COEFFICIENTS, C <sub>p</sub>			
SURFACE	L/B	C <sub>p</sub>	USE WITH
WINDWARD WALL	ALL VALUES	0.8	Q2
LEEWARD WALL	0.6	-0.5	Q2
	1.68	-0.37	Q2
SIDE WALL	ALL VALUES	-0.7	Q2

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WINDWARD WALL PRESSURES				COMBINED WW + LW	
Z (FT)	$q_z G C_p$ (PSF)	W/ + $q_z G C_{pi}$ (PSF)	W/ - $q_z G C_{pi}$ (PSF)	47.25' WALL	28.25' WALL
0 - 15	15.22	11.1	19.4	25.1	22.5
18	15.76	11.6	19.9	25.6	23.0

ROOF PRESSURE				
HORIZONTAL DISTANCE	$C_p$	$q_H G C_p$ (PSF)	W/ + $q_H G C_{pi}$ (PSF)	W/ - $q_H G C_{pi}$ (PSF)
0 TO h/2	-0.9	-26.7	-13.5	-21.9
0' TO 6.5'	-0.9	-26.7	-13.5	-21.9
h/2 TO h	-0.9	-26.7	-13.5	-21.9
6.5' TO 13'	-0.9	-26.7	-13.5	-21.9
h to 2h	-0.5	-14.9	-5.6	-14
13' TO 26'	-0.5	-14.9	-5.6	-14
> 2h	-0.3	-8.9	-1.7	-10.1
> 26'	-0.3	-8.9	-1.7	-10.1



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CSI 06 12 16

Listing Report: **SIPA120908-10**

**PRODUCT:** Structural Insulated Panels (SIPs)  
**DIVISION:** Wood and Plastics (06)  
**SECTION:** Structural Panels (06 12 16)

**Report Holder**  
Structural Insulated Panel Association (SIPA)  
PO Box 1699  
Gig Harbor, WA 98335

**Manufacturing Locations**  
Energy Panel Structures, Inc. (NTA Plant #549)  
102 East Industrial Park  
Graettinger, IA 51342

FischerSIPS, LLC (NTA Plant #545)  
1800 Northwestern Parkway  
Louisville, KY 40203

Foard Panel, Inc. (NTA Plant #634)  
53 Stow Road  
West Chesterfield, NH 03466

IB Panels (NTA Plant #621)  
50 West 100 South  
Jerome, ID 83338

The Murus Company (NTA Plant #660)  
3234 Route 549  
Mansfield, PA 16933

PorterCorp (NTA Plant #538)  
4240 North 136<sup>th</sup> Avenue  
Holland, MI 49424

Timberline Panel Company, LLC (NTA Plant #624)  
141 Morse Road  
Bennington, VT 05201

Vantem Panels (NTA Plant #654)  
710 FM 306  
New Braunfels, TX 78130

1. **SUBJECT**  
SIPA Structural Insulated Panels. Wall and Roof Panels 8 ft. to 20 ft. long, 4-5/8 in. to 12-1/4 in. thick.
  
2. **SCOPE**
  - 2.1. NTA, Inc. has evaluated the above product(s) for compliance with the applicable sections of the following codes:
    - 2.1.1. 2006, 2009 International Building Code (IBC)
    - 2.1.2. 2006, 2009 International Residential Code (IRC)
  
  - 2.2. NTA, Inc. has evaluated the above product(s) in accordance with:
    - 2.2.1. NTA IM 014 Structural Insulated Panel Evaluation
    - 2.2.2. NTA IM 036 Quality System Requirements
  
  - 2.3. NTA, Inc. has evaluated the following properties of the above product(s):
    - 2.3.1. Structural performance under axial, transverse and racking loads.

To obtain the most current NTA Listing Report visit [www.ntainc.com/product-certification/](http://www.ntainc.com/product-certification/).
  
3. **USES**
  - 3.1. **General.** *SIPA Structural Insulated Panels* are used as structural insulated roof and wall panels capable of resisting transverse, axial and in-plane shear loads.
  
  - 3.2. **Construction Types.** *SIPA Structural Insulated Panels* shall be considered combustible building elements when determining the Type of Construction in accordance with 2009 IBC Chapter 6. (IM 014 NACU1)
  
  - 3.3. **Fire Resistive Assemblies.** *SIPA Structural Insulated Panels* shall not be used as part of a fire-rated assembly unless suitable evidence and details are submitted and approved by the authority having jurisdiction. (IM 014 ACU14)

*This listing report is intended to indicate that NTA Inc. has evaluated product described and has found it to be eligible for labeling. Product not labeled as specified herein is not covered by this report. NTA Inc. makes no warranty, either expressed or implied, regarding the product covered by this report.*

NTA, INC. • 305 NORTH OAKLAND AVENUE • P.O. BOX 490 • NAPPANEE, INDIANA 46550  
WEB: WWW.NTAINC.COM

PHONE: 574-773-7975  
FAX: 574-773-2260

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This report is subject to annual renewal.  
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#### 4. DESCRIPTION

**4.1. General.** *Structural Insulated Panels* are factory-assembled, engineered-wood-faced, structural insulated panels (SIPs) with an expanded polystyrene (EPS) foam core. The panels are intended for use as load-bearing or non-load bearing wall and roof panels. Panels are available in 4-5/8 in. through 12-1/4 in. overall thicknesses. The panels are custom made to the specifications for each use and are assembled under factory-controlled conditions. The maximum panel size is 8 ft. wide and up to 20 ft. in length.

#### 4.2. Materials

**4.2.1. Facing.** The facing consists of two single-ply oriented strand board (OSB) facings a minimum of 7/16 in. thick conforming to 2009 IRC Table 613.3.2 and DOC PS 2-04, Exposure 1, Rated Sheathing with a span index of 24/16. Panels may be manufactured with the facing strength axis oriented in either direction with respect to the direction of SIP bending provided the appropriate strength values are used.

**4.2.2. Core.** The core material is EPS Foam conforming to the Type I specification defined in ASTM C578. The foam core, up to 11-3/8 in. thickness, has a flame spread rating not exceeding 75 and a smoke-developed rating not exceeding 450 in compliance with 2009 IBC Section 2603.3 Exception 4.

**4.2.3. Adhesive.** Facing materials are adhered to the core material using a structural adhesive. The adhesive is applied during the lamination process in accordance with the in-plant quality system documentation.

**4.2.4. Material Sources.** The facing, core and adhesive used in the construction of *Structural Insulated Panels* shall be composed only of materials from approved sources as identified in the in-plant quality system documentation. A list of material suppliers is provided in Table 9.

**4.2.5. Splines.** *Structural Insulated Panels* are interconnected with surface splines or block splines (Figure 1). Connections using dimensional lumber splines or engineered structural splines are not specifically addressed in this report and must be designed in accordance with accepted engineering practice to meet applicable code requirements. <sup>(IM 014 ACU20)</sup>

**4.2.5.1. Surface Splines.** Surface splines (Figure 1) consist of 3 in. wide by 7/16 in. thick or thicker OSB. At each panel joint, one surface spline is inserted into each of two tight-fitting slots in the core. The slots in the core are located just inside the facing.

**4.2.5.2. Block Splines.** Block splines (Figure 1) are manufactured in the same manner as the SIP except with an overall thickness that is 1 in. less than the overall thickness of the panel to be joined.

#### 5. DESIGN

**5.1. Overall Structural System.** The scope of this report is limited to the evaluation of the SIP component. Panel connections and other details related to incorporation of the panel into the overall structural system of a building are beyond the scope of this report. <sup>(IM 014 NACU3)</sup>

**5.2. Design Approval.** Where required by the authority having jurisdiction, structures using *Structural Insulated Panels* shall be designed by a registered design professional. Construction documents, including engineering calculations and drawings providing floor plans, window details, door details and connector details, shall be submitted to the code official when application is made for a permit. The individual preparing such documents shall possess the necessary qualifications as required by the applicable code and the professional registration laws of the state where the construction is undertaken. Approved construction documents shall be available at all times on the jobsite during installation. <sup>(IM 014 NACU4)</sup>

**5.3. Design Loads.** Design loads to be resisted by the SIPs shall be as required under the applicable building code. Loads on the panels shall not exceed the loads noted in this report.

*This listing report is intended to indicate that NTA Inc. has evaluated product described and has found it to be eligible for labeling. Product not labeled as specified herein is not covered by this report. NTA Inc. makes no warranty, either expressed or implied, regarding the product covered by this report.*

NTA, INC. • 305 NORTH OAKLAND AVENUE • P.O. BOX 490 • NAPPANEE, INDIANA 46550  
WEB: WWW.NTAINC.COM

PHONE: 574-773-7975  
FAX: 574-773-2260

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**5.4. Allowable Loads.** Allowable axial, transverse, and racking loads may be calculated using the panel properties provided in Tables 1 and 2 or may be selected from Tables 3 through 7. Maximum and minimum panel heights, spans and thicknesses are limited as provided in Table 2 through 7. Unless otherwise noted, all properties and allowable loads apply to panels joined with surface or block splines. Allowable loads for reinforced panel capacities shall be designed by a registered professional. Calculations demonstrating that the loads applied are less than the allowable loads described in this report shall be submitted to the code official for approval. <sup>(IM 014 NACU5)</sup> For loading conditions not specifically addressed herein, structural members designed in accordance with accepted engineering practice shall be provided to meet applicable code requirements.

**5.5. Concentrated Loads.** Axial loads shall be applied to the SIP through continuous members such as structural insulated roof or floor panels or repetitive members such as joists, trusses or rafters spaced at regular intervals of 24 in. on center or less. Such members shall be fastened to a rim board or similar member to distribute the load to the SIP. For other loading conditions, reinforcement shall be provided. This reinforcement shall be designed in accordance with accepted engineering practice. <sup>(IM 014 ACU12)</sup>

**5.6. Eccentric and Side Loads.** Axial loads shall be applied concentrically to the top of the SIP. Loads shall not be applied eccentrically or through framing attached to one side of the panel (such as balloon framing) except where additional engineering documentation is provided. <sup>(IM 014 ACU13)</sup>

**5.7. Openings.** Openings in panels shall be reinforced with wood or steel designed in accordance with accepted engineering practice to resist all loads applied to the opening as required by the adopted code. Details for door and window openings shall be provided to clarify the manner of supporting axial, transverse and/or racking shear loads at openings. Such details shall be shown on approved design documents and subject to approval by the local authority having jurisdiction. <sup>(IM 014 ACU8)</sup>

**5.8. In-Plane Shear Design.** Shear walls utilizing block or surface splines shall be sized to resist all code required wind and seismic loads without exceeding the allowable loads provided in Tables 6 and 7. Shear wall chords, hold-downs and connections to transfer shear forces between the wall and surrounding structure shall be designed in accordance with accepted engineering practice. Allowable strengths for shear walls with structural splines along each panel edge shall be designed in accordance with accepted engineering practice and subject to the limitations for wood sheathed shear walls.

**5.8.1. Seismic Design Categories A, B and C.** The use of the shear wall configurations in Table 6 is limited to structures in Seismic Design Categories A, B and C. Where SIPs are used to resist seismic forces the following factors shall be used for design: Response Modification Coefficient,  $R = 2.0$ ; System Overstrength Factor,  $\Omega_0 = 2.5$ ; Deflection Amplification Factor,  $C_d = 2.0$ . <sup>(IM 014 ACU16)</sup> The maximum panel height-to-width ratio shall be 2:1. <sup>(IM 014 ACU17)</sup>

**5.8.2. Seismic Design Categories D, E, and F.** The shear wall configurations in Table 7 are permitted in Seismic Design Categories D, E and F. Such walls shall be designed using the seismic design coefficients and limitations provided in ASCE 7-05 for light-framed walls sheathed with wood structural panels rated for shear resistance (SFRS A13). These SIPs shall use the following factors for design: Response Modification Coefficient,  $R = 6.5$ ; System Overstrength Factor,  $\Omega_0 = 3.0$ ; Deflection Amplification Factor,  $C_d = 4.0$ . <sup>(IM 014 ACU16)</sup> The maximum panel height-to-width ratio shall be 1:1. <sup>(IM 014 ACU17)</sup>

**5.8.3. Adhesives and Sealants.** Adhesives and sealants shall not be applied at wood-to-wood or spline-to-facing interfaces in shear walls in Seismic Design Categories D, E and F <sup>(IM 014 NACU10)</sup>. Adhesives and sealants may be applied to wood-to-foam or facing-to-foam interfaces. Flexible SIP tape may be applied over panel joints.

**5.9. Horizontal Diaphragms.** Horizontal diaphragms shall be sized to resist all code required wind and seismic loads without exceeding the allowable loads provided in Table 8. Diaphragm chords and connections to transfer shear forces between the diaphragm and surrounding structure shall be designed in accordance with accepted engineering practice. The maximum diaphragm length-to-width ratio shall not exceed 3:1. <sup>(IM 014 ACU18)</sup>

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WEB: WWW.NTAINC.COM

PHONE: 574-773-7975  
FAX: 574-773-2260

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**5.10. Combined Loads.** Panels subjected to any combination of transverse, axial or in-plane shear loads shall be analyzed utilizing a straight line interaction in accordance with *NTA IM014 TIP 01 SIP Design Guide*.

**6. INSTALLATION**

**6.1. General.** *Structural Insulated Panels* shall be fabricated, identified and erected in accordance with this report, the approved construction documents and the applicable code. In the event of a conflict between the manufacturer's published installation instructions and this report, this report shall govern. Approved construction documents shall be available at all times on the jobsite during installation. <sup>(IM 014 NACU7)</sup>

**6.2. Splines.** *Structural Insulated Panels* are interconnected at the panel edges through the use of a spline. The spline type may be of any configuration listed in Section 4.2.5 as required by the specific design. The spline shall be secured in place with not less than 0.131 in. x 2-1/2 in. nails, spaced 6 in. on center on both sides of the panel, or an approved equivalent fastener. All joints shall be sealed in accordance with the SIP manufacturer's installation instructions. Alternate spline connections may be required for panels subjected to in-plane racking forces. Such panels shall be interconnected exactly as required in Table 6 or 7 or as directed by the designer.

**6.3. Plates.** The top and bottom plates of the panels shall be dimensional or engineered lumber sized to match the core thickness of the panel. The plates shall be secured using not less than 0.131 in. x 2-1/2 in. nails, spaced 6 in. on center on both sides of the panel, or an approved equivalent fastener.

A second plate composed of 1-1/8 in. minimum thickness dimensional or engineered lumber with a specific gravity of 0.42 that is cut to the full thickness of the panel shall be secured to the first top plate using 0.131 in. x 3 in. nails or an approved equivalent fastener.

**6.4. Cutting and Notching.** No field cutting or routing of the panels shall be permitted except as shown on approved drawings. <sup>(IM 014 NACU6)</sup>

**6.5. Protection from Decay.** SIPs that rest on exterior foundation walls shall not be located within 8 in. of exposed earth. SIPs supported by concrete or masonry that is in direct contact with earth shall be protected from the concrete or masonry by a moisture barrier. <sup>(IM 014 ACU6)</sup>

**6.6. Protection from Termites.** In areas subject to damage from termites, SIPs shall be protected from termites using an approved method. Panels shall not be installed below grade or in contact with earth. <sup>(IM 014 ACU7)</sup>

**6.7. Heat-Producing Fixtures.** Heat-producing fixtures shall not be installed in the panels unless protected by a method approved by the code official or documented in test reports. This limitation shall not be interpreted to prohibit heat-producing elements with suitable protection. <sup>(IM 014 NACU9)</sup>

**6.8. Voids and Holes**

**6.8.1 Voids in Core.** In lieu of openings designed in accordance with section 5.7, the following voids are permitted. Voids may be provided in the panel core during fabrication at predetermined locations only. Voids parallel to the panel span shall be limited to a single 1 in. maximum diameter hole. Such voids shall be spaced a minimum of 4 ft. on center measured perpendicular to the panel span. Two 1/2 in. diameter holes may be substituted for the single 1 in. hole provided they are maintained parallel and within 2 in. of each other. <sup>(IM 014 ACU11)</sup>

Voids perpendicular to the panel span shall be limited to a single 1 in. maximum diameter hole placed not closer than 16 in. from the support. Additional voids in the same direction shall be spaced not less than 28 in. on center.

**6.8.2 Holes in Panels.** Holes may be placed in panels during fabrication at predetermined locations only. Holes shall be limited to 4 in. x 4 in. square. The minimum distance between holes shall not be less than 4 ft. on center measured perpendicular to the panel span and 24 in. on center measured parallel to the panel span. Not more than three holes shall be permitted in a single line parallel to the panel span. The holes may intersect voids permitted elsewhere in this report. <sup>(IM 014 ACU15)</sup>

**6.9. Panel Cladding**

**6.9.1 Roof Covering.** The roof covering, underlayment and flashing shall comply with the applicable code(s). All roofing materials must be installed in accordance with the manufacturer's installation instructions. The use of roof coverings requiring the application of heat during installation shall be reviewed and approved by a registered design professional.

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**6.9.2 Exterior Wall Covering.** Panels shall be covered on the exterior by a water-resistive barrier as required by the applicable code. The water-resistive barrier shall be attached with flashing in such a manner as to provide a continuous water-resistive barrier behind the exterior wall veneer. <sup>(IM 014 ACU9)</sup> The exterior facing of the SIP wall shall be covered with weather protection as required by the adopted building code or other approved materials. <sup>(IM 014 ACU10)</sup>

**6.9.3 Interior Finish.** The SIP foam plastic core shall be separated from the interior of the building by an approved thermal barrier of 1/2 in. gypsum wallboard or equivalent thermal barrier where required by 2009 IBC Section 2603.4.

**7. CONDITIONS OF USE**

*Structural Insulated Panels* as described in this report comply with the codes listed in Section 2.0, subject to the following conditions:

- 7.1. Installation complies with this report and the approved construction documents.
- 7.2. This report applies only to the panel thicknesses specifically listed herein. <sup>(IM 014 ACU3)</sup>
- 7.3. In-use panel heights/spans shall not exceed the values listed herein. Extrapolation beyond the values listed herein is not permitted. <sup>(IM 014 ACU2)</sup>
- 7.4. The panels are manufactured in the production facilities noted in this report. <sup>(IM 014 NACU8)</sup>

**8. EVIDENCE SUBMITTED**

NTA, Inc. has examined the following evidence to evaluate this product:

- 8.1. Review of each manufacturing facility's quality system documentation for conformance to NTA IM 036.
- 8.2. Qualification test data in accordance with NTA IM 14 *Standard Evaluation Plan 01* (IM 014 SEP 01).
- 8.3. Periodic quality system audits of the production facilities.
- 8.4. Periodic testing in accordance with NTA IM 014.

Evaluation evidence and data are on file with NTA, Inc. NTA, Inc. is accredited by the International Accreditation Service (IAS) as follows:

*ISO17020 Inspection Agency (AA-682)*  
*ISO17025 Testing Laboratory (TL-259)*  
*ISO Guide 65 Product Certification Agency (PCA-102)*

The scope of accreditation related to testing, inspection or product certification pertain only to the test methods and/or standard referenced therein. Design parameters and the application of building code requirements, such as special inspection, have not been reviewed by IAS and are not covered in the accreditation. Product evaluations are performed under the direct supervision of Professional Engineers licensed in all jurisdictions within the United States as required by the building code and state engineering board rules.

**9. FINDINGS**

**All products referenced herein are manufactured under an in-plant quality assurance program to insure that the production quality meets or exceeds the requirements of the codes noted herein and the criteria as established by NTA, Inc. Furthermore, panels must comply with the conditions of this report.**

*This report is subject to annual renewal.*

**10. IDENTIFICATION**

Each eligible panel shall be permanently marked to provide the following information:

- a) The NTA, Inc. listing mark, shown below
- b) NTA's Listing No. SIPA120908-10
- c) In-plant quality assurance stamp
- d) Identifier for production facility
- e) Project or batch number.



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**Table 1: Basic Properties<sup>1,2</sup>**

Property	Weak-Axis Bending	Strong-Axis Bending
Allowable Tensile Stress, $F_t$ (psi)	245	495
Allowable Compressive Stress, $F_c$ (psi)	340	580
Elastic Modulus (Bending), $E_b$ (psi)	738900	658800
Shear Modulus, $G$ (psi)	270	405
Allowable Core Shear Stress, $F_v$ (psi)	4.5	5.0
Core Compressive Modulus, $E_c$ (psi)	360	360
Reference Depth, $h_o$ (in.)	4.625	4.625
Shear Depth Factor Exponent, $m$	0.84	0.86

<sup>1</sup> All properties are based on a minimum panel width of 24 in.  
<sup>2</sup> Refer to NTA IM14 TIP 01 SIP Design Guide for details on engineered design using basic panel properties.

**Table 2: Section Properties**

Panel Thickness, $h$ (in.)	Core Thickness, $c$ (in.)	Dead Weight, $w_d$ (psf)	Facing Area, $A_f$ (in. <sup>2</sup> /ft)	Shear Area, $A_v$ (in. <sup>2</sup> /ft)	Moment of Inertia, $I$ (in. <sup>4</sup> /ft)	Section Modulus, $S$ (in. <sup>3</sup> /ft)	Radius of Gyration, $r$ (in.)	Centroid-to-Facing Dist., $y_c$ (in.)
4.625	3.75	3.2	10.5	50.3	46.0	19.9	2.09	2.31
6.50	5.625	3.3	10.5	72.8	96.5	29.7	3.03	3.25
8.25	7.375	3.5	10.5	93.8	160.2	38.8	3.91	4.13
10.25	9.375	3.6	10.5	117.8	252.7	49.3	--	--
12.25	11.375	3.8	10.5	141.8	366.3	59.8	--	--



**Figure 1: SIP Spline Types**

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**Table 3: Allowable Uniform Transverse Loads<sup>1,4</sup>**

Panel Length (ft)	4-5/8 inch Thick SIP			6-1/2 inch Thick SIP		
	Deflection Limit <sup>2</sup>			Deflection Limit <sup>2</sup>		
	L/180	L/240	L/360	L/180	L/240	L/360
8 WAB <sup>3</sup>	50.8	40.9	27.3	73.8	64.7	43.1
8	68.8	51.6	34.4	80.6	80.6	56.6
10	45.1	33.8	22.5	62.0	57.9	38.6
12	30.8	23.1	15.4	50.4	40.9	27.3
14	21.7	16.3	--	39.6	29.7	19.8
16	--	--	--	29.4	22.1	14.7
18	--	--	--	22.4	16.8	--

See Table 4 for notes.

**Table 4: Allowable Uniform Transverse Loads (continued)<sup>1,4</sup>**

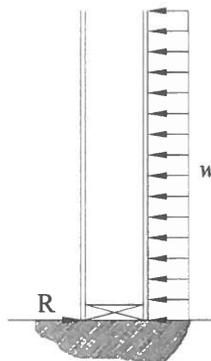
Panel Length (ft)	8-1/4 inch Thick SIP			10-1/4 inch Thick SIP			12-1/4 inch Thick SIP		
	Deflection Limit <sup>2</sup>			Deflection Limit <sup>2</sup>			Deflection Limit <sup>2</sup>		
	L/180	L/240	L/360	L/180	L/240	L/360	L/180	L/240	L/360
8 WAB <sup>3</sup>	81.4	81.4	58.3	89.9	89.9	75.9	98.6	98.6	93.6
8	88.5	88.5	78.4	97.3	97.3	97.3	106.4	106.4	106.4
10	67.4	67.4	54.8	73.1	73.1	73.1	78.8	78.8	78.8
12	54.4	54.4	39.6	58.6	58.6	54.6	62.5	62.5	62.5
14	45.6	43.9	29.3	48.8	48.8	41.1	51.9	51.9	51.9
16	39.3	33.2	22.1	41.9	41.9	31.5	44.3	44.3	41.7
18	34.1	25.6	17.1	36.7	36.7	24.6	38.7	38.7	32.9
20	26.7	20.0	13.4	32.6	29.2	19.5	34.3	34.3	26.3

Table values assume a simply supported panel with 1.5 in. of continuous bearing on facing at supports ( $C_v = 1.0$ ) with solid wood plates at bearing locations. Values do not include the dead weight of the panel. For wall panel capacities utilizing a zero bearing configuration, shown in Figure 2, multiply the allowable uniform load shown by  $C_v = 0.4$ .

<sup>2</sup> Deflection limit shall be selected by building designer based on the serviceability requirements of the structure and the requirements of adopted building code. Values are based on loads of short duration only and do not consider the effects of creep.

<sup>3</sup> Tabulated values are based on the strong-axis of the facing material oriented parallel to the direction of panel bending. WAB indicates weak-axis bending of the facing material; the strong-axis of the facing material is oriented perpendicular to the direction of panel bending.

<sup>4</sup> Permanent loads, such as dead load, shall not exceed 0.50 times the tabulated load.



**Figure 2: Zero Bearing Support**

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**Table 5: Allowable Axial Loads (plf)<sup>1,2,3,4</sup>**

Lateral Brace Spacing (ft)	Panel Thickness		
	4-5/8 inch	6-1/2 inch	8-1/4 inch
8 WAB <sup>5</sup>	2320	2470	2530
8	3630	4070	4240
10	3260	3890	4130
12	2810	3660	4000
14	--	3390	3830
16	--	3090	3640
18	--	2790	3430
20	--	--	3190

1. Permanent loads, such as dead load, shall not exceed 0.50 times the tabulated load.
2. All values are for normal duration and may not be increased for other durations.
3. Axial loads shall be applied concentrically to the top of the panel through repetitive members spaced not more than 24 in. on center. Such members shall be fastened to a rim board or similar member to distribute along the top of the SIP.
4. The ends of both facings must bear on the supporting foundation or structure to achieve the tabulated axial loads.
5. Tabulated values are based on the strong-axis of the facing material oriented parallel to the direction of panel bending. WAB indicates weak-axis bending of the facing material; the strong-axis of the facing material is oriented perpendicular to the direction of panel bending.

**Table 6: Allowable In-Plane Shear Strength (Pounds per Foot) for SIP Shear Walls (Wind and Seismic Loads in Seismic Design Categories A, B and C)<sup>1,3</sup>**

Spline Type <sup>4</sup>	Nominal SIP Thickness (in.)	Minimum Facing Connections <sup>3,5</sup>			Shear Strength (plf)
		Chord <sup>3</sup>	Plate <sup>3</sup>	Spline <sup>4</sup>	
Block or Surface Spline	4.625	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	380
	6.625	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	380
	8.375	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	0.131"x 2-1/2" nails, 6" oc	400

See Table 7 for notes.

**Table 7: Allowable In-Plane Shear Strength (Pounds per Foot) for SIP Shear Walls (Wind and Seismic Loads in Seismic Design Categories D, E and F)<sup>2,3</sup>**

Spline Type <sup>4</sup>	Nominal SIP Thickness (in.)	Minimum Facing Connections <sup>3,5</sup>			Shear Strength (plf)
		Chord <sup>3</sup>	Plate <sup>3</sup>	Spline <sup>4</sup>	
Block or Surface Spline	6.5	0.131"x 2-1/2" nails, 3" oc (3/8" edge distance)	0.131"x 2-1/2" nails, 3" oc (3/8" edge distance)	0.131"x 2-1/2" nails, 3" oc (23/32" thick, 3" wide spline)	900

- <sup>1</sup> Maximum shear wall dimensions ratio shall not exceed 2:1 (height: width) for resisting wind or seismic loads.
- <sup>2</sup> Maximum shear wall dimension ratio shall not exceed 1:1 (height: width) for resisting wind or seismic loads.
- <sup>3</sup> Chords, hold downs and connections to other structural elements must be designed by a registered design professional in accordance with accepted engineering practice.
- <sup>4</sup> Spline type at interior panel-to-panel joints only. Solid chord members are required at each end of each shear wall segment.
- <sup>5</sup> Required connections must be made on each side of the panel. Dimensional or engineered lumber shall have an equivalent specific gravity of 0.42 or greater.

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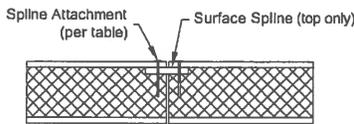
**Table 8: Allowable In-Plane Shear Strength (Pounds per Foot) for Horizontal Diaphragms Subjected to Wind or Seismic Loading**

Nominal SIP Thickness (in.)	Minimum Connections			Shear Strength (plf)	Max. Aspect Ratio
	Block Spline <sup>1</sup> (Figure 3a)	Boundary <sup>2</sup> (Figure 3b)			
		Support	Spline		
8.25	0.131" x 2-1/2" nails, 6" oc 7/16" x 3" x 7-3/8" OSB Surface Spline	10" Length, 0.190" shank diameter, 0.255" thread o.d., 2.750" thread length 0.625" head diameter SIP Screw 6" oc	0.131" x 2-1/2" nails, 6" oc	265	3:1
	0.131" x 2-1/2" nails, 4" oc 7/16" x 3" x 7-3/8" OSB Surface Spline	10" Length, 0.190" shank diameter, 0.255" thread o.d., 2.750" thread length 0.625" head diameter SIP Screw 4" oc	0.131" x 2-1/2" nails, 4" oc	330	3:1
	0.131" x 2-1/2" nails, 2" oc staggered 3/8" (Figure 3c) 7/16" x 3" x 7-3/8" OSB Surface Spline	10" Length, 0.190" shank diameter, 0.255" thread o.d., 2.750" thread length 0.625" head diameter SIP Screw 3" oc	0.131" x 2-1/2" nails, 2" oc staggered 3/8" (Figure 3c)	575	3:1

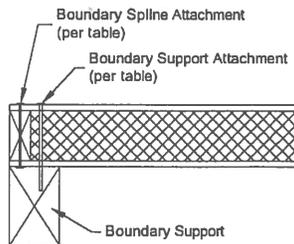
<sup>1</sup>Top spline or block spline only at interior panel-to-panel joints. Specified fasteners are required on both sides of panel joint through the top surface only, as shown in Figure 3a.

<sup>2</sup>Boundary spline shall be solid lumber 1.5 in. wide minimum and have a specific gravity of 0.42 or greater. Specified fasteners are required through both facings as shown in Figure 3b.

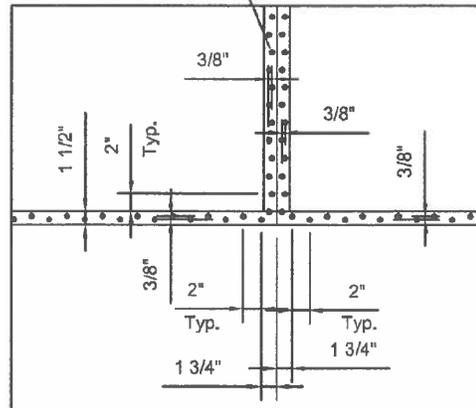
0.131" x 2 1/2" Nails, 2" O.C. (Staggered 3/8"), Fasteners Applied to Both Sides at SPF Members and Only One Side (the Side Opposite of Load Application) at All Block Splines



**Figure 3a: Surface Spline**



**Figure 3b: Boundary**



**Figure 3c: Boundary Spline**

**Figure 3: Diaphragm Connection Types**

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**Table 9: Component Material Sources**

Facing	Core	Adhesive
Ainsworth Group of Companies Suite 3194 Bentall 4 1055 Dunsmuir Street Vancouver BC, Canada V7X 1L3	ACH Corporation Plant U-37 - Fond du Lac, WI	Ashland Specialty Chemical Company 5200 Blazer Parkway Dublin, OH 43017
Georgia-Pacific 9918 Buford Bridge Road Fairfax, SC 29827	Atlas EPS, A Division of Atlas Roofing Corporation 8240 Byron Center Road SW Byron Center, MI 49315	Foam Supplies, Inc. 4387 N. Rider Trail Earth City, MO 63045
Huber Engineered Woods 1000 Chaney Lane Crystal Hill, VA 24539	Iowa EPS Products, Inc. 5554 N.E. 16 <sup>th</sup> Street Des Moines, IA 50313	Rohm and Haas Company 5005 Barnard Mill Road Ringwood, IL 60072
Louisiana-Pacific Corporation Sagola, MI  Sales and Marketing by: Affiliated Resources, Inc. River Forum 1 4380 SW Macadam Avenue, Suite 200 Portland, OR 97239	Northwest Foam Products, Inc. 2390 Rostron Circle Twin Falls, ID 83301	
Tolko Industries, Ltd. 3203 30 <sup>th</sup> Avenue Vernon BC, Canada V1T 6M1	OPCO, Inc. P.O. Box 101 Latrobe, PA 15650	
	Plymouth Foam 1 Southern Gateway Drive Gnadenhutten, OH 44629	
	Polar Industries, Inc. 32 Gramar Avenue Prospect, CT 06712	
	Powerfoam Insulation 550 Murray Street/Highway 287 Midlothian, TX 76065	

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**E. SUMMARY OF TENK SOLAR WIND TUNNEL FORCE COEFFICIENTS**

## Summary of tenKsolar wind tunnel force coefficients

Lowell Berg, 5/3/2012

### **Summary**

Structural loading from wind is governed by applicable standards, but all are based on the same basic physics. Wind tunnel testing may be used for photovoltaic arrays to measure wind force coefficients. The measured wind force coefficients are much smaller than what one would get from assuming the array is a standard building. The resulting smaller estimated wind forces put significantly less wind force on the supporting building.

### **Background**

TenKsolar photovoltaic arrays are unique in their ability to gather more energy from the sun than what falls directly on the photovoltaic module. The reflector directs additional light onto the photovoltaic module. The result is that more solar radiation is converted to electricity than without the reflector.

The reflector also serves to “close” the array so the south end (all references here are for the northern hemisphere) with a photovoltaic module on it and the north end have approximately the same wind profile. The resulting unique “wave” structure has very good wind load characteristics compared to some of the approximation that can be made using standard wind load prediction tools.

### **Array Design Requirements**

In North America, ASCE 7 (*Minimum Design Loads for Buildings and Other Structures*, published by ASCE) specifies loads on structures, and Chapter 6 specifies how to estimate wind loads on typical structures. In Europe, Eurocode (*Eurocode 1: Actions on Structures – General Actions – Part 1-4: Wind Actions*) provides similar directions on estimating wind loads on structures. The two codes are very similar in intent and content. This should come as no surprise as neither the basic physics nor the wind recognizes geographic boundaries.

Both ASCE 7 and Eurocode provide for the use of wind tunnel testing for buildings or structures having unusual shapes. ASCE 7 specifies the characteristics the flow in the wind tunnel must meet to make valid measurements. Eurocode defers to the “appropriate Authority” but does specify that one must use appropriate models of the natural wind.

ASCE 7 specifies the wind conditions to use in all parts of the United States and its territories. Eurocode, provides a unified calculation procedure across all participating countries but defers to a “country annex” where country-specific parameters like design wind speed are documented.

In Romania, the appropriate authorities have published a document that specifies how to estimate wind loads. This document refers to best practices adopted from both ASCE 7 and Eurocode, and provides all the information for Romania that would be in a Eurocode country annex.

## Wind Tunnel Testing

TenKsolar sponsored wind tunnel testing of scale models of tenKsolar's roof-mounted arrays. Tests were conducted in the atmospheric boundary layer wind tunnel at the University of Minnesota's St. Anthony Falls Lab. Wind speeds and profiles were adjusted to match the conditions of turbulent flow in urban and suburban areas or other wooded areas (exposure B in ASCE 7, section 6.5.6.2, corresponding to 30% turbulence intensity). This high turbulence intensity is very difficult to achieve, so most of the data is for very low turbulence "smooth" flow and a multiplier is used on the data to account for the additional forces due to correlated and uncorrelated turbulence. The smooth flow forces are multiplied by 1.09 to account for the influence of turbulence. See Appendix 1 for more details.

For sharp-edged bodies (like photovoltaic modules or reflectors), the forces are proportional to the square of the wind speed. This was confirmed in the wind tunnel for scale models of tenKsolar arrays. This means we can use results at one wind tunnel speed to estimate forces at other speeds.

More importantly, this means we can use the results at one wind tunnel speed and accurately estimate the result on full-size structures at other speeds. In particular, we can use the same wind tunnel results in places with different basic wind speed requirements.

The wind tunnel measurements are forces. The scale models are one eighth the size of the real hardware, so the forces measured in the wind tunnel are multiplied by 64 to get estimates of the forces on the full-sized hardware. Further, the forces are then multiplied by 1.09 to account for the effect of turbulence.

In wind loading codes it is typical to estimate wind reference pressure

$$p_{ref} = \text{constant} * \text{Velocity}^2$$

The constant is usually half of the air density. The resulting pressure is known as the stagnation pressure. The reference pressure is multiplied by several factors to account for height, local topography, wind direction variability, and the function of the structure. This gives the design pressure

$$p_{design} = \text{factors} * p_{ref}$$

The forces on a structure come from the design pressure times the structure's area times a form factor,  $C$

$$Force = p_{design} * Area * C$$

Values of  $C$  are provided in the codes and depend on the structure used. Typical magnitudes are 0.2-1.0 and may be positive or negative.

In the wind tunnel, we measure the forces and calculate  $C$ . To calculate  $C$ , we need to define the characteristic area. The forces are measured on a combined photovoltaic module plus its associated reflector. This structure resembles a house roof. We do not have forces in individual photovoltaic modules and individual reflectors.

The characteristic area we will use is the width (east-to-west) of the photovoltaic module times the total length of the glass (north-to-south, or up-and-down the array waves).

Glass and reflector east-to-west, 49.198 in

Glass up-down 38.677 in

Reflector up-down 50.236 in

Glass plus reflector up-down  $38.677 + 50.236 = 88.913$  in

$$Area = 49.198 * 88.913 = 4374 \text{ in}^2 = 30.38 \text{ ft}^2$$

The shape factor is

$$C = \frac{F}{p_{design} * A}$$

All the details of the wind tunnel testing, including worst case wind forces are provided in a separate document. Worst case wind approaches the array from the corners with about equal forces from southeast, northeast, southwest, or northwest for an array with photovoltaic modules aimed directly south.

### Wind Tunnel Test Results

The forces for the 180-190W module system (known internally as Neptune), after scaling to 90 mph, scaling to full module size, and multiplying by 1.09 to account for turbulence, are (from the document “Scaling Wind Tunnel Results from Jupiter to Neptune 2-0.pdf”)

	Drag (lb)			
	West			East
North	12.1	41.7	85.9	121.1
	20.6	46.7	84.8	131.2
	10.6	35.3	86.8	142.5
South	117.6	123.4	134.8	209.4

		Cross (lb)			
		West		East	
North		0.0	11.8	47.4	104.8
		0.0	8.9	50.0	105.2
		0.0	4.6	45.9	105.4
South		49.5	64.0	82.7	167.9

		Lift (lb)			
		West		East	
North		12.3	44.3	147.8	317.0
		31.8	61.6	118.3	309.7
		28.0	70.0	135.1	309.1
South		20.5	79.6	185.9	294.2

If we divide these values by the area computed above, 30.38 ft<sup>2</sup>, and divide by a reference pressure of

$$p_{ref} = 0.00256 * (90mph)^2 = 20.74 \frac{lb}{ft^2}$$

we get the force coefficients. The reference pressure comes from ASCE 7-05, eq. (6-15), where the constant 0.00256 is approximately half the density of air in the appropriate units. The resulting force coefficients are

		Drag			
		West		East	
North		0.02	0.07	0.14	0.19
		0.03	0.07	0.13	0.21
		0.02	0.06	0.14	0.23
South		0.19	0.20	0.21	0.33

		Cross			
		West		East	
North		0.00	0.02	0.08	0.17
		0.00	0.01	0.08	0.17
		0.00	0.01	0.07	0.17
South		0.08	0.10	0.13	0.27

		Lift			
		West		East	
North		0.02	0.07	0.23	0.50
		0.05	0.10	0.19	0.49

	0.04	0.11	0.21	0.49
South	0.03	0.13	0.30	0.47

There are several important things to note about these values.

- The largest coefficients are generally in the bottom right corner. The wind blows from bottom right to top left (a wind from the southeast to the northwest is a southeast wind).
- As one moves from east to west, the coefficients decrease in size.
- As one moves from south to north, some of the coefficients decrease while others don't change much.

It is interesting to compare these coefficients with those for other structures. For a closed building with a simple two-plane, sloped roof, the coefficients are -1.0 (downwind, forces away from roof) and +0.9 (upwind, forces toward roof). (These are from ASCE 7-05, Figure 6-11D for 27-45 deg roof. Similar results can be found in Eurocode, -0.8 to +0.6 for 45 deg roofs.) For the array, the net force is upward (positive lift), but the worst case coefficient is about 0.5 and the coefficient reduce to 0.02 toward the middle of the array.

This means that one will predict significantly larger forces if one assumes the array is a closely packed group of "houses". Further, large forces will be predicted if one does not account for the variation of force through the array.

This demonstrates the intent of both Eurocode and ASCE 7 (as well as derivative documents) in allowing wind tunnel data to estimate force coefficients.

Because all the photovoltaic modules and reflectors are structurally coupled together through the rails, forces can be transmitted through the array. It is not necessary to react to all the wind force at a single photovoltaic module. Instead, one can usually ballast or tie down corners of small arrays and use occasional tie downs on the edges of larger arrays.

The middle of large arrays has very small wind forces that can easily be reacted with friction forces.

## Summary

Structural loading from wind is governed by applicable standards, but all are based on the same basic physics. Wind tunnel testing may be used for photovoltaic arrays to measure wind force coefficients. The measured wind force coefficients are much smaller than what one would get from assuming the array is a standard building. The resulting smaller estimated wind forces put significantly less wind force on the supporting building.

## Appendix 1: Including the effects of turbulence on forces

The simplest way to incorporate the effects of turbulence is to recognize that the wind force is proportional to the square of the free stream velocity.

$$F \propto u^2 = (U + \bar{u})^2$$

Here, we have introduced the Reynolds decomposition. The first term in parentheses is the long-term mean wind speed. The second term is the variable wind speed (which is the wind speed minus the long-term mean speed). This is the instantaneous force. The long-term average force is most useful.

$$\begin{aligned} F_{average} &\propto \left\{ (U + \bar{u})^2 \right\}_{average} = \left\{ U^2 + 2U\bar{u} + \bar{u}^2 \right\}_{average} = \left\{ U^2 \right\}_{average} + \left\{ 2U\bar{u} \right\}_{average} + \left\{ \bar{u}^2 \right\}_{average} \\ &= U^2 + \left\{ \bar{u}^2 \right\}_{average} \end{aligned}$$

The terms in brackets are individual vector components. The average of the variable wind speed is necessarily zero, so the mixed product term vanishes. If we introduce the turbulence intensity, we have

$$F_{average} \propto U^2 + \left\{ \bar{u}^2 \right\}_{average} = U^2 \left( 1 + \left\{ \frac{\bar{u}^2}{U^2} \right\}_{average} \right) = U^2 (1 + \text{turbulence intensity})$$

For exposure B, the turbulence intensity is 30%

$$F_{average} \propto U^2 (1 + \text{turbulence intensity}) = U^2 (1 + (0.3)^2) = 1.09U^2$$

The force due to smooth flow is proportional to the square of the average speed,

$$F_{smooth} \propto U^2$$

With this, we can estimate the average force on the structure for turbulent flow

$$F_{average} = 1.09F_{smooth}$$

This is the simplest possible way of incorporating the effect of the turbulence. A better approach is perhaps to use the methodology of Wieringa where he attempts to account for the correlation of forces due to finite wind eddy size relative to finite array size. See “Gust Factors over Open Water and Built-up Country”, J. Wieringa, *Boundary Layer Meteorology* **3** (1973), pp. 424-441. For a typical tenKsolar array, the gust factor (a force multiplier) accounting for turbulence using the Wieringa approach is about 1.2 for a 40 kW array. However, ASCE 7 recommends using a gust factor (a force multiplier) of 0.85 on turbulent flow forces.

The question of how to properly account for gusty flow is one of active research. I am not an expert in this area and am following the guidelines of wind engineers at CPP in Boulder

Colorado. I have been using ASCE 7-05. I understand that a newer version of ASCE 7 may account for gustiness more like Wierings suggests.

What does this mean? My multiplier is 1.09. Wieringa's approach would suggest 1.2 for a 40 kW array, <1.1 for a much larger array, and 1.5 for a 5kW array. It would seem this is the level of uncertainty typical in wind engineering, and is not really surprising given that in all wind loading codes, force coefficients are only given to one decimal place.

I would use the 1.09 multiplier on smooth flow results and a healthy factor of safety of 1.5 on wind loads.

The wind speed variability adds even more complexity. If one measures the instantaneous wind speed, one can develop a histogram of speeds and assign a probability that the wind speed is above a certain speed. Further, one can estimate the time the wind speed is above that speed. The approach taken in ASCE 7 is to use the 3 second wind burst as the basic design wind speed. For much of the United States, the design requirement is a 3 second wind burst at 40 m/s. This is equivalent (using the appropriate wind speed probability curve, the so-called Durst curve) to a 3600 second "burst" at about 27 m/s. Clearly using steady state smooth flow wind speeds corresponding to 40 m/s is conservative, and erases any distinction between the multiplier 1.09 and some other approximation for turbulence.

Wind engineering is a complex business and is an area of active academic and commercial research.

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**F. SCALING WIND TUNNEL RESULTS FROM JUPITER TO NEPTUNE**

## Scaling Wind Tunnel Results from Jupiter to Neptune

Lowell Berg, 6-4-2011

### Summary

tenKsolar is releasing a new PV solar panel. It will still be mounted in the same “wave” array configuration. The new panel is slightly larger than the old panel in the direction “up-and-down” the slope as mounted in the array. It is significantly wider east-to-west as mounted in the array. There is also a new reflector that is mated to the new panel. The panel and reflector angles (from the horizontal, and relative to one another) remain unchanged. The existing format is called Jupiter; the new format is Neptune. Both of these are internal project names, not marketing names.

Here, we document the changes and propose a means to use the existing wind tunnel data to make wind loading assessments of the new format PV panel.

### Scaling Wind Tunnel Data

The wind tunnel data was taken on a 1:8 scale model of the Jupiter system. Forces are measured on the scale models of a PV panel and reflector pair. The forces as measured on the model are multiplied by  $8^2 = 64$  to arrive at estimated forces on full scale hardware.

Ideally, for perfect similarity, the wind tunnel would be run at tunnel speeds that are a factor of 8 higher than full scale speeds. This is not possible. In fact, the wind tunnel cannot be run at 90 mph – eight times lower than required for perfect similarity. Wind tunnel data does, however, confirm that the lift and drag coefficients are independent of Reynolds number over a reasonable speed range. This means the forces can be scaled up or down from in-tunnel values to on-roof values by the square of the speed ratio.

Finally, the wind tunnel force data is multiplied by a factor of  $1.09 = (1 + 0.3^2)$  to account for the incremental forces due to the difference in turbulence in the tunnel and the turbulence in the wind at suburban exposure conditions, 30% turbulence intensity.

The height of the Jupiter array, from the bottom of the roof rail to the apex of the panel frame extensions is 907.9 mm. The height to the same locations on the Neptune array is 929.9 mm. The ratio of these two lengths is 1.024 or 0.976.

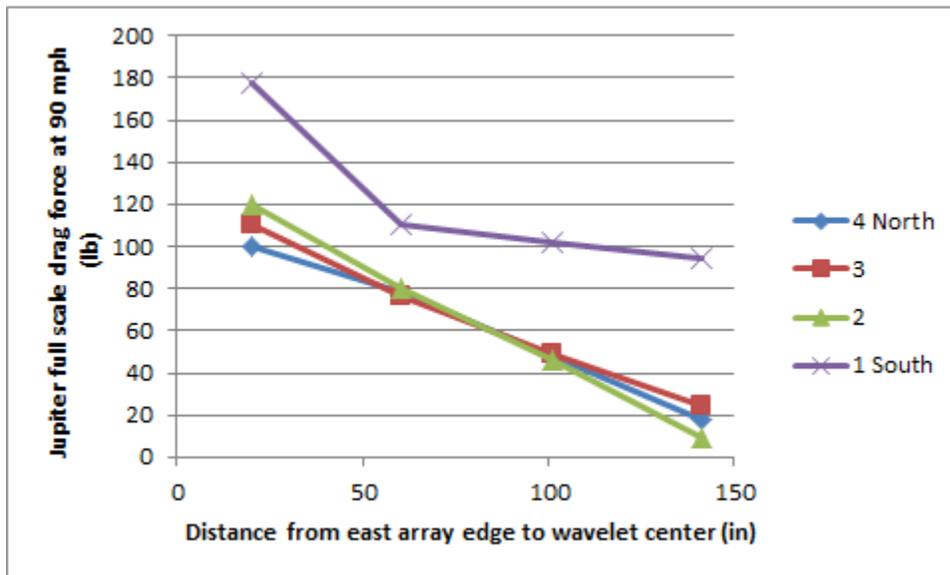
The Jupiter wind tunnel model was a one eighth scale model, scaling ratio 0.125. Based just on the array height, the scale factor for Neptune is a bit more than 1:8. The Neptune scale factor is  $0.125 * 0.976 = 0.122 = 1 / 8.197$ , or 1:8.197.

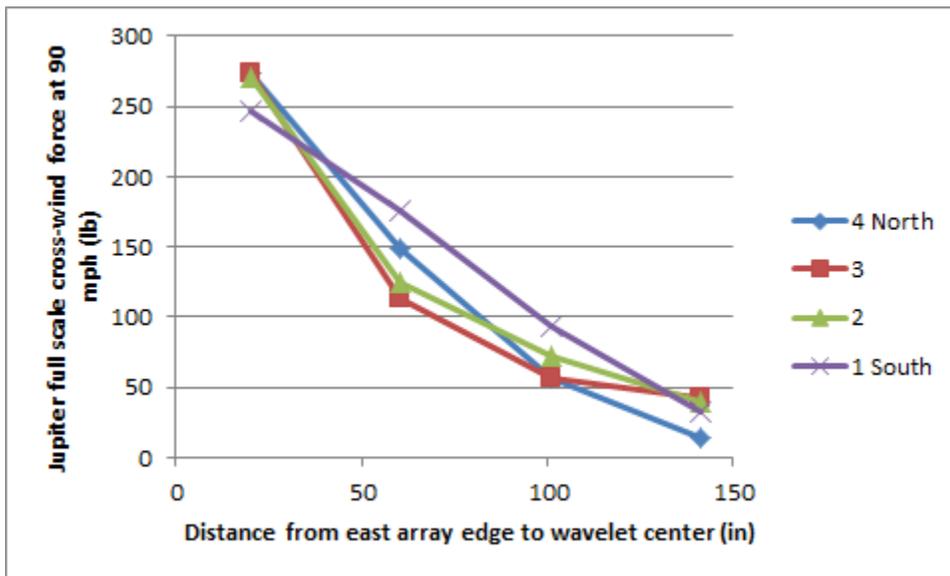
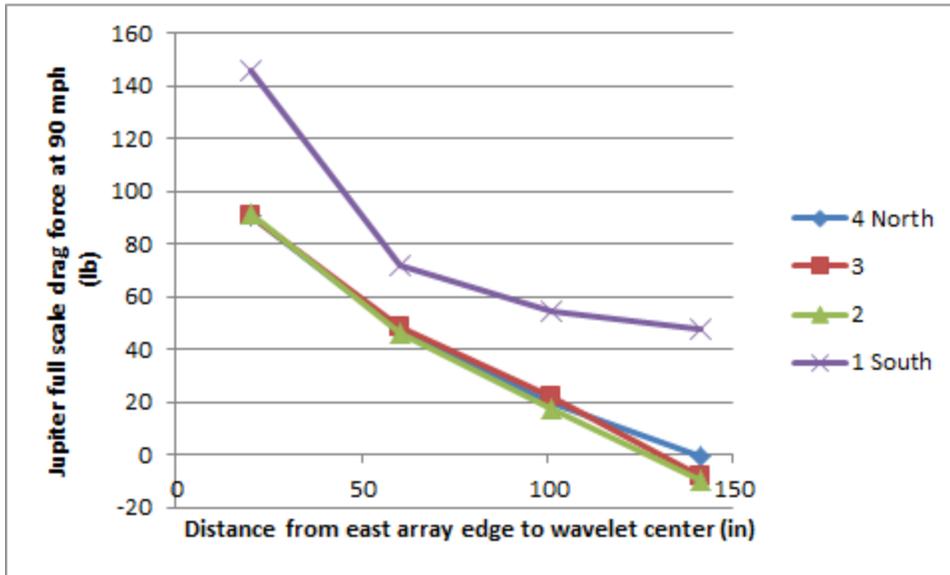
If the Neptune and Jupiter panel were scaled the same in both directions, we would be done. We could simply scale the Jupiter forces up by  $1.024^2 = 1.049$  and use the larger forces for each wavelet.

The Jupiter panel is installed at a 40.388” pitch east-to-west (40.075” for the panel, 0.313” for the fin). The Neptune panel is installed at a 49.510” pitch (49.197” for the panel, 0.313” for the fin). The ratio of these is 1.226 or 0.816, not quite the same as the ratio of the array heights. In what follows, we underpin a rational means of interpolating and extrapolating the Jupiter forces to the Neptune conditions.

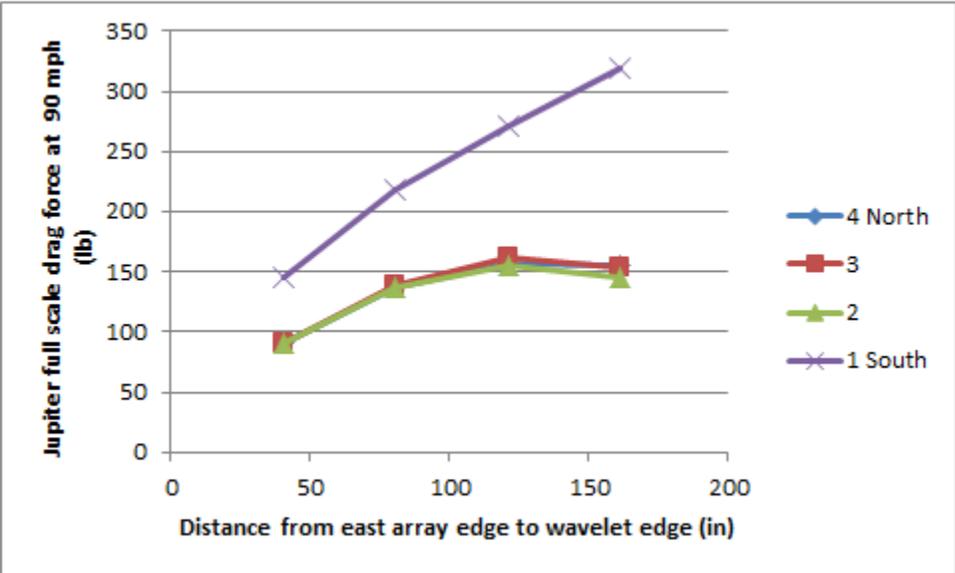
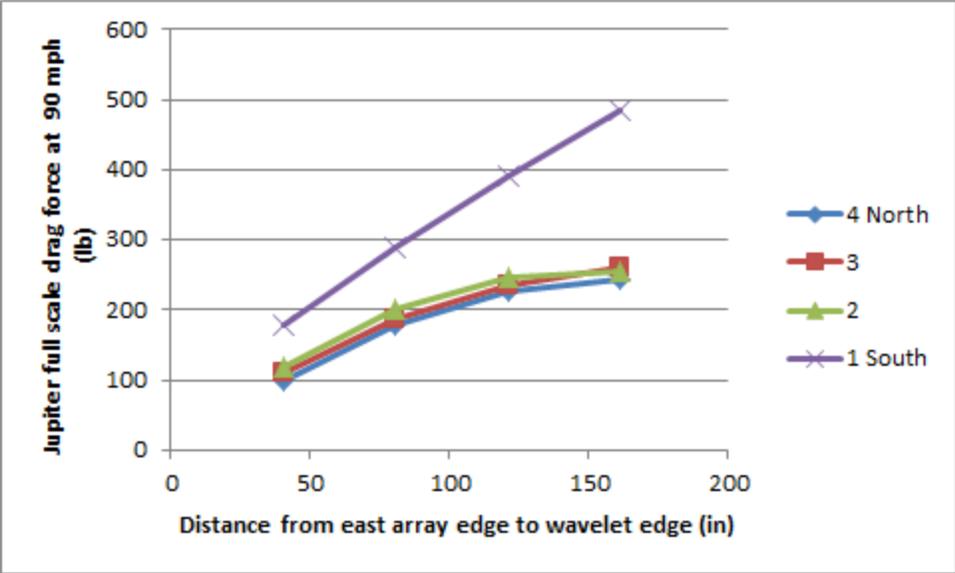
We proceed in two steps. First, we account for the larger width of the Neptune panel. Second, we account for the overall larger size of the array. All the data in what follows is for a southeast wind. As with Jupiter, it is expected that Neptune ballast design will be dominated by winds from southeast, southwest, northeast, or northwest. It is also expected that the worst case loading will result from either southeast or southwest winds. Due to symmetry, we need only consider one case, southeast.

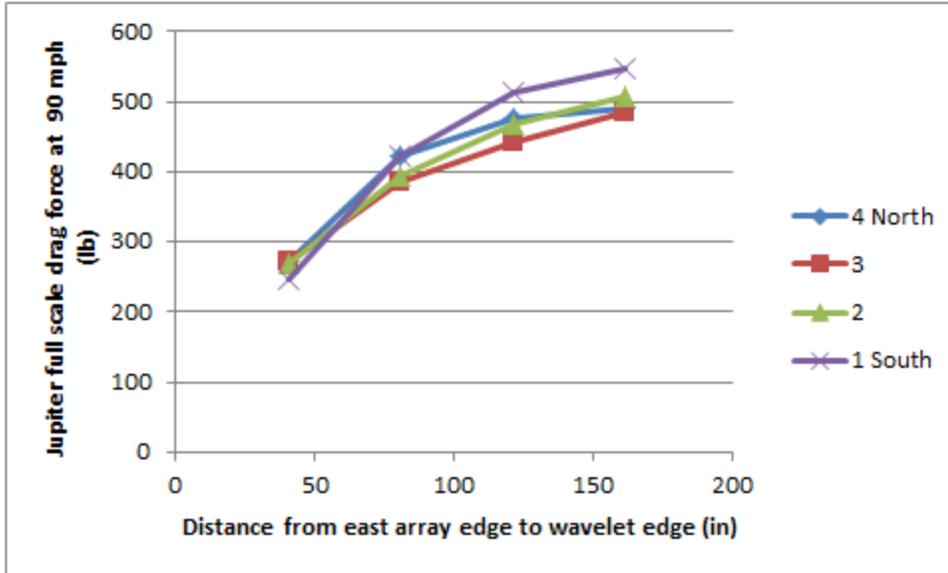
The forces on the Jupiter panel are for individual wavelets. These forces are plotted below – forces on actual full-sized Jupiter panels, scaled to 90 mph, and multiplied by 1.09 to account for the differences in forces for smooth flow and 30% TI flow). The three plots that follow show drag forces (along the wind in the plane of the roof), cross-wind forces (perpendicular to the wind in the plane of the roof), and lift forces (perpendicular to the roof). Each curve is for an east-west row in the array in a southeast wind with east to the right and west to the left on the horizontal axes.





Next, replot the same data, but make the horizontal axis be distance from the edge of the array to the edge of the wavelets, and make the vertical axis be the cumulative force to the edge of the wavelets. (If we knew the pressure and integrated pressure to get forces from the west edge of the array eastward into the interior of the, these plots would simply be discrete points plotted along the integrated pressure.)

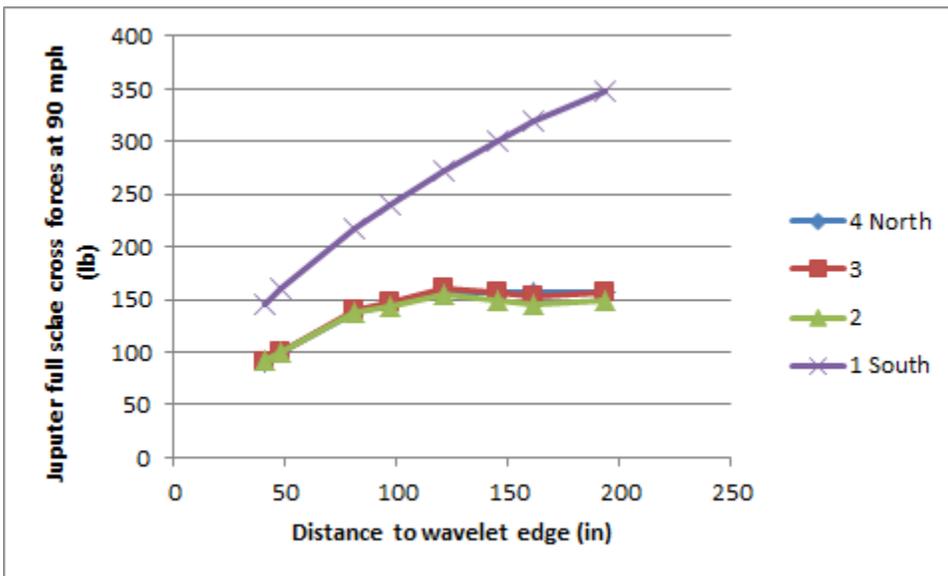
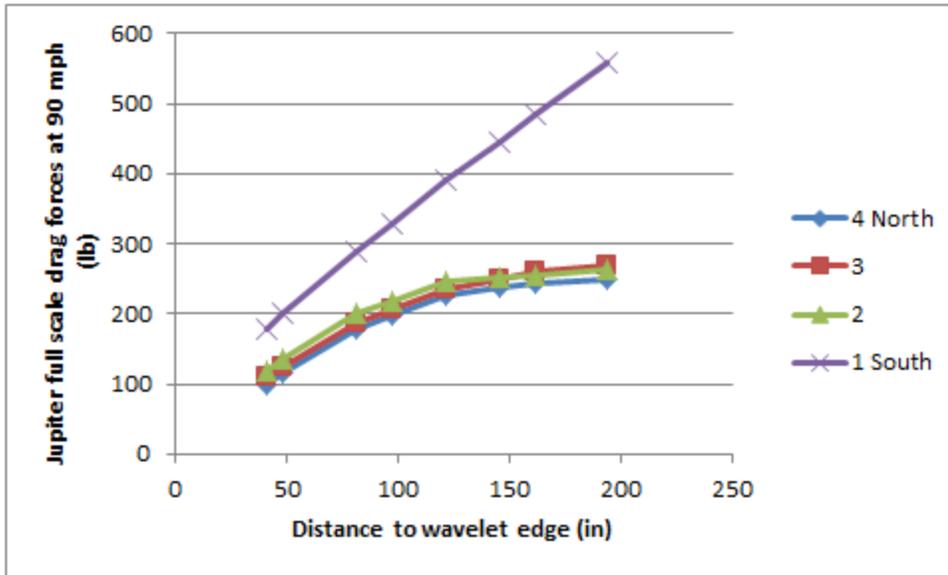


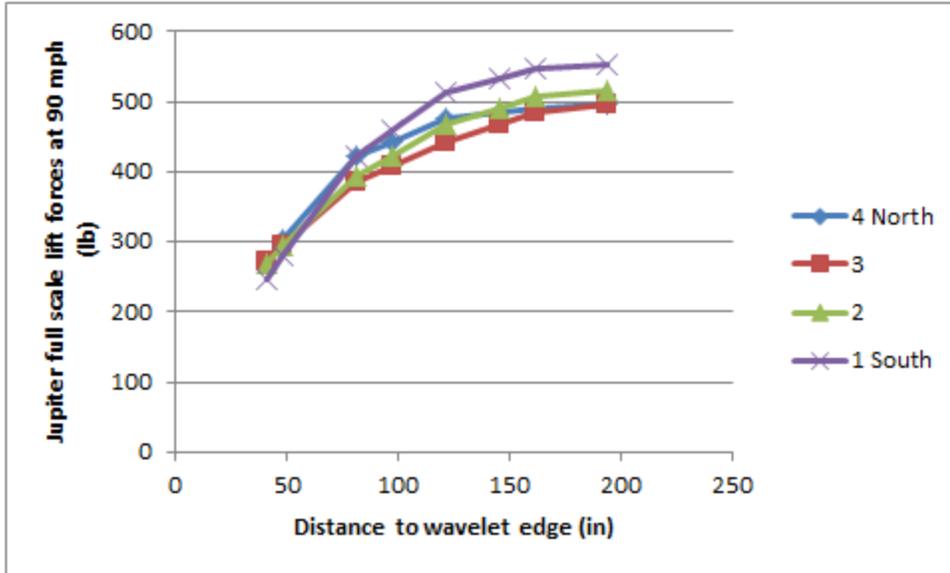


From these plots, we can easily extract the cumulative forces at the edge of our hypothetical Neptune array. The actual Neptune array has an east-west wavelet pitch of 49.510". This actual Neptune array is scaled up in both height and width from the Jupiter array by a factor of 1.024.

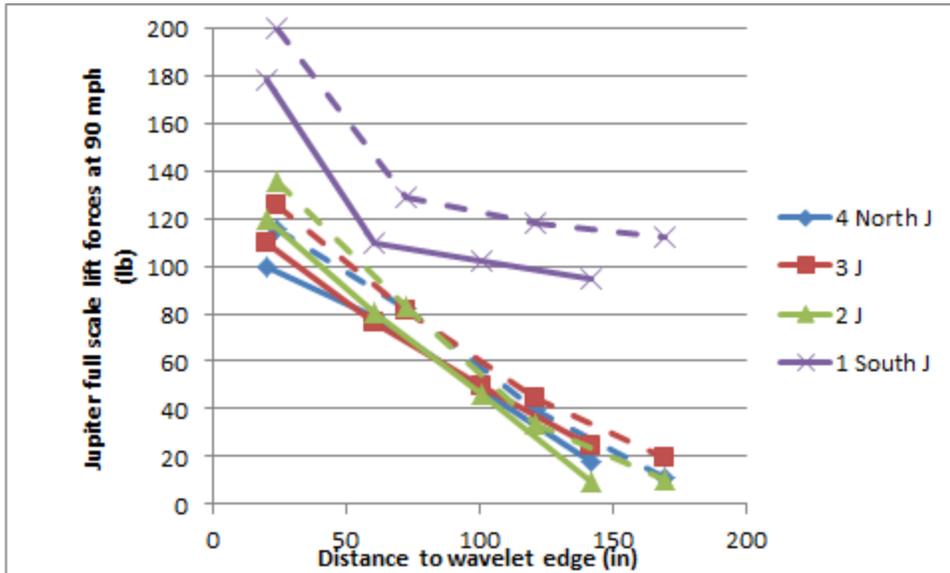
We will defer for a moment this overall scaling. We will take an intermediate step, and scale just the east-west width to a hypothetical intermediate array that has an east-west wavelet pitch of  $49.510/1.024 = 48.338$ ". The cumulative forces on our hypothetical array can be picked off the above cumulative force plots by selecting the force at integer multiples of 48.338". For the smallest three values of position, we simply interpolate the data. For the largest position, we perform a strict linear extrapolation, then a minor ad-hoc adjustment of the forces to account for the curvature of the actual cumulative force plots.

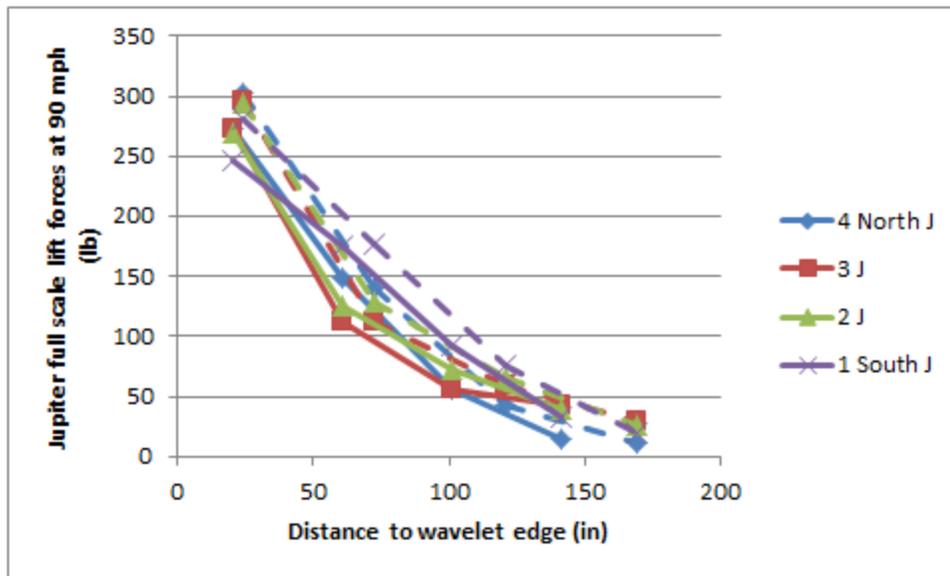
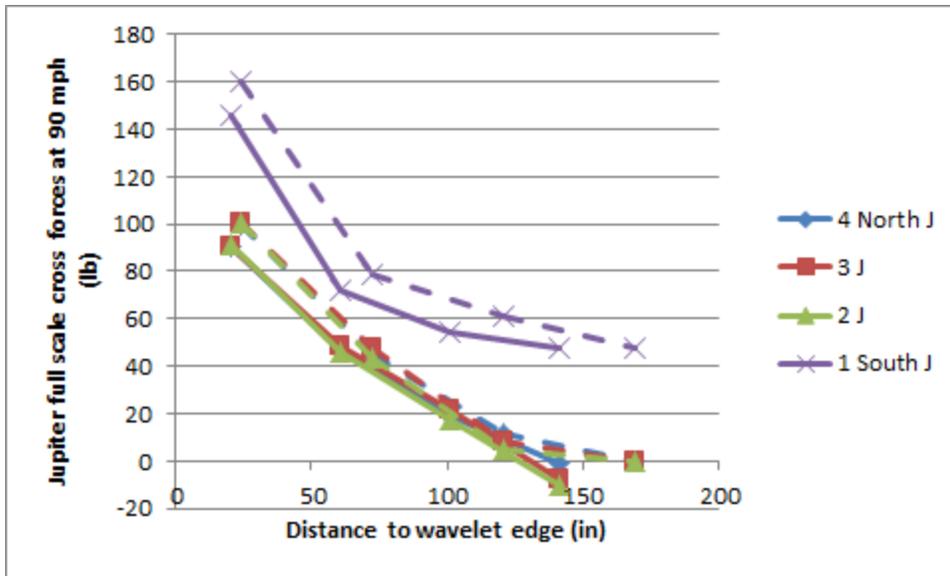
These points are shown on the following plots – identical to the three preceding plots but with added points at 48.338" wavelet spacing.





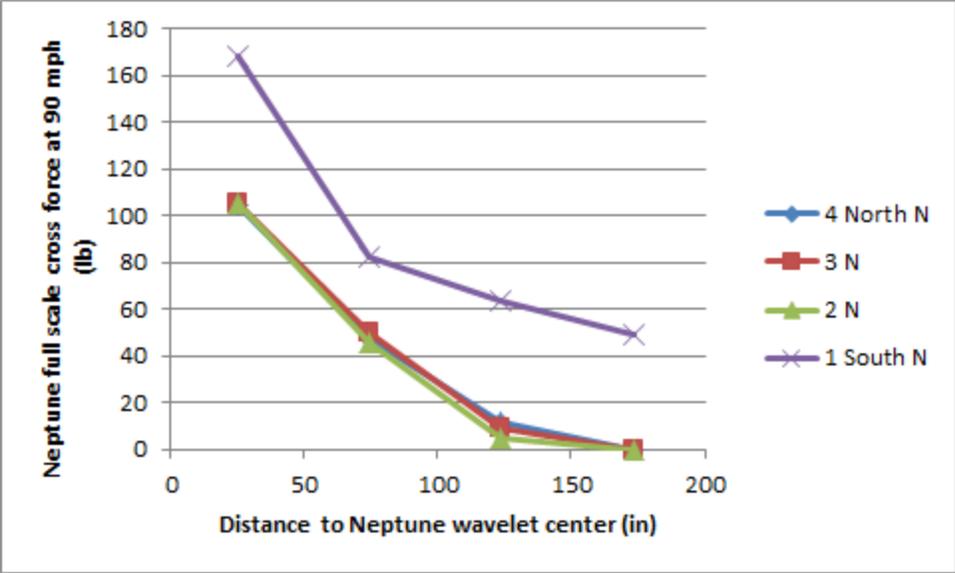
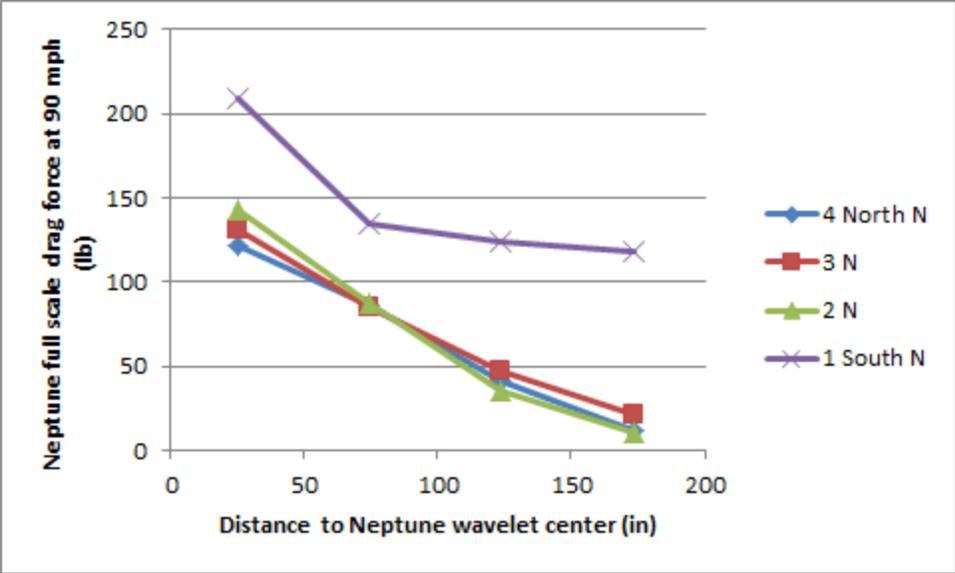
From the data on the above plots, it is now a simple matter of computing the force on each individual hypothetical wavelet by undoing the accumulation of forces. To be consistent with the initial plots, we also plot the points' horizontal position at the middle of the hypothetical wavelet.

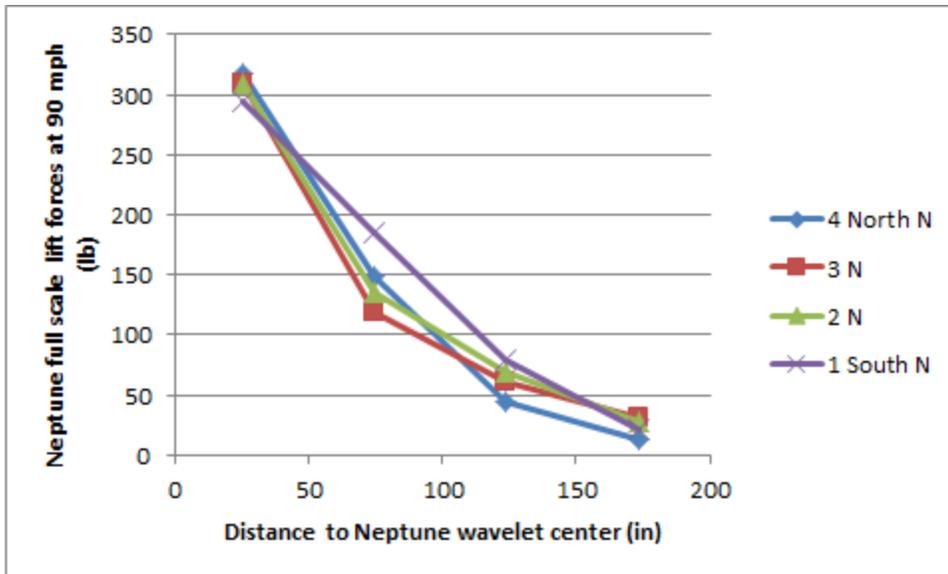




As might be expected, the forces on the hypothetical wider Jupiter panel are uniformly slightly larger.

From here, it is a simple matter of scaling all the forces up to account for the actual Neptune array being larger than the hypothetical wider-Jupiter array. Using the data in the preceding three plots, multiply the forces by a factor of  $1.024^2 = 1.049$ , and plot the position on the horizontal axis as integer multiples of the actual Neptune width, 49.510".





Numerical values of all these data are in the following tables

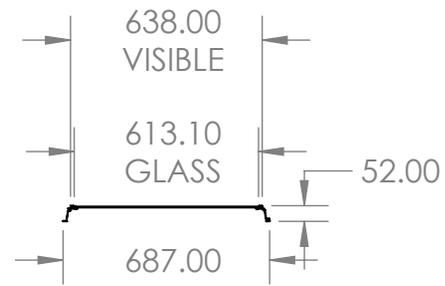
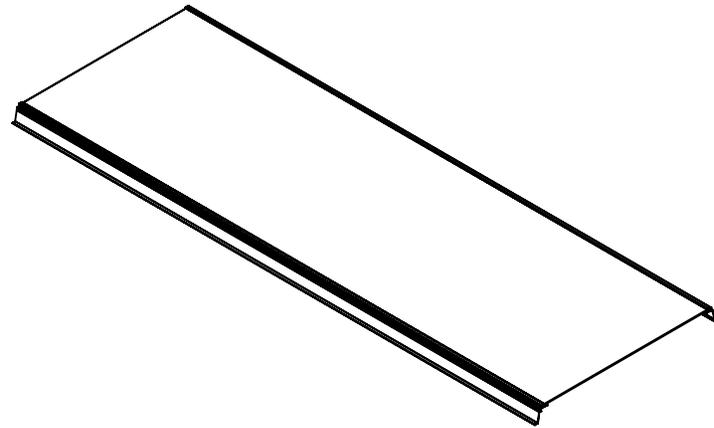
	Drag (lb)			
Position (in)	173.3	123.8	74.3	24.8
4 North N	12.1	41.7	85.9	121.1
3 N	20.6	46.7	84.8	131.2
2 N	10.6	35.3	86.8	142.5
1 South N	117.6	123.4	134.8	209.4

	Cross (lb)			
Position (in)	173.3	123.8	74.3	24.8
4 North N	0.0	11.8	47.4	104.8
3 N	0.0	8.9	50.0	105.2
2 N	0.0	4.6	45.9	105.4
1 South N	49.5	64.0	82.7	167.9

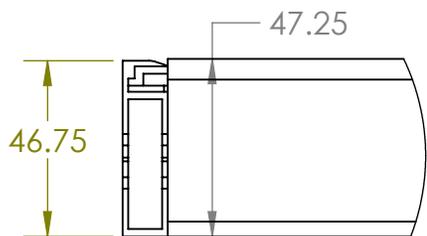
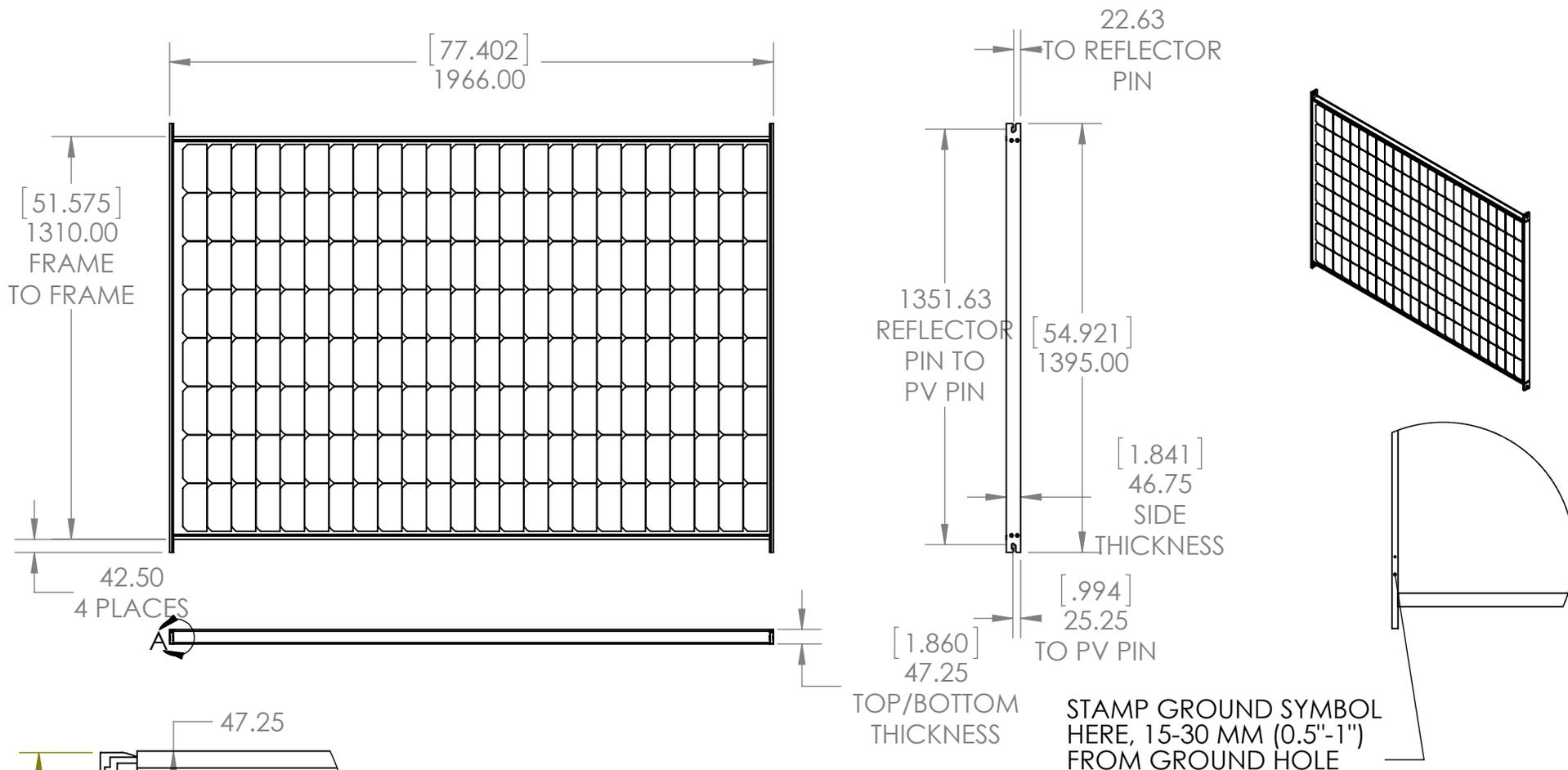
	Lift (lb)			
Position	173.3	123.8	74.3	24.8
4 North N	12.3	44.3	147.8	317.0
3 N	31.8	61.6	118.3	309.7
2 N	28.0	70.0	135.1	309.1
1 South N	20.5	79.6	185.9	294.2

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**G. TENK SOLAR PANEL DIMENSIONS AND ANGLES**



REVISIONS			
REV.	DESCRIPTION	DATE	APPROVAL
1	Added BOM details and ground stamp	9/25/2012	LB



DETAIL A  
SCALE 1 : 2

3RD ANGLE PROJECTION		UNLESS OTHERWISE SPECIFIED:		<b>tenKsolar</b>	
		DIMENSIONS ARE MM			
DRAFTER		DATE		TITLE:	
LB		8-3-2012		Assembly, Module w/o elec., Titan	
<b>PROPRIETARY AND CONFIDENTIAL</b> THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <b>tenKsolar</b> . ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <b>tenKsolar</b> IS PROHIBITED.		TOLERANCES: ONE PLACE DECIMAL ±.2 TWO PLACE DECIMAL ±.15		INTERPRET GEOMETRIC TOLERANCING PER:	
		MATERIAL NA		SIZE	
		FINISH NA		DWG. NO.	
DO NOT SCALE DRAWING		SCALE: 1:20		REV <b>1</b>	
				SHEET 1 OF 2	

8 7 6 5 4 3 2 1

D

D

C

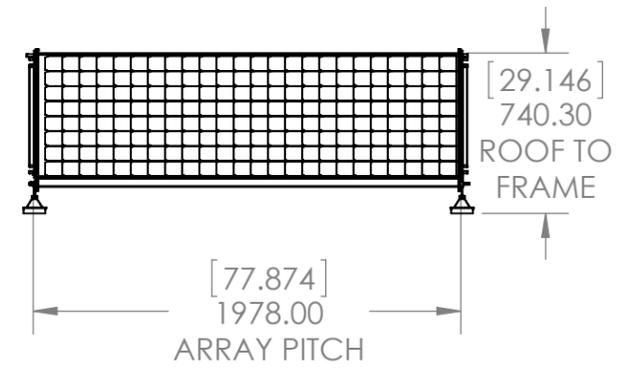
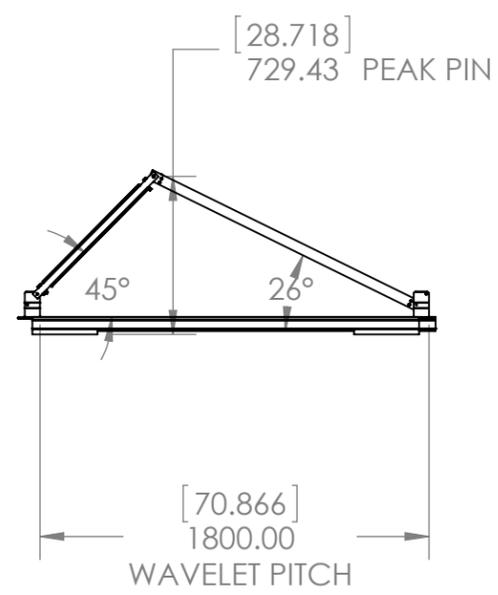
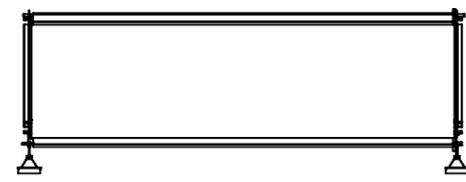
C

B

B

A

A



NOTES  
ALL DIMENSIONS ARE REFERENCE DIMENSIONS  
FOR PARTS DIMENSIONS, SEE THE ACTUAL PARTS

3RD ANGLE PROJECTION		UNLESS OTHERWISE SPECIFIED:		<b>tenKsolar</b>	
		DIMENSIONS ARE MM			
DRAFTER		TOLERANCES:		SIZE    DWG. NO.    REV <b>B</b> 000538 <b>4</b>	
LB		ONE PLACE DECIMAL    ±.2 TWO PLACE DECIMAL    ±.15			
DATE		DO NOT SCALE DRAWING		SCALE: 1:33.3	
8-28-2012				SHEET 1 OF 1	
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CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

## H. SEISMIC FOOTING CALCULATIONS

# SHEAR FOOTING BOLT CONSIDERATIONS

MAX SHEAR = 4.037 KIP

TABLE J3.2

BOLT AREA

1" DIAMETER

$$A_{BOLT} = \frac{\pi D^2}{4} = \frac{\pi (1)^2}{4} = 0.785 \text{ in}^2$$

$$\text{MAX RES} = \frac{4.037 \text{ KIP}}{0.785 \text{ in}^2} = 5.14 \text{ KSI}$$

1/2" DIAMETER

$$A_{BOLT} = \frac{\pi D^2}{4} = \frac{\pi (\frac{1}{2})^2}{4} = 0.196 \text{ in}^2$$

$$\text{MAX RES} = \frac{4.037 \text{ KIP}}{0.196 \text{ in}^2} = 20.56 \text{ KSI}$$

2 BOLTS @ 10.28 KSI RESISTANCE

MINIMUM SPACING

SPACING CENTER TO CENTER =  $3d \Rightarrow 3(\frac{1}{2}) = 1.5"$

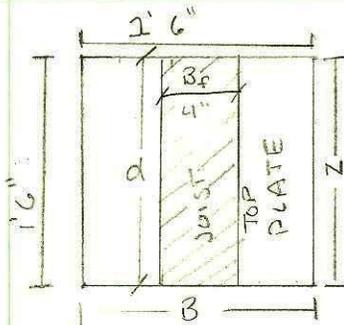
MINIMUM EDGE DISTANCE

DISTANCE FROM CENTER OF HOLE TO EDGE (ACCORDING TO TABLE J3.4) =  $\frac{3}{4}"$

USE BASIC CORRESPONDING WASHERS

SHEAR FOOTING  
PLATE THICKNESS CALCULATION

SHEAR FOOTING D1



LRFD  
EQN 14-7a

TOP PLATE ANALYSIS

$$t_{min} = l \sqrt{\frac{2P_u}{0.9 F_y B N}}$$

A36 STEEL  $\therefore F_y = 36 \text{ ksi}$

$$P_u = 6819.77 \text{ lb}$$

$$B + N = 1.5' = 18''$$

$$l = \lambda n'$$

$$\lambda = 1$$

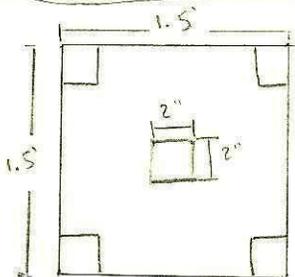
$$n' = \frac{\sqrt{d b_f}}{4} = \frac{\sqrt{(1.5')(0.33')}}{4} = 0.176 \text{ FT}$$

$$d = 1.5'$$

$$b_f = 4'' = 0.33'$$

$$l = (1)(0.176 \text{ FT}) = 0.176 \text{ FT} = 2.11 \text{ IN}$$

$$t_{min} = (2.11 \text{ IN}) \sqrt{\frac{2(6819.77 \text{ lb})}{(0.9)(36,000 \text{ psi})(18'')^2}} = \underline{0.076 \text{ IN}}$$



BOTTOM PLATE ANALYSIS

ASSUME ALL FORCE IS GOING THROUGH CENTER POST

$$t_{min} = l \sqrt{\frac{2P_u}{0.9 F_y B N}}$$

A36 STEEL  $\therefore F_y = 36 \text{ ksi}$

$$P_u = 6819.77 \text{ lb}$$

$$B = N = 18''$$

$$l = \lambda n'$$

$$\lambda = 1$$

$$n' = \frac{\sqrt{d b_f}}{4} = \frac{\sqrt{(2'')(2'')}}{4} = 0.5 \text{ IN}$$

$$l = (1)(0.5 \text{ IN}) = 0.5 \text{ IN}$$

$$d = b_f = 2''$$

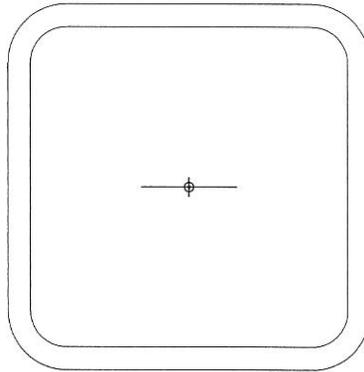
$$t_{min} = (0.5 \text{ IN}) \sqrt{\frac{2(6819.77 \text{ lb})}{(0.9)(36,000 \text{ psi})(18'')^2}}$$

$$\underline{t_{min} = 0.018 \text{ IN}}$$

Rev. Date: 6/8/2013 11:21:53 AM

By: Roger LaBoube

Printed: 6/8/2013 11:23:19 AM



### Section Inputs

---

Material: A500 Shaped Grade A

No strength increase from cold work of forming.

Modulus of Elasticity, E 29500 ksi

Yield Strength, Fy 39 ksi

Tensile Strength, Fu 45 ksi

Warping Constant Override, Cw 0 in<sup>6</sup>

Torsion Constant Override, J 0 in<sup>4</sup>

Tube, Thickness 0.125 in

Placement of Part from Origin:

X to center of gravity 0 in

Y to center of gravity 0 in

Outside dimensions, Closed shape

	Length (in)	Angle (deg)	Radius (in)	Web	k Coef.	Hole Size (in)	Distance (in)
1	2.0000	0.000	0.19400	Single	0.000	0.0000	1.0000
2	2.0000	90.000	0.19400	Single	0.000	0.0000	1.0000
3	2.0000	180.000	0.19400	Single	0.000	0.0000	1.0000
4	2.0000	-90.000	0.19400	Single	0.000	0.0000	1.0000

Rev. Date: 6/8/2013 11:21:53 AM  
 By: Roger LaBoube  
 Printed: 6/8/2013 11:23:19 AM

Member Check - 2007 North American Specification - US (ASD)

Material Type: A500 Shaped Grade A, Fy=39 ksi

Design Parameters:

Lx	1.0833 ft	Ly	1.0833 ft	Lt	1.0833 ft
Kx	1.0000	Ky	1.0000	Kt	1.0000
Cbx	1.0000	Cby	1.0000	ex	0.0000 in
Cmx	1.0000	Cmy	1.0000	ey	0.0000 in
Braced Flange: None		Red. Factor, R: 0		Stiffness, kφ: 0 k	

Loads:	P	Mx	Vy	My	Vx
	(k)	(k-in)	(k)	(k-in)	(k)
Entered	0.000	0.000	0.000	0.000	0.000
Applied	0.000	0.000	0.000	0.000	0.000
Strength	18.802	11.641	4.980	11.641	4.980

Effective section properties at applied loads:

Ae	0.88245 in <sup>2</sup>	Ixe	0.49849 in <sup>4</sup>	Iye	0.49849 in <sup>4</sup>
		Sxe(t)	0.49849 in <sup>3</sup>	Sye(l)	0.49849 in <sup>3</sup>
		Sxe(b)	0.49849 in <sup>3</sup>	Sye(r)	0.49849 in <sup>3</sup>

Interaction Equations

NAS Eq. C5.2.1-1	(P, Mx, My)	0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. C5.2.1-2	(P, Mx, My)	0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. C3.3.1-1	(Mx, Vy)	Sqrt(0.000 + 0.000) = 0.000 <= 1.0
NAS Eq. C3.3.1-1	(My, Vx)	Sqrt(0.000 + 0.000) = 0.000 <= 1.0

A & C:  $M = 1089 \text{ k-in}$

$F_7 = 36 \text{ ksi}$

$M = S_x F_7 / 1.67$  ← steel PL attached to top, horizontal leg of angle

$S_x = \frac{M}{1.67 F_7} = \frac{1089 \text{ k-in} \left(\frac{12}{1}\right)}{1.67(36)} = 0.605 \text{ in}^3$

$L 3 \times 3 \times 5/16$ ,  $S_x = 0.688 > 0.605 \text{ ok}$

B: Use  $L 3 \times 3 \times 5/16$

But use  $L 4 \times 4 \times 5/16$  - enables post to be moved or removed for  $M = 2.169 \text{ k-in}$

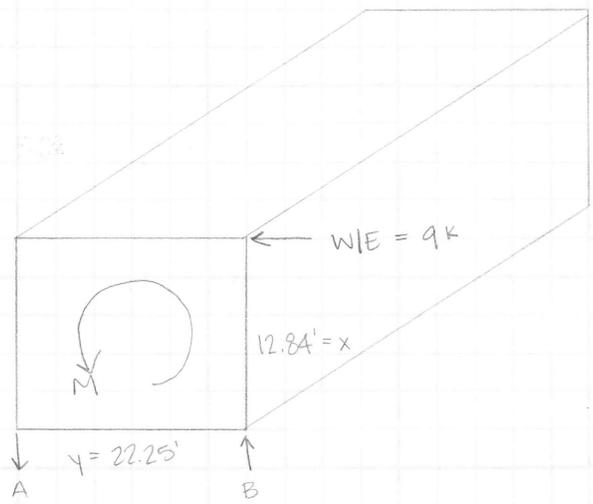
Post:  $L = 13''$

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**I. STEEL STRAPPING CALCULATIONS**

3-0235 — 50 SHEETS — 5 SQUARES  
 3-0236 — 100 SHEETS — 5 SQUARES  
 3-0237 — 200 SHEETS — 5 SQUARES  
 3-0137 — 200 SHEETS — FILLER

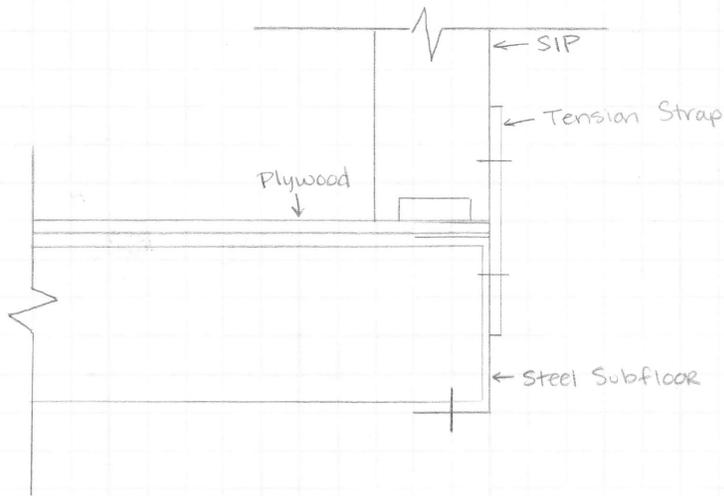
COMET



$$B = \frac{(WIE)x}{y} = \frac{(9k)(12.84ft)}{22.3ft}$$

$B = 5.2k$
$A = -5.2k$

- \* Straps to footings must resist 5.2k
- \* bolts to footings must resist 5.2k pull-out
- \* Steel subfloor must be able to resist 5.2k
- \* largest shear on bolt will be 4k



\* Tension Strap (Appendix A-(2))

(a) Yielding in gross section

$$\phi T_n = A_g F_y \quad \phi = 0.9$$

$$A_g = \frac{\phi T_n}{F_y} = \frac{(0.9)(5.2k)}{55 \text{ ksi}} = 0.085 \text{ m}^2$$

$$A_g = \frac{\phi T_n}{F_y} = \frac{(0.9)(5.2k)}{33 \text{ ksi}} = 0.142 \text{ m}^2$$

(b) Rupture in net section

$$\phi T_n = A_n F_u \quad \phi = 0.75$$

$$A_n = \frac{\phi T_n}{F_u} = \frac{(0.75)(5.2k)}{65 \text{ ksi}} = 0.06 \text{ m}^2$$

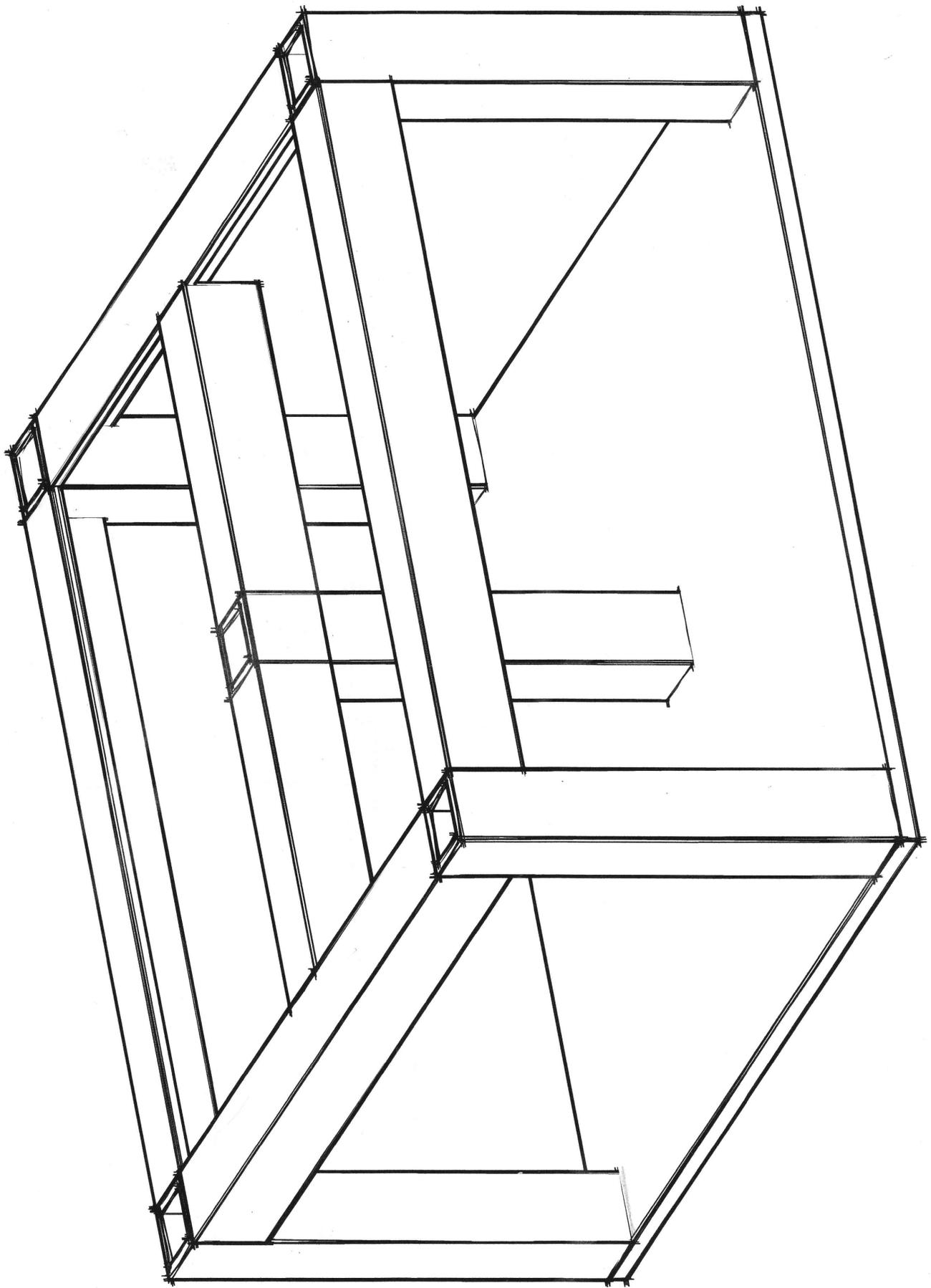
$$A_n = \frac{\phi T_n}{F_u} = \frac{(0.75)(5.2k)}{45 \text{ ksi}} = 0.087 \text{ m}^2$$

∴ Use 1/2" x 8" strap for constructability

\* Screw Strength

3-0235 — 50 SHEETS — 5 SQUARES  
 3-0236 — 100 SHEETS — 5 SQUARES  
 3-0237 — 200 SHEETS — 5 SQUARES  
 3-0137 — 200 SHEETS — FILLER

COMET



# Footing E3 (Largest)

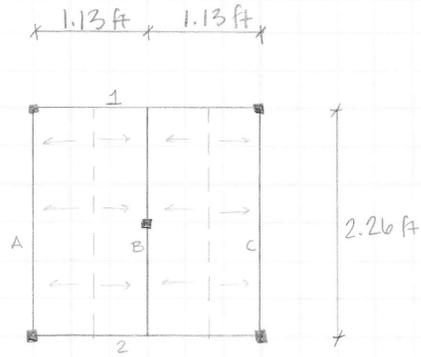
$$P = 15381 \text{ lb}$$

$$L = 2.26 \text{ ft}$$

$$W = 2.26 \text{ ft}$$

\* one-way action \*

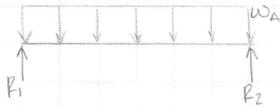
$$w = \frac{15381 \text{ lb}}{(2.26 \text{ ft})^2} = 3011 \text{ psf}$$



Beams A & C:  $A_T = (1.13 \text{ ft} / 2) \times (2.26 \text{ ft}) = 1.28 \text{ ft}^2$

Beam B:  $A_T = (1.13 \text{ ft}) \times (2.26 \text{ ft}) = 2.55 \text{ ft}^2$

Beams A & C:

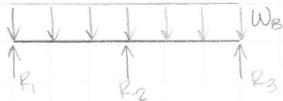


$$w_A = \frac{(3011 \text{ psf}) \times (1.28 \text{ ft}^2)}{2.26 \text{ ft}} = 1705 \text{ lb/ft}$$

$$R_1 = R_2 = w_A l / 2 = \frac{(1705 \text{ lb/ft}) \times (2.26 \text{ ft})}{2} = 1927 \text{ lb}$$

$$M = \frac{w_A l^2}{8} = \frac{(1705 \text{ lb/ft}) \times (2.26 \text{ ft})^2}{8} = 1089 \text{ ft-lb}$$

Beam B:



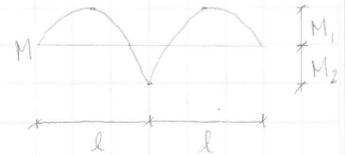
$$w_B = \frac{(3011 \text{ psf}) \times (2.55 \text{ ft}^2)}{2.26 \text{ ft}} = 3397 \text{ lb/ft}$$

$$R_1 = R_3 = w_B l / 4 = \frac{(3397 \text{ lb/ft}) \times (2.26 \text{ ft})}{4} = 1919 \text{ lb}$$

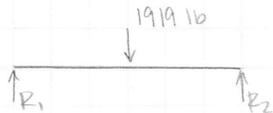
$$R_2 = w_B l / 2 = \frac{(3397 \text{ lb/ft}) \times (2.26 \text{ ft})}{2} = 3839 \text{ lb}$$

$$M_1 = \frac{9 w_B l^2}{128} = \frac{9 (3397 \text{ lb/ft}) \times (1.13 \text{ ft})^2}{128} = 305 \text{ ft-lb}$$

$$M_2 = \frac{w_B l^2}{8} = \frac{(3397 \text{ lb/ft}) \times (1.13 \text{ ft})^2}{8} = 542 \text{ ft-lb}$$



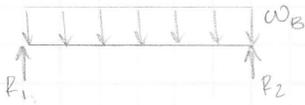
Beams 1 & 2:



$$R_1 = R_2 = (1919 \text{ lb}) / 2 = 960 \text{ lb}$$

$$M = \frac{P l}{4} = \frac{(1919 \text{ lb}) \times (2.26 \text{ ft})}{4} = 1084 \text{ ft-lb}$$

Beam B (Unsupported):



$$w_B = 3397 \text{ lb/ft}$$

$$R_1 = R_2 = w_B l / 2 = \frac{(3397 \text{ lb/ft})(2.26 \text{ ft})}{2} = 3839 \text{ lb.}$$

$$M = \frac{w_B l^2}{8} = \frac{(3397 \text{ lb/ft})(2.26 \text{ ft})^2}{8} = 2169 \text{ ft-lb}$$

3-0235 — 50 SHEETS — 5 SQUARES  
3-0236 — 100 SHEETS — 5 SQUARES  
3-0237 — 200 SHEETS — 5 SQUARES  
3-0137 — 200 SHEETS — FILLER

COMET

JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**J. GABRIEL CRANE INFORMATION**

# GABRIELE

## Critical Lift Permit

Issue Date 7/10/2013

1. Project Name <b>CHAMELEON</b>	2. Contractor <b>UNIV of MISSOURI</b>	3. Lift Date <b>TBA</b>	4. Lift Location <b>POLOA CAMPUS</b>
5. Crane Manufacturer <b>G-LOVE</b>	6. Model # <b>SRT GMK 5120 B</b>	7. Serial # <b>5100-9222</b>	8. Total Boom/Boom Ext. &/or Jib Length @ time of Lift: <b>73' MAIN</b>
9. Max radius during lift (pick, swing, and set) <b>35</b>	10. Swing Dir. And Degrees of swing <b>Left to Right</b>	11. Lift Elevation (ft.) <b>15' Max. 6' Min</b>	12. Boom Angle <b>56° Pick 72° Set</b>

13. Will Jib &/or Boom Ext be used? Yes  No

If Yes: Length (ft) \_\_\_\_\_ Erected ( ) \_\_\_\_\_  
Weight (lb) \_\_\_\_\_ Stowed ( ) \_\_\_\_\_

14. Mfg. (75% chart) rated capacity from chart as outlined in Clcks 5 - 13  
**73,000 lbs @ 35' Radius**

15. Component Weights

Jib / Boom extension: \_\_\_\_\_  
Headache Ball Size: \_\_\_\_\_  
Load Block Size: **50TON CAP 1800 lbs**  
Auxiliary Boom Head: \_\_\_\_\_  
Weight of Cable (Load Fall): \_\_\_\_\_  
Slings, Rigging, Shackles, Etc. **> 1200 lbs**  
Lifting Booms or Bars: \_\_\_\_\_  
Allowance for Unaccounted Material in Equipment: \_\_\_\_\_  
Other: \_\_\_\_\_  
Total Weight: **3000 lbs**

16. Load Description & Weight:  
**Some House Boxes 31,400 lbs**

17. Who determined weight of load and Lift?  
Name: **Gene Gabriele II**  
How: \_\_\_\_\_

18. Total Lift Load (Block 15 = 16)  
**34,400**

19. Load % of Crane Capacity (Divide Block 18 by 14)  
**49.9% CAP!**

20. Rigging Safety Factor 6 to 17  
Yes  No

21. Rigging accessories size and condition  
Slings: **4 - 1 1/8" x 20' Steel**  
Shackles: **4 - 1 1/4" 12 TON**  
Other: **4 - 1 3/8" 13 1/2 TON  
6" x 40' NYLOW SLINGS**

22. Tagline Required? Yes  No

23. Parts of Wire on Block  
**4 PWT @ 15,000  
LINE PULL  
60,000 lbs**

24. Soil Conditions? Poor  Good   
Calculations? - Required  Not Required   
Crane Mats? - Required  Not Required

25. Hazards:

Electrical? Yes  No  If Yes, explain: \_\_\_\_\_  
Overhead? Yes  No  If Yes, explain: \_\_\_\_\_  
Underground? Yes  No  If Yes, explain: \_\_\_\_\_  
Others? Yes  No  If Yes, explain: \_\_\_\_\_

26. Inspection/Testing:  
Load Test Date: \_\_\_\_\_  
Periodic Inspection Date: \_\_\_\_\_  
Test Lift: \_\_\_\_\_ Remote Area \_\_\_\_\_  
Lift Location \_\_\_\_\_  
(Block 4)

27. Pre-Lift Meeting Date: **TBA/A**

28. Attach Sketch **Yes**

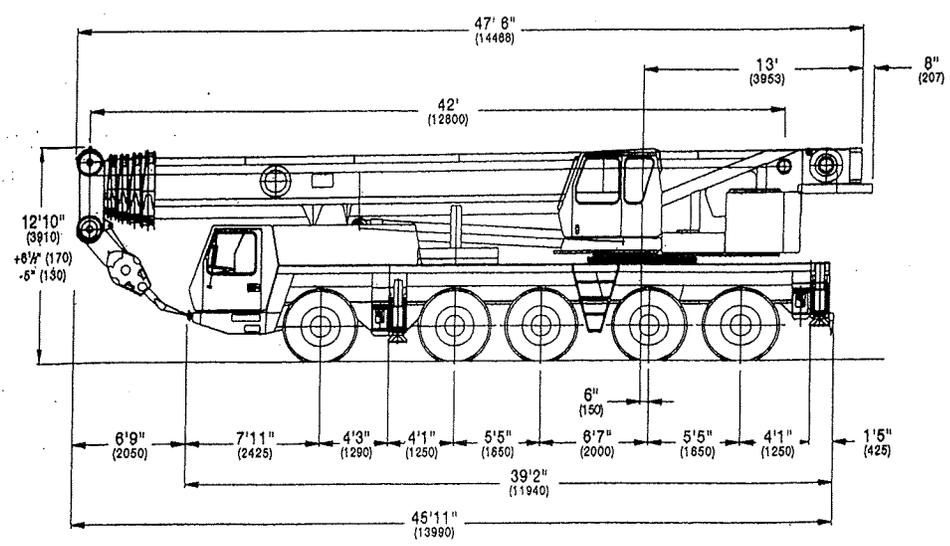
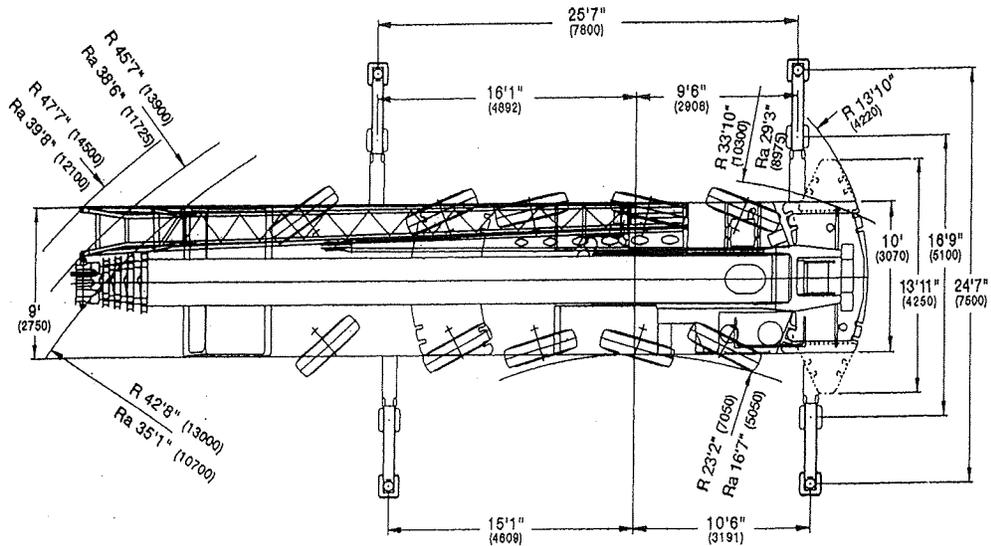
29. Piperack Inventory & Isolation points completed? Yes  No   
Operating Supervisor: \_\_\_\_\_

30. Signatures:  
**Gene Gabriele II 7-10-2013**  
**Gene Gabriele II**

1. Operator <b>Gene Gabriele SR</b> Date: <b>7-10-2013</b>	4. Project Construction Manager Date
2. Rigger Date	5. Safety Manager Date
3. Rigger Date	

# Dimensions

# GABRIELE GMK5120B 120 TON



Note: ( ) Reference dimensions in mm

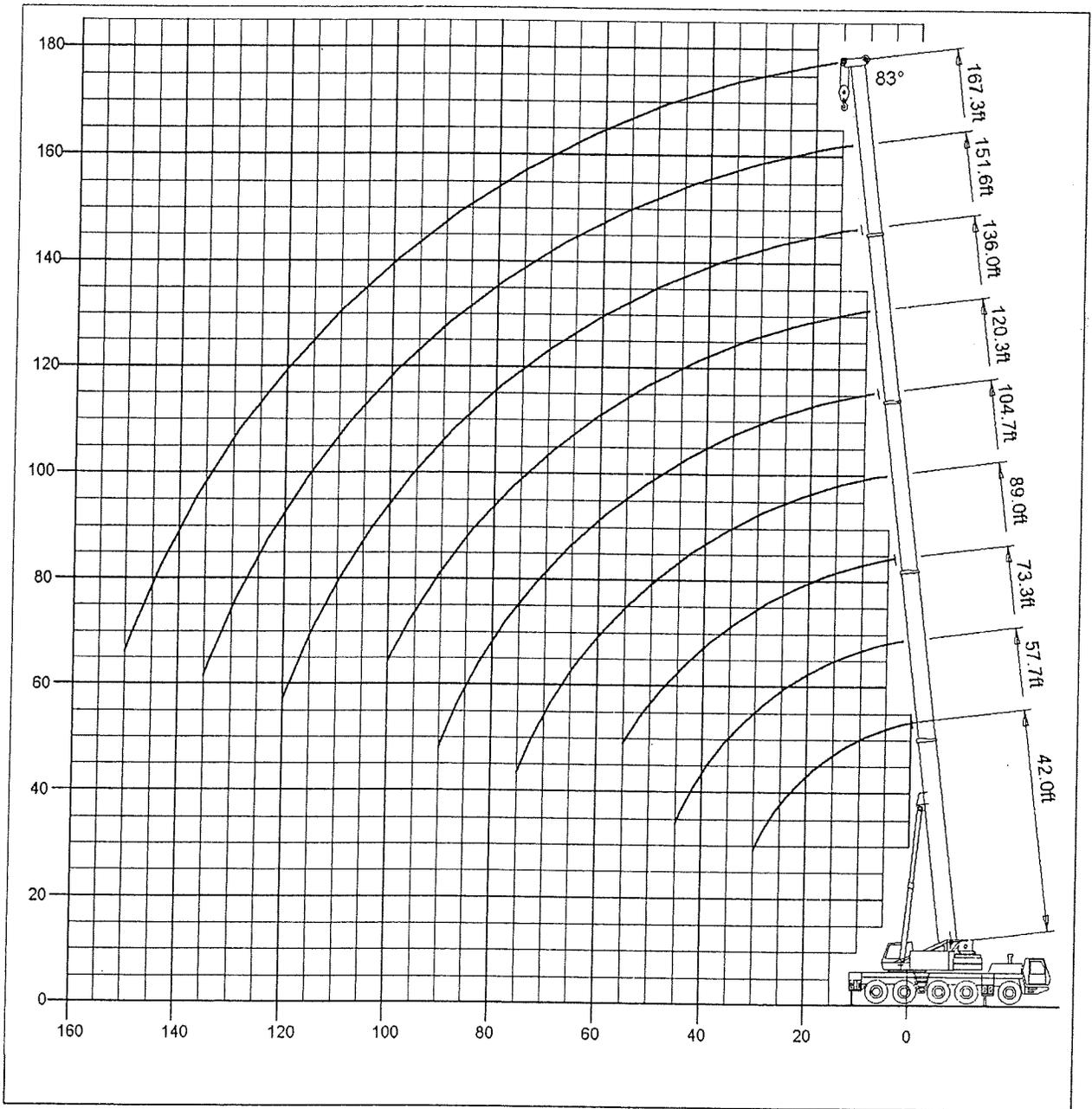
BASIC WEIGHTS (LBS.)	Axles 1- 3	Axles 4 & 5	Total
With Mercedes Power, 20.5 R25 Tires			
Auxiliary Hoist, 2nd Hydraulic Oil Cooler,			
Brackets for Lattice Extension	65,068	41,405	106,473
<b>Additions:</b>			
Outrigger Pads	119	190	309
Lattice Extension - 36/59 ft	3,788	-(613)	3,175
Auxiliary Boom Nose	362	-(207)	154
* 24,200 lbs Counterweight (15,400 lbs on Carrier)	11,274	10,750	22,024
* 44,000 lbs Counterweight (38,800 lbs on Carrier)	23,227	18,991	42,218
Engine Driveline Retarder	-(64)	717	653
Spare Tire - 14.00 R25	-(340)	924	584
Spare Tire - 16.00 R25	-(423)	1,140	717
Spare Tire - 20.5 R25	-(487)	1,296	809
<b>Removal:</b>			
* Substitute Counterweight IPO Auxiliary Hoist	93	-(46)	46
10 x 6 x 10 in I-beam	-(772)	-(22)	-(794)
16.00 R25 Tires in lieu	-(556)	-(370)	-(926)
14.00 R25 Tires in lieu	-(1,349)	-(899)	-(2,249)

Reflects weight with superstructure facing forward.  
 \* Auxiliary hoist is considered as part of the counterweight. Please see page 11 for counterweight build-up.

	Crane with 52 900 lbs ( 24 t ) counterweight (outrigger base 25.6 x 24.6 ft)								
	Main boom - fixed length in ft								
	42.0	57.7	57.7	57.7	57.7	73.3	73.3	73.3	73.3
Tel. sec. I	0.00	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Tel. sec. II	0.00	0.00	0.50	0.00	0.00	0.50	0.50	0.00	0.00
Tel. sec. III	0.00	0.00	0.00	0.50	0.00	0.00	0.50	0.50	0.00
Tel. sec. IV	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.50	1.00
Slewing range	360°								
Radius in feet	Lifting capacities in 1000 lbs								
10.0	220.0	192.0	153.0	121.0	120.0	139.0	121.0	120.0	85.0
15.0	168.0	161.0	153.0	121.0	102.0	139.0	121.0	100.0	71.0
20.0	138.0	132.0	134.0	114.0	89.0	129.0	112.0	84.0	61.0
25.0	114.0	112.0	114.0	100.0	79.0	110.0	98.0	73.0	53.0
30.0	88.0	89.0	92.0	89.0	71.0	89.0	86.0	65.0	47.0
35.0		69.0	71.0	72.0	65.0	70.0	73.0	58.0	42.4
40.0		54.0	56.0	58.0	59.0	56.0	59.0	52.0	39.2
45.0		44.0	46.0	48.0	49.0	46.0	48.0	48.0	35.8
50.0						38.0	40.8	42.8	32.4
55.0						32.0	34.8	36.8	29.8
SLI Code	610								
Max. permitted windspeed	14 m/s								

Lifting loads > 210. 000 lbs can be lifted only with additional equipment.

Height in ft



Radius in feet

**GABRIELE CRANE RENTAL  
INC.**

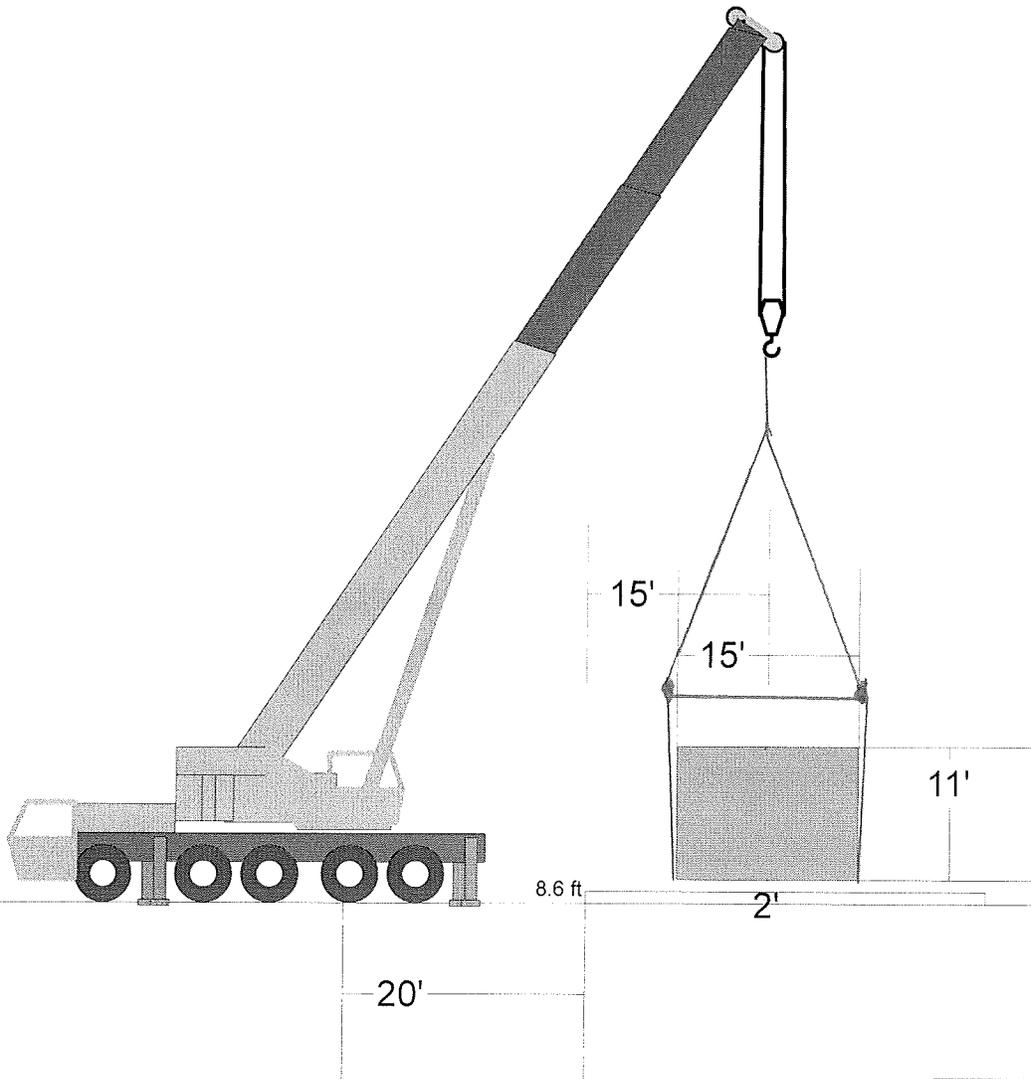
07-10-2013

Tip Height: 72.7 (ft)

% of Chart Capacity: 50% (100%  
Limit)

Original Load Weight: 36,400.0  
(lb)

	Load Radius (ft)	Boom Length (ft)		
Crane:	35.0	73.3	Load Weight:	36,400
Chart:	35.0	73.3	Capacity (lb):	73,000
Grove GMK 5120B Main Boom Only - 42' - 167.3' Main Boom Only, 100% Outriggers, 52900# Cwt, 360 Deg, 85% Cap, [3098721]				





# GABRIELE CRANE RENTAL, INC.



24-HOUR SERVICE  
HYDRAULIC CRANES  
WITH EXPERIENCED OPERATORS

OFFICE: (573) 364-6214  
CELL: (573) 465-2714  
RES: (573) 341-3331  
FAX: (573) 364-6706

GENE GABRIELE II  
DIRECTOR OF  
OPERATIONS

6 QUAIL RUN  
P.O. BOX 1383  
ROLLA, MO 65402

## MEDICAL EXAMINER'S CERTIFICATE

I certify that I have examined Gene Gabriele II in accordance with the Federal Motor Carrier Safety Regulations (49 CFR 391.41-391.49) and with knowledge of the driving duties. I find this person is qualified, and if applicable, only when:

- wearing corrective lenses
- wearing hearing aid
- accompanied by a \_\_\_\_\_ waiver/exemption
- driving within an exempt intracity zone (49 CFR 391.62)
- accompanied by a Skill Performance Evaluation Certificate (SPE)
- qualified by operation of (49 CFR 391.64)

The information I have provided regarding this physical examination is true and complete. A complete examination form with any attachment embodies my finding, conclusively and correctly, and is on file in my office.

SIGNATURE OF MEDICAL EXAMINER <i>W. David Meers</i>	TELEPHONE 364-9352	DATE 11/22/11
MEDICAL EXAMINER'S NAME (PRINT) W. David Meers	<input type="checkbox"/> MD <input checked="" type="checkbox"/> Physician Assistant	<input type="checkbox"/> Chiropractor <input type="checkbox"/> Advanced Practitioner Nurse
MEDICAL EXAMINER'S LICENSE OR CERTIFICATE NO. K7904	ISSUING STATE MO	
SIGNATURE OF DRIVER <i>Gene Gabriele II</i>	MEDICAL CERTIFICATE EXPIRATION DATE 11/22/14	
ADDRESS OF DRIVER 10360 CR 3010 Rolla MO 65401		
DRIVER'S LICENSE NO. 493829683	STATE MO	

OSHA 001976445



U.S. Department of Labor  
Occupational Safety and Health Administration

**GENE GABRIELE, II**

has successfully completed a 10-hour Occupational Safety and Health Training Course in

Construction Safety & Health

(Trainer)

*9/08*  
(Date)



**NCCCO CERTIFIED**  
Rigger

Certification #: 110581021  
Certification Designations:  
Rigger Level I



Issued to: **GENE GABRIELE II**  
Issue Date: 05/31/2011 Expiration Date: 05/31/2016

*Thom Sickelsteel*  
Thom Sickelsteel, President, NCCCO Board of Directors

*Graham J. Brent*  
Graham J. Brent, Executive Director, NCCCO

For identification purposes only. Subject to provisions of suspension or revocation.

**National Commission for the Certification of Crane Operators**



**NCCCO CERTIFIED**  
Crane Operator

Certification Number:  
060929358R  
Certification Designations  
TLL



Issue Date: 09/30/2011 Expiration Date: 09/30/2016  
Issued To: **GENE GABRIELE II**

*John M. Kennedy*  
John M. Kennedy, President, NCCCO Board of Directors

*Graham J. Brent*  
Graham J. Brent, Executive Director, NCCCO

For identification purposes only. Subject to provisions of suspension or revocation.

**National Commission for the Certification of Crane Operators**

## Gabriele Crane Rental Gene Gabriele II

Has completed safety training on 10/24/11

- Rigging
- Signals

*Mike Downie*

Mike Downie - Safety Consultant



OSHA / ASME ANNUAL/PERIODIC  
INSPECTION CHECKLIST

# Telescoping Boom Crane

craneinstitute.com • 3880 St. Johns Parkway • Sanford, FL 32771 • 1-800-832-2726

Owner: <b>Gabriele Crane Rental Inc</b>	Contact Person: <b>Gene Gabriele</b>	Date: <b>10 Sept 12</b>
Location: <b>ROLLA FACILITY</b>	Service Status: <b>Working</b>	Hours: <b>2979/3325.4</b>
Make: <b>GROVE</b>	Model: <b>GMK 5720 B</b>	Serial Number: <b>5100-9222</b>
Unit ID: <b>112</b>	Max. Capacity: <b>120 Ton</b>	Inspector: <b>Mark Rodman</b> <i>cert #12-0630 Exp 2/15/14</i>

- Before inspecting crane, lock out/tag out power source.
- Consult operator/service manual, service bulletins, etc. for additional inspection items.
- Before inspection, crane must be set up away from personnel and power lines, with outriggers/crawlers fully extended and crane leveled on firm ground.
- OSHA and ASME allow only qualified and competent persons to inspect cranes. To qualify, inspectors must have been through training, have extensive knowledge and demonstrated ability.

References: O = OSHA 1926 Subpart CC, 1926.601, 1910.180 A = PCSA #4, ASME B30.5, B30.10

Status: ✓ = Satisfactory X = Safety Hazard M = Monitor N/A = Not Applicable

REFERENCE	ITEM	Status	REFERENCE	ITEM	Status
<b>Historical Data</b>			<b>Carrier</b>		
O-1926.1412 (e)(3)	1. Monthly Inspection Records	✓	O-1926.601 (b)(14)	31. Transmission	✓
A-B30.5-2.3.1 (a)	2. Maintenance Records	✓	O-1926.601 (b)(14)	32. Drive Line	✓
O-1926.1412 (f)(7)	3. Annual Inspection Record	✓	O-1926.1412 (f)(2)(ix)	33. Tires / Wheels	✓
O-1926.1434 (a)	4. Modification Records	✓	O-1926.1412 (f)(2)(ix)	34. Tire Air Pressure	✓
A-B30.5-2.2.2 (a)(2)	5. Load Test Reports	✓	O-1926.1412 (f)(2)(i)	35. Main Frame Members	✓
<b>General</b>			O-1926.1412 (f)(2)(x)	36. Hydraulic Hoses / Tubing / Fittings	✓
A-B30.5-2.1.3(a)	6. Sheet Metal	✓	O-1926.1412 (d)(1)(iv)	37. Hydraulic Fluid Level	✓
O-1926.1433 (d)(8)	7. Guards / Covers	✓	O-1926.1423 (c)(3)(ii)	38. Anti-Skid Surface	✓
O-1926.601(2)(i)&(ii)	8. External Lights	✓	O-1926.1412 (f)(2)(xiii)	39. Axle Lockout	✓
A-B30.5-3.4.7	9. Housekeeping	✓	O-1926.601 (b)(4)(i)	40. Backup Alarm	✓
O-1926.1433 (d)(5)	10. Safety / Warning Decals & Labels	✓	41. Other		N/A
O-1926.1422	11. Hand Signal Chart	✓	<b>Outriggers</b>		
	12. Other	N/A	O-1926.1412 (f)(2)(i)	42. Boxes	✓
	13. Other	N/A	O-1926.1412 (f)(2)(i)	43. Beams	✓
<b>Driver's Cab &amp; Station</b>			O-1926.1412 (f)(2)(xiii)	44. Cylinders	✓
O-1926.601 (b)(1)	14. Brakes: Service, Emergency, Parking	✓	O-1926.1412 (f)(2)(xiv)	45. Floats / Pads	✓
O-1926.601 (b)(2)(i)	15. Headlights / Taillights	✓	O-1926.1412 (f)(2)(x)	46. Hydraulic Hoses / Tubes / Fittings	✓
O-1926.601 (b)(2)(ii)	16. Brake Lights	✓	O-1926.1412 (f)(2)(xii)	47. Holding Valves	✓
O-1926.601 (b)(3)	17. Audible Warning Device	✓	O-1926.1433 (d)(5)	48. Warning Signs	✓
O-1926.601 (b)(4)(i)	18. Backup Audible Alarm	✓	49. Other		N/A
O-1926.1433 (d)(7)(iii)	19. Windows	✓	50. Other		N/A
O-1926.601 (b)(5)	20. Powered Wipers	✓	<b>Operator's Cab &amp; Station</b>		
O-1926.1433 (d)(7)(i)	21. Defroster	✓	O-1926.1433 (d)(7)(iii)	51. Windows	✓
O-1926.1412(f)(2)(xviii)&(xix)	22. Seat	✓	O-1926.1433 (d)(7)(i)	52. Windshield Wiper	✓
O-1926.601 (b)(9)	23. Seatbelt(s)	✓	O-1926.1433 (d)(7)(ii)	53. Door Restraint	✓
O-1926.1412 (f)(2)(viii)	24. Steering	✓	O-1926.1433 (d)(7)(iv)	54. Cab Access	✓
O-1926.601 (b)(14)	25. Fire Extinguisher	✓	O-1926.1412 (f)(2)(xxi)	55. Guard Rails and Hand Holds	✓
<b>Carrier Power Plant (Lower)</b>			O-1926.1423 (c)(3)(ii)	56. Anti-Slip Walking Surfaces	✓
O-1926.1412 (f)(2)(vi)	26. Performance	✓	O-1926.1433 (d)(1)	57. Load Chart	✓
O-1926.1433 (d)(9)	27. Exhaust System / Guards & Insulators	✓	O-1926.1433 (d)(6)	58. Fire Extinguisher	✓
O-1926.1433 (d)(8)	28. Belts	✓	O-1926.1417 (c)(1)	59. Operator's Manual	✓
O-1926.1433 (d)(8)	29. Guards / Covers / Rotat. & Recip. Parts	✓	O-1926.1412(f)(2)(xviii)&(xix)	60. Seat	✓
	30. Other	N/A	A-B30.5-1.8.1 (e)	61. Seatbelts	✓

REFERENCE	ITEM
<b>Operator's Cab &amp; Station (continued)</b>	
O-1926.1407 (g)	62. Electrocutation Sign
O-1926.1415 (a)(1)	63. Level
O-1926.1415 (a)(7)	64. Horn
O-1926.1416 (e)(4)	65. Load Indicator
A-PCSA #4 6.1.10.1	66. Control Markings
O-1926.1412 (d)(1)(i&ii)	67. Controls (Function)
A-B30.5-1.6.3	68. Power Plant Controls
O-1926.1412 (f)(2)(iv)	69. Swing Brake & Lock
O-1926.1412 (f)(2)(viii)	70. Travel Brakes
O-1926.1412 (d)(1)(i)	71. Travel Controls
O-1926.1412 (f)(2)(vi)	72. Travel Mechanism
O-1926.1412 (f)(2)(viii)	73. Travel Locks
<b>Load Chart</b>	
O-1910.1433 (d)(1)	74. Per Configuration
O-1910.180 (c)(2)	75. Legible
O-1910.180 (c)(2)	76. Durable
O-1910.180 (c)(2)	77. Secured
O-1910.1433 (d)(1)	78. Visible From Operator's Station
<b>Safety Devices / Operational Aids</b>	
O-1910.1416 (e)(4)	79. Boom Angle Indicator
O-1926.1416 (e)(6)	80. Boom Length Indicator
O-1926.1416 (e)(5)(ii)	81. Main Drum Rotation Indicator
O-1926.1416 (e)(5)(ii)	82. Auxiliary Drum Rotation Indicator
O-1926.1416 (e)(4)	83. Load Moment Indicator
O-1926.1416 (e)(4)	84. Load Weight Indicator
O-1926.1416 (e)(1)	85. Radius Indicator
O-1926.1415 (a)(1)	86. Crane Level Indicator
O-1926.1416 (d)(3)(i)	87. Anti Two-Block Device
	88. Other
	89. Other
<b>Power Plant (Upper)</b>	
O-1926.1412 (f)(2)(vi)	90. Performance
O-1926.1433 (d)(9)	91. Exhaust System / Guards / Insulators
O-1926.1433 (d)(8)	92. Belts / Hoses
O-1926.1433 (d)(8)	93. Guards / Covers / Rotat. & Recip. Parts
<b>Rotating Upper Structure</b>	
O-1926.1412 (f)(2)(iii)	94. Turntable
O-1926.1412 (d)(1)(viii)	95. Electrical Collector Ring
O-1926.1412 (f)(2)(i)	96. Counterweight Frame
O-1926.1412 (f)(2)(xi)	97. Hydraulic Pump(s)
O-1926.1412 (f)(2)(x)	98. Hydraulic Hoses / Tubes / Fittings
O-1926.1412 (f)(2)(xi)(A)	99. Hydraulic Pressure
O-1926.1412 (f)(2)(xvi)	100. Electrical Wiring
O-1926.1412 (f)(2)(xi)	101. Main Hoist – Motor / Valves / Lines
	102. Other

REFERENCE	ITEM
<b>Rotating Upper Structure (continued)</b>	
O-1926.1413 (a)(4)(i)(B)	103. Main Hoist – Minimum (2) Rope Wraps
O-1926.1412 (f)(2)(xi)	104. Aux. Hoist – Motor / Valves & Lines
O-1926.1412 (d)(vi)	105. Drum Spooling
O-1926.1413 (a)(4)(i)(B)	106. Aux. Hoist – Minimum (2) Rope Wraps
O-1926.1412 (f)(2)(i)	107. Counterweight / Mounting
O-1926.1412 (f)(2)(xi)	108. Swing Gear Box
O-1926.1407 (g)	109. Electrocutation Warning Sign (Outside)
O-1926.1433 (d)(5)	110. Counterweight Warning Sign
	111. Other
<b>Main Boom</b>	
O-1926.1412 (f)(2)(xiii)	112. Lift Cylinder(s)
O-1926.1412 (f)(2)(xiii)	113. Telescoping Cylinder(s)
O-1926.1412 (f)(2)(x)	114. Hydraulic Hoses / Tubing & Fittings
O-1926.1412 (f)(2)(xii)	115. Holding Device
O-1926.1412 (f)(2)(i)	116. Boom Sections Alignment
O-1926.1412 (f)(2)(xv)	117. Wear Pads
O-1926.1412 (f)(2)(ii)	118. Sheave(s)
O-1926.1413 (a)(2)(i)(D)	119. Hoist Line Dead End
O-1926.1413 (a)(2)(i)(D)	120. Wire Rope Retainer
O-1926.1412 (f)(2)(iii)	121. Boom Hinge Pin
O-1926.1412 (f)(2)(i)	122. Boom Head Section
O-1926.1412 (f)(2)(i)	123. Auxiliary Boom Head
O-1926.1412 (f)(2)(f)	124. Structure
	125. Other
	126. Other
<b>Manual Section</b>	
O-1926.1412 (f)(2)(i)	127. Alignment
O-1926.1412 (f)(2)(iii)	128. Locking Device
O-1926.1412 (f)(2)(i)	129. Structure
<b>Lattice Boom Extension</b>	
O-1926.1412 (f)(2)(i)	130. Boom Extension Alignment
O-1926.1412 (f)(2)(i)	131. Cords
O-1926.1412 (f)(2)(i)	132. Lattices
O-1926.1413 (a)(2)(i)(D)	133. End Connections
O-1926.1412 (f)(2)(ii)	134. Sheave(s)
O-1926.1413 (a)(2)(i)(D)	135. Wire Rope Retainer
O-1926.1412 (f)(2)(i)	136. Structure
	137. Other
	138. Other
<b>Jib</b>	
O-1926.1415 (a)(3)	139. Positive Stops
O-1926.1412 (f)(2)(ii)	140. Sheave(s)
O-1926.1413 (a)(2)(i)(D)	141. Wire Rope Retainer(s)
O-1926.1412 (f)(2)(i)	142. Structure
	143. Other

144. <b>Wire Rope</b>											
Rope Application	Type	Size	Construct.	Grade	Core	Rope Damage	Measured Wear	Broken Wires	Lubrication	End Connections	Status
Main Hoist	CASAR	Star Lift		19MM							
Aux. Hoist	CASAR	Star Lift		19MM							
Pendants	N/A										

Main Load Block & Hook		
Manufacturer: <i>Johnson</i> S/N: <i>01-12317</i>		
Rated Capacity: <i>45 TON</i>		
Block Weight: <i>1188 lbs.</i>		
Hook Tram Meas: <i>9 1/2"</i>		
REFERENCE	ITEM	Status
O-1926.1433 (d)(3)	145. Capacity Marking	✓
O-1926.1433 (d)(3)	146. Weight Marking	✓
O-1926.1412 (f)(2)(ii)	147. Sheave(s)	✓
O-1926.1433 (d)(4)	148. Safety Latches	✓
A-B30.10-1.10.5(f)	149. 0° Hook Bend or Twist	✓
A-B30.10-1.10.5(g)	150. 5% Hook Opening or 1/4" Max.	✓
A-B30.10-1.10.5(e)	151. 10% Hook Wear Max.	✓
O-1926.1412 (f)(2)(iii)	152. Swivel	✓
O-1926.1412 (f)(2)(iii)	153. Bearing	✓
O-1926.1414 (f&g)	154. Wedge Socket / End Fitting	N/A
O-1926.1412(d)(1)(vi)	155. Reeving	✓
A-B30.5-2.1.3 (i)	156. NDT Results:	✓
	157. Other	N/A

Overhaul Ball & Hook			
Manufacturer:		S/N:	
Rated Capacity:			
Block Weight:			
Hook Tram Meas:			
REFERENCE	ITEM	Status	
O-1926.1433 (d)(3)	158. Capacity Marking		
O-1926.1433 (d)(3)	159. Weight Marking		
O-1926.1433 (d)(4)	160. Safety Latches		
A-B30.10-1.10.5(f)	161. 0° Hook Bend or Twist		
A-B30.10-1.10.5(g)	162. 5% Hook Opening or 1/4" Max.		
A-B30.10-1.10.5(e)	163. 10% Hook Wear Max.		
O-1926.1412 (f)(2)(iii)	164. Swivel		
O-1926.1412 (f)(2)(iii)	165. Bearing		
O-1926.1414 (f&g)	166. Wedge Socket / End Fitting		
A-B30.5-2.1.3 (i)	167. NDT Results:		
	168. Other		

No-Load Operational Test			
REFERENCE	ITEM	Status	<b>Caution:</b> Operation of cranes by Inspectors is limited to those crane functions necessary to accomplish the inspection. Inspectors must meet operator trainee qualification requirements in ASME B30.5 and only operated under the direct supervision of a certified operator.
O-1926.1412 (f)(3)	169. No-Load Operational Test		

170. REFERENCE: A-B30.5-2.2.2

Load Test							
Hoisting from:	Boom / Ext. / Jib Length	Load Radius	Boom Angle	Parts of Line	Rated Capacity	Test Weight	% of Rated Capacity
Main Boom	<i>No Load Test Done At This Inspection</i>						
Manual Section							
Boom Extension							
Jib							

Results of Load Test  Passed  Failed  Not Applicable

Explanation: *No Load Test Conducted at This Time*

# 1-800-832-2726

**Cautions:** Load Test shall be conducted by a qualified person. Operators must be certified through a nationally accredited and OSHA recognized certification program, such as CIC.

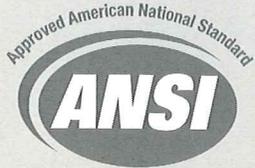


JOB \_\_\_\_\_  
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_  
CALC. BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

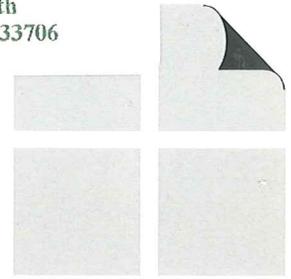
**K. WOOD FRAME CONSTRUCTION MANUAL REFERENCE**

● **2001 EDITION**

**ANSI/AF&PA WFCM-2001  
(New Standard)  
Approval Date: October 11, 2001**



AMERICAN FOREST & PAPER ASSOCIATION  
American Wood Council  
*Southeast Regional Office*  
350 Julia Circle North  
St. Peter Beach, Florida 33706



# WFCM

**WOOD | FRAME | CONSTRUCTION | MANUAL**

**FOR ONE- AND TWO-FAMILY DWELLINGS**

**American  
Forest &  
Paper  
Association**

**American Wood Council**

**Table 3.26B Rafter Spans for Common Lumber Species**

(Ceiling Attached to Rafters, Live Load = 20 psf, L/Δ = 240)

Joist Spacing (ft.-in.)	Species and Grade	Dead Load = 10 psf					Dead Load = 20 psf				
		2x4	2x6	2x8	2x10	2x12	2x4	2x6	2x8	2x10	2x12
		Maximum Rafter Spans <sup>1,2,3</sup>									
(ft.-in.)		(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)
12 in.	Douglas Fir-Larch SS	10 - 5	16 - 4	21 - 7	*	*	10 - 5	16 - 4	21 - 7	*	*
	Douglas Fir-Larch #1	10 - 0	15 - 9	20 - 10	*	*	10 - 0	15 - 4	19 - 5	23 - 9	*
	Douglas Fir-Larch #2	9 - 10	15 - 6	20 - 5	*	*	9 - 10	14 - 7	18 - 5	22 - 6	*
	Douglas Fir-Larch #3	8 - 9	12 - 10	16 - 3	19 - 10	23 - 0	7 - 7	11 - 1	14 - 1	17 - 2	19 - 11
	Hem-Fir SS	9 - 10	15 - 6	20 - 5	*	*	9 - 10	15 - 6	20 - 5	*	*
	Hem-Fir #1	9 - 8	15 - 2	19 - 11	25 - 5	*	9 - 8	15 - 2	19 - 2	23 - 5	*
	Hem-Fir #2	9 - 2	14 - 5	19 - 0	24 - 3	*	9 - 2	14 - 2	17 - 11	21 - 11	25 - 5
	Hem-Fir #3	8 - 7	12 - 6	15 - 10	19 - 5	22 - 6	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6
	Southern Pine SS	10 - 3	16 - 1	21 - 2	*	*	10 - 3	16 - 1	21 - 2	*	*
	Southern Pine #1	10 - 0	15 - 9	20 - 10	*	*	10 - 0	15 - 9	20 - 10	25 - 10	*
	Southern Pine #2	9 - 10	15 - 6	20 - 5	*	*	9 - 10	15 - 1	19 - 5	23 - 2	*
	Southern Pine #3	9 - 1	13 - 6	17 - 2	20 - 3	24 - 1	7 - 11	11 - 8	14 - 10	17 - 6	20 - 11
	Spruce-Pine Fir SS	9 - 8	15 - 2	19 - 11	25 - 5	*	9 - 8	15 - 2	19 - 11	25 - 5	*
	Spruce-Pine Fir #1	9 - 5	14 - 9	19 - 6	24 - 10	*	9 - 5	14 - 4	18 - 2	22 - 3	25 - 9
	Spruce-Pine Fir #2	9 - 5	14 - 9	19 - 6	24 - 10	*	9 - 5	14 - 4	18 - 2	22 - 3	25 - 9
Spruce-Pine Fir #3	8 - 7	12 - 6	15 - 10	19 - 5	22 - 6	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6	
16 in.	Douglas Fir-Larch SS	9 - 6	14 - 11	19 - 7	25 - 0	*	9 - 6	14 - 11	19 - 7	25 - 0	*
	Douglas Fir-Larch #1	9 - 1	14 - 4	18 - 11	23 - 9	*	9 - 1	13 - 3	16 - 10	20 - 7	23 - 10
	Douglas Fir-Larch #2	8 - 11	14 - 1	18 - 5	22 - 6	*	8 - 7	12 - 7	16 - 0	19 - 6	22 - 7
	Douglas Fir-Larch #3	7 - 7	11 - 1	14 - 1	17 - 2	19 - 11	6 - 7	9 - 8	12 - 2	14 - 11	17 - 3
	Hem-Fir SS	8 - 11	14 - 1	18 - 6	23 - 8	*	8 - 11	14 - 1	18 - 6	23 - 8	*
	Hem-Fir #1	8 - 9	13 - 9	18 - 2	23 - 1	*	8 - 9	13 - 1	16 - 7	20 - 4	23 - 7
	Hem-Fir #2	8 - 4	13 - 1	17 - 3	21 - 11	25 - 5	8 - 4	12 - 3	15 - 6	19 - 0	22 - 0
	Hem-Fir #3	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6	6 - 5	9 - 5	11 - 11	14 - 6	16 - 10
	Southern Pine SS	9 - 4	14 - 7	19 - 3	24 - 7	*	9 - 4	14 - 7	19 - 3	24 - 7	*
	Southern Pine #1	9 - 1	14 - 4	18 - 11	24 - 1	*	9 - 1	14 - 4	18 - 10	22 - 4	*
	Southern Pine #2	8 - 11	14 - 1	18 - 6	23 - 2	*	8 - 11	13 - 0	16 - 10	20 - 1	23 - 7
	Southern Pine #3	7 - 11	11 - 8	14 - 10	17 - 6	20 - 11	6 - 10	10 - 1	12 - 10	15 - 2	18 - 1
	Spruce-Pine Fir SS	8 - 9	13 - 9	18 - 2	23 - 1	*	8 - 9	13 - 9	18 - 2	23 - 0	*
	Spruce-Pine Fir #1	8 - 7	13 - 5	17 - 9	22 - 3	25 - 9	8 - 6	12 - 5	15 - 9	19 - 3	22 - 4
	Spruce-Pine Fir #2	8 - 7	13 - 5	17 - 9	22 - 3	25 - 9	8 - 6	12 - 5	15 - 9	19 - 3	22 - 4
Spruce-Pine Fir #3	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6	6 - 5	9 - 5	11 - 11	14 - 6	16 - 10	
19.2 in.	Douglas Fir-Larch SS	8 - 11	14 - 0	18 - 5	23 - 7	*	8 - 11	14 - 0	18 - 5	23 - 0	*
	Douglas Fir-Larch #1	8 - 7	13 - 6	17 - 9	21 - 8	25 - 2	8 - 4	12 - 2	15 - 4	18 - 9	21 - 9
	Douglas Fir-Larch #2	8 - 5	13 - 3	16 - 10	20 - 7	23 - 10	7 - 10	11 - 6	14 - 7	17 - 10	20 - 8
	Douglas Fir-Larch #3	6 - 11	10 - 2	12 - 10	15 - 8	18 - 3	6 - 0	8 - 9	11 - 2	13 - 7	15 - 9
	Hem-Fir SS	8 - 5	13 - 3	17 - 5	22 - 3	*	8 - 5	13 - 3	17 - 5	22 - 3	25 - 9
	Hem-Fir #1	8 - 3	12 - 11	17 - 1	21 - 5	24 - 10	8 - 2	12 - 0	15 - 2	18 - 6	21 - 6
	Hem-Fir #2	7 - 10	12 - 4	16 - 3	20 - 0	23 - 2	7 - 8	11 - 2	14 - 2	17 - 4	20 - 1
	Hem-Fir #3	6 - 9	9 - 11	12 - 7	15 - 4	17 - 9	5 - 10	8 - 7	10 - 10	13 - 3	15 - 5
	Southern Pine SS	8 - 9	13 - 9	18 - 2	23 - 1	*	8 - 9	13 - 9	18 - 2	23 - 1	*
	Southern Pine #1	8 - 7	13 - 6	17 - 9	22 - 8	*	8 - 7	13 - 6	17 - 2	20 - 5	24 - 4
	Southern Pine #2	8 - 5	13 - 3	17 - 5	21 - 2	24 - 10	8 - 4	11 - 11	15 - 4	18 - 4	21 - 6
	Southern Pine #3	7 - 3	10 - 8	13 - 7	16 - 0	19 - 1	6 - 3	9 - 3	11 - 9	13 - 10	16 - 6
	Spruce-Pine Fir SS	8 - 3	12 - 11	17 - 1	21 - 9	*	8 - 3	12 - 11	17 - 1	21 - 0	24 - 4
	Spruce-Pine Fir #1	8 - 1	12 - 8	16 - 7	20 - 3	23 - 6	7 - 9	11 - 4	14 - 4	17 - 7	20 - 4
	Spruce-Pine Fir #2	8 - 1	12 - 8	16 - 7	20 - 3	23 - 6	7 - 9	11 - 4	14 - 4	17 - 7	20 - 4
Spruce-Pine Fir #3	6 - 9	9 - 11	12 - 7	15 - 4	17 - 9	5 - 10	8 - 7	10 - 10	13 - 3	15 - 5	
24 in.	Douglas Fir-Larch SS	8 - 3	13 - 0	17 - 2	21 - 10	*	8 - 3	13 - 0	16 - 10	20 - 7	23 - 10
	Douglas Fir-Larch #1	8 - 0	12 - 6	15 - 10	19 - 5	22 - 6	7 - 5	10 - 10	13 - 9	16 - 9	19 - 6
	Douglas Fir-Larch #2	7 - 10	11 - 11	15 - 1	18 - 5	21 - 4	7 - 0	10 - 4	13 - 0	15 - 11	18 - 6
	Douglas Fir-Larch #3	6 - 2	9 - 1	11 - 6	14 - 1	16 - 3	5 - 4	7 - 10	10 - 0	12 - 2	14 - 1
	Hem-Fir SS	7 - 10	12 - 3	16 - 2	20 - 8	25 - 1	7 - 10	12 - 3	16 - 2	19 - 10	23 - 0
	Hem-Fir #1	7 - 8	12 - 0	15 - 8	19 - 2	22 - 2	7 - 4	10 - 9	13 - 7	16 - 7	19 - 3
	Hem-Fir #2	7 - 3	11 - 5	14 - 8	17 - 10	20 - 9	6 - 10	10 - 0	12 - 8	15 - 6	17 - 11
	Hem-Fir #3	6 - 1	8 - 10	11 - 3	13 - 8	15 - 11	5 - 3	7 - 8	9 - 9	11 - 10	13 - 9
	Southern Pine SS	8 - 1	12 - 9	16 - 10	21 - 6	*	8 - 1	12 - 9	16 - 10	21 - 6	*
	Southern Pine #1	8 - 0	12 - 6	16 - 6	21 - 1	25 - 2	8 - 0	12 - 3	15 - 4	18 - 3	21 - 9
	Southern Pine #2	7 - 10	12 - 3	15 - 10	18 - 11	22 - 2	7 - 5	10 - 8	13 - 9	16 - 5	19 - 3
	Southern Pine #3	6 - 5	9 - 6	12 - 1	14 - 4	17 - 1	5 - 7	8 - 3	10 - 6	12 - 5	14 - 9
	Spruce-Pine Fir SS	7 - 8	12 - 0	15 - 10	20 - 2	24 - 7	7 - 8	12 - 0	15 - 4	18 - 9	21 - 9
	Spruce-Pine Fir #1	7 - 6	11 - 9	14 - 10	18 - 2	21 - 0	6 - 11	10 - 2	12 - 10	15 - 8	18 - 3
	Spruce-Pine Fir #2	7 - 6	11 - 9	14 - 10	18 - 2	21 - 0	6 - 11	10 - 2	12 - 10	15 - 8	18 - 3
Spruce-Pine Fir #3	6 - 1	8 - 10	11 - 3	13 - 8	15 - 11	5 - 3	7 - 8	9 - 9	11 - 10	13 - 9	

\* Spans are limited to 26 feet in length. Check sources for availability of lumber in lengths greater than 20 feet.

See footnotes 1-3.

PRESCRIPTIVE DESIGN

**Table 3.26H Rafter Spans for Common Lumber Species**

(Ceiling Attached to Rafters, Ground Snow Load = 70 psf, L/Δ = 240)

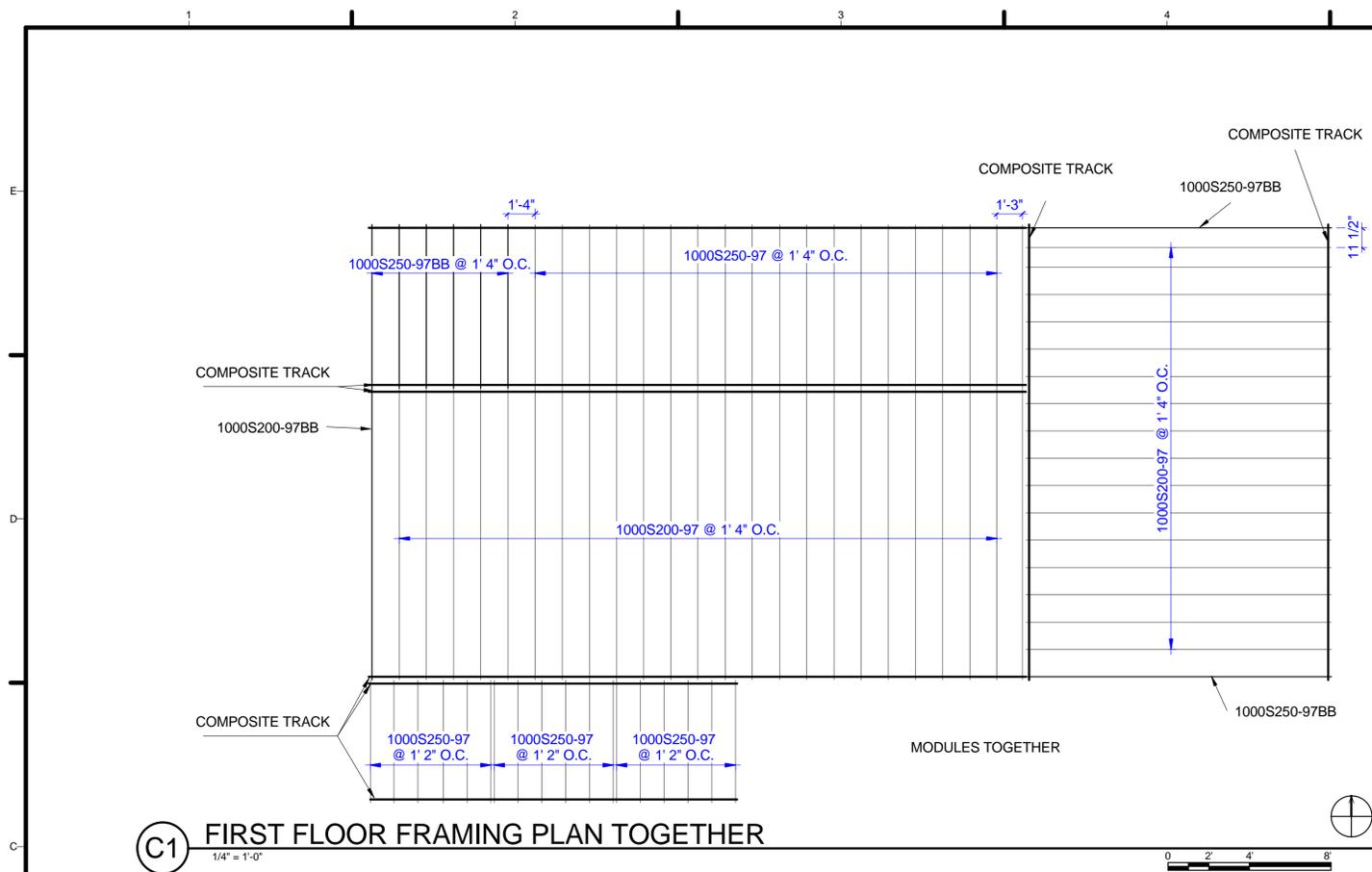
Joist Spacing (ft.-in.)	Species and Grade	Dead Load = 10 psf					Dead Load = 20 psf				
		2x4	2x6	2x8	2x10	2x12	2x4	2x6	2x8	2x10	2x12
		(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)	(ft.-in.)
		Maximum Rafter Spans <sup>1,2</sup>									
12 in.	Douglas Fir-Larch SS	6-6	10-3	13-7	17-3	†	6-6	10-3	13-7	17-3	†
16-8	Douglas Fir-Larch #1	6-4	9-9	12-4	15-1	17-6	6-4	9-3	11-9	14-4	†
15-9	Douglas Fir-Larch #2	6-2	9-3	11-9	14-4	16-7	6-0	8-10	11-2	13-7	16-8
12-1	Douglas Fir-Larch #3	4-10	7-1	9-0	10-11	12-8	4-7	6-9	8-6	10-5	15-9
19-8	Hem-Fir SS	6-2	9-8	12-10	16-4	19-10	6-2	9-8	12-10	16-4	12-1
16-5	Hem-Fir #1	6-1	9-6	12-3	14-11	17-4	6-1	9-2	11-7	14-2	19-8
15-4	Hem-Fir #2	5-9	9-0	11-5	13-11	16-2	5-9	8-7	10-10	13-3	16-5
11-9	Hem-Fir #3	4-9	6-11	8-9	10-8	12-5	4-6	6-7	8-4	10-2	15-4
†	Southern Pine SS	6-5	10-1	13-4	17-0	†	6-5	10-1	13-4	17-0	†
18-7	Southern Pine #1	6-4	9-11	13-1	16-5	19-7	6-4	9-11	13-1	15-7	†
16-5	Southern Pine #2	6-2	9-7	12-4	14-9	17-4	6-2	9-11	11-9	14-0	18-7
12-7	Southern Pine #3	5-0	7-5	9-5	11-2	13-3	4-9	7-1	9-0	10-7	16-5
18-7	Spruce-Pine Fir SS	6-1	9-6	12-6	16-0	19-5	6-1	9-6	12-6	16-0	12-7
15-7	Spruce-Pine Fir #1	5-11	9-2	11-7	14-2	16-5	5-11	8-8	11-0	13-5	18-7
15-7	Spruce-Pine Fir #2	5-11	9-2	11-7	14-2	16-5	5-11	8-8	11-0	13-5	15-7
11-9	Spruce-Pine Fir #3	4-9	6-11	8-9	10-8	12-5	4-6	6-7	8-4	10-2	15-7
17-8	Douglas Fir-Larch SS	5-11	9-4	12-4	15-8	18-7	5-11	9-4	12-4	15-3	11-9
14-5	Douglas Fir-Larch #1	5-9	8-6	10-9	13-1	15-2	5-6	8-0	10-2	12-5	17-8
13-8	Douglas Fir-Larch #2	5-6	8-0	10-2	12-5	14-5	5-2	7-7	9-8	11-9	14-5
10-5	Douglas Fir-Larch #3	4-2	6-2	7-9	9-6	11-0	4-0	5-10	7-4	9-0	13-8
17-1	Hem-Fir SS	5-7	8-10	11-8	14-10	18-0	5-7	8-10	11-8	14-8	10-5
14-3	Hem-Fir #1	5-6	8-4	10-7	12-11	15-0	5-5	7-11	10-0	12-3	17-1
13-3	Hem-Fir #2	5-3	7-10	9-11	12-1	14-0	5-1	7-5	9-4	11-5	14-3
10-2	Hem-Fir #3	4-1	6-0	7-7	9-3	10-9	3-11	5-8	7-2	8-9	13-3
19-10	Southern Pine SS	5-10	9-2	12-1	15-5	18-9	5-10	9-2	12-1	15-5	10-2
16-1	Southern Pine #1	5-9	9-0	11-10	14-3	17-0	5-9	9-0	11-4	13-6	18-9
14-3	Southern Pine #2	5-7	8-4	10-9	12-9	15-0	5-6	7-10	10-2	12-2	16-1
10-11	Southern Pine #3	4-4	6-5	8-2	9-8	11-6	4-2	6-1	7-9	9-2	14-3
16-1	Spruce-Pine Fir SS	5-6	8-8	11-5	14-6	17-0	5-6	8-8	11-4	13-11	10-11
13-6	Spruce-Pine Fir #1	5-4	7-11	10-0	12-3	14-2	5-2	7-6	9-6	11-7	16-1
13-6	Spruce-Pine Fir #2	5-4	7-11	10-0	12-3	14-2	5-2	7-6	9-6	11-7	13-6
10-2	Spruce-Pine Fir #3	4-1	6-0	7-7	9-3	10-9	3-11	5-8	7-2	8-9	13-6
16-1	Douglas Fir-Larch SS	5-7	8-9	11-7	14-8	17-0	5-7	8-9	11-4	13-11	10-2
13-2	Douglas Fir-Larch #1	5-3	7-9	9-9	11-11	13-10	5-0	7-4	9-3	11-4	16-1
12-6	Douglas Fir-Larch #2	5-0	7-4	9-3	11-4	13-2	4-9	7-0	8-10	10-9	13-2
9-6	Douglas Fir-Larch #3	3-10	5-7	7-1	8-8	10-0	3-8	5-4	6-9	8-3	12-6
15-7	Hem-Fir SS	5-3	8-4	10-11	14-0	16-5	5-3	8-4	10-11	13-5	9-6
13-0	Hem-Fir #1	5-2	7-7	9-8	11-10	13-8	4-11	7-3	9-2	11-2	15-7
12-1	Hem-Fir #2	4-10	7-1	9-0	11-0	12-9	4-7	6-9	8-7	10-5	13-0
9-4	Hem-Fir #3	3-9	5-6	6-11	8-5	9-10	3-7	5-2	6-7	8-0	12-1
18-1	Southern Pine SS	5-6	8-8	11-5	14-6	17-8	5-6	8-8	11-5	14-6	9-4
14-8	Southern Pine #1	5-5	8-6	10-11	13-0	15-6	5-5	8-3	10-5	12-4	17-8
13-0	Southern Pine #2	5-3	7-7	9-9	11-8	13-8	5-0	7-2	9-3	11-1	14-8
10-0	Southern Pine #3	4-0	5-10	7-6	8-10	10-6	3-9	5-7	7-1	8-4	13-0
14-8	Spruce-Pine Fir SS	5-2	8-1	10-8	13-4	15-6	5-2	8-1	10-5	12-8	10-0
12-4	Spruce-Pine Fir #1	4-11	7-3	9-2	11-2	13-0	4-8	6-10	8-8	10-7	14-8
12-4	Spruce-Pine Fir #2	4-11	7-3	9-2	11-2	13-0	4-8	6-10	8-8	10-7	12-4
9-4	Spruce-Pine Fir #3	3-9	5-6	6-11	8-5	9-10	3-7	5-2	6-7	8-0	12-4
14-5	Douglas Fir-Larch SS	5-2	8-2	10-9	13-1	15-2	5-2	8-0	10-2	12-5	9-4
11-9	Douglas Fir-Larch #1	4-9	6-11	8-9	10-8	12-5	4-6	6-7	8-4	10-2	14-5
11-2	Douglas Fir-Larch #2	4-6	6-7	8-4	10-2	11-9	4-3	6-3	7-11	9-7	11-9
8-6	Douglas Fir-Larch #3	3-5	5-0	6-4	7-9	9-0	3-3	4-9	6-0	7-4	11-2
13-11	Hem-Fir SS	4-11	7-8	10-2	12-8	14-8	4-11	7-8	9-10	12-0	8-6
11-7	Hem-Fir #1	4-8	6-10	8-8	10-7	12-3	4-5	6-6	8-2	10-0	13-11
10-10	Hem-Fir #2	4-4	6-4	8-1	9-10	11-5	4-2	6-1	7-8	9-4	11-7
8-4	Hem-Fir #3	3-4	4-11	6-2	7-7	8-9	3-2	4-8	5-10	7-2	10-10
16-3	Southern Pine SS	5-1	8-0	10-7	13-6	16-5	5-1	8-0	10-7	13-6	8-4
13-2	Southern Pine #1	5-0	7-9	9-9	11-7	13-10	5-0	7-5	9-3	11-0	16-3
11-7	Southern Pine #2	4-9	6-9	8-9	10-5	12-3	4-6	6-5	8-4	9-11	13-2
8-11	Southern Pine #3	3-7	5-3	6-8	7-11	9-5	3-4	5-0	6-4	7-6	11-7
13-2	Spruce-Pine Fir SS	4-10	7-6	9-9	11-11	13-10	4-10	7-4	9-3	11-4	8-11
11-0	Spruce-Pine Fir #1	4-5	6-6	8-2	10-0	11-7	4-2	6-2	7-9	9-6	13-2
11-0	Spruce-Pine Fir #2	4-5	6-6	8-2	10-0	11-7	4-2	6-2	7-9	9-6	11-0
8-4	Spruce-Pine Fir #3	3-4	4-11	6-2	7-7	8-9	3-2	4-8	5-10	7-2	11-0

† Spans are limited to 20 feet in length.  
See footnotes 1-3.









- GENERAL SHEET NOTES**
- 1 COLD FORM STEEL FY=50 KSI
  - 2 THICKNESS OF STEEL = 0.1017 INCH
  - 3 ALL LINES ARE CENTER LINES OF BEAMS



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 116 KUMER STUDENT DESIGN CENTER  
 ROLLA, MO 65401-11410  
 CONTACT: SOLARHOUSE@MST.EDU  
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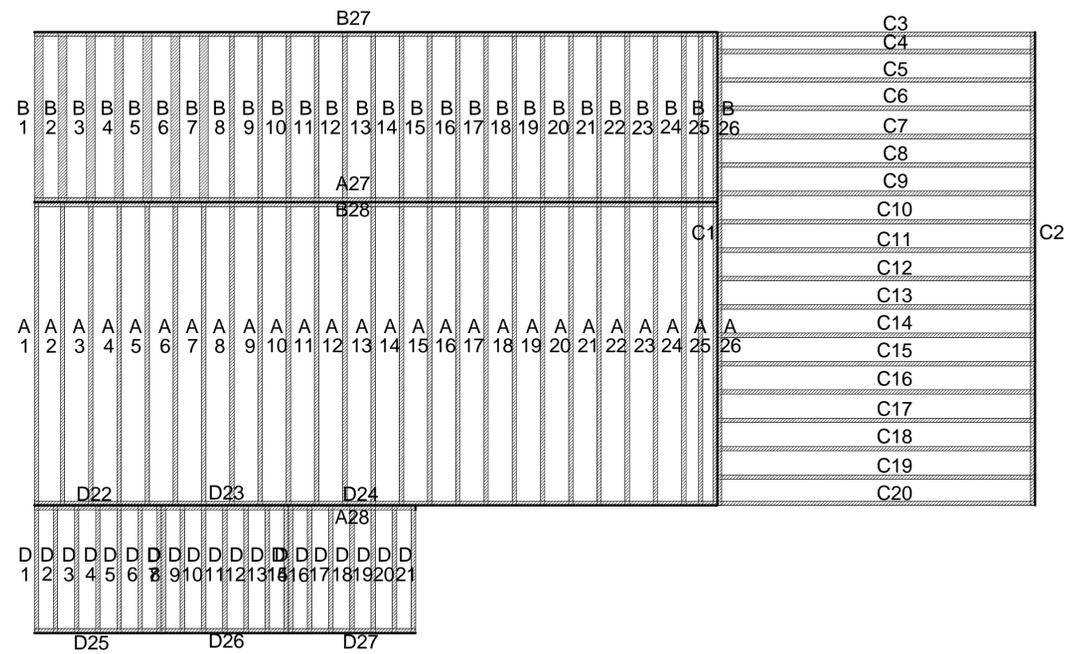


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SHEET TITLE  
**FIRST FLOOR FRAMING PLAN**

**S-103**

**C1** FIRST FLOOR FRAMING PLAN TOGETHER  
 1/4" = 1'-0"



**A1** FIRST FLOOR FRAMING PLAN DESIGNATION  
 1/4" = 1'-0"

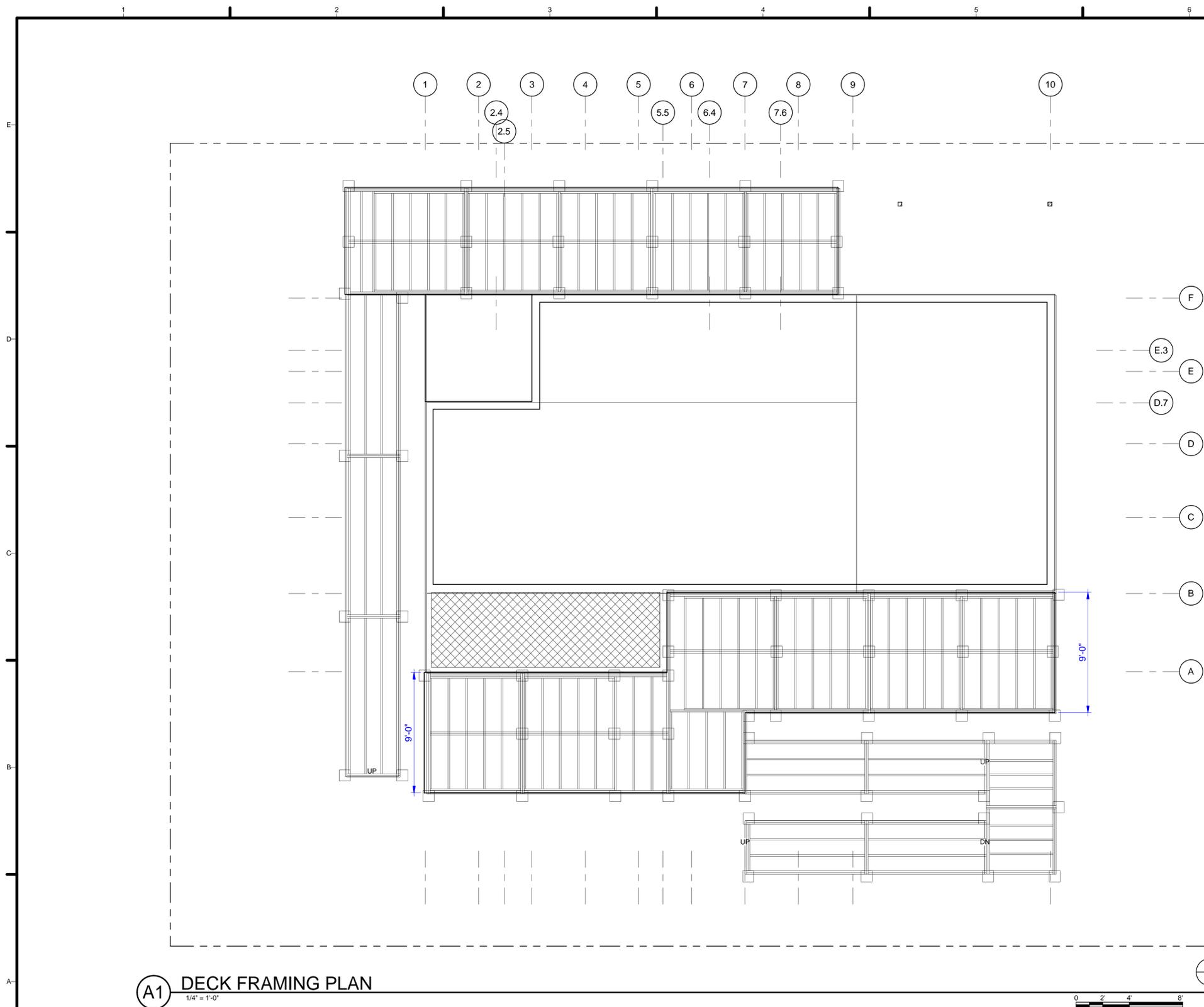
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**A1 DECK FRAMING PLAN**  
1/4" = 1'-0"

**GENERAL SHEET NOTES**

- 1 PRELIMINARY DECK DESIGN. SUBJECT TO CHANGE
- 2 DECK JOISTS 2X6 LUMBER
- 3 DECK GIRDERS 2X10 LUMBER
- 4 16" O.C. SPACING BETWEEN JOISTS



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SHEET TITLE  
**DECK FRAMING PLAN**

**S-105**

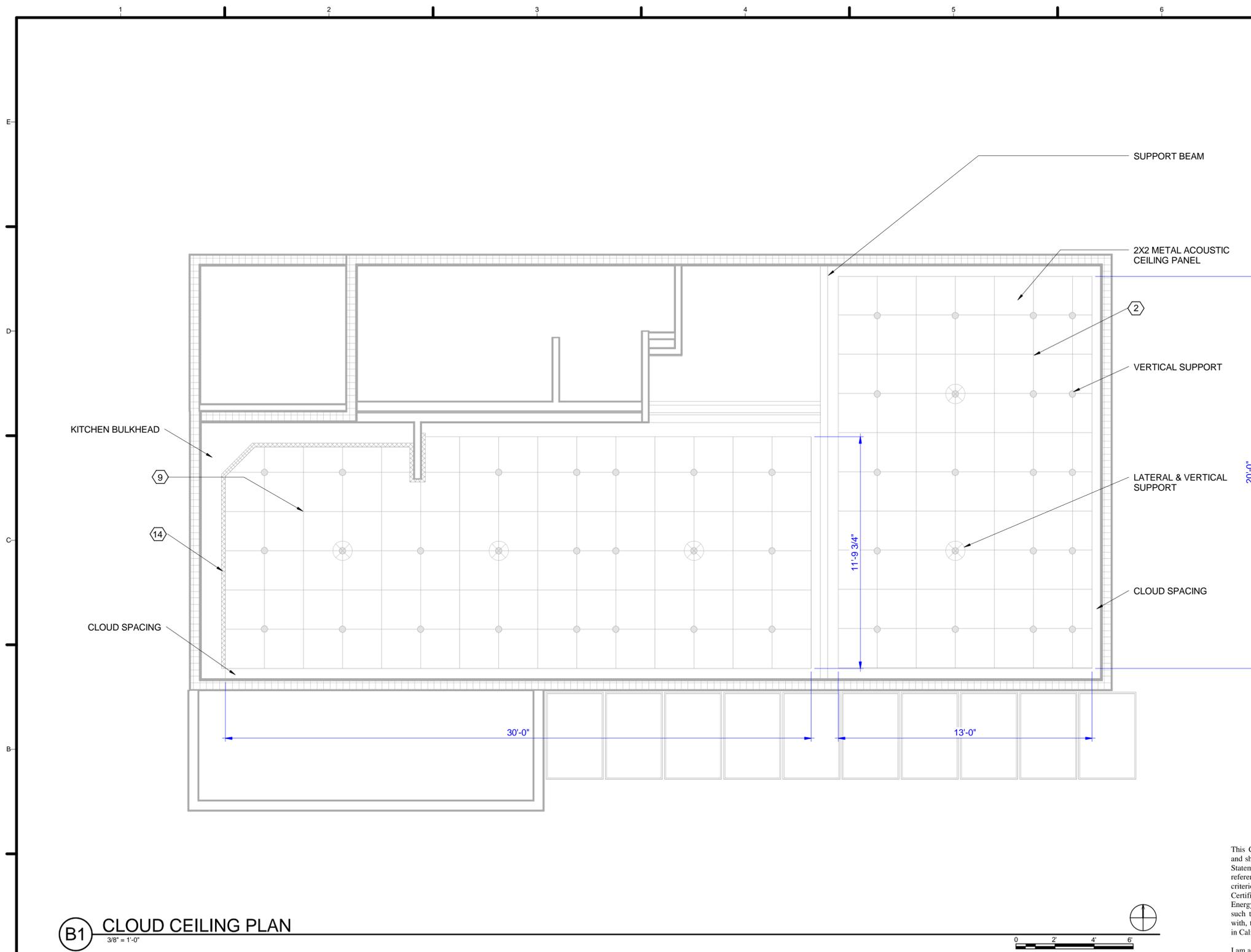
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**GENERAL SHEET NOTES**

- 1 SUSPENDED CLOUD CEILING DESIGNED TO COMPLY WITH ASTM E580 WITH SEISMIC DESIGN CATEGORIES D,E,F.
- 2 VERTICAL SUPPORT WILL CONSIST OF NO. 12 GAUGE HANGER WIRE HOWEVER, THOSE LOCATIONS WITH LATERAL BRACING WILL USE STEEL STUD FOR COMPRESSION POST AND VERTICAL SUPPORT.
- 3 LATERAL BRACING WILL CONSIST OF 4 NO. 12 GAUGE HANGER WIRES SPLAYED 90° FROM EACH OTHER AT AN ANGLE NOT MORE THAN 45° FROM THE MAIN BEAM OR CROSS TEE

**SHEET KEYNOTES**

- 2 BEDROOM CLOUD: MAIN BEAMS RUN NORTH TO SOUTH, CROSS TEES RUN EAST TO WEST
- 9 MAIN ROOM: MAIN BEAMS RUN EAST TO WEST, CROSS TEES RUN NORTH TO SOUTH
- 14 MAIN ROOM CLOUD WILL BE ATTACHED TO KITCHEN BULK HEAD AND WALL ALONG DIAGONAL CROSS HATCH



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SHEET TITLE  
**CLOUD CEILING ANCHOR LOCATIONS**

**S-108**

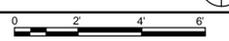
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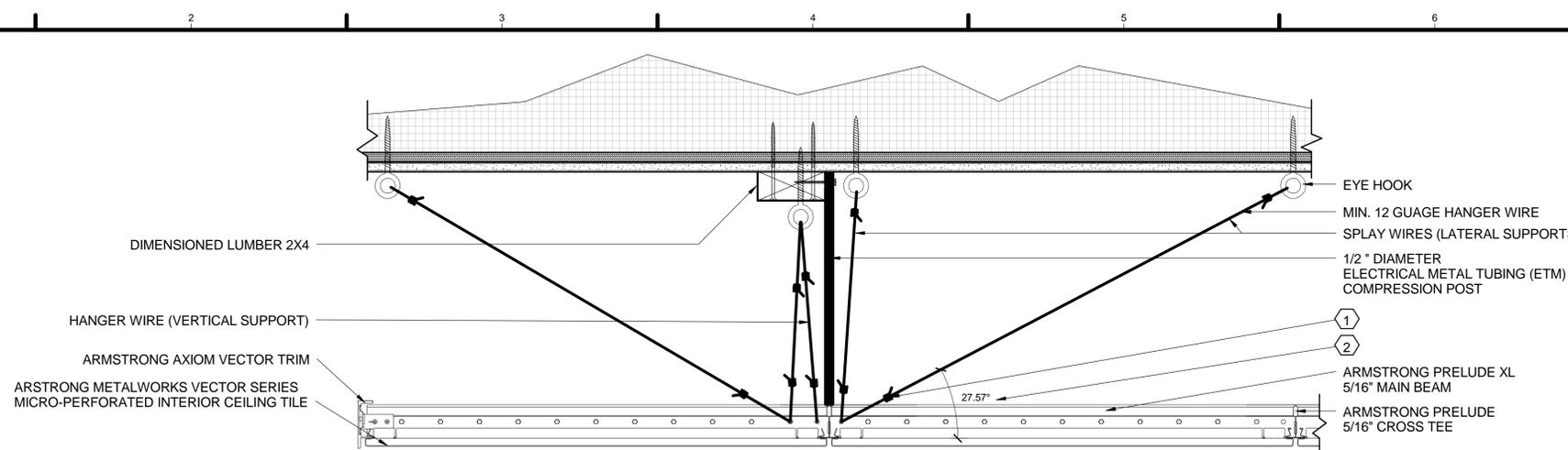


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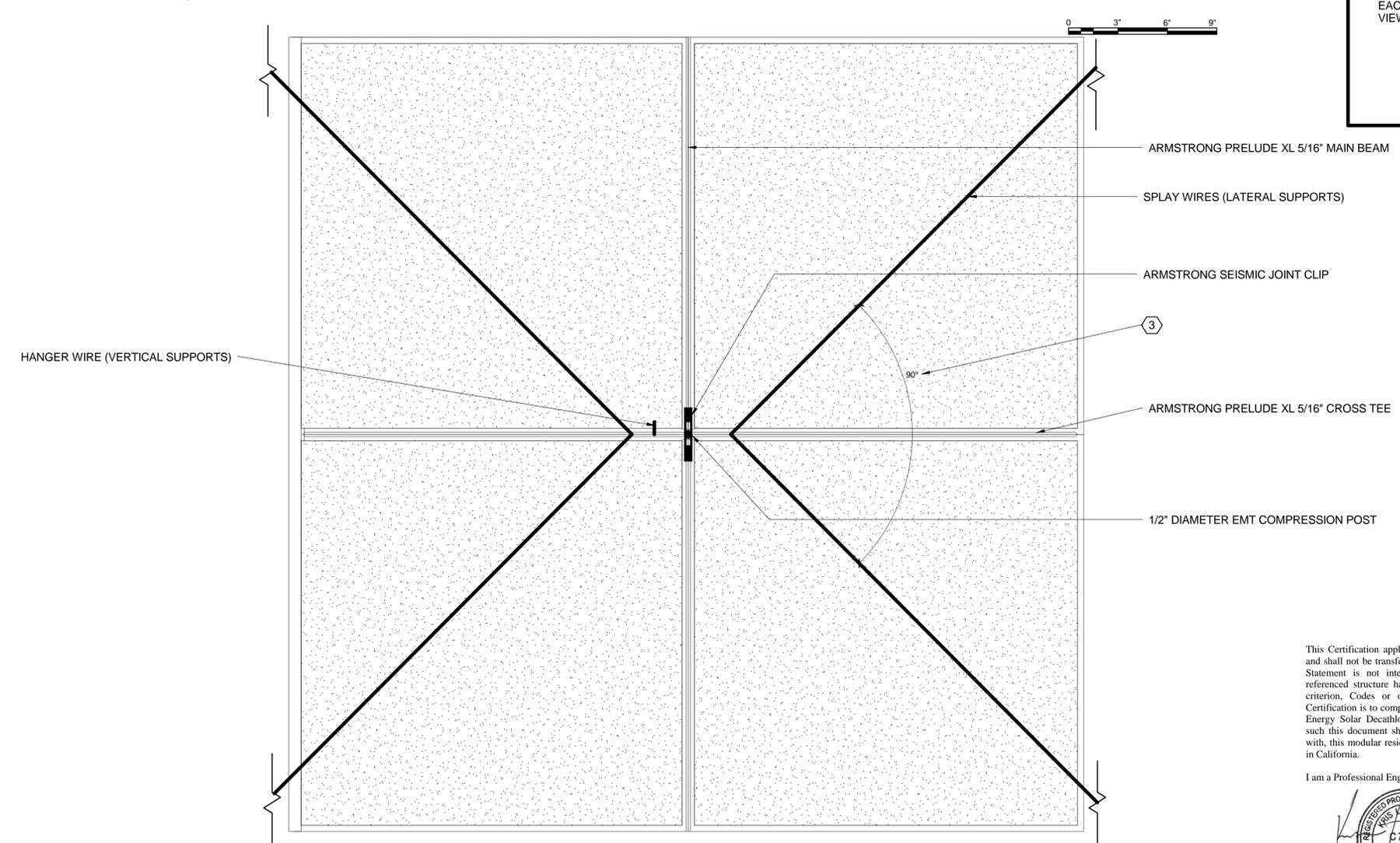
**B1 CLOUD CEILING PLAN**  
 3/8" = 1'-0"







**D2** SUSPENDED CEILING SECTION DETAIL  
3" = 1'-0"



**A2** SUSPENDED CEILING PLAN DETAIL  
3" = 1'-0"

**GENERAL SHEET NOTES**

- 1 HANGER WIRES (VERTICAL SUPPORTS) MUST BE POSITIONED EVERY 4'
- 2 COMPRESSION POSTS MUST BE POSITIONED EVERY 12'
- 3 SPLAY WIRES (LATERAL SUPPORTS) MUST BE POSITIONED EVERY 12'

**SHEET KEYNOTES**

- 1 ALL SUPPORT WIRES MUST BE SECURED WITH A MINIMUM OF 3 TWISTS
- 2 SPLAY WIRES (LATERAL SUPPORTS) MUST MAKE AN ANGLE OF 45° OR LESS WITH THE CEILING PLANE
- 3 SPLAY WIRES (LATERAL SUPPORTS) MUST MAKE AN ANGLE OF 90° WITH EACH OTHER WHEN MEASURED IN PLAN VIEW



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SHEET TITLE  
**SUSPENDED CEILING DETAILS**

**S-541**

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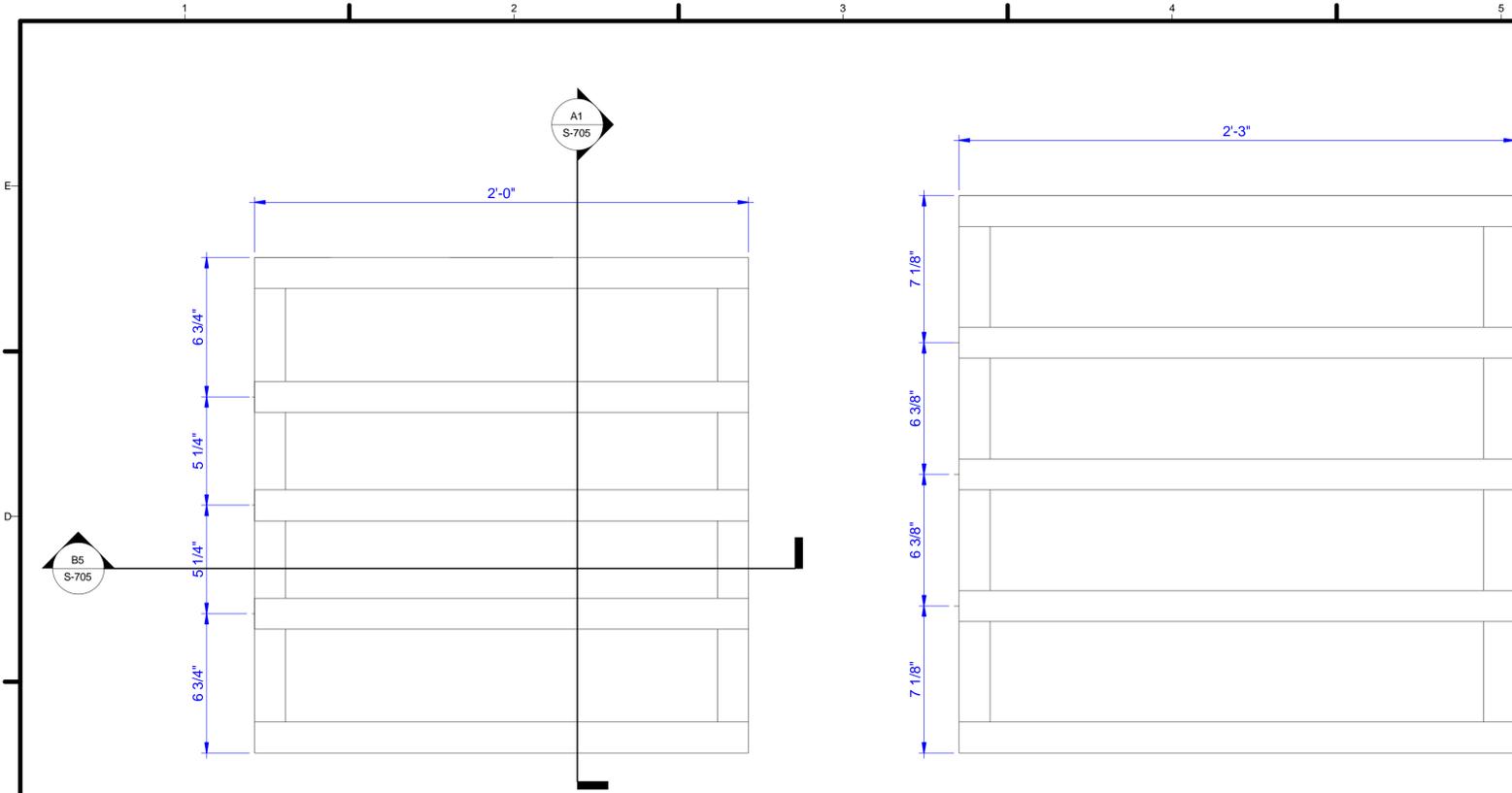




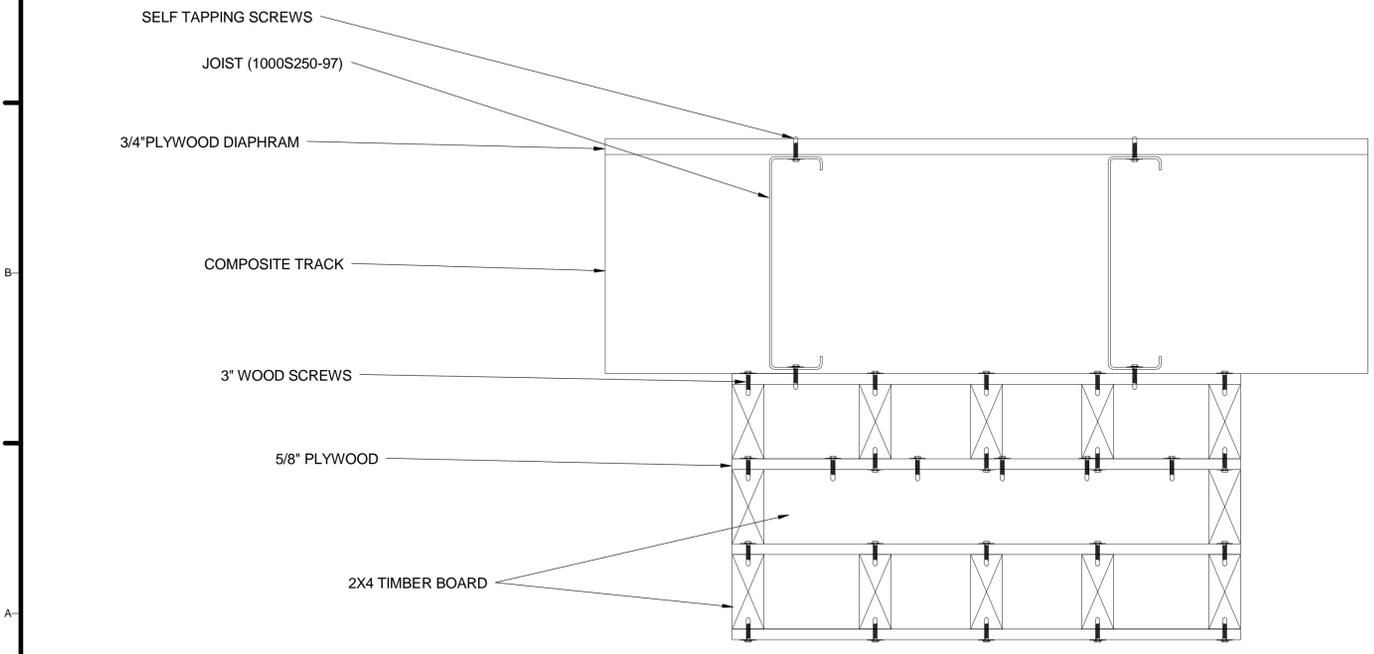








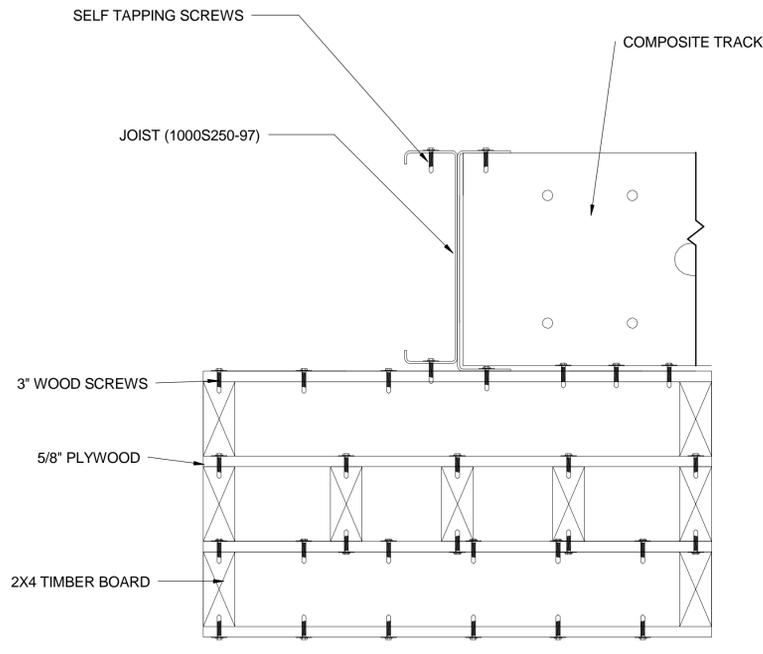
**C1** TYPICAL PIER LAYER PLAN VIEW (2' & 2' 3")  
3" = 1'-0"



**A1** TYPICAL PIER LAYER SECTION 2 (2' & 2' 3")  
3" = 1'-0"

**SHEET KEYNOTES**

17 WOODEN PIERS ARE CONSTRUCTED WITH 2X4 AND 5/8" PLYWOOD



**B5** TYPICAL PIER LAYER SECTION 1 (2' & 2' 3")  
3" = 1'-0"



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SHEET TITLE  
**TYPICAL PIER DETAILS**

**S-705**

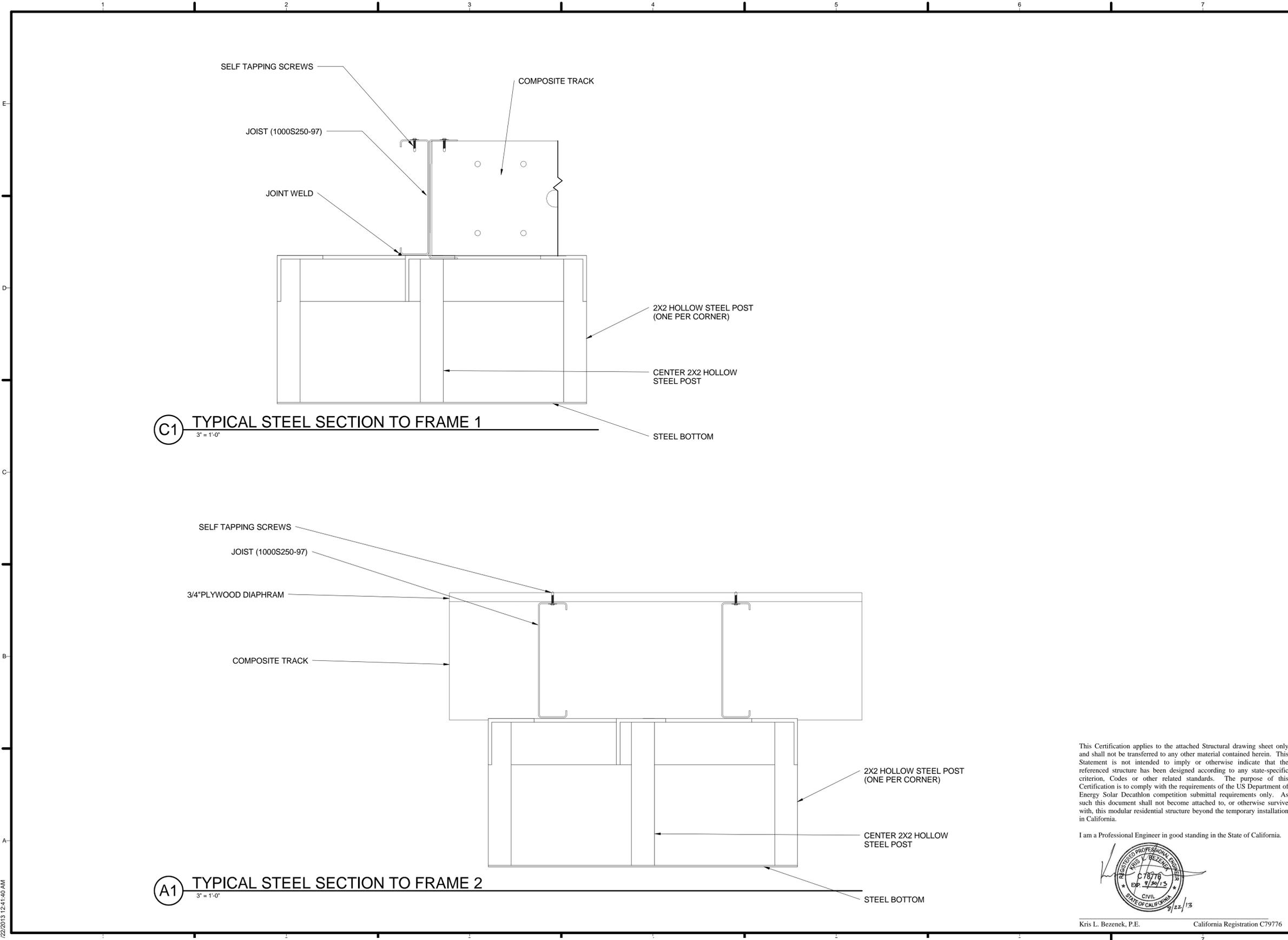
This Certification applies to the attached Structural drawing sheet only and shall not be transferred to any other material contained herein. This Statement is not intended to imply or otherwise indicate that the referenced structure has been designed according to any state-specific criterion, Codes or other related standards. The purpose of this Certification is to comply with the requirements of the US Department of Energy Solar Decathlon competition submittal requirements only. As such this document shall not become attached to, or otherwise survive with, this modular residential structure beyond the temporary installation in California.

I am a Professional Engineer in good standing in the State of California.



Kris L. Bezenek, P.E. California Registration C79776





TEAM NAME: MISSOURI S&T SOLAR HOUSE TEAM  
 ADDRESS: 1051 NORTH BISHOP AVENUE  
 116 KUMER STUDENT DESIGN CENTER  
 ROLLA, MO 65401-11410  
 CONTACT: SOLARHOUSE@MST.EDU  
 WWW.SOLARHOUSE.MST.EDU

CLIENT  
 U.S. DEPARTMENT OF ENERGY  
 SOLAR DECATHLON 2013  
 WWW.SOLARDECATHLON.ORG



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LOT NUMBER:	107	
DRAWN BY:	Author	
CHECKED BY:	US DOE SOLAR DECATHLON 2013	
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SHEET TITLE  
**TYPICAL STEEL PIER DETAILS**

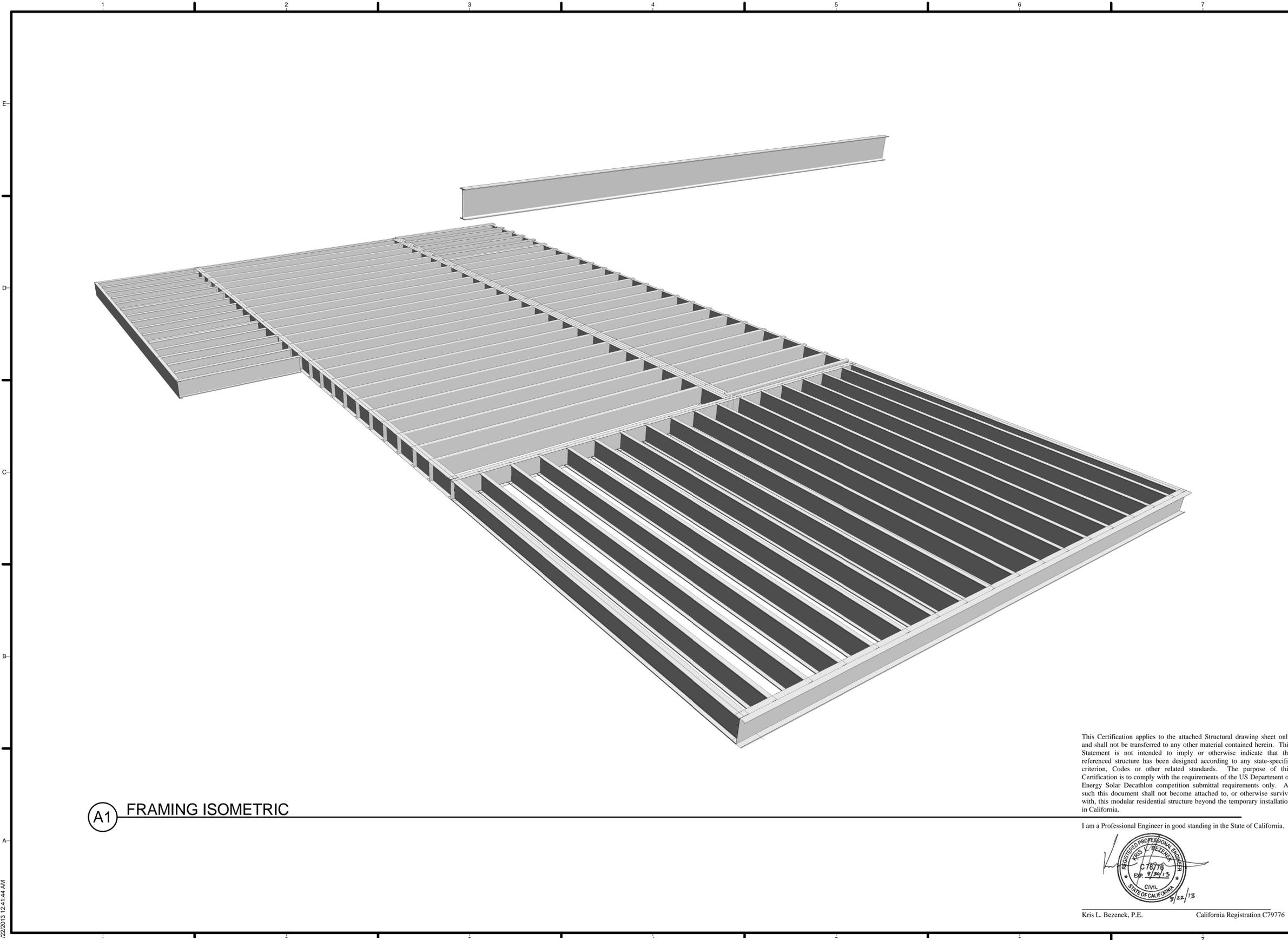
**S-707**

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Kris L. Bezenek, P.E. California Registration C79776



(A1) FRAMING ISOMETRIC

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 116 KUMER STUDENT DESIGN CENTER  
 ROLLA, MO 65401-11410  
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SHEET TITLE  
 FRAMING ISOMETRICS

S-901

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TEAM NAME: MISSOURI S&T SOLAR HOUSE TEAM  
 ADDRESS: 1051 NORTH BISHOP AVENUE  
 116 KUMER STUDENT DESIGN CENTER  
 ROLLA, MO 65401-11410  
 CONTACT: SOLARHOUSE@MST.EDU  
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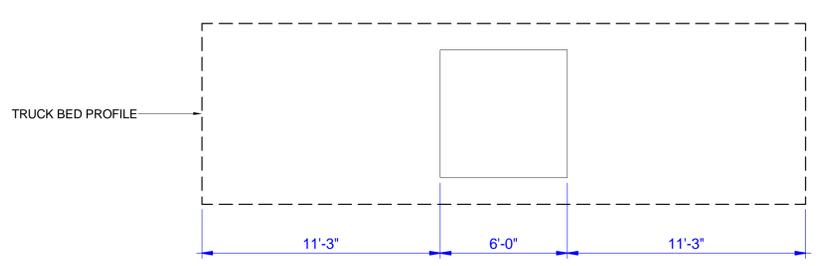
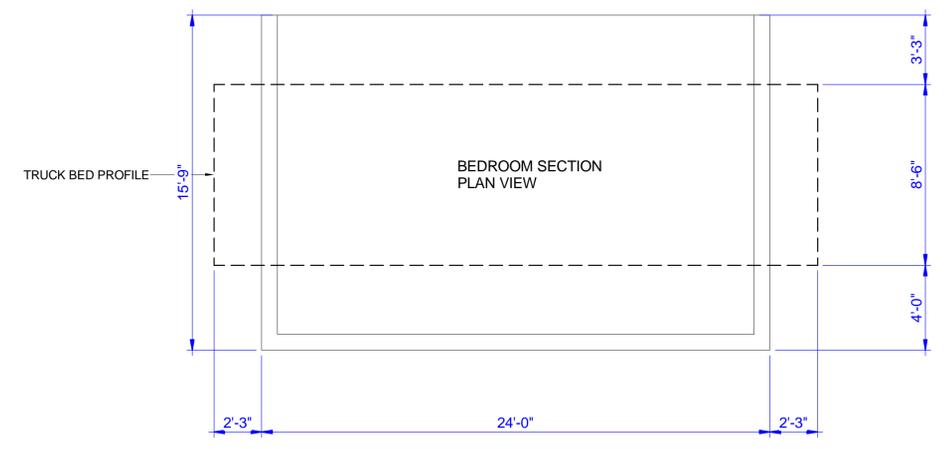
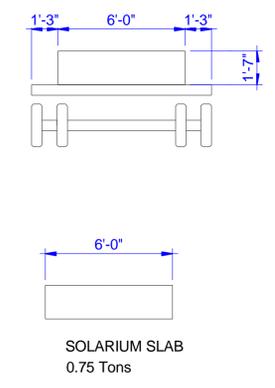
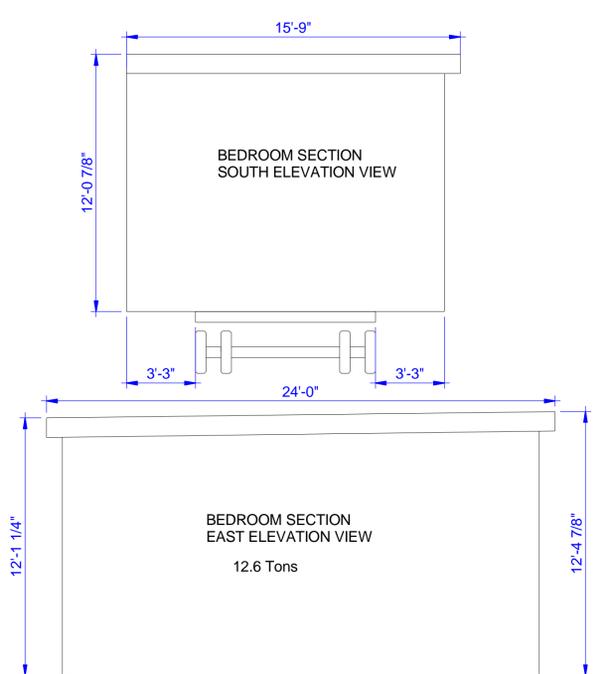
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LOT NUMBER:	107	
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SHEET TITLE  
**TRUCK LOADING DIAGRAMS**

**O-602**



**A1 TRUCK LOADING DIAGRAMS**  
 1/4" = 1'-0"

/22/2013 12:40:15 AM

This Certification applies to the attached Structural drawing sheet only and shall not be transferred to any other material contained herein. This Statement is not intended to imply or otherwise indicate that the referenced structure has been designed according to any state-specific criterion, Codes or other related standards. The purpose of this Certification is to comply with the requirements of the US Department of Energy Solar Decathlon competition submittal requirements only. As such this document shall not become attached to, or otherwise survive with, this modular residential structure beyond the temporary installation in California.

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Kris L. Bezenek, P.E. California Registration C79776



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 ADDRESS: 1051 NORTH BISHOP AVENUE  
 116 KUMER STUDENT DESIGN CENTER  
 ROLLA, MO 65401-11410  
 CONTACT: SOLARHOUSE@MST.EDU  
 WWW.SOLARHOUSE.MST.EDU

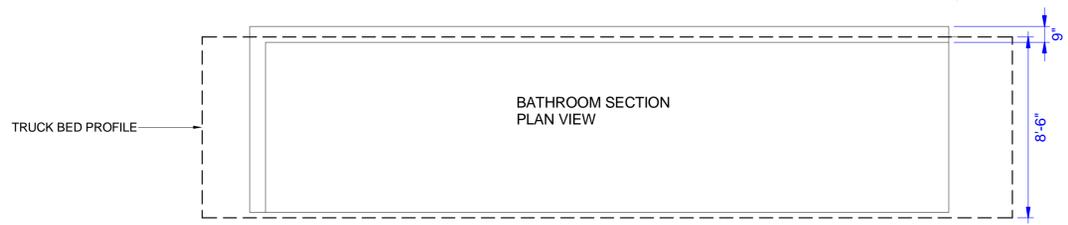
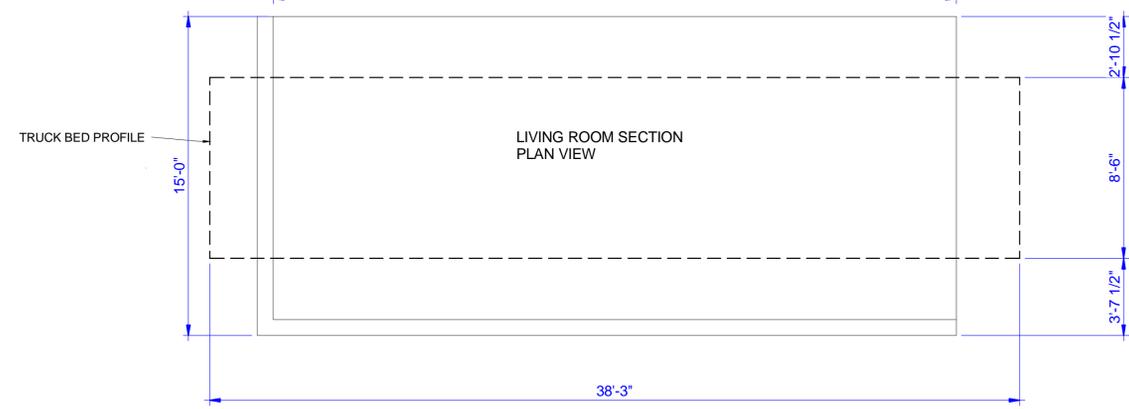
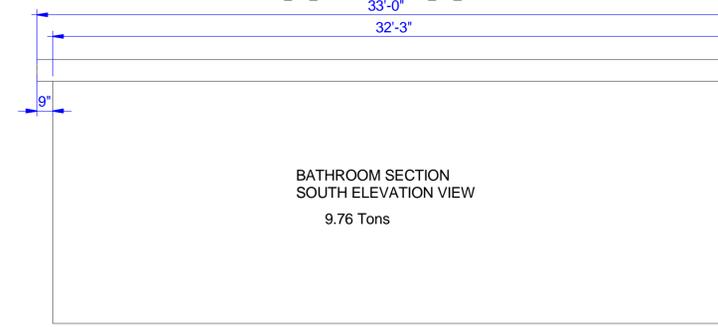
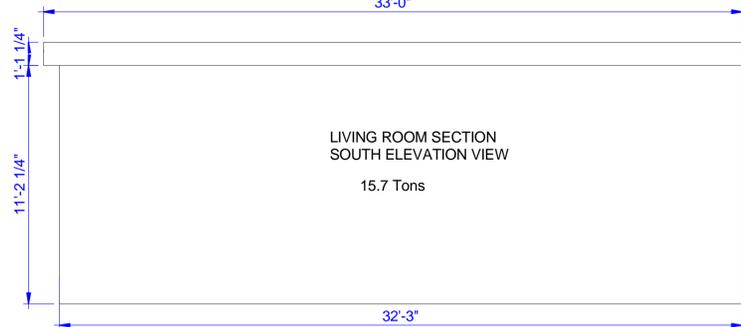
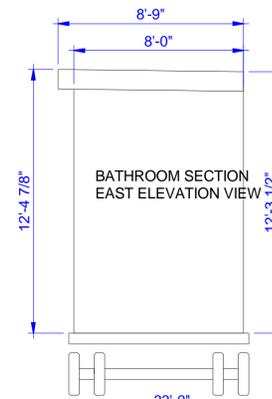
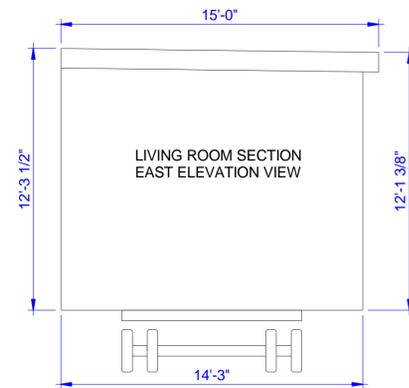
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MARK	DATE	DESCRIPTION

SHEET TITLE  
**TRUCK LOADING DIAGRAMS**

**O-603**



**(A1) TRUCK LOADING DIAGRAMS 2**  
 1/4" = 1'-0"

/22/2013 12:40:19 AM



ENERGY PANEL STRUCTURES  
 102 EAST INDUSTRIAL PARK  
 GRAETTINGER, IA 51342  
 PHONE: 712/859-3219  
 FAX: 712/859-3275  
 WWW.EPSBUILDINGS.COM

DESIGN LOADS
CODE BODY: IRC 2009
GROUND SNOW LOAD: 20 PSF
OCCUPANCY CATEGORY: II
Ct: 1.1
Ce: 1.0
Is: 1.0
Cs: 1.0
ROOF LIVE LOAD: 20 PSF
ROOF DEAD LOAD: 18 PSF
EXPOSURE: C
Iw: 1.0

SHEET	DRAWING INDEX
S0	TITLE SHEET
S1.0	PLANVIEW
S2.0	BUILDING SECTIONS
S3.0	BUILDING DETAILS
S4.0	PANEL ELEVATIONS
S4.1	ROOF PANEL LAYOUT
C1.0	CONSTRUCTION DETAILS



PROJECT NUMBER:  
2013/HOUSE/89539

CUSTOMER SERVICE:  
JB

DRAWN BY:  
MAB

REVIEWED BY:  
RGW

DATE:  
4/1/2013

REVISIONS:  
4/10/13  
4/11/13  
-

GENERAL INFORMATION				
DEALER: BBL — PERRYVILLE, MO PHONE: (573) 547-8363 FAX: --	OWNER: MISSOURI S&T 1051 NORTH BISHOP AVE ROLLA, MO	BUILDING TYPE: SOLID CORE	BUILDING DIMENSIONS: 47'-3" 22'-3"	AREA: 988 SQ. FT.

DEALER: BBL — PERRYVILLE, MO PHONE: (573) 547-8363 FAX: --	OWNER: MISSOURI S&T 1051 NORTH BISHOP AVE ROLLA, MO	BUILDING TYPE: SOLID CORE	BUILDING DIMENSIONS: 47'-3" 22'-3"	AREA: 988 SQ. FT.
---	--	------------------------------	--	----------------------

\* SITEWORK: THE SITE SHALL BE GRADED TO PROVIDE DRAINAGE AWAY FROM THE BUILDING.

\* WOOD FRAMING: ALL WOOD CONSTRUCTION SHALL BE IN CONFORMANCE WITH THE PROVISIONS OF THE 2005 EDITION OF THE NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION. UNLESS NOTED OTHERWISE ALL FRAMING LUMBER SHALL BE SPF#2 GRADE.

\* SHORING AND BRACING: CONTRACTOR SHALL BE RESPONSIBLE FOR ALL TEMPORARY SHORING AND BRACING.

\* THIS SET OF PLANS ARE INTENDED TO BE USED BY CONTRACTORS WITH BUILDING CONSTRUCTION KNOWLEDGE.

\* ENERGY PANEL STRUCTURES CAN NOT BE HELD RESPONSIBLE FOR MISUSE OR MISINTERPRETATION OF INFORMATION INCLUDED IN THESE DRAWINGS, OR THE USE OF THIS SET OF PLANS BY PEOPLE WITHOUT BUILDING CONSTRUCTION KNOWLEDGE.

\* SIP PANEL WALL CONSTRUCTION BUILDINGS ARE DESIGNED FOR MINIMAL AIR INFILTRATION. IT IS RECOMMENDED THAT GENERAL CONTRACTOR/OWNER WORKS IN CONJUNCTION WITH AN HVAC PROFESSIONAL TO DESIGN A SYSTEM TO INSURE AIR QUALITY AND MOISTURE CONTROL. AIR TO AIR EXCHANGERS ARE RECOMMENDED IN SUCH TYPE STRUCTURES.

\* RESPONSIBILITY OF THIS SET OF PLANS IS LIMITED TO THE BUILDING DESIGN SHOWN ON THE PLANS. BUILDING DESIGN IS BASED ON NUMBER, SIZE AND LOCATION OF OPENINGS SHOWN ON THE PLANS. NO RESPONSIBILITY IS ASSUMED FOR ADDITIONAL OPENINGS NOT SHOWN ON THE PLANS OR CHANGES IN THE LOCATION OR SIZE OF OPENINGS.

\* ALL DOOR AND WINDOW OPENINGS SHOWN ON THIS SET OF PLANS ARE THE ACTUAL SIZE OF THE OPENING PROVIDED. IT IS THE GENERAL CONTRACTOR/OWNER'S RESPONSIBILITY TO VERIFY ALL LOCATIONS AND SIZES OF OPENINGS PRIOR TO CONSTRUCTION.

\* EPS WALL PANELS ARE NOT DESIGNED FOR LATERAL LOADS IMPOSED BY CONCRETE FOUNDATION WALLS. CONCRETE WALLS TO BE DESIGNED TO ABSORB ALL LOADS IMPOSED BY EPS STRUCTURE AND 100% OF ALL MATERIAL/BACKFILL(ETC) (IF ANY) STORED AGAINST THEM. CONCRETE WALL TO IMPOSE NO HORIZONTAL LOAD TO EPS STRUCTURE.

\* THIS BUILDING IS DESIGNED USING THE ROOF AS A DIAPHRAGM(DEEP THIN BEAM) TO TRANSFER SIDEWALL AND ROOF WIND LOADS TO THE ENDWALL SHEAR WALLS SHOWN. SIP PANELS AND/OR SHEATHING IS AN INTEGRAL PART OF THE BUILDING STRUCTURE AND ANY FUTURE FIELD MODIFICATIONS MADE MAY BE DETRIMENTAL TO THE BUILDING'S STRUCTURAL PERFORMANCE.

\* THIS IS A STRUCTURAL FRAMING PLAN AND IS TO BE USED FOR THAT PURPOSE ONLY. CODES REGARDING FIRE SAFETY, PERSONAL SAFETY & INJURY ARE NOT ADDRESSED IN THIS SET OF PLANS AND ARE THE RESPONSIBILITY OF THE CONTRACTOR/OWNER.

\* TO MINIMIZE THE POSSIBILITY OF FASTENER POPPING AND CRACKING IN AREAS ADJACENT TO A WALL AND CEILING INTERSECTION, A FLOATING GYPSUM CORNER ANGLE METHOD OF APPLICATION SHOULD BE USED. PLEASE REFER TO THE GYPSUM ASSOCIATION'S SPECIFICATIONS FOR THE APPLICATION AND FINISHING OF GYPSUM PANEL PRODUCTS.

\* THERE MAY BE SOME "BOWING" OF EXTERIOR STRUCTURAL INSULATED PANELS DUE TO A TEMPERATURE AND MOISTURE DIFFERENTIAL BETWEEN INTERIOR AND EXTERIOR OSB SKINS. WHEN THE EXTERIOR SKIN EXPERIENCES COLD TEMPERATURE, ITS MOISTURE CONTENT RISES, WHICH CAUSES THE EXTERIOR SKIN TO EXPAND. THIS MAY CAUSE THE PANEL TO BOW OUT. TO MINIMIZE THE EFFECT, YOU MAY WANT TO CONSIDER:  
 A.) HIDE THE "BOW" BY USING FLOATING CORNERS ON THE INTERIOR GYPSUM BOARD.  
 B.) MECHANICALLY FASTENING ONE STRUCTURAL INSULATED PANEL TO THE CROSS WALLS. THE CROSS WALL WILL HAVE TO BE DESIGNED TO RESIST FORCES OF THE BOW, AS WILL THE MECHANICAL FASTENERS.

\* INTERIOR FINISH MUST BE COVERED WITH A MINIMUM OF 1/2" TYPE X SHEETROCK TO PROVIDE AN ADEQUATE THERMAL BARRIER

NOTE: WHEN APPLYING ICE & WATER OR "PEEL & SEAL" FOLLOW THE FOLLOWING INSTRUCTIONS TO PREVENT AIR INFILTRATION  
 1. BE SURE TEMPERATURE OF MATERIALS AND AMBIENT TEMPERATURE ARE BOTH ABOVE 50° F.  
 2. THOROUGHLY CLEAN SURFACES.  
 3. APPLY ACETONE(BY OTHERS) TO METAL SURFACE TO CLEAN.  
 4. ALLOW ACETONE TO FLASH OFF.  
 5. APPLY "PEEL & SEAL" OR ICE & WATER. BE SURE TO APPLY PRESSURE THROUGH OUT MATERIAL TO ENSURE 100% CONTACT.

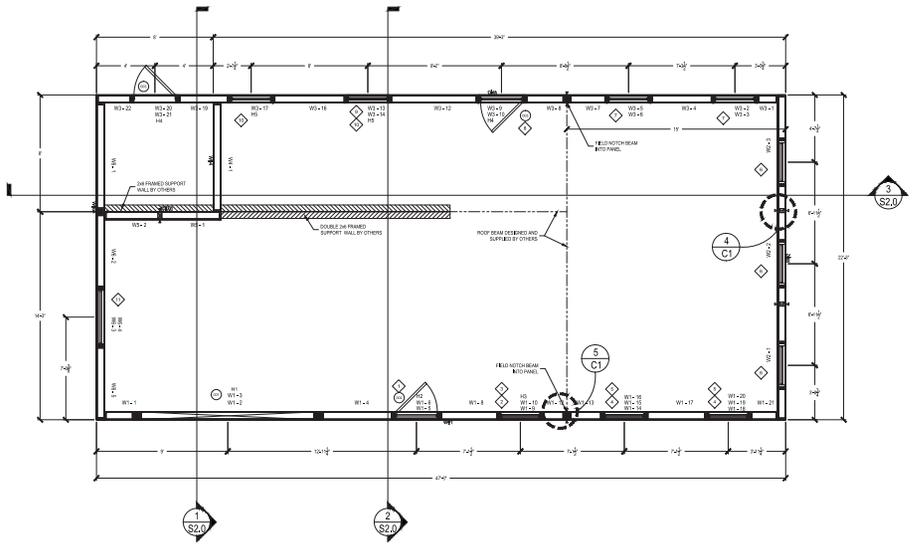
\* THIS SET OF PLANS ARE PANEL SHOP PLANS ONLY. OVERALL STRUCTURAL DESIGN OF THIS BUILDING IS BY OTHERS, AND NOT THE RESPONSIBILITY OF ENERGY PANEL STRUCTURES.

BBL  
 MISSOURI S&T  
 SOLID CORE BUILDING PACKAGE

BBL  
 MISSOURI S&T  
 SOLID CORE BUILDING PACKAGE  
 TITLE SHEET

PROJECT STATUS:

SHEET:  
**S0**



**1 PLANVIEW**  
 SCALE: 1/4" = 1'-0"

DOOR OPENING SCHEDULE							
Number	Quantity	Rough Width	Rough Height	Head Height	Header	Bearing Studs (Each Side)	Full Studs (Each Side)
001	1	12'-1"	6'-9"	7'-4 7/8"	2-PLY 1 3/4"x1-1/4" LVL w/ 2" FOAM CORE	2	2
002	1	3'-2 3/8"	6'-10 1/2"	7'-8 3/8"	2-PLY 1 3/4"x7-1/4" LVL w/ 2" FOAM CORE	1	0
003	2	3'-2 3/8"	6'-10 1/2"	7'-8 3/8"	2-PLY 1 3/4"x1-1/4" LVL (RIPPED TO 10 3/4") w/ 2" FOAM CORE	1	0

WINDOW SCHEDULE							
Number	Quantity	Rough Width	Rough Height	Head Height	Header	Bearing Studs (Each Side)	Full Studs (Each Side)
1	1	3'-2 3/8"	1'-2 1/2"	9'-8 1/8"	2-PLY 1 3/4"x7-1/4" LVL w/ 2" FOAM CORE	1	0
2	1	3'-0"	4'-11 1/2"	6'-10 1/4"	2-PLY 1 3/4"x7-1/4" LVL w/ 2" FOAM CORE	1	0
3	1	3'-0"	1'-2 1/2"	9'-8 1/8"	2-PLY 1 3/4"x7-1/4" LVL w/ 2" FOAM CORE	1	0
4	2	3'-0"	4'-11 1/2"	6'-10 1/4"	SIP HEADER	0	1
5	2	3'-0"	1'-2 1/2"	9'-8 1/8"	SIP HEADER	0	1
6	3	3'-0"	1'-2 1/2"	9'-8 1/8"	2x6 WRAPPED OPENING	0	0
7	2	3'-0"	1'-5"	9'-8 1/8"	SIP HEADER	0	1
8	1	3'-2 3/8"	1'-5"	9'-8 1/8"	2-PLY 1 3/4"x1-1/4" LVL (RIPPED TO 10 3/4") w/ 2" FOAM CORE	1	0
9	1	3'-0"	3'-0"	7'-4 7/8"	2-PLY 1 3/4"x1-1/4" LVL (RIPPED TO 10 3/4") w/ 2" FOAM CORE	1	0
10	2	3'-0"	1'-6"	9'-8 1/8"	2-PLY 1 3/4"x1-1/4" LVL (RIPPED TO 10 3/4") w/ 2" FOAM CORE	1	0
11	1	4'-0"	3'-0"	7'-4 7/8"	SIP HEADER	0	0



AN EMPLOYEE-OWNED COMPANY  
 ENERGY PANEL STRUCTURES  
 105 EAST INDUSTRIAL PARK  
 GRANTTOWN, IA 51442  
 PHONE: 712.609.3219  
 FAX: 712.609.3219  
 WWW.EPSBUILDINGS.COM

PROJECT NUMBER:  
 2013/HOUSE/89539  
 CUSTOMER SERVICE:  
 JB  
 DRAWN BY:  
 MAB  
 REVIEWED BY:  
 RGW

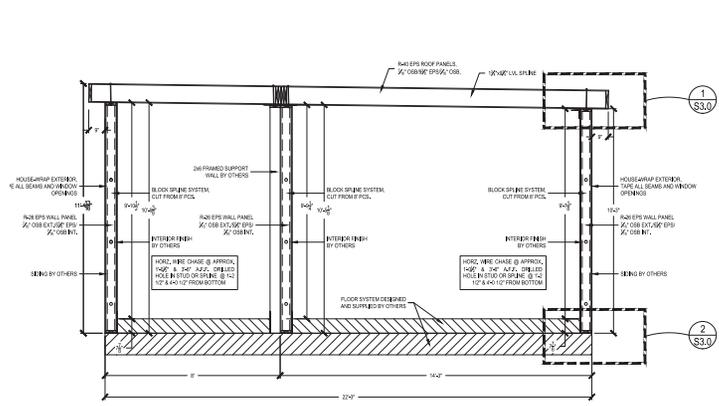
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 REVISIONS:  
 4/10/13  
 4/11/13  
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REVISIONS:

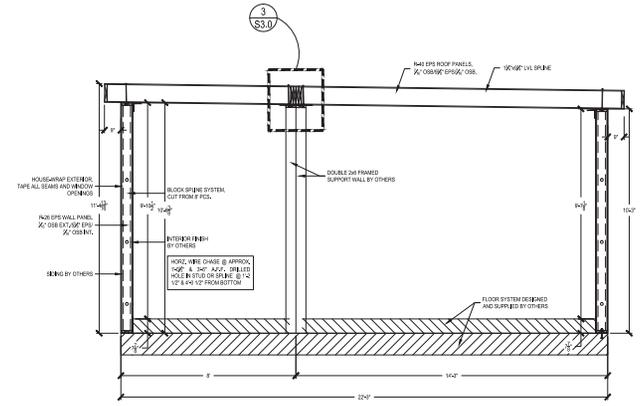
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 MISSOURI S&T  
 SOLID CORE BUILDING PACKAGE

PROJECT STATUS:

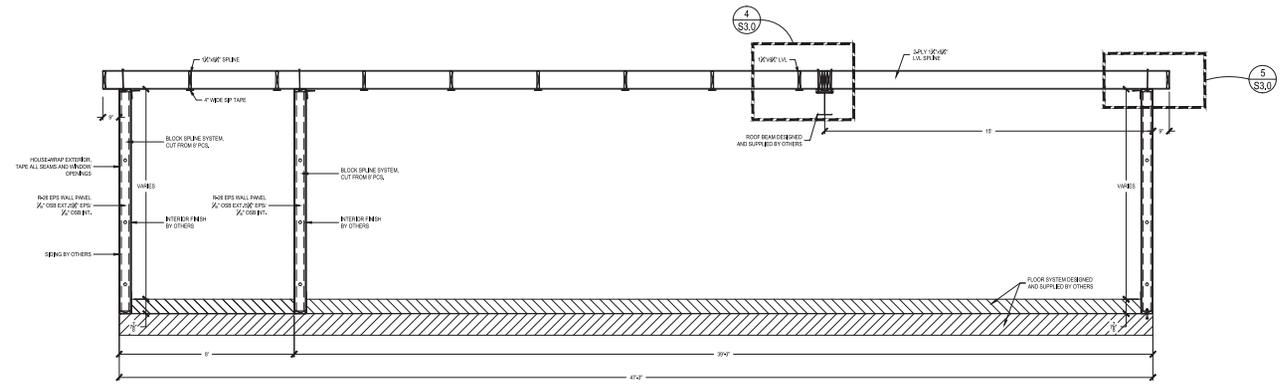
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 S2.0



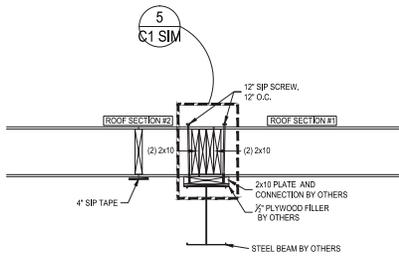
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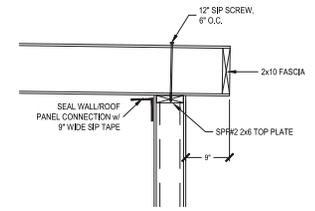
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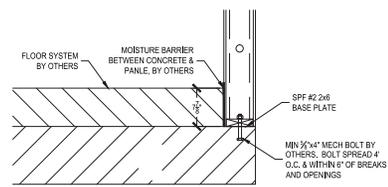
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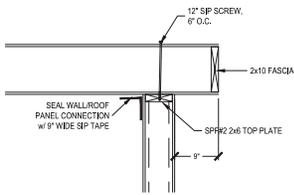
**4** ROOF PANEL SECTION JOINT  
 SCALE: 1"=1'-0"



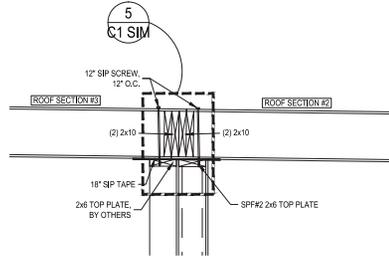
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 SCALE: 1"=1'-0"



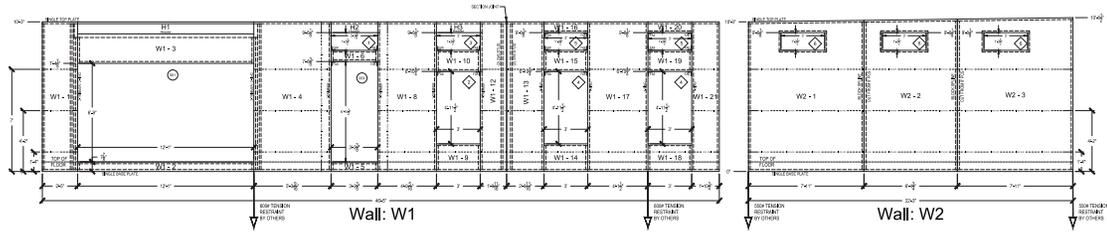
**2** BASE DETAIL  
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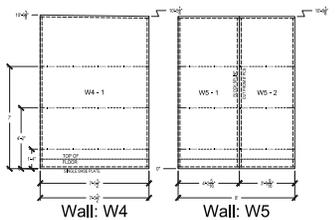
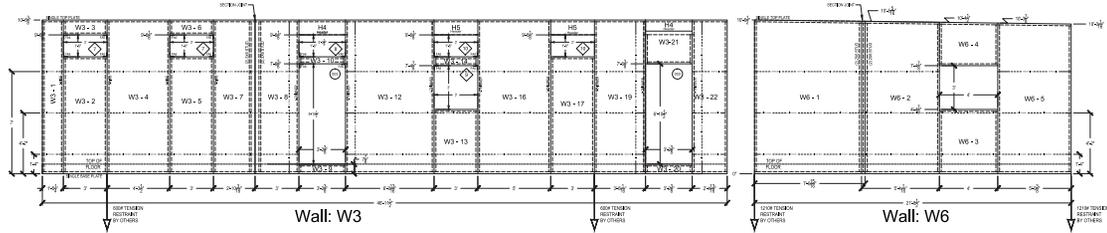
**5** RAKE DETAIL  
 SCALE: 1"=1'-0"

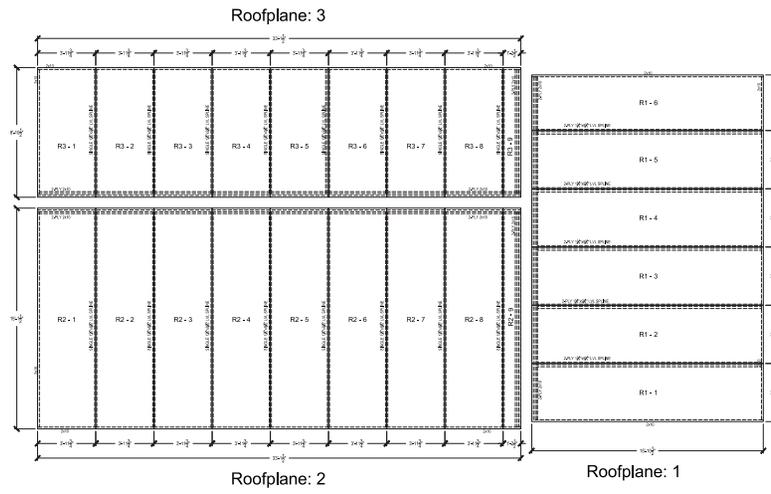


**3** ROOF PANEL SECTION JOINT  
 SCALE: 1"=1'-0"



**1** WALL PANEL ELEVATIONS  
 SCALE: 1/4" = 1'-0"





1 ROOF PANEL LAYOUT  
 SCALE: 1/8" = 1'-0"

